E-ISSN: 2708-0021
P-ISSN: 2708-0013
www.actajournal.com
AEZ 2021; 2(1): 19-23
Received: 18-10-2020
Accepted: 12-12-2020

Alvin T Reyes
Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines

Lorenz J Fajardo
Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines

Darel P Saludo
Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines

Corresponding Author:
Alvin T Reyes
Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines

Assessment of some biological aspects of yellowfin tuna (*Thunnus albacares*) in Dilasag bay, Dilasag, Aurora, Philippines

Alvin T Reyes, Lorenz J Fajardo and Darel P Saludo

DOI: https://doi.org/10.33545/27080013.2021.v2.i1a.25

Abstract
The study was conducted to assess the biological aspects of yellowfin tuna (*Thunnus albacares*) caught using hook and line in Dilasag Bay, Dilasag, Aurora, Philippines from July to September 2019. A total of 283 yellowfin tuna (total weight of 12,231.53 kg) was caught in Dilasag Bay by the 10 municipal fishermen in their 283 fishing trips. Large size yellowfin tuna (>110 cm) were commonly caught in Dilasag Bay. The monthly and combined growth data of the fish was described as negative allometric (b <3); the organism grows slender, so it gains length faster than weight. The length-weight relationship equation for the combined catches was $W = 2.240\ L^{1.129}$. The over-all value of condition factor (K), growth rate constant (k) and maximum length ($L\infty$) of yellowfin tuna were 1.88±0.12, 0.157 kg/year and 145.117 cm, respectively.

Keywords: *Thunnus albacares*, length-weight relationship, condition factor, allometric growth

1. Introduction

Tunas are widely distributed in temperate and tropical waters throughout the world, between about 45° north and south of the equator and are broadly classified either coastal, neritic or oceanic species. They are grouped under the family Scombridae, which consists of about 50 species, and forms the third largest product in the international seafood trade with almost 10% of the total trade in value terms [1]. In the Philippines, 21 species of tuna have been recorded but only six are caught in commercial quantity. Of the six species, only four form the bulk of catches and are listed in Philippine fisheries catch statistics, namely: yellowfin (*Thunnus albacares*), skipjack (*Katsuwonus pelamis*), eastern little tuna (*Euthynnus affinis*) and frigate tuna (*Auxis thazard*) [2].

The decline or collapse of tuna species could result to drastic social and economic consequences in some fisheries dependent countries such as Philippines. While these ecologically and economically important species continue to decline, large scale patterns of abundance and diversity that are so essential to effective conservation are relatively poorly understood [3]. Tunas as transboundary stocks make information-gathering expensive and time-consuming. Consequently, most of the information on these species comes from exploited fisheries data, which may be biased, inaccurate or lacking in quality. The issue is compounded by under- and over reporting of catches by countries reporting to the Food and Agriculture Organization (FAO) of the United Nations [3].

Scientific advice on fisheries management is generally based on the results of the application of some stock assessment techniques. Stock assessment usually involves estimating the limits of some form of population dynamics model by fitting it to research and monitoring data, and using the results of the fitting process to estimate quantities that are of interest to decision makers [4]. Several approaches are often used to determine the age and growth of the aquatic species, such as length-frequency analyses, tagging and recapture experiments and observations of the mark on the hard parts (scales, otoliths, spines and vertebrates) [5]. Particular morphometric measurements, such as length-weight relationship, are useful in fishery management and stock assessment models [6], and has been widely used in the environmental monitoring programs such as calculation of fish weight at a certain length and the conversion of an equation of growth in weight and vice versa, as well as the calculation of a condition index to allow for morphological comparisons of populations among different regions [7].

The collapse of tuna industry could result to drastic social and economic consequences in a particular country. Management of tuna and large pelagic fishes in the Philippines is hindered by inadequate statistical baseline information (catch and effort data) and biological information despite the three major tuna research programs (FAO and Bureau of Fisheries and Aquatic Resources (BFAR) Tuna Research Program, Regional Tuna Tagging Program and Philippine Tuna Research Project).

Sustained efforts to gather information on the reproductive biology, migration, growth, abundance and distribution of tuna in traditional and non-traditional fishing grounds are needed [2].

The general objective of this study was to assess some biological aspects of yellowfin tuna (*T. albacares*) caught using hook and line in Dilasag Bay, Dilasag, Aurora, Philippines. Specifically, the study aimed to: (1) determine the length-weight relationship and condition factor (K); (2) create a length-frequency and weight-frequency distribution; (3) estimate the asymptotic length (L∞) and growth rate constant (k); and (4) compute for catch per unit effort (CPUE).

