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Population parameters of the *Atlantic bumper* catching by beach seine at Jacqueville (Côte d'Ivoire)

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Abstract
Chloroscombrus chrysurus' length distribution was recorded from the Côte d'Ivoire continental shelf, from January to December 2021. ELEFAN I program was used to analyze the data. The biggest specimens are characterizing by 22 centimeters (Fork length) and 121 grams (weight) respectively. The von Bertalanffy growth function are characterized by: $L\infty$ = 22.25 centimeter; K = 0.47 per year and t_0 = -0.36 year. Based on the catch curve converted to length, the estimated value of the instantaneous total mortality rate, Z, was 1.24 per years. Fishing and natural mortality calculated were respectively 0.98 per years and 0.21 per year. Jacqueville's *Chloroscombrus chrysurus* species are overexploited. To preserve the exceptional Atlantic stock in the continental unit of Côte d'Ivoire, certain management measures must be implemented.

Keywords: *Chloroscombrus chrysurus,* growth parameters, beach seine, artisanal fishery, Côte d'Ivoire

Introduction
We can better understand fish stock dynamics by knowing when fish are born. It shows how fish populations respond to environmental stresses and exploitation. Furthermore, this knowledge can be used to analyze the impact of changes in exploitation patterns relating to stocks and we can provide more precise management advice to fisheries managers [1].
There is little data on population parameters in West African waters, if any; however, species of *Chloroscombrus chrysurus* (Carangidae) have been identified as the study of population parameters in West African waters [2-5].
This species is one of tropical and subtropical pelagic fish. Adults are present on the soft bottom of the continental shelf, sometimes forming schools near the surface. *C. chrysurus* inhabits between 5 and 110 meters. It is distributed in the Eastern Atlantic Ocean [6].
Both in industrial fishing and in coastal artisanal fishing, it has a significant economic impact. Current research examines the population dynamics of *C. chrysurus* were designed to provide information necessary for the sustainable management of this resource due to demand and lack of biological information on this species.

2. Material and Methods
2.1 Study area
Jacqueville is an island located between 5°12'N and 4°25'W in Ivory Coast, West Africa. The Ebrié lagoon separates it from most of the country and its other shore is in the Gulf of Guinea.
According Loukou *et al*., (2023) [7], the climate in the study area was defined by two marine's seasons. The monthly variations of Sea Surface Temperature (SST) of the Ivorian Economic Exclusive Zone (EEZ) in the Gulf of Guinea included Jacqueville area. Seasonal variations in this environmental parameter were observed with mean 28.35±0.74 °C and describe two principal marine's seasons, a Warm Season (WS) between November and May (About: 29.10 to 30.37 °C) and a Cold Season (CS) between June and October (about 25.17 to 28.39 °C). The lowest values of this parameter measured during the Cold Season (CS) correspond to the major upwelling activity with the lowest mean value of 25.17±1.07 °C obtained in August. For this study, Grand-Jack and Avagou (Fishing villages) were chosen. They are the main fish landing ports of Jacqueville (Fig. 1).

