Introduction of length conversion factors for billfish species captured by Sri Lankan multiday fishing vessels in the Indian Ocean to address challenges in data submission

Nuwan D.P. Gunawardane*, M.M. Ariyaratne*, Geethamali Chandrasiri*, Sinesha Karunararthana*, P.H. Harshani Priyangika*, K.Thisuri M. Perera*, P.Madhuwanthi Thathsarani*, G.G. Eranga M. Gunasekera†, S. Darsigan†

* Department of Fisheries and Aquatic Resources, Sri Lanka
† Pelagikos Pvt. Ltd.

Abstract

Sri Lanka's billfish fishery targets high-value pelagic species like swordfish, marlin, and sailfish, primarily as by-catch in tuna fisheries using longlines and, to a lesser extent, gillnets. Billfish catches peak seasonally, influenced by monsoon-driven migrations closer to the coast. While the catch serves local and export markets, Sri Lanka must comply with the Indian Ocean Tuna Commission (IOTC) requirements, including reporting size frequency data (Resolution 15/02). Data collection involves measuring length types such as fork length (FL) or lower jaw-fork length (LJFL). Challenges arise when billfish are sectioned at sea, complicating accurate data collection during port sampling. Therefore, an alternative method to establish length-length relationships is proposed to improve data accuracy and fulfill IOTC standards despite sectioned landings. An attempt made to drive these relationships using the measurements taken from various sources of Black marlin, Blue Marlin and sailfish. Results indicated that there are significant linear relationships of different length and girth measurements of Black marline, Blue Marline and Sailfish laded by Sri Lankan Fishermen. Therefore, it is recommended to use Length from base of the anal fin to the base of the caudal lobe and Girth measurement via beginning of 1st anal fin to generate the Upper jaw-total length and eye orbit fork length in the case of availability of the part of the these three types of fish species in order to use these length details for the management purposes.

1.0 Introduction

The billfish fishery in Sri Lanka primarily targets valuable pelagic species like swordfish (*Xiphias gladius*), black marlin (*Istiompax indica*), blue marlin (*Makaira nigricans*), stripped marline (*Tetrapturus audax*) and indo-pacific sailfish (*Istiophorus platypterus*). These species are utilized for local consumption and in some cases prized internationally, with exports aimed markets such as Japan and Europe. As part of the tuna fishery complex, billfish catches are often a by-product of tuna-targeted operations. (Joseph, 2016). The main fishing gear that recorded the billfish catches is longlinesi and to a lesser extent, gillnets. Longline gear is the most commonly used method in the offshore and deep-sea fisheries targeting tuna, as it allows for selective fishing at specific depths where billfish are also abundant (NARA, 2020). The composition of billfish catches varies seasonally, with peak catches typically occurring during certain monsoon seasons when fish migrate closer to Sri Lanka's coastal waters (Dissanayake and Sigurdsson, 2005).

The key resolution related to length-weight data submission is Resolution 15/02, which mandates that CPCs collect and report size frequency data for all major tuna species, billfish, and other species under IOTC management. Under this resolution (IOTC, 2021). To report billfish length-weight data to the Indian Ocean Tuna Commission (IOTC), fishery data collection programs in Sri Lanka need to follow specific guidelines to ensure accuracy and consistency with IOTC standards. Length measurements should be taken from the tip of the upper jaw (bill) to the fork of the tail, recorded as fork length (FL) in centimeters. If fork length is unavailable, straight length from the lower jaw to the fork (LJFL) can be recorded, Each fish's weight should be recorded, preferably measured as the round weight (whole fish). If the fish has been gutted or the head removed, the report should indicate the exact condition and method used to convert the dressed weight back to round weight (IOTC, 2021). Each entry should include species identification, date of capture, geographical coordinates, and fishing gear type to allow IOTC to account for gear-specific variations in catch composition and size distribution. Additionally, data should be validated before submission by comparing it with expected size distributions for the region, minimizing errors in species identification and size reporting.

