

Full Length Research Paper

Bycatch in 36 and 40 mm PA Turkish twin rigged beam trawl codends

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The Turkish twin rigged beam trawl which has two identical nets rigged side by side on the same beam targets mainly the *Parapenaeus longirostris*, although some bycatch fish species have also become target species. Thus, landings of the shrimp beam trawling fleet also include some commercially valuable fishes. Our study focused on the bycatch commercial species which are caught by the beam trawl fishery with nominal mesh sizes 36 and 40 mm PA (diamond) codend in the Sea of Marmara (Turkey) and also on the minimum landing size (MLS) established for *Merluccius merluccius*, *Merlangius merlangus euxinus*, *Mullus surmuletus*, *Trachurus trachurus* and *Pomatomus saltatrix*. Since there was no MLS value for *Spicara smaris*, the length at first maturity (LFM) was used for this species. Experiments were carried out onboard the commercial beam trawler. In 20 hauls, the average codend catch weight was 63.12 kg for 36 mm PA and 66.51 kg for 40 mm PA. On the other hand, for 36 mm PA, 83.5% of *M. merluccius*, 74.3% of *M. merlangus euxinus*, 29.7% of *T. trachurus*, 10.8% of *P. saltatrix* and 8.6% of *M. surmuletus* were below the MLS. For 40 mm PA, 88.9% of *M. merlangus euxinus*, 87.7% of *M. merluccius*, 42.5% of *T. trachurus*, 7.2% of *P. saltatrix* and 6.7% of *M. surmuletus* were below MLS. In addition, 7.5% of *S. smaris* were below length at first maturity (LFM) for 36 PA codends.

Key words: Beam trawl, rose shrimp, *Parapenaeus longirostris*, bycatch, discards, minimum landing size, Sea of Marmara, Turkey.

INTRODUCTION

Fishing has significant direct and indirect effects on the habitat, diversity and productivity of marine communities. The main direct effect of trawling is an increase in the mortality of marketable as well as discarded species (Stergiou et al., 1998; Hall, 1999; de Groot, 1984; Messieh et al., 1991; Jones, 1992; de Groot and Lindeboom, 1994; Dayton et al., 1995). Beam trawl fishery is characterized by a considerable bycatch of fish and invertebrates (van Beek et al., 1990; Ross and Hokenson, 1997; Cabral et al., 2002). A fraction of the

total bycatch includes non-target species of high commercial value, but a considerable portion consists of non-marketable target species, consisting of undersized or poor quality specimens and bycatch species with low or no commercial value that are discarded on board in relatively similar proportions in different trawl types (over 70%) (Monteiro et al., 2001). Discarding has been widely reported as ecologically-damaging, unethical and a waste of marine resources. In recent years, the European commission made commitments to address discarding and gear modifications are considered to be potentially useful tools that can partially mitigate the problem of discards (Wade et al., 2009). It is possible to limit the amount of bycatch in the region of high species diversity. Experiments suggest that selectivity can be substantially improved by relatively simple modifications (Stergiou et al., 1997; Sarda et al., 2004, 2005; Bahamon et al., 2006; Guijarro and Masutti, 2006; Cook, 2003;

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Abbreviations: TFR, Turkish fishery regulations; MLS, minimum landing size; LFM, length at first maturity.

Valdemarsen and Suuronen 2003; ICES, 2004).

Shrimp is the most abundant benthic species in the Sea of Marmara and currently 72% of the Turkish shrimp production is provided by shrimp fishing stocks (Zengin et al., 2007). Beam trawls are used extensively in the Sea of Marmara to catch rose shrimp (*Parapenaeus longirostris*). Almost all shrimp production in Turkey is obtained through fishing. With a total shrimp catch amounting to 2384 tons of shrimp in 2001, the Sea of Marmara occupies the first place among Turkish seas (overall shrimp production of 3856 tons) (TUIK, 2006). It is also assumed that the present data for the Sea of Marmara underestimates the actual catch. Compared with other Turkish seas, *P. longirostris* dominates the catch in the Sea of Marmara, indicating a high potential for Turkey's total shrimp production (Bayhan et al., 2005).

In the Sea of Marmara, *P. longirostris* is caught in the coastal zone by small beam trawlers with a maximum engine power of 160 hp (Zengin et al., 2004). The Turkish fishery regulations (TFR) allow catching rose shrimp in waters deeper than 50 m, using beam trawls with a maximum codend length of 11 m and a minimum mesh size of 32 mm. Each boat is allowed to use either two twin beam trawls with two codends and maximum total beam length of 15 m or three beam trawls each with 5 m maximum beam length (Anonymous, 2006). Traditionally, this beam trawl fishery targeted mainly rose shrimp but some bycatch fish species have become the main target species. Thus, nowadays the landings of the beam trawling fleet include some commercially valuable fish species, namely European hake (*Merluccius merluccius*), whiting (*Merlangius merlangus euxinus*), striped red mullet (*Mullus surmuletus*), horse mackerel (*Trachurus trachurus*), bluefish (*Pomatomus saltatrix*) and picarel (*Spicara smaris*). According to TFR, there is no minimum landing size (MLS) for rose shrimp, but there is MLS for these commercial fish species.