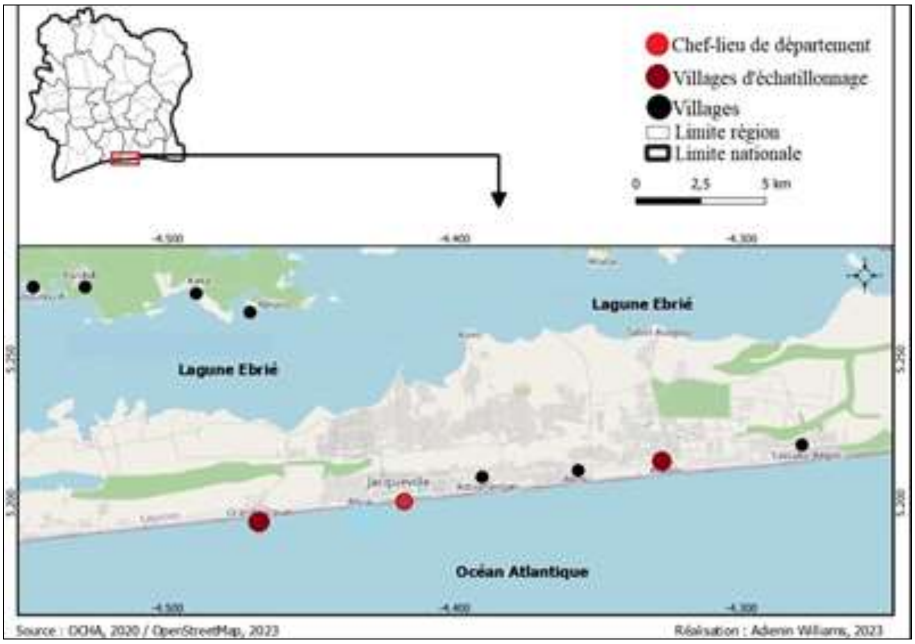

Fig 1: Map showing the sampling zone

Fish sampling and data collection

Chloroscombrus chysurus specimens were collected from January to December. Additionally, weekly fish samples were collected during commercial arrivals using beach seines. The fish that the fishermen caught were examined. All specimens of this species have been identified with the manuel of Paugy *et al*. (2003) [8].

Data analysis

Stocks of *Chloroscombrus chysurus* from the beach seine were distributed according to length, with intervals of 1 centimeter. The data are analyzed with the Electronic Length-Frequency Analysis I program of FAO-ICLARM Stock Assessment II [9] are used to analyse the data. The stock of *Chloroscombrus chysurus* was characterized using Bertalanffy growth equation (VBGE) parameters $Lt = L\infty (1-e^{-K (t - t0)})$, including length at age t, asymptotic length, body growth coefficient and hypothetical age. The t_0' value was calculated with the empirical equation [10]

$$Log10 (- t_0) = -0.392 – 0.275 Log10 L\infty - 1.038 Log10 K$$

The Electronic Length-Frequency Analysis I program [11] allows the curve to be adjusted according to the maximum number of peaks of the length-frequency distribution. An automatic computer determined Rn, a goodness-of-fit index [9]. The Pauly and Munro (1984) model was used to quantify the overall growth performance index (φ').

$$\varphi' = \log10 K + 2 \log10 L\infty.$$

The following equation [13] was used to calculate the potential lifespan of *C. chrysurus*: Maximum

$$Tmax = 2. 9957/ K.$$

The instantaneous total mortality rate (Z) was estimated using the FiSAT program using the length-converted catch curve technique [11]. The equations of Pauly (1980) [14] were used to determine the instantaneous natural mortality rate (M):

$$Log M = [- 0.0066 - 0.279 \log L\infty + 0.6543 \log K + 0.4634 \log T].$$

Fishing mortality (F) was calculated by subtracting the value of natural mortality from total mortality as F = Z – M, while the exploitation rate was E = F/Z. The moving average method was used to calculate Lc by converting the catch curve to length [15].

The Beverton and Holt (1966) [16] model, which was integrated into the FAO-ICLARM Stock Assessment program [17], was used to predict relative yield per recruitment and relative biomass per recruit, as

$$Y`/R = EUM/ K [1 - (3U/ 1+m) + (3U2/1+2m) – (U3/1+3m)]$$

Where

$$U = 1- (Lc /L\infty), m = (1-E)/ (M /K) = (K / Z).$$

M is the natural mortality, K is the body growth coefficient and E is the exploitation rate.

Biomass per recruit is also equal to (Y`/R)/F, with (Y`/R) being the relative yield per recruit and F being the fishing mortality.

Yield and biomass of recruits (Emax) model was used to determine the optimal exploitation rate that produces maximum yield. Furthermore, it was estimated that the exploitation rate where the marginal increase in Y'/R is 0.1 ($E_{0.1}$) and that the exploitation rate which reduces the biomass to 50% of its level unexploited ($E_{0.5}$).

