Abbreviated Key Title: Glob. J. Environ. Sci. Technol.
ISSN: 2384-5058 (Print) & Open Access
Vol. 12(2): Pp. 38-45, February, 2024.
DOI:10.54978
Global Journal of Environmental Science and Technology: ISSN-2360-7955, (Print) & Open Access
Volume-12 | Issue-2| February, 2024 | Research Paper

State of blue crab *Callinectes sapidus* population in Kune Lagoon, Albania

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Corresponding author: Stela Ruci , Accepted: 16/2/2024 Published: 22/2/2024

Abstract: The objective of this study was to investigate and assess the occurrence and quantity of the invasive blue crab population in Kune Lagoon, located in Albania, south-east Adriatic Sea. Additionally, the study aimed to assess the population structure by examining biometric parameters. In contrast to prior research in the same lagoon, this study revealed a notably higher abundance of the blue crab during various periods of field observations. The data analyzed extends in three years of field observations and collections, with a specific focus on the ingress (March – April) and egress (November) of the blue crab into and out of the lagoon, respectively. The highest number of crab individuals was documented in September and October. From the examination of biometric parameters, including total weight, carapace length, and carapace width of 80 individuals, it was observed that the population was predominated by adult and large individuals. The sex ratio analysis indicated a prevalence of the males, with a F : M ratio 0.4 : 0.6 within the lagoon. Questionnaires were distributed to local fishermen to gather additional insights into the status of the blue crab in Kune Lagoon. The questionnaires also gathered information on the socio-economic impact of the blue crab, as well as its effects on native populations in the lagoon. The results suggested that the trade of blue crab from Kune Lagoon remains at minimal levels, providing little economic benefit to local fishermen. Fishermen reported examples of aggressive behavior by the blue crab and damage to fishing nets. The high prevalence of other invertebrates, particularly the Mediterranean mussel (*Mytilus galloprovincialis*), might be a main reason for the high abundance of blue crab in this lagoon, as it serves as a primary food source for the blue crab. Continuous presence of the blue crab population, the presence of ovigerous females, and juveniles indicate the stability of this species in Kune Lagoon.

Keywords: Invasive alien species, population structure, biometric parameters, socio-economic impact, Adriatic Sea.

Published by GJEST

INTRODUCTION

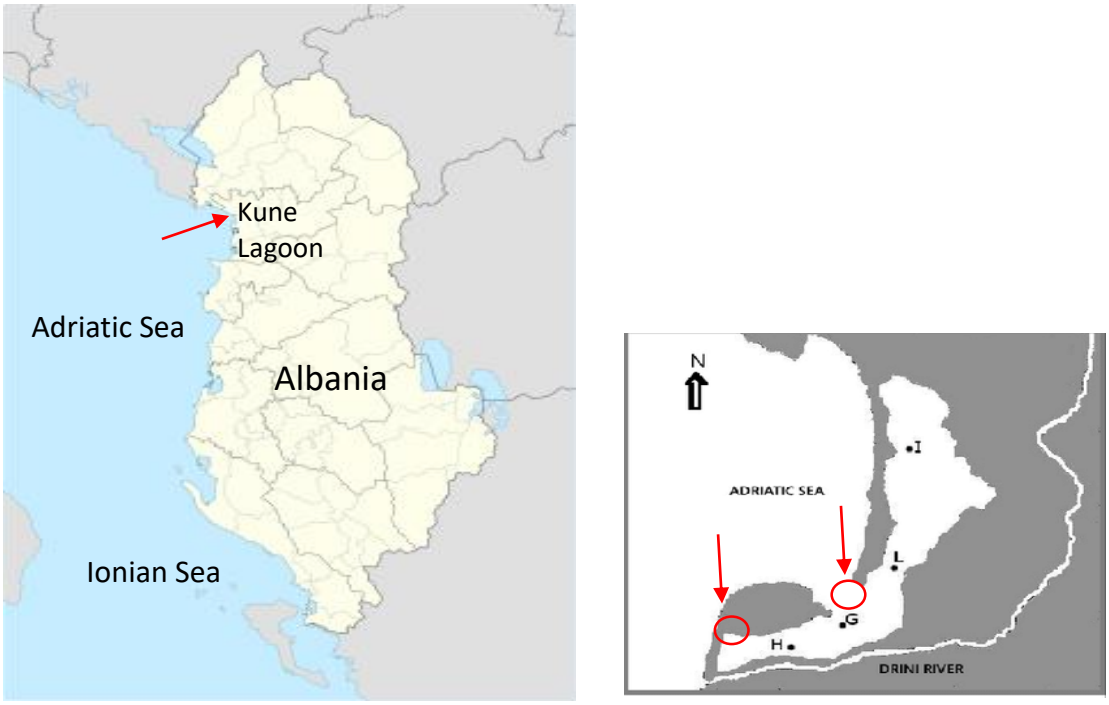
The blue crab (*Callinectes sapidus*) has been identified as one of nearly 40 marine alien species reported along the Albanian coast, as documented by Beqiraj and Zenetos (2021). The first scientific record of this species in Albania dates to 2009, with observations made in Patoku Lagoon, as reported by Beqiraj and Kashta (2010).

