New Approach for Codend Selectivity: a Case Study of Coastal Beach Seine for Big-Scale Sand Smelt (Atherina boyeri) Fishery in İznik Lake

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Abstract

Sand smelt (Atherina boyeri Risso, 1810), which is an exotic species with invasive character, is the third most caught species in the small-scale fisheries among the inland fisheries in Turkey. The fact that it has become an important source of income for the fishermen with low income due to its export potential has led to the maintenance of its stock recently. In this study, the selectivity of coastal beach seine used in the fishing of the species was investigated. A specially designed coastal beach seine with 10 m codend consisting of 4 different compartments was used in the study. Among the compartments of the codend, which was surrounded by a 6 mm mesh cover, in the codend panels mesh with 9, 12 and 14 mm were used. Field studies were carried out on a monthly basis in 4 different stations of İznik Lake in 2014. Selectivity data were collected by the covered codend method and analyzed by means of a logistic equation with the maximum likelihood method. A totally 3053 individuals were caught length ranged from 2.6-11.2 cm and weight ranged from 0.11-11.02 g. The mean L50 values of 14, 12- and 9-mm panels were determined as 6.71, 5.62 and 4.51 cm total length, respectively. It is concluded that 12 mm mesh size panel is suitable for sustainable A. boyeri fishery by beach seine net when considered given by length at first maturity size.

Introduction

Actually, marine origin species big scale sand smelt (Atherina boyeri Risso, 1810) has rapid spread to isolated inland water thanks to adaptability. It was first reported in 1940 from Sapanca Lake in Turkey (Battalgil, 1941; Ekmekçi et al., 2013). After 1988, when first observation year in İznik Lake, A. boyeri is one of the first commercial fish species of the lake and its production has shown increase trend year by year (Dogan, 2009). Production was started from 60 t/year in 1989 (Dogan, 2009), and increasing approximately 1350 t in 2017.

During the A. boyeri adaptation periods to the lake ecosystem fishermen were investigated the suitable fishing methods and gears. In the first years, fishermen used small beach seine (maximum length approximately 50-60 m) with manpower. Following years, gears are developed with the giant ones (length range 200-400 m) and also engine power began to be used instead of manpower. Portable net drum (with tractor) has been utilized for hauling of very big seine from the lake. In 2007, annual gross income of a fisherman was reported as 27 788 $USD based on A. boyeri fishing in İznik Lake (Dogan, 2009).

According to the 2017 data, A. boyeri was the third caught species in Turkey inland fisheries. Their economic value of 4892 t of A. boyeri production was almost 2 065 150 $USD (TUİK, 2019). ¼ of total Turkey’s production has been provided from İznik Lake. Almost all individuals are proceeding as a crisps and export to
some European county such as Italy, England, France and Spain. Due to hardening of scale and spine of larger individuals (larger than 6-7 cm total length) not preferred for crisps production, this circumstance is causes abnormal fishing pressure on young individuals.

İznik Lake is the fifth larger lake of Turkey with 300 km² surface area. A total 180 licensed fishermen work as commercially in four fishing area. Besides A. boyeri, Cyprinus carpio, Carassius gibelio, Rutilus frisii, Siluris glanis and Astacus leptodactylus have been caught in the lake. Fishing operation for sand smelt is made by beach seine with 4-5 fishers (a team). According to the 2018 data, there are 42 teams in the lake. Beach seines with smaller than 9 mm mesh size (stretched) were commonly used for A. boyeri fishing.

There are some studies conducted on A. boyeri fishing; Rodríguez-Climent et al. (2012) presented gillnet selectivity of A. boyeri in Ebro Delta Lagoon (North-East, Spain) by using SELECT method. Catch composition, CPUE, bycatch and discard rate studies were carried out on beach seine fishing (Broadhurst et al., 2008; Akyol, 2003; Cabral et al., 2003; El-Mor et al., 2002; Gray & Kennelly, 2003; Vanderklift et al., 1998; Hutchings & Lambeth, 2002a; Hutchings & Lambeth, 2002b). However, there are very limited beach seine selectivity studies both in the sea and inland water; Tosunoğlu (2003), determined Mullus barbatus, Pagellus erythrinus and Diplodus annularis selectivity parameters in Turkey’s Aegean Sea by using cove red codend method. The other study was conducted by Tesfaye, Wolff and Taylor. (2016) for investigated O. niloticus, C. gariepinus and C. carpio selectivities in Lake Koka (central Ethiopia).

