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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

Mass mortality report of the critically endangered *Pinna nobilis* (Linnaeus, 1758) in Gökçeada (North Aegean Sea, Turkey)

Gökçeada'da (Kuzey Ege Denizi, Türkiye) nesli kritik şekilde tehlike altında olan *Pinna nobilis* (Linnaeus, 1758)'in toplu ölüm raporu

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Abstract: In August 2020, a total area of 38000 m² around Gökçeada has been scanned to determine the current population status of *Pinna nobilis*. 9 stations (Yıldızkoy, Manastır, Marmaros, Gizli Liman, Laz Koyu, Kapıkaya, Karaçavuş, Karaçavuş shore and Kefalos) have been detected by means of SCUBA and ABC diving techniques. All specimens were found dead (total mass mortality of 100%). The total length range of *P. nobilis* was between 30.8 – 38.3 cm.

Keywords: *Pinna nobilis,* length, habitat, density, mass mortality, Aegean Sea

Öz: *Pinna nobilis*'in mevcut populasyon durumunu ortaya koymak için, 2020 Ağustos ayında Gökçeada kıyılarında, 38000 m²'lik bir alan incelenmiştir. 9 istasyon (Yıldızkoy, Manastır, Marmaros, Gizli Liman, Laz Koyu, Kapıkaya, Karaçavuş, Karaçavuş altı ve Kefalos), SCUBA ve ABC dalış teknikleri kullanılarak taranmıştır. Çalışma süresince bulunan bütün bireyler ölüdür (%100 kütlesel ölüm görülmüştür). *P. nobilis* 'in toplam boy aralığı 30,8 – 38,3 cm arasında ölçülmüştür.

Anahtar kelimeler: *Pinna nobilis*, boy, habitat, yoğunluk, kütlesel ölüm, Ege Denizi

INTRODUCTION

The island, as called, "Imbros", until 1970's and after "Gökçeada", is a district of Çanakkale and is the largest island of Turkey. It is located in the north of Aegean Sea and the entrance of Saros Bay. The total shoreline is 91 km. Tourism, agriculture, stock breeding, and fisheries are the main subsistence on the island. Specifically, harpoon fishery for swordfish along the coasts is peculiar to Gökçeada (Altın et al., 2016). The marine ecosystem along the coasts of Gökçeada is also quite rich in biodiversity (Öztürk and Pazarkaya, 2014; Acarli et al., 2020a). *Pinna nobilis* (Linnaeus, 1758), an endemic bivalvia species of the Mediterranean, lives in *Posidonia oceanica* or *Cymodocea nodosa* meadows, embedded with a part of umbo and attached with byssus, on a sandy, sandy-muddy, gravel substratum (Tebble, 1966; Zavodnik et al., 1991; Hendriks et al., 2011). The hard shells are home to many benthic organisms (Acarli et al., 2010). *P. nobilis* filter-feed on organic and inorganic materials in the water column, this helps to enhance water quality in the area (Vicente et al., 2002; Natalotto et al., 2015; Acarli, 2021). Individuals with a length of 30 cm were reported to filter more than 2500 L of water per day, depending on their physiological energy (Hernandis Caballero, 2021). However, their population is affected by overfishing, environmental pollution, habitat deterioration, and tourism. Thus, *P. nobilis* has been taken under conservation by the European Council's regulations in 1992. Since 2016, the population is under the thread of a parasite *Haplosporidium pinnae* which caused many mass mortalities recorded along the Mediterranean (Vázquez-Luis et al., 2017). Greece, Italy, Croatia, Turkey, Tunisia, France and Morocco are the Mediterranean countries that have reported mass mortality (Acarli et al., 2020a; Čižmek et al., 2020; Šarić et al., 2020; Öndes et al., 2020; Zotou et al., 2020; Betti et al., 2021; Acarli et al., 2022a). International Union for Conservation of Nature (IUCN) has changed the status of *P. nobilis* as Critically Endangered Species (Kersting et al., 2019).

Although there have been many studies conducted along Gökçeada coasts, such as the fish fauna from shallow waters, species composition, fish egg and larvae (Altın and Ayyıldız, 2018; Kocabaş and Acarli 2019; Acarli et al., 2020b; Daban et

al., 2020); only one study on the status of *P. nobilis* population in Gökçeada has been found (Çanak et al., 2006). In this context, the current study aimed to determine the present status of the *P. nobilis* population in Gökçeada, which is located in the northernmost part of the Aegean Sea.

