International Journal of Agricultural Policy and Research Vol.3 (7), pp. 300-307,July 2015
Available online at http://www.journalissues.org/IJAPR/
http://dx.doi.org/10.15739/IJAPR.053

ISSN 2350-1561

*Original Research Article*

# The dynamics of population of *Alestes nurse* (African Pink) in Gubi Dam - Nigeria using simplified empirical models

Accepted 8 July, 2015

**Yusuf Z.A.[1]**
**and**
***Abdulkarim M[2].**

[1]Department of Biological Sciences, Faculty of Science, Abubakar Tafawa Balewa University, Bauchi, Bauchi State, Nigeria.
[2]Department of Animal Production, Faculty of Agriculture and Agricultural Technology in Abubakar Tafawa Balewa University, Bauchi, Bauchi State, Nigeria.

*Corresponding Author
E-mail:mashemau@yahoo.com
Tel: +2348067038162

**Length – frequencies data (LFD) were extensively collected on *Alestes nurse* (African pink) fish in Gubi dam for a period of one year as to study the population dynamics of the stock. The samples of LFD were adjusted against biasness using an empirical method since they were obtained from commercial catches fished with gill nets. The LFD were analysed with simplified empirical models such as ABC – DU Y/R Model and new empirical methods used for estimating total mortality (Z), that was developed alongside with introduction of new concepts: Net Reproductive Rate ($R_o$) and Maximum Recruit ($R_\infty$) into fisheries stock assessment. The analysis shows that population parameters: growth coefficient K = 1.21/year; mortality rates – natural (M), fishing (F) and Z are 2.22/year, 0.47/year and 2.69/year respectively while the stock status indicates that *A. nurse* is productive and resilient with exploitation rate, E = 0.17. However, current annual effort, $f_A$ = 49,388 man days should be increased by 17.65% so as to attain maximum sustainable yield of 646,388, 485.4g.**

**Key words:** *Alestes nurse*, population parameters, stock status, empirical models, Gubi dam.

## INTRODUCTION

Stock assessment is a method of estimating population parameters of fish of same species living in a common geographical region. It is practically difficult to count fish in a water body. Therefore, many growth models are developed to estimate population dynamics of fish in water bodies. Unlike analytical models, empirical models are less rigorous and give similar output as analytical models. As long as the outputs of empirical models guide to making good fisheries management decisions, they are equivalent to analytical models. In fact, empirical models may be more advantageous than analytical models in terms of being cost effective in collection of data as they require fewer inputs compared to analytical models, saving time as well as easy to handle. The parameters that are usually estimated from fish populations are growth coefficient, recruitment and mortality rates and are important in making management decisions on the sustainable utilization of fish stock in particular and aquatic resources in general.

Majority of people living close to water bodies in numerous countries, particularly in Africa, are often forced into fishing as a means of livelihood. As a result, pressure on inland fish resources has tended to increase over the whole continent over the last 20 years. As fishing effort increases, the impact is felt as larger individual and species from multi species communities are being replaced by smaller species (Welcome, 2003).

Large rivers and streams generally support large number of fish species. Alteration of water quality, seasonal flows and patterns of flow variability, for instance, by damming and abstraction, have substantial consequences for the maintenance of biodiversity in many rivers (Bunn and Arthington, 2002). *Alestes* species are among the commercial fish caught in Gubi dam (Abdulkarim et al., 2005). The fish is mostly preferred by consumers especially when they are sun dried or fried. The potential of *Alestes* species for aquaculture is yet to be fully realized because of insufficient knowledge on their biology, particularly, breeding in captivity and stock status which include their growth performance index that could be used in assessing their aqua cultural potentiality.

Sparre and Venema (1998) stated that the primary objective of fish stock assessment is to provide information that will enhance strategy formulations for the optimum exploitation of living aquatic resources for the benefit of man such that, the exploitation rate keep pace with its renewability. Under this perception, an attempt has been made to assess population dynamics of *Alestes nurse* fish in Gubi dam of Bauchi state in Nigeria.

## MATERIALS AND METHODS

### Study Area

Gubi dam is located at Piro village, Ganjuwa Local Government Area, Bauchi State, Nigeria. The dam is mostly recharged by rivers whose main sources of water are rainfall and flooded water. The rivers are seasonal and dry out during the dry period of the year. Gubi dam is an earth filled dam with clay core. It has a total storage capacity of $3.84 \times 10^6\ m^3$. The maximum depth of the dam is 27 meters (m), length of the embankment 3.8 kilometres (km), free board is 3m and the spill way is 70m.The dam has a catchments area of $179 km^2$, reservoir area of 590ha and the expected yield from the reservoir is approximately $90,000 m^3$ / day (Anon, 2005).

