Some biometric parameters of *Auxis thazard* (Lacepède, 1800) (frigate tuna) – data from fishery dependent and fishery independent surveys conducted in Sri Lankan waters.

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Abstract.

The neritic tuna catch in Sri Lankan waters is mainly composed of *Auxis thazard* (frigate tuna), *Auxis rochei* (bullet tuna), *Euthynnus affinis* (kawakawa) and *Scomberomorus commerson* (narrow- barred Spanish mackerel). Among them, frigate tuna is the dominant species presently contributing over 40% to the total neritic tuna production. Though several studies have been conducted to estimate some biometric parameters of the frigate tuna in Sri Lankan waters, all of the studies have focused on fishery dependent data. This paper attempts to estimate the biometric parameters of frigate tuna using both fishery independent data and fishery dependent data. Length–weight relationship (LWR) was calculated using the equation $W = aL^b$ and the Fulton's condition factor (K) was estimated from the relationship $K=100W/L^3$ (W = total weight; L = total length) to assess the condition of the selected fish. Fishery dependent data from 373 specimens was obtained from the samples collected from the coastal fisheries catches from October 2015 to September 2017. Fishery independent data of 254 specimens was obtained from the samples collected from R/V Dr. Fridtjof Nansen Ecosystem survey conducted in Sri Lankan waters from 24 June 2018 to 16 July 2018. The total length and the weight of the fishery dependent samples ranged from 21.50 cm – 44.20 cm and 118.89 g – 1430.90 g respectively while those parameters of fishery independent samples ranged from 14.00 cm – 19.00 cm and 20.00 g – 80.00 g respectively. The LWR for the commercial catch and the fishery independent catch were $W = 0.003L^{3.428}$ and $W = 0.037L^{2.540}$ respectively. The estimated K value for the commercial catch and fishery independent catch were 1.48 ± 0.15 and 1.03 ± 0.16 respectively. Considering the growth pattern of the two studies, commercial catch showed a positive allometric growth while fishery independent survey showed a negative allometric growth. Based on the results of the K, it can be concluded that the population consisting of larger fish from the commercial catches was at a better condition than the juvenile population studied during the fishery independent survey. According to the results of the

fishery independent survey, two possible nursery grounds for *Auxis thazard* in the Sri Lankan waters were identified.

Keywords: Frigate tuna, Length weight relationship, Fulton's condition factor, fishery dependent survey, fishery independent survey

Introduction.

Tuna fishery in Sri Lanka.

Sri Lanka is one of the oldest and most important tuna producing island nations in the Indian Ocean (Maldeniya & Amarasooriya, 1998). The tuna fishery in Sri Lanka was developing rapidly with the expansion of offshore and deep sea /high seas fishing as with more and more tuna fishing boats making multi-day fishing trips in offshore waters (Jayasooriya & Bandara, 2013). Exploration and exploitation of tuna fishery resources around this island have shown that the tuna resources of Sri Lanka are mainly comprised of Yellow fin tuna (*Thunnus albacares*), big eye tuna (*Thunnus obsesus*), skipjack tuna (*Katsuwonus pelamis*), kawakawa (*Enthynnus affinis*), frigate tuna (*Auxis thazard*) and bullet tuna (*Auxis rochei*) (Jayasooriya & Bandara, 2013). Among tuna species, skipjack dominates in both coastal and off shore areas, followed by yellow fin in the offshore area. The contribution of small tuna species (frigate tuna, kawakawa and bullet tuna) is also substantial in coastal waters (Maldeniya & Amarasooriya, 1998).

Neritic tuna fishery in Sri Lanka.

Neritic tuna is a major component in the coastal large pelagic catch. The neritic tuna catch in Sri Lankan waters is mainly composed of *Auxis thazard* (frigate tuna), *Auxis rochei* (bullet tuna), *Euthynnus affinis* (kawakawa) and *Scomberomorus commerson* (narrow- barred Spanish mackerel) (Bandaranayake, *et al*., 2015; Haputhantri, 2016). Among them, frigate tuna is the dominant species presently contributes over 40% to the total neritic tuna production (Haputhantri, 2016). Though there are several gear types and combinations in use for catching neritic tunas, gillnet (GN), and ring net (RN) are the two major fishing gears that significantly contribute to neritic tuna production (Perera *et al*, 2014).

Even though *Auxis thazard* (frigate tuna) is the dominant species in the neritic tuna catch in Sri Lankan waters, few studies have been conducted relating to the biological aspects of *Auxis thazard*. Further all studies were based on fisheries dependent data. This paper discusses some biological aspects related to this species using the data from the commercial catch of the coastal waters as well as from the fishery independent survey.