MATERIAL AND METHODS

This study was carried out in August 2020 at 9 stations around Gökçeada (Figure 1). Gökçeada is located at the northernmost part of the Aegean Sea. The coordinates of 9 stations are; Yıldızkoy (40˚14.110' N - 25˚54.230' E), Manastır (40˚11.591' N - 25˚58.696' E), Marmaros (40˚11.620' N - 25˚45.289' E), Gizli Liman (40˚7.432' N - 25˚40.269' E), Laz Koyu (40˚5.975' N - 25˚47.050' E), Kapıkaya (40˚6.288' N - 25˚48.542' E), Karaçavuş (40˚6.944' N - 25˚53.322' E), Karaçavuş shores (40˚7.228' N - 25˚55.285' E) and Kefalos (40˚9.497' N - 25˚59.952' E).

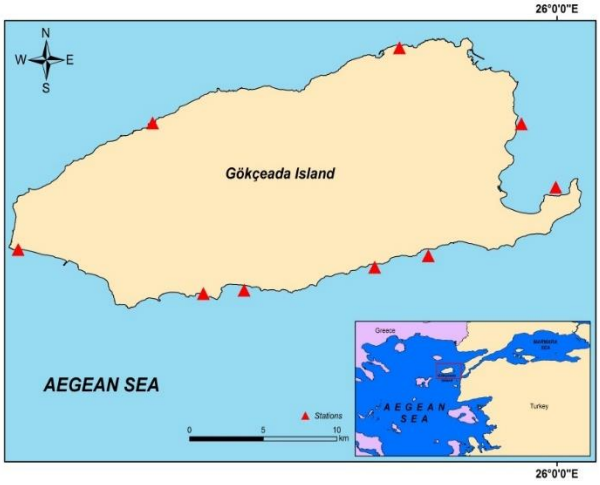

Figure 1. Study area

Depth and temperature values at the stations were measured by the dive computer, Oceanic Geo 2. Current status of *P. nobilis* population was observed by means of SCUBA and ABC dives. Transect method of visual census technique was used to detect the *P. nobilis* individuals. In each station, two divers, with 10 m distance in between, scanned rectangular areas perpendicular to the shore. The rectangles were, minimum 100 m and maximum 300 m in length, and 2-10 m in width. The properties of the scanned area, habitat structure (sandy, seagrass meadow, gravel etc.) and the number and status of *P. nobilis* specimens were recorded on underwater slates. Photographs were taken by an underwater camera (Nikon Coolpix).

During the observation, if the specimen was fully over the sediment, total length of the shell was measured, or if it was buried in the sediment, only the width of the shell was measured and recorded on slates. The length of these buried specimens was later calculated by the equation (1) revealed by Acarli et al. (2018) which was determined with the previously obtained raw data.

$$a=0.8061b+28.61;\ (r^2=0.717) \qquad (1)$$

In this equation *a* is the calculated total length and *b* is the measured width of the shell.

RESULTS

Habitat structure, depth range, underwater visibility, surveyed area, no of individuals per 100 m^2, and mortality ratio of 9 stations are given in (Table 1). A total of 8 *P. nobilis* individuals were found in 5 stations (Figure 2) with a total length range of 30.8-38.3 cm. Only two shells were found buried and they were in Yıldızkoy, all the other individuals (6) were encountered lying over the sediment. The highest number of individuals (3) was in Kefalos Station. There were no dead or alive individuals encountered in stations Marmaros, Gizli Liman, Laz Koyu and Kapıkaya. Mortality rate was 100% for all the stations (Figure 3).