### Data Collection

Field visits to Gubi dam were conducted two to three times a week between 7.30 to 10.30am for a period of twelve months (August, 2007 – July, 2008). *Alestes nurse* were caught by fishermen using gill net of not more than 1½ inch (3.75 cm) mesh size from identified fishing sites (Kwata, Tatumari, Arewa, Lakarina, Kumi, Tower, Dutsen tsintsiya and Spillway) of the dam. The fish were landed at the most popular landing site (Kwari) and counted immediately as they were removed from nets.

### Size Frequency Data

Samples of landed *Alestes nurse* at the Kwari landing site of Gubi dam were each weighed separately on CS200 digital measuring scale to the nearest grams (1g). Immediately after weighing the fish, their total length was measured with metric ruler to the nearest centimetre (1 cm).

### Adjustment of Sample of Length – Frequencies Data

The sample of Length – frequencies data were collected from commercial catches caught with gill nets. Sparre and Venema (1998) have shown that such data are biased due to the gear selectivity, therefore, they have to be adjusted to be unbiased using Selection Ogive Curve (SOC). However, the method used is similar to the work of Sparre and Venema (1998) but are based on deduced methods as elucidated below:

Gear Selectivity Estimate (St. Est.) = $1/ [1 + \exp (T_1 - T_2 * t)]$ (01)

Eq. 01 can be rewrite as a straight line equation:

$\ln [(1/S) - 1] = T_1 - T_2 * t$ (02)

Where S is percentage of fish to be retained in net as a function of their ages; t is age of fish while $T_1$ and $T_2$ are Gear Selectivity Constants. Rather than plotting graph of S against t, to determine $T_1$ and $T_2$ as intercept and slope respectively, simultaneous equations were used in this work as follows:

$\ln [(1/S_a) - 1] = T_1 - T_2 * t_a$ (03)

$\ln [(1/S_b) - 1] = T_1 - T_2 * t_b$ (04)

$t_{0.5} = t_m$ (05)

Where $t_{0.5}$ is age when 50% of the fish shall be retained in the net when caught as age of massive maturation with $L_m$ as its corresponding length. Eq. 03 and 04 are solvable using the coordinates ($S_a$, $t_a$) and ($S_b$, $t_b$) which are generalized to be (0.5 – 0.01, $t_{0.5}$ – 0.01) and (0.5 + 0.01, $t_{0.5}$ + 0.01) respectively or simply: $S_a = 0.49$; $t_a = t_{0.5} - 0.01$; $S_b = 0.51$ and $t_b = t_{0.5} + 0.01$. The estimate of $T_1$ and $T_2$ is valid if it satisfies Eq. 06:

$t_{0.5} = T_1/ T_2$ (06)

Furthermore, the selection range from $t_{0.25}$ to $t_{0.75}$ can be estimated from equations below

$t_{0.25} = (T_1 - \ln 3) / T_2$ (07)

$t_{0.75} = (T_1 + \ln 3) / T_2$ (08)

### Determination of Population Parameters of *Alestes nurse* in Gubi Dam

### The Von Bertalanffy Growth Model (VBGM)

The length at specific age of the *Alestes nurse* in the dam was determined by using VBGM (1934 in Sparre and Venema, 1998):

$L_t = L_\infty * [1 - \exp (- k * (t - t_o))]$ (09)

Where: $L_t$ is length to be determined at age t; $L_\infty$ is asymptotic length or L – infinity, K is the curvature parameter or coefficient of growth; t is age t (certain age) inputted for which its corresponding length is to be determined and $t_o$ is age at zero length, that is age when the fish has zero length. $L_\infty$ is biologically regarded as the length of fish if it were to grow forever or practically the largest attainable length. K is the rate at which the fish grows to attain $L_\infty$.