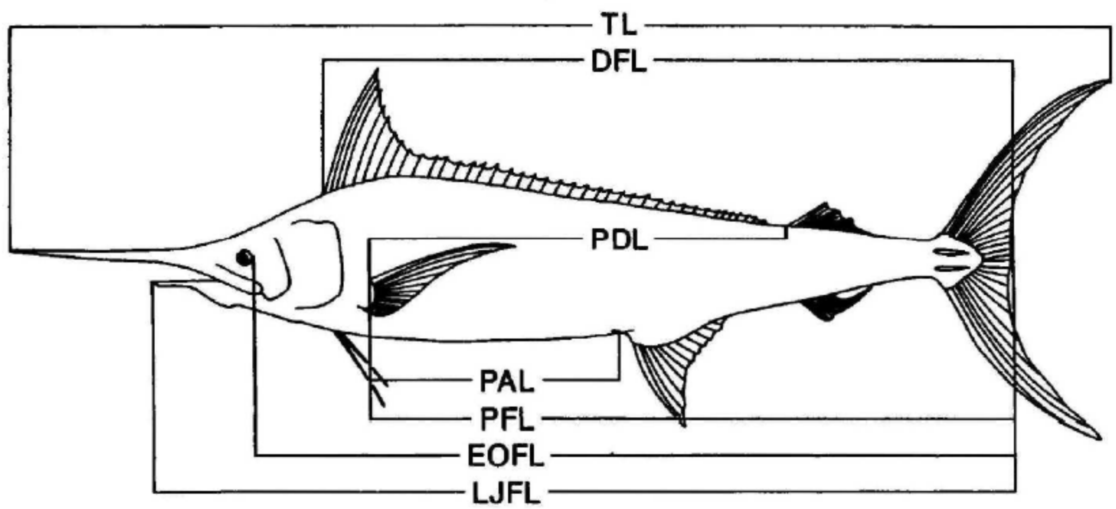

Figure 01: Length measures used for recording lengths of bill fishes (Istiophoridae) landed in commercial and recreational harvests. TL, total length; DFL, Dorsal-fork length; PDL, Pectoral-second dorsal length; PAL, pectoral-anus length; PFL; pectoral-fork length; EOFL, eye orbit-fork length; UFL, lower jaw-fork length.

In Sri Lanka, Department of Fisheries and Aquatic Resources (DFAR) is one of the main agencies who responsible for gathering fisheries data related to large pelagic fish landings. To facilitate this, DFAR have set up an extensive port sampling program to collect data on catch and fishing effort for large pelagic species. Each year, Sri Lanka submits this catch, effort, and biological data to the Indian Ocean Tuna Commission (IOTC) in compliance with their reporting requirements. The information collected through port sampling is stored in the MSDFAR database.

However, in many instances, Sri Lankan fishing vessels do not land whole billfish; instead, the fish are cut into sections at sea, with two or three pieces brought onboard and then landed at the port (Figure 02). This practice limits the ability to accurately measure length and weight during port sampling, thus collecting detailed biological data on billfish remains challenging (Haputhantri and Perera, 2014). This study, therefore, proposes an alternative method for gathering morphometric data specifically of billfish. Here an attempt made to calculate relationships for weight and various lengths for billfish. These derived relationships could also serve as conversion factors to generate the lengths such as TL, FL and LJFL enabling to submit the same to IOTC as part of data submission programme according to the technical guidelines for Length and Weight Data Collection (IOTC, 2021).

Figure 02: Example of the Billfish landing by Sri Lankan Fishermen

2.0 Methodology

Prager et al, 1995 presented Ten methods used to dress billfishes (Istiophoridae) at sea (Figure 03) here the Sri Lankan often use the method indicated under sub figure 09 and 10. Also, they tend to cut the fish from the dotted edges indicated (Figure 03)