Materials and Methods.

Fishery dependent data

Data from 373 specimens from the single day boat catch was obtained from the samples collected from three provinces around the Sri Lankan coast. All the specimens had come from the coastal waters. Sample collection was carried out from October 2015 to September 2017. The samples were collected from Negombo and Beruwela in the Western Province, Chilaw and Kalpitiya in the North western Province and Dodanduwa, Galle and Weligama in the Southern Province of Sri Lanka (Fig. 1). The samples were obtained by visiting the landing sites twice a month.

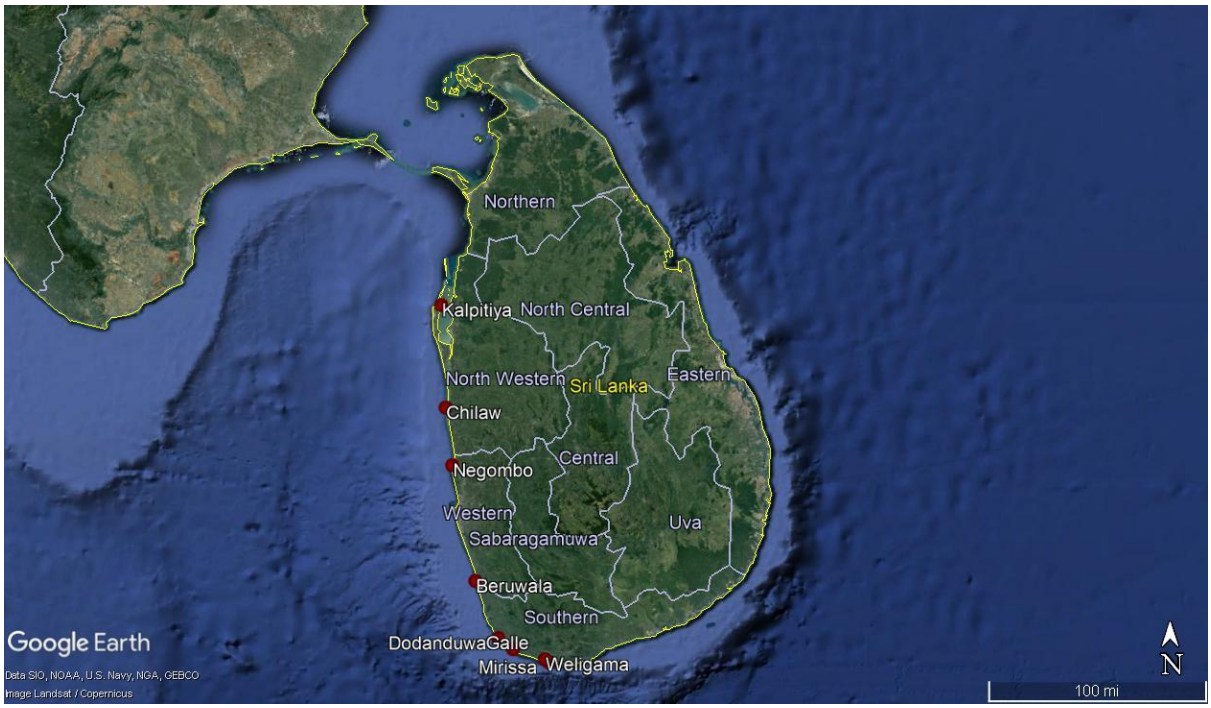


Figure 1: Sampling locations of *A. thazard* for fishery dependent data.

Fishery independent data

Data of 253 specimens was obtained during the ecosystem survey carried out by the RV Dr Fridtjof Nansen Survey Programme in Sri Lankan waters from 24 June 2018 to 16 July, 2018. Biological sampling of the fish was carried out using pelagic and bottom trawls. In shallow water (<30 m) or at night when pelagic fish was close to the surface, the pelagic trawl with floats or bottom trawl with floats were operated. At the end of the survey, a total number of 111 trawling stations (bottom and pelagic) had been completed among which 4 stations had recorded *Auxis thazard* (Figure 2). Details of the trawling stations that found *Auxis thazard* in the catch are tabulated in the Table 1.

Table 1: Details of the trawling stations.

