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Estimation of length-weight relationship and some morphometric relationships of Indo-Pacific Sailfish (*Istiophorus platypterus*) using biological data of gillnet fishery and longline fishery in Sri Lanka

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Abstract

Indo – Pacific Sailfish (*Istiophorus platypterus*) is one of the important billfish species found in the large pelagic fishery in Sri Lanka. Though tuna is the key target group in the gillnet fishery and longline fishery in Sri Lanka, billfish including sailfish is also frequently caught as a non-target species. In many cases, the whole billfish is not landed by the vessels. The billfish caught at sea is cut into two or three pieces and brought onboard to the fishing port. Therefore, it is not possible to obtain accurate length and weight measurements during the port sampling. In addition, since there is no proper onboard observer programme existing for Sri Lankan fishing vessels, collecting biological data for billfish is a challenging task. In order to minimize this issue, an initial attempt was made to obtain some morphometric relationships for sailfish. For this purpose, morphometric measurements of occasionally landed whole sailfish in the gillnet fishery and longline fishery were obtained at the fishing ports in the west coast of Sri Lanka in 2014. Accordingly, different length measurements (upper jaw-total length (UJTL), upper jaw-fork length (UJFL), lower jaw-total length (LJTL), lower jaw -fork length (LJFL), pectoral-dorsal length (PDL) and pectoral-anal length (PAL)), total body weight (w) and girth measurements (girth via beginning of pectoral fin (PG) and girth via beginning of 1st anal fin (1AG)) were obtained. The estimated length-weight relationship between the length (L) (lower jaw-total length -LJTL) and the body weight (W) was $W = 0.01L^{2.7}$, thus showing a negative allometric pattern of growth. All length-weight, length-length and length-girth relationships were significant. Some of these relationships could be incorporated as conversion factors in particular,

for the new large pelagic database of Sri Lanka (new PELAGOS database) which is in the process of being developed.

Introduction

Fisheries sector plays an important role in the Sri Lankan economy. The large pelagic fish which mainly comprises of tuna and tuna-like species, contributes over 32% to the total fish production in Sri Lanka (MFARD, 2014). Billfish is also an important group in the large pelagic fish production since it contributes at present over 8% to the total large pelagic fish production (PELAGOS, 2015). Billfish comprises of three species of marlins, one species of sailfish and one species of sword fish. The three species of marlins are Indo-Pacific Blue Marlin (*Makaira mazara*), Black Marlin (*Makaira indica*) and Striped Marlin (*Tetrapturus audax*). The single species of Sailfish and Swordfish found in billfish catches are Indo-Pacific Sailfish (*Istiophorus platypterus*) and Swordfish (*Xiphias gladius*) respectively. Sailfish has contributed over 22% to the total billfish catch recorded in Sri Lanka in 2014 (PEAGOS, 2015).

Though a wide range of fishing gear is being used for catching large pelagic fish including billfish, gillnet and longline are the widely used most popular gear. Both gears are sometimes operated in combination. Multiday fishing boats are mostly operated with these gears. The gear and vessels operating in the large pelagic fishery in Sri Lanka, the species composition and details about fishing operations etc are well documented (Haputhantri and Maldeniya, 2011; Haputhantri, 2012; Hasarangi et al., 2012; Haputhantri and Bandaranayake, 2013; Perera et al., 2013; Haputhantri, 2014).

National Aquatic Resources Research and Development Agency (NARA) and Department of Fisheries and Aquatic Resources (DFAR) in Sri Lanka are responsible for collecting fisheries statistics in relation to the large pelagic fish landings. Accordingly, NARA and DFAR have implemented a comprehensive port sampling programme for the collection of large pelagic fisheries data including catch and effort data. Sri Lanka provides catch and effort data and biological data to the Indian Ocean Tuna Commission (IOTC) annually as per the IOTC data reporting requirements. The data collected by NARA and DFAR via port sampling is entered into a database (PELAGOS database). The data collection programme has been recently revised

and the PELAGOS database is also being upgraded. A number of conversion factors have been proposed in the new version of the database in view of providing accurate estimates to IOTC.

In many cases, the whole billfish is not landed by the Sri Lankan fishing vessels. The billfish caught at sea is cut into two or three pieces and brought onboard to the port. Therefore, it is not possible to obtain accurate length and weight measurements during the port sampling. One of the alternative methods for collecting the biological samples for billfish is implementing a proper onboard observer programme. Since the recently implemented observer programme by the Department of Fisheries and Aquatic Resources (DFAR) is still in a primitive stage, biological data collection for billfish is still problematic. Therefore, the present study attempts to propose an alternative way of collecting biological data for sailfish. Accordingly, the length-weight and various morphometric relationships of billfish were obtained as an alternative way of recording key biological data on sailfish. Some of these relationships could be incorporated as conversion factors in the new PELAGOS database which is still being developed.

Method and materials

Morphometric measurements of occasionally landed whole sailfish in the gillnet fishery and longline fishery were obtained in 2014 at the three major fishing ports in the west coast of Sri Lanka: Beruwala, Negombo and Chilaw (Figure 1). Accordingly, different length measurements (upper jaw-total length (UJTL), upper jaw-fork length (UJFL), lower jaw-total length (LJTL), lower jaw -fork length (LJFL), pectoral-dorsal length (PDL) and pectoral-anal length (PAL)), total body weight (w) and girth measurements (girth via beginning of pectoral fin (PG) and girth via beginning of 1st anal fin (1AG)) were obtained (Figure 2). Length and girth measurements of the fish were recorded to the nearest centimeter whereas the weight was recorded to the nearest gram. Morphometric relationships of length-weight, length-girth and the length-length of sailfish were obtained using linear regression. The determination coefficient (R^2) was used as an indicator of the quality of the linear regressions. All the statistical analyses were considered at the 5% level of significant ($p<0.05$).

