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The invasive mollusk *Rapana venosa* (Mollusca: Neogastropoda: Muricidae) in the mid-southern Black Sea: Distribution, growth, and stock structure

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Abstract

The rapa whelk, *Rapana venosa* (Valenciennes, 1846), known also as the veined rapa whelk or the Asian rapa whelk, settled in the Black Sea in 1940 and within the past 30 years has become an important economic contribution to local fishers along the coastline. This study examines the annual change in biomass, population structure, and interaction of the species with the ecosystem of rapa whelk in the mid-southern Black Sea. The samples were collected monthly in 2011 and 2012 by hydraulic dredge at different sites. Stock biomass was estimated at five different subregions and along four depth contours. In 2012 the biomass of rapa whelk increased significantly in in all subregions compared with the previous year sampling. Food availability is the main factor for species distribution, and in parallel, striped Venus clams, *Chamelea gallina* (Linnaeus, 1758), the main food source for rapa whelks, was significantly concentrated in the study area. The von Bertalanffy growth parameters (VBGP) were expressed as $L_t = 121.78(1 - e^{-0.246(t + 0.33)})$. As a fisheries management point, our results highlight the overpopulation of rapa whelk in the region.

Keywords

alien species, biomass, Black Sea, *Rapana venosa*, spatial distribution, VBGP

Introduction

One of the biggest challenges to biodiversity and community structure is the encroachment of non-indigenous species into ecosystems (Mack et al. 2000; Bailey et al. 2020). One of such species is *Rapana venosa* (Valenciennes, 1846), a large predatory marine gastropod, known as the rapa whelk, the veined rapa whelk, or the Asian rapa whelk, and it represents one of four major successful invasions of estuarine ecosystems worldwide that have been documented so far (Harding and Mann 2005; Slynko et al. 2020). The other three were the zebra mussel, *Dreissena polymorpha* (Pallas, 1771); European green crab, *Carcinus maenas*, (Linnaeus, 1758); and sea walnut, *Mnemiopsis leidyi* Agassiz, 1865. The rapa whelk is indigenous to the western Pacific's coastal and estuarine waters. This species is distributed in various parts of the world, including the Sea of Japan, Yellow Sea, Bay of Bohai, East China Sea, northern Adriatic Sea, Black Sea, Aegean Sea, Sea of Marmara, Gulf of Quiberon, and North Atlantic (Mann et al. 2004). It is an invasive alien species transported to the Black Sea via ballast water from the Pacific Ocean during the 1940s (Mann et al. 2004). Since 1969, it has created a dynamic stock (Bilecik 1975), with high adaptation capability in the Black Sea. Following its introduction, the rapa whelk spread rapidly throughout the Black Sea between the 1970s and 1980s (Bilecik 1990), due to its extremely high tolerance to environmental changes, such as low salinity, water pollution, and low oxygen (Munari and Mistri 2011). Sağlam et al.

(2009) reported that the reproductive period of *R. venosa* along the coast of Türkiye occurs between June and August. As far as reproductive success is concerned, each female produces an average of 575 capsules per breeding season (Sağlam and Düzgüneş 2007). Rapa whelk shows the imposex characteristics (Smith 1971), which has also been proven for Black Sea populations (Micu et al. 2009). Imposex individuals are formed as a result of the toxic effects of antifouling agents on organisms. This could be briefly explained as superimposition of male sexual organs (penis and vas deferens) on female gastropods (An et al. 2013). Fast growing was reported up to 40–45 mm in length in the first 2–3 years, with 8–9 years of longevity (Sampson et al. 2014). However, growth is slower in some regions such as the eastern Black Sea region due to nutritional and environmental factors (Dağtekin et al. 2023).

Rapa whelks caused serious destruction to the benthic life of the Black Sea (Zolotarev 1996; Sağlam et al. 2008; Sağlam and Düzgüneş 2014; Sampson et al. 2014; Dağtekin et al. 2016). Extensive damage, caused by those predatory gastropods, was observed on mussel beds (Bilecik 1990). The rapa whelk is a major predator of many bivalve species such as mussels, *Mytilus galloprovincialis* Lamarck, 1819; striped Venus clams, *Chamelea gallina* (Linnaeus, 1758); and oysters, *Ostrea edulis* Linnaeus, 1758, throughout the world's oceans (Savini et al. 2002). Since the 1950s, the depletion of large stocks of commercial bivalves (especially *M. galloprovincialis*) and the associated communities was reported in the Black Sea (Zolotarev 1996; Uyan and Aral 2003; Salomidi et al. 2012). In Ukrainian waters, the destruction of oyster banks (*O. edulis* and *Magallana gigas* (Thunberg, 1793)) around Kerch Strait and Karkinitsky Bay was also reported (Bondarev 2014).

