Scholars Journal of Agriculture and Veterinary Sciences
OPEN ACCESS
Abbreviated Key Title: Sch J Agric Vet Sci
ISSN 2348–8883 (Print) | ISSN 2348–1854 (Online)
Journal homepage: https://saspublishers.com

Population Dynamics of *Perna perna* (Linnaeus, 1758) from Dakar Coastal Waters, Senegal

Abdoulaye Diouf[1], Jean Fall[1], Alioune Faye[2*], Malick Diouf[3]

[1]University Institute of Fisheries and Aquaculture, Cheikh Anta Diop University of Dakar, Dakar, Senegal
[2]Institute of Environmental Sciences, Faculty of Science and Technology, Cheikh Anta Diop University of Dakar, Dakar, Senegal
[3]Department of Animal Biology, Cheikh Anta Diop University of Dakar, Dakar, Senegal

DOI: 10.36347/sjavs.2024.v11i04.001 | **Received:** 29.05.2024 | **Accepted:** 06.07.2024 | **Published:** 09.07.2024

***Corresponding author:** Alioune Faye
Institute of Environmental Sciences, Faculty of Science and Technology, Cheikh Anta Diop University of Dakar, Dakar, Senegal

Abstract **Original Research Article**

Perna perna is a species of bivalve mollusk found along the Senegalese coast from the Cape Verde peninsula to the Saloum Islands. Due to the generation of income and jobs, this species is extremely significant to Senegal's socioeconomic landscape, especially in the Dakar area. This work constitutes a first study on the population dynamics of *Perna perna* in Senegal. The specimens used for this study were caught in the Mamelles site on the Cape Verde Peninsula from March 2018 to February 2019. To assess population parameters, the FiSAT II software and its ELEFAN sub-program were used to analyze the monthly length-frequency data. The results obtained show that the asymptotic length ($L\infty$), growth coefficient (K), growth performance index (Φ') and longevity (t_{max}) were 13.65 cm, 1 yr^{-1}, and 2.27; 2.80 yr, respectively. Total mortality (Z) was esteemed to be 3.51 yr^{-1}. Natural mortality (M) and fishing mortality (F) were 2 yr^{-1} and 1.51 y^{r-1}, respectively. The recruitment pattern is a continuous with a major peak occurring in May-Jun. The current exploitation level (E) of *Perna perna* was 0.43 while the maximum allowable limit of exploitation (E_{max}) was 0.453; which implies that in order to prevent overexploitation, management actions will need to be taken.
Keywords: *Perna perna*, Senegal, Cape Verde, population dynamcs.

INTRODUCTION

Perna perna is native to the western Indian Ocean and to the west coast of Africa at least as far north as the Congo (Siddall, 1980; Rajagopal *et al*., 1997). In the Senegalese coastal regions, ranging from the Saloum Islands to the Cape Verde peninsula, *Perna perna* is widely distributed (Diouf *et al*., 2020).

In Senegal, particularly in the Dakar region, this species plays a very important socio-economic role through the creation of employment and wealth. Indeed, its exploitation occupies a certain number of actors who devote to the collection and sale of this species and other types of molluscs.

However, any research has been done on the population dynamics of *Perna perna* in Senegal, despite its socio-economic importance. The few studies on *Perna perna* in Senegal focus on aspects relating to heavy metal contamination (Sagna, 2019; Diankha *et al*., 2020), size-weight relationships (Diouf *et al*., 2020); while the study of the dynamics of bivalve populations is of crucial scientific interest. Indeed, sufficient knowledge on the natural stock, population and exploitation level would be very essential to start to manage the production activity (Nurul-Amin *et al*., 2005). Background knowledge on the ecology and growth would contribute to the success of any management plan for the sustainable production (Kassim *et al*., 2017).

Thus, this study would be the first comprehensive study on growth parameters, mortality, recruitment patterns and virtual population analysis of *Perna perna* from Dakar coastal waters in Senegal.

MATERIAL AND METHODS

Study Area

The Mamelles site on the Cape Verde Peninsula was selected for the 12-month study (from March 2018 to February 2019) (Figure 1). This area of the ocean is characterized by a rocky bottom, which also serves as an anchorage for mussels. Every month, local fishermen collect about fifty mussels *Perna perna* (Linne, 1758) from the rocks by hand using diving equipment. Mussels were kept in seawater and transported to the laboratory in coolers. From these monthly collected mussels, approximately 30 mussels were selected for sex identification and biometric measurements.

