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BIOLOGICAL DATA ON TUNA AND TUNA-LIKE SPECIES GATHERED AT THE IOTC SECRETARIAT: STATUS REPORT (UPDATE)

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PURPOSE

To provide an overview of the availability and range of length-weight equations for selected IOTC species, for consideration of Working Party on Data Collection and Statistics. Specifically:

- present definitions of the standard and processed lengths of tuna and tuna-like species;
- identify the various states of fish for which measurements are available;
- highlight data available to the IOTC Secretariat for the purpose of reporting size frequency and for scientific research, including the range of conversion factors available, and identify where deficiencies in the current data exist.

The document is intended as an update to paper IOTC-2005-WPTT-05.

BACKGROUND

Basic biological data on fish size (i.e., minimum, maximum, and mean) and size relationships, including conversions from length-to-weight and from non-standard length-to-standard length, are essential for understanding growth rate, age structure, and other aspects of population dynamics.

In artisanal and industrial tuna fisheries, tuna, billfish, tuna-like species and by-catch species are processed in many different ways and landed in different states (round, gilled and gutted, etc.). Measurements of actual size (length and weight) are recorded prior to processing only when observers are onboard fishing vessels or when fish are landed whole. Given that processing is common practice, it is essential that accurate and up-to-date information in able to enable conversion of different measures of dressed and undressed fish to whole fish.

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As information about conversion factors for fish – particularly from the Indian Ocean – is limited, a review of conversion factors data available for tuna, billfish, and tuna-like species has been carried out. Information has been obtained from a range of sources including IOTC, other regional fisheries bodies and the scientific literature.

LIST OF DOCUMENTS

1. Definition of length measurements for tuna species, billfish, and shark species (**Appendices I & II**).
   - For tuna, tuna-like species and the more common by-catch species such as sharks and dolphinfish, fork length (FL) is considered to be the 'standard length' used to construct size frequency distributions.
   - For billfish, lower jaw fork length (LJFL) is used but references to eye-fork length (EFL) can also be found in the literature (portrayal and definitions of the measurement types are also shown in Appendix 1).
   - While variations to these measurements result due to people measuring either "projected straight" or "curved-body distance" measurements, greater challenges in deriving the standard length arise when alternate length measurements are provided — this usually occurs when the measurements are taken on processed fish. Because of this a range of length alternates need to be collected. In order to construct size frequencies distributions from these alternate lengths data, the relationships between alternate length and the standard length needs to be determined. A list of the different processing types is given in Appendix II.

2. Availability of current biological information in the IOTC database (**Appendix III**).
   Data provided to IOTC are of variable quantity and quality but the database is set up to contain the following information for each individual fish sampled:

   - Species, data source, type of fleet, gear, year, time strata (e.g., month, quarter), geographical area definition (size of rectangle area; from 1°x1° to FAO area) length measurements (standard length and alternate lengths), weight (dressed or round), sex and maturity.

   Appendix III outlines the content of the current status of the IOTC database related to availability of biological information

3. Conversion factors from Other length – Standard length (**Appendices IV & V**)
   - Linear regressions of other length to standard length are documented and presented with their corresponding regression coefficients, sample sizes, size ranges, geographic area and original

sources referenced. Separate relationships for each sex are also presented where available (Appendix IV).

- For some species, there is need to use more than one–step conversion to obtain the standard length of measurement ('projected straight distance') because no one relationship is available to convert from the alternate length measurement to standard length (Appendix V).

4. Standard length –weight conversion (**Appendices VI - VIII**)

Conversion factors from standard length to (processed or round) weight for selected tuna species, billfish and sharks is detailed in Appendices VI-VIII, expressed in the form of the allometric length-weight equation:

$W = (a)L^b$

where WT = round or dressed carcass weight (kg),

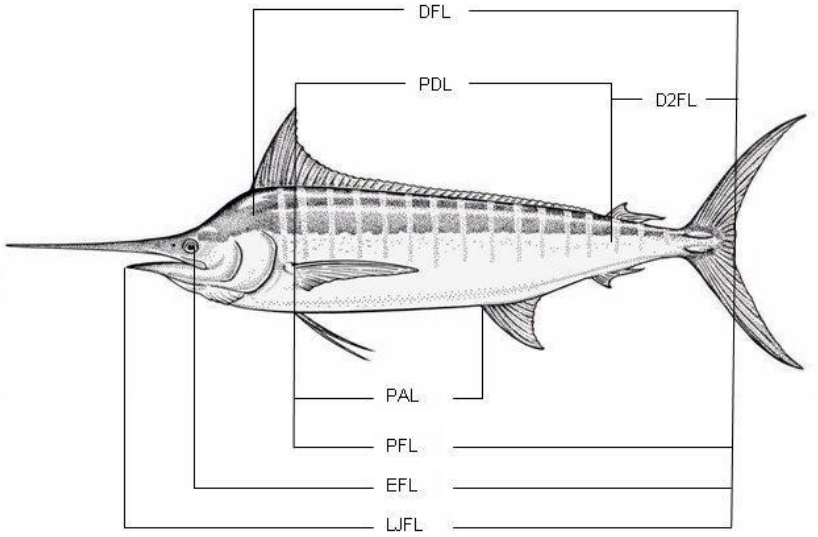
L = length (cm),

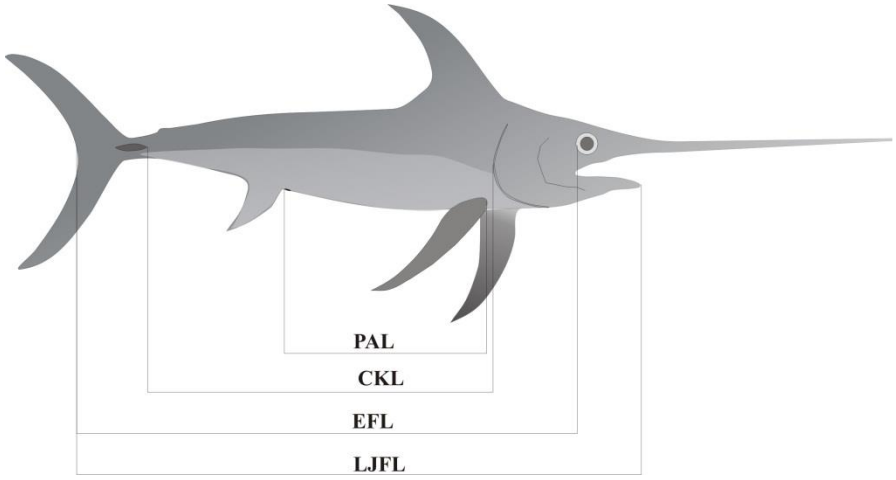
a and b are constants for each species

The tables and figures show the extent of variation between the different conversion factors available for each species.