**Total Mortality Rate (Z)**

Total mortality (Z) is obtained according to the empirical formula developed in this work as:
$Z = K (2.1053 * U - 1.9) / (U - 1)$ (10)

Where
$U = L_{max} / L_{min}$ (11)

And $L_{max}$ is maximum length of fish in the sample while $L_{min}$ is minimum length of fish in the sample; K is growth coefficient of VBGM

**Natural Mortality Rate (M)**

Natural mortality of *A. nurse* in the dam was determined according to the method of Cubillos (2003).
$M = (3K (1-w))/w$ (12)

Where M is the Natural mortality rate, K is growth coefficient and w is ratio of optimum length to asymptotic length and equals 0.62 for all species of fish, therefore, Cubillos' model for estimating natural mortality rate becomes:
$M = 1.8387K$ approximately (13)

**Fishing Mortality Rate (F)**

$F = Z – M$ (14)

**Exploitation Rate (E)**

$E = F/ Z$ (15)

**Growth Coefficient (K) and Asymptotic Length ($L_\infty$) of *A. nurse***

Growth coefficient (K) of *A. nurse* in Gubi dam was obtained by using Cubillos – Pauly Growth Coefficient Model (CPKM) by (Abdulkarim et al., 2009) and further simplified in this paper as below:
$K = 0.1576T^{1.339} / L_{max}^{0.807}$ (16)

Where T is the annual average environmental temperature of the water measured in degrees Celsius - $^0C$) and $L_{max}$ is fish with maximum length in the sample.

The Pauly Length Asymptotic Model (PALM) by Pauly (1983) was used to determine the asymptotic length of *Alestes nurse:*
$L_\infty = L_{max} / 0.95$ (17)

Where: $L_\infty$ is the asymptotic length, $L_{max}$ is maximum length of fish among the fish sample.

**Change in Length (from L1 to L2) per Time Unit**

$\Delta L/\Delta t = K (L_\infty - L_t)$ cm/ year (Sparre and Venema, 1998) (18)

Where ΔL is change in length from L1 (*i. e.* length at previous age) to L2 (*i.e.* length at another higher age than the previous) while Δt is the corresponding period of time taken for the change in the length. The only inputs required are current length of the fish at a specific age t, $L_t$ and $L_\infty$

**Weight Based Von Bertalanffy Growth Model and Asymptotic Weight ($W_\infty$)**

The weight based Von Bertalanffy Model is used for finding weight at specific age of *A. nurse*:
$W_t = W_\infty * [1 – \exp (- K * (t – t_o))]^3$ (19)

Where $W_t$ is the weight of the fish at certain age and $W_\infty$ is the asymptotic weight which was determined using model of Abdulkarim et al. (2009):
$W_\infty = (W_{max} / L_{max}) * L_\infty^3$ (20)

Where: $W_{max}$ is the weight of fish with the maximum length ($L_{max}$) among the fish sample.

Equation 20 was found to give similar result as Pauly Asymptotic Weight Model (PAWM) provided $L_\infty$ is determined using PALM (Eq.17):
$W_\infty = W_{max} / 0.86$ (21)

**Inverse Von Bertalanffy Growth Model (IVBGM)**

The IVBGM was used to determine the age at specific length of *Alestes nurse* for ages of optimum age ($t_{opt}$); age at first spawning or at maturity ($t_m$); age at first capture ($t_{min}$) and age at recruitment ($t_r$) of their corresponding optimum length ($L_{opt}$); length at first spawning or at maturity ($L_m$); length at first capture ($L_{min}$) and length at recruitment ($L_r$) respectively. The equation is
$t_L = t_o – (1/K) [\ln (1 – L/L_\infty)]$ (22)

Where $t_o = 0$

**Determination of Optimum Length ($L_{opt}$)**

$L_{opt}$ (cm) was obtained following the method described by Beverton (1992):
$L_{opt} = L_\infty * [3 / (3+M/K)]$ (23)

Eq. 23 was further deduced and simplified in this work as Beverton – Cubillos – Pauly Model (BCPM) for optimum length:
$L_{opt} = L_{max} / 1.53$ (24)

Alternatively, as Beverton – Cubillos Model (BCM) for optimum length:
$L_{opt} = 0.62 L_\infty$ (25)

**Determination of Length at First Spawning or at Maturity ($L_m$)**

Based on the suggestion of Beverton and Holt (1959) $L_m$

was determined using:
$L_m = (2 * L_\infty) / 3$ (26)

Eq. 26 was also simplified as Beverton – Holt – Pauly Model (BHPM) of length at first spawning:
$L_m = L_{max} / 1.425$ (27)