Later on, the presence of the blue crab in different coastal areas of Albania, mainly lagoons and river mouths, was reported from a rapid assessment study, namely from the lagoons of Vilun, Kune, Patok, Karavasta, Narta, Orikum, Butrint and the Erzeni River mouth (Agolli et al., 2012), as well as from other river mouths: Buna, Mat, Ishem, Shkumbin and Bistrica (Milori et al., 2013). More specific studies on the blue crab population structure and its state of establishment were done for the Patoku Lagoon (Agolli, 2012; Çami, 2015), Narta and Orikumi lagoons (Zhori, 2013), as well as Viluni Lagoon (Qorri, 2015). A comprehensive investigation into the occurrence, abundance, and demographic composition of the blue crab across the entire Adriatic coast of Albania has been published by Milori (2022). This study encompasses a comparative analysis with previously gathered data referenced in the earlier studies mentioned. The present study in this paper represents data on the population structure and establishment status of the blue crab, after the first report of this species in Kune Lagoon that has been reported by (Agolli, 2012).

Kune Lagoon is part of the Kune-Vain wetland complex in the Drini river mouth, situated in Lezha region, in the North-West of Albania, at the Adriatic coast (N 41,030'; E 19,030'), (Figure 1 and Figure 2). Kune-Vain represents the inaugural designated protected area in Albania, originally established as a hunting reserve in 1940. Since its first designation, the protection status and spatial extent of the reserve have undergone multiple revisions. The most recent revision, in 2010, enforced its status to that of a Managed Nature Reserve, classified under the IUCN category IV. The revised designation encompasses a comprehensive surface area of 4393 hectares, including the entire Kune-Vain wetland complex. The Kune Lagoon, a constituent part of this complex, spans an area of 3.08 km^2, featuring a maximum length of 4.8 kilometers and a width of 2.1 kilometers. The average depth of the lagoon is 0.75 m, while the maximum depth is 1.3 m (Reçi., 1998). The lagoon communicates with the sea through a natural channel, where water circulation is 5-10 m3/s. The atmospheric conditions within the lagoon vicinity exhibit a climatic range, with a minimum air temperature of 1.8°C observed in January and a peak of 38.3°C recorded in July. The lagoon experiences an annual evaporation rate of 850 mm, while the average yearly precipitation stands at 1463.5 mm. Consequently, the water balance in this lagoon is characterized by a positive equilibrium (Pano, 2015). The salinity levels in the western segment of the lagoon range from 25‰ to 36‰, while the eastern counterpart registers salinity levels between 5.7‰ and 13‰ (Reçi, 1998). Dissolved oxygen concentrations in the water exhibit variability within optimal ranges, fluctuating from 4.83 mg/l to 15.29 mg/l. In 2011, Miho et al. (2013) documented a decline in dissolved oxygen levels within this lagoon, indicating a deterioration in water quality.