Despite its negative environmental effects, *R. venosa* is a commercially important whelk in the Turkish Black Sea. Since the early 1980s, it has been intensively fished by beam trawls and divers in the southeastern Black Sea. Landings have decreased in recent years after showing a great increase (Fig. 1). In Bulgaria, *R. venosa* became a target of the fishing industry in the 1990s. Data show that catches vary between 3000–5000 tonnes. The rapa whelk, which is an important species for Romanian fisheries, constitutes more than half of the total catch. Similarly,

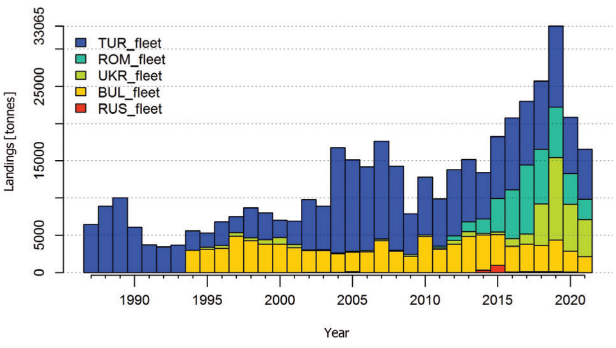

Figure 1. Amount of *Rapana venosa* landing in the Black Sea basin (GFCM 2023).

the rapa whelk is an important target species in Ukrainian fisheries. However, until recent years, Ukraine ranked only fourth in rapa whelk fisheries in the Black Sea. This was mostly because, rapa whelk just began to spread throughout the northwestern portion of the Sea, from 2000 (GFCM 2023). The rapa whelk is not consumed domestically as human food, but the vast majority of products in Türkiye are exported to international seafood markets (Dağtekin et al. 2016). Other countries in the Black Sea region also export some of the catch for domestic consumption (GFCM 2023). In recent years, while about half of the world's stocks have been estimated, problems have been experienced in analyzing a significant portion of them. The main reason for this is the problems in obtaining reliable data. In addition to catch data, survey data are needed (Ovando et al. 2021). This study aimed to contribute to the creation of stock assessment and management plans by producing solutions for the above-mentioned lack of data on a regional basis. Another factor is the destruction of the benthic habitats and discards rates of the fishing gear used to catch this species (Erik and Dağtekin 2022). Because when the fishing effort increases, the negative impact on the benthic habitat may also increase.

The presently reported study was intended to determine the growth characteristics, distribution pattern, and stock structure of *R. venosa* in the mid-southern Black Sea. Despite its commercial importance, information on the life history, distribution, and status of rapa whelk is scarce in the Black Sea. Therefore, growth parameters, length–weight relations, mortality, and exploitation rates were estimated to contribute to its population status. The difference in its distribution and estimated biomass was considered within the area colonized by the striped Venus clam (*C. gallina*) beds is an essential commercial bivalve species in Turkish fisheries. Exploitation rate and stock distribution results were considered for better management actions in the fishing areas.

Materials and methods

Sampling. The presently reported study was carried out in the western Black Sea, especially in the important region where the sandy substrate is dense and baby clam beds can be found. This study was carried out considering the reproduction season of *Rapana venosa*, because during the reproduction period, this species migrates toward the coasts (Sağlam et al. 2009). The hydraulic dredge was used in this study and was based on the design of dredges used in Türkiye (300 cm long, 180 cm wide). The cutting blade was 80 cm wide and extended 20 cm below the dredge. During all tows in each experiment, tow speeds (2 knots), tow duration (Each operation took 2 min), the ratio of warp length to water depth, and water pressure at the water pump on deck (3 bars) were similar in commercial operations. The samples were stored without sieving and transferred to the laboratory in a cooler for further analysis. For each sample, the total length

(TL) was measured using a Vernier caliper to the nearest 0.1 cm, and the total wet weight (TW) was weighed using an electronic scale to the nearest 0.01 g. The study region covered the mid-southern coast of the Turkish Black Sea between Sinop and Cide. It was divided into five sub-regions (Cide, İndebolu, Türkeli, Ayancık, and Sarıkum) and four depth contours (0–5 m, 5–10 m, 10–15 m, 15–20 m). The coastal length between these areas is approximately 90 nautical miles (Fig. 2).

