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Comparison of biological characteristics of the horse Mackerel (*Trachurus trachurus* L. 1758) which caught of different fishing gears in the Southern Black Sea (Turkey)

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Total of 6035 horse mackerel, *Trachurus trachurus* L. 1758, found in the Black Sea, caught by various types of fishing gear, as purse seines, bottom trawls, gillnets, mid-water trawls and fishing lines had been examined during January to December 2003. Length, weight, sex distribution, the ratio of fish under the minimum legal landing size and distribution of juvenile fish and the types of gear used were compared as a part of the study. Mean total lengths of the horse mackerel caught using all these types of fishing gear (purse seines, bottom trawls, gillnets, mid-water trawls and fishing lines) are measured at 12.69, 12.01, 15.35, 13.18 and 14 centimeters, respectively. According to their sex, the minimum mean total length and weight were measured for a purse seine at 13.34 cm and 20 g for females, 13.33 cm and 19.73 g for males. Minimum legal landing size (MLLS) is 13 cm and the ratios of under 13 cm for purse seines, bottom trawls, gillnets, mid-water trawls and fishing lines were measured at 60.79%, 65.04%, 9.66%, 39.14% and 20.42%, respectively. The bottom trawl and purse seine were more capable than other fishing gear in catching juvenile fish.

[**Keywords:** Horse mackerel, *Trachurus trachurus*, Biological characteristics, Different fishing methods, MLLS, Black Sea]

Introduction

The statistical analysis of FAO reveals that fishing over the last 50 years, 366 sources for fishing had completely subsided. This is one-fourth of the total sources[1]. The genus *Trachurus* species is one of the most important species in fisheries[2]. It is found in the Mediterranean and Black Seas, Zone No. 37 in statistical sub-zones of the FAO. The amounts of horse mackerel fishing examined between 1990-2000, for *Trachurus* species caught in both Seas, had a total rate of 70% in Turkey[3].

There are prime annual variation in the amount of *Trachurus* fishing. While the average fishing amount between 1983 and 1990 was 102,146 tons, it decreased to 33,848 tons in 1991 and to 29,334 tons in 1992. There is little fluctuation until 1999. It decreased to the least amount, 13, 220 tons, that same year. During the year 2007, *Trachurus* species is the second most important species with an average of 32,021 tons of the total production[4].

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During the period when the mid-water trawl is not so commonly used in the Black Sea, *Trachurus* fishing is at 98.5% using a purse seine; 0.3%, a bottom trawl; 0.9%, a gillnet; and at 0.3% using a fishing line[5]. Recently the mid-water\ trawl was used for *Trachurus* fishing, which makes it all the more important that the effect of these types of fishing gear be examined for sustainable exploitation.

The present study examined the length, weight, sex distribution, and the ratio of individual fish under minimum legal landing size (MLLS) pertaining to horse mackerel, *Trachurus trachurus* L. 1758 caught by a purse seine, a bottom trawl, a gillnet, a mid-water trawl and a fishing line in the Black Sea. The effect of these gears on horse mackerel stocks was also examined. Mentioned above, this comparison was used to identify potential overlapping and competence of the gear, as well as the suitability of the different types of gear for sustainable exploitation.

Materials and Methods

During the year 2003, a total of 6,035 individuals of the horse mackerel were collected from the middle area of the Black Sea, (between latitude 42° 07′ N and 41° 38′ N; longitude 34° 29′ E and 36° 54′ E) one of the most predominant fishing areas of any Turkish sea, using commercial fishing gear; purse seines (nominal mesh size: 7 mm), bottom trawls (nominal mesh size: 20 mm), gillnets (nominal mesh size: 16 mm), mid-water trawls (nominal mesh size: 14 mm) and fishing lines (Mustad hook size: 10-12). In the laboratory, the total length (TL) was measured to the nearest 0.1 cm while total weight was measured with 0.01 g sensitivity. Length-weight relationship was determined by the equation $W=aL^b$, where W is the weight, L is the length, a and b are the coefficients of the functional regression between W and L for females and males[6].

Comparisons of the length frequency distribution with different types of fishing gear were conducted using the Kolmogorov-Smirnov test[7]. Length frequencies were also determined against the mean length at 50% maturity (L_m), the optimum exploitation length (L_{opt}). L_∞ was estimated from maximum total length (L_{max}: 19.8) using $L_\infty = L_{max}/0.95$[8] and the L_m and L_{opt} were estimated according to the empirical formula[9]. Minimum legal landing size (MLLS) was 13.0 cm for horse mackerel in Turkey[10]. A one-sided analysis of variance was used to compare the mean size and weight among the fishing gear. A chi-square (χ^2) test was used for differences in sex ratios.