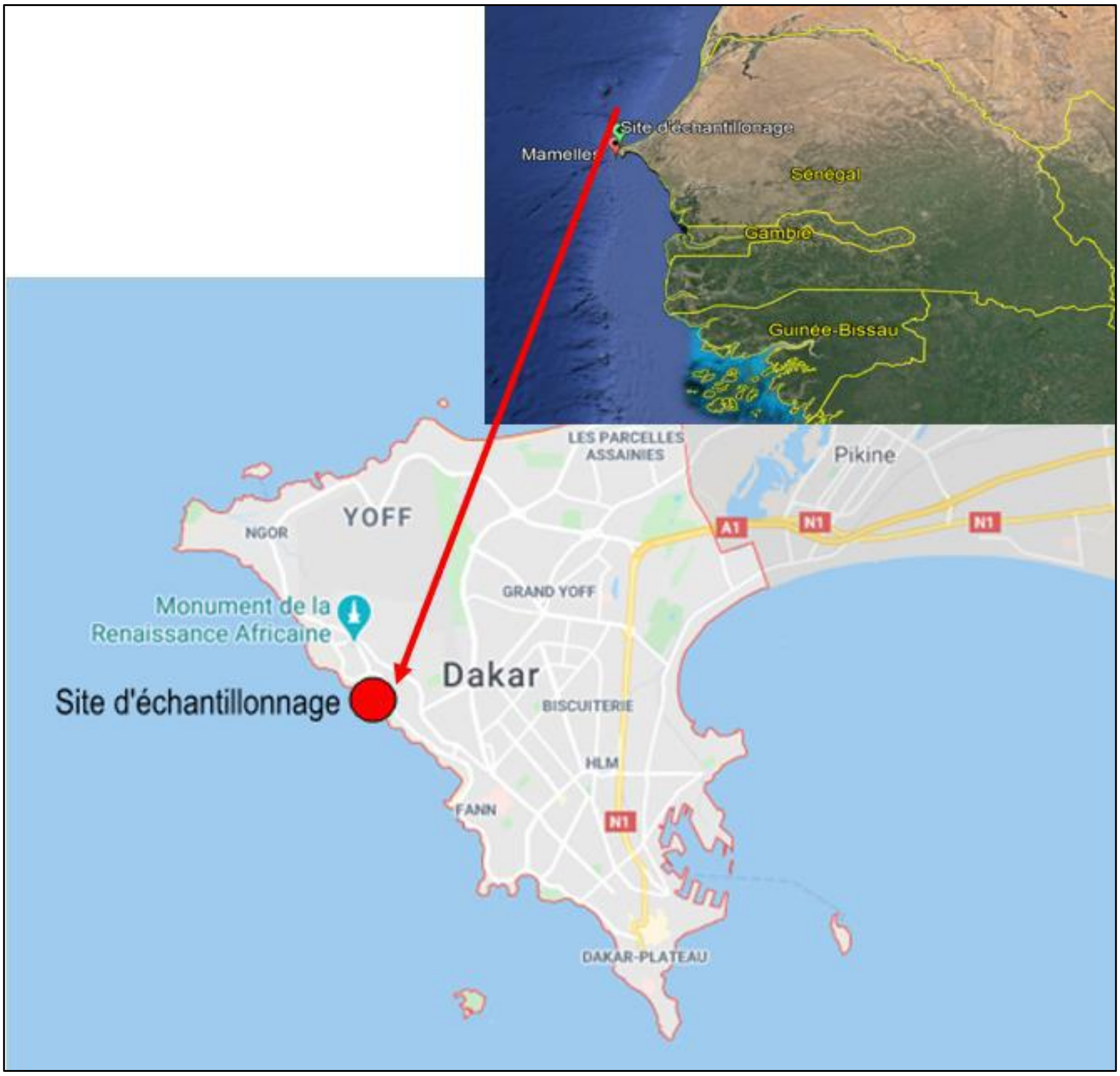

Figure 1: Sampling area (Diouf *et al.*, 2020)

Biometric measurements

A total of 600 mussels were gathered from Mamelles for this purpose; 30 mussels were used each month. A Vernier caliper was used to measure each individual's biometric measurements, such as length (maximum length along the anterior-posterior axis), with an accuracy of 0.1 mm. Using an electronic balance, the total weight of each person was determined after the interval-(or mantle) fluid was drained to the closest 0.1 g. After the male and female were dissected, the meat was carefully removed, and a 0.01 mg precision electronic scale-was used to weigh mussels.

Growth Parameters

To analyze the monthly frequency data, FAO-ICLARM Stock Assessment Tool (FiSAT II, version 1.2.2) the software was used (Gayanilo and Pauly, 1997). Using the ELEFAN-1 method, the parameters of the von Bertalanffy Growth function (VBGF), asymptotic length ($L\infty$), and growth coefficient (K) were estimated (Pauly and David, 1981).

The following expression, which represents VBGF, states that individual fish grew on average towards the asymptotic length at an instantaneous growth rate (K), with length at time (t) according to the following formula: $Lt = L\infty \times [1 - e^{-k\times(t - t_0)}]$, where Lt is the length at age t, $L\infty$ is the asymptotic length, which is the mean length that fish would reach if they were to grow indefinitely, K is the growth coefficient, and t_0 is the age of the fish at zero length. This parameter was obtained using Pauly's (1979) empirical equation for the theoretical age at length zero (t_0): $Log(-t_0) = -0.392 - 0.275\times Log(L\infty) - 1.038\times Log(K)$. The growth performance index (Φ') was computed from the equation (Pauly and Munro, 1984): (Φ') = 2 × Log(L∞) + Log(K), and the longevity (t_{max}) was estimated as (Pauly, 1983): $t_{max} = 3/K + t_0$.

Mortality Parameters

Using the length converted catch curve method as used in FiSAT II, the total mortality (Z) was calculated (Sparre and Venema, 1992). Pauly's (1980) empirical equation, Log(M) = - 0.0066 - 0.279×Log(L∞) + 0.6543×Log(K) + 0.463×Log(T), was used to calculate the instantaneous natural mortality rates (M). Here, M stands for natural mortality, L∞ for asymptotic length, K for the growth curvature of VBGF, and T for mean surface temperature in degrees Celsius (T = 22.2 °C). According to Gulland (1971), the formula for calculating fishing mortality (F) is F=Z - M, where Z represents overall mortality, F represents fishing mortality, and M represents natural mortality.

Recruitment patterns

Backward projection on the length axis of the collection of accessible length-frequency data was used to ascertain the recruitment pattern (Nurul-Amin *et al.*, 2009). Gheshlaghi *et al.*, (2012) determined that the mid-length of the smallest length interval was the length at first recruitment (Lr), whereas Beverton and Holt's (1957) findings on age at first recruitment were followed.