Table 1. Information about stations' characteristics

Stations	N	Length of *P. nobilis*	Habitat Structure	Depth Range (m)	Underwater visibility (m)	Surveyed area (m^2)	Density of Dead Shells (ind/100m^2)	Mortality rate (%)
Yıldızkoy*	2	36.0-36.40	Gravel 10%, Sandy 10%, *P. oceanica* 80%	6-12	9	3000	0.06	100
Manastır	1	38.3	Sandy 10%, *P. oceanica* 90%	8-9	10	3750	0.02	100
Marmaros	-	-	Rocky 30%, *P. oceanica* 70%	7-11	12	4000		-
Gizli Liman	-	-	Sandy 30%, Rocky 20%, *P. oceanica* 50%	7	10	5250		-
Laz Koyu	-		Sandy 30%, Rocky 20%, *P. oceanica* 50%	8	7	6500		-
Kapıkaya	-		Sandy 80%, Rocky 20%	6	5	5000		-
Karaçavuş	1	30.8	Sandy 10%, *P. oceanica* 90%	4	1.5	1000	0.1	100
Karaçavuş Shore	1	35	*P. oceanica* 100%	3.5-4	15	4000	0.02	100
Kefalos	3	36.0-37.0 37.9	Gravel 10%, Sandy 10%, *P. oceanica* 80%	11	12	5500	0.05	100

*Gökçeada Marine Park

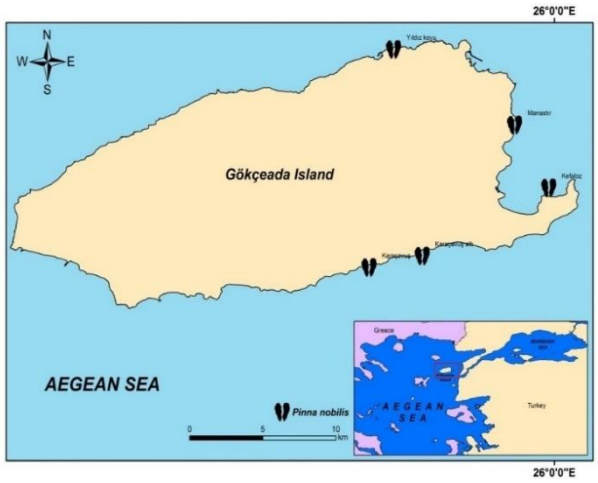

Figure 2. Stations where *P.nobilis* is observed

Habitat type along the study area was generally *P. oceanica* meadow, sand, gravel, and rock. *P. nobilis* individuals were mostly seen among *P. oceanica* meadows. Underwater visibility (horizontally) was lowest in Karaçavuş station (1.5 m) and highest in Karaçavuş shore station (15 m). The number of *P. nobilis* individuals per 100 m^2 was calculated to vary between 0.02-0.1. Water temperature varied between 24°C and 27°C throughout the study.

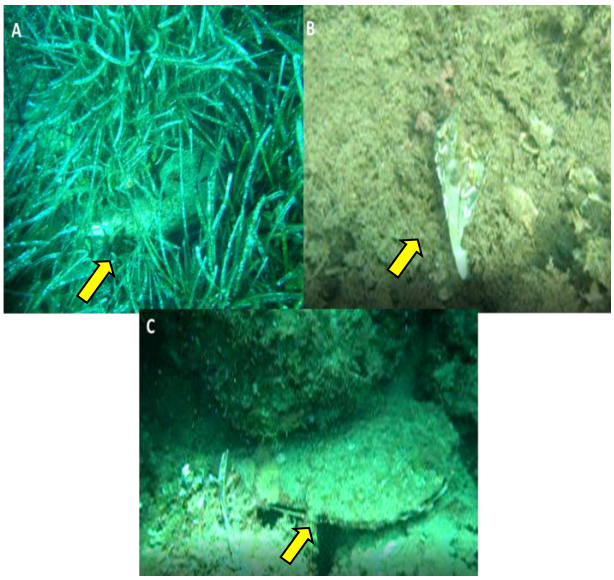

Figure 3. *P. nobilis* images from the stations Kefalos (A), Karaçavuş Shore (B) and Manastır (C)

DISCUSSION

Recently, researchers agreed on the main reason for the mass mortality of *P. nobilis*, is the parasite *H. pinnae* (Caballero 2021; Künili et al. 2021; IUCN 2021). Environmental factors, especially, temperature (over 13.5°C) and salinity (36.5-39.7 PSU) have also been declared as triggers for the mass mortality incidents (Cabanellas-Reboredo et al., 2019). However, mass mortality has been observed even in the Sea of Marmara, which is much colder and less saline than the Mediterranean Sea (Çınar et al., 2021a; Acarli et al., 2022a). Acarli et al., (2022a) indicated that low temperature and salinity conditions may help to prevent the spread of the disease, but they may not be adequate to inhibit the arising of it. In this study, sea temperature values have been recorded between 24-27°C. The fouling and boring organisms found inside the shells give rise to think that they died a while, nearly 3 years ago, before the mass mortality incidents occurred. The fact that not a single living individual was encountered in this region shows how badly the disease effects the population around Gökçeada.

