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Spat efficiency of the smooth scallop *Flexopecten glaber* in the Aegean Sea, Türkiye

by

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Abstract

This study was carried out to determine the spat efficiency of the smooth scallop *Flexopecten glaber* (Linnaeus) in surface and bottom water at the Ozbek coast (Türkiye) of the Aegean Sea from September 2017 to August 2018. The environmental parameters (temperature, salinity, chlorophyll-*a*, and total particulate matter) were also monitored at two depths. The average water temperature at the surface and bottom were 19.79 ± 5.62°C and 19.73 ± 5.24°C, respectively. The lowest chlorophyll-*a* values were recorded in February (1.12 g l^{-1}) and June (1.23 μg l^{-1}) at the surface and bottom, respectively. The highest chlorophyll-*a* value was recorded in August at both depths. Throughout the study, the number of *F. glaber* on the collectors was 270.33 ± 43.54 spat m^{-2} and 145.66 ± 18.03 spat m^{-2} were detected on the bottom collectors. A statistically significant difference was found between the growth of the spat attached to the surface and bottom collectors ($p < 0.05$).

Key words: *Flexopecten glaber*, smooth scallop, spat collector, bivalve, depth, spat attachment, growth, Aegean Sea

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1. Introduction

Due to the protein needs of the rapidly growing global population and fishing pressure on marine stocks, aquaculture is the main way to meet the growing demand for sustainable resource use and to provide healthy food in an environmentally friendly way (Anderson et al. 2017; FAO 2018; Boyd et al. 2020; Papa et al. 2021). In shellfish culture, live feed such as phytoplankton are only used for larval rearing in the hatchery; there is no need extra feed requirement for culture in the marine area. Because of this feature, shellfish aquaculture has a lower ecological impact on coastal ecosystems and is therefore considered highly sustainable and is referred to as a green industry (Shumway et al. 2012; Papa et al. 2021).

Flexopecten glaber, also called smooth (or white) scallop, is an edible mollusk widely distributed in the Mediterranean Sea (Bondarev 2018), the Eastern Atlantic and the Black Sea (Shcherban & Melnik, 2020). *Flexopecten glaber*, *Mimachlamys varia* (Linnaeus) and *Pecten jacobaeus* (Linnaeus), different scallop species distributed throughout this region, are high-value seafood products which enjoy a very high market demand in Europe (Arellano-Martinez et al. 2011; Tsotsios et al. 2016; Vural & Acarli, 2021a, b). The global production of scallops with economic value was 1,262,410 tons in 2008, reaching 1,917,993 tons in 2018. The production by fishing was 751,000 tons in 2012 and 756,000 tons in 2018 (FAO, 2020). The global market for scallops is worth approximately USD 1.5 billion (FAO, 2020). Therefore, their cultivation can be profitable and can provide a good product with high market value for human consumption (Papa et al. 2021).

Bivalve culture has expanded considerably following the successful development of methods for collecting spat. The most common method is to supply species such as scallops and pearl oysters from the wild with polyethylene mesh and netlon bags (Yiğitkurt et al. 2020; Papa et al. 2021). Spat formation after metamorphosis is influenced by environmental factors, such as food availability, spawning density, water temperature, and light intensity (Lök & Acarli, 2006; Tsotsios et al. 2016). During metamorphosis, bivalve spat tend to attach to a suitable substrate (Southgate 2011), for which collectors can be used. Successful attachment depends on the depth, biological and chemical changes in the water, and the type of collector material (Acarli et al. 2011). Collecting spat is more economical than producing larvae in a hatchery. To sustain the production of bivalves, spat collection should continue annually or seasonally. The sustainability of this process depends on the survival of newly collected spat in growing systems (Burke et al. 2008; Yiğitkurt et al. 2017).

The aim of this study is to investigate the efficiency of collectors in terms of the amount of smooth scallop *F. glaber* collected at different depths and the effect of water conditions on this efficiency throughout the year. This information can determine the appropriate timing for deployment of collectors in the sea.

2. Materials and methods

This study was conducted on the Ozbek coast (38°20'19.95"N, 26°40'51.09"E) between September 2017 and August 2018 in Izmir Bay, Türkiye (Fig. 1).

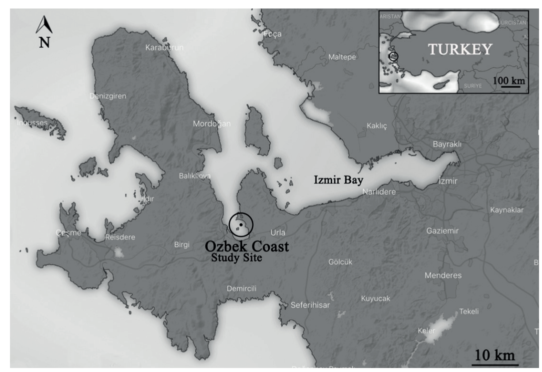

Figure 1

The study area on the Ozbek Coast in Türkiye

2.1. Study area

The depth of the study area was approximately 6–7 m. The bottom in this area consists of sandy and partly stony sediment. This area has less fishing activity.