Virtual Population Analysis (VPA)

The length weight relationship's "a" and "b" constants, fishing mortality (F), natural mortality (M), terminal fishing mortality (F), and growth parameters (asymptotic length (L∞) and growth rate (K) were among the inputs for the VPA (Amponsah *et al.*, 2017b). It was estimated that the t_0 value was zero. Using the formula $W = a \times L^b$, where W is the body weight and Length is the corresponding standard length, the constants "a" and "b" (exponent) for the species were calculated from the length-weight relationship (Pauly, 1984).

Relative yield per recruit (Y/R)

As a function of exploitation, the relative yield per recruit (Y/R) and relative biomass per recruit (B/R) were computed. Additionally, the Knife-edge option was applied to determine the exploitation rate at the maximum (E_{max}), the exploitation rate at 0.1 of the virgin biomass ($E_{0.1}$), and the exploitation rate at 0.5 of the virgin biomass ($E_{0.5}$).

RESULTS

Growth parameters

A total of 600 of *Perna perna* were used for this study. According to ELEFAN-I, the best value for the VGBF growth constant (K) was 1 yr^{-1} (Figure 2) and the corresponding asymptotic length (L∞) was 13.65 cm.

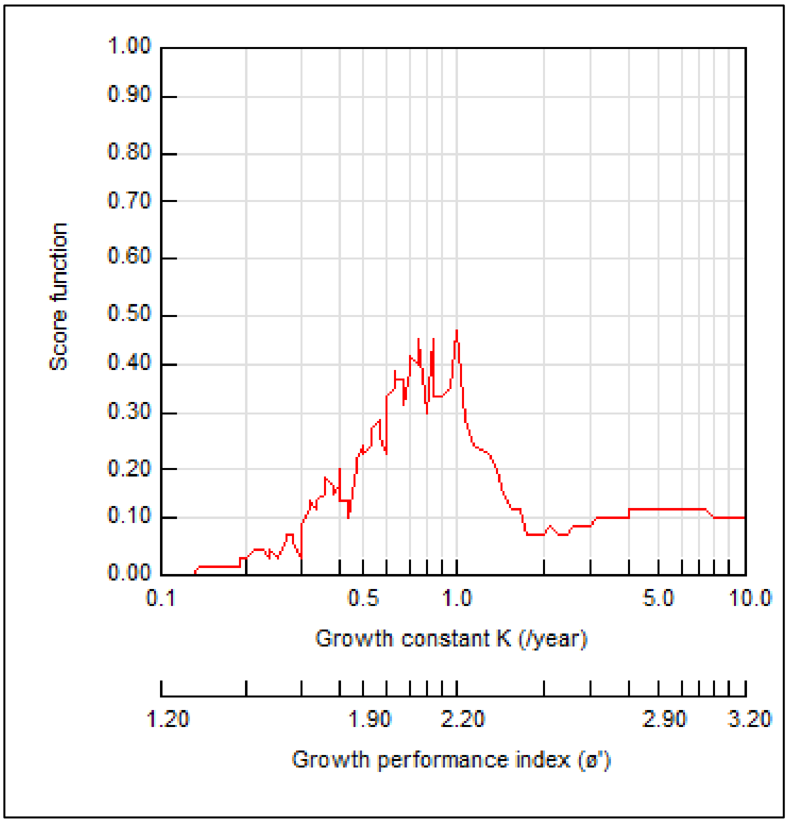

Figure 2: Growth performance index of *Perna perna*

The reconstructed length frequency distribution diagram and growth curves provided by the ELEFAN I method are shown in Figure 3. The calculated values of growth capacity index (Φ'), theoretical age t_0 and longevity (t_{max}) of *Perna perna* were calculated to be 2.27; -0.197 yr and 2.80 yr, respectively.

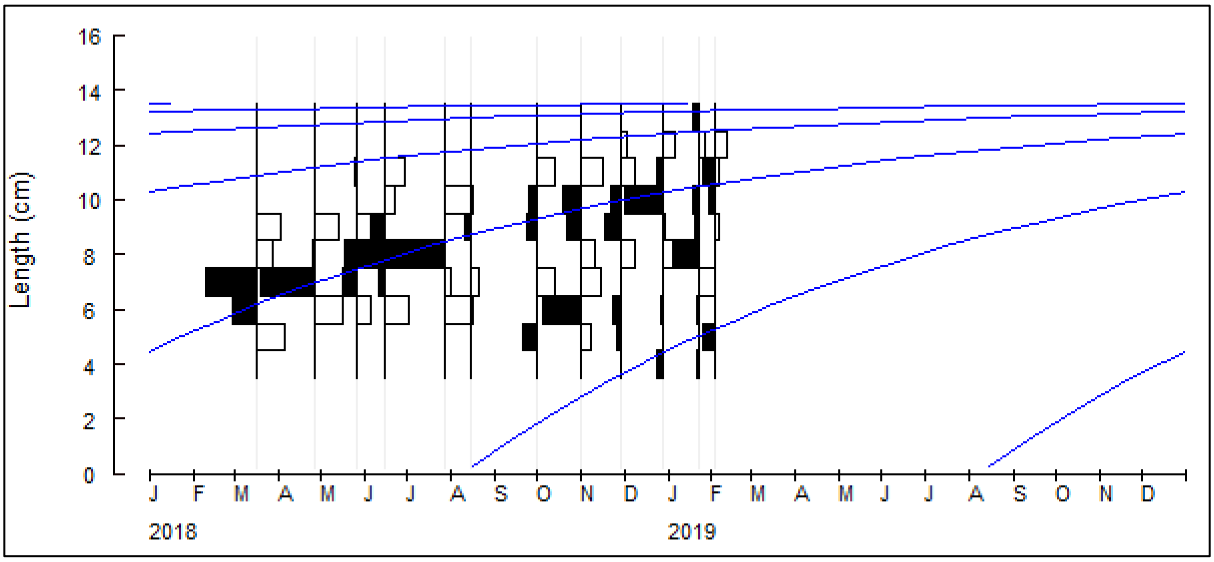

Figure 3: Restructured Length frequency distribution output from FiSAT II with superimposed growth curves (Dark bars=actual frequency bars & White bars=reconstructed bars)

Mortality Parameters

The mortality rates pertaining to *Perna perna* were illustrated in Figure 4. The total mortality rate (Z) was determined to be 3.51 yr^{-1}. The natural (M) and fishing (F) mortality rates were approximated at 2 yr^{-1} and 1.51 yr^{-1}, respectively. The present exploitation rate (E) was identified as 0.43.