Some researchers aimed to reduce discards in beam trawls (Fonteyne and M'Rabet, 1992; Fonteyne and Polet, 2002; Revill and Jennings, 2005; Van Marlen, 2003; Van Marlen et al., 2004), but those studies have generally focused on only a few fish species or specifically on benthic invertebrates. There are several recent studies on selectivity of trawl codends (Kaykaç et al., 2009; Düzbastilar et al., 2010; Ates et al., 2010a; Aydın et al., 2011) that have been performed in Turkey, some of them specifically on selectivity of beam trawl codends in the Sea of Marmara (Deval et al., 2006; Bök et al., 2010; Ates et al., 2010b). No studies mentioned here calculated MLS and LFM except Ozbilgin et al. (2006) in the Aegean Sea for 40 mm PE demersal trawl codend.

Our study focused on the commercially valuable fish species caught as bycatch by the beam trawl fishery with 36 and 40 mm diamond codend in the Sea of Marmara, including a comparison with the MLS legally stipulated for *M. merluccius*, *M. merlangus euxinus*, *M. surmuletus*, *T.*

trachurus, *P. saltatrix* and *S. smaris*.

MATERIALS AND METHODS

The fishing surveys were conducted between March and April 2007. A total of 20 hauls (10 hauls for 36 mm PA codend and 10 hauls for 40 mm PA codend) were carried out onboard the commercial beam trawler "Deniz" (length 13 m; engine power 130 hp), during daylight hours, under stable weather and sea conditions. Fishing was performed in the northern Sea of Marmara (Figure 1), on commercial fishing grounds at depths from 50 to 100 m. The gear studied was a commercial shrimp beam trawl with a beam length of 7 m and vertical net opening of 0.5 m. The length of the headline and the ground rope (chain) were 3.5 and 4.3 m, respectively. The Turkish twin rigged beam trawl has two identical nets rigged side-by-side on the same beam (Figure 2). The towing duration was 3 to 4 h for all the hauls and the towing speed varied between 2.0 and 2.5 knots (like in commercial fishing). The warp length used during the trials was 250 to 350 m.

Data were collected by using the covered codend method. Overall dimensions of the covers were 1.5 times larger than the width and length of the codends. Each cover was held opened by a 1.0 m diameter half hoop over the top panel of the codend (Polet, 2000). Two different codends in nominal mesh sizes were tested: 36 mm PA diamond mesh and 40 mm PA diamond mesh. Covers were constructed of single twisted PA 24 mm mesh netting with a twine thickness of 1.0 mm. The net plan is illustrated in Figure 3.

Once the catch was taken on board, codend and cover components were separately sorted by species and weighed to the nearest 0.05 kg. Then, the total length of six commercial species, namely *M. merluccius*, *M. merlangus euxinus*, *M. surmuletus*, *T. trachurus*, *P. saltatrix* and *S. smaris* was measured to the nearest 0.5 cm. Total numbers and weights of fish below MLS were calculated. According to TFR, the following MLS values were used: 25 cm for *M. merluccius*, 14 cm for *P. saltatrix*, 13 cm for *M. merlangus euxinus* and *T. trachurus* and 11 cm for *M. surmuletus*. As the TFR does not specify a MLS value for *S. smaris*, the length at first maturity (LFM = 11 cm) was used for this species (Soykan et al., 2010). Finally, percentages of bycatch for each species were calculated using the total numbers and total weights of individuals below MLS or LFM.

RESULTS

A total of 40 species were caught in codend and cover during 20 valid hauls. Average weight and percentage total weight of each species are given in Table 1. Among the species caught, 16 were marketable at various commercial values. For 36 mm PA codend, the most abundant commercial fish in total catch was *M. merluccius* (9.9%), followed by *P. saltatrix* (7.2%), *T. trachurus* (3.1%) and *M. surmuletus* (1.8%). In addition, *Raja clavata* (19.4%), *Raja asterias* (16.8%) and Portunidae crabs (10.3%) were the most frequent non-commercial species. For 40 mm PA codend, the most abundant commercial fish in total catch was also *M. merluccius* (12.4%), followed by *P. saltatrix* (5.1%), *T. trachurus* (3.3%) and *M. surmuletus* (1.9%). *R. asterias* (22.3%), Portunidae crabs (11.4%) and *R. clavata* (7.6%) dominated among the non-commercial species.

