

### Estimation of catches at size for IOTC species

Equations used to convert from non-standard measurement to fork length (Table 1) and from fork length to round weight (Table 2)

Table 1: Regression equations used to convert from non-standard measurements into standard lengths (tunas: tip of the snout to fork length; swordfish: lower-jaw to fork length) per species

Species: Yellowfin tuna				Standard length: Tip of snout to fork of tail				
Type Measurement	Equation	Parameters	Sample size	Size	Variance	Covariance ab	Mean Residual	Gradient
Weight gilled and gutted <sup>A</sup>	$a * W^b$	a= 44.28699 b= 0.3008591	2,361	Min:14 Max:71	a=0.00752476509 b=2.86244E-07	-4.626246E-05	4.095958	a=3.033852 b=495.6385
Length to the base of the 1 <sup>st</sup> dorsal fin <sup>B</sup>	$a * L^b$	a=2.0759 b=1.1513	7,036	Min: 29 Max: 164				

Species: <i>Bigeye tuna</i>	Standard length: Tip of snout to fork of tail
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Type Measurement	Equation	Parameters	Sample size	Size	Variance	Covariance ab	Mean Residual	Gradient
Weight gilled and gutted <sup>A</sup>	$a \cdot W^b$	a= 42.2186 b= 0.3012349	316	Min:12 Max:107	a=0.0321755341 b=1.299934E-06	-0.0002034041	3.98137	a=3.03806 b=473.1455
Length to the base of the 1 <sup>st</sup> dorsal fin <sup>C</sup>	$\frac{(L+a)^2}{(b)^2}$	a=21.45108 b=5.28756	2,858	Min:13 Max:48				

Species: Albacore	Standard length: Tip of snout to fork of tail
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Type Measurement	Equation	Parameters	Sample size	Size	Variance	Covariance $ab$	Mean Residual	Gradient
Weight round <sup>D</sup>	$(W/a)^{(1/b)}$	$a=0.000013718$ $b=3.0793$	n/a	n/a				

Species: <i>Swordfish</i>	Standard length: Tip of lower-jaw to fork of tail
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Type Measurement	Equation	Parameters	Sample size	Size	Variance	Covariance ab	Mean Residual	Gradient
Cleithrum-Fork length <sup>E</sup>	(L+b)/a	a= 0.8087 b= 8.6712	n/a	n/a				
Cleithrum-keel length <sup>F</sup>	(a*L)+b	a= 1.55108 b= 13.5025	179	Min:88 Max:252				
Eye orbit-fork length <sup>G</sup>	(a*L)+b	a= 1.066 b= 10.449	123	Min:48 Max:255				
Pectoral-anal length <sup>I</sup>	(a*L)+b	a= 2.5407 b= 25.698	1,806	Min:18 Max:105				
Pectoral-fork length <sup>K</sup>	(a*L)+b	a= 1.2398 b= 11.204	55	Min:60 Max:157				
Weight round <sup>L</sup>	(W/a)^(1/b)	a= 0.000003815 b= 3.188	3,608	Min:89 Max:266				
Weight gilled and gutted <sup>H</sup>	(W/a)^(1/b)	a= 0.0000043491 b= 3.188	3,608	Min:89 Max:266				
Weight headed <sup>I</sup>	(W/a)^(1/b)	a= 0.000004592 b= 3.137	n/a	n/a				

*A: Data from Penang Sampling Programme (1992-93)*

***B: Data from the Indian Ocean (Marsac, F. et al in IOTC-2006-WPTT-09)***

C: Data from the Atlantic Ocean, Champagnat et Pianet (1974) (ibid. B)

**D: Inverted length-weight relationship; ICCAT South Atlantic**

*E: Reference not available (to be provided)*

F: Two step conversion as  $CKL = (0.690253 * EFL) - 3.541823$  in formula  $LJFL = 8.00884 + (1.07064 * EFL)$ ; NOAA Data (Pacific Ocean)

*G, J, K: Data from Reunion Island, Indian Ocean Poisson 2001 (in IOTC-2005-WPTT-05)*

*H: Inverted length-weight equation (ICCAT Mejuto et al 1998 South-East Atlantic Ocean)*

*I: Inverted length-weight equation; Reference not available (to be provided)*

*L*: Converted to GGT ( $GGT = RND / 1.14$  (Mejuto et al. 1998)) and inverted length-weight equation (ICCAT Mejuto et al 1998 South-East Atlantic Ocean)

Table 1(cont): Regression equations used to convert from non-standard measurements into standard lengths (eye orbit to fork length), per species