Brčić et al. (2018) investigated the selectivity of the commercial creels with 41mm mesh, which were used in fishing Nephrops norvegicus in the Mediterranean, using the control creel with 41mm mesh and he found the ISO value as 31.82 for 1 soak time. In another study, Deval et al. (2016) investigated the selectivity of T0 and T90 codends with 50 mm mesh on commercial shrimp species in Turkish deepwater trawl fishery, Eastern Mediterranean; it was found that there was an increase in the escape rates of Aristaeomorpha foliacea, Aristeus antennatus, Parapenaeus longirostris and Plesionika martia in case the codend was transformed from T0 to T90. Sala, Brčić, Herrmann, Lucchetti, & Virgili (2016) investigated the selectivity of a grid system, which was designed for grading of striped venus clam (Chamelea gallina) after fishing with hydraulic dredge. The grid system with 5 different sequential holes spacing (Filter: 32.5 mm, Grid 1: 21.5 mm, Grid 2: 21.1 mm and Grid 3: 20.3 mm and Filter:10.5 mm) was used in the study. L50 sizes for Grid 1, Grid 2 and Grid 3 were found to be 25.01, 24.29 and 22.84 mm. A similar approach to our study was demonstrated in pooling the data used in the calculations. However, there are not any study conducted on beach seine selectivity for A. boyeri fishing.

In this study, our goal is to determine the selectivity characteristics of coastal beach seine, which was designed to determine the selectivity of codends with different meshes (9, 12- and 14-mm nominal stretched mesh size) in the same hauling simultaneously, in sand smelt fishing.

**Material and Method**

**Study Area**

The study was conducted in İznik Lake that is one of most important A. boyeri producer (Figure 1). As a tectonic origin, Lake İznik locate southeastern part of the Marmara region in Turkey. Altitude is 85 m and maximum depths was determined as a little bit more than 70 m at near south coast. Lake’s surface area is 285 km² and length is 32 km (Ceribasi, 2018). Lake located between 40°2’-40°30’N latitudes and 29°20′ - 29°42’ E longitudes (Yağci & Ustaoğlu, 2012).

**Sampling Process**

Experiments were carried out 4 different station of lake in 2014 with monthly period. Only one hauling

![Figure 1. Study area and sampling stations.](image-url)
applied each station. A beach seine used in hauling which was specially designed and rigged to determine multi
codend mesh selectivity parameters at same hauling
operation. More information about the geometry and
characteristics of the used beach seine given Figure 2.

Multimesh codend model was generated from four
different codend compartment by connected with each
other using touch & close tape. First compartment’s tag-
end rigged codend mesh with 14 mm and it surrounded
with cover mesh (6 mm); second compartment’s tag-
end rigged codend mesh with 12 mm and it surrounded
with cover mesh (6 mm); third compartment’s tag-end
rigged codend mesh with 9 mm and it surrounded with
cover mesh (6 mm) and finally all of last compartment
covered by 6 mm cover mesh (Figure 3).

A unique data pooled model was used in the study
due to the possibility that the length distributions of the
haul obtained from different stations in the same period
could be different. Due to the possibility that the schools
different length distributions will be evaluated each
time during the sampling, it was expected to see that
there were inconsistencies in the estimated \( L_{50} \) values at
the classic single codend & cover application, which
stemmed from the diverse size distributions of the

Data Analysis

Caught fish were classified by codend type and
measured total length with 0.1 cm precision and gaged
total weight with 0.01 g precision. Covered codend
techniques was utilized estimation of selectivity
parameters (Wileman et al., 1996). The data were
analyzed using a logistic equation with the maximum
likelihood method (Wileman et al., 1996). The mean
selectivity of the individual hauls was calculated by
taking into account between-haul variation according
to Fryer (1991) using the ECModeller software (ConStat,
1995) which adopts the REML method (residual
maximum likelihood). The choice of the model which
best describes the data was based on the lowest value
for Akaike’s Information Criterion-AIC (Fryer &