Appendix I. Definition of length measurements for tuna species, billfish, and shark species

Fig. 1. Type of measurements used for billfish





Source: Poisson and Taquet, 2001

Fig 1. Types of measurements used for tuna

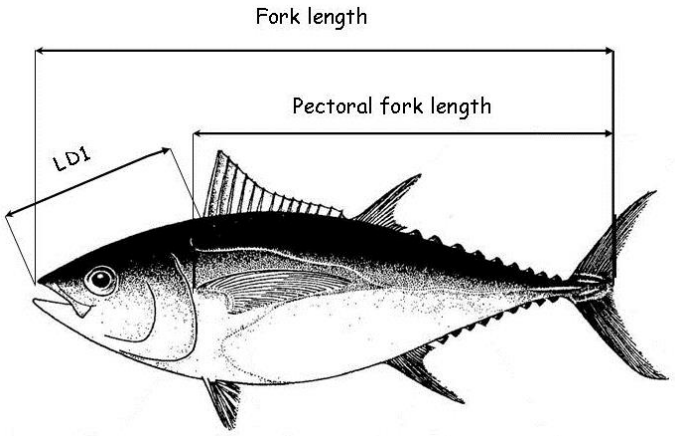
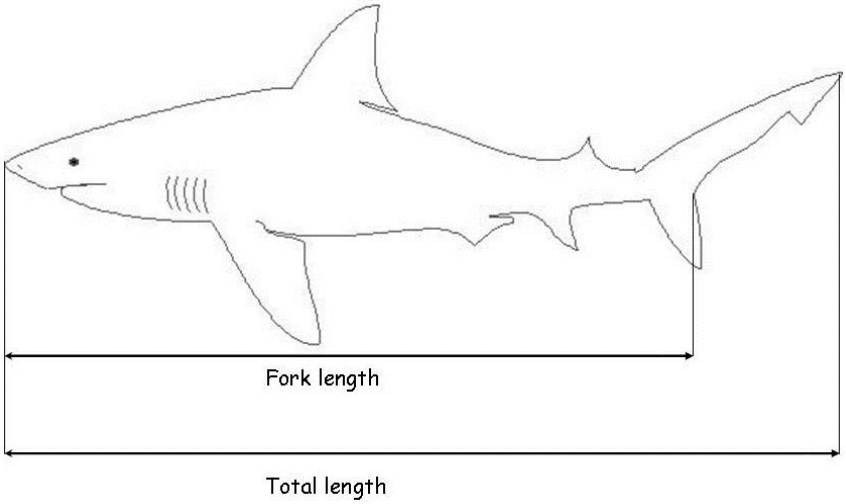


Fig 3. Type of measurements used for sharks



Appendix I (continued) Table 1. Definition of length measurements for tuna species, billfish, and shark species.

Length	tools	Type	Description
CKL	caliper	Cleithrum-Keel length	Projected straight distance between the point on the cleithrum that provides the shortest possible measurement to the anterior portion of the caudal keel. The cleithrum is the semicircular bony structure at the posterior edge of the gill opening.
D2FL	caliper	Second dorsal fork length	Projected straight distance between the most anterior insertion of the second dorsal fin and the fork of the tail
DFL	caliper	Dorsal Fork Length	Projected straight distance between the most anterior insertion of the dorsal fin and the fork of the tail
EFL	caliper	Eye Fork Length	Projected straight distance from the caudal margin of orbit to the fork of the tail.
FL	caliper	Fork Length	Projected straight distance from the tip of the upper jaw (snout) to the shortest caudal ray (fork)
IDS	caliper	Interdorsal space	First Dorsal-Second Dorsal Calliper (Projected straight distance between the most posterior insertion of the first dorsal fin and the most anterior insertion of the second dorsal fin)
LD1	caliper	Pre-dorsal length	Length to the first dorsal fin Calliper (Projected straight distance from the tip of the snout to the anterior base of the first dorsal fin)
LJFL	caliper	Lower jaw-fork length	Projected straight distance from the tip of the lower jaw to the shortest caudal ray (fork of the caudal fin.).
P1A	caliper	Pectoral anterior margin	(shark fins) Projected straight distance between the tip and the base of the anterior margin of the pectoral fin
PAL	caliper	Pectoral- anal length	Projected straight distance between the most anterior insertion of the pectoral fin to the most posterior rim of the anal sphincter.
PDL	caliper	Pectoral dorsal length	Projected straight distance between the most anterior insertion of the pectoral fin and the most anterior insertion of the second dorsal fin.
PFL	caliper	Pectoral-fork length	Projected straight distance between the most anterior insertion of the pectoral fin and the fork of the tail.
PPS	caliper	Pectoral-pelvic space	Projected straight distance between the most posterior insertion of the pectoral fin to the most anterior insertion of the pelvic fin.
TL	caliper	Total Length (relaxed)	Projected straight distance from the most forward point of the head to the tip of the tail when the tail is left in the “natural position” (unsqueezed).
CKLT	tape measure	Curved Cleithrum-Keel length	Projected curved-body distance between the point on the cleithrum that provides the shortest possible measurement to the anterior portion of the caudal keel. The cleithrum is the semicircular bony structure at the posterior edge of the gill opening.
D2FLT	tape measure	Curved Second dorsal fork length	Projected curved-body distance between the most anterior insertion of the second dorsal fin and the fork of the tail.
DFLT	tape measure	Curved Dorsal Fork Length	Projected curved-body distance between the most anterior insertion of the dorsal fin and the fork of the tail.

Appendix I (continued) Table 1. Definition of length measurements for tuna species, billfish, and shark species.

Length	tools	Type	Description
EFLT	tape measure	Curved Eye Fork Length	Projected curved-body distance from the caudal margin of orbit to the fork of the tail along the contour of the body in a line that runs along the top of the pectoral fin and the top of the caudal keel
FLT	tape measure	Curved Fork Length	Projected curved-body distance from the tip of the upper jaw (snout) to the shortest caudal ray (fork)
IDST	tape measure	Curved Interdorsal space	First Dorsal-Second Dorsal Tape (Projected curved-body distance between the most posterior insertion of the first dorsal fin and the most anterior insertion of the second dorsal fin)
LD1T	tape measure	Curved Pre-dorsal length	Length to the first dorsal fin Tape (Projected curved-body distance from the tip of the snout to the anterior base of the first dorsal fin)
LJFLT	tape measure	Curved Lower jaw-fork length	Projected curved-body distance from the tip of the lower jaw to the shortest caudal ray (fork of the caudal fin.).
P1AT	tape measure	Curved Pectoral anterior margin	(shark fins) Projected curved body distance between the tip and the base of the anterior margin of the pectoral fin .
PALT	tape measure	Curved Pectoral- anal length	Projected curved-body distance between the most anterior insertion of the pectoral fin to the most posterior rim of the anal sphincter.
PDLT	tape measure	Curved Pectoral dorsal length	Projected curved-body distance between the most anterior insertion of the pectoral fin and the most anterior insertion of the second dorsal fin.
PFLT	tape measure	Curved Pectoral-fork length	Projected curved-body distance between the most anterior insertion of the pectoral fin and the fork of the tail.
PPST	tape measure	Curved Pectoral-pelvic space	Projected curved body distance between the most posterior insertion of the pectoral fin to the most anterior insertion of the pelvic fin.
TLT	tape measure	Total Length (relaxed)	Projected curved-body distance from the most forward point of the head to the tip of the tail when the tail is left in the “natural position” (unsqueezed).