2. Materials and Methods

2.1 Collection of samples

A courtesy call was made in the Fisheries Section of the Department of Agriculture in Dilasag, Aurora, Philippines to ask for existing secondary data on yellowfin tuna (*T. albacares*) catches in Dilasag Bay, Dilasag, Aurora, Philippines.

There were no records of catches of yellowfin tuna in Dilasag Bay, thus, the authors conducted their own data collection with the help of municipal fishermen that operate hook and line in the said area. The ten (10) municipal fishermen were oriented first before officially included as part of the study.

2.1 Data gathered

Every after-fishing operation, each fisherman was tasked to measure the fork length and weight of caught yellowfin tuna.

Time spent in fishing was recorded also. To ensure proper recording of data, each fisherman was provided with a notebook. The researcher collated the records in a weekly basis.

2.1.1 Length-frequency and weight-frequency distribution

The fork length or weight was graphed against the observed frequency of each particular length or weight.

2.1.2 Catch per unit effort (CPUE)

CPUE was expressed as catch per hour spent fishing (kg/hr).

2.1.3 Length-weight relationship

The length and corresponding weight of caught tuna in three months' period was tabulated. The relationship between fork length (L, cm) and wet weight (W, g) was calculated by power regression $W = a \times L^b$ (a = intercept of the regression curve and b = regression coefficient).

The degree of association between L and W was calculated by the relation coefficient (r^2). In the length-weight relationship, value of exponent b provides information on fish growth. When $b = 3$, the increase in weight is isometric. The increase of weight is positive allometric if $b > 3$, while the increase of weight is negative allometric if $b < 3$ [8].

2.1.4 Condition factor

The condition factor (K) was calculated from the relationship, $K = 100W/L^3$, where W = weight (g) and L = fork length (cm) [9].

2.1.5 Asymptotic length (L∞) and growth rate constant (k)

Using the length-frequency distribution, the L_t (length at particular time) and $L_t + 1$ (length after one year) were deduced. L_t was plotted against $L_t + 1$ in order to get the value of a and b. Using Ford Walford equation, asymptotic length (L∞) and growth rate (k) were computed using the formula, $L\infty = a/1\text{-}b$ and $k = -\ln b$, respectively.

2.2 Statistical analysis

Statistical difference in monthly condition factor and CPUE was determined using One-way Analysis of Variance.

3. Results and Discussion

3.1 Length-frequency and weight-frequency distribution

The length of the caught yellowfin tuna ranged from 120 to 145 cm. Length-frequency distribution revealed that the top three dominant sizes were 125 to 130 cm, 135 to 140 cm and 130 to 135 cm (Figure 1a). Meanwhile, the weight of caught yellowfin tuna ranged from 38 to 50 kg wherein the top three dominant weights were 42 to 44 kg, 40 to 42 kg and 44 to 46 kg (Figure 1b).

With respect to the stock structure in the western Pacific, it was noticed in the Philippine fisheries, one of the most diverse and substantial yellowfin fisheries in the world, that both very small fish from 15 to 60 cm and large fish over 110 cm are common, but that middle-sized fish between 60 to 110 cm are relatively scarce [10].

In this present study, large size yellowfin tuna (over 110 cm) were only caught in Dilasag Bay.

In a catch survey of yellowfin tuna in the municipalities of Masinloc, Sta. Cruz, Palauig and Candelaria, Zambales, Philippines from June to October 2018 and February 2019, the authors found out that the length ranged from 17 to 50 cm with size 45 cm as the most frequent. In the same study, three cohort groups were observed namely 17 to 30 cm, 30 to 39 cm and 39 to 50 cm [11].

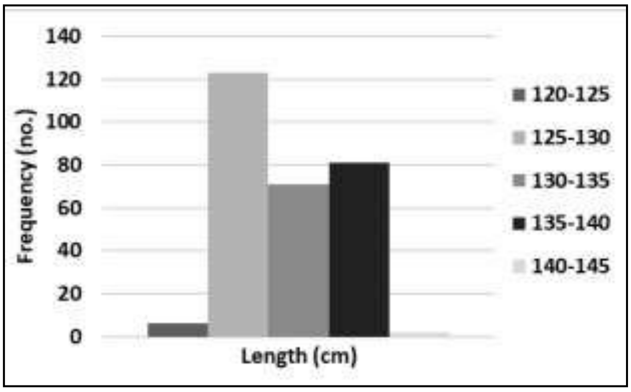

Fig 1a: Length-frequency distribution of yellowfin tuna (*Thunnus albacares*) caught in Dilasag Bay, Dilasag, Aurora, Philippines using hook and line from July to September 2019

