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Research Article

Experiments on the Cod-end Selectivity of Beach Seine Nets on the Turkish Coast of the Aegean Sea

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Abstract: Beach seine nets are commonly used in Turkish coastal areas, especially the Aegean Sea, to catch fish commercially. However, it is known that these nets place excessive pressure on juvenile fish stocks. The aim of the present study was to examine the selection of fish species caught by a beach seine net with a 36 mm mesh size cod-end. In the experiments, the covered cod-end method was used to catch fish escaping from the cod-end. The selectivity of fish species which were caught in higher proportions in terms of both number and weight within the commercial catch composition was evaluated. Fifty percent retention lengths (l_{50}) were 13.43, 11.22 and 9.84 cm for red mullet (*Mullus barbatus*), common pandora (*Pagellus erythrinus*) and annular sea bream (*Diplodus annularis*), respectively. While the l_{50} values for the beach seine cod-end were higher than the minimum landing size for red mullet, lower l_{50} values were established for the other two species. Moreover, most beach seine fishermen attach a small mesh bag (13-21-24 mm mesh size) to the end of the cod-end to catch small sardines (papalina), anchovies, sardines and picarels legally. In this case there is no selectivity for the cod-end. Consequently, these results also support the prohibition of beach seine nets as a management tool.

Key Words: Beach seine net, cod-end selectivity, covered cod-end method, 50% retention length (l_{50}).

Türkiyenin Ege Kıyılarında Kıyı Sürütme Ağlarının (Trata) Torba Seçiciliği Üzerine Denemeler

Özet: Kıyı sürütme ağlarından trata Türkiye Denizlerinde özellikle Ege'de, kıyı bölgesindeki balıkları yakalamada yaygın olarak kullanılan ticari bir av aracıdır. Fakat bu ağların yavru balık stokları üzerine aşırı bir avcılık baskısı oluşturduğu da bilinmektedir. Bu çalışmada, 36 mm göz genişliğine sahip trata ağının torbasında yakalanan balık türlerinin seçiciliğinin araştırılması amaçlanmıştır. Denemelerde torbadan kaçan balıkları yakalamada örtü torba yöntemi kullanılmıştır. Av kompozisyonu içinde sayı ve ağırlık olarak yüksek oranlarda yakalanan balık türlerinin seçiciliği değerlendirmeye alınmıştır. % 50 yakalama boyları (l_{50}) barbunya (*Mullus barbatus*), kırma mercan (*Pagellus erythrinus*) ve ısparoz (*Diplodus annularis*) için sırasıyla 13,43, 11,22 ve 9,84 cm bulunmuştur. Trata ağının torbası sadece barbunya için minimum yasal yakalama boyunun üzerinde bir l_{50} değeri verirken diğer iki tür için bu değerler düşüktür. Bununla birlikte çoğu kıyı sürütme balıkçısı yasal olarak, torba sonunda papalina, hamsi, sardalya ve izmarit yakalamak için küçük göz genişliğinde (13-21-24 mm) ağlar da kullanabilmektedir. Bu tür kullanımlar seçiciği imkansız hale getirmektedir. Sonuç olarak, balıkçılık yönetiminde kıyı sürütme ağlarının avcılık faaliyetlerinin yasaklanmasını, yapılan bu seçicilik çalışması da desteklemektedir.

Anahtar Sözcükler: Kıyı sürütme ağı (trata), torba seçiciliği, örtü torba yöntemi, % 50 yakalama boyu (l_{50})