Station No:	**Gear type**	**Depth (m)**
66	Bottom trawl	10 – 15
68	Bottom trawl	14 – 14
73	Bottom trawl	70 – 73
80	Pelagic trawl	46 – 46

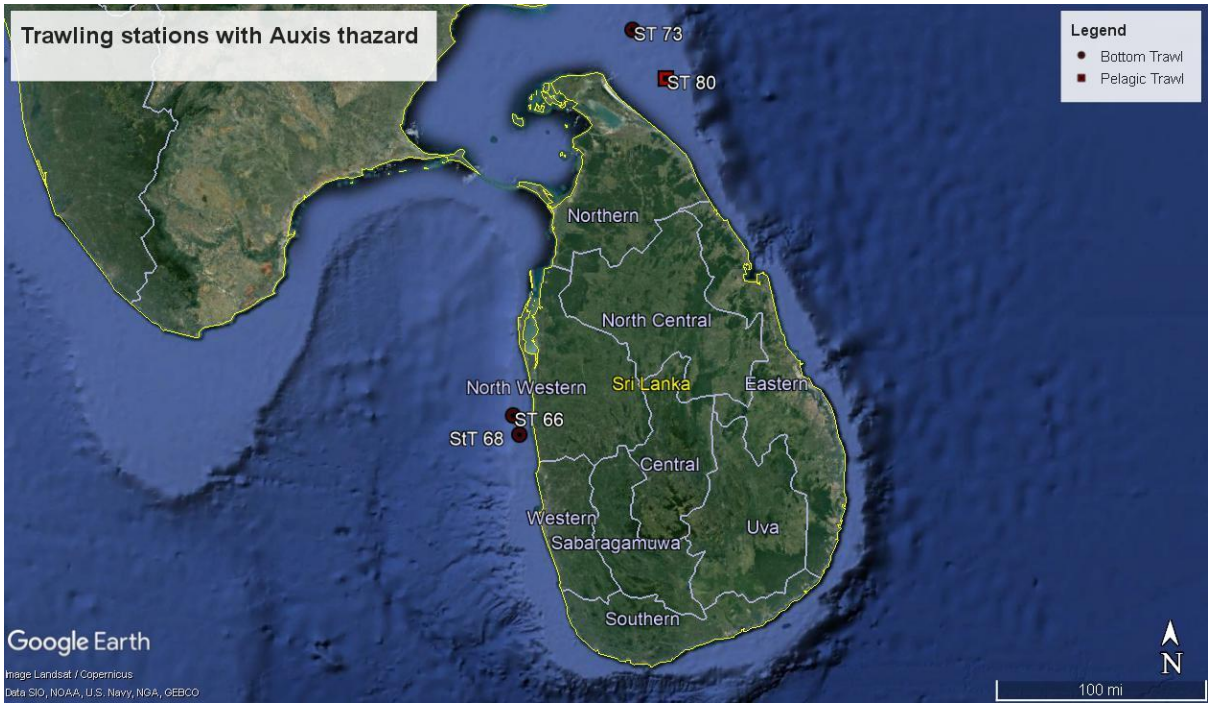


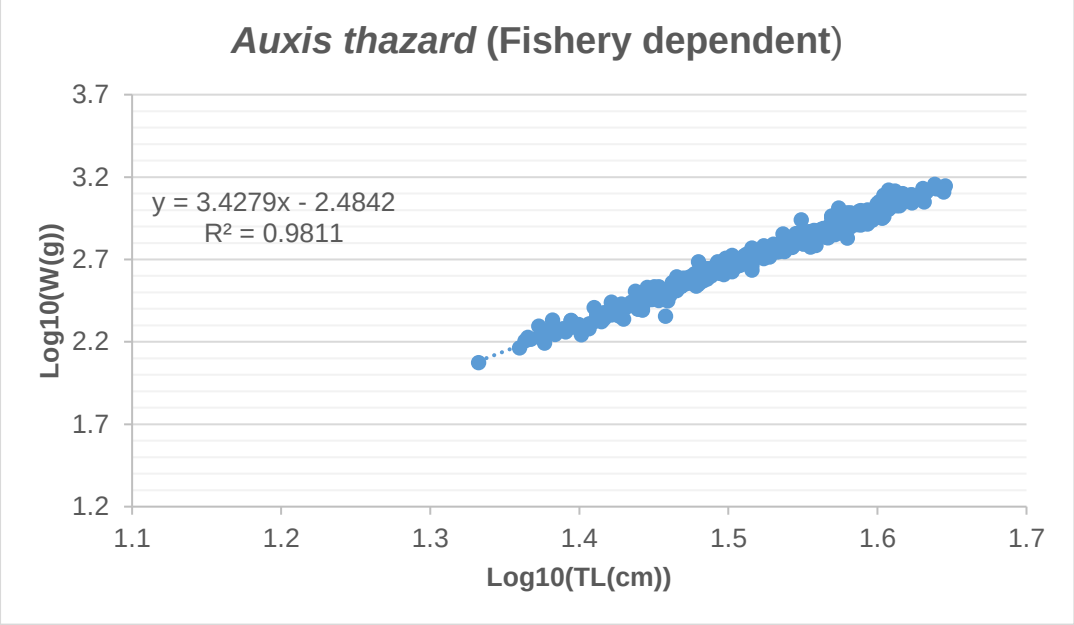
Figure 2: Trawling stations of which *Auxis thazard* recorded.