Results

Length-frequency distribution

Chloroscombrus chrysurus (N = 1,626) found from January to December 2021 had a fork length of 5.5 centimeters (total weight 3 grams) to 22 centimeters (total weight 121 grams). The average fork length was 10.71 centimeters (give or take 2.88 centimeters). Length frequencies were unimodal. The modal size class was [11.5-12.5] centimeters and the frequency was 15.49% (Fig. 2).

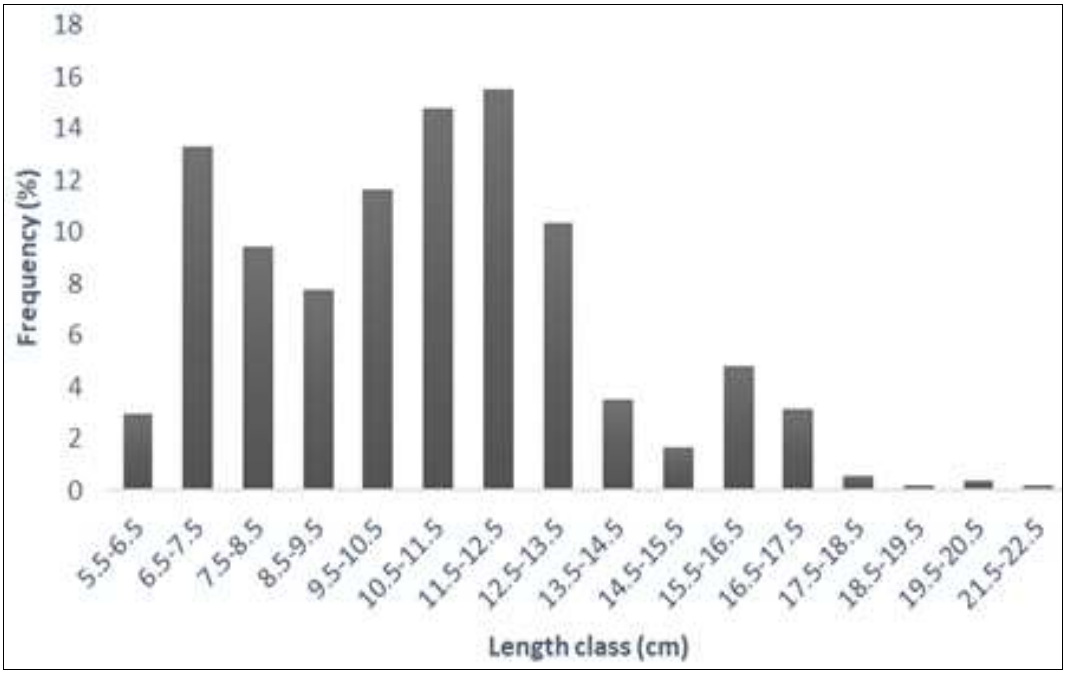

Fig 2: *Chloroscombrus chrysurus* 'distribution of length

Length-weight relationship

Length-weight relationships' graphic (Fig. 3) provide a good fit for *Chloroscombrus chrysurus*. This study's results ($W = 0.015FL^{2.93}$) demonstrated that for this species, the isometric value of 3, which represented negative allometric growth, had a significantly different slope from the regression equation. ($p< 0.05$).