Introduction

The Aegean Sea has a rich biological diversity owing to the hilly morphology of its bed, and the differing physico-chemical characteristics of the water. The Turkish coast of the Aegean Sea contains many suitable areas for fisheries. A few of the most important fisheries areas are Edremit Bay, Çandarlı Bay, İzmir Bay and Sığacık (1). These coasts are also the habitat and breeding areas of many valuable fish species, particularly the demersal fish that have a high commercial value. In these areas the beach seine fleets catch a multitude of species, the most important being gilt head sea bream (*Sparus aurata*), common pandora (*Pagellus erythrinus*), red mullet (*Mullus barbatus*), common dentex (*Dentex dentex*), common sole (*Solea vulgaris*), two-banded bream (*Diplodus vulgaris*), saddled bream (*Oblada melanura*), European pilchard (*Sardine pilchardus*), bogue (*Boops boops*), picarel (*Spicare smaris*) and squid (*Loligo*

vulgaris). This fish fauna is limited to the Mediterranean Sea, which seems to lack representative families characteristic of neighbouring waters, such as the Atlantic Ocean (2).

Approximately 17% (46,950 t/y) of Turkey's fishing yield comes from the Aegean, and 4-5% of that (1.980 t/y) is caught by 309 beach seine vessels (3). Some 60% of fish by weight are discarded in a beach seine operation (4). These nets sweep about 4 million da/y, and approximately 200-250 of immature fish are caught every year (5). This production was not commercially utilised in any way and had an increasingly harmful effect on fish stocks. Finally, these led to a ban on these nets during the 2000-2002 fishing period according to the Turkish Annual Fishery Regulations (6).

One of the measures used in fisheries management is the regulation of the size at first capture. The regulation may have several objectives, including the optimisation of yield or the reduction of the number of discards. The size at first capture is dependent, among other factors, on the selectivity characteristics of the gear. Conventionally, selectivity has been regulated by means of a legally defined minimum mesh size for the cod-end. In beach seine and trawl cod-end selectivity experiments it was suggested that it is not sufficient to regulate selectivity in fisheries just by setting a minimum mesh size (7). Mesh size, shape and twine material, the meshes around the circumference and lastridge ropes fitted in different hanging ratios all play an important role in the size selectivity of Aegean mixed fish species (8,9).

Beach seines are also among other fishing techniques frequently preferred for sampling littoral fishes for scientific purposes. Some advantages of seining over other techniques are the simplicity of the gear and its ease of use, fast sampling and an ability to sample large areas. Beach seines are widely used in the study of fish communities along exposed sandy, sandy-muddy and posidonia habitats, a highly dynamic environment, which imposes many constraints on sampling (10).

This study was aimed at determining the selection capacity of beach seine nets used in commercial fishing. Legally, the minimum cod-end mesh size of the beach seine net is 32 mm. However, it was found that the aft end of the cod-end mesh size was generally 13 and 21 mm, and occasionally 24 mm, for catching small sardine, anchovy, sardine and picarel at the fitted end of the cod-end. In the selectivity experiments a 36 mm mesh size beach seine cod-end was used to compare previous studies with the same gear and bottom trawls. For comparison purposes the cover mesh size was taken as 24 mm.

Materials and Methods

This study was carried out on the Aegean coasts of Turkey (National Fishery Zone) between May 1996 and April 1997. The fishing grounds studied were, from north to south: Çandarlı, Aliağa, Foça, İzmir Bay, Gülbahçe, Mordağan, Yeni Liman, Gerence, Çeşme, Alaçatı, Sığacık and Kuşadası. A total of 13 tows were made for selectivity trials and 54 for catch composition and discard rate trials.

A beach seine net with a total length of approximately 400 m was used in the experiments. This is easy to identify by the long wings on each side and forward of the main net body, which tapers to the cod-end (11). The same fishing gear as used in Akyol and Özekinci (12) was employed in this study. The mesh size and twine diameter of the net decrease from the wings to the cod-end. The nominal mesh sizes of the cod-end and cover used in the experiments were 36 mm and 24 mm, respectively. The mesh of both the cod-end and the cover was diamond-shaped. The cod-end used was constructed from dark red, single–twisted polyamide twine (Rtex 390) and was of two-panel construction with 800 meshes on its circumference. The cod-end was separated into two sections; the forward section was about 11 m and the section aft about 2 m in length. During all hauls the aft section of the cod-end was enclosed with a cover to retain fish which passed through the cod-end meshes. The cover material was made of single–twisted polyamide twine (Rtex 310).