In the fishery dependent samples, the weight of the fish was measured to the nearest 0.1 g whereas the total length (TL) was measured to the nearest 0.1 cm. In the RV Dr Fridtjof Nansen Survey, total weight was measured to the nearest 0.5 g whereas the total length (TL) was measured to the nearest 1cm. Length–weight relationships (LWR) were calculated by the equation $W = aL^b$ (Schneider, *et al*., 2000). The relationships between the length and weight of the fish was estimated using least squares method applied to the log transformed data of males and females given as: log W = log a + b log L, where 'W' is the body weight of the fish, 'L' is the total length, 'a' is the intercept of the regression curve and 'b' is the regression coefficient. The Fulton's condition factor (K) was estimated according to Htun-Han (1978) from the relationship $K=100W/L^3$ to assess the fish condition in Sri Lankan waters.

Results.

Bio metric parameters.

Figure 3 illustrate the estimated LWR for of *Auxis thazard* in the Sri Lankan waters using fishery independent and dependent data.



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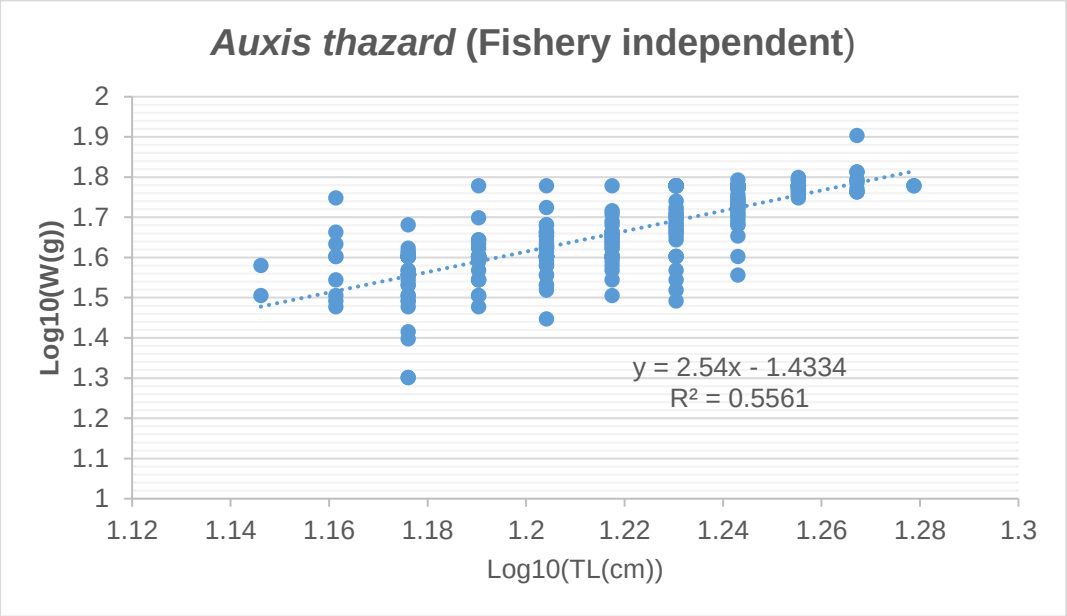

B

Figure 3: A – LWR from the commercial catch; B – LWR from the fishery independent survey

Results of the LWR of *Auxis thazard* for samples collected via fishery independent survey and fishery dependent survey is tabulated in the Table 2.

Table 2. Length- Weight Relationship (LWR) of *Auxis thazard*

Survey type	**N**	**LWR**	**Parameters of LWR**		**r^2**	**Growth type**
			a	**b**		
Fishery dependent	373	$W = 0.003TL^{3.43}$	0.003	3.43	0.98	Positive Allometric
Fishery independent	253	$W = 0.04TL^{2.54}$	0.04	2.97	0.56	Negative Allometric

Table 3 shows a summary of the values for parameters obtained for *Auxis thazard* from fishery independent and fishery dependent surveys: Length (cm), Weight (g) and Fulton's Condition Factor (K).