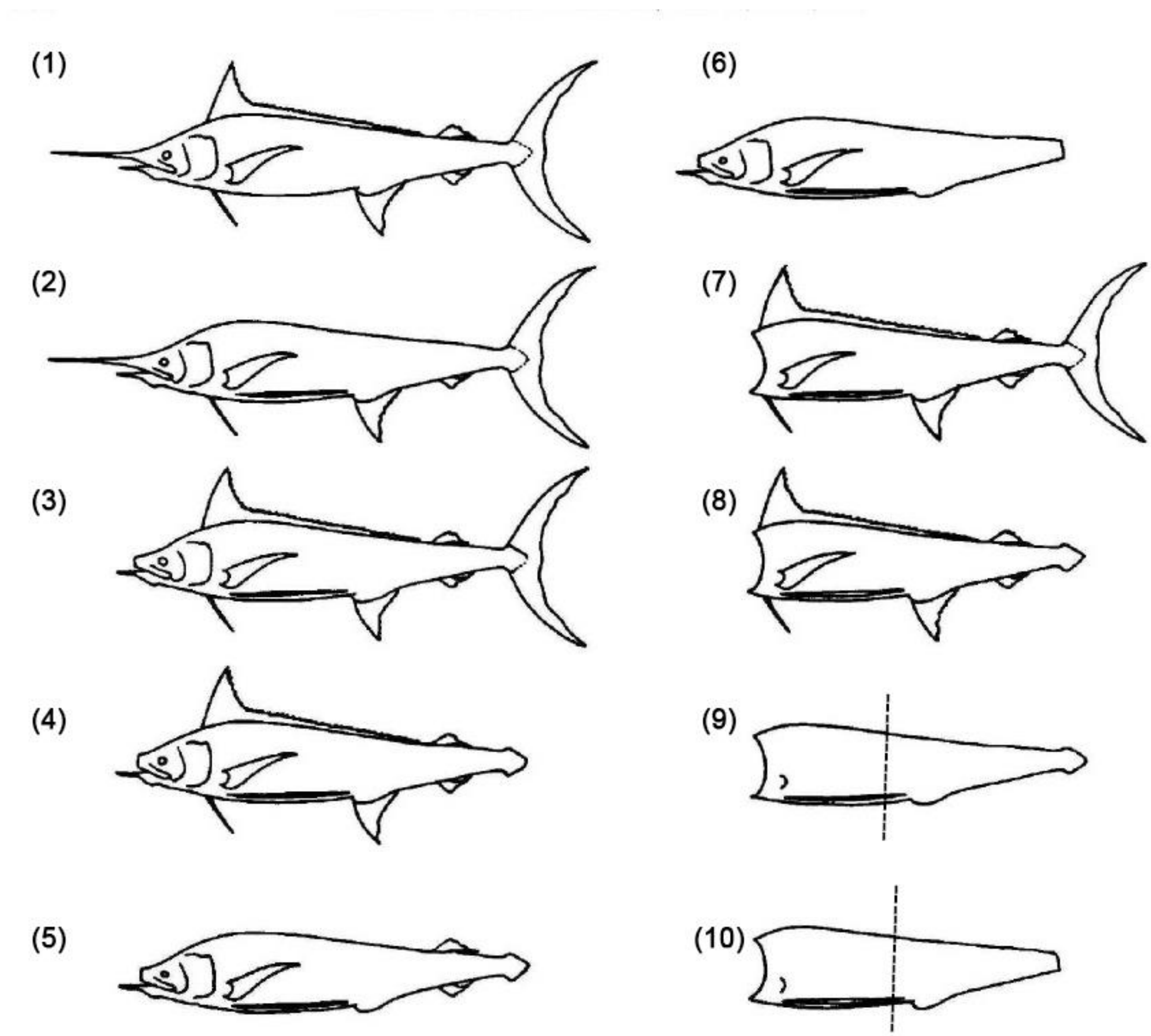

Figure 03: Ten methods used to dress billfishes at sea. Length measurements are generally taken on dressed carcasses, making conversion to a standard-length measurement necessary. (Adopted from Prager et al, 1995)

Morphometric measurements of occasionally whole sailfish in the long line and gillnet fishery were obtained in year 2023 and 2024 from major harbours of Sri Lanka. Here following methods used for the collection of data.

- Skippers under crew-based observer scheme were asked to measure the lengths and weights of billfish before they are dressed onboard. Here also the photographic evidence were also used
- Onboard observers were asked to measure the fish
- Occasionally landed whole billfishes were measures at harbour by the fisheries offices

Skippers and offices who measures the fish were provided with facilities to do the measurements and recorded the same in the recording formats given in Annex 1.