Results

In the study, the mean lengths from a purse seine, a bottom trawl, a gillnet, a mid-water trawl and a fishing line were measured at 12.69±0.045 cm, 12.01±0.051 cm, 15.35±0.051 cm, 13.18±0.074 cm and 14.00±0.064 cm, respectively (Table 1). Among the fishing gear, the horse mackerel having the

Table 1—Mean total length (cm±SE) and weight (g±SE) of horse mackerel by fishing gears in the Middle Black Sea

	Purse Seine	Bottom Trawl	Gillnet	Midwater Trawl	Fishing Line
Lt	12.69±0.045b	12.01±0.051 a	15.35±0.051 e	13.18±0.074d	14.00±0.064 c
Min-max	7-19.1	7.3-18.4	8.6-19.8	6.7-18.1	9.9-17.8
W	17.53±0.203b	15.19±0.204 a	29.38±0.292 e	20.37±0.313d	22.73±0.382 c
Min-max	2.51-58.52	2.82-53.86	4.7-60.82	2.4-53.03	7.49-46.76
N	2015	1805	1046	792	377

(P<0.05) →a,b,c,d,e: Mean values in similar rows different letters are significantly different

Table 2—Mean total length (cm±SE) and weight (g±SE) of horse mackerel according to fishing gears and sexes

Fishing Methods	Lt		W	
	Female	Male	Female	Male
Purse Seine	13.34±0.058a	13.33±0.056a	20.00±0.323ab	19.73±0.287a
Bottom Trawl	13.51±0.061a b	13.53±0.059a	20.37±0.327b	20.53±0.328ab
Gillnet	15.25±0.070d	15.56±0.066c*	28.71±0.408d	30.49±0.398d*
Midwater Trawl	13.72±0.079b c	13.55±0.080a	22.36±0.432c	21.36±0.386b
Fishing Line	13.84±0.085b c	14.16±0.094b*	21.82±0.499ab c	23.65±0.574c*

↓ a,b,c,...:Mean values in similar columns different letters are significantly different (Tukey's HSD, P<0.05)
→ * : Mean values in similar rows different letters are significantly different (Student's t test, P<0.05)

smallest length of 6.7 cm was caught by a mid-water trawl and the largest length was 19.8 caught by a gillnet. As determined, the values of length and weight were significantly different among the types of fishing gear ($P<0.001$). (Table 1).

When examined according to sex, looking at the mean values of length and weight, the smallest mean length and weight values were 13.34 cm and 20.00 g for females caught by a purse seine. Also among male fish, the smallest length and weight values measured at 13.33 cm and 19.73 g, again caught by a purse seine. The largest length and weight values for both sexes were determined for gillnet fishing (Table 2).

An important difference was found statistically according to sex in both lengths and weights of horse mackerel caught by gillnet and fishing line ($P<0.05$). According to the types of fishing gear, important differences were found between a purse seine and gillnet and between a mid-water trawl and fishing line in the lengths of female fish ($P<0.05$). While a difference was not found in the lengths of males caught by a purse seine, a bottom trawl and a mid-water trawl ($P>0.05$), important differences were discovered between gillnet and fishing line and all other types of fishing gear ($P<0.05$). Among the weights of male fish according to the types of fishing gear, a difference was observed between gillnet and fishing line, also between these two types of fishing gear and the other types of gear, and between a purse seine and mid-water trawl. Among the weights of female fish, a difference was noted between gillnet and all other types of fishing gears. As per these types of gear, the numbers of female, male and juvenile horse mackerel are given in Table 3. The sex ratio was measured approximately at 1:1 for all fishing gear and no statistical difference was found ($P>0.05$). Ratio of juvenile fish with no detections of sex was found to be 41% for a bottom trawl, 20% for a purse seine and 9% for a mid-water trawl. These ratios for gillnet and fishing line were at 0.9% and 0%, respectively.

The asimptotic length was estimated at L_{∞}=21 cm from 19.8 cm. This value was computed with formulas calculating L_{opt}=12.70 cm and L_m=12.85 cm. Because the minimal legal landing size (MLLS) is 13.0 cm for horse mackerel, length frequency distributions of fishing gear according to the MLLS were compared. Thus, the ratios below 13 cm of horse mackerel caught by a purse seine, a bottom trawl, a gillnet, a mid-water trawl and a fishing line were 60.79%, 65.04%, 9.66%, 39.14% and 20.42%, respectively (Figure 1, Table 3). The Kolmogorow-Smirnov test indicated that the length frequencies of horse mackerel differed significantly between all pairs of gear ($P<0.001$). (Figure 1)