Estimation of growth parameters and mortality rates. The estimation of length–weight relations (LWRs) was calculated according to the Ricker (1975) equation as

$$W = aL^b$$

This formula can be expressed in the linearized form as

$$\log W = \log a + b \log L$$

where W is the total body weight in grams, L is the total body length in cm, b is the slope, and a is the intercept. The growth parameters of von Bertalanffy were estimated according to Beverton and Holt (1959) as

$$L_t = L_\infty(1 - e^{-K(t-t_0)})$$

where L_t is the length at time t, L_∞ is the theoretical asymptotic length, K is the growth coefficient and t_0 is the theoretical age at length zero. The values of L_∞ and K were calculated in the ELEFAN in the TropFishR version 1.6.3 (Mildenberger et al. 2017). The value of t_0 was calculated using the following empirical equation of Pauly (1980)

$$\text{Log}(-t_0) = -0.3922 - 0.2752 \log(L_\infty) - 1.038 \log(K)$$

Natural mortality (M) was calculated using Then's growth formula empirical equation (Then et al. 2015)

$$M = 4.118K^{0.73} L_\infty^{-0.33}$$

where M is natural mortality, L_∞ and K parameters of von Bertalanffy equation.

Total mortality (Z) was estimated utilizing a catch curve. Fishing mortality (F) was determined as

$$Z = F + M$$

while exploitation rate (E) was calculated as suggested by Pauly et al. (1984)

$$E = F \times Z^{-1}$$

Estimation of stock size. The swept area method was used to estimate rapa whelk stock size in the whole study region and separately for individual sub-regions. In this study, data were collected annually from the same 174 stations, selected to best represent the continental shelf of the western region of Türkiye (Table 1).

The swept area formula proposed by Sparre and Venema (1992) was used to determine the area covered by the hydraulic dredge in one hour to calculate the swept area's size.

$$A_S = D \times L_{HR} \times X_2$$

where: A_S is the swept area [km^2], X_2 is a fraction expressing the width of the swept area, D = towing distance, and L_{HR} is the length of the head rope. The towing distance (D) was estimated in units of km^2 (1 nautical mile = 1.852 km), by

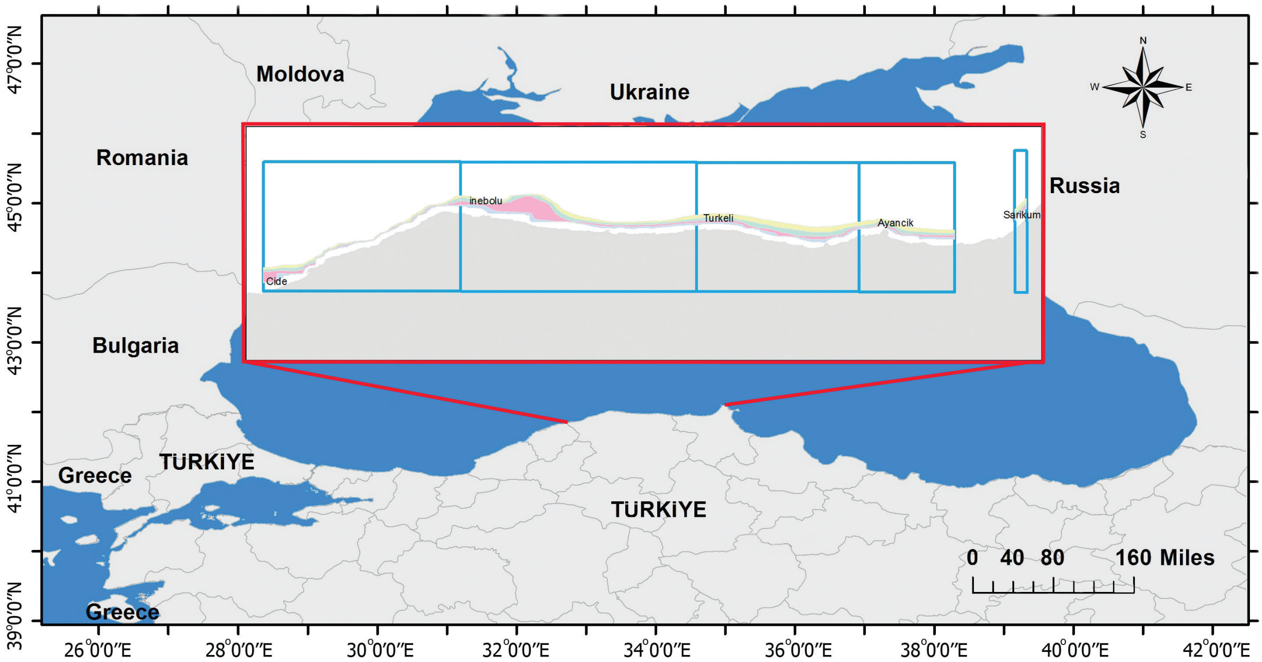

Figure 2. Study region and sub-region in the mid-southern part of the Black Sea.

$$D = 60\sqrt{(\mathrm{Lat1}-\mathrm{Lat2})^2 + (\mathrm{Lon1}-\mathrm{Lon2})^2 \times \cos^2 0.5(\mathrm{Lat1}+\mathrm{Lat2})}$$

Lat1 is the latitude at the start of the haul (degrees) and Lat2 is the latitude at the end of the haul (degrees). Similarly, Lon1 is the longitude at the start of the haul (degrees) and Lon2 is the longitude at the end of the haul (degrees).