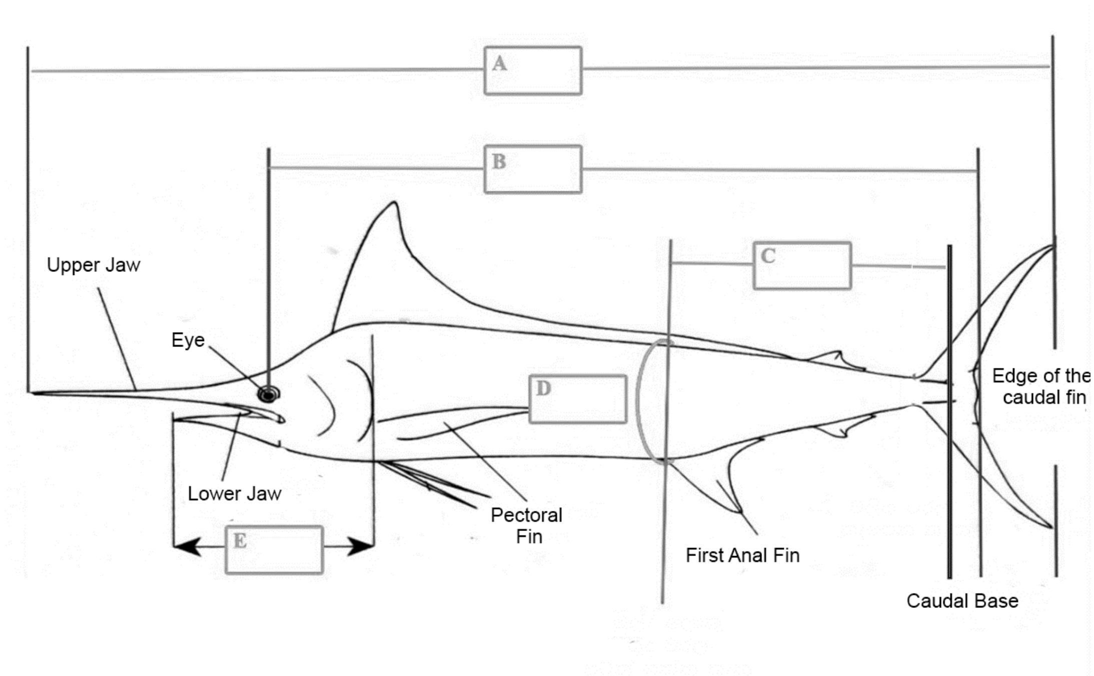

Figure 04: Length measurements used for the present study

Here it was proposed to define length types available in the dressed or cut billfish that can be used as an indicator to generate the standard-length types. These lengths are indicated in Figure 04. Here a specific length from the base of the anal fin to the base of the caudal lobe (ACL) was defined for this particular calculation (indicated as C in the Figure 04). Additionally, girth measurement via beginning of 1st anal fin (AG)) were also obtained (indicated as D in Figure 03). Then A= Upper jaw-total length (UJTL), B= eye orbit fork length (EOFL), E = Head length based from the tip of lower jaw length (LJHL), of each fish were also measures obtained (Figure 04). Length and girth measurements of the fish were recorded to the nearest centimeter. Weight recoded in kilograms. The best sampling sizes were determined using the moving average method. Here only the following billfish species reached the acceptable sampling sizes and thus included in the analysis.

Table 01: Billfish species subjected to the data analysis of the present study

Common name	**Scientific name**	**Sampling size**	**Mean length (cm), weight (Kg) ± standard deviations**					
			UJTL	**EOFL**	**ACL**	**LJHL**	**AG**	**W**
Black Marlin	*Istiompax indica*	151	218.01 ±41.52	166.89 ±31.25	64.79 ±16.33	39.61 ±10.52	55.51 ±13.77	47.84 ±22.38
Blue Marlin	*Makaira nigricans*	66	204.35 ±43.91	154.63 ±32.49	59.07 ±15.60	38.045 ±14.45	55.33 ±18.46	44.48 ±23.09
Indo Pacific Sail fish	*Istiophorus platypterus*	138	219.72 ±36.12	157.96 ±27.61	59.57 ±12.54	38.93 ±7.96	37.10 ±7.79	16.57 ±7.38

Sampling sizes of swordfish (*Xiphias gladius*), stripped marline (*Tetrapturus audax*) were not reached to the acceptable level according to the moving average method and thus not included in the analysis.

