Diagnosis, Growth and Exploitation Rate of the Sapater (Chloroscombrus chrysurus, Linnaeus 1766) Fishing by Purse Seine in the Nearshore Waters of Benin

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Abstract Chloroscombrus chrysurus (Linnaeus 1766) is one of the most abundant species of Carangidae family occurring in the nearshore waters of Benin. To ascertain the exploitation level of this fishery resource, some demographic parameters of the species were studied for management and conservation measures. 605 specimens were collected randomly from commercial catches from August to November 2014. Morphometric, meristic and weight data were analyzed using SPSS software and the ELEFAN I routine from FISAT. The population of C. chrysurus was not heterogeneous with a sex-ratio of 1.4:1 (p < 0.05; χ² = 312.485) and masculinity and femininity rates were 58.31% and 41.69% respectively. Length frequencies showed low percentage of small sized individuals and independent distribution of sex (r = 0.16, p < 0.05). The monthly variations of the gonad-somatic index (GSI) and the condition factor (Kc) showed a decreasing trend over the review period and corresponding probably to the period of gametes emission. von Bertalanffy growth parameters estimated were L∞ = 28.35 cm, K = 0.49 year⁻¹, t₀ = -0.33 year and φ’ = 2.59. Total mortality, natural mortality and fishing mortality are 1.39, 1.17 and 0.22 respectively. The exploitation rate (E = 0.16) showed that the resource was underexploited implying that the purse seine is not a danger for this species.

Keywords Chloroscombrus chrysurus; growth parameters; mortalities; underexploited

1. Introduction

Fisheries and aquaculture make a decisive contribution to the welfare and prosperity of the inhabitants of this world and fish is now an important source of nutritious foods and animal protein for a large part of the world population (FAO, 2012). This also explains the continual increase of fishery resources sampling rates which endanger the balance of the oceans. Because of the services so rendered whose importance and diversity made them a global appropriation stake, marine and coastal biodiversity is under pressure affecting the integrity of its resources (Etoga, 2009).
Marine and coastal biodiversity is experiencing strong erosion (FAO, 2006). Many stocks are in a poor state at varying degrees. This can result in either reduced reproductive biomass, or by an unsustainable rate of exploitation in the medium term, or a combination of both effects. Two essential causes that led to this situation are recognized: on one hand, fishing capacities implemented far outweigh the stocks renewal potential; on the other hand the captures of young population are important. These two causes have led to a scarcity of many resources, landings significantly lower than what they should be in a better balanced exploitation and a weakening of the populations boosting their abundant natural fluctuations.

Samples taken by the fisheries reduce stock biomass. These react by increasing their rate of natural increment in order to regain the equilibrium position they had when there was no fishing. A new apparent equilibrium is then established at a lower level of biomass and captures match that faculty of resources to recover their level of abundance in a virgin state (Graham, 1935).

In addition to the increase in fishing effort, the decrease in landings could be explained by the degradation of fish habitat and the use of non-selective or unfavorable machine for the preservation of the resource.

In Benin as in all the countries of the Gulf of Guinea, two types of fishing are being practiced: industrial fishing and artisanal fishing. The latter is exerted on the continental shelf, usually in coastal waters below five miles (Okpeitcha, 2010). Artisanal fishing in Benin nearshore waters takes place throughout the year through various fishing machines most of which are unfavorable for the preservation of fishery resources.

The purse seine often used in the nearshore waters of Benin has proved an unrivaled productivity in artisanal fishing, sometimes even exceeding that of small industrial units (sardine fishers) (Freoj and Weber, 1981). They can capture on a haul several tons of fish and Carangidae are one of the main species caught by that machine according to the statistics from the Fisheries Department.

The biological material of this study, Chloroscombrus chrysurus, is the subject of a major fisheries activity. On Benin nearshore waters, it is subjected to a relatively intense artisanal activity. Chloroscombrus chrysurus species is highly consumed in Benin due to its abundance and relatively cheaper cost.