The catch per unit area (C_A) [kg · km^{-2}] was determined as

$$C_A = \frac{\overline{C_W}}{A_S}$$

where C_W is the weight of rapa whelk collected in one sampling and A_S is the area swept in one haul [km^2].

The mean biomass per unit area ($\overline{B}$) [kg · km^{-2}], was estimated as follows.

$$\overline{B} = \frac{\overline{C_W / A_S}}{X_1}$$

where X_1 is the coefficient of catch. The hydraulic dredge coefficient of fishing has been accepted as “1”. This reflects the dredge efficiency and is considered to have collected all samples during towing.

The total biomass (B_T) [kg · km^{-2}] was estimated as

$$B_T = \frac{\overline{C_W / A_S}}{X_1} \times A_T$$

where A_T is km^2 total size of area under investigation.

Analysis of Variance (ANOVA) was used to test differences for estimated stock sizes among sub-regions, depths, and years. ArcGIS software package was used for rapa whelk distribution biomass. Data were analyzed in R (R Core Team 2020).

Table 1. Area covered by the beds of *Rapana venosa* in the mid-southern part of the Black Sea, according to sub-areas and number of hauls.

Sub-area	Depth [m]	Number of hauls	Area [km^2]
Cide	15–20	13	13.75
	10–15	13	13.09
	5–10	12	17.29
	0–5	11	8.94
Inebolu	15–20	15	24.24
	10–15	12	25.42
	5–10	9	56.65
	0–5	5	21.5
Türkeli	15–20	12	35.44
	10–15	13	28.26
	5–10	10	16.15
	0–5	11	12.97
Ayancık	15–20	6	15.44
	10–15	6	10.96
	5–10	8	7.22
	0–5	6	6.62
Sarıkum	15–20	3	2.25
	10–15	3	1.91
	5–10	3	1.16
	0–5	3	0.82

Results

Growth and mortality. The mean TL of rapa whelk, *Rapana venosa*, in 2011 was 47.43 ± 0.36 mm and the mean TW was 24.20 ± 0.66 g (Figs. 3, 4). In 2012, the mean TL was 59.82 ± 0.52 mm, and the mean TW was 48.18 ± 1.22 g. The LWR of the *R. venosa* was found to be TW = 0.004TL$^{2.82}$ in 2011 and TW = 0.0001TL$^{3.08}$ in 2012.

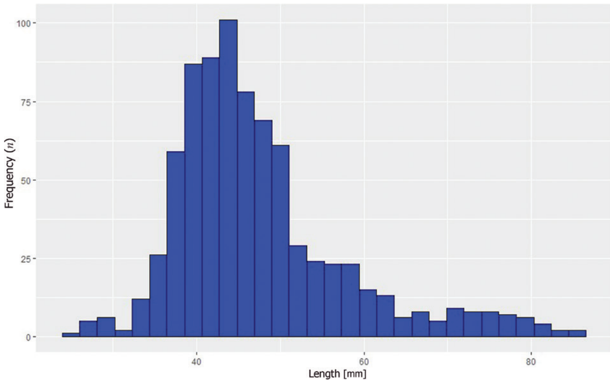

Figure 3. Length frequency of *Rapana venosa* from the mid-southern part of the Black Sea in 2011.

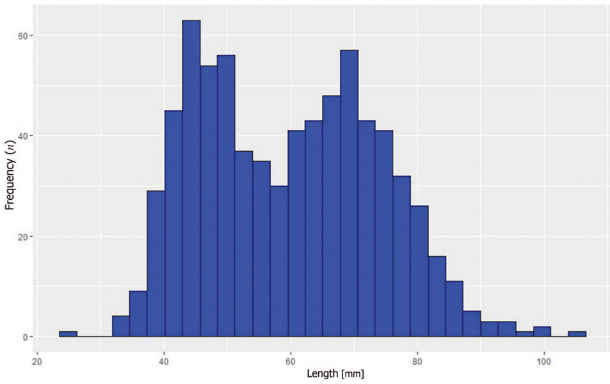

Figure 4. Length frequency of *Rapana venosa* from the mid-southern part of the Black Sea in 2012.

The results of growth parameter analysis showed that rapa whelk can reach an asymptotic length (L_∞) of 121.78 mm, with a mean K of 0.246 per year and the age of t_0 at −0.33 years. L_t can be estimated by obtaining the parameter values of K, L_∞, and t_0 (Fig. 5). The growth curves for this species followed the relation of $L_t = 121.78\,(1 - e^{-0.246(t + 0.33)})$. Total mortality ($Z$) was estimated at 1.151 in the sampling region (Fig. 6). Natural mortality (M) and fishing mortality (F) rates were calculated as 0.304 yr^{-1} and 0.847 yr^{-1}, respectively. The exploitation rate (E) of the population was calculated as 0.735 yr^{-1}.