2.2. Water conditions

Temperature (°C) and salinity (PSU) were measured in situ using a mercury thermometer and a refractometer, respectively. Seawater samples were collected at two depths using a five-liter Niskin bottle. Thereafter, each liter of the seawater samples was filtered using 0.45-µm filters (Whatman GF/C). The chlorophyll-*a* and total particle matter (TPM) values were calculated according to Strickland and Parsons (1972).

2.3. Collector position and time of sample collection

The collector systems were positioned at the surface (1 m depth) and at the bottom (5 m depth) about 15 m away from the coast in August 2017. Samples were collected monthly from the systems between September 2017 and August 2018.

2.4. Collector system and sample collection

The collector systems were made from polyethylene mesh bags with PVC pipes. The height and width of the mesh bags were 50 and 20 cm (1 m²), respectively, with a mesh size of the polyethylene bag of 5 × 4 mm. A total of 72 collectors were placed in groups of three replicates in August 2017. The collector system was designed as a "surface collector" and "bottom collector" as shown in Figure 2. Each collector system consisted of eight mesh bags, four of which were placed at the surface and four at the bottom. Nine of these units were prepared and placed in the area and sampled for 12 months. The mesh bags were tied to PVC pipes with a plastic rope at 15-cm intervals. Two PVC pipes (diameter = 5 cm) were attached to the main rope at depths of 1 and 5 m, with the surface and bottom collectors on either side. A buoy (20 litres) at the top and an anchor (100 kg) at the bottom were used to keep each system stable in the water column. Six mesh bags were cut from each collector system (three surface and three bottom collectors) to be transferred to the laboratory for visual inspection at each sampling time.

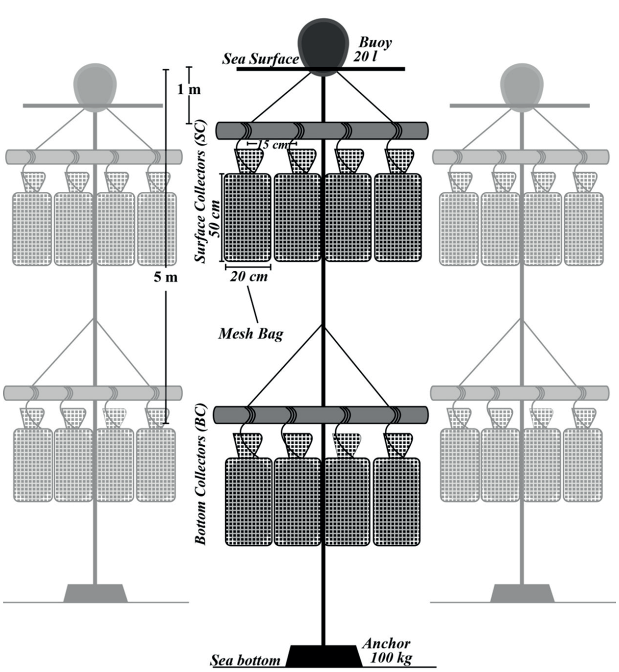

Figure 2

Design of the surface and bottom collectors

In order to determine the newly attached spat and those growing on the collectors, the scallop spat were classified as <10 mm, 11–20 mm, or >20 mm according to their height. This was measured at the dorsal (hinge) and ventral edges using a Mitutoyo digital caliper (IP66). Other non-target species were counted to determine their ratio on the collector.

2.5. Statistical analysis

The Kolmogorov–Smirnov test was applied to test whether the distribution was normal. Pearson's correlation analysis was used to determine the relationship between spat attachment and environmental parameters (temperature, salinity, chlorophyll-*a*, and TPM). Spat efficiency for the surface and bottom collector groups was examined using the Mann–Whitney U test. The difference in the counts of newly attached (<10 mm) scallop spat in the surface and bottom collectors was analyzed with the Mann–Whitney U test. Monthly differences in the amount of spat and newly attached spat in the surface and bottom collectors were examined using the Kruskal–Wallis test. The descriptive statistics were prepared using Microsoft Excel and the statistical analysis was performed in SPSS 15.0.