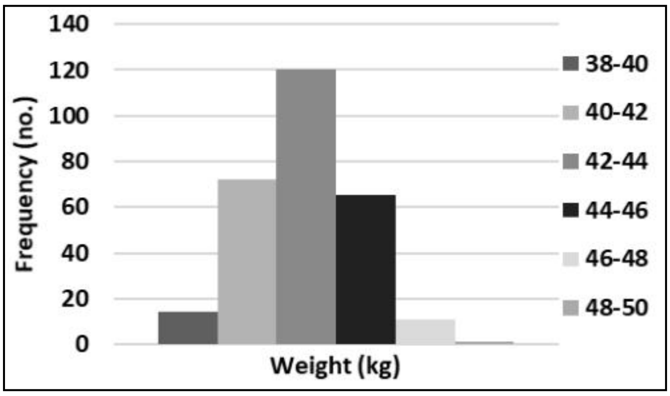

Fig 1b: Weight-frequency distribution of yellowfin tuna (*Thunnus albacares*) caught in Dilasag Bay, Dilasag, Aurora, Philippines using hook and line from July to September 2019

3.2 Length-weight relationship and condition factor

As provided in Table 1, yellowfin tuna caught from July to August 2019 and the combined (over-all) catches showed very strong association between length and weight; this was reflected for having value of r from 0.80 to 0.99 (July = 0.864, August = 0.929, September = 0.884, over-all = 0.892). On the other hand, the value of b ranged from 1.082 to 1.165. In the length-weight relationship, value of exponent b provides information on fish growth: b <3 is said to be negative allometric, b = 3 is isometric and b >3 is positive allometric [8]. Isometric growth means that as the organism grows, there is no change on the body shape, and that the weight is increasing as the cube of length. Negative allometric means that the organism grows slender, so it gains length faster than weight; while positive allometric means that the organism becomes stouter as it increases in length, so it gains weight faster than length [8]. The monthly and combined (over-all) data showed that the growth of yellowfin tuna in Dilasag Bay, Dilasag, Aurora, Philippines was described as negative allometric (Table 1). In the study of Alberto and Reyes [11], the LW association of yellowfin tuna caught in Zambales, Philippines was very strong, with r value of 0.90. The growth of yellowfin tuna in Zambales was also described as negative allometric because the computed b was less than 3 (b = 2.22).

The length-weight relationship equation of July catches was $W = 2.297\ L^{1.102}$, $W = 2.162\ L^{1.165}$ for August, $W = 2.340\ L^{1.082}$ for September and $W = 2.240\ L^{1.129}$ for combined or over-all catches. In the study of Alberto and Reyes [11], the computed length-weight relationship equation of yellowfin tuna in Zambales, Philippines was $W = 0.62\ L^{2.227}$. This length-weight relationship equation is needed to understand the relationship of length of the fish to its given weight and to understand the relationship of weight of the fish to its given length.

The highest condition factor (K) was recorded during September (K = 1.91±0.12) but this was not significantly higher as compared to July (1.87±0.13) and August (1.88±0.12). The over-all K value of yellowfin tuna caught in Dilasag Bay was 1.88±0.12 (Table 1). The value of K can be interpreted as differences in fatness, abundance of food and gonad development [12].

Table 1: Equation parameters of length-weight relationship and condition factor of yellow fin tuna (*Thunnus albacares*) caught in Dilasag Bay, Dilasag, Aurora, Philippines using hook and line from July to September 2019.

	r^2	r	a	b	LWR Equation	K
July	0.748	0.864	2.297	1.102	$W = 2.297\ L^{1.102}$	$1.87{\pm}0.13^{a}$
August	0.834	0.929	2.162	1.165	$W = 2.162\ L^{1.165}$	$1.88{\pm}0.12^{a}$
September	0.782	0.884	2.340	1.082	$W = 2.340\ L^{1.082}$	$1.91{\pm}0.12^{a}$
Over-all	0.796	0.892	2.240	1.129	$W = 2.240\ L^{1.129}$	1.88±0.12

3.3 Asymptotic length (L∞) and growth rate constant (k)

The generated over-all length-frequency distribution of yellowfin tuna (Figure 1) was used for the estimation of growth curvature (k) and asymptotic length (L∞) following the formula of Ford-Walford. The length at particular time (Lt) and length after one year (Lt + 1) were inferred from the length-frequency distribution of the fish. Lt was plotted in the X-axis while Lt + 1 was plotted in the Y-axis to generate the equation of the line using trendline analysis in MS Excel. Yellowfin tuna caught in Dilasag Bay had k value of 0.157 kg/year and L∞ value of 145.117 cm. The computed values were open for changes as additional data become available. Yellowfin tuna in Zambales waters had k value of 0.41 cm/year and L∞ value of 56.89 cm (Alberto & Reyes, unpublished). According to some authors, the maximum length and weight of unsexed yellowfin tuna is 239 cm and 200 kg, respectively [13, 14].