Rational management of renewable fishery resources is required to provide animal protein and an economic and social well-being to the population (Ekouala, 2013). The estimate of the age and growth of aquatic animals is an indispensable operation for the study of demography and dynamics of natural populations (Lamotte, 1975). Knowledge on the terms of their growth, longevity and all the events marking their lives (age at recruitment, age at sexual maturity, mortality, etc.) is useful for assessing the biomass likely to be fished but also to determine the optimal captures size. Therefore it is necessary to study the selectivity of fishing gear used in relation to the exploitation of fishery resources.

The aim of this study is to assess some demographic parameters of C. chrysurus fished by the purse fishing gear and propose conservation and management measures.

### 2. Materials and Methods

#### 2.1. Study area, Fish sampling and Data collection

The Artisanal Fishing Port of Cotonou (AFPC) in the southern Benin (Figure 1), which is the core area of this study, is a public utility infrastructure located in the dock on the East side of industrial fishing port. It is a space developed in 1972 to facilitate canoes landing.
The basic biological material of this study comprises *Chloroscombrus chrysurus* (Carangidae) specimens caught with purse seining haul in the nearshore waters of Benin and landed at AFPC.

The data collection equipment is made of fish length measuring board, a stop ruler and a tape measure to perform the various measurements on fish namely: the fork length ($L_f$); the eye diameter ($O$) and head length ($HL$). A scale of Sartorius type (Model 6200S LP) 0.1 g precision and scope 500g allowed taking the total weight ($W_t$), eviscerated weight ($W_e$) and organ weight (gonads and stomach). No secondary sexual external characteristic could be detected so far for sex identification with *Chloroscombrus chrysurus*, the examination of gonads is necessary for this purpose. To this effect, the fish were dissected and gonads were subjected to macroscopic observation.

The monthly sampling of 150 fish specimens was made randomly from purse seining haul, from August to November 2014 (four months). In total of 605 fish specimens were sampled throughout the period. Each fish specimen was identified according to the determining keys of Paugy et al. (2003). Individuals were immediately transferred under ice to the Zoology Laboratory for different measurements, counting and dissection.

![Location of the sampling site](image)

**Figure 1: Location of the sampling site**

### 2.2. Population structure and sex ratio

The size frequency was analyzed at 2 cm interval total length ($TL$, cm) class using a histogram to determine the type of distribution which characterizes the fish population. With numerical abundance by sex, the following ratio was computed:

$$\text{Sex ratio} = \frac{\text{number of males}}{\text{number of females}}$$  (Chakroun et al., 2003)

### 2.3. Length-weight relationship

The commonly used relationship $W = aL^b$ (Ricker, 1975) was applied to establish the length-weight relationship by sex, where $W$ is the ungutted weight ($W_t$, g), $L$ is the total length ($TL$, cm) and “a” and “b” are intercept end slope of the regression curve of the length and the weight of the fish, respectively. Tests for differences between sexes were performed to consider pooled population together. The correlation ($r^2$), which is the degree of association between the length and weight, was computed from the linear analysis.

In fact this relationship is closely related to the biological and physiological condition of the fish (degree of the stomach repletion, degree of development of genital glands and stage of maturation).

Among the applications of length-weight relationships in fisheries biology, knowledge of this relationship is useful for estimating fish weight from its length, this value is an indicator of the fish
living conditions or status of the fish stock (Petrakis and Stergiou, 1995; Froese and Pauly, 2006), also allows assessing the fish biomass.

### 2.4. Fish condition factor (Kc)

To check the stoutness, the condition factor (Kc) was calculated using the following formula:

\[
Kc = 100 \times \frac{Wt}{TL^b}
\]

(Chakroun et al., 2003)

Where \(Wt\) = total fish weight (g); \(Lt\) = total length (cm).