3. Results

The water temperature at the surface was 28.4°C and 12.0°C in August and February, respectively (Fig. 3a). The bottom water temperature was highest in August (27.6°C) and lowest in January (11.3°C) (Fig. 3b). The highest salinity was recorded in August 2018 at the surface (37.5 PSU) and in June and the bottom (36.4 PSU) (Figs. 3a and 3b). While the highest value of chlorophyll-*a* was 6.95 μg l^{-1} at the surface, the lowest chlorophyll-*a* level was 1.12 μg l^{-1} at the bottom (Fig. 3b). The highest and lowest TPM concentrations at the bottom were recorded in October (25.6 mg l^{-1}) and August (10.25 mg l^{-1}) (Fig. 3c). There was no correlation between spat growth and environmental conditions or the number of spat ($p > 0.05$).

The total number of smooth scallops detected on the all collectors throughout the study was 270.33 ± 43.54 spat m^{-2}. Although the number of spat collected on the bottom collectors (145.66 ± 18.03 spat m^{-2}) was higher than that of the surface collectors (Fig. 4), there was no statistically significant difference between the counts on the surface and bottom collectors ($p > 0.05$).

The maximum counts of scallop spat on the surface and bottom collectors were 20 ± 3 and 44.66 ± 1.26 spat m^{-2}, respectively. The best month for scallop spat

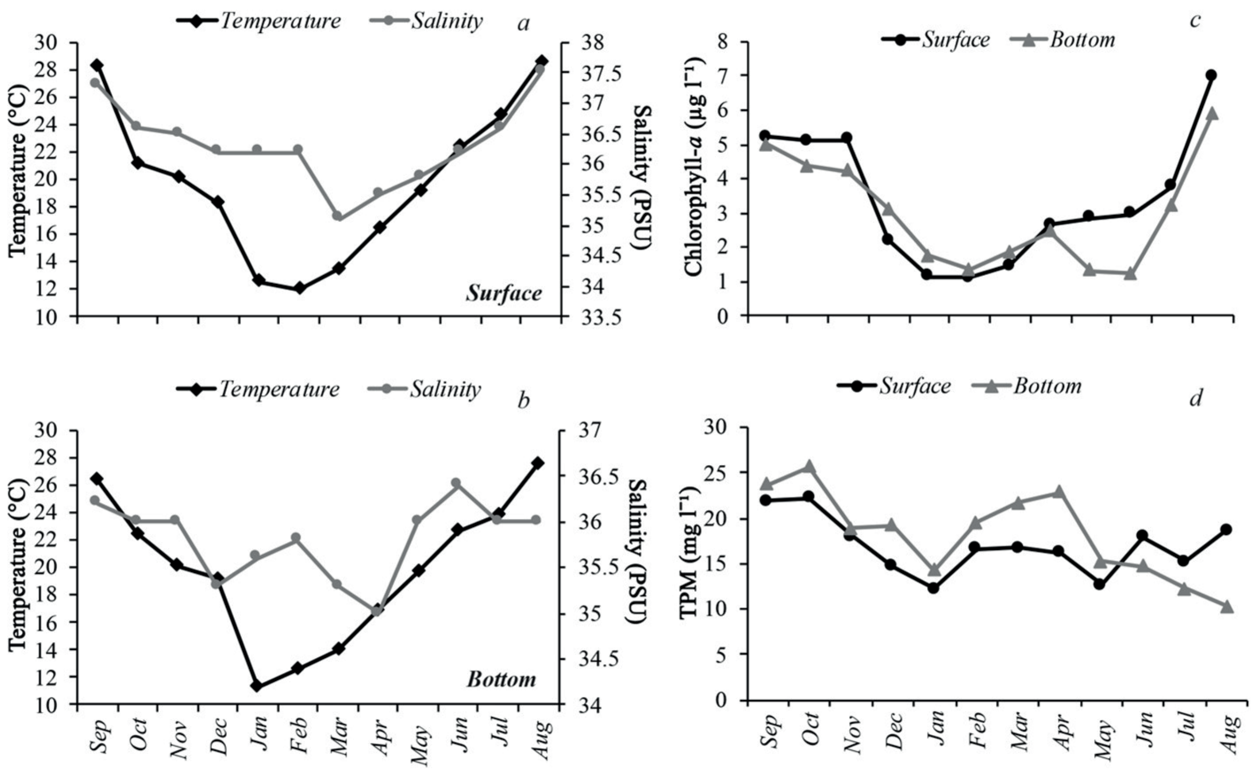

Figure 3

Hydrological parameters in the study area: (a) surface temperature and salinity, (b) bottom temperature and salinity, (c) chlorophyll-*a*, and (d) TPM

on the bottom collectors was found to be April (Fig. 5).

The average height of the scallops on the surface collector was 4.5 mm in September and 18.47 ± 7.64 mm in August (Fig. 6a). The height of the scallops on the bottom collectors in the same months was 5.5 mm and 16.41 ± 6.71 mm, respectively (Fig. 6b). There was a statistically significant difference between the height growth of individuals in surface and bottom collectors ($p < 0.05$).