Appendix II. List of the different processing types and definitions.

Diagnostic Features	Code for measured and Estimated weight
Fish not processed Small tuna, tuna-like and shark By-catch species are commonly not processed.	WHO /EWHO
Bills (if any), gills and fins off, gutted. Tuna specimens usually undergo this form of processing.	GGT/EGGT
Dressed carcasses with heads and fins off and tail present	HDD/EHDD
Dressed carcasses with fins and caudal peduncles off Gutted with gills Billfish (mainly sailfish) and by-catch specimens are sometimes processed this way	GWG/EGWG
Dressed carcasses with heads and fins off and caudal peduncles present. Billfish (mainly sailfish) and by-catch specimens are sometimes processed this way as are some shark by-catch specimens.	TAL/ETAL
Dressed carcasses with heads, fins and caudal peduncles off. Billfish export, reject and by-catch specimens are usually processed this way as are some shark by-catch specimens.	PDD/EPDD
Fish processed and dried on-board (skipjack)	DRY/EDRY

Appendix III. Summary of biological information available to the IOTC Secretariat (as of October 2013).

TYPE OF DATA	RAW DATA	PERIOD	SOURCE
Length-length-weight data of tuna and billfish caught by fresh tuna longliners in the Indian Ocean	Available	2000-06	AFDEC Thailand (IOTC Sampling Programmes) NARA Sri Lanka (IOTC Sampling Programs) RIMF Indonesia (IOTC Sampling Programs) FRI Malaysia (IOTC Sampling Programs) IFREMER Reunion-France (PPR Programme) BRS (Pelagic Observer Program)
Length-length-weight-sex-maturity of tuna and tuna-like species caught by longliners and purse seiners within the EEZ of Chagos	Available	1996-06	MRAG United Kingdom (observer data)
Length-weight-sex data of tuna & sharks species caught by longliners from the republic of Korea	Available	2001-03; 2007, 2012	MOMAF Korea
Length-length-weight-sex of sharks caught as a by-catch by Spanish longline vessels	Available	2006-07	IEO Spain
Compilation of biological data collected during several years at the IOT canning factory (Seychelles)	Not available	1984-2006	IRD and SFA (IOTC-2006-WPTT-09)
Biological data available from Atlantic: -Length-length-weight data of tuna and billfish -Relationships between straight and curved body measurements -Length-length-weight data of sharks Biological data available from Pacific: -Length-length-weight data of billfish	 Not available Available Available Not available Not available	 1992-04 1992-04 - 2004	 ICCAT, Literature NMFS Pelagic Observer Program NMFS Pelagic Observer Program Literature SPC, Literature
Length-weight-sex data of Bigeye species caught by longliners from the India	Not available	2003-09	IOTC-2010-WPTT-41
Length-sex data of Yellowfin species caught by Purse seine fisheries in Western and Central Indian Ocean	Not available	2009	IRD-Seychelles (IOTC-2010-WPTT-48)
Length-weight-sex data of sharks species caught by Soviet longliners in Indian Ocean	Not Available	1961-89	IRD France (IOTC-2009-WPEB-06)
Size distribution and length-weight relationships for some large pelagic sharks in the Indian Ocean	Not Available		PROSPER Project (IOTC-2012-WPEB-22)
Observations on the ratio between fin and body weights for the blue shark caught by the Portuguese longline fleet in the Indian Ocean	Not Available		IP/IPIMAR, CCMAR (IOTC-2011-WPEB07-37)
Population dynamic parameters of *Thunnus tonggol* in the north of the Persian Gulf and Oman sea	Not Available	2006-07	Iranian Fisheries Research Organisation (IOTC-2011-WPNT01-18)
Status and Potential of neritic tunas exploited from Indian waters	Not Available		CMFRI (IOTC-2012-WPNT02-10)
Catch and size distribution of Albacore (*Thunnus alalunga*) in the Eastern Indian Ocean	Not Available	2011	RITF , RCFMC (IOTC-WPTmT04-13)
Length and Length/ weight relationships for the Silky shark Carcharhinus falciformis, in Western Indian Ocean	Not Available		IRD France (IOTC-2012-WPEB-19)
Growth and Mortality parameters of *Euthynnus affinis* in the northern part of the Persian Gulf and Oman Sea	Not Available		Iranian Fisheries Research Organisation (IOTC-2012-WPNT02-14)
A review on oceanic tuna fishery in Sri Lanka and estimation of the length-weight relationships for the yellowfin tuna and bigeye tuna	Not Available		NARA (IOTC-2013-WPTT15-16)
The reproductive biology, condition and feeding ecology of Skipjack, *Katsuwonus pelamis*, in the Western Indian Ocean	Not Available		AZTI, IRD (IOTC-2013-WPTT15-INF09)
Fishery, Biology and Population characteristic of the Narrow Barred Spanish Mackerel *Scomberomorus Commerson* exploited in India	Not Available		ICMFRI (OTC-2013-WPTN03-26)
Neritic tuna fishery along the Indian coast and biology and population characteristics of longtail and frigate tuna	Not Available		CMFRI (IOTC-2013-WPTN03-18)
Analysis of Kawakawa (*Euthynnis affinis*) landings in Sri Lanka and estimation of the length-weight and length-length relationships	Not Available		NARA (IOTC-2013-WPNT03-34)

The length-weight relationship of Albacore, *Thunnus alalunga*, from the Indian Ocean	Not Available	1990-91	Institute of Oceanography, National Taiwan University

Appendix IV. Conversion from other length measurements to standard length for selected tuna, billfish and shark species.

Table 2: Regression equation for predicting Standard length from an other measurement L (in cm) for tuna soecies using the equation Y=a*L+b

Bigeye tuna

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
PFL	1.2129	18.191	0.8988	Combined	calliper	FL	Atlantic	33-141	3174	Yes	NMFS Pelagic Observer Program
CKL	0.6215	-5.5109	0.9255	Combined	calliper	FL	Atlantic	29-110	570	Yes	NMFS Pelagic Observer Program
PFLT	1.4572	-2.287	0.9564	Combined	calliper/tape measure	FL	Atlantic	44-110	59	Yes	NMFS Pelagic Observer Program
PFLT	1.3418	7.1818	0.9733	Combined	tape measure	FLT	Atlantic	44-110	59	Yes	NMFS Pelagic Observer Program

Yellowfin tuna

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
PFL	1.2211	10.733	0.9729	Combined	calliper	FL	Atlantic	31-127	5153	Yes	NMFS Pelagic Observer Program
CKL	1.3693	21.399	0.9208	Combined	calliper	FL	Atlantic	31-111	1814	Yes	NMFS Pelagic Observer Program
PFLT	1.1566	15.667	0.9122	Combined	Calliper/Tape measure	FL	Atlantic	45-120	258	Yes	NMFS Pelagic Observer Program
PFLT	1.2596	8.527	0.9656	Combined	tape measure	FLT	Atlantic	45-120	59	Yes	NMFS Pelagic Observer Program