Figure 1. A map of the fishing ports in the west coast of Sri Lanka (Beruwala, Negombo and Chilaw) selected to obtain morphometric measurements of sailfish

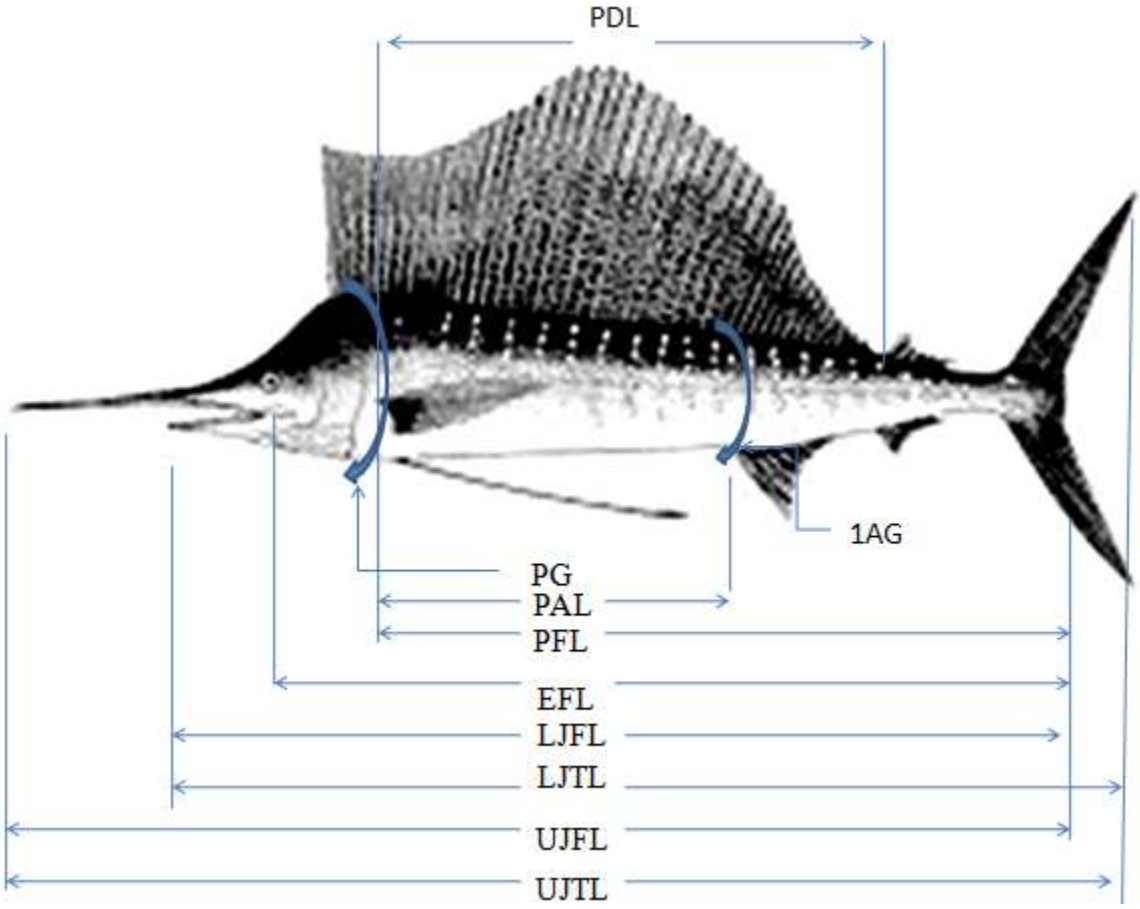

Figure 2. Illustration of different length and girth measurements of Indo-Pacific Sailfish

Results and discussion

The lower jaw-total length (LJTL) of the sailfish varies in the range of 65 – 251 cm. The sample chosen to measure the morphometric parameters is obviously a biased one towards the smaller sizes of fish because larger sailfishes are incidentally landed with the full carcass. The estimated length-weight relationship between the length (L) (lower jaw-total length- LJTL) and the body weight (W) was $W = 0.01L^{2.7}$ (Figure 3).

The estimated length-weight relationship shows a negative allometric growth which is in agreement with most of the results obtained from morphometric studies for sailfish (Froese and Pauly, 2015).

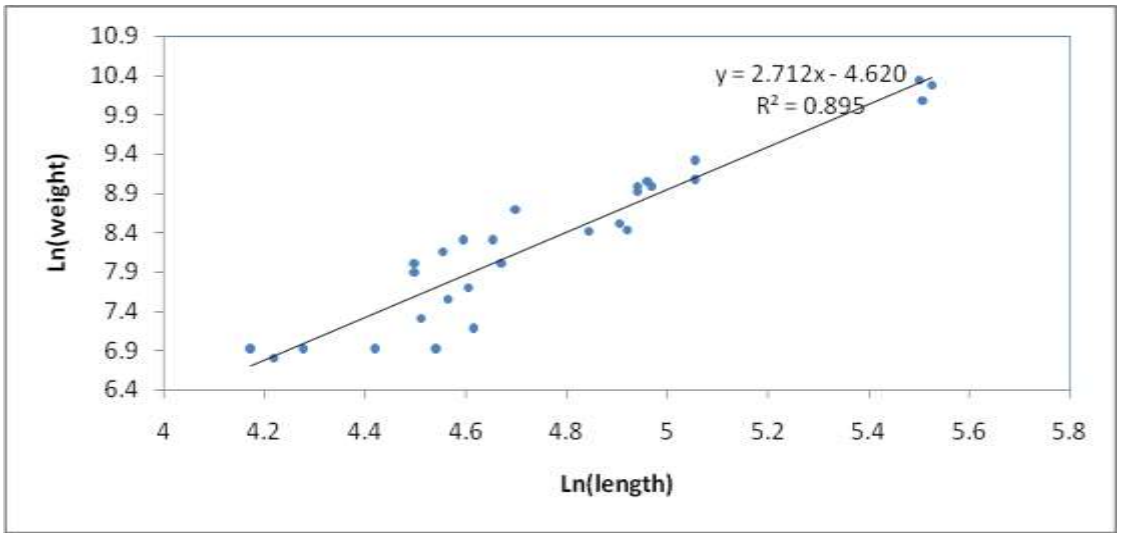

Figure 3. The natural log transformed body weight Vs natural log transformed length (LJTL) relationship of Indo-Pacific Sailfish

All the length-length and length-girth relationships obtained for sailfish were significant with R^2 value greater than 0.80 (Table 1 and Figures 4 – 20). The morphometric relationships are important in fisheries management for comparative growth studies but they are still scarce for most tropical and subtropical species including Indo-Pacific Sailfish (Harrison, 2001; Montopoulos and Stergiou, 2002 and Ecoutin *et al.*, 2005).