Stock distribution and structure. Results showed that *R. venosa* biomass increased threefold from 2011 to 2012 and reached 1062.41 tonnes during the sampling period. In 2011, the highest stock size was estimated in Inebolu, while the lowest was in Sarıkum. In 2012, it was determined that the biomass was higher in the Cide region (Table 2).

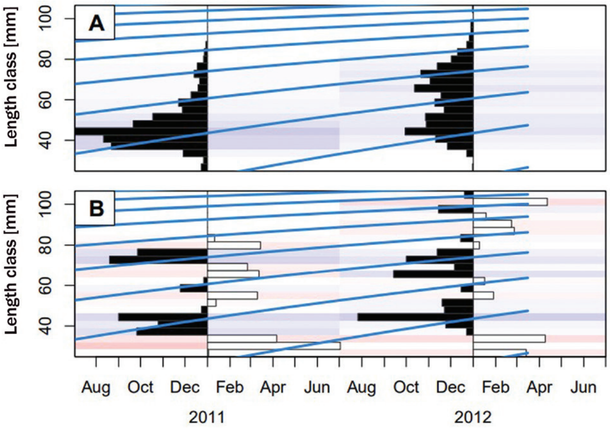

Figure 5. Uploaded raw (**A**) and restructured (**B**) length-frequency data of *Rapana venosa* from the mid-southern part of the Black Sea with overlaid von Bertalanffy growth (VBG) curves fitted by ELEFAN with a genetic algorithm. Ideally, the growth curves overlay with length bins with a high count or high positive value (blue shading) for raw (**A**) and restructured (**B**) data, respectively.

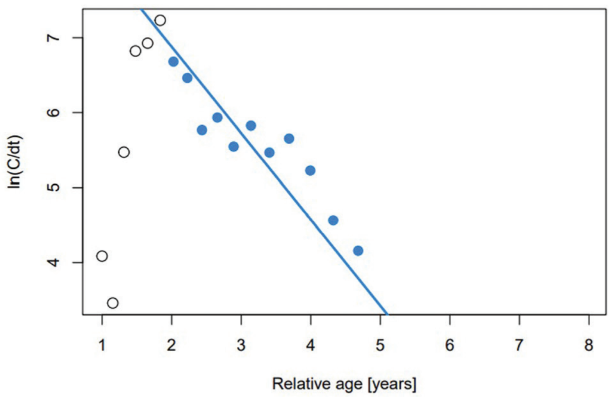

Figure 6. The logarithm of catch per length interval of *Rapana venosa* from the mid-southern part of the Black Sea against relative age. Blue points correspond to points used in the regression analysis (blue line) of the catch curve for the estimation of total mortality (Z), which corresponds to the slope of the displayed regression line. C is the number of specimens caught within a length class, dt is time needed by rapa whelk to grow through a length class].

Table 2. Estimated biomass of *Rapana venosa* from the mid-southern part of the Black Sea.

Year	Sub-area	Biomass [tonnes]	Confidence interval [tonnes]
2011	Cide	76.24	±73.55
2011	Inebolu	134.24	±203.02
2011	Türkeli	98.58	±58.67
2011	Ayancık	37.66	±37.16
2011	Sarıkum	17.18	±22.99
Total		363.92	±395.39
2012	Cide	330.62	±31.83
2012	Inebolu	140.89	±65.79
2012	Türkeli	268.89	±230.46
2012	Ayancık	301.64	±332.23
2012	Sarıkum	20.36	±37.73
Total		1062.41	±984.51

Estimated biomass values showed significant differences between the years. However, no significant differences were found among sub-regions and depths for overall results (Table 3; Fig. 7), while in 2012, significant differences were found due to the low stock size in the Sarıkum sub-region. The stock size was increased five times in the Cide, while threefold was estimated in Türkeli, and ten times in Ayancık from 2011 to 2012. Inebolu and Sarıkum showed no difference between years (Figs. 8, 9).