In a beach seine operation a boat works from an anchored buoy, sets the net, then returns to its mooring and hauls the gear in by the ropes. Synthetic polypropylene ropes were generally used symmetrically in front of the wings. In a typical operation up to 3-5 coils, each of 100 m, are used. Long warps are laid out to surround an area of the seabed with a net similar to a trawl except for the long wings placed at mid length. The two free ends of the warps are hauled in such a way that they move together, herding the fish inwards and into the path of the net, to be scooped up and brought aboard the operating vessels. Due to the movement of the warps the

fishing action is across the seabed, which disturbs and guides the fish within the area to be worked.

The water depths fished ranged from 4 m to 30 m at the infra–littoral zone of the Aegean coast. At the end of the setting the net wings are in shallow water whereas the cod-end is in deep water. A beach seine operation was performed in 60-120 min depending to the number of ropes shot, on the condition of the deep currents and on the towing speed of the net. All tows were carried out during daylight hours.

Sea trials were carried out on the research vessel "Hippocampus", owned by the Fisheries Faculty of Ege University. This is 16.5 m in length, has a gross tonnage of about 20 mt, and a 135 hp main engine with a hydraulic trawl winch system.

The selectivity of the beach seine net was measured with the covered cod-end method. In this method both fish retained in the cod-end and those which escape from the cod-end (captured in the cover) are required to estimate the selection parameters. The aim of the cover design is to ensure as far as possible that the methods of escape from the cod-end are not changed by the presence of the cover. For this purpose, according to Holden (13), the cover length and width are designed 1.5 times larger then the cod-end.

At the end of each tow, the number and weight of all the species caught in the test cod-end and cover were recorded. The total lengths of the fish in the cover and cod-end were measured separately with a 0.5 cm class interval. The data from all valid hauls were pooled for each species to calculate selection parameters and to draw selectivity curves.

The selection curve, $r(l)$, is the probability that a fish of length l is retained given that it has entered the cod-end. A logistic curve was fitted to original data from covered cod-end experiments on the beach seine. The logistic curves are symmetrical about the 50% retention length (l_{50}). This selection curve is so named because it is the cumulative distribution function of a logistic random variable. It is specified by

$$r(l) = \frac{\exp(a+bl)}{1 + (\exp(a + bl))}$$

where a and b are parameters to be estimated,

l_{50} = -a/b: simple algebra gives the selection range (SR) and also the selection factor (SF),

$$\text{Selection Range (SR)} = l_{75} - l_{25} = \frac{2\log e(3)}{b} = \frac{2.197}{b}$$

$$\text{Selection Factor (SF)} = \frac{l_{50}}{\text{Mesh Size}} \quad (14).$$

Underwater observations of the beach seine net were made by three scuba divers with camera and video. Images were taken by Nikonos-V underwater camera and Sony Handycam V8 video inside Ikelite housing. The whole net and its components were observed under actual towing conditions. In addition, fish behaviour in the cod-end related to the operation was photographed.

Results

A total of 15,569 individuals from 45 different species were caught in 54 hauls. Annular sea bream had the highest percentage, at 13.19%, by number of individuals in the catch composition. Other species were as follows; 9.46% for two-banded bream, 8.52% for bogue, 5.99% for common pandora, 5.56% for squid, 5.40% for red mullet, 5.29% for *Spicare flexuosa* and 46.59% for the other species (Figure 1). These percentages were different from the weights. The catch data for the beach seine net show that this was composed of 93.42% bony fish, 6.29% invertebrates and 0.29% cartilaginous fish. Attention is drawn to the high percentage of bony fish.