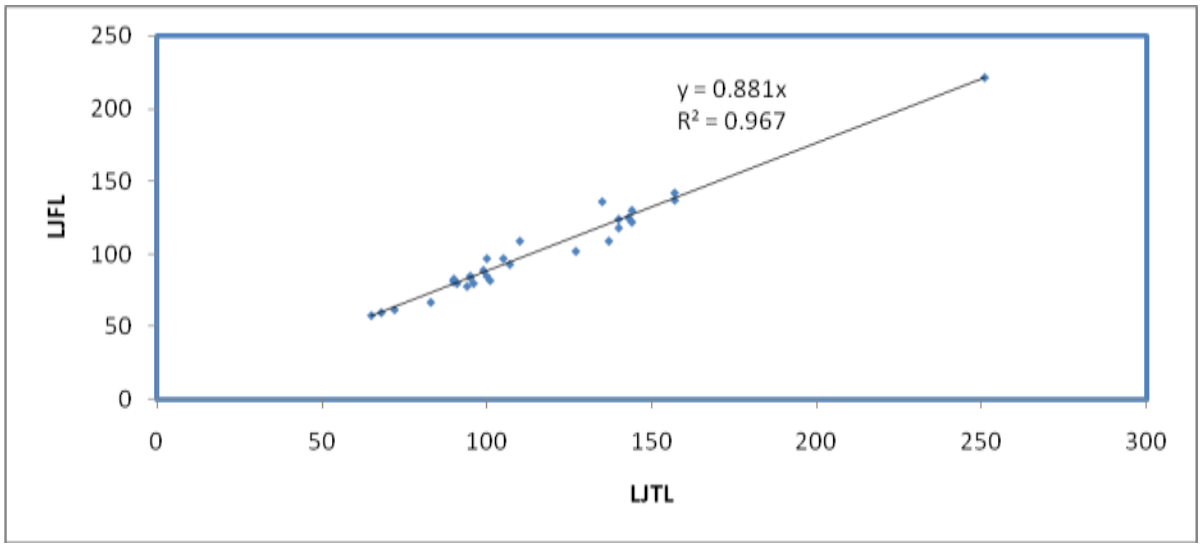

Figure 4. The relationship between lower jaw total length (LJTL) and lower jaw fork length (LJFL) of Indo-Pacific Sailfish

Table 1. Relationships between length measurements (upper jaw-total length (UJTL), upper jaw-fork length (UJFL), lower jaw-total length (LJTL), lower jaw -fork length (LJFL), pectoral-dorsal length (PDL) and pectoral-anal length (PAL), total body weight (w) and girth measurements {girth via beginning of pectoral fin (PG) and girth via beginning of 1st anal fin (1AG)} (Figures 4-20)

Linear relationship between		Value of "gradient"	Value of "R^2 "
X	Y		
LJTL	LJFL	0.881	0.967
UJTL	UJFL	0.863	0.972
LJTL	UJFL	0.998	0.948
LJFL	UJTL	1.313	0.960
LJFL	UJFL	1.136	0.975
LJTL	PDL	0.510	0.897
LJTL	PAL	0.352	0.805
LJFL	PDL	0.581	0.934
LJFL	PAL	0.381	0.932
UJFL	PDL	0.554	0.833
UJFL	PAL	0.328	0.899
PDL	PAL	0.808	0.901
PDL	UJTL	2.106	0.803
PAL	UJTL	3.436	0.894
PG	UJTL	4.075	0919
1AG	UJTL	6.457	0.836

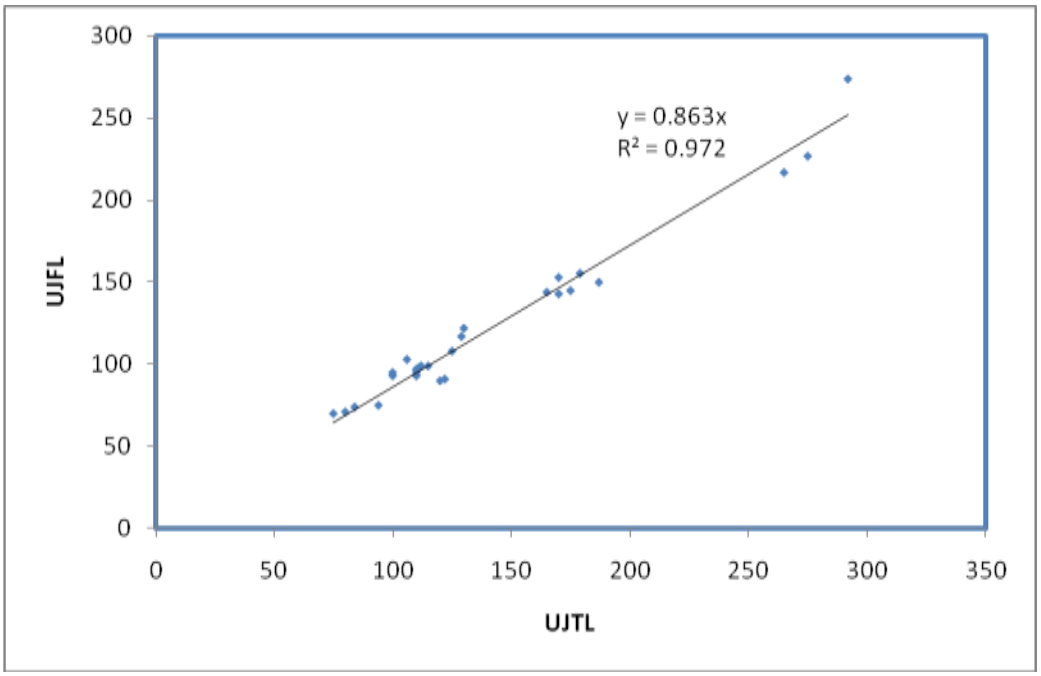

Figure 5. The relationship between upper jaw total length (UJTL) and upper jaw fork length (UJFL) of Indo-Pacific Sailfish