To assess the wellbeing of the fish, "b" is compared to 3 and the evolution of Kc is analyzed in the sample size range. If "b" is not significantly different from 3, the species has a good adaptation with regard to the dominant ecological habitat condition. In contrast, if "b" is significantly different from 3, there is less adaptation (Bijot et al., 1994).

### 2.5. Growth and mortality parameters

The estimate of the age and growth of aquatic animals is an indispensable operation for the study of demography and dynamics of natural populations (Lamotte, 1975). Knowledge on the terms of their growth, their longevity and on all the events marking their lives (age at recruitment, age at sexual maturity, mortality, etc.) is useful for assessing the biomass likely to be fished but also to determine the optimal captures size.

Fish growth is expected to follow the growth function of von Bertalanffy (VBF), whose equation is:

\[
L_t = L_\infty \{1-\exp[-K (t-t_0)]\}
\]

(King, 1995)

With \(L_t\) = length of the fish at time \(t\) (mm); \(L_\infty\) = theoretical asymptotic length (mm) \(K\) = coefficient of growth or growth rate; \(t_0\) = hypothetical age at which the total length is zero or fictitious age corresponding to the size zero.

This model is based on an assumption that the instantaneous speed of growth is the result of two opposing physiological processes: anabolism proportional to organisms’ surface and catabolism proportional to the volume of their body (weight).

Pauly empirical equation below permits to determine the hypothetical age when fish size is zero.

\[
\log_{10} (-t_0) = -0.392 - 0.275 \log_{10} L_\infty - 1.038 \log_{10} K
\]

(Pauly, 1979)

The estimated \(K\) and \(L_\infty\) are used to determine the growth performance index \((\phi')\) of the species from the equation developed by Pauly and Munro (1984) is as follows:

\[
\phi' = \log_{10} K, 2\log_{10} L_\infty
\]

The growth performance index is an indication of the wellbeing of the species with regard to its external environment.

### 2.6. Mortality Estimation parameters (Z, M and F)

Total mortality \((Z)\) was determined using the software FiSAT (Gayanilo et al., 1995). The instantaneous natural mortality \(M\) was calculated by the empirical equation of Pauly (1980) using an average surface temperature in the following manner:
\[ \log_{10} M = -0.0066 - 0.279 \log_{10} L_{\infty} + 0.6543 \log_{10} K + 0.463 \log_{10} T \]

The instantaneous mortality rate by fishing, \( F \), was estimated from the relationship:

\[ F = Z - M \] (Pauly, 1980)

### 2.7. Longevity (\( t_{\text{max}} \))

To get an independent estimation of the instantaneous natural mortality rate (\( M \)), Pauly (1983) established that \( M \) is in correlation with the fish longevity defined as follows:

\[ t_{\text{max}} = 3 / K \] (Anato, 1999)

The assessment of stock conditions and mortality rate was done by the calculation of the exploitation rate (\( E \)) from:

\[ E = F / Z \] (Pauly, 1983)

With \( F \) = mortality annual rate by fishing; \( Z \) = total mortality annual rate.

Value of \( E \) is approximately equal to 0.5 supposing that the performance is optimized when \( F \) is approximatively equal to \( M \) (Gulland, 1971).

### 2.8. Capture probability and size at first capture (\( L_c \) or \( L_{50\%} \))

The capture probability gives a clear idea on the estimate of the actual size of the fish in the fishing area and that are caught by specific devices. At the same time, it is an important tool for fisheries managers who in regulating the minimum mesh size of a fishing fleet can roughly conclude what should be the minimum size of the target species fishing. The probability of capture was estimated by extrapolation back to the descending portion of the linearized curve length converted in capture.

Selectivity curve generated using linear regression fitted to the data points in ascending capture probability and the length is used to estimate the final value of \( L_{25} \), \( L_{50} \) and \( L_{75} \) (that is to say, lengths at which 25%, 50% and 75% of those fish are proving vulnerable to the fishing machine used. Estimates of the length at first capture (\( L_{50} \)) are derived from the probabilities of capture generated by analyzing the capture curve produced by FiSAT.