Species: Black marlin				Standard length: Eye orbit to fork of tail				
Type Measurement	Equation	Parameters	Sample size	Size	Variance	Covariance ab	Mean Residual	Gradient
Cleithrum-Keel length	No equation available							
Lower-jaw - fork length <sup>M</sup>	(a*L)+b	a= 0.8972 b= -4.6673	13	Min:119 Max:314				
Weight gilled and gutted <sup>N</sup>	a*L <sup>^</sup> b	a= 41.56681 b= 0.309442	24	Min:8.6 Max:279				

Species: <i>Blue marlin</i>				Standard length: Eye orbit to fork of tail				
Type Measurement	Equation	Parameters	Sample size	Size	Variance	Covariance ab	Mean Residual	Gradient
Lower-jaw - fork length <sup>O</sup>	(a*L)+b	a= 0.9039 b= -7.248	26	Min:143 Max:295				
Weight gilled and gutted <sup>P</sup>	a*L <sup>^</sup> b	a= 46.0356637 b= 0.283377	154	Min:10 Max:381				

Species: Striped marlin				Standard length: Eye orbit to fork of tail				
Type Measurement	Equation	Parameters	Sample size	Size	Variance	Covariance ab	Mean Residual	Gradient
Lower-jaw - fork length <sup>Q</sup>	(a*L)+b	a= b=		Min: Max:				
Weight round <sup>R</sup>	a*L <sup>^</sup> b	a= 51.3506 b= 0.300417	1427	Min:7 Max:100				
Weight gilled and gutted <sup>S</sup>	a*L <sup>^</sup> b	a= 45.443009 b= 0.300417	1427	Min:7 Max:100				

Species: Indo-Pacific sailfish				Standard length: Eye orbit to fork of tail				
Type Measurement	Equation	Parameters	Sample size	Size	Variance	Covariance ab	Mean Residual	Gradient
Cleithrum-Keel length	No equation available							
Lower-jaw - fork length <sup>T</sup>	(L+b)/a	a= 0.8845 b= -3.7025	1166	Min:78 Max:232				
Weight gilled and gutted <sup>u</sup>	a*L <sup>b</sup>	a= 45.5076 b= 0.347166	35	Min:5 Max:38				

*M: BRS (Ward, pers.com.) Eastern and western Australia (on IOTC-2005-WPTT-05)*

N: PIFSC Administrative report: (Updated Weight-on-Length Relationships for Pelagic Fishes Caught in the Central North Pacific Ocean and Bottom fishes from the Northwestern Hawaiian Islands). With value of a (46.9705) divided by 1.13 to account for conversion of gilled-and-gutted weight into round weight

*O: BRS (Ward, pers.com.) Eastern and western Australia (on IOTC-2005-WPTT-05)*

*P:PIFSC Administrative report: (Updated Weight-on-Length Relationships for Pelagic Fishes Caught in the Central North Pacific Ocean and Bottom fishes from the Northwestern Hawaiian Islands) Value of a (52.0203) divided by 1.13 to account for conversion of gilled-and-gutted weight into round weight*

*Q: BRS (Ward, pers.com.) Eastern and western Australia (on IOTC-2005-WPTT-05)*

*R:PIFSC Administrative report: (Updated Weight-on-Length Relationships for Pelagic Fishes Caught in the Central North Pacific Ocean and Bottom fishes from the Northwestern Hawaiian Islands)*

*S:PIFSC Administrative report: (Updated Weight-on-Length Relationships for Pelagic Fishes Caught in the Central North Pacific Ocean and Bottom fishes from the Northwestern Hawaiian Islands) Value of a (51.3506) divided by 1.13 to account for conversion of gilled-and-gutted weight into round weight*

T: Wei-Chuan Chiang et al., 2004; inverted EFL-FL equation (M+F sexes pooled)

*U: PIFSC Administrative report: (Updated Weight-on-Length Relationships for Pelagic Fishes Caught in the Central North Pacific Ocean and Bottom fishes from the Northwestern Hawaiian Islands) Value of a (51.4235) divided by 1.13 to account for conversion of gilled-and-gutted weight into round weight*