**Determination of Growth Performance Index (ϕ)**

Growth performance index (ϕ) was determined according to the model of Pauly (1979):
$\phi = \text{Log } K + 2 \text{ Log } L_\infty$ (28)

**Determination of Life Span ($t_{max}$)**

Life span or Maximum age shall be determined using model of Pauly (1980):
$t_{max} = t_o + (3/K) = 3/K$ approximately ($t_o = 0$) (29)

**Determination of Stock Status Parameters of *Alestes nurse***

**Determination of Maximum Sustainable Yield (MSY)**

MSY was estimated using model of Cadima (in Troadec, 1977) and suggestion of Beddington and Coke (1983) to derive Beddington – Cadima – Cooke Model (BCCM) used in Abdulkarim et al. (2009) as further simplified in this work as below:
$MSY = Y^* [0.2 + (M/Z)]$ (30)

Where Y is annual yield (in weight – g, kg or tons); M is Natural Mortality and Z is Total Mortality

**Determination of Annual Yield (Y)**

Annual yield (Y) was estimated using the formula below:
$Y = \Sigma$ (CPUE * f * Total days in a month) (31)
Where CPUE is Catch per Unit Effort measurable in weight of fish generally or in number of fish for artisan fisheries; f is effort measured in this work as man-days. In this work, CPUE was observed and estimated for each month while effort was observed and estimated to be constant per day for all months within a season but vary between seasons (dry and wet).

**Determination of Effort for Maximum Sustainable Yield ($f_{MSY}$)**

$f_{MSY}$ was estimated using a deduced model as below:
$f_{MSY} = 0.2f_A / E$ (32)
Where $f_A$ is annual efforts and E is current exploitation rate (obtainable from Eq.15)

**Determination of Mean annual Biomass (B)**

Mean Annual Biomass was estimated using Beverton – Holt Model (BHM); Beverton – Holt (1957):
$B = Y / F$ (33)

Where Y is annual yield and F is fishing Mortality

**Determination of Intrinsic Rate of Population Increase ($r_m$) and Maximum Biomass ($B_\infty$)**

$r_m$ was determined using model of Ricker (1975):
$r_m = 2^* F_{MSY}$ (34)

Eq. 34 is further deduced in this work as $r_m = 0.4Z$ (35)

Where Z is total mortality and $F_{MSY} = 0.2Z$ (36)

$B_\infty$ was determined from model of Ricker (1975):
$MSY = r_m * B_\infty / 4$ (37)

Eq. 37 is further simplified as
$B_\infty = (10Y/Z) * [0.2 + (M/Z)]$ (38)

**Determination of Biomass per Recruit (B/R), Yield per Recruit (Y/R) and Recruit (R)**

B/R was determined using model of Beverton and Holt (1957):
$B/R = (Y/R) * (1/F)$ (39)

Where Y/R is yield per recruit and F is fishing mortality
Y/R was determined from a simplified model of Beverton and Holt (1957) in combination with models of Cubillos (2003) and Pauly (1983) as backed up by some generalized assumptions about Length at recruitment ($L_r$) giving rise to a form called ABC – DU yield per recruit model (ABC – DU Y/R Model):
$Y/R = A * B * (C - 1.8387) * (W_{max} / 0.86)$ (40)

Where
$A = [(U - 0.95) / (U - 0.475)]^{1.839}$ (41)

$B = (1/ C) - (3D/C + 1) + (3D^2/ C + 2) - (D^3/ C + 3)$ (42)

$C = Z/K = (2.1053U - 1.9) / (U - 1)$ (43)

$D = 1 - (0.95 / U)$ (44)

$U = L_{max} / L_{min}$ as in Eq. 11
Recruit was determined using the model below
$R = Y/ (Y/R)$ (45)

**Determination of Net Reproductive Rate ($R_o$) of the Population, Maximum Recruit ($R_\infty$) and Overfished Recovery Period ($t_d$)**

It is worthy of note that to the best of the authors' knowledge $R_o$ and $R_\infty$ are concepts newly introduced to stock assessment by the authors during the course of this work and were determined using the following models:
$R_o = \exp(0.4Z * t_m)$ (46)