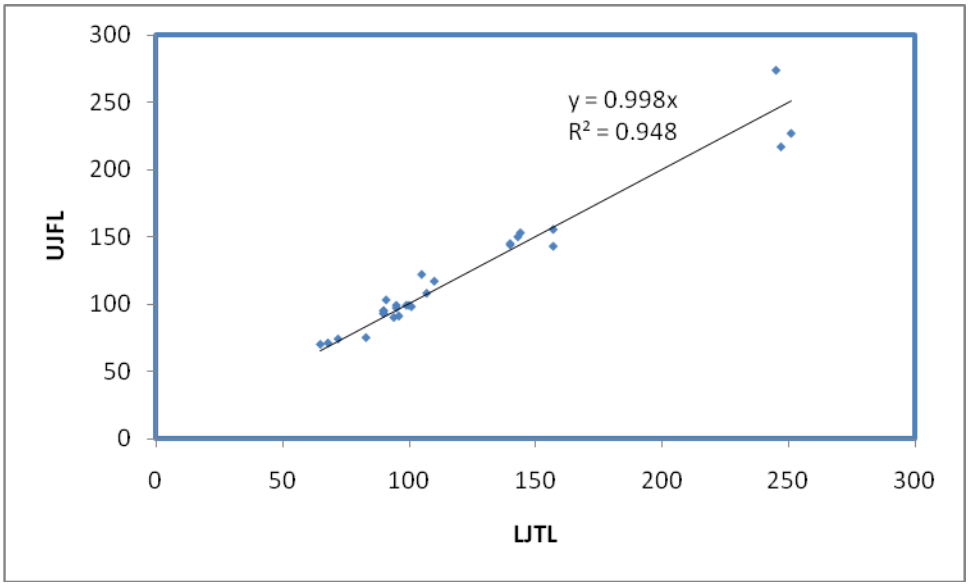

Figure 6. The relationship between lower jaw total length (LJTL) and upper jaw fork length (UJFL) of Indo-Pacific Sailfish

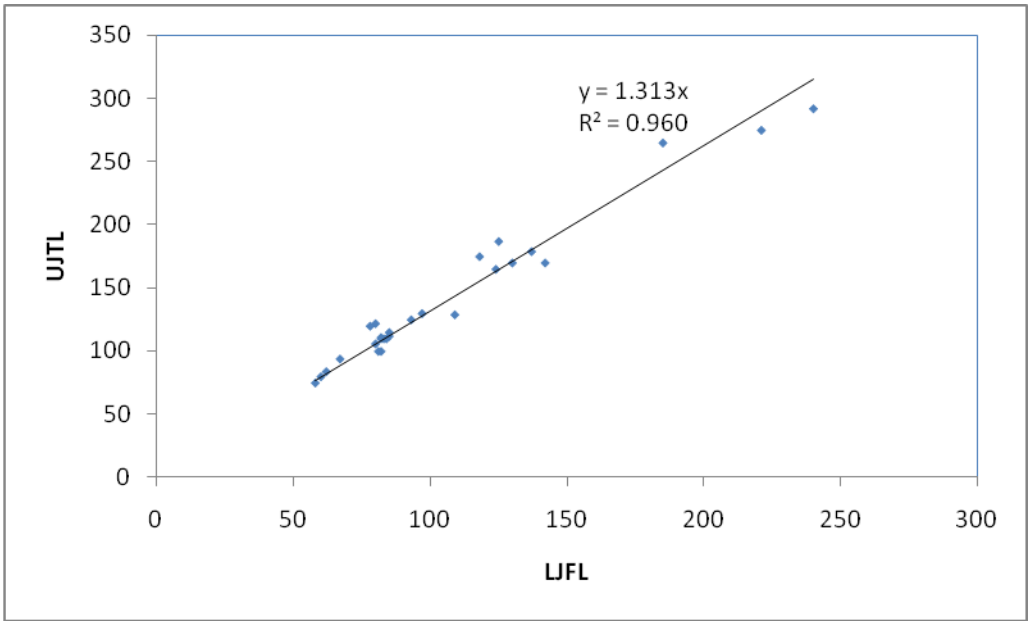

Figure 7. The relationship between lower jaw fork length (LJFL) and upper jaw total length (UJTL) of Indo-Pacific Sailfish

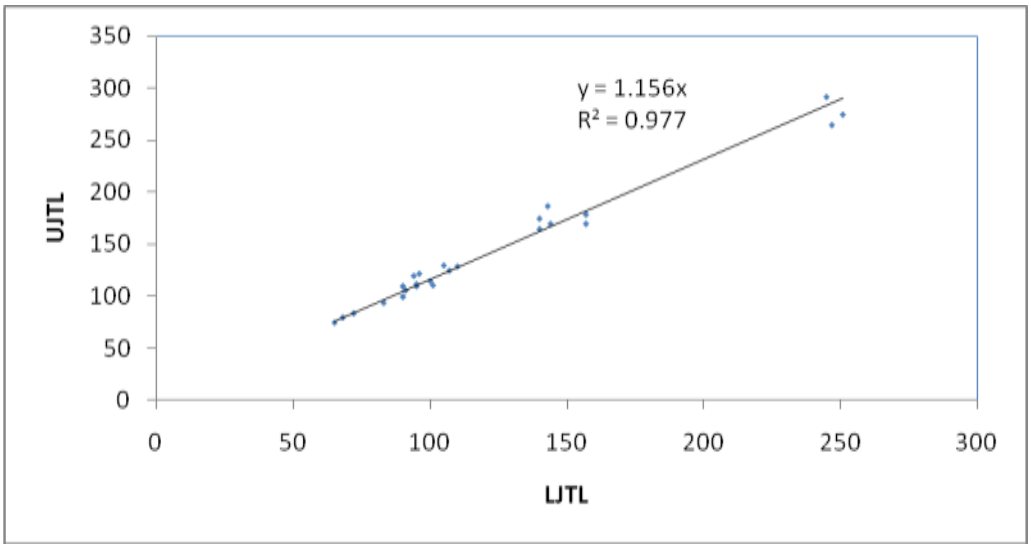

Figure 8. The relationship between lower jaw total length (LJTL) and upper jaw total length (UJTL) of Indo-Pacific Sailfish