Average codend catch weight of the 20 hauls was 63.12

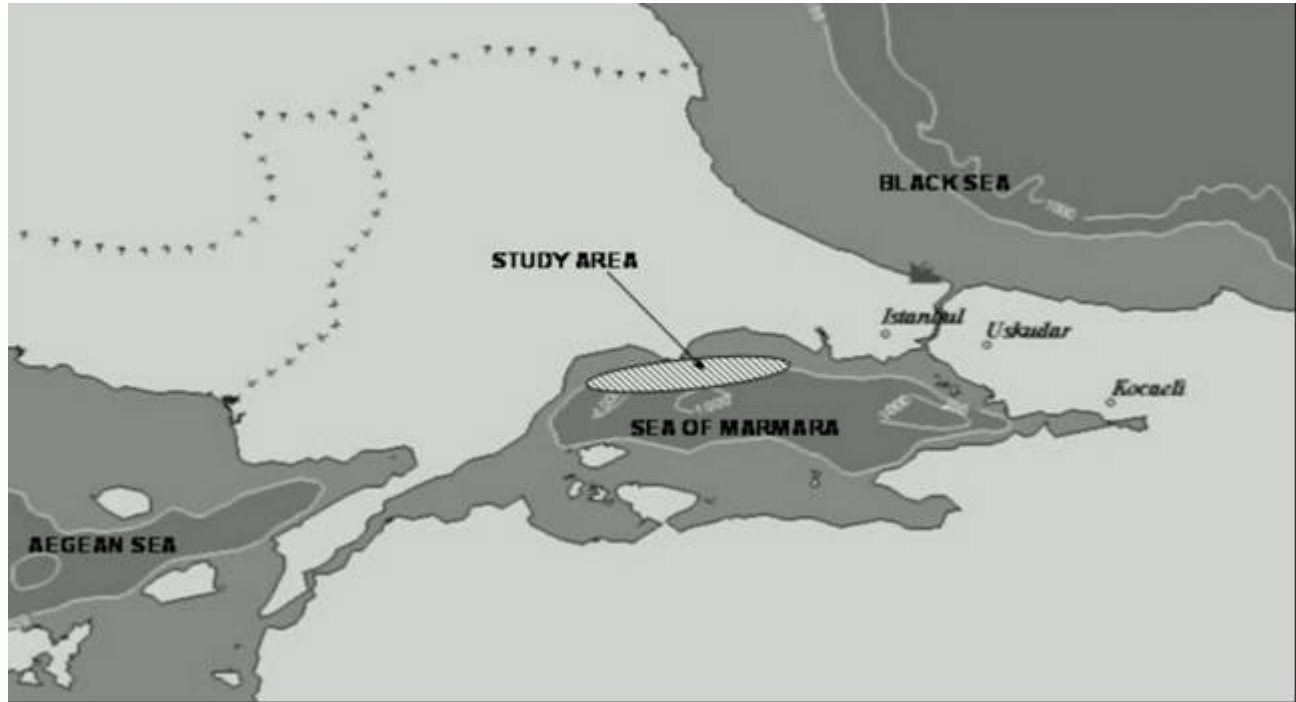


Figure 1. The Sea of Marmara and the study area.