MATERIAL AND METHOD

Blue crabs in Kune Lagoon were collected multiple times each year over a three-year period, 2014, 2015, and 2016, following the methods in existing literature on collection of this species in Mediterranean lagoons, as referenced in Cabal et al. (2006), Florio et al. (2008), Galil (2000), Gennaio et al. (2006), Onofri et al. (2008), Kirincic & Stevcic (2008), and Tuncer & Bilgin (2008). Based on these references, it was determined that the blue crab typically enters the Mediterranean lagoons during March - April and leaves in October – November.



a) **b)**

Figure 1. a) Map of Albania, showing the position of Kune Lagoon; **b)** sampling sites of the blue crab in the Kune Lagoon.

The blue crabs were collected as by-catch from the gillnets and fyke nets of local fishermen. The following characteristics were assessed and / or measured from the collected individuals: sex, to evaluate the ratio between males and females (F: M sex ratio), weight (g), carapace width (mm) and carapace length (mm) (Figure 2), referring to the methods of Cadman & Weinstein, (1985); Florio et al., (2008). Carapace width and height have been measured to evaluate crabs' age after Hines et.al., (1990) and their maturity after Cadman and Weinstein (1985). Spearman correlation has been evaluated to assess correlation between weight, width, and height.

a) **b)**

Figure 2. a) Collected blue crabs in the gillnets; **b)** Biometric measurements in the field.

Besides direct observations and collection in the studied area, questionnaires have been distributed to local fishermen, to collect additional information about the state of blue crab, its socio-economic impact, and its possible impact on the other native populations in Kune Lagoon.

RESULTS AND DISCUSSIONS

Previous reports on the blue crab from other Adriatic lagoons have documented lower quantities of this species compared to the consistently higher quantities found during various field observation periods in Kune Lagoon, as documented in Beqiraj & Kashta (2010), Beqiraj et al. (2012), Agolli et al. (2012), Florio et al. (2008), Kirincic & Stevcic (2008), and Onofri et al. (2008).

Notably, the months of September and October recorded the highest number of individuals.

The increased abundance of the blue crab in Kune Lagoon is likely attributed to the high abundance of benthic invertebrates, which serves as a primary food source for the crabs, as indicated by Harding (2003) and Milliken & Williams (1984). Beqiraj (2004) and Beqiraj (2007) have previously documented the richness of benthic macroinvertebrates in Kune Lagoon.

Local fishermen report the blue crab usually enters Kune Lagoon in March, corresponding to the period of opening of fishing weirs by them. They keep the fishing weirs close from June to March every year.

The closure of lagoon outlet channels through fishing weirs presents an impediment to the migration of ovigerous females to the sea, consequently diminishing the opportunity for successful spawning. 11 ovigerous females were captured in Kune Lagoon during May and September. This aligns with the information in existing literature, which notes that blue crab spawning usually takes place during May - June and August – September (Hines et al., 1990). The capture of females in fishing weirs during the reproduction period in this study can be explained by their inclination to migrate towards the sea for spawning, despite the barrier posed by the fishing weirs.

F : M sex ratio of approximately 0.4:0.6 was observed in this lagoon, where, out of 80 individuals analysed, 36 were females, 42 were males, while two individuals were of undetermined sex.

Table 1: Number of individuals of blue crab collected in Kune Lagoon.

Sex	Number of individuals
Females	36
Males	42
Undetermined	2
Total	80

Table 2: Classification of individuals into juveniles and adults according to the Harding system (2003).

	Juvenile individuals (CW< 120 mm)	Adult individuals (CW> 120 mm)	Total
Female	5	31	36
Male	3	39	42
Undetermined	2		2
Total	10	70	80

Based on carapace width, Harding (2003) has classified the blue crab individuals into juveniles (CW< 120 mm) and adults (CW> 120 mm).