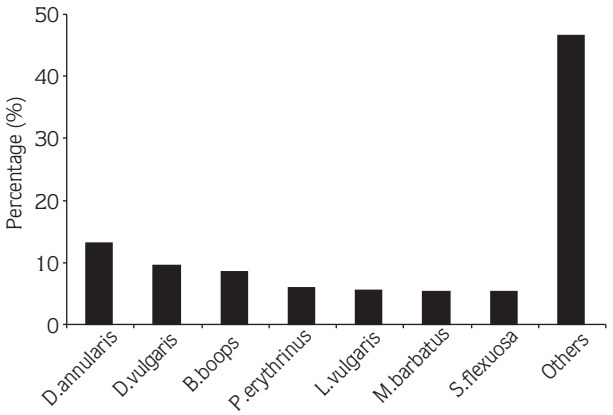

Figure 1. Catch composition of beach seine nets by number of individuals.

From 13 successful hauls, seven combined hauls gave a valid selection curve for the red mullet, three for the

annular sea bream and six for the common pandora. The number of individuals, the mean, standard deviation and other statistical parameters belonging to the cod-end and the cover of the beach seine net for these species are given in Table 1. The mean total lengths obtained from the cod-end were higher than those from the cover. The length distribution of red mullet in the cod-end ranged from 8.5 to 19.5 cm and the mean was 13.03 cm. For the cover these values were 9.0-15.0 cm and 11.65 cm, respectively. There is a significant difference in the mean total length between cod-end and cover for red mullet. Similar results were found for the other fish species. While this difference was smallest at 0.61 cm for annular sea bream, it was highest at 3.76 cm for common pandora.

Selective properties of the beach seine net were obtained for only three fish species: red mullet, annular sea bream and common pandora. The selection curve of red mullet was at the right of the selection curve for annular sea bream and common pandora, whereas the steepest curve was found with common pandora (Figure 2). The l_{50} of the red mullet was obtained at 13.2 cm (Table 2). The respective values were 9.84 cm for annular sea bream and 11.22 cm for common pandora.

The selection ranges were 4.12 cm, 7.68 cm and 1.77 cm for red mullet, annular sea bream and common pandora, respectively (Table 2). The selection factors were 3.73, 2.73 and 3.11.

The majority of immature red mullet under the minimum landing size did not escape from the 36 mm mesh size cod-end of the beach seine net into the cover. The proportion of the fish was 50%. This ratio was even higher, at 98%, for annular sea bream and 75% for common pandora (Table 3).

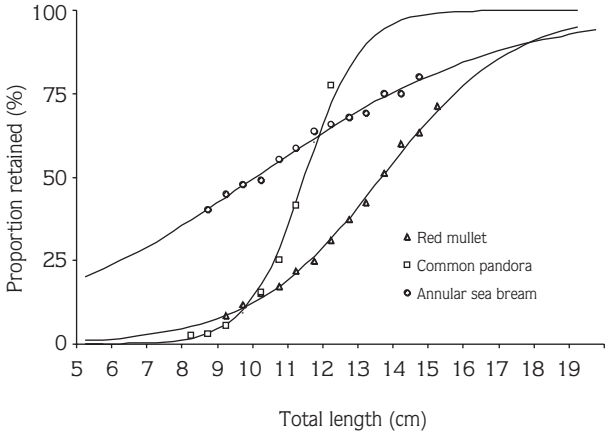

Figure 2. Selection curves for three fish species caught in a 36 mm mesh size cod-end.

It was observed that selection in the beach seine operation took place only in the last few minutes of the tow (1 or 2 min). Fish schools strongly penetrated the meshes of the aft end of the cod-end. It was also observed that some of them passed into the cover; some of the red mullet became meshed, and most of the bigger fish were retained in the cod-end (Figure 3). The divers also observed that fish swam easily in the cod-end, so the towing speed of the net can be classified as slow.

Discussion

Selectivity data were obtained for all three fish species from the beach seine cod-end, enabling comparisons to be drawn. The l_{50} and selection factors of red mullet were higher than those of the other species (Table 2). For red mullet the selection of the 36 mm mesh size cod-end of the beach seine net may be considered appropriate.