During the study, *F. glaber* spat in both collectors were classified into the following height ranges: > 10 mm, 10–20 mm, and < 20 mm. The smooth scallop spat less than 10 mm in height collected from the surface collectors accounted for 84.21% (n=16) of those collected in December. While the scallops measuring 10–20 mm were the most frequently observed group in March, those with a height of more than 20 mm were most common in April, June, and August. The height of the *F. glaber* spat detected on the surface collectors varied from 4.50 to 34.48 mm (Table 1). The difference between the number of spat newly attached to the surface and bottom collectors was statistically significant ($p < 0.05$).

Most of the scallops were collected on the bottom collector in April, including 82.22% of the scallops between 10 and 20 mm in height. No *F. glaber* spat smaller than 10 mm were found on the bottom collectors during the months of October, November, January, February, March, May, or June. Scallops larger than 20 mm were mostly found in August. The size of scallops found on the bottom collectors ranged from 5.50 mm to 35.40 mm (Table 2).

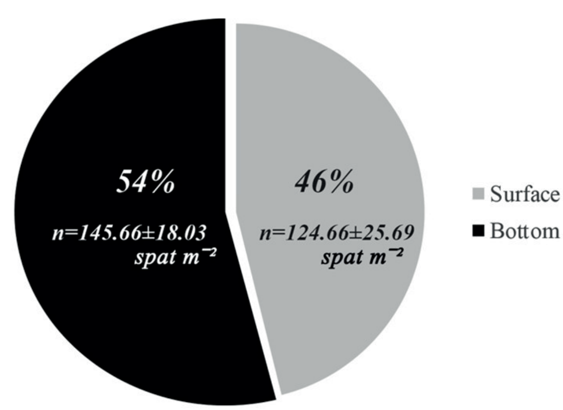

Figure 4

Total number of smooth scallop spat in both collectors (± SD)

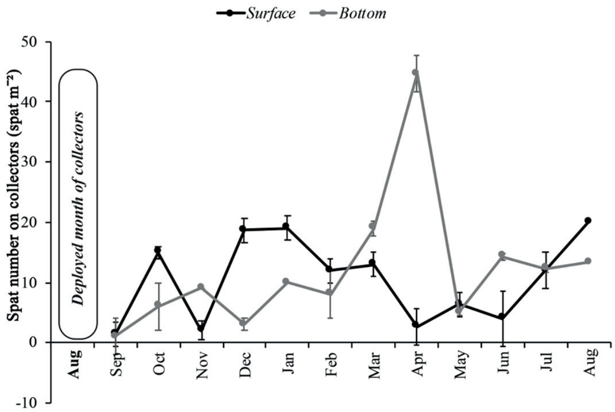

Figure 5

Number of smooth scallop spat in both collectors (± SD)

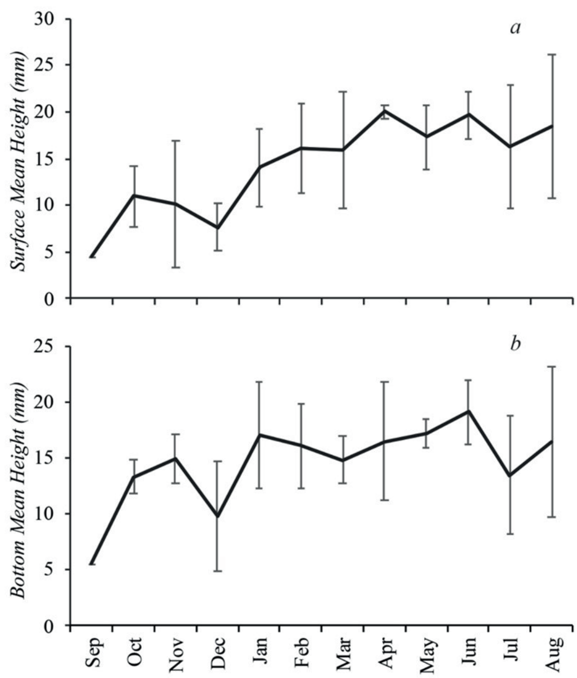

Figure 6

Mean height of smooth scallop spat on the surface (a) and bottom (b) collectors (± SD)

A total of 7770 non-target bivalves were collected during the study: 69.31% from the surface collector and 30.68% from the bottom collector. Economically valuable species such as *Pinctada radiata* (Leach), *Ostrea edulis* (Linnaeus), *Anadara inaequivalvis* (Bruguiere), *Mimachlamys varia*, *Modiolus barbatus* (Linnaeus), and *Cardium tuberculatum* (Linnaeus) were identified on the collectors. When it comes to the surface collectors, most *P. radiata* were found in October, *O. edulis* in May, *A. inaequvalvis* in February, and *M. varia* in December (Table 3).