### 2.9. Statistical analysis

SPSS statistical software was used for \( \chi^2 \) test (Scherrer, 1984) and averages correlation and comparison. The assumption of heterogeneity and the sex ratio 1:1 were tested by the \( \chi^2 \) test (Scherrer, 1984).

Assuming an equal distribution of males and females within the sampling and by reference to properties normal distribution, we will say that there is a 5% chance that a difference between the observed and theoretical values is purely coincidental. We will also say that the difference in the probability level of 5% is significant if it is superior to \( \chi^2 = 3.842 \).

Allometric coefficients "b" of males and females were compared with the theoretical value "3" by the T test for single sample and between the sexes by T test for independent sample.

Monthly distributions of length frequency were analyzed to have indirect growth. The amplitude of the classes was arbitrarily defined taking into account the different sizes of fish in the population.
Von Bertalanffy growth parameters namely asymptotic length ($L_\infty$) and the growth coefficient ($K$), are obtained using the routine ELEFAN1 of FiSAT (Pauly and David, 1981) recommended by FAO, the software FiSAT is based on Von Bertalanffy equation (1938), it permits to provide initially the assessments of different parameters and uses iterative algorithms.

3. Results

3.1. Diagnosis

Table 1: Diagnosis of Chloroscombrus chrysurus (Linnaeus, 1766) of the nearshores waters off Benin

| Parameters used                  | Minimum | Maximum | Average + Gap-type |
|----------------------------------|---------|---------|--------------------|
| Rays (1st dorsal fin)            | 6       | 7       | 6.9±0.28           |
| Rays (2nd dorsal fin)            | 24      | 29      | 27.0±0.77          |
| Rays (anal fin)                  | 24      | 29      | 27.0±0.77          |
| Rays (pectoral fin)              | 15      | 21      | 17.6±0.80          |
| Rays (pelvic fin)                | 4       | 6       | 4.9±0.25           |
| Rays (caudal fin)                | 12      | 14      | 12.0±0.19          |
| Branchiospines (inferior arc)    | 21      | 39      | 31.9±1.94          |
| Branchiospines (superior arc)    | 0       | 12      | 8.8±1.27           |
| Branchiospines (whole racher)    | 27      | 45      | 40.7±2.39          |
| Total Length (TL)                | 13.7    | 27.7    | 21.0±2.28          |
| Fork Length (FL)                 | 11.0    | 23.5    | 17.5±1.96          |
| Standard Length (SL)             | 10.3    | 21.1    | 16.2±1.80          |
| Pre-dorsal Distance (DP)         | 3.5     | 6.8     | 5.3±0.56           |
| Pre-anal Distance (PA)           | 5.4     | 10.9    | 8.4±0.90           |
| Pre-Pectoral Distance (PP)       | 2.5     | 4.8     | 3.7±0.38           |
| Pre-ventral Distance (PV)        | 3.6     | 6.9     | 5.3±0.54           |
| Head Length (HL)                 | 2.4     | 4.6     | 3.7±0.37           |
| Pre-orbital Distance (Pr-O)      | 0.6     | 1.40    | 1.0±0.12           |
| Eye Diameter (O)                 | 0.7     | 1.7     | 1.0±0.11           |
| Post-orbital Distance (Pt-O)     | 0.7     | 1.4     | 1.1±0.18           |
| Inter-orbital Distance (I-O)     | 1.0     | 2.0     | 1.5±0.13           |
| Great Height (H)                 | 4.7     | 8.4     | 6.7±0.64           |
| Small height (h)                 | 0.4     | 1.0     | 0.7±0.09           |
| Circumference (Circ)             | 10.2    | 18.8    | 14.5±1.38          |
| Density (Thick)                  | 0.9     | 2.2     | 1.6±0.23           |

To confirm the characteristics of Chloroscombrus chrysurus species (Linnaeus, 1766) which constitutes the biological material on which we conducted our study, a number of observations, measurements and counting were performed on specimens that make up the sample. Table 1 summarizes the various distinctive characteristics of the species.