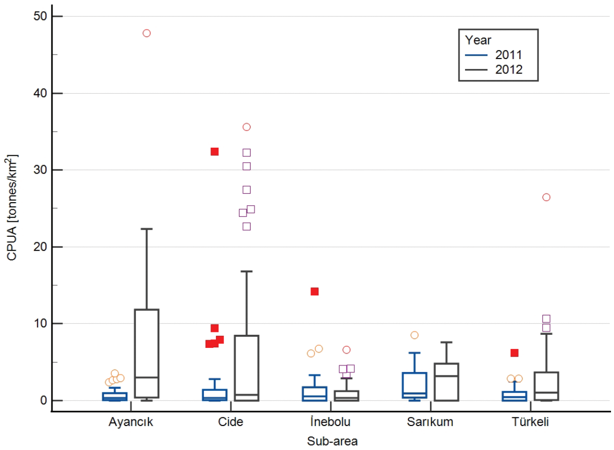

Figure 7. Box plots of estimated stock size of *Rapana venosa* with 95% CI according to sub-region, and years in the mid-southern part of the Black Sea. Horizontal lines in the boxes represent the mean values, and whiskers represent the standard deviations. Error bars represent 95% confidence intervals.

Discussion

LWR changes depending on many factors such as access to food, nutritional habits, season, gonad development, and reproduction time (Erkoyuncu 1995). According to Erik et al. (2017), *Rapana venosa* has different growth characteristics on the east, central, and west Turkish Black Sea coasts. It is stated that the main reason for the difference in LWR is the physical aspects such as a substrate. The LWR in 2011 was similar to those reported in previous studies in the Black Sea (Table 4).

Table 3. ANOVA table for differences in estimated stock biomass of *Rapana venosa* from the mid-southern part of the Black Sea among sub-regions, depth, and years.

Factor	Df	SS	MS	*F*	*P*
			All		
Sub-region	4	10743.98	2685.99	2.09	0.11
Depth	3	3039.35	1013.12	0.79	0.51
Year	1	12201.05	12201.05	10.84	**0.00**
			2011		
Sub-region	4	2197.34	549.34	1.61	0.22
Depth	3	254.05	84.68	0.19	0.90
			2012		
Sub-region	4	16775.73	4193.93	3.37	**0.04**
Depth	3	4646.76	1548.92	0.80	0.51

Bold prints denotes significance level ($P < 0.05$). Df = degrees of freedom, SS = sum of squares, MS = mean square, F = F-value.

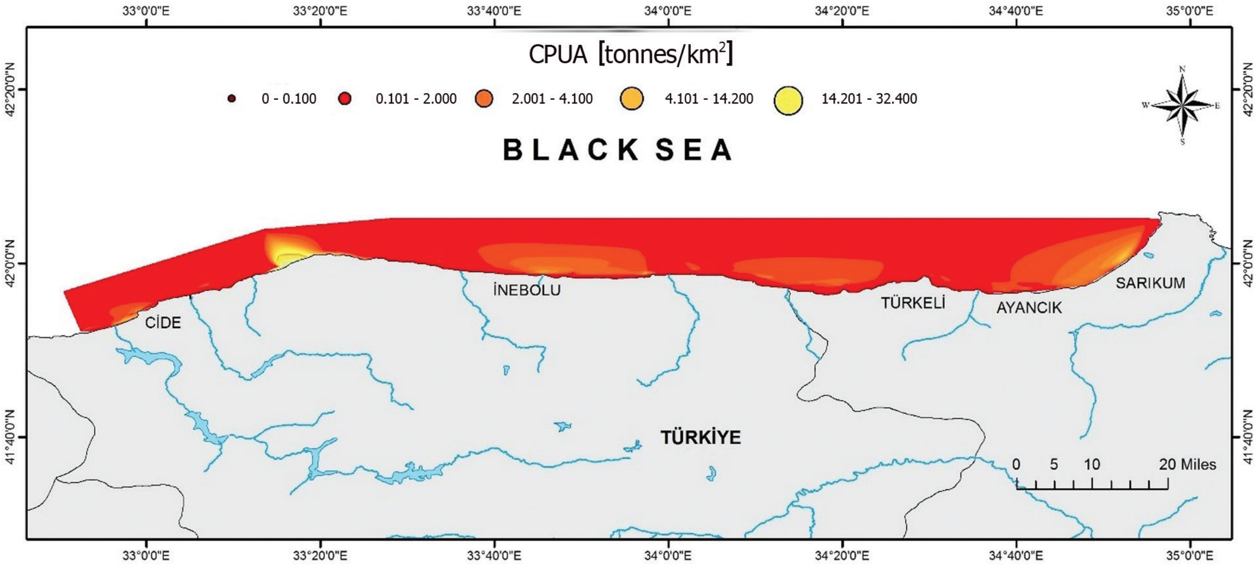

Figure 8. The catch per unit area [kg · km^{-2}] distribution of *Rapana venosa* from the mid-southern part of the Black Sea in 2011.