Table 1

Height range of the smooth scallop on the surface collector

Surface	n (spat m^{-2} ± Sd)	Height Range (mm)	<10 mm (%)	10-20 mm (%)	>20 mm (%)
Sep	1.33±0.57	4.50	100	0	0
Oct	15.00±2.00	6.32-18.73	46.66	53.33	0
Nov	2.00±1.00	5.27-14.96	50.00	50.00	0
Dec	18.66±1.52	4.00-13.40	84.21	15.78	0
Jan	19.00±2.00	8.02-28.07	10.52	84.21	5.26
Feb	12.00±2.00	7.40-23.40	16.66	66.66	16.66
Mar	13.00±2.00	10.19-34.48	0	92.30	7.69
Apr	2.66±2.08	19.50-20.50	0	50.00	50.00
May	6.33±3.05	13.00-22.20	0	66.66	33.33
Jun	4.00±2.00	17.00-22.20	0	50.00	50.00
Jul	12.00±4.58	8.60-25.60	33.33	25.00	41.67
Aug	20.00±3.00	8.50-28.90	30.00	20.00	50.00

P.S: (spat number ± SD)

From the bottom collectors, *P. radiata* was collected in each month of the study and was recorded as 182.33 ± 16.25 spat m^{-2} in November. The European oyster *O. edulis* was detected in all months except September. *A. inaequvalvis* was most often detected in March. In addition, *M. varia* was mostly detected in December as 21.66 ± 5.03 spat m^{-2} (Table 4).

Undesirable species such as *Anomia ephippium*, *Musculus sp.*, *Lima lima*, *Pisidia longimana*, *Pilimnus hirtellus*, *Macropodia longirostris*, *Bulla sp.*, and *Styla cleva* – which are known as fouling organisms and predators – were detected in all collectors. *A. ephippium* was more often found on the surface collectors than on the bottom collectors (Table 5).

The maximum number of *A. ephippium* was 276.66 ± 70.23 spat per all bottom collectors in November. *P. longimona* was found on the bottom collectors in all months except September (Table 6).

Table 2

Height range of the smooth scallop on the bottom collector

Bottom	n (spat m^{-2} ± Sd)	Height Range (mm)	<10 mm (%)	10 - 20 mm (%)	>20 mm (%)
Sep	1.00	5.50	100	0	0
Oct	6.00 ± 3.00	11.16 - 15.47	0	100	0
Nov	9.00 ± 4.00	11.31 - 19.51	0	100	0
Dec	3.00	6.60 - 15.40	66.66	33.33	0
Jan	10.00 ± 1.00	12.43 - 28.56	0	80.00	20.00
Feb	8.00	9.99 - 22.66	0	87.50	12.50
Mar	19.00 ± 4.00	10.14 - 18.69	0	100	0
Apr	44.66 ± 1.26	7.40 - 35.40	6.66	82.22	11.11
May	5.00 ± 3.00	15.70 - 18.60	0	100	0
Jun	14.33 ± 0.57	15.60 - 23.50	0	64.28	35.71
Jul	12.33 ± 0.57	7.60 - 24.60	33.33	50	16.66
Aug	13.33 ± 0.57	8.40 - 28.90	23.08	30.76	46.15

P.S: (spat number ± SD)

Table 3

Shellfish spat of economic value on the surface collector

	P.radiata	*O. edulis*	*A. inaequvalvis*	*M. varia*	*M. barbatus*	*C. tuberculatum*
Sep	11.00 ± 2.00	0	0	0	0	0
Oct	291.00 ± 9.00	2.00 ± 1.00	48.00 ± 14.00	0	1.00	0
Nov	189.00 ± 21.00	7.00 ± 2.00	3.00 ± 2.00	0	0	0
Dec	160.00 ± 40.00	6.00 ± 5.00	11.00 ± 6.00	15.00 ± 10.00	1.33 ± 0.57	4.00 ± 2.00
Jan	153.00 ± 2.00	9.00 ± 4.00	71.00 ± 30.00	1.33 ± 0.57	1.33 ± 0.57	1.00
Feb	205.00 ± 10.00	23.00 ± 10.00	98.00 ± 30.00	4.00 ± 2.00	0	3.00 ± 2.00
Mar	166.00 ± 20.00	32.33 ± 20.00	26.00 ± 3.00	0	1.33 ± 0.57	0
Apr	112.00 ± 30.00	9.00 ± 8.00	1.33 ± 0.57	1.00	0	0
May	220.00 ± 12.00	65.00 ± 4.00	14.33 ± 10.01	8.00 ± 4.00	1.33 ± 0.57	0
Jun	180.00 ± 20.00	43.00 ± 30.04	5.00 ± 2.00	4.00 ± 3.00	1.00	0
Jul	210.00 ± 4.00	35.33 ± 7.50	3.00 ± 2.00	2.00 ± 1.00	1.00	0
Aug	250.00 ± 22.00	32.00 ± 6.00	2.00 ± 1.00	1.00	1.00	0