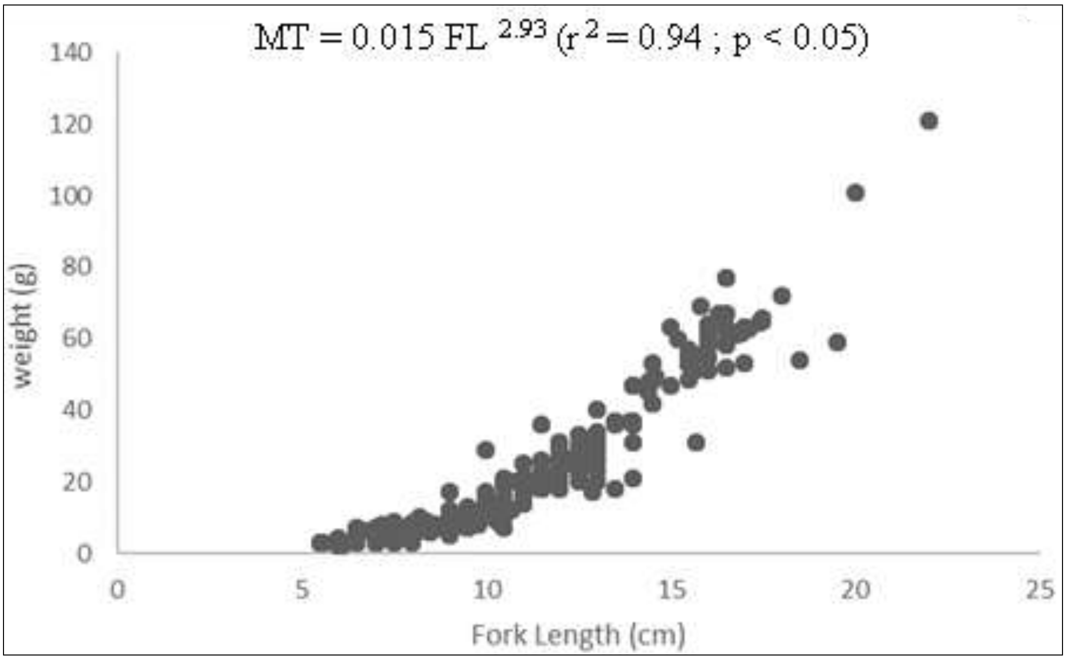

Fig 3: *Chloroscombrus chrysurus'* length Weight relationship

Growth parameters

Growth curves of *Chloroscombrus chrysurus* were restructured based on length frequency. The annual growth coefficient (K) and asymptotic length (L∞) measured using the K-scan technique of the Electronic Length-Frequency Analysis I program were 0.47 per year and 22.25 centimeters, respectively (Fig. 4). The growth performance index (Ø) was estimated at 2.36, the age at zero length at -0.36 years and the maximum longevity (tmax) at 6.37 years. The growth in length of *Chloroscombrus chrysurus* according to the Von Bertalanffy equation, which is derived from the parameters of the current study, is written as follows:

Lt = 22.25* (1– e – 0.47(t -0.36))