As can be seen from table 2, from the 80 individuals analysed in Kune Lagoon, 10 individuals were juveniles (12%) and 70 individuals were adults (88%). From 70 individuals assessed as adults, 31 were females and 39 were males, while from 10 individuals assessed as juveniles, 5 were females, 3 were males, while two individuals were of undetermined sex.

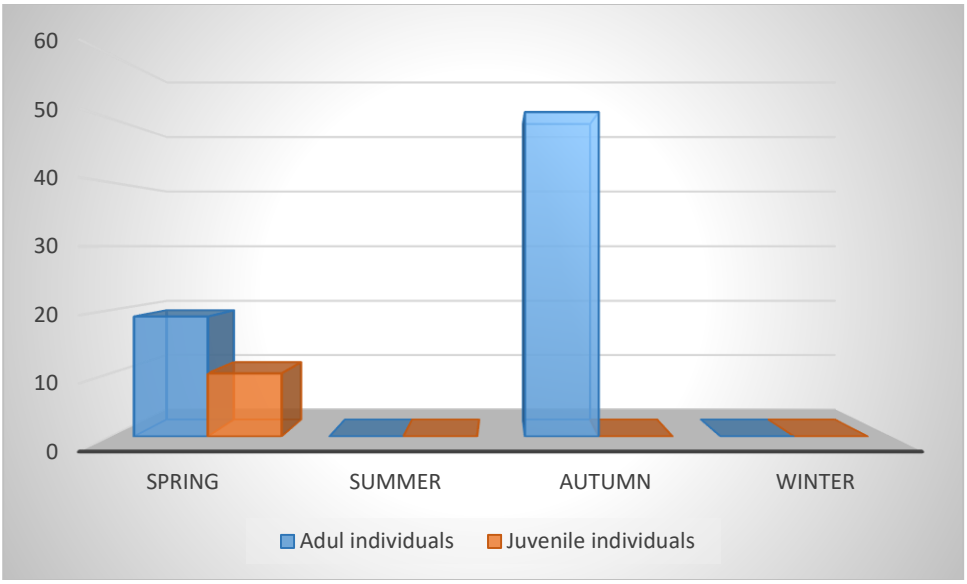


Figure 3: The ratio between juvenile and adult individuals of blue crab in each season.

As seen from figure 3, the number of juvenile individuals in spring was 10 and the number of adult individuals was 19. Neither juvenile nor adult individuals were found in summer. All individuals found in autumn, 51 in total, were adults. No juvenile individuals were found in this season.

It is worthy to note that in winter no blue crabs were caught in the lagoon, due to their migration to the sea, while in summer the local fishing companies were not given the license, so they did not fish in that season.

Table 3: Classification of individuals according to size (based on the Cadman & Weinstein, 1985 system).

Sex	Small individuals (CW<80mm)	Medium individuals (CW 80-120mm)	Large individuals (CW>120mm)	Total
Female	1	5	30	**36**
Male	1	2	39	42
Undetermined	2			**2**
Total	**4**	**7**	**69**	**80**

Collected individuals were classified based on carapace width into small individuals (CW< 80mm), medium individuals (CW 80 - 120mm) and large individuals (CW> 120m), according to Cadman & Weinstein (1985).