P.S: (spat number ± SD)

Table 4

Shellfish spat of economic value on the bottom collector

	P.radiata	*O. edulis*	*A. inaequvalvis*	*M. varia*	*M. barbatus*	*C. tuberculatum*
Sep	19.00 ± 4.00	0	0	0	0	0
Oct	103.33 ± 22.54	2.00 ± 1.00	9.33 ± 3.51	0	0	0
Nov	182.33 ± 16.25	19.00 ± 4.00	6.33 ± 2.51	1.00	0	0
Dec	140.00 ± 20.00	3.00 ± 1.00	3.66 ± 2.08	21.66 ± 5.03	0	3.00 ± 2.00
Jan	110.00 ± 5.00	39.00 ± 9.00	4.33 ± 2.30	0	0	1.00
Feb	123.00 ± 10.00	16.66 ± 6.50	3.33 ± 1.52	0	0	0
Mar	50.00 ± 12.00	10.66 ± 5.50	9.66 ± 6.02	0	1.00	0
Apr	16.00 ± 10.00	11.33 ± 6.02	0	0	0	0
May	24.00 ± 10.00	5.66 ± 2.08	0	0	2.00 ± 1.00	1.00
Jun	49.00 ± 4.00	11.33 ± 5.50	0	0	0	2.00 ± 1.00
Jul	110.00 ± 8.00	10.66 ± 6.02	0	0	0	1.00
Aug	159.00 ± 20.00	9.33 ± 5.50	0	0	0	1.00

P.S: (spat number ± SD)

Table 5

Undesirable species on the surface collector

	Ae	Ms	Li	Pl	Ph	Ml	Bs	Sc
Sep	13.00 ± 8.00	0	0	0	0	0	1.00 ± 0.00	0
Oct	226.33 ± 100.59	1.00 ± 0.00	0	13.00 ± 4.00	2.33 ± 0.57	0	0	0
Nov	313.33 ± 100.16	2.00 ± 1.00	0	7.00 ± 4.00	2.00 ± 1.00	0	0	0
Dec	25.00 ± 3.00	1.00 ± 0.00	0	5.00 ± 4.00	7.00 ± 2.00	0	3.00 ± 2.00	0
Jan	240.00 ± 25.00	4.00 ± 1.00	0	2.33 ± 0.57	1.33 ± 0.57	0	0	0
Feb	457.00 ± 45.13	10.00 ± 2.00	0	2.00 ± 1.00	1.33 ± 0.57	0	0	0
Mar	534.00 ± 50.02	1.33 ± 0.52	0	2.66 ± 0.57	0	0	0	0
Apr	33.00 ± 10.00	0	2.00 ± 1.00	1.00 ± 0.00	2.33 ± 0.57	0	0	0
May	270.00 ± 100.00	0	1.00 ± 0.00	5.33 ± 2.51	3.33 ± 0.57	0	0	0
Jun	150.00 ± 25.00	0	1.00 ± 0.00	3.00 ± 2.00	3.33 ± 0.57	0	0	0
Jul	89.00 ± 10.00	0	1.33 ± 0.57	4.00 ± 3.00	2.00 ± 1.00	0	0	0
Aug	110.00 ± 15.00	0	1.00 ± 0.00	2.66 ± 0.57	2.00 ± 0.00	0	0	0

(BC – bottom collector, Ae – *A. ephippium*, Ms – *Musculus* sp., Li – *L. lima*, Pl – *P. longimana*, Ph – *P. hirtellus*, Ml – *M. longirostris*, Bs – *Bulla* sp., Sc – *S. cleva*); P.S: (spat number ± SD)

Table 6

Undesirable species on the bottom collector

	Ae	Ms	Li	Pl	Ph	Ml	Bs	Sc
Sep	6.33 ± 1.52	0	4.33 ± 1.52	0	0	0	0	0
Oct	81.33 ± 16.92	0	14.33 ± 8.08	7.33 ± 2.51	4.66 ± 2.08	0	0	0
Nov	276.66 ± 70.23	0	6.66 ± 2.08	2.00 ± 0.00	3.66 ± 2.08	0	0	0
Dec	21.00 ± 7.54	0	0	3.00 ± 1.00	4.33 ± 1.52	1.00 ± 0.00	0	0
Jan	253.33 ± 83.57	3.00 ± 2.00	5.66 ± 3.05	7.66 ± 2.08	1.00 ± 0.00	0	0	5.33 ± 3.51
Feb	35.00 ± 8.54	3.00 ± 2.00	0	3.33 ± 0.57	0	0	0	4.33 ± 1.52
Mar	187.33 ± 26.57	0	29.66 ± 7.63	1.00 ± 0.00	3.00 ± 1.00	0	0	0
Apr	9.66 ± 3.05	0	7.33 ± 2.51	1.00 ± 0.00	3.00 ± 1.00	0	0	0
May	0	0	11.33 ± 5.50	4.33 ± 2.51	4.66 ± 0.57	0	0	0
Jun	0	0	16.00 ± 8.54	5.66 ± 2.08	7.00 ± 1.00	0	0	3.66 ± 1.15
Jul	0	0	10.33 ± 8.08	6.00 ± 3.00	5.33 ± 1.52	0	0	1.33 ± 0.57
Aug	0	0	6.33 ± 3.05	3.66 ± 1.15	4.33 ± 0.57	0	0	1.33 ± 0.57