![Figure 2. General view (not in scale) and net cutting plan of modified beach seine.](attachment:image)
Shepherd, 1996). \textit{t-test} and \textit{one-way ANOVA} with Tukey\textsuperscript{SSD} were used for statistical comparing of normal disturbed data evaluations process for catch total length and weight by month. Also, Fulton’s condition factor (K) was calculated using $K=(W/TL^3) \times 100$ formula. Kolmogorov-Smirnov (K-S) test was used to determine differences between size frequency distributions of fish caught by different codend. We used the “mgcv” package (Wood, 2019) in RStudio (v11.2.5019) to model the relationships between total length and influencing factors (sampling month, sampling station, codend type) in Generalized Additive Models (GAMs) evaluating process. The GAMs is given by:

\begin{equation}
\text{Model: } tl \sim s(sm)+s(ss)+s(tc)
\end{equation}

Where, $tl$: total length, $sm$: sampling month, $ss$: sampling station, $ct$: test codend, $s(.)$ is a spline smoothing function. RStudio (v11.2.5019) computer software was used all statistical analysis.

**Result**

**Catch Composition**

A total of 13 valid/successful hauls were carried out for estimating selectivity parameters. End of fishing trial, a total of 3053 \textit{A. boyeri} were caught total length range between 2.6-11.2 cm and total weight between 0.11-11.02 g. Mean total length and total weight are shown statistical differences by sampling month (Table 1) ($P<0.05$).

Statistical differences were found mean total length and weight values ($P<0.05$) between codends. There are no statistical differences in 6 and 12 mm codends between male and female total length of \textit{A. boyeri} ($P>0.05$), while differences were found in 9 and 14 mm codends between male and female individuals ($P<0.05$). The highest mean total length was observed in Göllüce station, while lowest was Iznik station. Statistical differences were found between mean total lengths of sampling stations ($P<0.05$). Mean total lengths of catch are shown statistical differences between stations for same sampling period ($P<0.05$).

Used GAMs model parameters to compare catch total length and other response (sampling, month, sampling station, test codend) given Table 2 and scatter plot matrix for predictors given Figure 4. Model residual $d.f.$ and residual deviation were found as 3042.0 and 1480.6 respectively. All response shown statistical difference by fish total lengths.

The effects of sampling month, sampling station and test codend variables on total length was modeled through GAMs and the results were given in Figure 5. It can be stated that the sampling from Iznik station negatively affected the total length, the total length as affected negatively from the summer months towards the winter months, and that the increase of mesh size used in codend affected total length positively.

From the K-S test results (Table 3), in the all paired compare, statistical differences were found length frequency distribution of \textit{A. boyeri} from different codend.
Table 1. Length-weight distribution and condition factor of captured A. boyeri by sampling month

| Month     | N (%) | Total Length (cm) Mean±SE Min. | Max. | Total Weight (g) Mean±SE Min. | Max. |
|-----------|-------|-------------------------------|------|-------------------------------|------|
| March     | 165   | 5.4 5.95±0.09c                | 3.4  | 10.3 1.44±0.09bc             | 0.26  | 8.24 | 0.584 |
| April     | 642   | 21.0 6.33±0.06d               | 3.1  | 11.2 2.14±0.07d              | 0.14  | 11.02 | 0.679 |
| May       | 502   | 16.4 6.00±0.06c               | 3.5  | 9.8  1.58±0.05c              | 0.19  | 6.74  | 0.623 |
| June      | 431   | 14.1 5.86±0.10c               | 2.6  | 10.6 1.87±0.09d              | 0.11  | 9.25  | 0.660 |
| July      | 573   | 18.8 5.16±0.05a               | 2.6  | 9.7  1.11±0.03a              | 0.12  | 5.65  | 0.713 |
| August    | 400   | 13.1 5.51±0.07b               | 2.8  | 9.5  1.42±0.05bc             | 0.22  | 4.53  | 0.738 |
| September | 340   | 11.1 5.32±0.07ab              | 3.1  | 8.9  1.23±0.05ab             | 0.20  | 4.86  | 0.699 |

Different letters within columns show significant differences between month (P<0.05).

Table 2. Comparison of models for total length using ANOVA nonparametric effects

| Response            | df | F     | p     |
|---------------------|----|-------|-------|
| Sampling month      | 3  | 66.670| <0.001|
| Sampling station    | 2  | 42.448| <0.001|
| Test codend         | 2  | 108.082| <0.001|

Figure 4. Scatter plot matrix for predictors used GAMs analysis.