Table 3—The parameters of the length-weight relations, sexes and smaller than minimum landing legal size (13.0 cm) for each different gear (F: female, M: male, O: overall)

Fishing Methods	Sex	N	A	b	Confidence limits of b	r^2	Growth	F/M	<13cm
Purse seine	F	706	0.0031	3.3655	3.3124-3.4185	0.96	+ Allometric		
	M	911 (398)	0.0042	3.2394	3.1958-3.2829	0.96	"	1:1.29	60.79
	O	2015	0.0052	3.1621	3.1395-3.1847	0.98	"		
Bottom trawl	F	515	0.0037	3.2908	3.2043-3.3772	0.92	"		
	M	550 (740)	0.0032	3.3451	3.2574-3.4328	0.90	"	1:1.07	65.04
	O	1805	0.0066	3.0692	3.0449-3.0936	0.98	"		
Gillnet	F	530	0.0051	3.1530	3.0795-3.2266	0.92	"		
	M	507 (9)	0.0052	3.1506	3.0652-3.2359	0.92	"	1.05:1	9.66
	O	1046	0.0053	3.1428	3.0923-3.1933	0.94	"		
Midwater trawl	F	319	0.0029	3.4036	3.3173-3.4899	0.94	"		
	M	406 (67)	0.0045	3.2278	3.1627-3.2929	0.96	"	1:1.27	39.14
	O	792	0.0055	3.1538	3.1204-3.1861	0.98	"		
Fishing line	F	191	0.0029	3.3830	3.2403-3.5257	0.92	"		
	M	186	0.0027	3.4560	3.3109-3.6012	0.92	"	1.03:1	20.42
	O	377	0.0026	3.4204	3.3199-3.5208	0.92	"		

( ), Juvenile

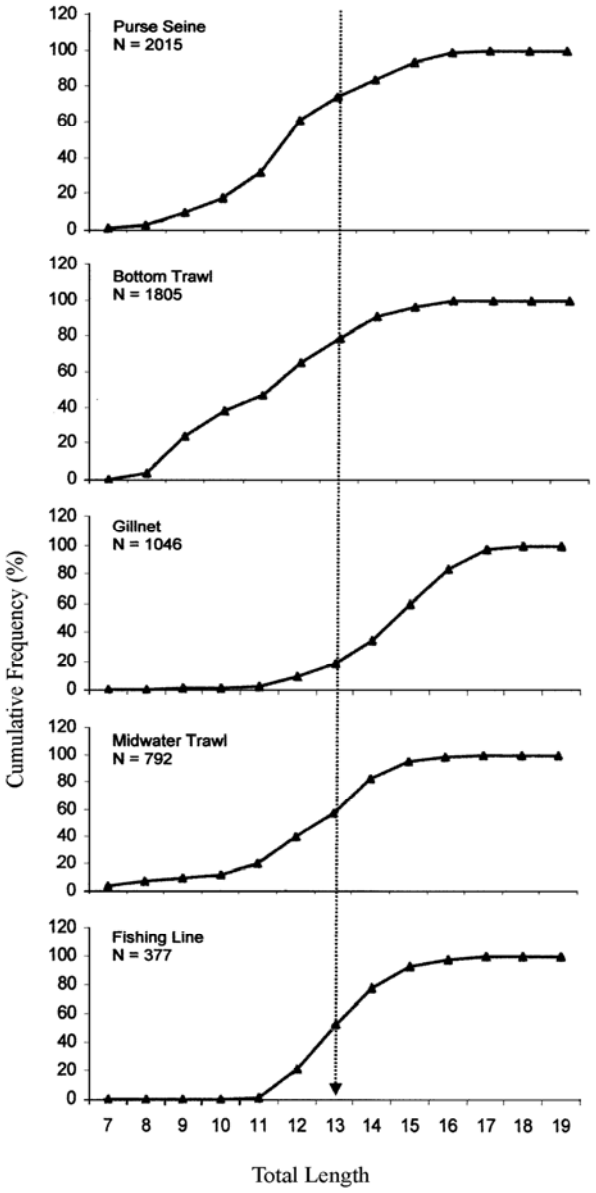

Fig. 1—Cumulative length frequency distributions of horse mackerel for each fishing gear. Arrow indicate the legal fish size (13.0 cm)

The length-weight relation of horse mackerel according to the fishing gear and sex is noted in Table 3. The b values of horse mackerel caught by all gear were found to be higher than b in both sexes ($b \neq 3$, $P<0.05$) and the growth was determined as positive allometric.