(BC – bottom collector, Ae – *A. ephippium*, Ms – *Musculus* sp., Li – *L. lima*, Pl – *P. longimana*, Ph – *P. hirtellus*, Ml – *M. longirostris*, Bs – *Bulla* sp., Sc – *S. cleva*); P.S: (spat number ± SD)

4. Discussion

The collection of scallop spat has historically been the most common way of obtaining young scallops. It was greatly improved in the 1960s due to the success in collecting natural scallop spat (Kosaka, 2016). Spat collectors are set in areas of high scallop productivity where spat numbers are naturally high. Trial collectors are often laid at a variety of different sites to define the most appropriate areas. The high variability in the natural collection of scallops is a common feature of many pelagic bivalve species in the larval stage; therefore, detailed knowledge of settlement patterns and spat availability is needed to reduce costs and labor (Cry et al. 2007; Papa et al. 2021). The abundance of spat on collectors can be influenced by several factors: spawning season, time of collector deployment, suitability of the substrate, fouling and/or predation, food availability, and water conditions (Avendano et al. 2007; Acarli et al. 2011; Yiğitkurt et al. 2020; Yigitkurt 2021). After spawning, scallop larvae swim for 3–4 weeks until metamorphosis; it is very important to deploy the collectors two weeks before this period (to ensure that a microfilm layer forms on the collectors). Cry et al. (2007) reported that spat were obtained by placing artificial collectors four to six weeks after scallop spawning. Four weeks after the collectors were set out in August, 1 spat m^{-2} of *F. glaber* was detected on both top and bottom collectors. The low number of spat can be attributed to insufficient microfilm formation on the collectors and the low population density in this region.

The spawning peak can be estimated from the recruitment of newly settled scallops by submerging artificial collectors throughout the settlement period (Cyr et al. 2007), because it takes approximately three to four weeks from veliger larvae to spat settlement. Therefore, reproduction time also may be guessed from the duration of spat attachment. The reproductive cycle may differ according to geographical region or water temperatures. For example, in the northwestern Adriatic Sea, there are two spawning peaks in July and September (Marceta et al. 2016) and spat can be collected in shallow water (2–20 m deep) in spring and summer (Tsotsios et al. 2016). In this study, the number of newly attached scallop spat settled on the collectors also allowed the reproductive period, population density, and reproduction ability of the scallops to be predicted. While the total number of spat may increase with the condition of spat attached in previous months, all individuals less than 10 mm in height in the month of sampling represent newly settled spat. Considering the months when individuals under 10 mm in height are concentrated, breeding peaks can be determined in November/December and July/August.

Prato et al. (2016) reported that the water temperatures of the study area where they collected scallop spat in Taranto varied between 12°C and 27°C and the salinity was 37–38 PSU throughout the year. Yiğitkurt et al. (2017) reported that bivalve spat were detected from collectors placed off Karantina Island, where the water temperature was between 12.5°C and 27°C and the salinity was 36.21 ± 0.15 PSU throughout the year. In this study, the water temperature varied between 12°C and 28.4°C at the surface and between 11.3°C and 27.6°C at the bottom. The average salinity was determined to be 36.30 ± 0.67 PSU at the surface and 35.8 ± 0.41 PSU at the bottom. Yigitkurt et al. (2020) reported that the most important environmental parameters triggering reproduction in bivalves are temperature and chlorophyll-*a* and that the amount of chlorophyll-*a* increases in parallel with the increase in temperature. Antonio et al. (2021) reported that environmental parameters such as food availability and TPM can affect the reproductive cycle of oysters. However, in this study, no correlation was found between the number of newly attached individuals, chlorophyll-*a*, and TPM ($p > 0.05$). The number of scallops less than 10 mm in height collected from the surface and bottom waters was highest in December, when low levels of chlorophyll-*a* and TPM were recorded. The highest spat count was observed in the bottom collectors in April, with higher chlorophyll-*a* and TPM levels.