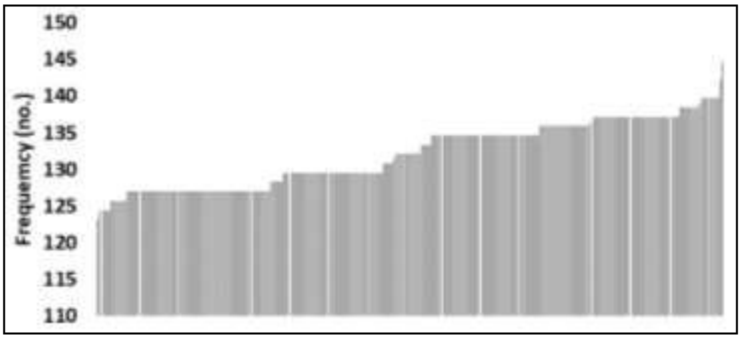

Fig 1: Length-frequency distribution of yellowfin tuna (*Thunnus albacares*) caught in Dilasag Bay, Dilasag, Aurora, Philippines using hook and line from July to September 2019

3.4 Catch per unit effort (CPUE)

A total of 283 yellowfin tuna (total weight of 12,231.53 kg) was caught in Dilasag Bay, Dilasag, Aurora, Philippines from July to September 2019 using hook and line. The 10 municipal fishermen have completed 283 fishing trips, 91 were made in July, 140 in August and 52 in September. The average weight of caught yellowfin tuna was 43.22±0.18 kg with an average exerted effort of 7.55±0.02 hrs. The computed CPUE (kg/hr) was 5.76±0.44 in July, 5.72±0.42 in August and 5.69±0.43 in September. Statistical analysis using One-way ANOVA revealed no significant difference when CPUE across months were compared (p>0.05) (Table 2).

Table 2: Computed catch per unit effort (CPUE) of the 10 hook and liners of Dilasag Bay, Dilasag, Aurora, Philippines from July to September 2019.

Month	Number of Fishing Trips	Total Catch (kg)	Average Catch (kg)	Average Hours Spent in Fishing (hr)	CPUE (kg/hr)
July	91	3,952.13	43.43±1.89^a	7.54±0.48	5.76±0.44^a
August	140	6,038.20	43.13±0.42^a	7.54±0.48	5.72±0.42^a
September	52	2,241.20	43.10±0.43^a	7.57±0.48	5.69±0.43^a
Total/Average*	283	12,231.53	43.22±0.18*	7.55±0.02*	5.72±0.43*

4. Summary and Conclusion

The general objective of this study was to assess some biological aspects of yellowfin tuna (*Thunnus albacares*) caught using hook and line in Dilasag Bay, Dilasag, Aurora, Philippines. From July to September 2019, a total of 283 yellowfin tuna (total weight of 12,231.53 kg) was caught in the Dilasag Bay by the 10 municipal fishermen that were included in this study. The 10 fishermen have completed 283 fishing trips. The average weight of caught yellowfin tuna during the study period was 43.22±0.18 kg with an average exerted effort of 7.55±0.02 hrs. The length ranged from 120 to 145 cm with 125 to 130 cm as the most common size. Meanwhile, the weight ranged from 38 to 50 kg with 42 to 44 kg as the dominant weight. The monthly and combined (over-all) data showed that the growth of yellowfin tuna in Dilasag Bay was described as negative allometric (b <3). Negative allometric means that the organism grows slender, so it gains length faster than weight. The length-weight relationship equation for the combined or over-all catches was $W = 2.240\ L^{1.129}$. The over-all value of condition factor (K) of yellowfin tuna in Dilasag Bay was 1.88±0.12. Yellowfin tuna caught in the area had growth rate constant (k) value of 0.157 kg/year and maximum length ($L\infty$) value of 145.117 cm. Particular morphometric measurements, such as length-weight relationship, description of growth using the value of b, computation of condition factor (K) and estimation of growth rate (k) and maximum length ($L\infty$) have been widely used in the environmental monitoring programs for the management of stocks.

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