Table 3. K-S test result of A. boyeri captured from different codend

| Net 1 | Net 2 | Kolmogorov-Smirnov Test | Decision |
|-------|-------|-------------------------|----------|
| Mesh Size | N | Mesh Size | N | D max | Critical Values ($α=0.05$) | |          |
| 14 | 824 | 12 | 771 | 0,3288 | 0,0681 | H₀ Reject |
| 14 | 824 | 9 | 767 | 0,3138 | 0,6820 | H₀ Reject |
| 14 | 824 | 9 | 767 | 0,3741 | 0,0702 | H₀ Reject |
| 12 | 771 | 9 | 767 | 0,2805 | 0,0694 | H₀ Reject |
| 12 | 711 | 6 | 771 | 0,4123 | 0,0712 | H₀ Reject |
| 9 | 767 | 6 | 691 | 0,3569 | 0,0713 | H₀ Reject |
Data by pooling process are given in Table 4 and explain in Figure 3. From the data, statistical differences were found (P<0.05) mean total length of fish that obtained from both codend and cover of beach seine.

Selectivity Parameters

Catch ratio, retrieved from codend were founded as 26.36(%), 51.76(%) and 77.14(%) for 14, 12 and 9 mm codend respectively (Figure 6). Selectivity parameters of experimental codend’s are given Table 5, 6, 7. L50 lengths and SR values were determined as 6.71 (0.76), 5.62 (0.59) and 4.51 (0.35) cm for 14, 12 and 9 mm codends, respectively. Statistical differences were found between L50 values of the codends (P<0.05). There are no statistical differences between 12 and 14 mm codends SR values. However, statistical difference was estimated (P<0.05). When comparing to this value with 9 mm, Selectivity curves and normalized frequency plots are given Figure 4. Estimated L50 and SR values are given Figure 5, in addition length at first maturity of A. boyeri reported by Anonymus (2015) are shown same graph for male (4.52 cm) and female (4.96 cm) separately.

Estimated L50 vs SR values and its standard errors shown in Figure 7. Codend with 12 mm mesh size is suitable for sustainable A. boyeri fishery with beach seine net by length at first maturity size of species.

Discussion

It is first time presented beach seine selectivity for A. boyeri in the study. 13 successfully hauls were utilized for estimating selectivity parameters. However, totally 48 fishing operations were performed. Due to the not obtained, 35 hauls not including the data for estimated selectivity parameters. A. boyeri schools migrating to deeper water in conjunction with decreasing the water temperature in Fall and Winter seasons, so it could not be caught in these months except September. Most of samples were obtained in April, while least were in March (Table 1). Production shown decreasing trend towards fall season and there are no individuals in late fall and winter season. This circumstance associated with bio-ecological properties of A. boyeri. In general, as a species originated from mild climate marine system, A. boyeri migrate to deeper areas for protect itself in cold water temperature. This case directly connected with water temperature by Işiklıkaya (2017), although A. boyeri is a species that can be adapted very hard conditions, if water temperature is decreasing below 8⁰C feeding of species comes to halt; moreover, water temperature below the 4⁰C is cause deadly effect on A. boyeri. Whereupon it is seeing that A. boyeri migrate to marine from freshwater system if there is a connection between both of them; otherwise flocks are clustering relatively hotter deeper locations of lake’s in winter. It is impossible catching of this fish with beach seine in this circumstance.

Naturally mean total length were increase in keeping with mesh size increasing used in codend (Figure 5). Similar observations are seen L50 values (Figure 7). These results shown similarity to other selectivity studies based on logistic model (Bolat, Demirci & Mazlum, 2010; Dereli et al., 2016; İlkyaz et al., 2017; Nguyen & Larsen, 2013; Reeves et al., 1992). Risk of selectivity modal used in this study was pillying probability of the school front of codend panel. In this situation, smaller fish would not pass from one compartment to others. A. boyeri scholl has a specifically spiral circle movement and this habit was
Table 4. Pooled data and mean length

| Codend Mesh Size (mm) | Total Length (cm) | Cover | P |
|----------------------|-------------------|-------|---|
|                      | Pooled Codend N   | Mean±SE | Pooled Codend N | Mean±SE |
| 14                   | 14 824            | 7.43±0.04  | 12+9 6         | 2229 5.12±0.02 | 0.000 |
| 12                   | 14+12 1595        | 6.79±0.03  | 9+6 1458       | 4.61±0.02 | 0.000 |
| 9                    | 9+12+9 2362       | 6.30±0.02  | 6 691         | 3.87±0.02 | 0.000 |

Different letters within columns show significant differences between codends (P<0.05).