Table 3: Regression equation for predicting Standard length from an other measurement L (in cm) for billfish using the equation Y=a*L+b

Blue Marlin

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
LJFL	0.9039	-7.248	0.95	Combined	calliper	EFL	East and western Australia	143-295	26	Yes	BRS (Ward, pers.com)
EFLT	1.092	10.127		Combined	tape measure	LJFLT	North Atlantic	120-300	250	No	Prager et al., 1994
PFLT	1.248	9.486		Combined	tape measure	LJFLT	North Atlantic	65-280	732	No	Prager et al., 1994
PDLT	1.738	12.626		Combined	tape measure	LJFLT	North Atlantic	60-190	482	No	Prager et al., 1994
PALT	1.92	72.161		Combined	tape measure	LJFLT	North Atlantic	30-120	453	No	Prager et al., 1994
DFLT	1.206	8.303		Combined	tape measure	LJFLT	North Atlantic	100-280	271	No	Prager et al., 1994
EFL	1.09	10.52	0.97	female	caliper	LJFL	Atlantic			No	ICCAT
PFL	2.2	19.23	0.97	female	caliper	LJFL	Atlantic			No	ICCAT
D2FL	1.2	10.02	0.96	female	caliper	LJFL	Atlantic			No	ICCAT
PDL	1.61	33.29	0.9	female	caliper	LJFL	Atlantic			No	CCAT
EFL	1.1	7.15	0.97	male	caliper	LJFL	Atlantic			No	ICCAT
PFL	1.24	9.34	0.95	male	caliper	LJFL	Atlantic			No	ICCAT
D2FL	1.2	9.08	0.95	male	caliper	LJFL	Atlantic			No	ICCAT
PDL	1.33	50.15	0.75	male	caliper	LJFL	Atlantic			No	ICCAT

Black Marlin

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
LJFL	0.8972	-4.6673	0.99	Combined	caliper	EFL	East and western Australia	119-314	13	Yes	BRS (Ward, pers.com)
EFL				male	caliper	LJFL	Atlantic			No	ICCAT
PFL				male	caliper	LJFL	Atlantic			No	ICCAT
D2FL				male	caliper	LJFL	Atlantic			No	ICCAT
PDL				male	caliper	LJFL	Atlantic			No	ICCAT

Striped Marlin

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
LJFL	1.334	0.8395	0.87	Combined	calliper	EFL	East and western Australia		443	Yes	BRS (Ward, pers.com)

Shortbill spearfish

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
LJFL	0.9524	-13.4441	0.99	Combined	caliper	EFL	East and western Australia	61-197	106	Yes	BRS (Ward, pers.com)

Table 3. Regression equation for predicting Standard length from an other measurement L (in cm) for billfish using the equation Y=a*L+b (continued)

Sailfish

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
EFLT	1.076	11.24		Combined	tape measure	LJFLT	North Atlantic	85-175	251	No	Prager et al., 1994
PFLT	1.083	29.441		Combined	tape measure	LJFLT	North Atlantic	75-180	1810	No	Prager et al., 1994
PDLT	1.332	38.322		Combined	tape measure	LJFLT	North Atlantic	55-180	330	No	Prager et al., 1994
PALT	0.999	107.196		Combined	tape measure	LJFLT	North Atlantic	30-100	1553	No	Prager et al., 1994
DFLT	0.958	38.438		Combined	tape measure	LJFLT	North Atlantic	75-165	252	No	Prager et al., 1994
EFL	1.08	9.14	0.98	female	calliper	LJFL	Atlantic			No	ICCAT
PFL	1.23	10.02	0.98	female	calliper	LJFL	Atlantic			No	ICCAT
D2FL	1.14	11.75	0.96	female	calliper	LJFL	Atlantic			No	ICCAT
PDL	1.55	18.79	0.93	female	calliper	LJFL	Atlantic			No	
EFL	1.1	8.01	0.98	male	calliper	LJFL	Atlantic			No	ICCAT
PFL	1.27	5.06	0.97	male	calliper	LJFL	Atlantic			No	ICCAT
D2FL	1.23	-0.18	0.96	male	calliper	LJFL	Atlantic			No	ICCAT
PDL	1.64	9.83	0.92	male	calliper	LJFL	Atlantic			No	ICCAT
EFL	0.893	-5.196	0.983	male	calliper	LJFL	Pacific, East Taiwan	78-221	720	No	Wei-Chuan Chiang et al., 2004
EFL	0.876	-2.209	0.983	female	calliper	LJFL	Pacific, East Taiwan	80-232	446	No	Wei-Chuan Chiang et al., 2004

Swordfish

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
EFLT	1.066	10.449	0.99	Combined	tape measure	LJFLT	Reunion Island , Indian Ocean	48-255	123	Yes	Poisson , 2001
PFLT	1.2398	11.204	0.98	Combined	tape measure	LJFLT	Reunion Island , Indian Ocean	60-157	55	Yes	Poisson , 2001
CKLT	1.5411	19.605	0.97	Combined	tape measure	LJFLT	Reunion Island , Indian Ocean	32-180	801	Yes	Poisson , 2001
PALT	2.5407	25.698	0.94	Combined	tape measure	LJFLT	Reunion Island , Indian Ocean	18-105	1806	Yes	Poisson , 2001
PFLT	1.138	3.625	0.99	Combined	tape measure	EFLT	Reunion Island , Indian Ocean	60-157	55	Yes	Poisson , 2001
CKLT	1.4419	8.6256	0.97	Combined	tape measure	EFLT	Reunion Island , Indian Ocean	32-147	483	Yes	Poisson , 2001
PALT	2.4444	11.954	0.94	Combined	tape measure	EFLT	Reunion Island , Indian Ocean	19-89	613	Yes	Poisson , 2001
LJFLT	0.9295	-7.5732	0.99	Combined	tape measure	EFLT	Reunion Island , Indian Ocean	69-252	646	Yes	Poisson , 2001
LJFL	0.9114	-4.1547	0.96	Combined	calliper	EFL	East and western Australia	53-260	1114	Yes	BRS (Ward, pers.com)
CKL	1.50935	210.654	0.97	Combined	calliper	LJFL	Brazilian coast, Atlantic	32-147	483	No	Meneses de Lima et al, 2000

Table 4. Regression equation for predicting Standard length from an other measurement L (in cm) for sharks using the equation Y=a*L+b

Bigeye Thresher

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
TL	0.5598	17.666	0.8944	Combined	calliper	FL	North Atlantic	155-371	56	No	Kohler N. E. *et al*, 1996

Thresher Shark

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
TL	0.5474	7.0262	0.8865	Combined	calliper	FL	North Atlantic	291-450	13	No	Kohler N. E. *et al*, 1996

Shortfin Mako

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
TL	0.9286	-1.7101	0.9972	Combined	calliper	FL	North Atlantic	70-368	199	No	Kohler N. E. *et al*, 1996
Pre-caudal	1.0933	3.2469	0.9884	Combined	n/a	FL	n/a	n/a	354	No	Romanov, 2012