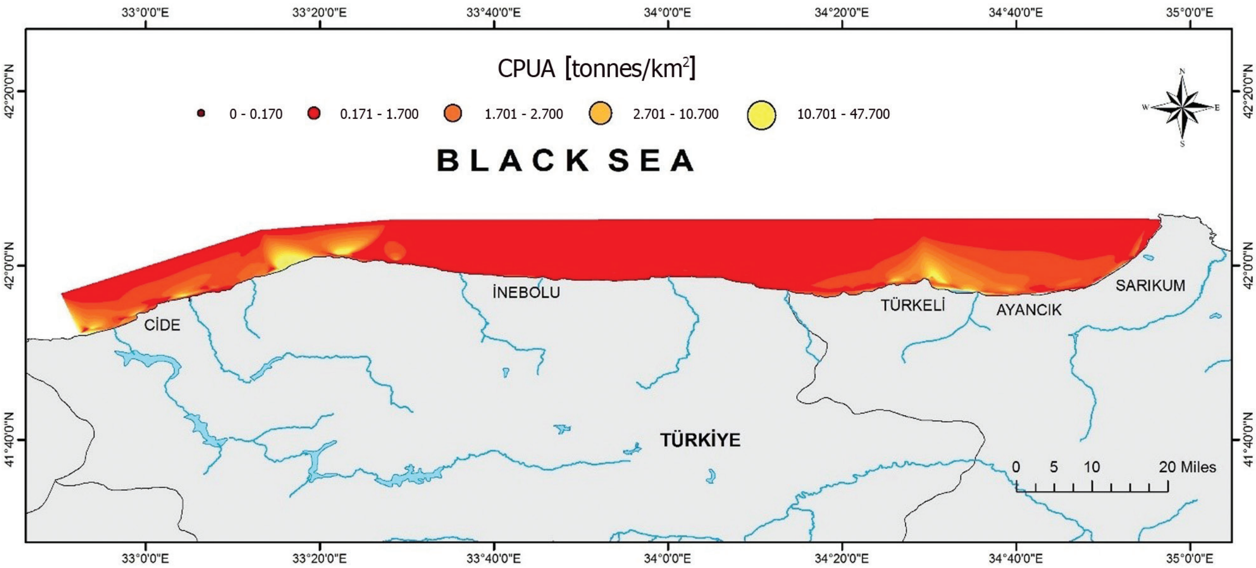

Figure 9. The catch per unit area [kg · km^{-2}] distribution of *Rapana venosa* from the mid-southern part of the Black Sea in 2012.

The *b* value of *R. venosa* in 2012 was 3.08. These findings are similar to the values found by Şahin et al. (2009) in the eastern Black Sea. Rapa whelk has been evaluated as not a slow-growing species. It is well known that food availability and environmental conditions such as temperature, pH, salinity, and water geography are crucial to species growth (Jennings et al. 2001). In this study, the fishing mortality rate was found to be significantly higher than the natural mortality rate, which indicated that the mortality of *R. venosa* was mainly caused by fishing activities. Additionally, lower *M* to higher *F* can be evaluated as the occurrence of overfishing, in which younger individuals were caught more than old ones (Sparre and Venema 1992). The exploitation rate of 0.735 also clearly indicated that the exploitation for rapa whelk was higher than the optimum exploitation level as it was suggested $E = 0.5$ for the optimum exploitation of resource (Gulland 1983). Therefore, fisheries management should consider precautionary approaches to ensure the sustainability of the *R. venosa* stock in the region. It is thought that high fecundity will be effective in maintaining the current level of stocks despite the high fishing pressure (Harding 2003). Since it is an important source of income for fishermen today, there is no expectation of stakeholders to completely remove it from the ecosystem (Dağtekin et al. 2023).

Considering sub-regions, the *R. venosa* population in Cide, Türkeli, and Ayancık increased significantly in one year, related to the increase in *C. gallina* in abundance. Inebolu sub-region was an important distribution area of *R. venosa*, and estimated stock sizes are the highest. Additionally, the amount of *C. gallina*, its main prey, was high (62 000 tonnes) in this area (Dağtekin et al. 2016). Food availability is the main factor for species distribution and affects population

Table 4. Comparison of length–weight relations of *Rapana venosa* from various studies carried out in the Black Sea.