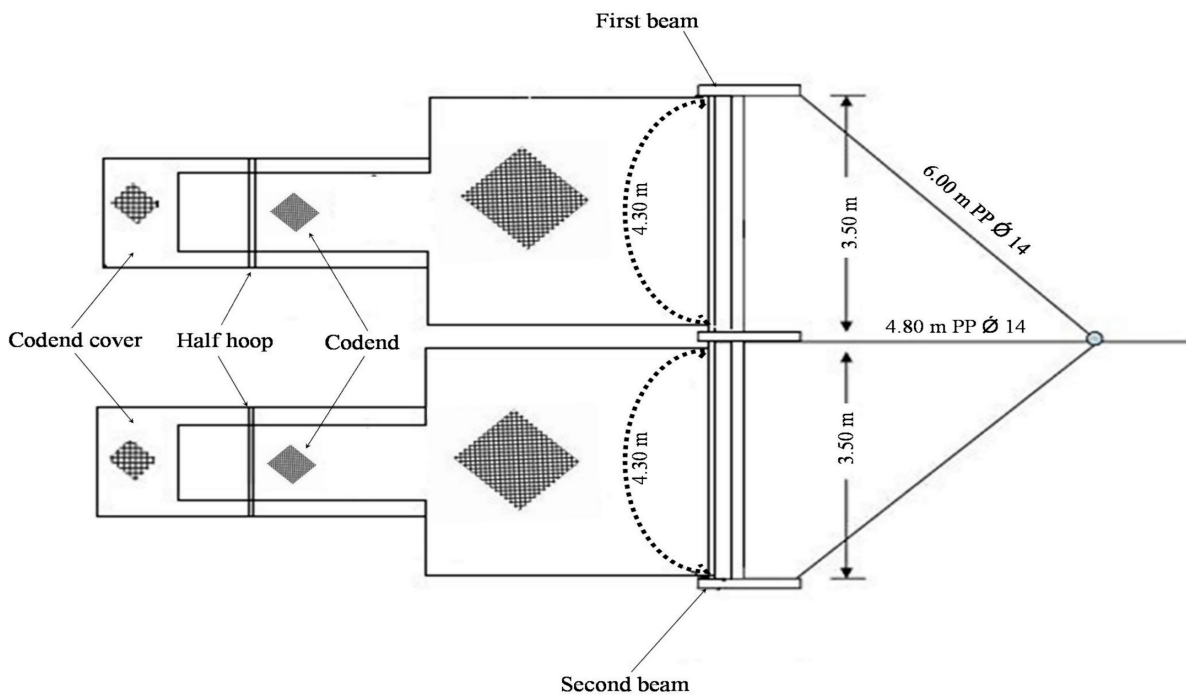


Figure 2. Drawing of the twin rigged shrimp beam trawl used in the study.

kg for 36 mm PA and 66.51 kg for 40 mm PA. From Table 1 it can be calculated that, for 36 and 40 mm, an average of 22.6% (14.24 kg) and 23.6% (15.69 kg) of

codend catch was composed of target species and 28.9% (18.24 kg) and 27.8% (18.47 kg) of codend catch was composed of commercial species, while the

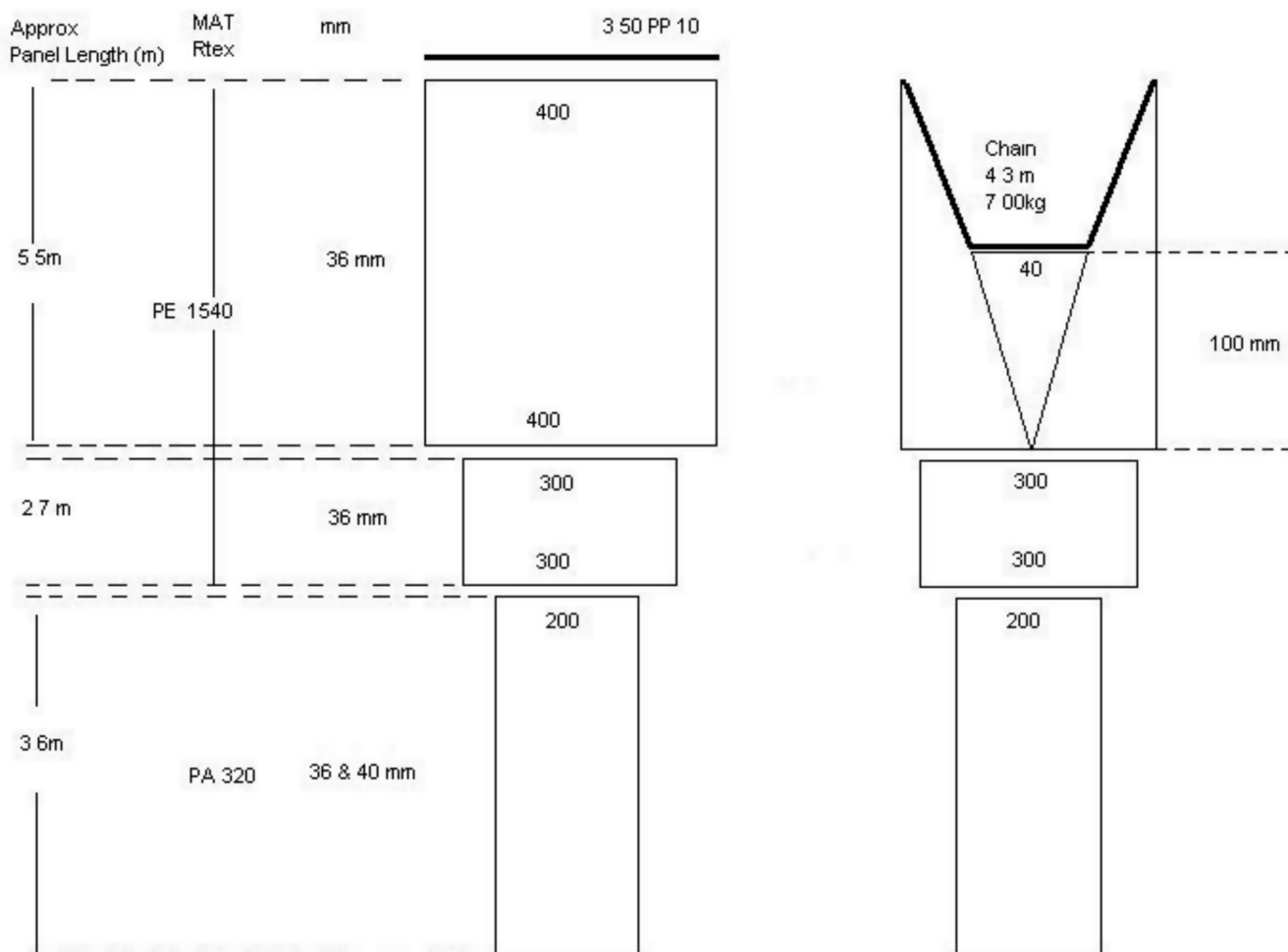


Figure 3. Technical plan of the beam trawl net used during the fishing surveys.

