POPULATION PARAMETERS: FRIGATE TUNA (*AUXIS THAZARD*)

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Frigate tuna (*Auxis thazard*) is a highly migratory epipelagic species inhabiting neritic and oceanic waters of the tropical Indo-Pacific and Atlantic oceans (Figure 1) (Froese & Pauly 2016). Numerically abundant, frigate tuna are an important forage species for tunas and other larger fishes. Frigate tuna are primarily taken by line (longline, hand line, troll line) and gillnet gear in coastal waters, and are also an important bycatch for industrial purse seine vessels. Catches are concentrated in Indonesia and to a lesser extent in India and Sri Lanka (Geehan & Pierre 2015). Most research on growth for this species derives from those countries, particularly India, and is predominately based on length-frequency studies (Table 1). Variation in growth parameter estimates among length-based studies may arise from differences in size selectivity of the sampling gear and analytical methods rather than from biological differences (Ghosh et al. 2010). Age-based estimation of growth parameters is lacking in the Indian Ocean but age determination based on vertebrae has been undertaken in Taiwan (Yu et al. 2012).

Estimates of growth parameters vary extensively among studies with k values ranging from 0.49 (Silas et al. 1985) to 1.4 (Yesaki 1989). Variability in estimated growth parameters may be due to differences in estimation techniques, regional biological differences or differences in size selectivity across fish sampling methods. A comparison of the growth model parameters and growth curves derived from each study are provided in Table 1 and Figure 2. Estimates of mortality and length-weight relationship parameters are provided in Table 2.

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Figure 1. Distribution of *Auxis thazard* in the Indian Ocean[2]

[2] Reviewed distribution map for *Auxis thazard* (Frigate tuna), with modelled year 2100 native range map based on IPCC A2 emissions scenario. www.aquamaps.org, version of Aug. 2015. Web Accessed 12 Apr 2016.

Table 1. Estimated growth parameters for frigate tuna (*Auxis thazard*) with details of the type of analysis from which they have been determined and the region. LF: length frequency studies; ELEFAN: Electronic Length Frequency Analysis; M: male; F: female; FL: fork length.

Region			Von Bertalanffy growth parameters			Length at age (cm)				n	Ageing method	Analysis type	Reference
	L_{m50} (cm)	L_{max} (cm)	L_∞ (cm)	K (year^{-1})	t_0 (years)	Yr 1	Yr 2	Yr 3	Yr 4				
Philippines	21.2	65.0	36.6 (FL)	1.21	-0.120								Fishbase
Taiwan		47.0	48.2 (FL)	0.52	-0.332					584	Vertebrae	Annual increments	(Yu et al. 2012)
India (Veraval)		47.9	46.6 (FL)	0.93	-0.015	28.5	39.5	43.8		1788	LF	ELEFAN	(Ghosh et al. 2010)
India	29.7	55.0	57.9 (FL)	1.20	-0.008	40.7	52.7			884	LF	ELEFAN	(Ghosh et al. 2012)
India (East coast)		48.0	53.8	1.04		33.5	46.6				LF	ELEFAN	(Kasim & Abdussamad 2003)
India (Tuticorin):			49.0 (M) 51.2 (F)	1.30 1.30	-0.003 -0.004	35.7 37.3	45.4 47.4	48.0 50.2			LF	ELEFAN	(Kasim 2002)
India			63.0	0.49	-0.27	29.0	42.0	50.0			LF	ELEFAN	(Silas et al. 1985) [3]
Indonesia			47.5	0.70		24.0	36.0	42.0			LF	ELEFAN	(Dwinpongo et al. 1986) [2]
Sri Lanka			58.0	0.54		25.0	39.0	47.0			LF	ELEFAN	(Joseph et al. 1986) [2]
Thailand (Gulf of)			52.0	1.4		39.0	49.0				LF	Modal progressions	(Yesaki 1989) [2]
Thailand (West coast)			47.2	0.80		26.0	37.0	43.0			LF	Modal progressions	(Yesaki 1982) [2]
Philippines			47.0	0.73		24.0	36.0	42.0			LF	ELEFAN	(Ingles & Pauly 1985) [2]

[3] Cited in Yesaki & Arce (1994)

Table 2. Mortality parameters and length-weight relationships

Region	Mortality estimates		Lifespan (y)	Length-weight relationship			Reference
	M (year^{-1})	Z (year^{-1})		a	b	Units	
Philippines	1.95		2.4	0.006	3.19	TL(cm) - g	Fishbase
Taiwan	0.91	1.31		0.000002	3.39	FL(cm) - g	(Yu et al. 2012)
India (Veraval)	1.48	5.97	3.2	0.125	3.17	FL(cm) - g	(Ghosh et al. 2010)
India (Bengal)				0.021	2.90	TL(cm) - kg	(Rugpan et al. 2008)
India (Tuticorin)				0.000003	3.51	FL(cm) - kg	(Siraimeetan 1985)
India (Karnataka)				0.008	3.23	TL(cm) - g	(Abdurahiman et al. 2004)