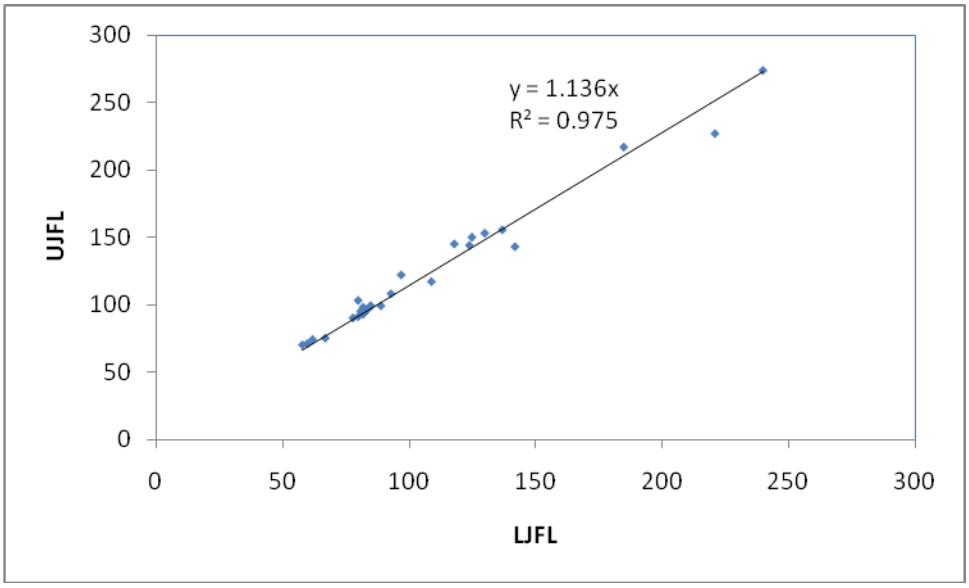

Figure 9. The relationship between lower jaw fork length (LJFL) and upper jaw fork length (UJFL) of Indo-Pacific Sailfish

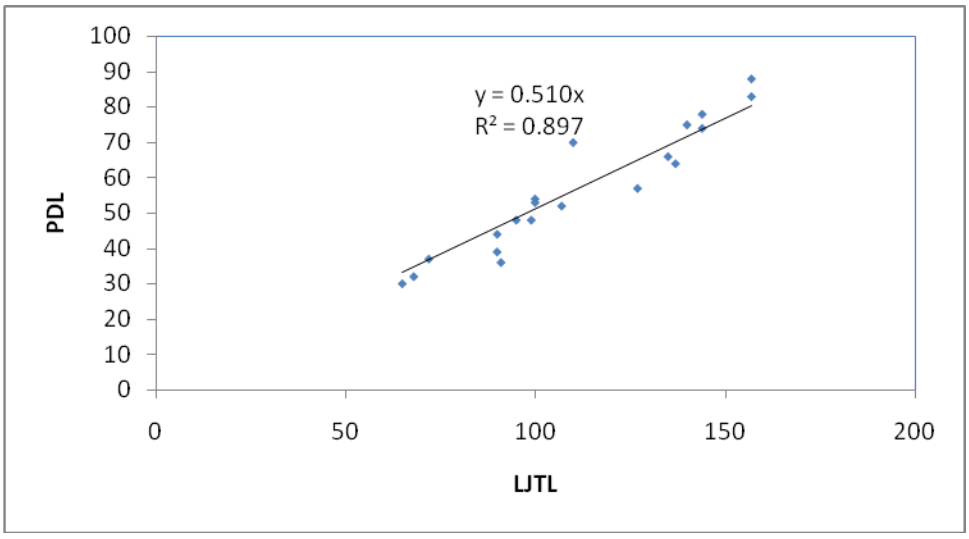

Figure 10. The relationship between lower jaw total length (LJTL) and pectoral-dorsal length (PDL) of Indo-Pacific Sailfish

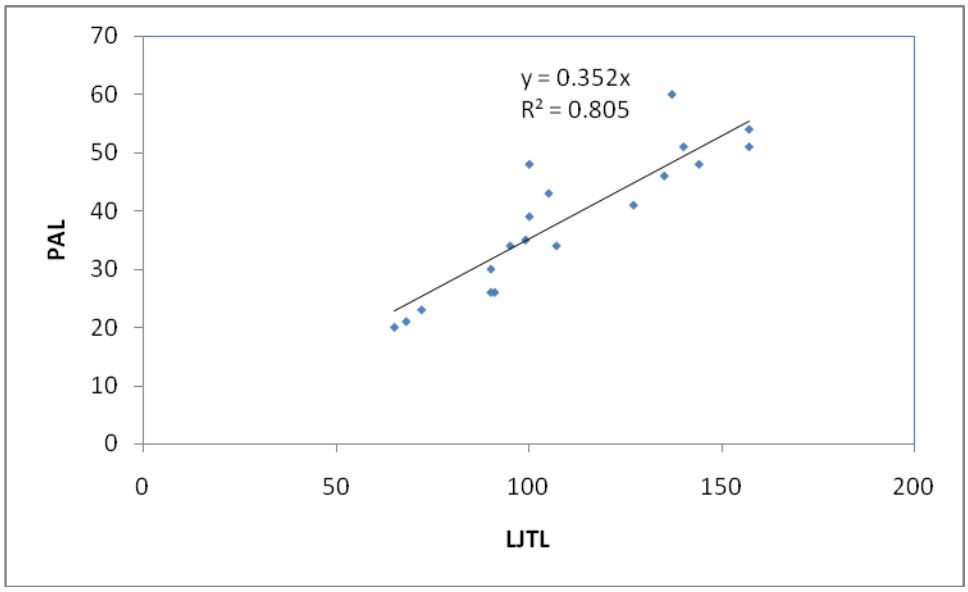

Figure 11. The relationship between lower jaw total length (LJTL) and pectoral-anal length (PAL) of Indo-Pacific Sailfish