During the study, *F. glaber* was found in the collectors at both depths each month, with most scallops being collected from the bottom. Tsiotsios et al. (2008) noted that they collected the highest number of *F. glaber* spat from collectors at a depth of 8 m and that the number of spat decreased towards the surface. Some researchers have explained the tendency of spat to settle in the deeper substrates by strong wave action, a preference for high-density water, fouling, and water turbulence (Slater 2006). The study area did not contain high-density water, turbulent water, or strong waves. Spat attachment may have been affected by the density of fouling organisms or environmental factors. Yigitkurt et al. (2017) detected 160 ind m^{-2} of *F. glaber* on the surface collectors in August on Karantina Island. Prato et al. (2016) reported that a total of 782 ± 331 ind m^{-2} of bivalves (23.2% *F. glaber*) was found in collectors placed on the bottom in Taranto. The total number of *F. glaber* in the collectors over five months was 31.11 ± 1.21 ind m^{-2} in the Gulf of Amvrakikos (Tzovenis et al. 2016). The smooth scallop found on the collectors was consistently 270.33 ± 43.54 ind collector^{1} in this study (Table 7). Moreover, in this study, the highest spat counts on the surface and bottom collectors were 18.66 ± 1.52 ind m^{-2} in December and 44.66 ± 1.26 ind m^{-2} in April. Prato et al. (2016) reported that *F. glaber* reached a height of 36 mm on the collector over a period of seven months. In this study, the maximum height of *F. glaber* on the surface and bottom collectors was 34.48 mm and 35.4 mm, respectively.

Fouling organisms were found on the surface and bottom collectors in varying numbers each month. In general, fouling organisms were more abundant on the surface collectors than the bottom collectors. In particular, *A. ephippium* was found in large numbers on the collectors at both depths between November and March, whereas this species was absent from the bottom collectors between May and August. The higher number of scallop species on the bottom collectors may be explained by a preference for less fouling. Fouling can slow scallop growth due to food affinity and spatial competition and can increase scallop mortality due to hunting or species cover (Yiğitkurt 2021; Coleman et al. 2022). In addition, large numbers of unwanted organisms increase the weight of the collectors, reducing their buoyancy and forcing them to the bottom. As a result, they may be damaged by friction and the scallops may be eaten by benthic predators. Preventing the movement and fouling of the collectors increases the labor costs (Cyr et al. 2007).

The observation of non-target species was expected on the surface and bottom collectors. Yigitkurt et al. (2017) reported that *P. radiata* spat preferred collectors placed in seawater at the surface. In this study, rayed pearl oyster was also mainly focused on the surface collectors. Although it is a well-known fact that oyster larvae prefer to settle on a hard substrate, in this study oyster spat were collected throughout the year (apart from September) using soft polyethylene materials. *Anadara inaequivavlis* spat were mainly concentrated on the surface collectors in February. Acarli et al. (2012) reported collecting *A. inaequivalvis* spat (n = 150 spat collectors^{-1}) from pearl oyster collectors on Karantina Island in the middle of Izmir Bay in the Aegean Sea in May 2007. However, the number of spat and the attachment times may vary depending on the collector types, region, and reproductive activity. It was determined that *M. varia* spat preferred surface collectors for settlement, while *C. tuberculatum* mostly preferred bottom collectors.

As a result, it was determined in our study that scallop spat can be collected in surface and bottom waters and that the difference in depth was not

Table 7

Studies on the collection of *F. glaber* spat

Location	Species	Temperature (°C)	Salinity (PSU)	Spat m^{-2}	Author(s)
Gulf of Taranto (The Mediterranean, Italy)	*F. glaber*	12-27	37-38	181	Prato et al. 2016
Amvrakikos Gulf (Ionian Sea, Greece)		18-29	22-32	31	Tsotsios et al. 2016
Izmir Bay (Karantina Island, Aegean Sea, Türkiye)		12.5-27	36-36.5	160	Yigitkurt et al. 2017
Izmir Bay (Özbek Coast, The Aegean Sea, Türkiye)		12-28.4	35.1–37.5	270	This study
Izmir Bay (The Aegean Sea, Türkiye)		12-28.4	35.1–37.5	145 (Bottom)	This study
Izmir Bay (The Aegean Sea, Türkiye)		12-28.4	35.1–37.5	124 (Surface)	This study

statistically significant. However, there was a difference in depth in terms of newly attached spat on the collectors. Polyethylene collectors can be used in the region to collect many types of economically valuable bivalve spat. Moreover, many fouling organisms and predators were detected and recorded on the collectors. The collectors were not damaged for 12 months, and the scallops were able to grow inside the collectors. It is necessary to determine whether it is possible to create a spat stock for possible entrepreneurial activities thus there is not commercial enterprise for scallop farming in Türkiye. This study is the first in the region to collect scallop spat, so the results will guide further studies and entrepreneurial activities.

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