Generally, Chloroscombrus chrysurus of the nearshore waters off Benin has a sufficiently compressed oval body, the ventral profile more convex than the dorsal profile with an oblique mouth and a small eye. The top of the head and trunk are colored black, while the bottom is a shiny gray. Specimens have a black spot on the upper caudal peduncle. They have two dorsal fins; the first ray is 6.9±0.28 and the second 27±0.77. The upper lobe of the caudal fin is longer than the lower lobe. The pectoral fins have 17.6±0.80 rays and the pelvic fins have 4.9±0.25 rays. There is an anal fin with 27±0.77 rays. Counting of gill rakers permitted to observe on the upper blade of the 1st branchial arch 8.8±1.27 branchiospines. It could be noted that cases where the upper plate does not exist are rare. The lower blade has 31.9± 1.94 branchiospines. Scutes could not be counted because of their very small size.
3.2. Population structure and sex ratio

The assumption of heterogeneity and that of sex ratio 1: 1 were tested by the $X^2$ test (Scherrer, 1984). A total of 605 specimens of *Chloroscombrus chrysurus* comprising 347 males, 248 females and 10 unsexed were sampled. The difference between the number of males and females, was statistically significant ($p <0.05$, $\chi^2 = 312.485$). The population is not sexually heterogeneous and sex ratio (number of males/number of females) is 1.4: 1.

The proportions of males (masculinity rate) and females (feminity rate) are expressed in percentages as follows: Males = masculinity rate ($M / M + F$) * 100 = 58.31%; Females = femininity rate = ($F / M + F$) * 100 = 41.68%.

Size distribution of population of males, females and total population are reported in Figs 2-4 of the study sample.

The size distribution of the population of males and females and pooled sex are unimodal. The most represented classes range from 18 to 24 totaling 82.4% of the total number of the population. The sizes of females vary from 13.7 to 25.9 cm, while those of the males range from 15.3 to 27.7 cm with the same modal class 20, 22.

Sex seems to play any role in the determination of any difference in size distribution ($r = 0.16$; $n = 595$, $p <0.05$).

![Figure 2: Size structure of males](image1)

![Figure 3: Size structure of females](image2)

![Figure 4: Size structure of pooled sexes (males and females)](image3)
3.3. Length-weight relationship

The length-weight relationship is $Wt = 0.007TL^{3.027}$ ($r = 0.96; n = 347$) for males, $Wt = 0.005TL^{3.141}$ ($r = 0.945; n = 248$) for females and $Wt = 0.006TL^{3.038}$ ($r = 0.949; n = 605$) for both sexes. The value of the slope “$b$” is significantly different between the sexes (t-test: $t = 14.97, p < 0.05$) and is significantly higher than the theoretical value of 3 for males (t-test: $t = 21.401; p < 0.05$) and females (t-test: $t = 50.544; p < 0.05$) for all the curves (Figures 5, 6 and 7), the experimental points are strongly ordered around the theoretical curve (regression lines), this is explained by the fact that the lowest value of the coefficient of determination $r^2$ is very close to 1 ($r^2 = 0.945$).

The calculated equations reflect a positive or majored allometric growth for males, females and for the whole population (male + female). The fish, all sex put together, grows faster in weight than in length.

![Figure 5: Length-weight relationship for males](image1)
![Figure 6: Length-weight relationship for females](image2)
![Figure 7: Length-weight relationship for pooled sexes (males+ females)](image3)

3.4. Fish condition factor (Kc)

The condition factor (Kc) in males, females and both sex (Figure 8), even though they were not significantly different from one month to the other ($p > 0.05$) decreased from August to November.