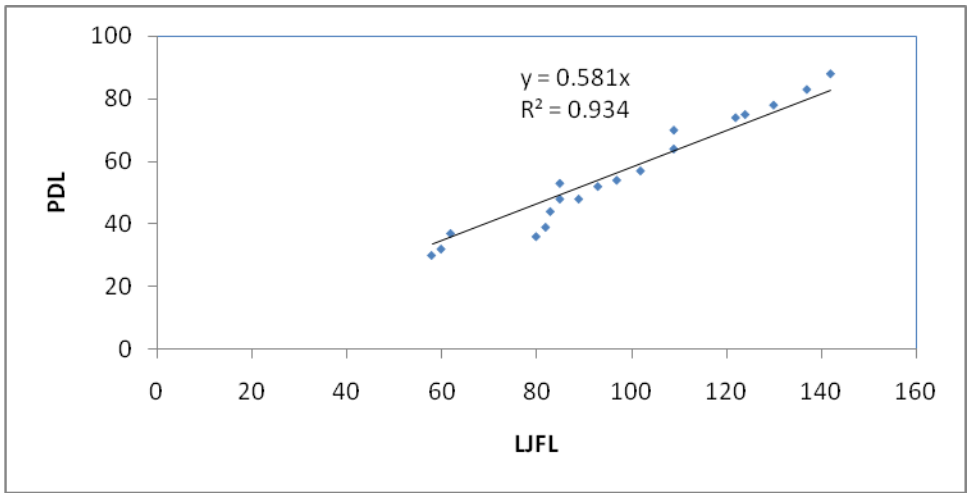

Figure 12. The relationship between lower jaw fork length (LJFL) and pectoral-dorsal length (PDL) of Indo-Pacific Sailfish

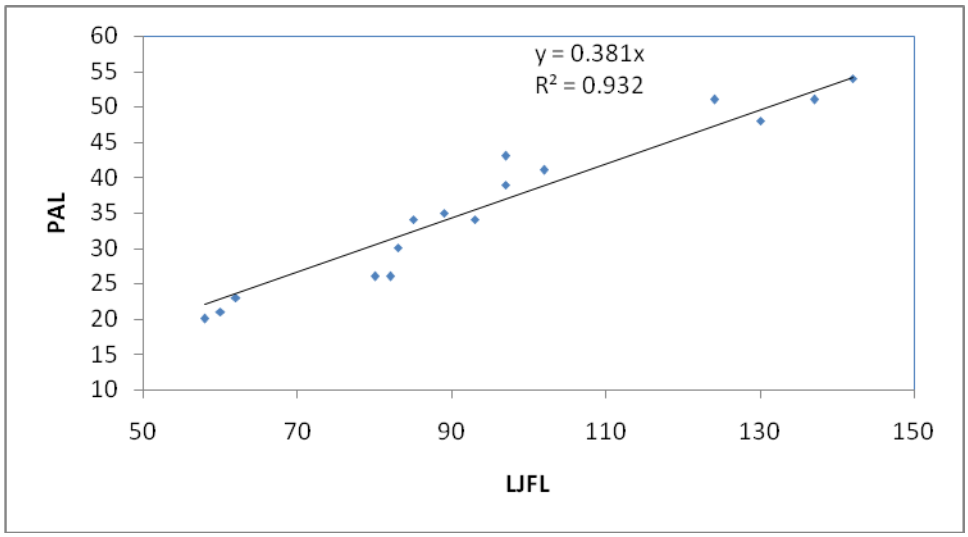

Figure 13. The relationship between lower jaw fork length (LJFL) and pectoral-anal length (PAL) of Indo-Pacific Sailfish

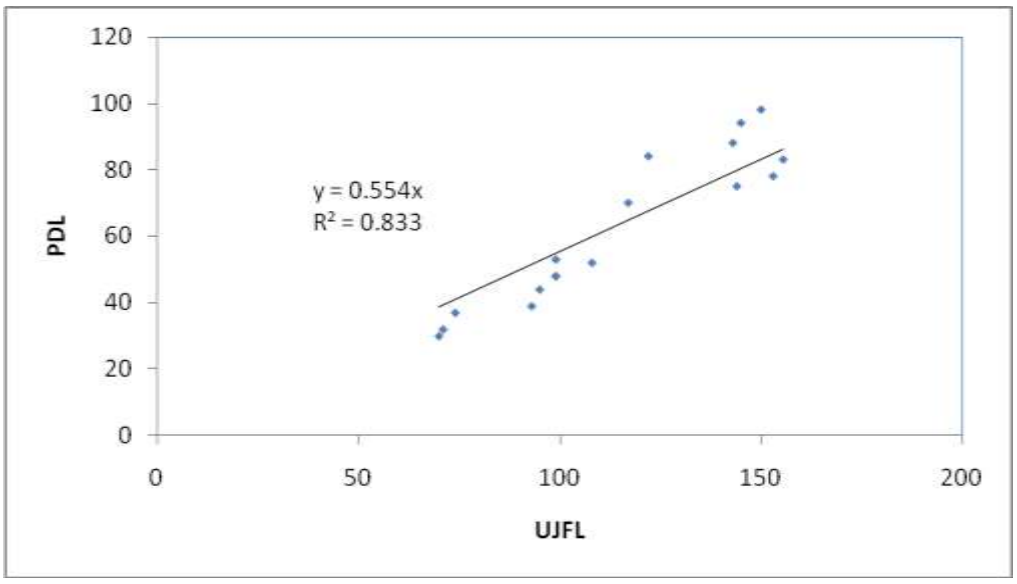

Figure 14. The relationship between upper jaw fork length (UJFL) and pectoral-dorsal length (PDL) of Indo-Pacific Sailfish

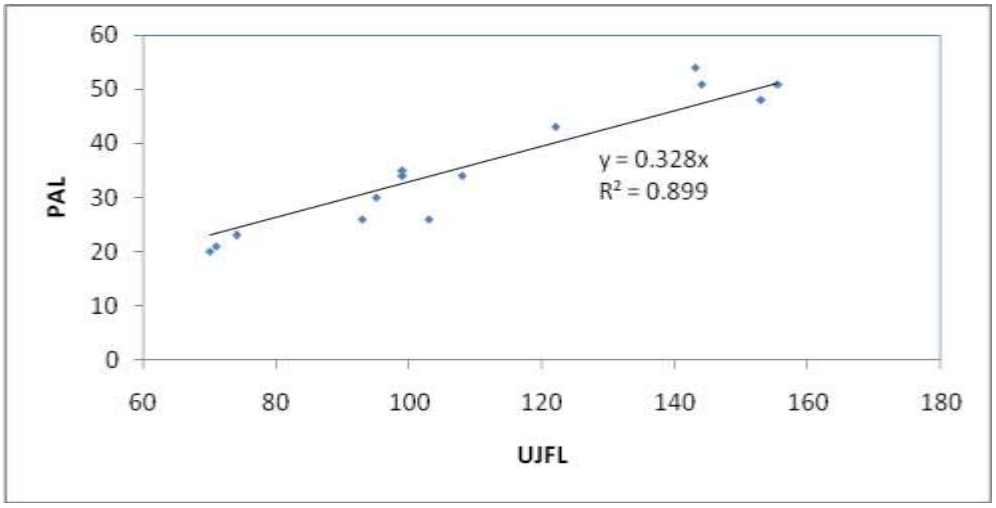

Figure 15. The relationship between upper jaw fork length (UJFL) and pectoral-anal length (PAL) of Indo-Pacific Sailfish