Table 5. Selectivity parameters of A. boyeri for codend with 14 mm

| Parameters | Op1 | Op2 | Op3 | Op4 | Op5 | Op6 | Op7 | Op8 | Op9 | Op10 | Op11 | Op12 | Op13 | P | F |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|---|---|
| L₅₀ (SE)   | 0.70 | 6.78 | 6.56 | 6.77 | 7.21 | 6.85 | 7.01 | 7.82 | 6.27 | 6.18 | 6.65 | 6.53 | 6.48 | 1.00 | 0.11 |
| L₅₀ (%)    | 20.42 | 19.54 | 19.29 | 20.04 | 20.37 | 19.58 | 19.76 | 20.65 | 19.05 | 18.93 | 19.45 | 19.27 | 19.22 | 19.41 | 0.65 |
| SR         | 1.75 | 0.69 | 0.75 | 0.58 | 1.49 | 0.48 | 0.69 | 0.75 | 1.05 | 0.97 | 1.12 | 0.45 | 0.49 | 1.00 | 0.76 |
| SR (SE)    | 1.09 | 1.00 | 1.02 | 1.05 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.00 | 0.07 |
| Deviance   | 8.81 | 6.96 | 4.99 | 1.95 | 15.27 | 1.78 | 13.15 | 3.32 | 2.71 | 10.29 | 3.54 | 3.99 | 5.07 | 44.66 | 6.45 |

| Cod. | 48.68 | 397.2 | 267.28 | 266.25 | 40.19 | 333.6 | 134.16 | 330.76 | 93.05 | 143.87 | 123.17 | 123.89 | 177.22 | 2485.46 |
| Weight Cov. | 100.96 | 118.5 | 293.87 | 286.19 | 112.98 | 305.87 | 202.36 | 137.35 | 152.84 | 248.57 | 164.49 | 149.03 | 241.01 | 2256.76 |
| Tot. | 149.64 | 515.9 | 561.15 | 294.94 | 153.17 | 639.47 | 336.6 | 114.87 | 668.11 | 245.89 | 392.44 | 287.66 | 418.23 | 4742.22 |

Table 6. Selectivity parameters of A. boyeri for codend with 12 mm

| Parameters | Op1 | Op2 | Op3 | Op4 | Op5 | Op6 | Op7 | Op8 | Op9 | Op10 | Op11 | Op12 | Op13 | P | F |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|---|---|
| L₅₀ (SE)   | 0.55 | 5.71 | 5.64 | 4.43 | 5.67 | 5.87 | 5.88 | 6.14 | 5.38 | 5.17 | 5.63 | 5.52 | 5.46 | 5.58 | 5.62 |
| L₅₀ (%)    | 13.83 | 18.45 | 18.36 | 20.93 | 18.43 | 18.59 | 18.62 | 18.90 | 18.10 | 17.92 | 18.37 | 18.26 | 18.18 | 18.29 | 1.77 |
| SR         | 0.70 | 0.49 | 0.66 | 1.33 | 0.80 | 0.60 | 0.81 | 0.51 | 0.31 | 0.79 | 0.62 | 0.55 | 0.42 | 0.74 | 0.59 |
| SR (SE)    | 1.00 | 1.00 | 1.02 | 1.30 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.04 |
| Deviance   | 4.60 | 1.39 | 7.38 | 0.37 | 6.48 | 3.37 | 9.90 | 1.04 | 1.29 | 24.38 | 7.46 | 3.88 | 2.66 | 17.27 | 3.76 |

| Cod. | 102.72 | 483.4 | 431.51 | 291.71 | 103.63 | 492.97 | 244.63 | 427.11 | 177 | 272.59 | 216.66 | 207.19 | 280.34 | 3731.44 |
| Weight Cov. | 49.87 | 32.5 | 129.64 | 3.23 | 49.51 | 146.55 | 92.13 | 41 | 68.89 | 119.85 | 71 | 71.67 | 137.89 | 1013.73 |
| Tot. | 152.59 | 515.9 | 561.15 | 294.94 | 153.17 | 639.47 | 336.6 | 114.87 | 668.11 | 245.89 | 392.44 | 287.66 | 418.23 | 4745.17 |