remaining 48.5% (30.64 kg) and 49.2% (32.71 kg) were non-commercial species, respectively. However, not all the marketable species were landed, as some of them were small (below MLS) or because there is no market demand for small specimens. Figure 4 presents the length frequency distributions of *M. surmuletus*, *M. merluccius*, *M. merlangus euxinus*, *T. trachurus*, *P. saltatrix*, and *S. smaris* caught in 36 and 40 mm PA diamond codends, respectively.

It can be seen from Table 2 that a considerable amount of fish, even from some commercial species, are caught as bycatch in 36 and 40 mm PA codends. It was observed that, for 36 mm PA, 83.5% of *M. merluccius*, 74.3% of *M. merlangus euxinus*, 29.7% of *T. trachurus*, 10.8% of *P. saltatrix* and 8.6% of *M. surmuletus* were below MLS. It was also found that, for 40 mm PA, 88.9% of *M. merlangus euxinus*, 87.7% of *M. merluccius*, 42.5% of *T. trachurus*, 7.2% of *P. saltatrix* and 6.7% of *M. surmuletus* were below MLS. In addition, 7.5% of *S. smaris* were below the LFM for 36 mm PA codend, while *S. smaris* was not recorded for 40 mm PA codend.

DISCUSSION

In Turkey, beam trawl is an effective fishing gear to catch demersal crustacean and fish species, such as *P. longirostris*, *M. merluccius*, *M. merlangus euxinus*, *M. surmuletus*, but also *M. barbatus*, *Trigla lyra*, *T. lucerna*, *Lophius piscatorius* and *Solea solea*.

Commercial beam trawling is a very important activity in the northern Sea of Marmara and generates significant amounts of bycatch, with the great majority of the total catch being captured accidentally (total bycatch). There are currently 40 registered beam trawlers (Zengin et al., 2004), based on the ports of Tekirdağ and Istanbul, operating in the waters around the northern Sea of Marmara. They are between 7 and 13 m long, each towing two twin beam trawls with two codends and maximum total beam length of 15 m or three beam trawls of 5 m beam length each. This mixed-species beam trawl fishery in the Sea of Marmara captures mostly bycatch species and produces a large amount of discards.

Studies on beam trawl bycatch are rather limited in

Table 1. Fish and invertebrate species caught in the beam trawl 36 and 40 mm PA codend and its cover (24 mm) in the Sea of Marmara.