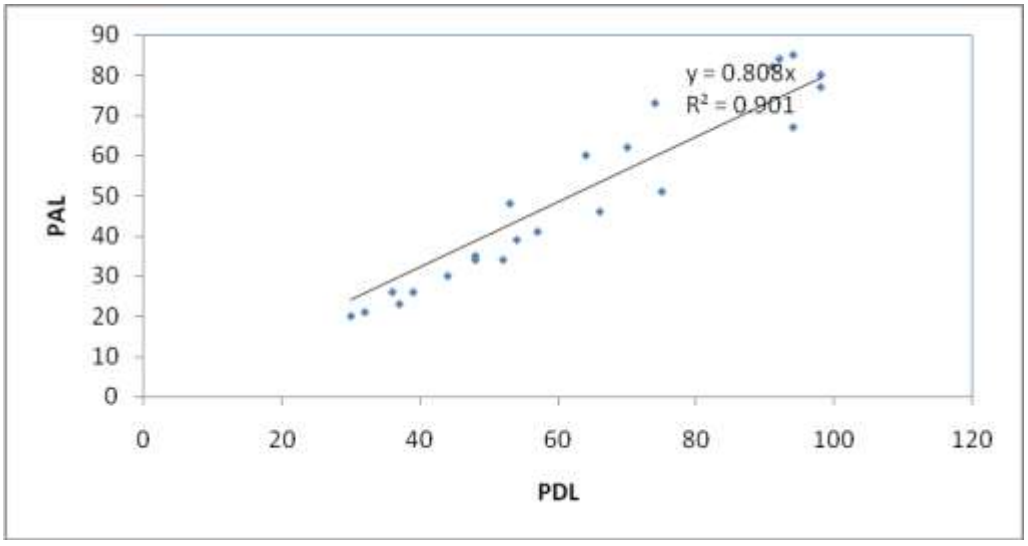

Figure 16. The relationship between pectoral-dorsal length (PDL) and pectoral-anal length (PAL) of Indo-Pacific Sailfish

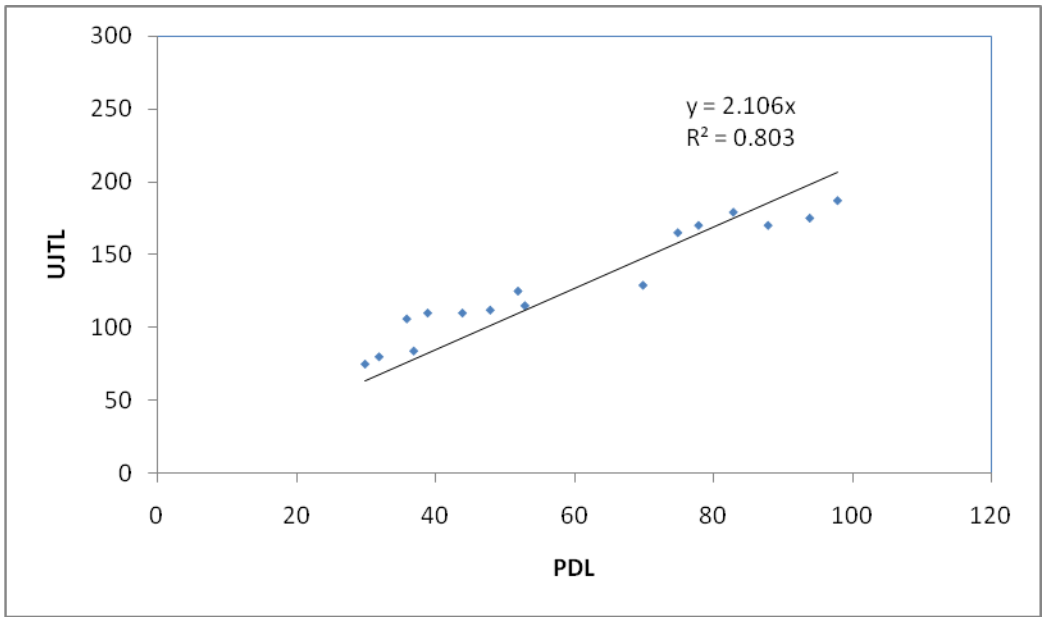

Figure 17. The relationship between pectoral-dorsal length (PDL) and upper jaw total length (UJTL) of Indo-Pacific Sailfish

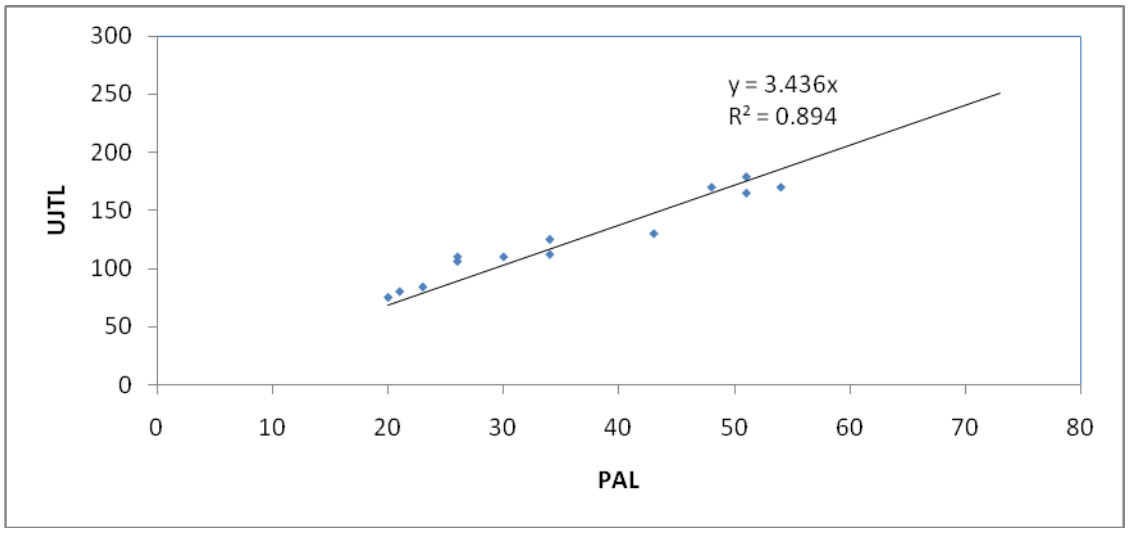

Figure 18. The relationship between pectoral-anal length (PAL) and upper jaw fork length (UJTL) of Indo-Pacific Sailfish