Portbeagle

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
TL	0.8971	1.7939	0.9877	Combined	calliper	FL	North Atlantic	119-247	13	No	Kohler N. E. *et al*, 1996

Silky Shark

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
TL	0.8388	-2.651	0.9972	Combined	calliper	FL	North Atlantic	90-258	15	No	Kohler N. E. *et al*, 1996

Dusky shark

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
TL	0.8396	-3.1902	0.9947	Combined	calliper	FL	North Atlantic	92-330	148	No	Kohler N. E. *et al*, 1996

Sandbar Shark

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
TL	0.8175	2.5675	0.9933	Combined	calliper	FL	North Atlantic	51-249	3734	No	Kohler N. E. *et al*, 1996

Table 4. Regression equation for predicting Standard length from an other measurement L (in cm) for sharks using the equation Y=a*L+b (continued)

Tiger Shark

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
TL	0.8761	-13.3535	0.9887	Combined	calliper	FL	North Atlantic	145-375	44	No	Kohler N. E. *et al*, 1996

Blue Shark

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
TL	0.8313	1.3908	0.9932	Combined	calliper	FL	North Atlantic	64-337	572	No	Kohler N. E. *et al*, 1996
Pre-caudal	1.0934	0.9095	0.9847	Combined	n/a	FL	n/a	n/a	2845	No	Romanov, 2012

Scalloped Hammerhead

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
TL	0.7756	-0.3132	0.9868	Combined	calliper	FL	North Atlantic	82-278	111	No	Kohler N. E. *et al*, 1996

Appendix V. Conversion from other length measurements to standard length for selected tuna, billfish and shark species.

Table 5: Relationships between straight and curved body measurements for bigeye and yellowfin tuna using the equation Y=a*L+b

Bigeye tuna

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
FLT	0.9676	0.9082	0.9891	Combined	calliper/tape measure	FL	Atlantic	63-169	304	Yes	NMFS Pelagic Observer Program

Yellowfin tuna

Length	a	b	R^2	Sex	tool	Standard Length	Area	Range (cm)	Sample n	Dataset available	Reference
FLT	0.9749	1.7998	0.9702	Combined	calliper/tape measure	FL	Atlantic	64-206	581	Yes	NMFS Pelagic Observer Program

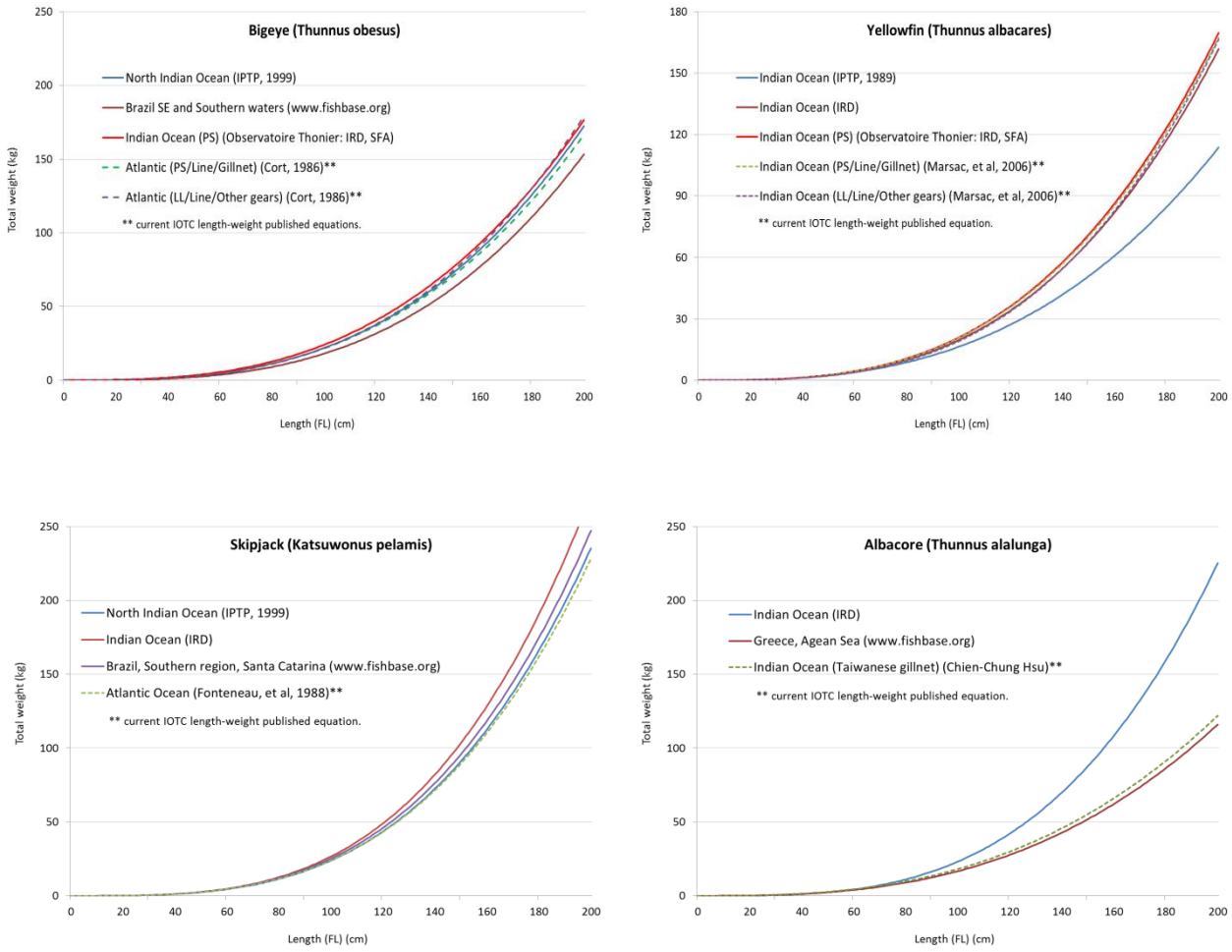
Appendix VI. Selected IOTC tuna and tuna-like species: range of coefficients for the general equation: $W=(a)FL^b$ for predicting fish weight (round) (kg) from standard length (FL) (cm) for selected IOTC tuna and tuna-like species.