**Table 1**. Annual Yield (in number) from Monthly catches of *Alestes nurse* in Gubi Dam (August, 2007 – July, 2008)

| Month | Catch Per Unit Effort (CPUE) | Effort (f) Per Day | Catches per Month (CPUE * f * Total Days in a Month) |
|---|---|---|---|
| August | 360 | 250 | 2,790,000 |
| September | 15 | 250 | 112,500 |
| October | 25 | 40 | 31,000 |
| November | 44 | 40 | 52,800 |
| December | 924 | 40 | 1,145,760 |
| January | 65 | 40 | 80,600 |
| February | 260 | 40 | 291,200 |
| March | 243 | 40 | 301,320 |
| April | 399 | 145 | 11,970 |
| May | 796 | 250 | 6,169,000 |
| June | 1997 | 250 | 14,977,500 |
| July | 1256 | 250 | 9,734,000 |
| **Annual Yield** | | | **35,697,650** |

**Table 2**. Sample of Length - frequencies of *A. nurse* in Gubi Dam, Adjusted for Gear Selectivity Using Selection Ogive Curve: L∞ = 20 cm; K = 1.21 per year; t0.5 = 0.90 year and to = 0 year.

| L1 – L2 (cm) | (L1 + L2)/2 (cm) | tL (year) | C(L1, L2) Sample | Selection Estimated (St. Est.) | C(L1, L2) Adjusted |
|---|---|---|---|---|---|
| 7 – 9 | 8 | 0.42 | 29,838 | 0.13 | 229,523 |
| 9 – 11 | 10 | 0.57 | 54,224 | 0.21 | 258,210 |
| 11 – 13 | 12 | 0.76 | 395,801 | 0.36 | 1,099,447 |
| 13 – 15 | 14 | 1.00 | 111,143 | 0.60 | 185,238 |
| 15 – 17 | 16 | 1.33 | 13,541 | 0.85 | 130,756 |
| 17 – 19 | 18 | 1.90 | 2,696 | 0.98 | 2,751 |
| 19 – 20 | 19 | 2.48 | 5,453 | 1.00 | 5453 |
| **Total** | | | **612,696** | | **1,911,378** |

Where Z is total mortality and $t_m$ is age at first spawning corresponding to $L_m$

$R_\infty = R / \exp[- M (t_r – t_o)]$ (47)

Where R is recruit, M is natural mortality, $t_r$ is age at recruitment corresponding to $L_r$ and $t_o$ is age at zero length, here, it is presumed to be zero (that is, $t_o = 0$). However, the generalized assumption regarding $L_r$ as shall be discussed is

$L_r = 0.5L_{min}$ (48)

$t_d = \ln 2 / r_m$ (49)

Where $t_d$ is the period of time for an overfished stock to double its biomass if fishing is stopped (Ricker, 1975).

## RESULTS AND DISCUSSION

Despite the relative constancy of efforts per day with 250 man days for months in rainy season and 40 mandays for months in dry season and an average of 145 in April: CPUE varies from month to month with lowest of 15 CPUE in September probably due to high effort while the month is the end of wet season and highest of 1997 CPUE was observed in the month of June which is usually the peak month of raining (Table 1).

St. Est. = 1/ [1 + exp (3.6 – 4t)] (Table 2): It has been observed that using the empirical method in this work for estimation of selection ogive curve for Gear Selectivity, usually $T_2 = 4$ (constantly), therefore, $T_1 = 4t_{0.5}$ (from Eq. 06), so that, $T_1$ will be varying with the value of $t_{0.5}$ for St. Est. for different stock of fish. Table 2 shows that the initial sample (612,696) was biased by 67.94% compared to the adjusted value (1,911,378) due to the gill net used in catching the fish. The highest biasness came from smallest range of length (7- 8 cm) as many will escape uncaught while the St. Est. shows that all fish of highest length range are retained in the net when caught, hence, the sample of such lengths is unbiased. However, it is worthy of note that the adjustment was made to make the sample truly a normal distribution statistically so as to reflect randomness in the collected length- frequencies data as demonstrated by Sparre and Venema (1998).

The percentages of unbiased adjusted Length-frequencies from Table 2 are used to raise the sample length-frequencies to annual catches in number (Table 3). The $L_{opt}$ and $L_m$ (Table 7) falls within the length class with the highest frequency indicating a tendency (but most probably