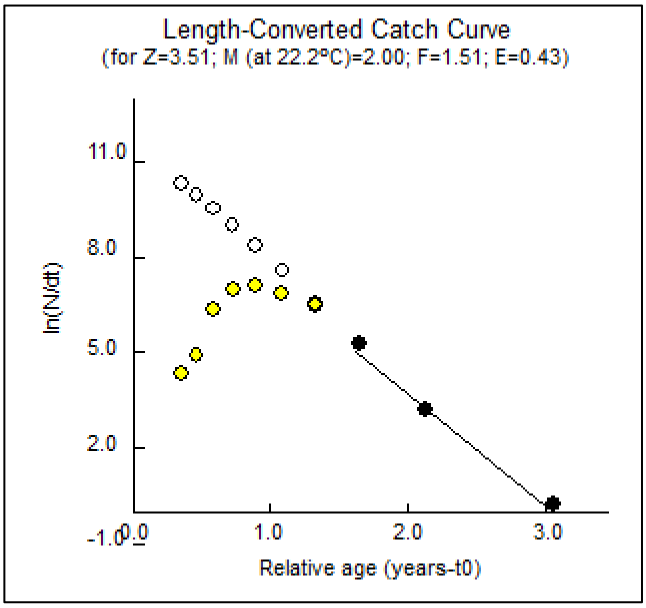

Figure 4: FISAT II output of linearized length-converted catch curve for *Perna perna* (Yellow dots are dots used in calculation and White dots are dot not used in calculations)

Recruitment patterns

Based on the recruitment pattern analyses, the species exhibited one recruitment peak throughout the year. The peak was observed in May-Jun (Figure 5). The peak pulse produced 21.21% of the observed recruitment during the study period.

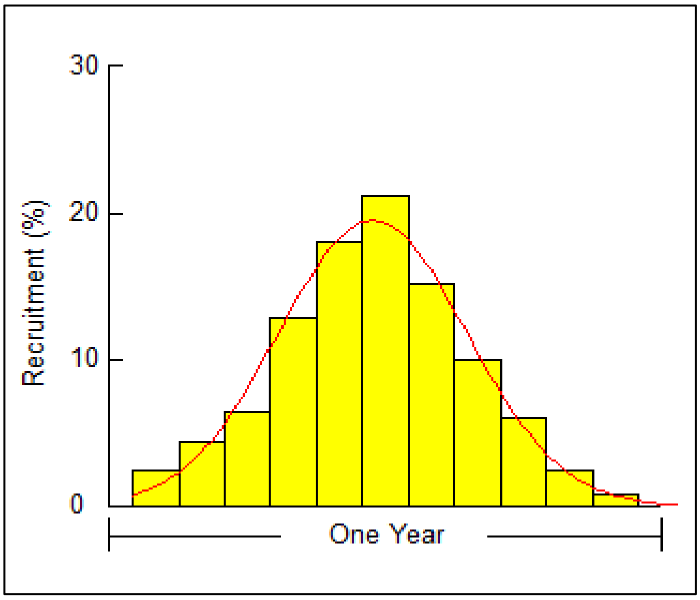

Figure 5: Recruitment pattern of *Perna perna*

Virtual Population Analysis (VPA)

Figure 7 displays the virtual population analysis of *Perna perna*. Natural mortality is higher in juveniles (L= 4 cm) than in adults (L= 11 cm). Natural mortality is decreasing while fishing mortality is gradually increasing. The more mature the individuals become, the more they are captured (Figure 6).

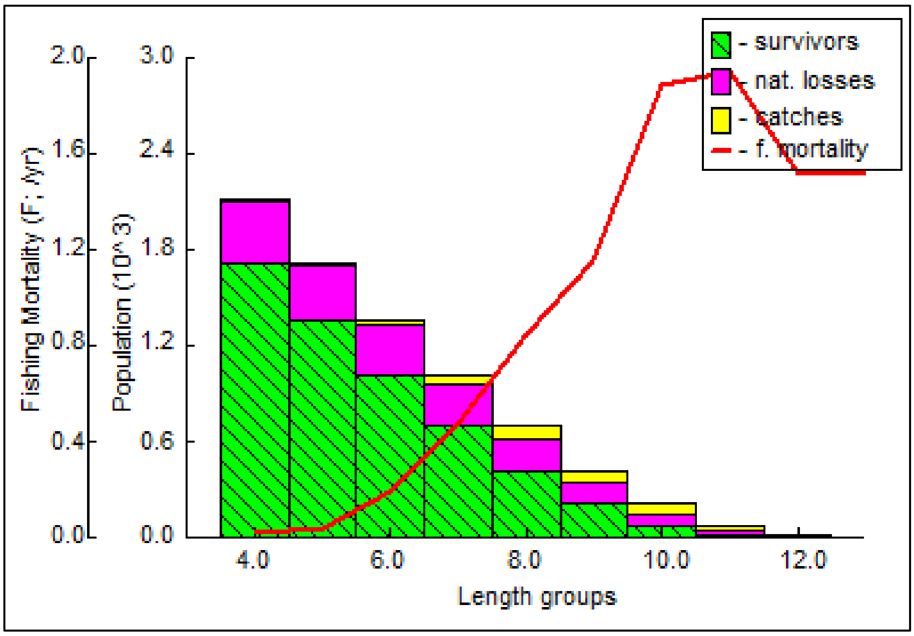

Figure 6: Length structured virtual population analysis of *Perna perna*

Relative yield per recruit (Y'/R)