Region	*a*	*b*	R^2	Year	Reference
East Black Sea	0.0004	2.798		1991	Düzgüneş et al. 1992
Bulgaria	0.0005	2.813			Prodanov et al. 1995
East Black Sea	0.0001	3.146			Sağlam, unpublished
Romania	0.0002	2.568			Micu et al. 2008
East Black Sea	0.0006	2.712		2007	Saglam et al. 2008
East Black Sea	0.00009	3.145			Şahin et al. 2009
Trabzon (EBS)	0.0004	2.826	0.89	2007	Sağlam et al. 2015
Terme (EBS)	0.0006	2.735	0.84	2007	Sağlam et al. 2015
Samsun (EBS)	0.0011	2.556	0.85	2007	Sağlam et al. 2015
Yakakent (EBS)	0.0076	2.728	0.91	2015	Bayraklı et al. 2016
Türkiye	0.0002	2.876	0.98	2016	Erik et al. 2017
Türkiye	0.0002	2.9868		2017	GFCM 2023
Türkiye	0.0001	3.085		2018	GFCM 2023
Türkiye	0.0001	3.104		2019	GFCM 2023
Türkiye	0.0002	2.949		2020	GFCM 2023
Türkiye	0.0002	2.981		2021	GFCM 2023
Türkiye	0.0002	2.921		2022	GFCM 2023
Ukraine	0.334	2.725		2017	GFCM 2023
Ukraine	0.4304	2.533		2018	GFCM 2023
Ukraine	0.2328	2.893		2019	GFCM 2023
Ukraine	0.469	2.568		2020	GFCM 2023
Ukraine	0.309	2.756		2021	GFCM 2023
Bulgaria	0.16	2.99		2017	GFCM 2023
Bulgaria	0.1642	2.99		2018	GFCM 2023
Bulgaria	0.0005	2.726		2021	GFCM 2023
Bulgaria	0.00024	2.915		2022	GFCM 2023
West Black Sea	0.0004	2.824	0.89	2011	Presently reported study
West Black Sea	0.0001	3.089	0.94	2012	Presently reported study

EBS = East Black Sea.

* Sağlam H (2003) Doğu Karadeniz'deki deniz salyangozunun *Rapana thomasiana* Crosse, 1861 Biyoekolojisi. Doktora tezi Trabzon, Türkiye. 101 pp. [In Turkish]

growth. Düzgüneş et al. (1992) reported that *R. venosa* biomass is between 18 and 160 tonnes · km^{-2} in the eastern Black Sea. Sağlam et al. (2015) found Trabzon and Samsun (The eastern Black Sea) respectively 2.25 and 4.17 tonnes · km^{-2}. Comparing our results with previous studies showed that the stock sizes are lower than those calculated for the Samsun shelf area (eastern part of the Black Sea), where *R. venosa* fishing is the most concentrated. The fact that *R. venosa* fishing is not common (only scuba diving) in our sampling area, but the higher abundance of two important prey items (*Chamelea gallina* and *Anadara inaequivalvis* (Bruguière, 1789)) is thought to be the factors responsible for the increase in the estimated stock size of *R. venosa* in 2012 (Dağtekin et al. 2016). Depending on the season, the regions and depths utilized by *R. venosa* vary; while it shows a dense distribution at depths down to 15 m in the summer months, it migrates down to the depth range of 40–45 m in winter (Sağlam et al. 2009). Based on the number of empty bivalve shells collected during the research, it can be said that *R. venosa* exerts severe predator pressure on *C. gallina*. It is known that fishing mortality owing to hydraulic dredges and sudden changes in environmental parameters impact the natural mortality of bivalve species (López-Rocha et al. 2018). Therefore, it is recommended to develop a policy against the population growth of rapa whelk in a certain sub-region, such as Inebolu.

Conclusions

In conclusion, many studies on the *Rapana venosa* stocks have settled along the Black Sea coastline and become an important economic contribution for fishers over the past 30 years. Some researchers have suggested that this species should be removed entirely owing to its substantial harmful effects (Čuhčin 1984; STECF 2017). Zengin and Knudsen (2006) showed that the rapa whelks exert pressure on *Mytilus galloprovincialis*, *Chamelea gallina*, and *Anadara* spp. Several studies emphasize that due to *R. venosa* having destroyed the mussel beds, their population may not be able to increase (Dalgıç and Karayücel 2007). Today, mussel beds are considered seriously threatened by all Black Sea countries and there has also been an increase in *R. venosa* caught in the Black Sea recently (STECF 2017). On the other hand, many undesirable species continue to enter the Black Sea due to both climate change and biological pollution. The Pacific oyster, *Magallana gigas* (Thunberg, 1793), which is widely distributed in the Black Sea nowadays, is the best example of this situation (Aydın and Gül 2021). Therefore, it would be good to make evaluations by bringing all these components together. The kind of changes that will occur in the functioning of *R. venosa* in the ecosystem with these species should be investigated. It is important that studies on *R. venosa* are carried out continuously. Habitat-based assessments are needed in fisheries management. Dağtekin et al. 2022 found that the mean length was low in the Eastern Black Sea region. While there is predator pressure in this region, there have been decreases in the Samsun shelf region due to excessive fishing pressure.

Additionally, the rapa whelk has become a component of the Black Sea ecosystem. Therefore, there is a need for clear outcomes to be discussed and actions to be implemented to monitor the fisheries of this species. This includes creating and monitoring management scenarios or taking the necessary measures to eliminate this species from the ecosystem owing to the damage it causes to the habitat.

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