In the course of current study, the sea floor was scanned from 0.5 m depths to 30 m and individuals were encountered between 4-12 m depths. Two local divers also declared that there had been a dense population they used to encounter along the shores of Kefalos at 5-15 m depths (S. Konya and V. Günel, personal communication August 15, 2020). According to Albayrak (2000), 1 individual with a length of 40.62 cm and a width of 16.11 cm had been found in Aydıncık-Kefalos bay, at 3 m depth, on a fine sandy substratum. On the other hand, Efe (2019), (without giving a location) reported 1 individual of 27 cm long and 12 cm wide, weighting 65.1 g. Çanak et al. (2006) indicated that the highest number of individuals were found from 5 to 10 m depths. These researchers measured the unburied length of *P. nobilis* from 8.5 cm to 44.3 and the width from 6 cm to 29.3 cm between 4.6 m to 27 m depths. In the current study, regarding the population distribution, the number of individuals per 100 m^2 was found to be between 0.02 and 0.1, and 100% mass mortality was recorded. Çanak et al. (2006) encountered 37 living and 5 dead individuals between Kaleköy and Yelkenkaya, where the population density of *P. nobilis* was reported as 0.022 ind./100 m^2. According to the other studies; Acarli et al. (2022b) reported 4.9-27.0 ind./100 m^2, Öndes et al. (2020) reported 1.2-13.6 ind./ 100 m^2, Acarli et al. (2021a) reported 0.6-8.2 ind./100 m^2 and finally Acarli et al. (2021b) recorded 10-112 ind./100 m^2.

P. nobilis appears to prefer environments with ideal hydrodynamic characteristics, such as low current velocities and turbulences, low wave action, and a sandy-muddy or muddy substratum, mostly among meadows of the sea grasses (Rabaoui et al., 2008). Even the habitat type of the coast in Gökçeada is mostly pebbles and rocks, dead *P. nobilis* was found on sandy substratum and among sea grass meadows during this study. On the other hand, high tourist activity has been observed on sandy coast of Gökçeada. Consequently, intense deaths seen all over the Mediterranean were encountered on the shores of Gökçeada and the *P. nobilis* population seems to disappear totally.

In case, *P. nobilis* populations with low densities, as in Gökçeada, face any harm from various sources, their ability to survive and sustain is more likely to be inadequate than many other bivalve species, due to *P. nobilis*' low reproduction rate.

According to the studies that have been conducted along the Turkish coasts (Öndes et al. 2019; Öndes et al. 2020; Özalp

and Kersting 2020; Çınar et al. 2021a, 2021b; Acarli et al., 2020a, 2021a, 2021b, 2022b), the density of *P. nobilis* was found to be between 0.3-112.0 ind./100m^2. Depending on the current study and the study by Çanak et al. (2006), the density values were 0.020 ind./100 m^2 and 0.022 ind./100 m^2 respectively, which represented the lowest values among the all the studies those have been conducted up to now.

P. nobilis contributes to the ecology in a variety of ways. Large amount of organic matter is filtered from the water column which helps to improve the area's water quality and also many benthic organisms live on the hard shells. It is critical to implement an immediate conservation and management plan aimed at protecting and restoring *P. nobilis* stocks. To detect and monitor the remaining living *P. nobilis* individuals and areas with healthy populations that have not yet been exposed to parasites and even to declare those areas as Marine Protected Areas, is vital for the marine ecosystem. Also collecting and culturing the spat of the population is crucial for the revival and sustainability of damaged populations as Gökçeada's.

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AUTHORSHIP CONTRIBUTIONS

Deniz Acarli, Sefa Acarli and M. İdil Öz designed the study. Deniz Acarli and M. İdil Öz carried out underwater observations. Sefa Acarli supervised the study concept. Writing the first draft, data management, and statistical analyses were conducted by M. İdil Öz and Sefa Acarli. All authors read and approved the final manuscript.

CONFLICTS OF INTEREST STATEMENT

The authors declare that there is no known financial or personal conflict that may affect the research.

ETHICS APPROVAL

No specific ethical approval was necessary for this study.

DATA AVAILABILITY

The datasets analysed during the current study are available from the corresponding author on reasonable request.

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