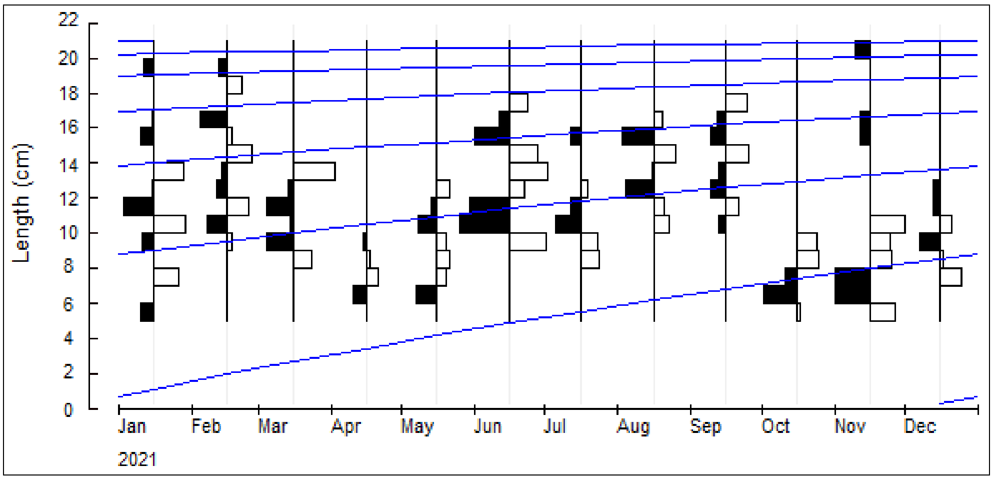

Fig 4: *Chloroscombrus chrysurus'* length-frequency data and growth curves

Mortality rates and Exploitation ratio

Total mortality rate (Z), natural mortality rate (M) and fishing mortality rate (F) were all estimated at 1.24 per years, 0.98 per years and 0.26 per years respectively (Fig. 5). The exploitation rate (E) was 0.21, lower than the maximum exploitation rate (Emax) of 0.69 obtained by the selection curve. This suggests that there is under exploitation of *Chloroscombrus chrysurus*.

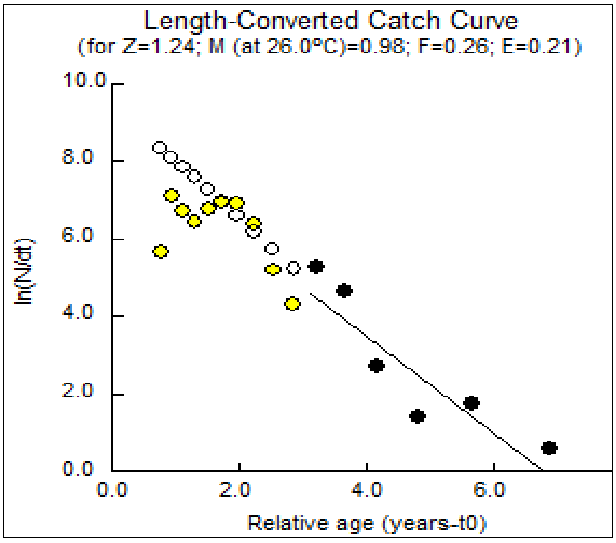

Fig 5: *Chloroscombrus chrysurus*' length-converted catch curve

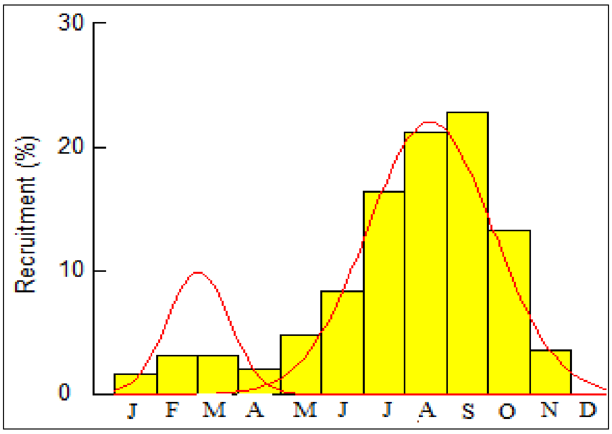

Fig 6: *Chloroscombrus chrysurus'* recruitment pattern

Recruitment Pattern

The recruitment profile shows that *Chloroscombrus chrysurus* was continuously recruited to the fishery throughout the year. The highest recruitment occurred from August to September, peaking at 22.86% in September, while the lowest recruitment occurred from January to April. In the sampled data, the average length of the lowest size class (5.5 centimeters) was used as the length at first recruitment (Lr).

Probability of capture

The length at first capture (Lc), which is the length at fifty percent probability of capture, was estimated at 9.68 centimeters. The 25% (Lc25) and 75% (Lc75) capture probability lengths were estimated at 5.16 centimeters and 14.20 centimeters, respectively (Fig. 7).