**Table 3**. Raised Length – frequencies From Adjusted Samples (A.S.) of *A. nurse* in Gubi Dam to Annual Catches (A.C.)

| L1 – L2 (cm) | (L1 + L2)/2 (cm) | $t_L$ (year) | C(L1, L2) Adjusted Sample(A.S.) | C(L1, L2) Percentage of A.S. | C(L1, L2) A.C.(in Number) |
|---|---|---|---|---|---|
| 7 – 9 | 8 | 0.42 | 229,523 | 12.01 | 4,287,288 |
| 9 – 11 | 10 | 0.57 | 258,210 | 13.51 | 4,822,753 |
| 11 – 13 | 12 | 0.76 | 1,099,447 | 57.52 | 20,533,288 |
| 13 – 15 | 14 | 1.00 | 185,238 | 9.69 | 3,459,102 |
| 15 – 17 | 16 | 1.33 | 130,756 | 6.84 | 2,441,719 |
| 17 – 19 | 18 | 1.90 | 2,751 | 0.14 | 49,977 |
| 19 – 20 | 19 | 2.48 | 5453 | 0.29 | 103,523 |
| **Total** | | | **1,911,378** | **100** | **35,697,650** |

**Table 4**. Mid – length, Age, Corresponding Weight, Annual Catches (A.C.) (in Number) and Annual yield (grams) of *A. nurse* in Gubi Dam

| L1 – L2(cm) | (L1 + L2)/2(cm) | $t_L$(year) | $W_t$(g) | C(L1, L2)A. C. | C * $W_t$( g) |
|---|---|---|---|---|---|
| 7 – 9 | 8 | 0.42 | 5.07 | 4,287,288 | 21,736,550.16 |
| 9 – 11 | 10 | 0.57 | 9.93 | 4,822,753 | 47,889,937.29 |
| 11 – 13 | 12 | 0.76 | 17.44 | 20,533,288 | 358,100,542.70 |
| 13 – 15 | 14 | 1.00 | 27.73 | 3,459,102 | 95,920,898.46 |
| 15 – 17 | 16 | 1.33 | 41.07 | 2,441,719 | 100,281,399.30 |
| 17 – 19 | 18 | 1.90 | 58.42 | 49,977 | 2,919,656.34 |
| 19 – 20 | 19 | 2.48 | 68.84 | 103,523 | 7,126,523.32 |
| **Total** | | | | **35,697,650** | **627,561,636.30** |

**Table 5.** Age, Corresponding Length and the Growth Rate of *A. nurse* in Gubi Dam

| Age(Month) | Corresponding Length(cm) | Growth Rate(ΔL / Δt cm/Month) |
|---|---|---|
| 4 | 6.85 | 1.33 |
| 8 | 11.11 | 0.90 |
| 12 | 14.04 | 0.60 |
| 16 | 16.00 | 0.40 |
| 20 | 17.35 | 0.27 |
| 24 | 18.22 | 0.18 |
| 28 | 18.81 | 0.12 |
| 32 | 19.21 | 0.08 |

unknown to the artisan fishermen) and the fisheries management is optimising its catches to have higher possible yield per catch according to Beverton (1992) who suggested that fisheries managers could obtain possible higher yield if they adjust their catches to be between $L_{opt}$ and $L_m$.

Estimates of annual catches in weight (grams) by using the weight version of VBGM to estimate the corresponding weights of mid-lengths with the ages as the main inputs is presented in Table 4. The highest yield comes from the length class of 11 – 13 cm where $L_{opt}$ and $L_m$ fall.

Table 5 shows that, though fish grow, their growth rate decreases as they get closer to the highest attainable size in the population ($L_\infty$) as indicated above where at four month of age a fish can grow at the high rate of 1.33 cm per month while when the fish is 32 months old, they grow at the low rate of 0.08 cm per month.

From Table 6, it can be observed that the Y is yet to attain MSY; however, by increasing $f_A$ by 17.65% it will attain MSY. Though Gulland (1971) referred to optimally exploited stock should have E = 0.5 but Beddington and Cooke (1983) showed an overestimation of MSY in that work. Hence, $E_{opt}$ = 0.2 (from Eq. 36) in this work is considered to be an optimum exploitation rate and the current exploitation rate (E= 0.17) is close to $E_{opt}$.