Species	Scientific name	Code	Gears	Length	Sex	a	b	r^2	Sample size	Length range (cm)	Area, fishery, reference period	Reference
Albacore	Thunnus alalunga	ALB	n/a	FL	Combined	0.000006303	3.2825	n/a	n/a	n/a	Indian Ocean	IRD (refer to IOTC-2005-WPTT-05)
			Gillnet	FL	Combined	0.000056907	2.7514	n/a	n/a	n/a	Indian Ocean, Taiwanese gillnet	Chien-Chung Hsu (IOTC published length-weight equations)
			n/a	FL	Combined	0.000041830	2.8	0.97	598		Greece, Aegean Sea, 1989-93	www.fishbase.org
Bigeye tuna	Thunnus obesus	BET	n/a	FL	Combined	0.000023960	2.98	n/a	n/a	n/a	North Indian Ocean	IPTP, 1989 (refer to IOTC-2005-WPTT-05)
			PS, GN, Pole and Line	FL	Combined	0.000027	2.951	n/a	n/a	n/a	Atlantic	Cort, et al, 1986 (IOTC published length-weight equations)
			LL, Line, Other gears ***	FL	Combined	0.000015921	3.0415414023	n/a	12,047	70-187	Atlantic	Cort, et al, 1986 (IOTC published length-weight equations)
			PS	FL	Combined	0.00004218666	2.877628	n/a	404	n/a	Indian Ocean	Observatoire Thonier (IRD, Seychelles Fishing Authority)
			n/a	FL	Unsexed	0.000011900	3.09	0.96	123	n/a	Brazil: Southeastern and southern regions, 1995-1996	www.fishbase.org
Yellowfin tuna	Thunnus albacares	YFT	n/a	FL	Combined	0.000041000	2.8	n/a	n/a	n/a	North Indian Ocean	IPTP, 1989 (refer to IOTC-2005-WPTT-05)
			n/a	FL	Combined	0.000015849	3.046	n/a	n/a	n/a	Indian Ocean	IRD (refer to IOTC-2005-WPTT-05)
			PS	FL	Combined	0.000018664	3.024133	n/a	22,909	n/a	Indian Ocean	Observatoire Thonier (IRD, Seychelles Fishing Authority)
			PS, GN, Pole and Line	FL	Combined	0.000018860	3.0195	n/a	6,752	29-164	Indian Ocean	Marsac, et al, 2006 (IOTC published length-weight equations)
			LL, Line, Other gears ***	FL	Combined	0.000009401	3.126843987	n/a	15,133	72-177	Indian Ocean	Marsac, et al, 2006 (IOTC published length-weight equations)
Skipjack	Katsuwonus pelamis	SKJ	n/a	FL	Combined	0.000006	3.3	n/a	n/a	n/a	North Indian Ocean	IPTP, 1989 (refer to IOTC-2005-WPTT-05)
			n/a	FL	Combined	0.000005320	3.34958	n/a	n/a	n/a	Indian Ocean	IRD (refer to IOTC-2005-WPTT-05)
			All gears		Combined	0.000007480	3.2526	n/a	14140	n/a	Atlantic Ocean	Fonteneau, et al, 1988 (IOTC published length-weight equations)
			n/a	FL	Combined	0.000006540	3.293	0.963	n/a	n/a	Brazil, Southern region, Santa Catarina	www.fishbase.org
Kawakawa	Euthynnus affinis	KAW	n/a	FL	Combined	0.000026	2.9	n/a	n/a	n/a	North Indian Ocean	IPTP, 1989 (refer to IOTC-2005-WPTT-05)
Frigate	Auxis thazard	FRI	n/a	FL	Combined	0.000017000	3.0	n/a	n/a	n/a	North Indian Ocean	IPTP, 1989 (refer to IOTC-2005-WPTT-05)
Bullet tuna	Auxis rochei	BLT	n/a	FL	Combined	0.000017000	3.0	n/a	n/a	n/a	North Indian Ocean	IPTP, 1989 (refer to IOTC-2005-WPTT-05)
Seerfishes nei	Scomberomorus spp.	KGX	n/a	FL	Combined	0.000011760	2.9002	n/a	n/a	n/a	North Indian Ocean	IPTP, 1989 (refer to IOTC-2005-WPTT-05)
Narrow-barred Spanish mackerel	Scomberomorus commerson	COM	n/a	FL	Combined	0.000011760	2.9002	n/a	n/a	n/a	North Indian Ocean	IPTP, 1989 (refer to IOTC-2005-WPTT-05)
Wahoo	Acanthocybium solandri	WAH	n/a	FL	Combined	0.000001544	3.2945	n/a	n/a	n/a	North Indian Ocean	IPTP, 1989 (refer to IOTC-2005-WPTT-05)

NOTE: Conversion factors refer to the calculation of FL to Round weight (RND), with the exception of rows denoted by *** which refer to the coefficients in conversion from FL to Gilled and Gutted Weight (GGT). Conversion from GGT to RND weight calculated as follows: RND=GGT*1.13.

Appendix VI (continued)

Fig. 4 Selected IOTC tuna species: plots showing the range of coefficients available to convert from standard length into weight. Plots express the general allometric equation $W = (a)FL^b$, for predicting fish weight (round) (kg) from standard length (FL) (cm).