Fishing exploitation led to a decrease in relative yield per recruit (Y'/R) as shown in Figure 7. According to the Beverton and Holt (1957) model, the optimal sustainable yield ($E_{0.5}$), maximum sustainable yield (E_{max}), and economic yield target ($E_{0.1}$) values were determined to be 0.292; 0.453 and 0.363, respectively.

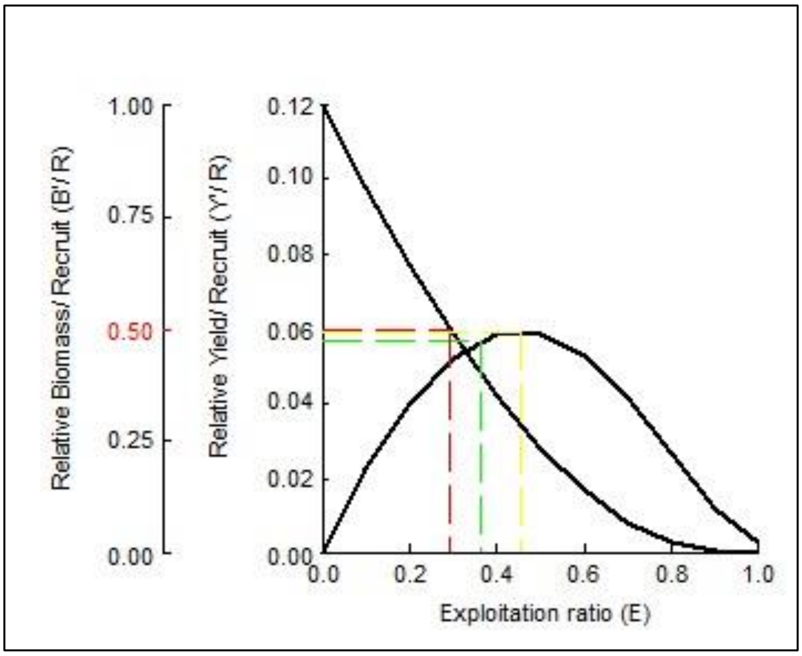

Figure 7: Beverton and Holt's relative yield per recruit and average biomass per recruit models, showing levels of yield indices for *Perna perna* in south Coastal Senegalese waters (Red dashes=$E_{0.1}$, Green dashes=$E_{0.5}$ and Yellow dashes=E_{max})

DISCUSSION

Analyzing growth and exploitation parameters is crucial for comprehending the ecology and life cycle of marine species (Zhong, 2019). Results of analysis of growth parameters of *Perna perna* is shown in Table 1. *Perna perna* could reach an asymptotic length (L_∞) of 13.65 cm, a growth rate (K) of 1 yr^{-1}, an age t_0 of 0.197 years and growth performance index (Φ') of 2.27. The growth parameters estimated for some species of the genus *Perna* from different geographical regions are given in Table 1. Direct comparison ($L\infty$) and (K) does not make a much biological contribution since one species or stock has different growth rate during their life stages (Etim *et al*., 2002; Abdullah and Zain, 2019). Therefore, growth performance index (Φ') is a more comprehensive method to be used in fishery sciences to compare the growth performance of a different population of fish species (Pauly and Munro, 1984; Abdullah and Zain, 2019). It was found that the growth performance index (Φ') with very similar values within neighboring taxa was the best overall in terms of minimal variance (Chakroun-Marzouk and Ktari, 2003; Faye *et al*., 2023). In the present study, the estimated growth performance index (Φ') of *Perna perna* was comparable with the (Φ') values reported by Nurul-Amin *et al*. (2005) and Khan *et al*., (2010) for *Perna viridis* in Bangladesh. However, it is smaller than those found by Taib *et al*., (2016) in Malaysia, Hemachandra *et al*., (2017) in India, Nwe *et al.* (2020) in Myanmar, Khan *et al*., (2010) in Bangladesh, Nurul-Amin *et al*., (2005) in Bangladesh for *Perna viridis*, Krampah *et al*., (2019) in Ghana for *Perna perna*, Ramesha and Thippeswamy (2009b) in India for *Perna favidens*, Kuriakose (1973) in india for *Perna indica*, Malathi and Thippeswamy (2013) in India for *Perna corrugate* and bigger than that found by Lindsay (1998) in USA for *Perna perna* (Table 1). Growth performance of bivalves could be as a result of influences of environmental factors, and thus, bivalves found at different geographical locations may have different growth performance indices which could be as a result of the prevailing environmental conditions (Krampah *et al*., 2019; Nwe *et al*., 2020). The combined effects of several dominant environmental factors, including water temperature, food availability, settling density, currents, exposure, and pollution, could be the cause of these variations in growth rates (Vakily, 1989). The apparent complexity of the interactions between the various factors makes it challenging to quantify these relationships between growth and environmental factors (Wilbur and Owen, 1964; Vakily, 1992; Krampah *et al*., 2019).

Table 1: Growth parameters estimated for *Perna* genus from different regions of the world.