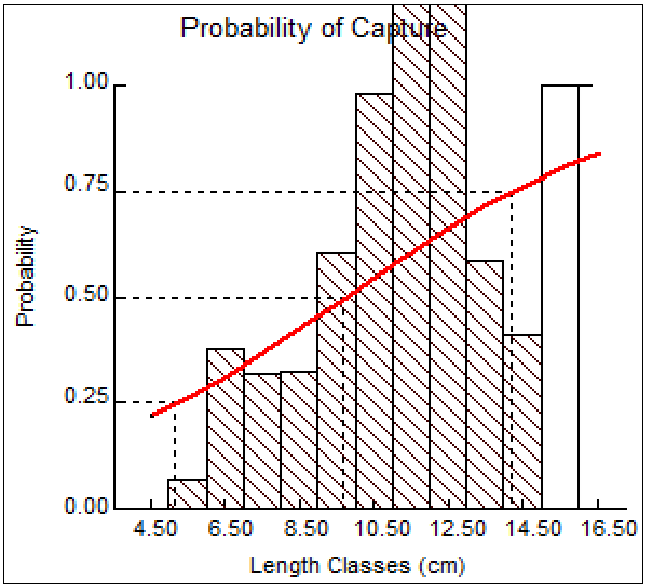

Fig 7: *Chloroscombrus chrysurus*' probability of capture estimation

Virtual Population Analysis

The minimum and maximum fishing mortalities for an average length of 5.5 cm and 11.5 cm were 0.07 and 0.89 $year^{-1}$, respectively, according to the virtual population analysis of *Chloroscombrus chrysurus*. For medium-sized exploited groups, fishing mortality was 0.42 $year^{-1}$. Natural mortality of fish is higher than mortality caused by fishing.

Relative Yield and Relative Biomass per Recruit

A relative analysis of Y/R and B/R was estimated using $Lc50/L\infty$ = 0.43 and M/K = 2.08 as inputs for the knife selection procedure (Fig. 9). The maximum operating level (Emax) allowed was 0.69. For a marginal increase in relative yield per recruit of 10% of its value, the exploitation level ($E_{0.1}$) was 0.55, while the exploitation level ($E_{0.5}$) was 50% of the B /R relative to an unexploited resource. The stock was evaluated at 0.34.

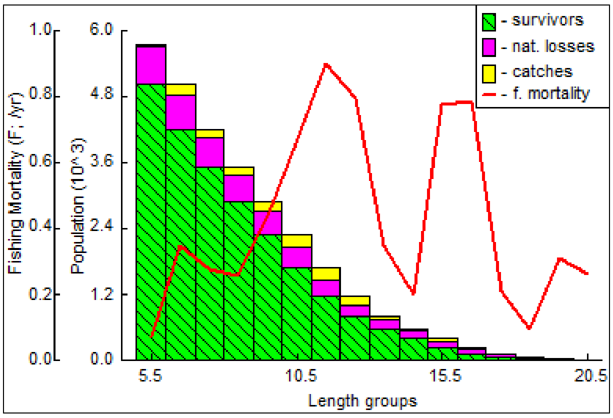

Fig 8: *Chloroscombrus chrysurus'* Virtual Population Analysis

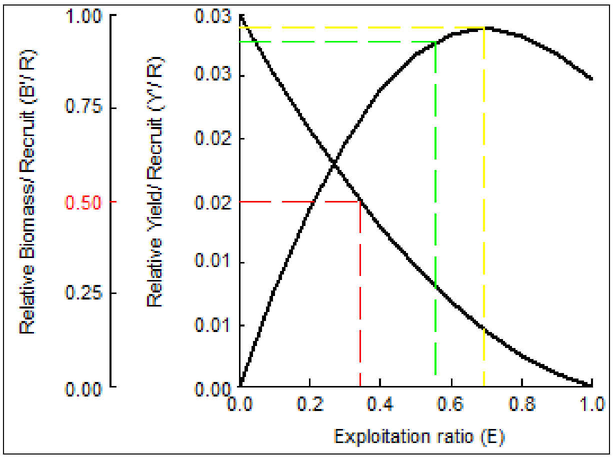

Fig 9: Yield-per-recruit and biomass per recruit for *Chloroscombrus chrysurus*

Discussion

The size range of fish in Ivorian coastal waters appears smaller than in other places. Da Costa *et al*. (2005) [18] and Sossoukpe *et al*. (2017) [4] found a larger distribution area (2–30 cm) in Sepetiba Bay, northern Brazil, and a larger distribution area (13.7–27.7 cm) in the coastal water of Benin. This restriction in the size range could be due to two factors. One is the choice of fishing gear used for fishing, and the other is the scarcity of large people in areas where fishing was carried out.