Species	36 mm PA codend					40 mm PA codend			
	Type	Kg	%	N	%	Kg	%	N	%
<i>Parapenaeus longirostris</i>	T	14240.59	22.6	1732	50.0	15697.91	23.6	2322	59.4
<i>Merluccius merluccius</i>	C	6222.91	9.9	91	2.6	8246.77	12.4	130	3.3
<i>Merlangius merlangus euxinus</i>	C	500.61	0.8	35	1.0	965.46	1.5	68	1.7
<i>Mullus surmuletus</i>	C	1151.62	1.8	35	1.0	1291.84	1.9	47	1.2
<i>Spicara smaris</i>	C	654.09	1.0	33	1.0	656.83	1.0	30	0.8
<i>Pomatomus saltatrix</i>	C	4565.50	7.2	158	4.6	3421.73	5.1	124	3.2
<i>Trachurus mediterraneus</i>	C	1978.36	3.1	91	2.6	2224.62	3.3	124	3.2
<i>Chelidonichthys lucerna</i>	C	104.61	0.2	1	0.03	47.78	0.1	3	0.1
<i>Trigla lyra</i>	C	222.40	0.4	12	0.3	260.24	0.4	14	0.4
<i>Lophius piscatorius</i>	C	830	1.3	1	0.03				
<i>Solea solea</i>	C	120	0.2	1	0.03	110.32	0.2	1	0.03
<i>Uranoscopus scaber</i>	C	903.73	1.4	5	0.1	575.0	0.9	8	0.2
<i>Gaidropsarus mediterraneus</i>	C	25.04	0.04	4	0.1	16.31	0.02	3	0.1
<i>Scorpeana porcus</i>	C					276.0	0.4	2	0.1
<i>Paneus kerathurus</i>	C	109.88	0.2	34	1.0	80.67	0.1	25	0.6
<i>Plesionika heterocarpus</i>	C	786.69	1.2	417	12.0	221.17	0.3	78	2.0
<i>Sephia officinalis</i>	C	61.44	0.1	3	0.1	76.90	0.1	2	0.1
<i>Serranus hepatus</i>	NC	83.70	0.1	6	0.2	82.72	0.1	9	0.2
<i>Serranus cabrilla</i>	NC	42.54	0.1	2	0.1				
<i>Cepola macrophthalma</i>	NC	44.79	0.1	3	0.1				
<i>Gobius niger</i>	NC	100.47	0.2	8	0.2	130.84	0.2	11	0.3
<i>Lesueurigobius friesii</i>	NC	102.53	0.2	37	1.1	132.02	0.2	52	1.3
<i>Callionymus lyra</i>	NC	164.92	0.3	6	0.2	63.13	0.1	2	0.1
<i>Callionymus sp.</i>	NC	40.51	0.1	2	0.1	85.97	0.1	6	0.2
<i>Arnoglossus laterna</i>	NC	93.03	0.1	14	0.4	17.01	0.03	2	0.1
<i>Solea kleinii</i>	NC	6.42	0.01	1	0.03	8.05	0.01	1	0.03
<i>Eutrigla gurnardus</i>	NC	73.51	0.1	3	0.1	101.0	0.2	3	0.1
<i>Aspitrigla cuculus</i>	NC	145.37	0.2	4	0.1	44.35	0.1	1	0.03
<i>Syngnathus acus</i>	NC	19.19	0.03	2	0.1	7.86	0.01	1	0.03
<i>Raja clavata</i>	NC	12256.37	19.4	9	0.3	5041.86	7.6	8	0.2
<i>Raja astarias</i>	NC	10578	16.8	7	0.2	14886.0	22.4	12	0.3
<i>Raja oxyrinchus</i>	NC					2572.0	3.9	1	0.03
<i>Mustelus asterias</i>	NC					58.38	0.1	1	0.03
<i>Torpedo marmorata</i>	NC					473.0	0.7	1	0.03
Portunidae	NC	6471	10.3	512	14.8	7637.04	11.5	352	9.0
<i>Latreilla sp.</i>	NC	3.55	0.01	1	0.03	3.55	0.01	2	0.1
Sepiolidae	NC	10.65	0.02	2	0.1	26.80	0.04	4	0.1
<i>Illex coindetii</i>	NC	57.62	0.1	3	0.1	49.38	0.1	1	0.03
<i>Ophiura sp.</i>	NC			9	0.3			6	0.2
<i>Astropecten irregularis</i>	NC	350.56	0.6	177	5.1	916.26	1.4	453	11.6
Total		63122.20		3461		66506.77		3910	

W, weight (g); C, commercial; NC, non-commercial.

Turkish waters. Yazici et al., (2006) calculated a bycatch of 2.19% in the southern Sea of Marmara for the following species: *M. merluccius*, *M. merlangus euxinus*, *T. trachurus*, *S. smaris*, *S. solea*, *Mullus barbatus*, *T. lyra*, *Diplodus annularis*, *R. clavata*, *Zeus faber*, *Scorpaena*

scrofa, *Loligo vulgaris* and *Sepia officinalis*. They also reported bycatch (in terms of weight) for *M. merluccius*, *T. trachurus*, *S. smaris* and *M. merlangus euxinus* of 15.54, 1.17, 0.48 and 5.37%, respectively. In terms of number of bycatch individuals, Bayhan et al. (2006)