Species	Country	L_∞ (cm)	K (yr^{-1})	$-t_0$ (yr)	(Φ')	Author
Perna perna	Senegal	13.65	1	0.197	2.27	Present study
Perna perna	USA	6.56	0.31	-	1.12	Lindsay (1998)
Perna perna	Ghana	8.01	0.49		3.49	Krampah *et al*., (2019)
Perna viridis	Malaysia	11.34	1.7	-	4.34	Taib *et al*., (2016)
Perna viridis	India	13.69	0.42	0.36	3.896	Hemachandra *et al*., (2017)

Species	Country	L_∞ (cm)	K (yr^{-1})	$-t_0$ (yr)	(Φ')	Author
Perna viridis	Myanmar	16.275	0.87		4.363	Nwe *et al*., (2020)
Perna viridis	Bangladesh	13.65	1.30		2.380	Khan *et al*., (2010)
Perna viridis	Bangladesh	19.43	0.56		2.325	Nurul-Amin *et al*., (2005)
Perna favidens	India	6.46	1.20	0.0073	3.699	Ramesha and Thippeswamy (2009b)
Perna indica	India	11	0.095	-	3.062	Kuriakose (1973)
Perna corrugata	India	6.076	0.470	-0.042	3.239	Malathi and Thippeswamy (2013)

Mortality is an important aspect in the population dynamics of mussels (Fabens, 1965) and it could vary enormously depending on environmental conditions (Nwe *et al*., 2020). In the present study, the coefficients of total mortality, natural mortality and fishing mortality were estimated to be Z = 3.51 yr^{-1}, M = 2 yr^{-1} and F = 1.51 yr^{-1}, respectively. Total mortality and natural mortality rates in this study were higher than those found in other geographical area for *Perna* gender (Hemachandra *et al*., 2017; Krampah *et al*., 2019; Nwe *et al*., 2020) (Table 2). The different result in mortalities rate is attributed to a different environment where the Mussels lived. Thus, it is subjected to a different level of predation, competition, food resource, and disease (Sparre and Venema 1998; Abdullah and Zain, 2019). For this study, it seemed that fishing mortality (F) was lower than natural mortality (M) suggesting that fishing activities did not affect *Perna perna* population in that area.

Table 2: Comparison of mortality coefficients for *Perna gender* from different regions of the world

Species	Country	Z (yr^{-1})	M (yr^{-1})	F (yr^{-1})	Author
Perna perna	Senegal	3.51	2	1.51	Present study
Perna perna	Ghana	2.79	0.87	1.92	Krampah *et al*., (2019)
Perna viridis	India	1.18	0.42	0.76	Hemachandra *et al*., (2017)
Perna viridis	Myanmar	1.86	0.81	1.05	Nwe *et al*., (2020)

The recruitment is defined as a young fish that has undergone complete metamorphosis, and its growth is sufficiently described by the VBGF. This occurs at the fishing grounds, with an instantaneous rate of natural mortality similar to that of the adults (Gayanilo *et al*., 1989). The recruitment pattern suggests that annual recruitment consist of one seasonal peak, meaning one cohort is produced per year. The main spawning season coincide with the major recruitment peak (May-Jun) found in this study. Similar results were reported for *Perna viridis* from Peninsular Malaysia (Al-Barwani *et al*., 2007). However, it has been reported that the *Perna viridis* spawn mainly during September-December from east coast of India (Rajagopal *et al*., 1998b).

Length structured virtual population analysis of *Perna perna* show a progressive decline in natural mortality. This result could be due to the fact that young individuals would be more vulnerable to natural predation. Actually, *Perna perna* is a prey for a number of species, including Octopus vulgaris (Mangold, 1983). There are also other predators as blue crabs which are important predators that affect the diversity and structure of benthic communities, and they can control the distribution and abundance of populations of benthic species locally (Wirnstein, 1977; Hines *et al*., 1990; Ebersole and Kennedy, 1995). Fishing mortality increases gradually unlike natural mortality. This means that the probability of capture increases with the size of the species.

The current exploitation rate (E) for *Perna perna* is 0.43. Based on the assumption that a stock is optimally exploited when F=M or E=0.5 (Gulland, 1971). The results indicate that the mussel *Perna perna* stock is not overexploited (E = 0.43 < E_{max} = 0.453). This indicates that the stocks of this species are not overexploited in Dakar coastal waters. However, if the current level of exploitation is not checked, the exploitation of this stock could soon approach the maximum sustainable yield.

CONCLUSION

This study constitutes the first study of the population dynamics of *Perna perna* in Senegal. The results obtained indicate that the species exhibits relatively rapid linear growth with natural mortality higher than fishing mortality. Recruitment is continuous throughout the year with one peak in observed in May-Jun. This study revealed that the *Perna perna* species is not in a state of overexploitation, however the current exploitation rate is close to the maximum sustainable yield rate. Hence the need to take precautions for the sustainable management of this species. The present study provides important basic information on the population dynamics of the Brown Mussels in the coastal waters of Dakar. The results of this study could be used in developing a management plan for the sustainable exploitation of the *Perna perna* fishery in Senegalese coastal waters.

Acknowledgement

The authors would also like to thank all of the fishermen who helped with the sampling.