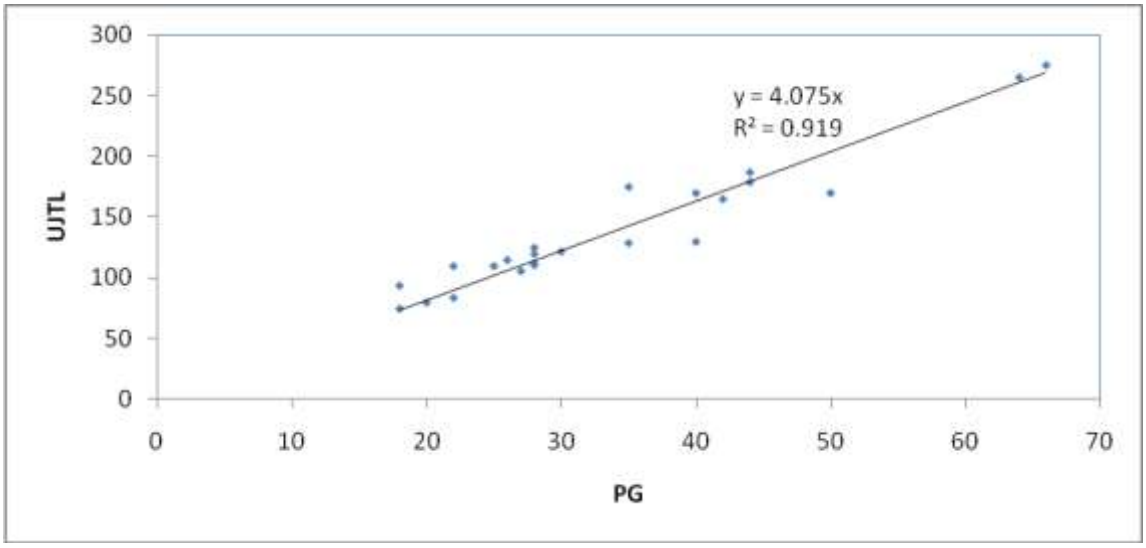

Figure 19. The relationship between girth via beginning of pectoral fin (PG) and upper jaw total length (UJTL) of Indo-Pacific Sailfish

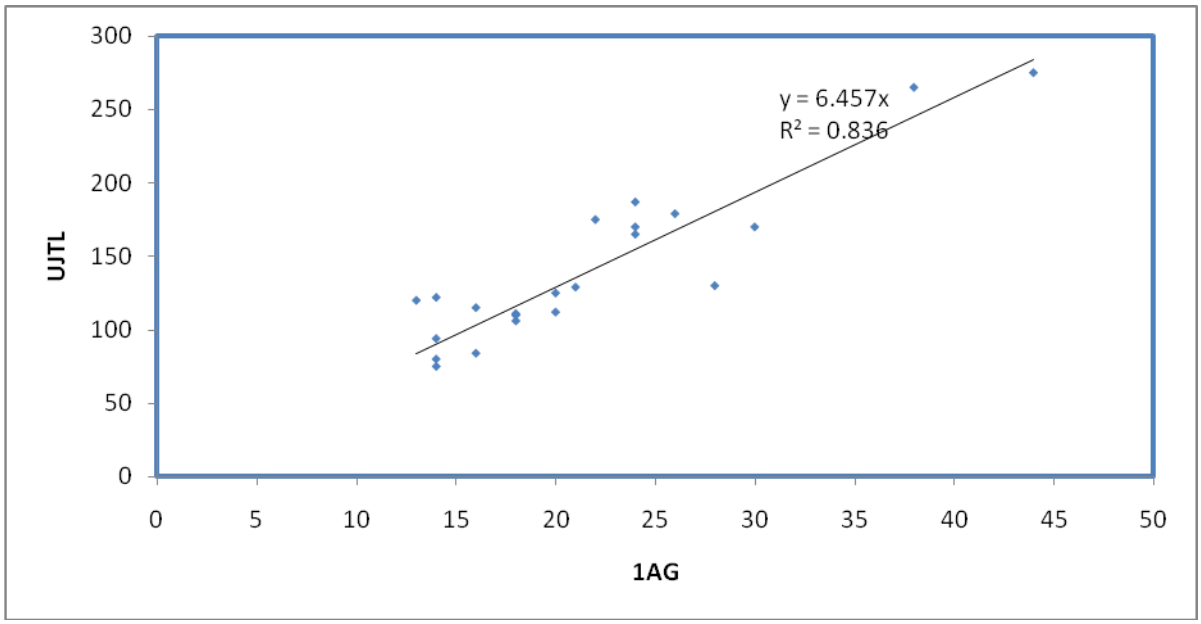

Figure 20. The relationship between girth via beginning of 1st anal fin (1AG) and upper jaw total length (UJTL) of Indo-Pacific Sailfish

Since measuring the total length and weight of a whole sailfish is difficult during the port sampling in Sri Lanka, the port sampling has to be revised so that taking the relevant measurements of the body parts of the fish described above. Accordingly, the estimates for key unknown biological parameters such as weight of the whole fish could be easily derived from the above described morphometric relationships.

Conclusion

This study provides useful length-weight, length-length and length-girth relationships of Indo-Pacific Sailfish. Since obtaining key biological data for sailfish at the fishing ports in Sri Lanka is difficult, the results of this study could be used to propose an alternative way of obtaining the missing biological parameters of sailfish for management purposes. Accordingly, some of the relationships could be incorporated as conversion factors in particular, for the new large pelagic database of Sri Lanka (new PELAGOS database) which is in the process of being developed.

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