Table 1. Descriptive statistics of the total length distribution of three fish species retained in and escaped from the cod-end of the beach seine net (N: Number of individuals; x: Sample mean; Sx: Standard error of the mean; SD: Standard deviation; Min.: Minimum; Max.: Maximum; CI: Confidence interval).

Fish Species		N	x ± Sx	SD	Min.	Max.	CI (95%)
Red mullet	Retained	435	13.03 ± 0.076	1.59	8.5	19.5	12.91-13.16
	Escaped	761	11.65 ± 0.054	1.50	9.0	15.0	11.56-11.74
Annular sea bream	Retained	201	11.16 ± 0.097	1.38	8.5	15.5	11.01-11.32
	Escaped	155	10.55 ± 0.110	0.11	8.0	15.5	10.37-10.73
Common pandora	Retained	489	13.27 ± 0.102	0.10	8.0	26.5	13.11-13.48
	Escaped	710	09.51 ± 0.034	0.92	7.5	15.5	09.46-09.57

Table 2. Selection parameters for three fish species caught by 36 mm mesh size cod-end (a: Intercept; b: Slope; r: Correlation coefficient; l_{25}, l_{50}, l_{75} ; Proportion retained; SF: Selection factor; SR: Selection range).

	l_{50}	SR	S	l_{25}	l_{75}	b	a	r
Red mullet	13.43	4.12	3.73	11.36	15.49	0.53	-7.156	0.998
Annular sea bream	09.84	7.68	2.73	05.99	13.68	0.28	-2.812	0.994
Common pandora	11.22	1.77	3.11	10.34	12.11	1.24	-13.92	0.992

Table 3. A comparison of the percentage of fish under the minimum landing size (* according to Mater, 1968).

Fish species	MLS (TL)	Hoşsucu et al., 1990		Ertoslok, 2000	This research	
		32 mm	36 mm	13 mm	36 mm	24 mm
Red mullet	13	40	15	52	50	71
Common pandora	15	80	81	74	75	90
Annular sea bream	15*				98	99
Striped mullet	11	40	15	59		
Two-banded bream	15	93	72	43		

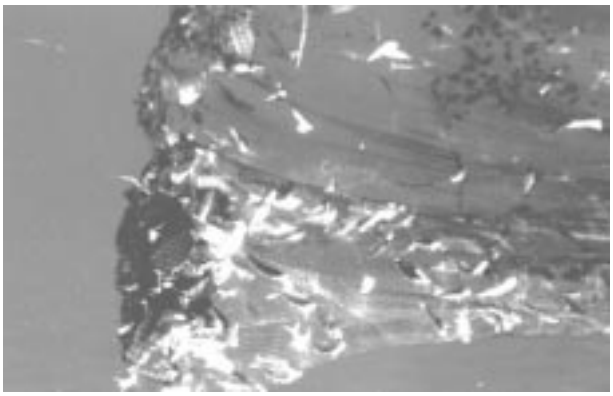

Figure 3. Meshed fish in cod-end meshes of beach seine net.

However, the selection range of all three species is higher than that from the trawl cod-ends made of polyamide (Table 4). The higher selectivity in the beach seine may be explained by the exhaustion of red mullet in relation to the tow duration (15). A short swimming duration enables fish to make strong escape attempts through the cod-end meshes. The schooling of red mullets in the beach seine might also affect escape behaviour. A wider selection range might be due to the size of the cod-end. The mean and l_{50} were the same only for red mullet. The lengths for annular sea bream and common pandora were quite variable.

The annular sea bream data gave the poorest selection. The selection data showed that the design of the beach seine cod-end is not suitable for annular sea bream. It is also possible that the body shape of the annular sea bream caused the low selectivity (16). Figure 2 shows the common pandora selection curve to be steeper than the other curves. This result is also shown in narrow selection range in Table 2.