REFERENCES

- Abdullah, M. I. C., & Zain, K. M. (2019). Length-weight relationship, condition factor and growth parameter of *Periophthalmus chrysospilos* (Bleeker, 1852) (Gobiiformes: Gobiidae) in Bayan Bay, Penang, Malaysia. *Sains Malaysiana*, *48*(2), 271-279. https://doi.org/10.17576/jsm-2019-4802-02.
- Al-Barwani, S. M., Arshad, A., Amin, S. M. N., Japar, S. B., Siraj, S. S., & Yap, C. K. (2007). Population dynamics of the green mussel *Perna viridis* from the high spat-fall coastal water of Malacca, Peninsular Malaysia. *Fisheries Research*, 84, 147-152. https://doi.org/10.1016/j.fishres.2006.10.021.
- Amponsah, S. K. K., Ofori-Danson, P. K., Nunoo, F. K. E., & Ameyaw, G. A. (2017b). Virtual population analysis and estimates of maximum sustainable yield of some commercially important fish species in the coastal waters of Ghana and management implications. *International Journal of Fisheries and Aquatic Research*, *2*(3), 1-7.
- Beverton, R. J. H., & Holt, S. J. (1957). On the dynamics of exploited fish populations. UK Ministry Agriculture and Fish, Fish. Invest (Ser. 2), 19, 533 p.
- Chakroun-Marzouk, N., & Ktari, M. H. (2003). The brown meagre from Tunisian coasts, *Sciaena umbra* (Sciaenidae): sexual cycle, age and growth. *Cybium*, *27*(3), 211-225.
- Diankha, O., Ndiaye, T., Agbogba, C., & Sarr, A. (2020). Determination of Total Mercury (HG) Levels in the *Perna Perna* Mussels and the *Echinometra Lucunter* Sea Urchin from Soumbédioune Bay (Senegal) and Assessment of Health Risks. *European Scientific Journal*, *16*(9), 15-27. https://doi.org/10.19044/esj.2020.v16n9p15.
- Diouf, A., Fall, J., Loum, A., Faye, A., Diago, M., & Diouf, M. (2020). Morphometric and length-weight relationships of the mussel *Perna perna* from the Mamelles coast, Dakar, Senegal. *Journal of Fisheries and Aquatic Studies*, *8*(3), 106-114.
- Ebersole, E. L., & Kennedy, V. S. (1995). Prey preferences of blue crabs *Callinectes sapidus* feeding on three bivalve species. *Marine Ecology Progress Series*, 118, 167-177. https://doi.org/10.3354/meps118167.
- Etim, L., King, R. P., & Udo, M. (2002). Breeding, growth, mortality and yield of the mudskipper *Periophthalmus barbarus* (Linneaus 1776) (Teleostei: Gobiidae) in the Imo river estuary, Nigeria. *Fisheries Research*, 56, 227-238. https://doi.org/10.1016/S0165-7836(01)00327-7.
- Fabens, A. J. (1965). Properties and fitting of the von Bertalanffy growth curve. *Growth*, 29, 265-289.
- Faye, A., Sarr, S., Diouf, M., Ndiaye, W., Fall, J., & Diankha, O. (2023). Growth, mortality, exploitation rate and recruitment patterns of *Gerres nigri* Günther, 1859 from Saloum estuary, Senegal. *International Journal of Aquatic Biology*, *11*(4), 279-287. https://doi.org/10.22034/ijab.v11i4.1993.
- Gayanilo, F. C. Jr., Soriano, M., & Pauly, D. (1989). A draft guide to the Compleat ELEFAN. ICLARM Software 2. 70p.
- Gayanilo, J., & Pauly, D. (1997). FAO-ICLARM stock assessment tools (FiSAT): Reference Manual, Computerized Information Series (Fisheries). FAO, Rome, 124 p.
- Gheshlaghi, P., Vahabnezhad, A., & Taghavi, M. S. A. (2012). Growth parameters, mortality rates, yield per recruit, biomass, and MSY of *Rutilus frisii kutum*, using length frequency analysis in the Southern parts of the Caspian Sea. *Iranian Journal of Fisheries Sciences*, *11*(1), 48-62.
- Gulland, J. (1971). The fish resources of the ocean. West by fleet, survey, fishing News (Books) Ltd. for FAO, 255 p. revised ed. of FAO fish. *Technical Paper* 97, 425 p.
- Hemachandra, S., Tenjing, Y., & Thippeswamy, S. (2017). Population dynamics of the Asian green mussel *Perna viridis* (L.) from St. Mary's islands off Malpe, *Indian Journal of Geo-Marine Sciences*, *46*(08), 1659-1666.
- Hines, A. H., Haddon, A. M., & Wiechert, L. A. (1990). Guild structure and foraging impact of blue crabs and epibenthic fish in a subestuary of Chesapeake Bay. *Marine Ecology Progress Series*, 67, 105-126.
- Kassim, Z., Omar, M. L., & Jasmani, S. (2017). Population growth of green mussel, *Perna viridis* Linnaeus from southern part of the Malacca straits. *Malaysian Applied Biology*, *46*(2), 149-152.
- Khan, A. A. M., Assim, Z. B., & Ismali, A. (2010). Population Dynamics of the Green-Lipped Mussel, *Perna viridis* from the Offshore Waters of Naf River Coast, Bangladesh. *Chiang Mai Journal of Science*, *37*(2), 344-354.
- Krampah, E.A., Yankson, K., & Blay, J. (2019). Population dynamics of the Brown mussel *Perna perna* at a Rocky beach near Cape Coast, Ghana. *Marine Ecology*, *41*(4), 1-9. https://doi.org/10.1111/maec.12575.
- Kuriakose, P. S. (1973). Studies on the *Mytilidae* of the Indian coasts. Ph. D. Thesis, University of Kerala, India.
- Lindsay, T. L. (1998). Population dynamics and growth rates of the brown mussel (*Perna perna*) on wave-exposed and wave-sheltered shores of South Africa. MSc thesis, Rhodes University.
- Malathi, S., & Thippeswamy, S. (2013). Population ecology of freshwater mussel *Parreysia corrugata* (Mullar, 1774) from River Malthi, tributary of River Tunga, in the Western Ghats, India. *Recent Research in Science and Technology*, *5*(4), 20-26.
- Mangold, K. (1983). Food, feeding and growth in cephalopods. 44, 81-93. In Roper, C. F. E., Lu, C. C., & Hochberg, F. G. (eds.) Memoirs of the National Museum of Victoria: Proceedings of the

Workshop on the Biology and Resource Potential of Cephalopods, Melbourne, Australia, 9-13 March, 1981.