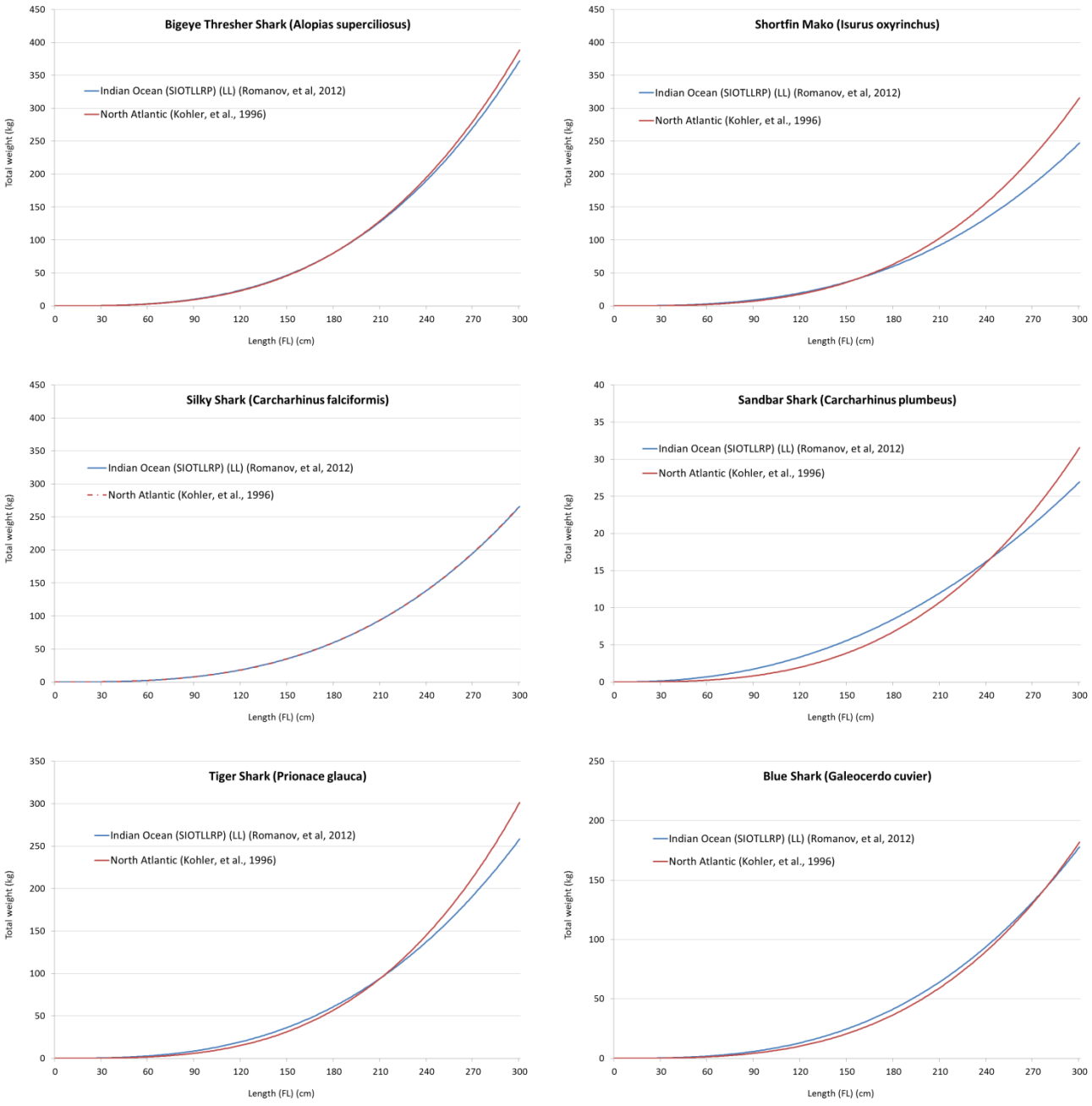


Appendix VII. Selected shark species: range of coefficients for the general equation: $W=(a)FL^b$ for predicting fish weight (round, kg) from standard length (cm).

Species	Scientific name	Code	Gear	Length	Sex	a	b	r^2	Sample size	Length range (cm)	Area, fishery, reference period	Reference
Bigeye Thresher	Alopias superciliosus	BTH	n/a	FL	Combined	0.0000091069	3.08020	0.91	55	100-228	North Atlantic (Gulf of Maine to Florida Keys)	Kohler, et al, 1996 (IOTC-2005-WPTT-05); www.fishbase.org
			LL	FL	Combined	0.00001413	2.99565	n/a	201	n/a	Indian Ocean, 1961-1989	Romanov, et al, 2012
Thresher Shark	Alopias vulpinus	THR	n/a	FL	Combined	0.000001882	2.51880	0.88	88	154-262	North Atlantic (Gulf of Maine to Florida Keys)	Kohler, et al, 1996 (IOTC-2005-WPTT-05); www.fishbase.org
Shortfin Mako	Isurus oxyrinchus	SMA	n/a	FL	Combined	0.0000052432	3.14070	0.96	2081	65-338	North Atlantic (Gulf of Maine to Florida Keys)	Kohler, et al, 1996 (IOTC-2005-WPTT-05); www.fishbase.org
			LL	FL	Combined	0.0000349	2.76544	n/a	906	n/a	Indian Ocean, 1961-1989	Romanov, et al, 2009
Porbeagle	Lamna nasus	POR	n/a	FL	Combined	0.000014823	2.96410	0.94	15	106-207	North Atlantic (Gulf of Maine to Florida Keys)	Kohler, et al, 1996 (IOTC-2005-WPTT-05); www.fishbase.org
Silky Shark	Carcharhinus falciformis	FAL	n/a	FL	Combined	0.000015406	2.92210	0.97	85	73-212	North Atlantic (Gulf of Maine to Florida Keys)	Kohler, et al, 1996 (IOTC-2005-WPTT-05); www.fishbase.org
			LL	FL	Combined	0.000016	2.91497	n/a	687	n/a	Indian Ocean, 1961-1989	Romanov, et al, 2012
Dusky shark	Carcharhinus obscurus	DUS	n/a	FL	Combined	0.000032415	2.78620	0.96	247	79-287	North Atlantic (Gulf of Maine to Florida Keys)	Kohler, et al, 1996 (IOTC-2005-WPTT-05); www.fishbase.org
Sandbar Shark	Carcharhinus plumbeus	CCP	n/a	FL	Combined	0.0000010885	3.01240	0.94	1548	44-201	North Atlantic (Gulf of Maine to Florida Keys)	Kohler, et al, 1996 (IOTC-2005-WPTT-05); www.fishbase.org
			LL	FL	Combined	0.00006573	2.26581	n/a	1615	n/a	Indian Ocean, 1961-1989	Romanov, et al, 2012
Tiger Shark	Galeocerdo cuvier	TIG	n/a	FL	Combined	0.0000025281	3.26030	0.96	187	5-499	North Atlantic (Gulf of Maine to Florida Keys)	Kohler, et al, 1996 (IOTC-2005-WPTT-05); www.fishbase.org
			LL	FL	Combined	0.00002614	2.82374	n/a	678	n/a	Indian Ocean, 1961-1989	Romanov, et al, 2012
Blue Shark	Prionace glauca	BSH	n/a	FL	Combined	0.0000031841	3.13130	0.95	4529	1-174	North Atlantic (Gulf of Maine to Florida Keys)	Kohler, et al, 1996 (IOTC-2005-WPTT-05); www.fishbase.org
			LL	FL	Combined	0.0000159	2.84554	n/a	2842	n/a	Indian Ocean, 1961-1989	Romanov, et al, 2009
Scalloped Hammerhead	Sphyrna lewini	SPL	n/a	FL	Combined	0.0000077745	3.06690	0.93	390	5-166	North Atlantic (Gulf of Maine to Florida Keys)	Kohler, et al, 1996 (IOTC-2005-WPTT-05); www.fishbase.org
			LL	FL	Combined	0.00002101	2.88029	n/a	241	n/a	Indian Ocean, 1961-1989	Romanov, E., et al, 2012

Appendix VII (continued)

Fig. 5 Selected shark species: plots showing the range of coefficients to convert from standard length into weight. Plots express the general allometric equation $W = (a)FL^b$, for predicting fish weight (round), (kg) from standard length (FL) (cm).

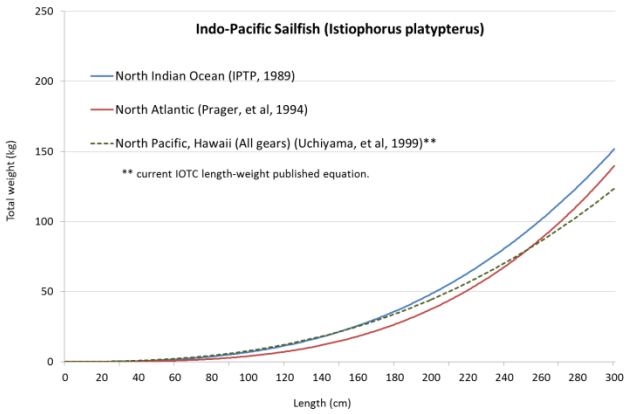


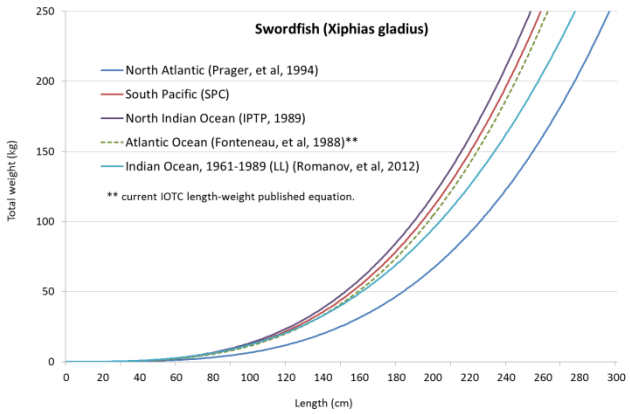
Appendix VIII. Selected IOTC billfish species: range of coefficients for the general equation: $W=(a)L^b$ for predicting fish weight (round, kg) from standard length (various) (cm).