Number Cov. | 69 | 52 | 171 | 3 | 72 | 169 | 152 | 68 | 100 | 200 | 100 | 100 | 202 | 1458 |

Total | 135 | 199 | 371 | 72 | 133 | 369 | 267 | 164 | 200 | 373 | 200 | 200 | 340 | 3023 |
Figure 6. Selection curves and length distribution of *A. boyeri* for different codend.
going on in seine compartment. The fish which would not pass other codend no waited front of the compartment, they continued circle movement. So, we could not see pilling observation in front of codend mesh. The beach seine compartments used in trial was divided of catch by lengths, this idea supported as scientifically with both mean total length differences and length frequency distribution differences that is revealed by K-S test result (Table 3). This result show that applied trial modal has given successfully for selectivity analysis. Cover codend is specified as a proper method for measured selectivity by Pope, Margettes, Hamley and Akyüz (1975) due to no effect escaped all length group of fish from codend. As a disadvantage masking effect expressed by Tosunoğlu and Tokaç (1997) that arising from reposing of cover on codend mesh may be cause preventing effect of fish escaping.

Any masking effect was not observed between codend panels in this study in that each codend panel had 2.5 m free field front of compartment. Occurred hauling with manpower and very slowly positive

Table 7. Selectivity parameters of A. boyeri for codend with 9 mm

| Parameters | Op1 | Op2 | Op3 | Op4 | Op5 | Op6 | Op7 | Op8 | Op9 | Op10 | Op11 | Op12 | Op13 | P | F |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|
| L50       | 4.58| 4.21| 4.56| NA  | 4.42| 4.93| 4.55| 4.96| 4.59| 4.28| 4.38| 4.53| 4.46| 4.48| 4.51|
| L50 (SE)  | 1.00| 1.05| 1.00| 1.00| 1.00| 1.03| 1.52| 1.00| 1.00| 1.00| 1.00| 1.00| 1.00| 1.00| 0.06|
| L50 (%)   | -8.22/-9.22/-8.16| NA | -12.44/-7.86/-8.59| -62.89/-8.13/-8.53| -8.46/-8.19/-8.24/-8.32/-4.38/-8.32/-4.38/-8.32/
| (%CI)     | 17.38| 17.64| 17.28| 13.07| 17.74| 17.69| 72.82| 17.32| 16.90| 17.02| 17.26| 17.18| 17.19| 4.64|
| SR        | 0.71| 0.10| 0.30| NA  | 0.31| 0.10| 0.10| 0.10| 0.32| 0.37| 0.46| 0.33| 0.42| 0.44| 0.35|
| SR (SE)   | 1.01| 1.01| 1.00| 1.00| 1.01| 1.12| 1.52| 1.00| 1.00| 1.00| 1.00| 1.00| 1.00| 1.00| 0.02|
| SR (%)    | -12.13/-12.78/-12.42| NA | -12.44/-12.85/-14.22/-19.32/-12.40/-12.34/-12.29/-12.40/-12.30/-12.26/
| (%CI)     | 13.57| 12.98| 13.03| 13.07| 13.05| 13.09| 13.05| 13.23| 13.08| 13.15| 13.15| 13.15| 13.15| 13.04|
| R5        | 1.015| 1.117| 1.002| 1.004| 1.015| 1.070| 2.852| 1.003| 1.001| 1.006| 1.003| 1.002| 1.000| 1.000| 0.0037|
| R5 (%)    | 0.001| 0.001| 0.001| 0.001| 0.001| 0.001| 0.001| 0.001| 0.001| 0.001| 0.001| 0.001| 0.001| 0.001| 0.0005|
| R5 (%)    | 1.023| 1.028| 1.003| 1.008| 1.040| 1.271| 2.336| 1.003| 1.002| 1.009| 1.005| 1.003| 1.000| 1.000| 0.0005|
| a         | -14.17| -92.50| -33.39| -31.32| -108.3| -99.97| -108.9| -31.51| -24.82| -20.44| -30.16| -23.33| -22.37| -28.31| 6.27|
| b         | 3.09| 21.97| 7.32| NA  | 7.08| 21.97| 21.97| 21.97| 6.86| 5.93| 4.77| 6.65| 5.23| 4.99| 6.27|
| Deviance  | 2.29| 0.04| 0.75| NA  | 1.16| 0.01| 0.00| 0.00| 6.09| 2.73| 6.42| 1.71| 3.56| 4.41| -|
| Df        | 10  | 12  | 12  | NA  | 8   | 12  | 12  | 14  | 7   | 12  | 10  | 11  | 16  | -|

Figure 7. Estimated L50 vs SR values and error bars.
effect on this circumstance. Other beach seine selectivity study in which used covered codend method was carried out by Tosunoğlu (2003) in Aegean shore of Turkey. The study was conducted based on classically one codend (36 mm) and one cover net model (24 mm). Similar study was carried out by (Tesfaye et al., 2016) in Lake Koka (Ethiopia).