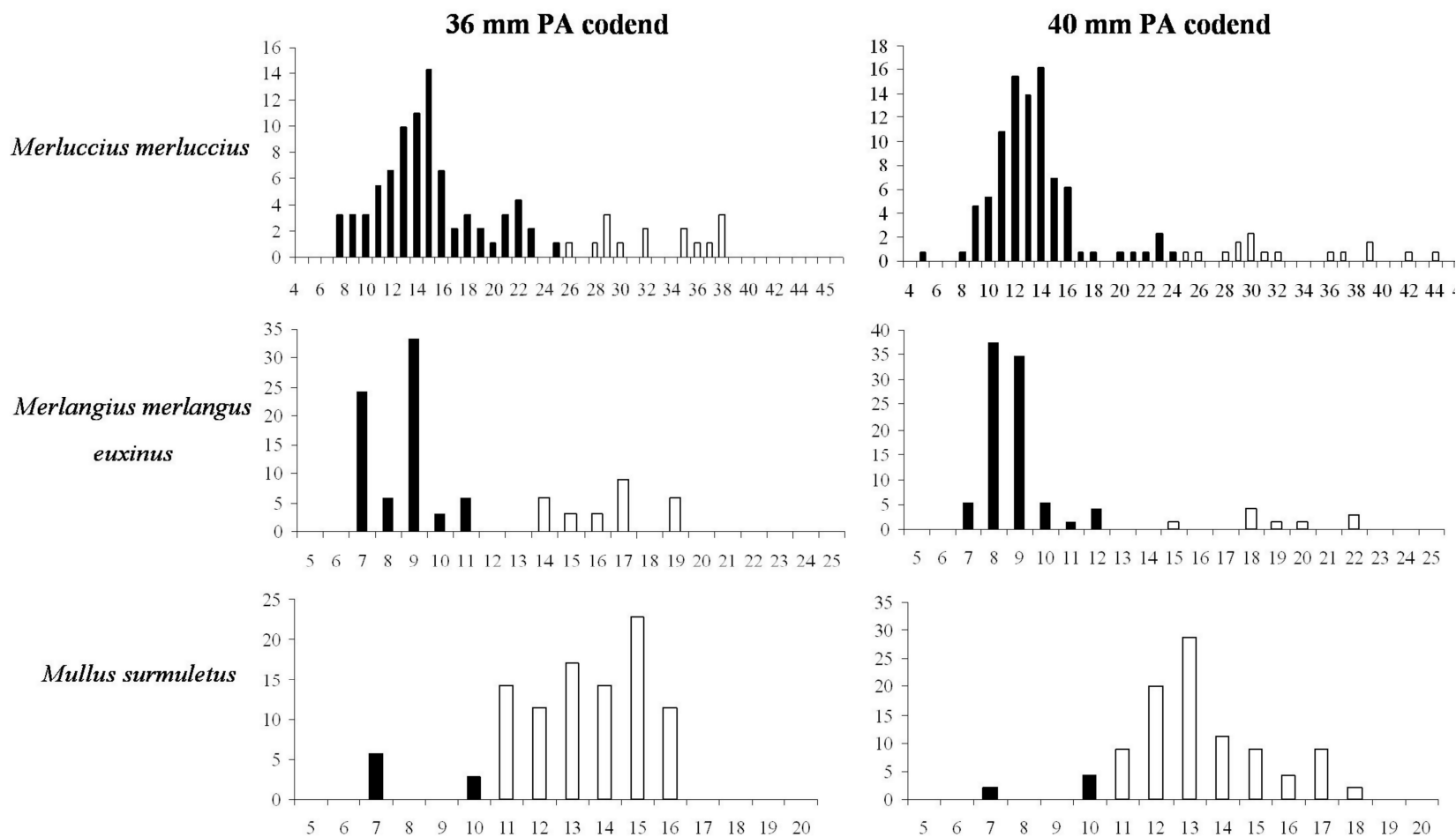


Figure 4. Length frequency distributions of *M. merluccius*, *M. merlangus euxinus*, *M. surmuletus*, *T. trachurus*, *P. saltatrix* and *S. smaris* captured in 36 and 40 mm PA codend. Dark bars denote length classes below MLS or LFM. White bars denote length classes above MLS or LFM.

reported 0.38, 2.53 and 0.03% for *M. merluccius*, *M. merlangus euxinus* and *T. trachurus*, respectively. In a study that covered the whole Sea of Marmara, Zengin et al. (2004) reported bycatch values of 12.1% in number and 24.4% in

weight, irrespective of mesh size. These studies focused on 32 mm codends, which is the mesh size currently used in commercial beam trawl fishery in Turkey. Except Ozbilgin et al. (2006), working with 40 mm PE demersal trawl codend in

the Aegean Sea, no other studies reported data on the proportion of the catches relative to MLS and LFM.

In this study, the data show that considerable amount of fish, including some commercial