Morphometric relationships of length-girth, length-length and the length-weight of billfish were the derived using linear regression (Sedgwick, 2012). The determination coefficient (r) was used as an indicator of the quality of the linear regressions. All the statistical analyses were considered at the 5% level of significant ($p<0.05$). Analysis was conducted via Minitab (Minitab® 17.1.0) statistical software.

3.0 Results

Results indicated (Figure 05,06 and 07) that ACL and also AG have significant liner relationships ($r >0.7$, $p>0.05$) with the JITL and EOFL for all three species. Significant liner relationship ($r >0.7$, $p>0.05$) between AG and ACL for all three species indicated that ACL can be used as a reliable measurement. It was interesting to observer that none of the species shows significant correlation of any of the length measurements with the weights (W) ($r <0.6$, $p>0.05$). it is obvious that significant liners relationship are there between UJTL and EOFL ($r >0.9$, $p>0.05$)

	UJTL	EOFL	ACL	LJHL	AG
EOFL	0.966				
	0.000				
ACL	0.819	0.891			
	0.000	0.000			
LJHL	0.516	0.407	0.106		
	0.000	0.000	0.195		
AG	0.681	0.713	0.709	0.230	
	0.000	0.000	0.000	0.005	
W	0.368	0.407	0.296	0.268	0.502
	0.000	0.000	0.000	0.001	0.000

Figure 05: Pearson correlation metrix for black marlin (UJTL= Upper jaw-total length, EOFL= eye orbit fork length, ACL=Length from base of the anal fin to the base of the caudal lobe, LJHL= Head length based from the tip of lower jaw length, AG= Girth measurement via beginning of 1st anal fin, W= Total weight)

	UJTL	EOFL	ACL	LJHL	AG
EOFL	0.973 0.000				
ACL	0.880 0.000	0.913 0.000			
LJHL	0.346 0.004	0.256 0.038	-0.017 0.893		
AG	0.791 0.000	0.774 0.000	0.765 0.000	0.106 0.395	
W	0.414 0.001	0.396 0.001	0.306 0.012	0.340 0.005	0.575 0.000

Figure 06: Pearson correlation metrix for Blue marlin (UJTL= Upper jaw-total length, EOFL= eye orbit fork length, ACL=Length from base of the anal fin to the base of the caudal lobe, LJHL= Head length based from the tip of lower jaw length, AG= Girth measurement via beginning of 1st anal fin, W= Total weight)

	UJTL	EOFL	ACL	LJHL	AG
EOFL	0.941 0.000				
ACL	0.882 0.000	0.933 0.000			
LJHL	0.614 0.000	0.521 0.000	0.362 0.000		
AG	0.703 0.000	0.722 0.000	0.703 0.000	0.276 0.001	
W	0.457 0.000	0.493 0.000	0.407 0.000	0.371 0.000	0.409 0.000

Figure 07: Pearson correlation matrix for Sail fish (UJTL= Upper jaw-total length, EOFL= eye orbit fork length, ACL=Length from base of the anal fin to the base of the caudal lobe, LJHL= Head length based from the tip of lower jaw length, AG= Girth measurement via beginning of 1st anal fin, W= Total weight)

Results indicated that it is possible to drive formulas to predict lengths between ACL and AG with the JITL and EOFL for all three species. These formulas are given from Figure 08, 09 and 10)