- Nurual-Amin, S., Arshad, A., Siraj, S., & Japar-Sidik, B. (2009). Population structure, growth, mortality and yield per recruit of sergestid shrimp, *Acetes japonicus* (Decapoda: Sergestidae) from the coastal waters of Malacca, Peninsular Malaysia. *Indian Journal of Marine Sciences*, 38, 57-68.
- Nurul-Amin, S.M., Halim, M.A., Barua, M., Zafar, M., & Arshad, A. (2005). Population dynamics and exploitation level of green-lipped mussel (*Perna viridis*) using FiSAT from the offshore island of the cox's bazar coast of Bangladesh. *Pertanika journal of tropical agricultural science*, *28*(2), 103-109.
- Nwe, W. W., Aye, Z. M., Oo, N. N., & Myint, M. N. (2020). Population Parameters of Green Mussel, *Perna viridis* (Linnaeus, 1758) from Ye Estuary, Mon Coastal Area, Myanmar. *International Journal of Science and Research*, *10*(12), 309-314. https://doi.org/10.29322/IJSRP.10.12.2020.p10830.
- Pauly, D. (1979). Theory and management of tropical multi-species stocks: A Review, with emphasis on the southeast Asian demersal fisheries. Studies and Review No. 1, International Center for Living Aquatic Resources Management, Manila, Philippines.
- Pauly, D. (1980). On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *Journal of Conservation and International Exploration of Maritime*, *39*(3), 175-192.
- Pauly, D. (1983). Length converted catch curves. A powerful tool for fisheries research in tropics. *Fishbyte*, 1, 9-13.
- Pauly, D. (1984). Length-converted catch curves: a powerful tool for fisheries research in the tropics (Part II). *Fishbyte*, *2*(1), 17-19.
- Pauly, D., & David, N. (1981). ELEFAN-I BASIC program for the objective extraction of growth parameters from Length frequency data. *Meeresforsch*, *28*(4), 205-211.
- Pauly, D., & Munro, J. (1984). Once more on the comparison of growth in fish and invertebrates. *Fishbyte*, *2*(1), 1-21.
- Rajagopal, S. (1997). The ecology of tropical marine mussels and their control in industrial cooling water systems. Ph.D. Thesis, University of Nijmegen, The Netherlands.
- Rajagopal, S., Venugopalan, V. P., Nair, K. V. K., van der Velde, G., Jenner, H. A., & den Hartog, C. (1998b). Reproduction, growth rate and culture potential of the green mussel, *Perna viridis* L. in Edaiyur backwaters, east coast of India. *Aquaculture*, 162, 187-202. https://doi.org/10.1016/S0044-8486(98)00166-5.
- Ramesha, M. M., & Thippeswamy, S. (2009a). Allometry and condition index in the freshwater bivalve *Parreysia corrugate* (Muller) from river Kempuhole, India. *Asian Fisheries Science*, *22*(1), 203-214. https://doi.org/10.33997/j.afs.2009.22.1.019.
- Sagna, L. A. (2019). Evaluation of the bioaccumulation of metallic trace elements (lead, cadmium, mercury, copper) in the *Perna perna* mussel in Hann Bay and the Ngor coast in Senegal. Master's thesis, Cheikh Anta Diop University of Dakar, Senegal.
- Siddall, S. E. (1980). A clarification of the genus *Perna* (Mytilidae). *Bulletin of Marine Science*, *30*(4), 858-870.
- Sparre, P., & Venema, S. C. (1992). Introduction to Tropical Fish Stock Assessment. Part 1. Manual FAO Fisheries, *Technical Paper* No. 306, 1, Rev. 1, FAO, Rome, 376 p.
- Sparre, P., & Venema, S. C. (1998). Introduction to tropical fish stock assessment - Part 1: Manual: FAO Fisheries, *Technical Paper* No.306.1 Rev. 2 Rome.
- Taib, A. M., Madin, J., & Ransangan, J. (2016). Density, recruitment and growth performance of Asian green mussel (*Perna viridis*) in Marudu Bay, Northeast Malaysian Borneo, three years after a massive mortality event. *Songklanakarin Journal of Science and Technology*, *38*(6), 631-639.
- Vakily, J. M. (1989). The biology and culture of mussels of the genus *Perna*. Manila: International Center for Living Aquatic Resources Management. *ICLARM Stud Rev*, 17.
- Vakily, J. M. (1992). Determination and comparison of bivalve growth, with emphasis on Thailand and other tropical areas. International Center for Living Aquatic Resources Management, Manila, Philippines, ICLARM *Technical Report*.
- Wilbur, K. M., & Owen, G. (1964). Growth. In K. M. Wilbur, & C. M. Yonge (Eds.), Physiology of Mollusca, Vol. I (pp. 211-242). New York, USA: Academic Press.
- Wirnstein, R. W. (1977). The importance of predation by crabs and fishes on benthic infauna in Chesapeake Bay. *Ecology*, 58, 1199-1217.
- Zhong, L. H., Xie, Y. H., HU, X. Z., Chen, Y. S., Feng, W. T., Zhang, Y., & Wang, A. T. (2019). Two new brackish-water species of *Pogaina* (Rhabdocoela: Provorticidae) from China. *Zootaxa*, *4679*(2), 353-364.