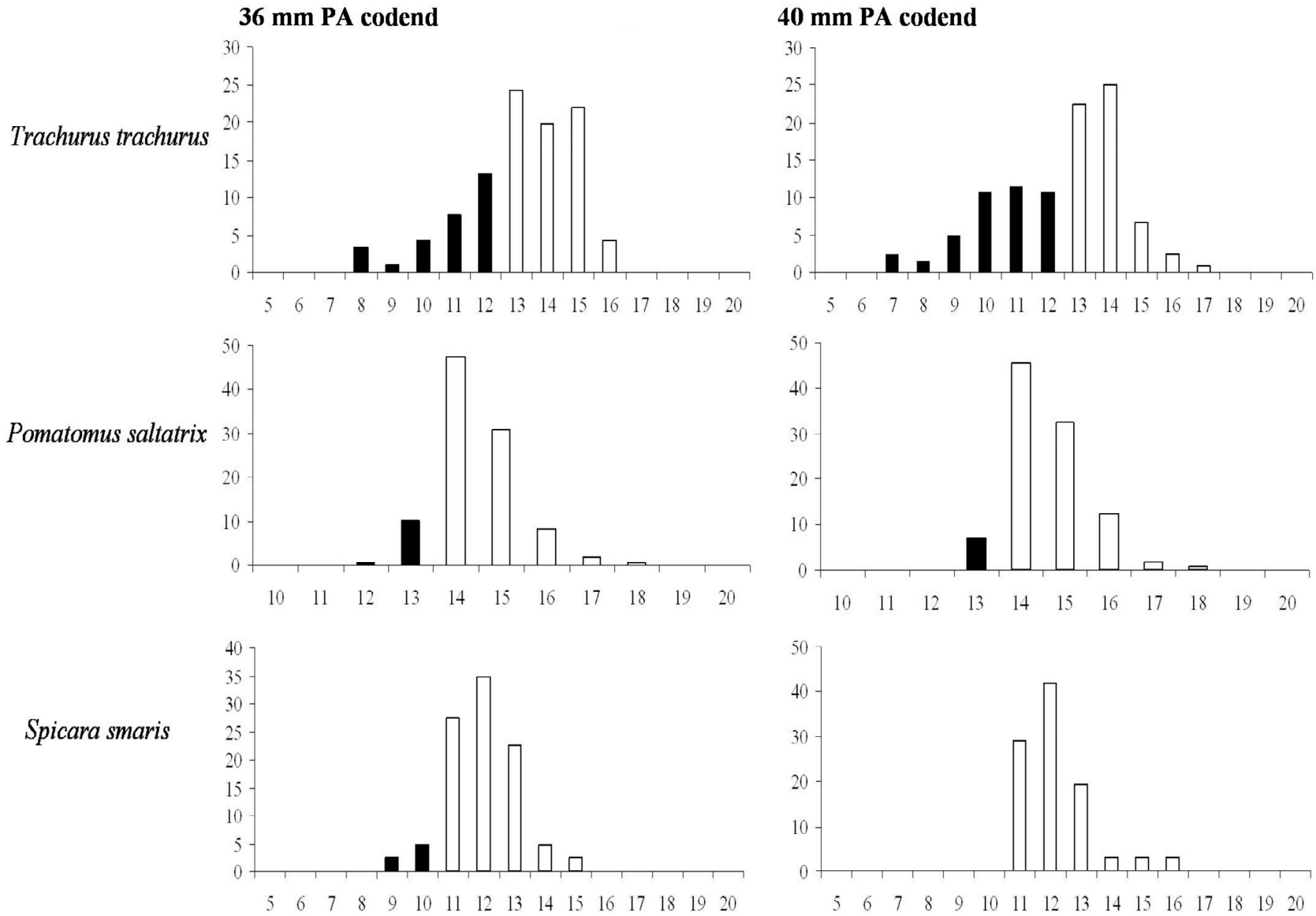


Figure 4. Contd.

Table 2. Number and percentage of bycatch for six commercial species (*M. merluccius*, *M. merlangus euxinus*, *M. surmuletus*, *T. trachurus*, *P. saltatrix* and *S. smaris*) caught in 36 and 40 mm PA codends. MLS data obtained from TFR. *S. smaris* LFM reported by Soykan et al. (2010).

Species	MLS or LFM (cm)	Number below MLS or LFM		Total number		Percentage below MLS or LFM	
		36 mm	40 mm	36 mm	40 mm	36 mm	40 mm
<i>Merluccius merluccius</i>	25	76	114	91	130	83.5	87.7
<i>Merlangius merlangus euxinus</i>	13	26	64	35	72	74.3	88.9
<i>Mullus surmuletus</i>	11	3	3	35	45	8.6	6.7
<i>Trachurus trachurus</i>	13	27	51	91	120	29.7	42.5
<i>Pomatomus saltatrix</i>	14	17	8	158	114	10.8	7.2
<i>Spicara smaris</i>	11	3		40	31	7.5	

species, are caught as bycatch in 36 mm PA and 40 mm PA beam trawl codends. The comparison of the proportion of the catches below MLS between 36 and 40 mm codends revealed that the percentages of *P. saltatrix*, *M. surmuletus* and *S. smaris* were higher for 36 mm PA, whereas the percentages of *M. merluccius*, *M. merlangus euxinus* and *T. trachurus* were higher for 40 mm PA. In addition, *S. smaris* below LFM was caught in 40 mm PA codend.

This study registered percentages of bycatch species of 28.9% for 36 mm PA and 27.8% for 40 mm PA. Overall, this means that total catches comprised more bycatch species than the target species (*P. longirostris*); this information encourages further studies on this subject and that should be considered in future management measures for the fishery targeting rose shrimp in the Sea of Marmara. It is also well known that reducing bycatch with grids is a very common method in the world. Bycatch reduction devices (BRD's) can be developed to eliminate bycatch and reduce the non-target species; especially juvenile commercial species and other unwanted catch in Turkish twin rigged beam trawl.

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