Table 4 shows that the same l_{50}s applied to the same mesh size cod-end of tailored bottom trawls made of polyamide (8,17) and that a lower length could be detected in a conventional bottom trawl cod-end made of polyethylene (9). Narrow selection ranges were obtained from the polyamide trawl cod-end whereas wider values were detected from the conventional trawl and beach seine. All of the l_{50}s for trawls were lower than those for the beach seine. In a trawl operation fish must swim for a long time, but for much less in a beach seine operation. At the end of the trawl tow, the fish in the trawl cod-end are exhausted and it is difficult for them to penetrate cod-end meshes freely by swimming. Under actual operation conditions the cod-end meshes of the trawl close due to

Table 4. The comparison of the selection parameters with the trawl cod-ends (PA: Polyamide; PE: Polyethylene).

	Gurbet, 1993 (PA)			Tokaç et al., 1998 (PA)			Tosunoğlu, 1998 (PE)		
	l_{50}	SR	SF	l_{50}	SR	SF	l_{50}	SR	SF
Red Mullet	12.44	2.27	3.46	12.38	1.76	3.43	11.72	3.97	2.66
Annular Sea bream	10.00	2.46	2.80	8.37	1.35	2.32	9.36	1.69	2.12
Common pandora							11.51	3.52	2.61

stretching, which leads to high towing resistance. Thus trawl selectivity decreases after the cod-end is partially filled. In a beach seine operation, the catching process is completed quickly in the last few minutes. The larger size of the beach seine cod-end compared to the trawl might cause the meshes to open and become slack. Diver observations showed that red mullets with a round body shape were not at all exhausted and attempted to escape through these slack and open meshes. The higher selection range of the beach seine might be caused by small red mullet entering back into the cod-end while in the cover.

For the selection of annular sea bream rather different results are shown in Table 4. These differences can be related to the cod-end material and design, to the shape of the gear during towing and to fish behaviour. There is only one reference, Tosunoğlu (9), concerning the selection parameters for common pandora in the cod-end of a commercial trawl. Whereas the l_{50}s were the same for the cod-ends of trawl and beach seine, the selection ranges were different. The wider selection range may be due to the same reasons as for annular sea bream.

There is only one reference to selection research on the cod-end mesh size of the beach seine nets in the eastern Mediterranean (18). The cod-end design was improved by a different fitting method. The minimum catch weight was increased by 8-10 g for all young fish. However, this measure was not sufficient to improve the selectivity of beach seines.

The percentages of fish below the minimum landing size in Table 3 considerably exceeded the legal limit of 5%. These results were highest in the cover (24 mm). The cover might have affected the escape behaviour of fish. The length at first maturity of annular sea bream was taken as 12.0-14.0 cm fork length at the age of IV in İzmir Bay (19).

Different cod-end designs gave better selection than the standard cod-end for the Scottish and Danish anchor seine in selectivity experiments. In particular, cod-end diameter, twine material and mesh shape, as well as mesh size, have highly significant effects on the proportion of fish retained, thus demonstrating their importance in determining the selectivity of a cod-end (7,20,21). The selectivity of a net increases as the mesh size increases but decreases with wider cod-ends (7). In addition, it was found that the square mesh cod-ends retained a smaller proportion of haddock (*Melanogrammus aeglefinus)* below the 50% retention length than the same mesh size diamond cod-ends in a Scottish seine net (20). Similarly, the cod-end selectivity of the Danish anchor seine was increased by a square mesh escape panel (21).

The selective properties of the beach seine cod-end tested (36 mm) did not meet the legal criteria with regard to minimum landing size and the percentage under this size. This happened even without the final part of the cod-end with a 13-21 mm mesh size, which is used commercially for catching small-size fish species. As a result in this commercial fishery, selection is nearly no-existent. Not only commercial-size fish but also all the young fish will be retained in such cod-ends. Consequently, these results support the prohibition of beach seine nets as a management tool.

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