Increasing water temperature parallelly increase food web in environment and fish metabolism speed. Therefore, fish condition is also increase. Highest fish condition was founded in August as 0.738, while lowest was 0.584 in March (Table 1). This circumstance caused on seasonal length frequency differences. Highest condition was reported by Lorenzoni et al. (2015) (Lake Trasimeno, Italy) and Gençoğlu and Ekmeckı (2016) (Hırfanlı Dam Lake, Turkey) for A. boyeri in July.

It was found that there are differences between mean total length of stations (P<0.05) which caught by hauling same time. This result might be stem from the ecological properties food abundance of fishing areas. Also, this finding supports to the assumption that flocks length frequency may be different from each other. İznik area is shallower than other locations for this reason water temperature is little higher, so it has relatively rich plankton abundance and this cause to positive effect on feeding regime of fish. In addition, many streams (such as, İltimat, Göksu, Karasu, Kavaklık, Söloz and Kırı Stream) entered in İznik lake, they are also direct and indirectly positive effected on water quality and lake productivity as well.

It is clearly revealed that multimesh codend selectivity model approach is very useful for presented mean lengths differences of fish at same time in different stations. If study had conducted classically one codend – one cover mesh approach, same codend’s L̅l values would be found different from each other, based on probability of surrounded stocks have different length distribution. In this context, it is thought that selectivity method used in the study can be utilized similar other selectivity studies, if there are no any masking effect front of the codend.

14 mm codend produce higher 19% and 49% L̅l values than 12 mm and 9 mm codend. 9 mm codend mesh size is commonly use in A. boyeri fishery in İznik Lake, L̅l values of 9 mm codend (5.62 cm) lower from first maturity length (4.52 cm for male and 4.96 cm for female) given by Anonymous (2015). Rodríguez-Climent et al. (2012) researched gillnet selectivity for A. boyeri using SELECT method in Ebro Delta (North-East of Spain) lagoon. Authors reported catch of gillnet with 10 mm mesh size were mostly below the first maturity length (5.22 cm). But, almost all of the caught fish lengths were above first maturity, when mesh size was increased to 12.5 mm. Although used selectivity method is different result are shown similarity with us.

When this species, which is defined as a species with invasive potential by Ekmeckı et al. (2013) and which cannot be completely removed from the İznik Lake, is considered in terms of its contributions both to the fishermen and the national economy, it is believed that it would be more advantageous to maintain its stock bio-economically. The most important method to prevent overpopulation of this species in the İznik Lake is the fishing pressure since it does not have an effective predator. In summary, fishermen should continue to catch this species in order to prevent excessive reproduction of the species in the lake. In order the fishermen to continue fishing, the members of the stock should grow in a certain range of length (5-6 cm) in terms of marketability.

There are very few studies on the selectivity of beach seine, which is widely used in small scale fisheries in many regions of the world. In addition to the selectivity of these sets, which are generally equipped with fine-meshed nets, there is a need for studies on their impact on the coastal ecosystem. In particular, it is necessary to determine the non-target ratios of other species on larvae and juvenile. In some areas, fishermen remove the structures such as stones, rocks, etc. from the environment in order to avoid the lead to be stuck during hauling; and this causes the destruction in the natural structure of the ground. In line with the current findings, it is believed that the method we used to reveal the selectivity of more than one codend simultaneously through the logistic model was very successful and could be used easily in studies of similar cases.

It is thought that logistic model is successfully for estimating multimesh codend selectivity. So current model can be adapted and use for similar other locations and different fish species. One important point that should not forget is selectivity not only related with net mesh size but also fish behavior (Tokai et al., 1995; Wileman et al., 1996; Fonseca et al., 2005). Hence, determining of beach seine codend selectivity with classical method (one codend – one cover) may be helpful for comparing of gained result in study.

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