![Figure 8: Monthly variations of the condition factor (Kc)](image4)
3.5. Gonad-somatic index relationship (GSI)

The monthly evolution of the gonad-somatic values (GSI) of *Chloroscombrus chrysurus* from Benin nearshore waters is reported in Figure 9.

![Figure 9: Monthly variations of gonad-somatic index (RGS)](image)

The values of gonad-somatic index of males (0.020 ± 0.008) and females (0.031 ± 0.009) remained almost static from August to September with a slight increase with female to reach 0.034 ± 0.011. From September to November they decreased (Figure 12) to reach 0.007 ± 0.004 and 0.019 ± 0.008, respectively, for males and females corresponding probably to the period of gametes emission. Generally, the values of gonad-somatic index (RGS) of *C. chrysurus* females are higher than those of males.

3.6. Estimate of growth and mortality parameters

Figure 13 shows the curves from which the parameters of the von Bertalanffy growth function for *Chloroscombrus chrysurus* (Figure 10) show five (5) curves representing five cohorts started in January with no fish size group represented. The first group of modal size 12 cm (Total length) appears from September and goes to August of the following year with a modal size of 18 cm (Total length).

$L_\infty$ and $K$ output from FiSAT were 28.35 cm and 0.490 year$^{-1}$ respectively. The parameters of von Bertalanffy equation are reported in Table 6. The hypothetical age ($t_0$) and the growth performance index ($\varphi'$) were -0.33 year and 2.595 respectively.
Figure 10: Monthly increase of modal class according to routine ELEFAN 1 from FiSAT II of Chloroscombrus chrysurus

Table 4: Von Bertalanffy equation parameters

| Mortality Parameters | Asymptotic Length ($L_\infty$) | Growth Coefficient (K) | Hypothetical Age ($t_0$) | Growth performance Index ($\phi'$) |
|----------------------|-------------------------------|------------------------|--------------------------|----------------------------------|
| Values               | 28.35 cm                      | 0.49 year$^{-1}$       | -0.33 year               | 2.59                             |

The von Bertalanffy growth function equation is:

$$L_t = 28.35 \{1 - \exp \left[-0.49(t + 0.328)\right]\}$$

3.7. Estimate of mortality parameters (Z, M and F) and exploitation rate (E)

The total mortality (Z), natural mortality (M) mortality by fishing (F) and exploitation rate (E) of C. chrysurus from the nearshore waters off Benin are estimated by FiSAT and generated (Figure 11) and reported in Table 6.

Figure 11: Mortality parameters of Chloroscombrus chrysurus of Benin nearshore waters

Longevity ($t_{\max}$)

The maximal lifespan ($t_{\max}$) of Chloroscombrus chrysurus calculated according to Anato, (1999) ($t_{\max} = 3/k$) is 6.12 years.

Probability of capture and size on first capture
The probability of capture estimated by FiSAT (Figure 12) show that 50% of *C. chrysurus* individuals are vulnerable to seining haul used in Benin nearshore waters at length of first capture \( L_{50} = 15.06 \text{ cm} \)

![Figure 12: Probability of capture of *C. chrysurus* of Benin nearshore waters](image)

**4. Discussion**

**4.1. Diagnosis**

After measurements it was noted that the morphometric and meristic distinctive characteristics found coincide with those given by Acosta et al. (2008) and by Smith-Vanish (2002). The species of *C. chrysurus* from the nearshore waters off Benin is not different from what described on other coasts such as those of South-East Brazil.

**4.2. Population structure and Sex ratio**

*C. chrysurus* size structure in Benin nearshore waters has unimodal distribution with modal class 13.7 - 27.7 cm (Total length). The size range between 18 and 24 cm represents over 82% of the capture (Table 3). There were very few small sized individuals in the samples (7%). Cunha et al. (2000) observed in contrast to current study, ranges including enough small sized fish (3-17 cm) in the bay of North-East of Brazil.