Table 3. Parameter values of Length (cm), Weight (g) and Fulton's Condition Factor (K) of *Auxis thazard*

Survey type	**TL(cm)**		**Weight (g)**		**K**
	Min - Max	**Mean ± SD**	**Min - Max**	**Mean ± SD**	**Mean ± SD**
Fishery dependent	21.50 – 44.20	33.84 ± 5.36	118.89 – 1430.90	634.81 ± 324.72	1.48 ± 0.15
Fishery independent	14.00 – 19.00	16.46 ± 1.09	20.00 – 80.00	46.20 ± 10.19	1.03 ± 0.16

Discussion and Conclusions.

The estimated mean TL of *Auxis thazard* from the samples obtained from RV Dr Fridtjof Nansen Survey (fishery independent data) was 16.46 ± 1.09 cm. The size at first sexual maturity of the *Auxis thazard* has been estimated in the other scientific studies as 29.5cm FL (Bahou, *et al*., 2016; FishBase, 2019). It was statistically proven that the corresponding sample mean FL of *Auxis thazard* from fishery independent survey data was significantly less than the size at maturity. Therefore, it is evident that fishery independent data has been gathered from a juvenile population of *Auxis thazard* in the Sri Lankan waters.

On the other hand, the corresponding mean FL value for the commercial catch from the single day boats was 32.11 cm. Accordingly, it was statistically proven that the samples obtained from commercial catches of *Auxis thazard* in the Sri Lankan waters are represented a matured fish population. Thus, single day boat fishery operated in the coastal zone in the Sri Lankan waters is sustainable in the means of not capturing immature juveniles of *Auxis thazard.*

According to Froese (2006), the exponent *b* should normally fall between 2.5 and 3.5. In this study the exponent *b* for the two studied populations were within this range and therefore the parameters can be used as the referred length range. The results further revealed that immature population of *Auxis thazard* showed a negative allometric growth ($b < 3$) while mature population showed a positive allometric growth ($b>3$). Positive allometric growth results of the mature population of *Auxis thazard* is in agreement with those obtained previously in the Indian Ocean (Tampubolon, *et al.,* 2016; Herath, *et al.,* 2019). Thus, it can be concluded that the

mature *Auxis thazard* gets relatively plumb as it grows. Considering the immature population of *Auxis thazard* in the Sri Lankan waters, their negative allometric growth is hard to compare with other similar studies in the region as all most all of those studies were concentrated on mature populations. However it can be concluded that the *Auxis thazard* in the Sri Lankan waters are favor increase in length than in mass as it grows till maturation. The LWR are not stable for different populations thus may vary in relation to their environmental factors like temperature, salinity, food (quality, quantity and size), habitat and gonad maturity, spawning period, season, and sex etc. (Froese, 2006; Jayaprabha, *et al.*, 2015). Therefore, the differences in the LWR for two populations of the same species may be due to the environmental factors and/or due to different growth stages.

According to Fulton (1902), a standard condition factor of 1.6 implies excellent condition, 1.4 - good and well-proportioned fish, 1.2 - fair condition, 1 - a long and thin fish in poor condition, and 0.8 - extremely poor condition. Thus, according to the results, it can be concluded that the mature population of *Auxis thazard* in the Sri Lankan waters was in a good condition. The resulted K value for the immature population was ~ 1. Thus, it can be concluded that the immature population of *Auxis thazard* in the Sri Lankan waters was in a poor condition at least during the period of the survey. The sustainability of a given fishery is a function of the number of sexually matured fish present in those water. If there is adverse condition for immature population, the natural replenishment in the fishing grounds through their maturation and spawning processes get disturbed which may lead to growth over fishing (Ganga, *et al*., 2014). However, the value of **K** is influenced by age of fish, sex, season, stage of maturation, fullness of gut, type of food consumed, amount of fat reserve and degree of muscular development (Barnham & Baxter, 1998). Therefore it is imperative to monitor the condition of the immature fish population of *Auxis thazard* in the Sri Lankan waters in order to ascertain the sustainability of the resources.

According to the results of the RV Dr Fridtjof Nansen Survey, *Auxis thazard* had been only recorded in four trawling stations at shallow depths. When considering the depth ranges of the stations, it varies from 10 m (station 66) to 73m (station 73) thus all of them were located in the coastal zone. According to the other studies of Uchida, 1963 and Siriraksophon, 2014, though the juveniles were recorded in coastal as well as oceanic environments, most of the nursery and spawning grounds of *Auxis thazard* had been identified in the shallow coastal areas. Therefore, it is fair to conclude that there are two possible nursery grounds of *Auxis thazard* in

the Northern and Western coastal waters of Sri Lanka. This might be the first record of possible nursery grounds reported for *Auxis thazard* in the Sri Lankan waters.

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