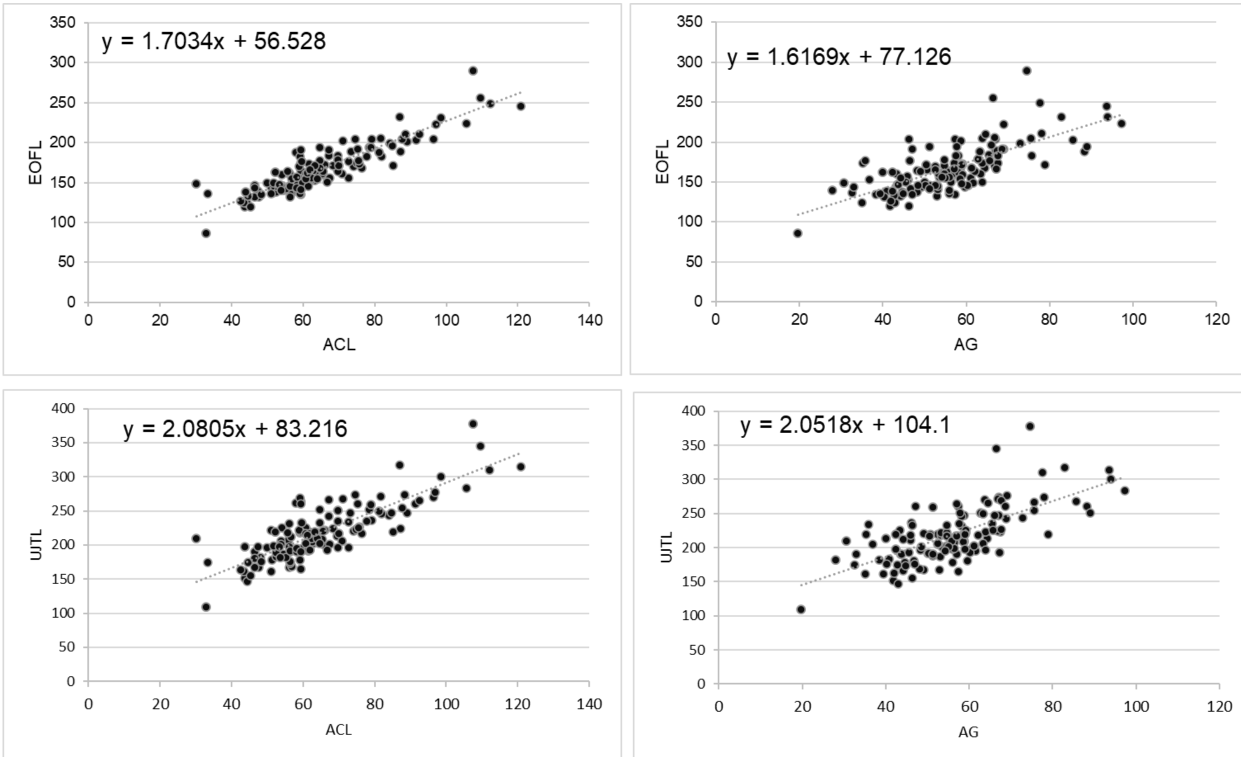

Figure 08: Calculated Liner relationships of length measurements (UJTL= Upper jaw-total length, EOFL= eye orbit fork length, ACL=Length from base of the anal fin to the base of the caudal lobe, AG= Girth measurement via beginning of 1st anal fin) for Black Marlin.