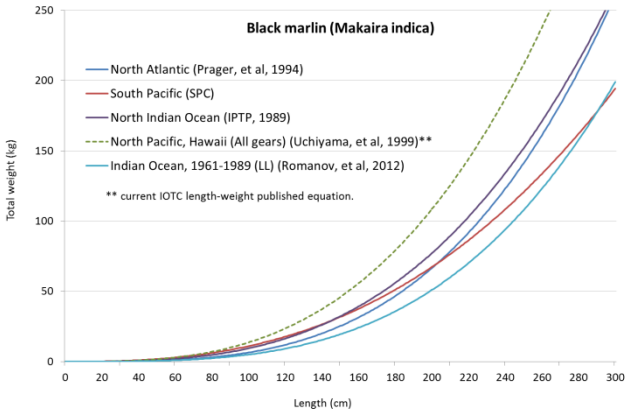
Species	Scientific name	Code	Gear	Length	Sex	a	b	r^2	Sample size	Length range (cm)	Area, fishery, reference period	Reference
Indo-Pacific Sailfish	Istiophorus platypterus	SFA	n/a	EFL	Combined	0.00001577	2.819	n/a	n/a	n/a	North Indian Ocean	IPTP, 1989 (refer to IOTC-2005-WPTT-05)
			n/a	LJFLT	Combined	0.0000012869	3.2439	n/a	2187	27.1-204.5	North Atlantic	Prager, et al, 1994 (refer to IOTC-2005-WPTT-05)
			All gears	EFL	Combined	0.0000690103	2.52429	n/a	35	86-187	North Pacific, Hawaii	Uchiyama, et al, 1999 (IOTC published length-weight equations)
Striped Marlin	Tetrapturus audax	MLS	LL	LJFL	Combined	0.00000039	3.50024	n/a	232	n/a	Indian Ocean, 1961-1989	Romanov, et al, 2012
		MLS	n/a	EFL	Combined	0.00000133263	3.41344	0.9621	17	101.5-178.2	North Pacific, Hawaii	Uchiyama, et al, 1999 (IOTC published length-weight equations)
Black marlin	Makaira indica	BLM	n/a	LJFLT	Combined	0.0000011955	3.36630	n/a	5245	23-378.5	North Atlantic	Prager et al.,1994 (refer to IOTC-2005-WPTT-05)
			n/a	LJFL	Combined	0.0000661	2.61109	0.742	19	n/a	South Pacific	SPC (refer to IOTC-2005-WPTT-05)
			n/a	EFL	Combined	0.00000810	3.03300	n/a	n/a	n/a	North Indian Ocean	IPTP, 1989 (refer to IOTC-2005-WPTT-05)
			All gears	EFL	Combined	0.0000144217	2.98851	0.9565	24	95-279	North Pacific, Hawaii	Uchiyama, et al, 1999 (IOTC published length-weight equations)
			LL	LJFL	Combined	0.00000096	3.35727	n/a	75	n/a	Indian Ocean, 1961-1989	Romanov, et al, 2012
Blue marlin	Makaira nigricans	BUM	n/a	EFL	Combined	0.00000173	3.0	n/a	n/a	n/a	North Indian Ocean	IPTP, 1989 (refer to IOTC-2005-WPTT-05)
			LL	LJFL	Combined	0.00000084	3.39404	n/a	213	n/a	Indian Ocean	Romanov, et al, 2012
			All gears	EFL	Combined	0.00000272228	3.30967	n/a	154	109-269	North Pacific, Hawaii	Uchiyama, et al, 1999 (IOTC published length-weight equations)
Swordfish	Xiphias gladius	SWO	n/a	LJFL	Combined	0.00000547	3.17439	0.9395	1965	n/a	South Pacific	SPC (refer to IOTC-2005-WPTT-05)
			n/a	EFL	Combined	0.00000633	3.16050	n/a	n/a	n/a	North Indian Ocean	IPTP, 1989 (refer to IOTC-2005-WPTT-05)
			LL	LJFL	Combined	0.00001443	2.96267	n/a	n/a	n/a	Indian Ocean	Romanov, et al, 2012
			All gears	LJFL	Combined	0.000004203	3.21340	n/a	2569	80-253	Atlantic Ocean	Fonteneau, et al, 1988 (IOTC published length-weight equations)

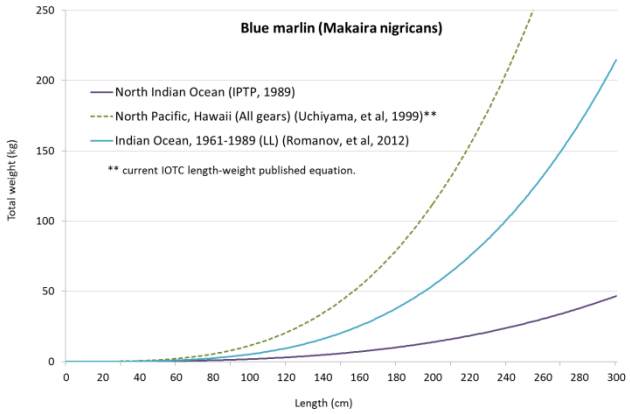
Appendix VIII (continued)

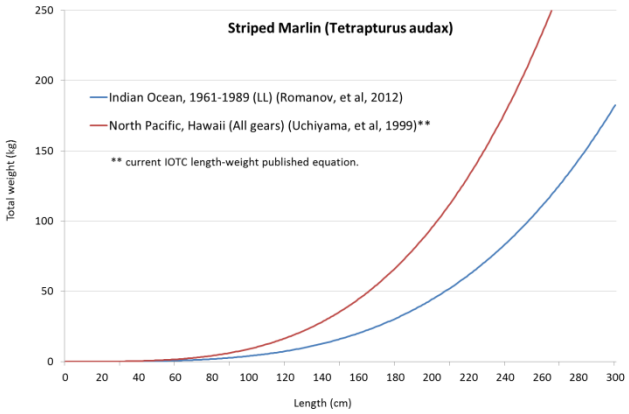
Fig. 6 Selected IOTC billfish species: plots showing the range of coefficients available to convert from standard length (various) into weight. Plots express the general allometric equation $W = (a)L^b$, for predicting fish weight (round) (kg) from length (various) (cm).











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