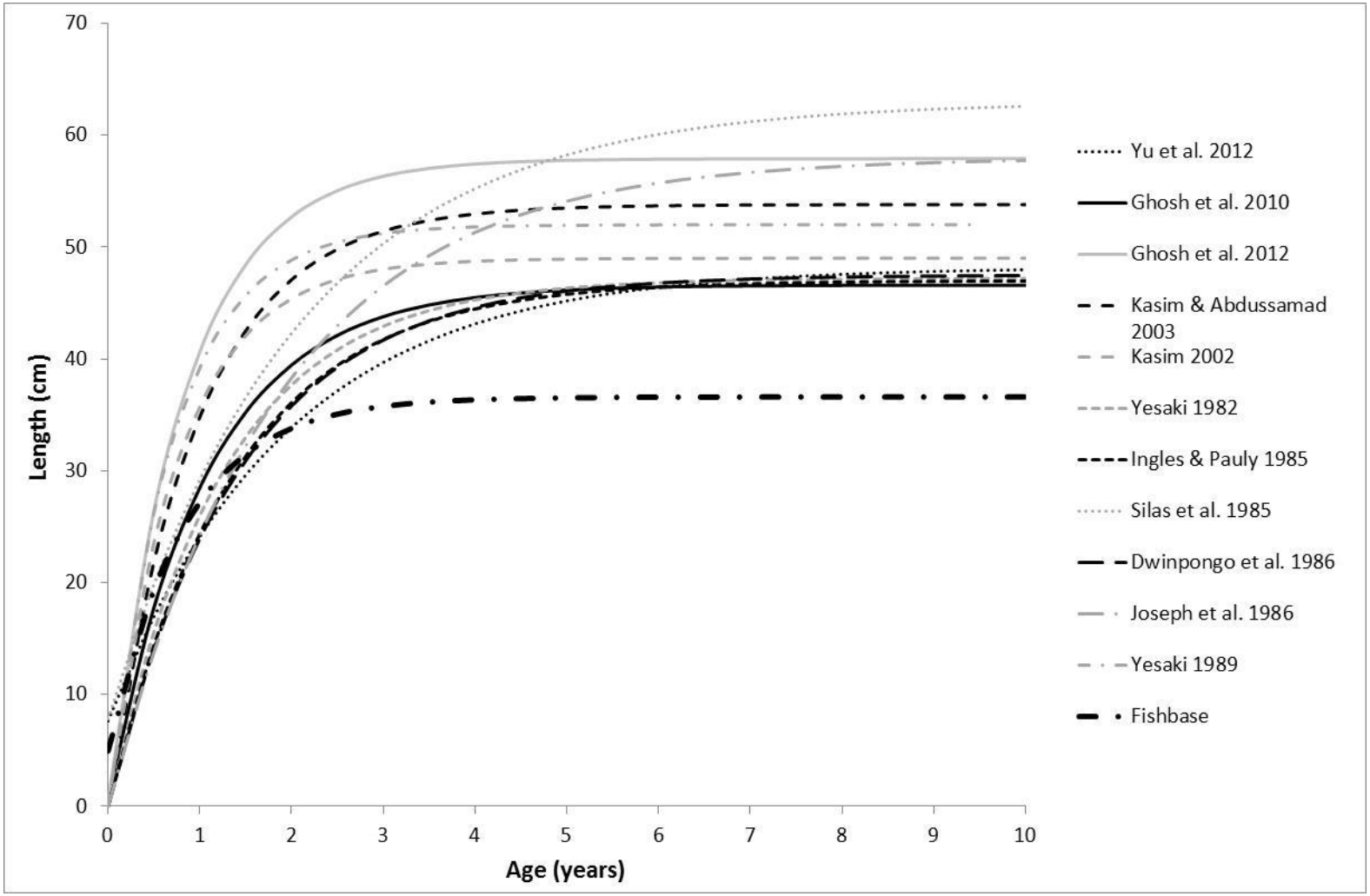

Figure 2. Length-at-age curves derived from ageing studies of frigate tuna (*Auxis thazard*) from different regions of the Indian Ocean. Curves may differ in terms of the length measurement (e.g. fork length vs. total length) taken, which is not specified in all studies (see table 1).

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