The length-weight relationship is often linked to providing population parameters required for effective fisheries management and sustainable stock performance, making it important in fisheries research. The b values found in Ivorian waters for C. chrysurus correspond to the typical range of values for this parameter in marine species, which is 2.5 to 3.5 [19]. The results of this study confirm the results of Oliveira *et al*. (2011) [20] in Brazil and Ndiaye *et al.* (2021) [21] in the Saloum delta in Senegal.

Climate type and differences in environmental conditions may be related to changes in growth parameters compared to other studies. Natural mortality and fishing mortality have an impact on total mortality. According to the results, total and natural mortality were higher than fishing mortality. Variations in fish length in the same cohort are a factor influencing total mortality [4]. Regarding natural mortality, it is influenced by both physiological factors such as diseases and old age, by environmental factors such as temperature and water flow, and finally by accidental factors such as encounters with predators.

But fishing effort is responsible for fishing mortality. A low exploitation rate (E = 0.21) compared to the optimal exploitation rate (E = 0.50) clearly confirms that the fishing effort on this species is relatively low. The fishery resources of *C. chrysurus* are not threatened by purse seine captures because it is underexploited in the coastal waters of Jacqueville. Sossoukpe *et al.* (2017) [4] discovered similar results for the same species in Benin. However, fishing mortality (F) was higher than natural mortality (M) according to Garcia and Duarte (2006) [23].

The comparison demonstrates that mortality estimates differ from one author to another and from one region to another. The main sources of variation in natural mortality values are the environmental temperature and the parameters of the von Bertalanffy equation [24].

A graph that shows how recruitment intensity varies over time can be used to illustrate the recruitment model. During the cold season, the woodpecker can be observed. Coastal upwelling encourages the growth of algae and plankton during this period and causes deep waters to rise to the surface, often rich in nutrients.

Plankton provides food for animals in marine and freshwater ecosystems. C. chrysurus would develop strategies adapted to the larval emergence period when there is a better chance of survival in the environment. Unlike natural mortality, fishing mortality increases slowly with size, according to virtual population analysis.

The current exploitation level (E), which was lower than the optimal exploitation level estimated by the Beverton and Holt method, was estimated at 0.21. According to Gulland (1971) [25], the optimal exploitation rate Eopt = 0.5 suggests that there is underexploitation of the stock of this species in the coastal waters of Jacqueville in Côte d'Ivoire. The maximum relative rate of return per new recruit was obtained at E = 0.69. The current level of exploitation is slightly lower than the level of exploitation which gives the maximum Y/R. The current exploitation rate was lower than both the exploitation rate ($E_{0.1}$), which had a marginal increase in relative yield per recruit of 10% (0.55), and the corresponding exploitation rate ($E_{0,5}$) at 50% of the unexploited relative yield biomass rate per new recruit (0.34). It also shows that the fishery is underexploited in terms of relative yield per recruit.

Conclusion

The growth and exploitation conditions of *Chloroscombrus chrysurus* in the coastal waters of Jacqueville in Côte d'Ivoire are examined in this study. Recruitment of this species occurs throughout the year. *Chloroscombrus chrysurus* is a short-lived fish that lives up to 6.37 years. The exploitation rate of 0.21 indicates that there is no overexploitation of the stock. It is necessary to put in place effective measures to guarantee sustainable management in order to avoid overexploitation of the stock of this species.

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