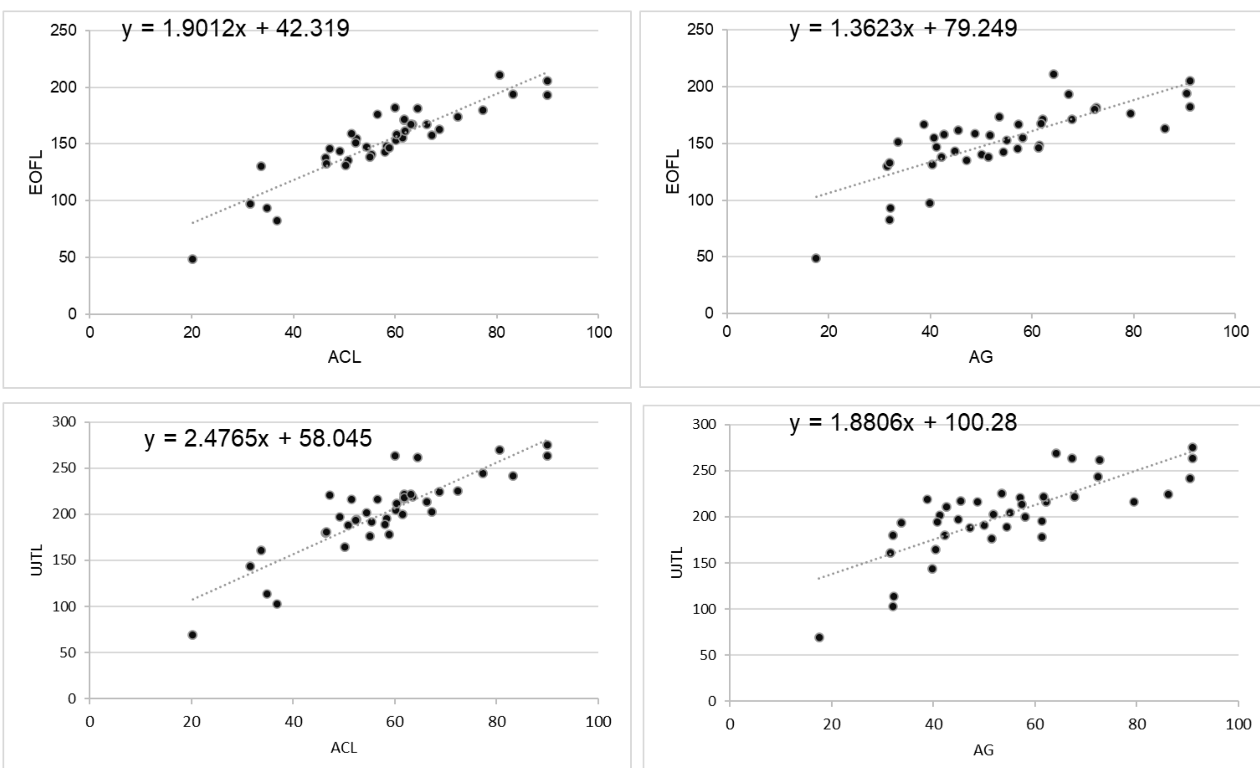

Figure 09: Calculated Liner relationships of length measurements (UJTL= Upper jaw-total length, EOFL= eye orbit fork length, ACL=Length from base of the anal fin to the base of the caudal lobe, AG= Girth measurement via beginning of 1st anal fin) for Blue Marlin