$B_\infty$ is considered as the Maximum Biomass of the population of fish that an ecosystem can support and it is usually corresponding to an unfished stock (Ricker, 1975). Hence in this case, Gubi dam can support *Alestes nurse* population to a maximum extent. R is the number of fish recruited based on the present Y while $R_\infty$ introduced in this work could be considered as number of survivors hatched on the Birth day if the Y is considered homogenously as a cohort. Hence, it could be used for empirical cohort analysis of the stock. According to Musick (1999), $r_m$ is a measure of fish stock population productivity / resilience to exploitation whereby $r_m$ value of > 0.50; 0.16 – 0.50; 0.05 – 0.15 and < 0.05 classifies stock

**Table 6.** Stock Status of *Alestes nurse in* Gubi Dam (August, 2007 – July, 2008)

| Parameters | Value |
|---|---|
| Yield per Recruit (Y/R) | 1.84g/R |
| Biomass per Recruit (B/R) | 3.91g/R |
| Annual Biological Yield (Y) | 627,561,636.30 g |
| Mean Annual Biomass (B) | 1,335,237,524 g |
| Maximum Biomass ($B_\infty$) | 2,402,931,172 g |
| Recruit (R) | 341,066,107 Per year |
| Maximum Recruit ($R_\infty$) | 487,237,296 Per year |
| Intrinsic Rate of Population Increase ($r_m$) | 1.08 per year |
| Net Reproductive Rate ($R_o$) | 2.64 |
| Current Effort ($f_A$) | 49.880 Man days |
| Effort for Maximum Sustainable Yield ($f_{MSY}$) | 58,682 Man days |
| Maximum Sustainable Yield (MSY) | 646,388,485.40 g |
| Exploitation Rate (E) | 0.17 |
| Overfishing Recovery Period ($t_d$) | 0.64 years (7.68 months) |

**Table 7.** Population Parameters of *Alestes nurse in* Gubi dam

| Parameters | Value |
|---|---|
| Maximum Length Caught ($L_{max}$) | 19cm |
| Minimum Length Caught ($L_{min}$) | 7cm |
| Length at recruit ($L_r$) | 3.5 cm |
| Asymptotic Length ($L_\infty$) | 20 cm |
| Length at Maturity ($L_m$) | 13.3 cm |
| Optimum Length ($L_{opt}$) | 12.4 cm |
| Asymptotic Weight ($W_\infty$) | 80.23 g |
| Growth Performance Index ($\phi$) | 2.68 cm per year |
| Growth Coefficient or Curvature (K) | 1.21 per year |
| Natural Mortality Rate (M) | 2.22 per year |
| Total Mortality Rate (Z) | 2.69 per year |
| Fishing Mortality Rate (F) | 0.47 per year |
| Fishing Mortality Rate for MSY ($F_{MSY}$) | 0.54 per year |
| Age at Maturity ($t_m$) | 0.90 year |
| Age at First Capture ($t_{min}$) | 0.36 years |
| Age at Optimum Size ($t_{opt}$) | 0.80 year |
| Age at Recruit ($t_r$) | 0.16 year |
| Life Span ($t_{max}$) | 2.48 years |

population to have High (Hi); Medium (Md.); Low (Lo) and Very Low (VL) Resilience/Productivity respectively based on convention of American Fisheries Society (AFS). From Table 6: $r_m$=1.08 which indicates that the population of *Alestes nurse* in Gubi dam is highly resilient/productive.

$R_o$ introduced in this research work measures net reproductive rate of a population in population ecology and is hereby extended to stock assessment. If $R_o < 1$ it indicates that the population is decreasing; if $R_o$= 1 it indicates that, the population is stagnant: neither increasing nor decreasing and if $R_o > 1$ it indicates that the population is increasing. As for the stock assessed in this work: $R_o$ = 2.64 which indicates that population of *Alestes nurse* in Gubi dam is increasing considerably.

Population parameters that are inputs for determining stock status were presented in Table 7. Test of validity of estimate of natural mortality is M/K ratio which Beverton and Holt (1959) recommended to be within the range of 1.5 to 2.5 and Cubillos empirical method for estimating the is M/K =1.84 (Eq. 13), therefore, both the value of M obtained and the use of the ratio in simplification of related models such as in ABC – DU Y/R MODEL are expected to give reliable outputs.

Also, the values of K, $t_m$ and $t_{max}$ are indicators of resilience/productivity of a fish population which according to Musick (1999), K value >0.30; 0.16 – 0.30; 0.05 – 0.15 and < 0.05 indicate Hi; Md.; Lo and VL; $t_m$ value < 1; 2 – 4; 5 – 10 and > 10 indicate Hi; Md.; Lo and VL while $t_{max}$ value 1 – 3; 4 – 10; 11 – 30 and > 30 indicate Hi; Md.; Lo and VL resilience/productivity respectively. In this work, K, $t_m$ and $t_{max}$ are 1.21 per year, 0.9 years and 2.48 years respectively and all values indicate that *A. nurse* population in Gubi dam were highly resilient and productive. Froese et al. (2005) made a comment that the method for estimating $r_m$ is not reliable, however, this is arguable to some extent for the value of $r_m$ obtained in this research serves as an indicator of high resilience and productivity of the stock just as for the values of K, $t_m$ and $t_{max}$ that are reliably estimated serve as similar indicators.