Moreover, the range of fish sizes observed in Benin nearshore waters seems smaller than those reported in other geographical environments. da Costa et al., (2005) observed for example a greater range (2-30 cm) in the Bay of Sepetiba in Northern Brazil. This restriction of the size range could be related either to the selectivity of the fishing gear used for fishing (purse seining haul) or the scarcity of small individuals in areas where fisheries were conducted. In addition, the maximum size found in Benin nearshore waters (27.7 cm) is lower than that reported in Brazil (30 cm) which may be due to better living conditions on the Brazilian coast. The lack of juveniles in the captures is due to the area where fisheries were conducted (full sea area) which are not areas of abundance of juvenile. According to Johnson (1978), the distribution of adults is done from coastal waters to marine waters up to a depth of 180 m. Juveniles of *Chloroscombrus chrysurus* are abundant in coastal areas close to estuaries, lagoons and bays (Flores-Coto and Sanchez-Ramirez, 1989). Sex ratio 1.4: 1 observed in *C. chrysurus* shows that there is dominance of males with respect to females. According to Aka et al. (2004), the variation of sex ratio is dependent upon to the physiological condition of the fish. In general, with the Teleost, males predominate during reproduction period while during sexual rest period; females are predominant (Paugy, 1980; Santos et al., 2007). Several factors such as moves to find food, differential growth and sex mortality rate also influence fish sex ratio (Mellinger, 2002).
4.3. Length-weight relationship

Values of "b" calculated being greater than the theoretical value 3, the calculated equations reflect a positive or increasing allometric growth for males, females and for the whole population (male + female). *Chloroscombrus chrysurus* in the nearshore waters of Benin for both sex, grows faster in weight than in length. This value is an indicator of the fish living condition or the condition of the fish stock (Petrakis and Stergiou, 1995; Froese and Pauly, 2006) may vary over time and space. It is also possible that the sampling mode influences the length-weight relationship.

4.4. Fish condition factor (Kc) and gonad-somatic Index (RGS)

Monthly variations of gonad-somatic index and Fulton condition factor indicate that the months of August, September, October and November probably correspond to the period of reproduction of the species and specifically the period of gametes emission. Although these results are consistent with those found by Conand and Franqueville (1973) that determined the period from July to October as the reproduction period and *Chloroscombrus chrysurus* larva abundance, this study needs to be conducted on a more extended period (at least one year) for confirmation of these results. Moreover, apart from the insufficient period of the study, it must also be complemented by a thorough study of reproduction by determining the monthly variation in the percentage of sexual maturity stages, the absolute fertility and oocyte diameters and distribution frequency.

4.5. von Bertalanffy growth parameters (L∞, K and t₀) and growth performance index (ϕ′)

von Bertalanffy growth parameters (L∞, K and t₀) and growth performance index (ϕ′) show a better adjustment due to the non-existence *Chloroscombrus chrysurus* of the alternation effect marked by cold season and dry season.

The estimated value of the asymptotic length from Benin coasts (L∞ = 28.35 cm) is less than what found by da Costa et al. (2005) in the Bay of Sepetiba in the South of Brazil (L∞ = 31.6 cm). In other words older fish in the Brazilian bay are of greater height than those studied of Benin coasts. This difference may be due either to age classes used in curve fitting or to the difference in environmental conditions in the two areas.

Growth coefficient (K) calculated in this study (K = 0.490 year⁻¹) is greater than the one reported by da Costa et al. (2005) in the Bay of Sepetiba (K = 0.380 year⁻¹), reflecting a faster growth of the species from the nearshore waters of Benin and indirectly a faster achievement of the asymptotic length. The growth performance index (ϕ′) is the same as what was reported by da Costa et al. (2005) and this could be attributed to environmental and dietary conditions comparable in these two environments.