**Table 2: Equations used to convert from standard length into round weight, per species**

Species	Gear Type/s	From type measurement – To type measurement	Equation	Parameters	Sample size	Length
Yellowfin tuna	Purse seine Pole and Line Gillnet	Fork length(cm) – Round Weight(kg) <sup>A</sup>	$RND=a*L^b$	$a=0.00002459$ $b=2.96670$	25,386	Min: 29 Max: 166
	Longline Line Other Gears	Fork length(cm) – Gilled and gutted weight(kg) <sup>B</sup> Gilled and gutted weight(kg) - Round Weight(kg) <sup>C</sup>	$GGT=a*L^b$ $RND=GGT*1.13$	$a=0.0000094007$ $b=3.126843987$	15,133	Min:72 Max:177
Bigeye tuna	Purse seine Pole and Line Gillnet	Fork length(cm) – Round Weight(kg) <sup>A</sup>	$RND=a*L^b$	$a=0.00002217$ $b=3.01211$	2,156	Min: 29.5 Max: 174
	Longline Line Other Gears	Fork length(cm) – Gilled and gutted weight(kg) <sup>B</sup> Gilled and gutted weight(kg) - Round Weight(kg) <sup>C</sup>	$GGT=a*L^b$ $RND=GGT*1.13$	$a=0.0000159207$ $b=3.0415414023$	12,047	Min:70 Max:187
Skipjack tuna	All gears	Fork length(cm) – Round Weight(kg) <sup>A</sup>	$RND=a*L^b$	$a=0.00000497$ $b=3.39292$	1,762	Min: 30 Max: 73
Albacore	All gears	Fork length(cm) – Round Weight(kg) <sup>F</sup>	$RND=a*L^b$	$a=0.0000569070$ $b=2.75140$	2,499	Min:46 Max:112
Swordfish	All gears	Tip of lower-jaw to fork of tail(cm) – Round Weight(kg) <sup>G</sup>	$RND=a*L^b$	$a=0.0000042030$ $b=3.21340$	2,569	Min:80 Max:253
Black marlin	All gears	Eye orbit to fork of tail(cm) – Round Weight(kg) <sup>H</sup>	$RND=a*L^b$	$a=0.0000144217$ $b=2.98851$	24	Min:95 Max:279
Blue marlin	All gears	Eye orbit to fork of tail(cm) – Round Weight(kg) <sup>H</sup>	$RND=a*L^b$	$a=0.00000272228$ $b=3.30967$	154	Min:109 Max:269
Striped marlin	All gears	Eye orbit to fork of tail(cm) – Round Weight(kg) <sup>H</sup>	$RND=a*L^b$	$a=0.00000133263$ $b=3.41344$	17	Min:101 Max:178
Indo-Pac. sailfish	All gears	Eye orbit to fork of tail(cm) – Round Weight(kg) <sup>H</sup>	$RND=a*L^b$	$a=0.0000690103$ $b=2.52429$	35	Min:86 Max:187

**A: Length-weight relationships for tropical tunas caught with purse seine in the Indian Ocean: Update and lessons learned (Chassot, E. et al in IOTC-2016-WPDSC12-INF05)**

**B: Multilateral catch monitoring Benoa (2002-04)**

**C: ICCAT Field Manual (Appendix 4: Population parameters for key ICCAT species. Product Conversion Factors)**

**D: Cort (1986)**

**E: Data from the Atlantic Ocean, Cayré et Laloë (Fonteneau, A. et J. Marcille (eds), 1988: Ressources, pêche et biologie des thonidés tropicaux de l'Atlantique Centre-Est. FAO Doc.Tech.Pêches, (292), page262)**

**F: Data from the Indian Ocean, Taiwanese gillnet fishery (Chien-Chung Hsu)**

**G: Data from the Atlantic Ocean, Spanish longline fishery (Mejuto et al., 1988, ICCAT)**

**H: PIFSC Administrative report: (Updated Weight-on-Length Relationships for Pelagic Fishes Caught in the Central North Pacific Ocean and Bottom fishes from the Northwestern Hawaiian Islands)**

**Table 2: Equations used to convert from standard length into round weight, per species**

Species	Gear Type/s	From type measurement – To type measurement	Equation	Parameters	Sample size	Length
Blue shark		Fork length – Round Weight(kg) <sup>A</sup>	$RND=a*L^b$	$a=0.0000031841$ $b=3.1313$		Min: Max:
		Precaudal length – Fork Length <sup>C</sup>	$FL=\frac{PCL+a}{b}$	$a=0.3956$ $b=0.9075$		Min: Max:
		Total length – Fork length <sup>D</sup>	$FL=a*TL+b$	$a=0.822$ $b=1.754$	10	Min:217 Max:265
						Min:70 Max:187
Shortfin Mako Shark		Fork length – Round Weight <sup>A</sup>	$RND=a*L^b$	$a=0.0000052432$ $b=3.1407$		Min: Max:
		Precaudal length – Fork Length <sup>C</sup>	$FL=a*PCL+b$	$a=1.100$ $b=0.766$	n/a	n/a
		Total length – Fork length	$FL=a*TL+b$	$a=0.9286$ $b=-1.7101$		Min: Max:

Oceanic whitetip shark		Fork length – Round Weight <sup>B</sup>	$RND = a * L^b$	$a = 0.000018428$ $b = 2.9245$		Min: Max:
		Total length – Fork length	$FL = a * TL + b$	$a = 0.7847$ $b = 1.211$		Min: Max:
Porbeagle		Fork length – Round Weight <sup>A</sup>	$RND = a * L^b$	$a = 0.000014823$ $b = 2.9641$		
		Precaudal length – Fork Length <sup>C</sup>	$FL = a * PCL + b$			
Silky Shark		Fork length – Round Weight <sup>A</sup>	$RND = a * L^b$	$a = 0.000015406$ $b = 2.9221$		
Bigeye Thresher Shark		Fork length – Round Weight <sup>A</sup>	$RND = a * L^b$	$a = 0.0000091069$ $b = 3.0802$		
Thresher Shark		Fork length – Round Weight <sup>A</sup>	$RND = a * L^b$	$a = 0.00018821$ $b = 2.5188$		

*A: Data from Western North Atlantic: NOAA Technical Memorandum NMFS-NE-110 (May 1996)*

*B: Data from Indian Ocean: Length-weight relationships, conversion factors and analyses of sex-ratio, by length-range, Observers onboard Spanish Longliners in South Western Indian Ocean during 2005; Ariz J, A Delgado de Molina, M.L Ramos, J.C Santana*

*C: Inverse equation from WCPFC Analysis of North Pacific Shark Data from Japanese Commercial Longline and Research/Training Vessels Record; Shelley Clarke, Kotaro Yokawa, Hiroaki Matsunaga and Hideki Nakano*

*D: Indian Ocean : Maldivian Oceanic Shark Longline Fishery; R.C. Anderson, M.S. Adam & M. Saleem*

*E: Data from the Atlantic Ocean, Cayré et Laloë (Fonteneau, A. et J. Marcille (eds), 1988: Ressources, pêche et biologie des thonidés tropicaux de l'Atlantique Centre-Est. FAO Doc.Tech.Pêches, (292), page262)*

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**Table 1**

Descriptive statistics and Length–weight relation parameters for bigeye tuna, yellowfin tuna, and albacore from the Atlantic, Indian, and eastern Pacific oceans

Species	Area	FL range [m]	Mean FL [cm]	Mean W [g]	n	a	b	95% CL of b	r <sup>2</sup>	t-test (H <sub>0</sub> : b = 3)	
										t value	P value
BET	Atlantic	43.2–206.0	128.0	36546.2	2280	0.0158	2.997	2.968–3.026	0.9471	9.837	< 0.001
YFT	Atlantic	83.0–176.8	143.2	45309.0	299	0.0166	2.969	2.884–3.054	0.9412	12.411	< 0.001
ALB	Atlantic	99.1–125.0	107.2	23985.1*	94	0.0438*	2.825*	2.499–3.151	0.7628	10.338	< 0.001
BET	Indian Ocean	54.8–201.0	134.0	45195.7	1052	0.0247	2.926	2.898–2.954	0.9649	199.492	< 0.001
YFT	Indian Ocean	78.0–171.0	125.9	32267.9	1033	0.0163	2.985	2.953–3.017	0.9696	29.149	< 0.001
ALB	Indian Ocean	93.0–119.0	105.7	24045.5	88	0.434	2.343	2.066–2.620	0.7644	44.196	< 0.001
BET	Eastern Pacific	60.0–202.0	127.3	41723.5	1436	0.0132	3.043	1.841–3.728	0.9742	123.717	< 0.001
YFT	Eastern Pacific	93.0–170.0	129.5	33211.5	520	0.00418	3.244	3.176–3.312	0.9449	161.705	< 0.001
ALB	Eastern Pacific	70.0–118.0	100.7	18846.9	147	0.0542	2.760	2.552–2.968	0.8256	27.609	< 0.001

\* Weight is whole weight [g]; BET = bigeye tuna; YFT = yellowfin tuna; ALB = albacore; n: sample size; FL: fork length [cm]; W: gilled-gutted weight [g]; CL = confidence limit; a = the parameter in the *W* *L* relation; b = slope; r<sup>2</sup> = coefficient of determination.

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