Finally, it is a fact that length at first capture in a population of fish is a function of gear size use in fishing and the probability of the fish to come to the fishing ground during fishing period, therefore, $L_r$ cannot be determined with certainty. However, it is certain that it will be within zero length to $L_{min}$ so it is rational that $L_r = (0 + L_{min}) / 2 = 0.5L_{min}$ that is, average range of length is deemed to be Length at recruitment, $L_r$.

## Conclusion

It is established that fish *Alestes nurse* have high growth rate and highly resilience and productive in Gubi dam. The fish is still underexploited in the dam. Fishermen operating in the dam should be encouraged to catch more fish of that species in the dam to attain maximum sustainable yield at effort of 58,682 man days per year.

## REFERENCES

Abdulkarim M, Bununu K, Mohammed A (2005). Fish and Fisheries of Gubi Dam, Ganjuwa Local Government Area, Bauchi. J. League of Researchers in Nigeria 7 (1): 7 – 12.

Abdulkarim M, Yusuf ZA, Musa BL and Ezra AG (2009). Population Parameters of *Clarias gariepinus* (Cat fish) in Gubi dam, Bauchi State, Nigeria. J. Animal and Plant Sci. 5(2): 531 – 538.

Anon (2005). Bauchi State Economic Empowerment and Development Strategy (BASEEDS, 2005 – 2007) pp. 66 – 70.

Beddington JR, Cooke JG (1983). The Potential yield of fish stocks. FAO Fish. Tech. Pap. (242): 47 p.

Beverton RJH (1992). Patterns of reproductive strategy parameters in some marine teleost fishes. J. Fish Biol. 41(B):137-160.

Beverton RJH, Holt SJ (1957). On the dynamics of exploited fish populations. Fish. Invest. Ser. II. Vol. 19, 533 p.

Beverton RJH, Holt SJ (1959). A Review of the Life Spans and Mortality Rates of Fish in Nature, and Their Relation to Growth and other Physiological Characteristics. Pp.142 – 180 in:Wolstenholme GEW, Connor MO (Eds.) CIBA Foundation,Colloquia on Ageing. The Lifespan of Animals. Vol.5. London, Churchill.

Bunn SE, Arthington AH (2002). Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. Environmental Management. 41: 333-346.Crossref

Cubillos LA (2003). An approach to estimate the natural mortality rate in fish stocks. NAGA. World-fish centre. 26 (1): 17 – 19.

Froese R, Palomares MLD, Pauly D (2005). Estimation of Life-History Key Facts. Retrieved April 12, 20013 from: http://www.fishbase.us/manual/key%2520facts.htm

Gulland JA (1971). The fish resources of the ocean. West By fleet, surrey, fishing News Books), Ltd., for FAO, 255 p. revised ed. of FAO fish. Tech. Pap. 97: 425 p

Musick JA (1999). Criteria to define extinction risk in marine fishes. Fisheries 24(12):6-14. Crossref

Pauly D (1983). Editorial Fishbyte Section: Naga, the ICLARM Quarterly. Vol.16 No. 2 -3: P36

Pauly D (1979). Theory and management of tropical multispecies stocks: a review with emphasis on the Southeast Asian demersal fisheries. ICLARM Stud. Rev., 1: 35p.

Pauly D (1980). On the interrelationship between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J. Cons. CIEM, 39(2): 175 – 192.Crossref

Ricker WE (1975). Computation and interpretation of biological statistics of fish populations. Bull. fish. Res. Board Can. 191:1-382.

Sparre P, Venema SC (1998). Introduction to tropical fish assessment. Part 1 manual FAO Fisheries Technical Paper. No.306: 1 Rev. 2 Rome. pp 1 – 407.

Troadec JP (1977). Méthodes semi-quantitative d'évaluation. FAO Circ. Peches. (701): 131 – 141.

Welcome RL (2003). River fisheries in Africa: their relation to flow regimes. NAGA, Worldfish centre quarterly. 26(3): 22 - 23.