4.6. Mortality parameters (Z, M and F)

Total mortality (Z), natural mortality (M) and fishing mortality (F) (Table 7) determined by FiSAT software (Gayanilo et al., 1995) for *Chloroscombrus chrysurus* from Benin coasts were 1.39 year⁻¹, 1.164 year⁻¹ and 0.226 year⁻¹ respectively. Factors that affect the determination of the total mortality are among others, variations in the lengths of fish in the same cohort (Gabche and Hockey, 1995). As for natural mortality, it depends on both physiological factors such as diseases and old age and environmental factors namely temperature and water flow and finally, factors due to hazard such as encounters with predators. But fishing mortality results from fishing effort. It is obvious that the fishing effort on this species is relatively low, as confirmed by a low rate of exploitation (E = 0.16) compared to the optimal exploitation rate (E = 0.5). *Chloroscombrus chrysurus* is underexploited on Benin coasts and seining haul is not a threat to this fish resource.
On the other hand, (Sossoukpè E. et al., 2013; 2016) found higher exploitation rate for *Pseudotholithus senegalensis* (E1 = 0.91; E2 = 0.82) and low exploitation rate for *Sardinella maderensis* (E = 0.33 per year) respectively in the nearshore waters of Benin. *C. chrysurus* is less exploited than those above-mentioned species because of its relatively low economic value but nevertheless it has a high fishing potential and a significant ecological value (Yañez-Arancibia and Sánchez-Gil, 1986; Flores-Coto and Sánchez-Ramírez, 1989; García-Tapia, 1991).

The longevity of *Chloroscombrus chrysurus* from Benin coasts (t\(_{max}\) = 6.12 years) is less than what reported da Costa et al. (2005) on Brazilian coasts (t\(_{max}\) = 7.89 years). There is a strong correlation between natural mortality rate and longevity. In the case of fish, natural mortality is inversely proportional to the longevity; therefore, it is related to K. It goes without saying that this mortality is inversely related to the size of the fish, as those of greater size have fewer predators. This natural mortality is also correlated with the environmental temperature (Pauly, 1980).

### 4.7. Probability of capture and length at first capture

Probability of capture and different corresponding sizes generated by the FiSAT software were used to determine the length at first capture (L\(_{50}\)), length at which 50% of individuals of this species are vulnerable to purse seining haul used in the nearshore waters of Benin, L\(_{50}\) = 15.06 cm. This value must be compared to the length at first sexual maturation. Knowing the size of first sexual maturation is important in the management of fishery resources (Dadebo et al., 2003). It was adopted as the minimum sized specimen not to be captured. This comparison would show whether the individuals of this species are massively captured before reaching their first sexual maturation. In case of need would be symptomatic of poor exploitation of the stock. Failing to have this data in this study, we will compare it to the first sexual maturity size found by Magro et al. (2000) in the South of Brazil (11.5 cm) and Cunha et al. (2000) in the North-East of Brazil (9.5 cm). It appears that these values are below the size at first capture on Benin coasts (L\(_{50}\) = 15.06 cm). On the basis of these comparisons, we can say with a minimum reservation that the resource is not badly exploited on Benin coasts with the use of seining haul. In other words fish have chance to reproduce at least once to ensure the renewal of the stock before being captured. This result, which is against all expectation, could be due to the relatively small size of *C. chrysurus* juveniles and therefore are not massively captured by seining haul although being recognized as a devastating machine. However it would be interesting to extend the study on different fishing machines used on Benin coasts.

The length-weight relationship reflects a positive allometric growth which suggests that the species is in a reproduction period. This assumption is partially confirmed by the monthly changes in Kc and GSI values, corresponding to a decreasing trend over the period from August to November.

The exploitation rate obtained in this study is low and seining haul seems harmless for the stock of that resource. Indeed, the size classes mostly captured by this machine are between 18 and 24 cm, highly above the size of first sexual maturity.

As adjustment measures, it is suitable to develop and implement an effective management plan for *C. chrysurus* in particular and species not fully exploited in general before considering to intensify the exploitation of these stocks, if we want to avoid overfishing similar to the one currently among the numbers of stocks overfished such as *P. typus* and *P. senegalensis*.

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