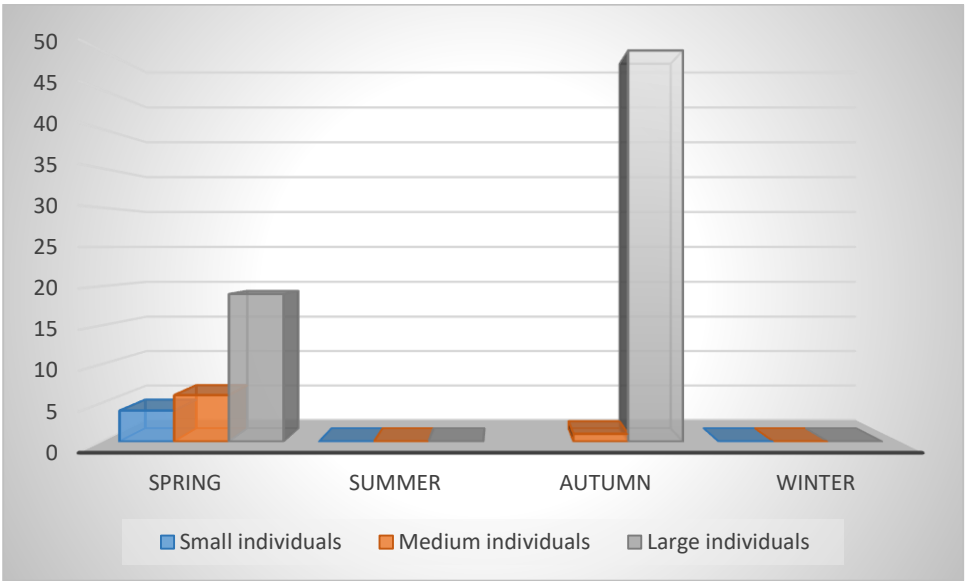


Figure 4: Size classification of blue crab individuals in each season.

Figure 4 shows the blue crab individuals classified according to size for each season. In spring there were recorded 4 small individuals, 6 medium individuals and 19 large individuals. 1 medium individual and 50 large individuals were counted in autumn.

Based on carapace width, blue crab individuals were also classified in 1-year-old individuals (CW < 100 mm), in individuals between 1 and 2 years (CW 100 - 170 mm) and in individuals over two years (CW > 170 mm), according to Hines et al., (1990).

Table 4: Classification of individuals by age (based on the system of Hines et al., 1990).

	Up to 1 year (CW < 100 mm)	Between 1 and 2 years (CW 100 - 170 mm)	Over 2 years (CW > 170 mm)	Total
Female	1	30	5	**36**
Male	3	19	20	**42**
Undetermined	2			**2**
Total	**6**	**49**	**25**	**80**

Based on the data in table 4, from the total number of individuals analysed in Kune Lagoon, 6 individuals were classified as of aged up to 1 year, 49 individuals from 1-2 years and 25 individuals over 2 years.

From individuals aged up to 1 year, one individual was female, three males, while 2 were of undetermined sex. From 49 analysed individuals aged 1-2 years, 30 individuals were females and 19 were males. From 25 individuals aged over 2 years, 5 individuals were females and 20 were males. Showed in percentage, individuals up to 1 year old make 8%, individuals between 1 and 2 years old 61% and individuals over 2 years old 31%.