Discussion

The sex ratio for horse mackerel is 1:1 in general (in the Black Sea[11-13]; in the Adriatic Sea[14]; in the Gulf of Biscay[2]).

The mean lengths were calculated for horse mackerel caught by a purse seine, a bottom trawl, a gillnet, a mid-water trawl and a fishing line as 12.69 cm, 12.01 cm, 15.35 cm, 13.18 cm and 14 cm, respectively. Reportedly, these values for the Black Sea were 15.16 cm for a purse seine[11]; 13.49 cm, a bottom trawl[13]; and 14.13 cm for mid-water trawl[15]. As also indicated, horse mackerel fishing in the Black Sea between 1990-1995 was performed with a purse seine at 98.5%, a bottom trawl at 0.3%, a gillnet at 0.9% and a fishing line at 0.3%. Reportedly, the mean length values of those fish caught using these types of fishing gear were 11.7 cm, 11.6 cm, 14.6 cm and 14 cm, respectively; and the ratio of those smaller than 13 cm was 52.2%[5].

The current study for horse mackerel caught with a purse seine, a bottom trawl, a gillnet, a mid-water trawl and a fishing line found that the ratios of lengths smaller than 13 cm were 60.79%, 65.04%, 9.66%, 39.14% and 20.42%, respectively. This ratio was 65% for a bottom trawl during 1991-1992[12], and 28.61% for a mid-water trawl during the 1995-1996 fishing season[15]. Reported that the ratio of horse mackerel fish smaller than 13 cm caught by a commercial mid-water trawl towed by two vessels in the middle of the Black Sea in 2000 was approximately 70.46%[16]. During November 2004 and May 2005, the seasonal fishing records of two fishing teams using a mid-water trawl, 75.84% sprat, 11.63% anchovy, 3.3% horse mackerel and 1.39% of other species were examined and noted in the total[17].

In a study on horse mackerel caught by different types of fishing gear on the Greek Islands in the Mediterranean, the smallest length value was determined in trawl fishing. The highest length value was in gillnet fishing. Length distribution of the majority of the samples caught by a purse seine, a trawl, a trammel net and a gillnet were smaller than L_{opt}; and, therefore it was determined that these fishing gear were not appropriate for sustainable fishing[18].

Both in this study and in other studies, the ratio of fish smaller than 13 cm for horse mackerel caught with a purse seine, a bottom trawl and a mid-water trawl is quite higher while lower in the horse mackerel caught with a gillnet and a fishing line. According to these results, 98.5% of horse mackerel are caught with a purse seine, a fishing gear having a

large ratio in catching smaller fish and putting pressure on the stocks. Differences in length and weight of horse mackerel were significant according to both sex and gear ($P<0.05$). Thus, the result demonstrated that significant differences ($P<0.001$) were found in the length frequencies for horse mackerel caught with different types of gears.

Present study infers that, in general, industrial fishing gears (purse seines, bottom trawls and mid-water trawls) caught fish of small lengths when compared to artisanal fishing gears (gillnets and fishing lines). This is typical of the Black Sea, where industrial gear landings are generally composed of the smallest, most immature fish of a species, with sizes smaller than the MLLS which are either discarded or marketed illegally. In addition, the majority of the fish caught both by industrial and artisanal gears had lengths smaller than the MLLS, a fact demonstrating that these gears are not appropriate for sustainable exploitation of fish stock.

Being calculated at a value of b higher than 3 for both sexes generally shows that the growth is positive allometric for horse mackerel,. This is further seen as positive allometric growth as well in studies previously published[12,13,15]. The b value is closely related to environmental factors directly affecting the growth, such as, temperature, abundance of food and reproduction with the differences according to years being probable[19]. Horse mackerel grow isometrically, although regional differences may be seen in the allometric parameter 'b' of the length-weight relationship related to latitude or food availability in the Mediterranean and Adriatic Seas[20].

The cumulative length frequency distributions (Fig. 1) revealed that for horse mackerel bottom trawl caught smaller individuals, than all other gears (Table 3). Gillnet and fishing line caught larger individuals than the remaining gears. As different sizes of fishes may occupy different habitats, the size caught may depend on the location, depth, mesh size, hook size and type of fishing.

Horse mackerel stocks, is the most important species after anchovy. To protect the above, catching fish smaller than 13 cm, the legal catch size, must absolutely be prevented. One way to prevent catching fish smaller than the legal size would be to close down all fishing at certain times and places after determining the time and the area where horse mackerel stocks are recruitment. Concomitantly, purse seines used for horse mackerel, improving the selectivity via scientific studies, and wide-spread use of the gear having more selectivity used for the fishing of pelagic and semi-pelagic species should be controlled based on these new factors

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