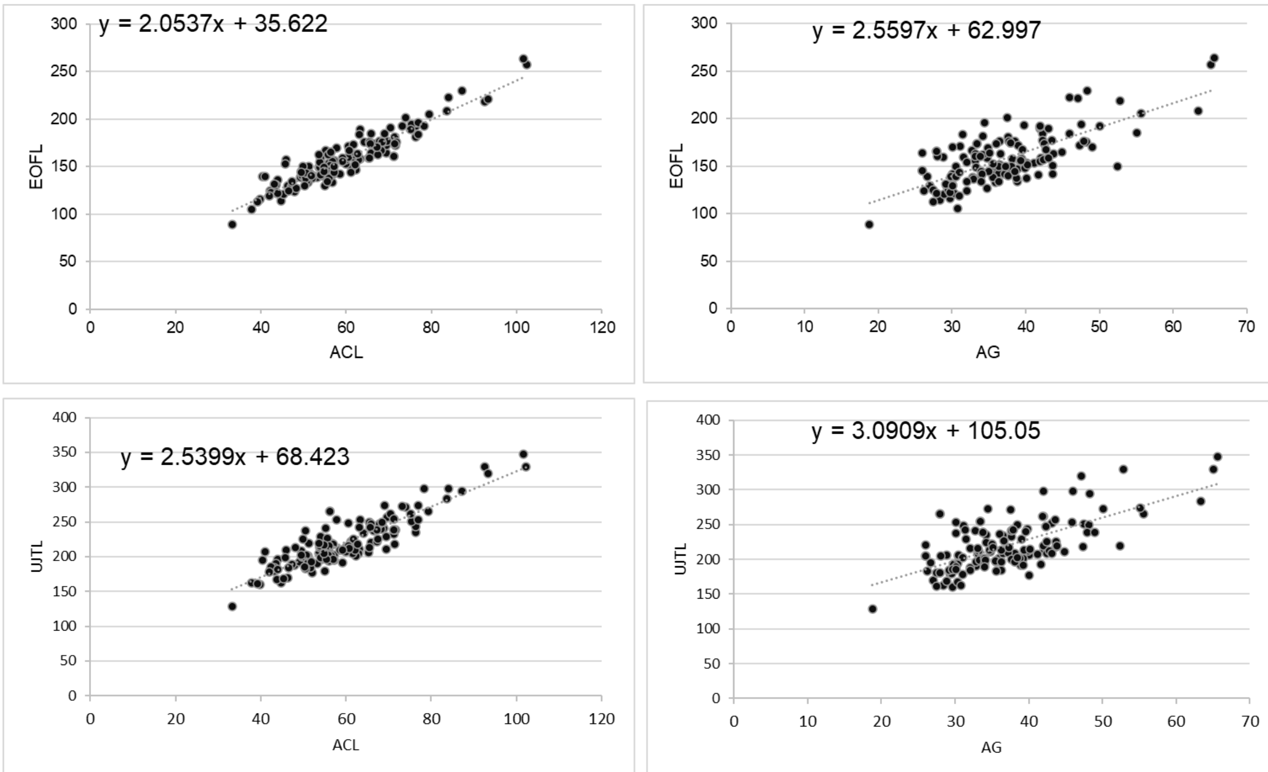

Figure 10: Calculated Liner relationships of length measurements (UJTL= Upper jaw-total length, EOFL= eye orbit fork length, ACL=Length from base of the anal fin to the base of the caudal lobe, AG= Girth measurement via beginning of 1st anal fin) for sail fish

4.0 Conclusion

Results indicated that there are significant linear relationships of different length and girth measurements of Black marline, Blue Marline and Sailfish laded by Sri Lankan Fishermen. Therefore it is recommend to use Length from base of the anal fin to the base of the caudal lobe and Girth measurement via beginning of 1st anal fin to generate the Upper jaw-total length and eye orbit fork length in the case of availability of the part of the these three types of fish species in order to use these length details for the management purposes.

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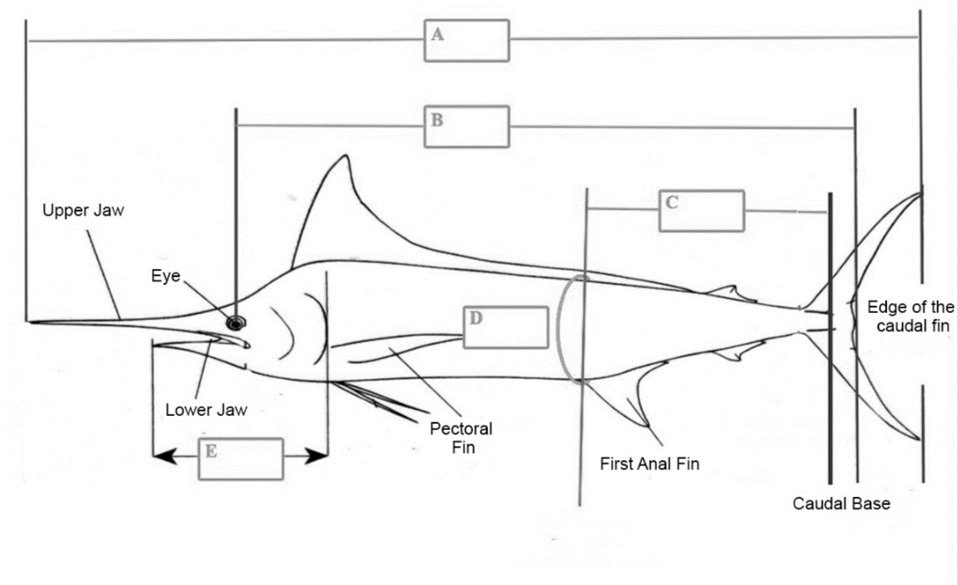
Annex -1



A= Upper jaw-total length (in centimeters)
B= eye orbit fork length (in centimeters)
C= length from the base of the anal fin to the base of the caudal lobe (in centimeters)
D= Girth measurement via beginning of 1st anal fin (in centimeters)
E = Head length based from the tip of lower jaw length (in centimeters)

Select the name of the fish
(X Mark)

- ☐ Blue Marlin
- ☐ Black Marlin
- ☐ Striped Marlin
- ☐ Sail Fish
- ☐ Sward fish

Date of capture
Year Month Date

Catch Location
Lat Lon

IMUL-A

Other Details

Total weight (Kg)

Skipper ID