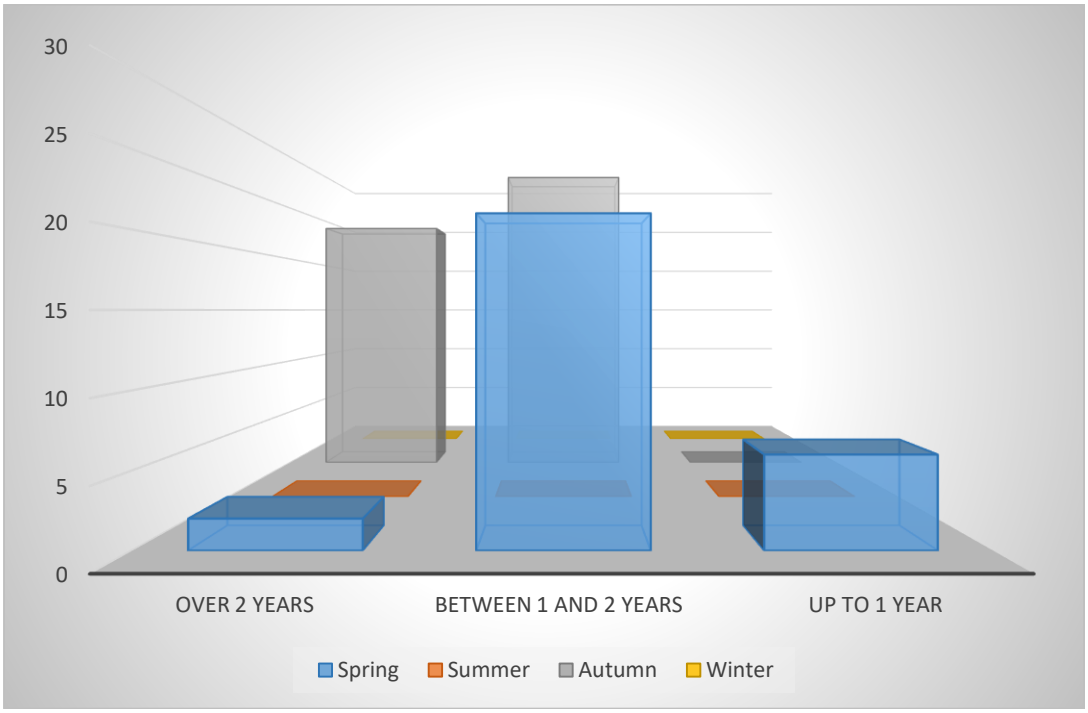


Figure 5: Grouping of age classes of blue crab individuals in each season.

From figure 5, which shows the classification of individuals by age, in spring there were 6 individuals aged up to 1 year, 21 individuals between 1 and 2 years old and 2 individuals over 2 years old. In autumn, we see that the number of individuals aged between 1 and 2 years and over 2 years old is 28 and 23 individuals respectively. This may be related to the increase in the size of medium individuals due to the large quantity of available food in the lagoon, as mentioned above. The significant quantity of individuals over 2 years that was found in the lagoon indicates the stability of the blue crab there.

Table 5: Spearman correlation between length, width, and weight of the blue crab in Kune Lagoon.

		Length	Width	Weight
Length	Correlation coefficient	1.000	.608**	**.625****
	Sig. (2-tailed)	.	.000	**.000**
	N	80	80	**80**
Width	Correlation coefficient	.608**	1.000	**.877****
	Sig. (2-tailed)	.000	.	**.000**
	N	80	80	**80**
Weight	Correlation coefficient	.625**	.877**	**1.000**
	Sig. (2-tailed)	.000	.000	**.**
	N	**80**	**80**	**80**

Based on table 5, the Spearman correlation shows a strong relationship between length, width, and weight of the blue crab in Kune Lagoon.

Questionnaires were distributed to local fishermen, to gather additional information about the state of the blue crab in this lagoon, its socio-economic impact, as well as the impact of the blue crab to native lagoon populations. Fishermen have documented the appearance of the blue crab in Kune Lagoon in 2010, followed by a significant increase of its population. They have reported the annual ingress of the blue crab in the lagoon during March, while information on egress remains unavailable due to the implementation of fishing weirs. Notably, a substantial increase in blue crab quantity has been reported by fishermen during the August-October period. Although, sporadic presence of blue crab was recorded in December and January.

Fishermen have claimed the capture of predominantly juvenile blue crabs, while females bearing eggs are predominantly observed in September and October. Despite the sustained presence of blue crab in Kune Lagoon, economic benefits derived from their trade remain inconsiderable for the fishermen. Furthermore, fishermen report instances of aggressive behaviour by blue crabs resulting in damage to fishing nets.

Field observations have indicated an increase in the population of the Mediterranean mussel (*Mytilus galloprovincialis*), especially in the pre-lagoon area. Considering that mussels are a preferred diet of the blue crab, the recorded increase of blue crab abondance in the lagoon may be driven by the increased population of the Mediterranean mussel.

The continuous presence of the blue crab individuals, increasing population abundance, presence of females with eggs, and juveniles indicate the stability of this species in Kune lagoon.

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