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Length – Weight Relationships for 73 Species and Species Groups as Reported in the 2011–2013 National Bycatch Reports for Pelagic Longline Fisheries in Hawaii and American Samoa[1]

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Introduction

This report provides summaries of length-weight relationships for pelagic species reported in the Hawaii and American Samoa based longline fisheries. NOAA periodically produces a National Bycatch Report (NBR) estimating total weight by species or species group for all species taken by these fisheries. Past reports have utilized both unpublished and published estimates of length-weight relationships to apply an average weight for an individual of each species to the total number reported in a fishery. The data sources used to generate the length-weight regression coefficients necessary to convert average length of a species (from observer collected length frequency data) have not been well documented. This report provides documentation on the data sources, sample sizes, size ranges, and assumptions used to generate the length-to-weight conversion equations for each species/species group as reported in the NBR report for 2011–2013 catch estimates. This report does not reflect any new regression analyses, it is an attempt at documentation of where the regression coefficients used in the NBR summaries originated.

Methods

In the absence of direct length-weight measurements within these fisheries, the NBR weight estimates rely on length-weight relationships from different literature and sources. This does introduce the potential for errors based on sampling variability (e.g., size distributions) and prediction errors such as use of different times and geographic locations (Kimmerer et al., 2015). Also, the use of annual mean lengths to estimate annual mean weights may have led to an underestimate of mean weights (~10% when "b" = 3) due to the non-linear relationship between length and weight (Lockwood and Hayes, 2000).

Various length units were used in the data sources and whenever possible, length-weight relationships were analyzed using a linear regression of log-transformed data and fit as an equation that estimates weight (W) in kg as a function of total length (L) in cm as developed by Hayes et al. 1995. Uchiyama and Kazama (2003) relationships were calculated by finding a least-squares solution to a nonlinear regression. Regardless of the original method(s) used for source

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data analyses, all relationships presented here, (Table 1) have been converted to conform to Hayes et al. 1995.

For the NBR, the average mean lengths (cm) used to derive mean weights (kg) were estimated from observer collected lengths aboard commercial longline vessels in American Samoa and Hawaii. The average mean lengths were estimated at an annual resolution within each fishery, used to determine the mean weight for each species, and then summed by total number of each species to create estimates of total weight for each species.

The regression coefficients ("a" and "b" in Table 1) were determined using available length and weight data for a species (sometimes from multiple sources of data) where $W = a * L^b$. For species where there is a paucity of available length-weight data, coefficients of a similar species were often used (e.g., pomfrets). For some species, not enough information was available to generate "a" and "b" coefficients and an average weight (kg) was estimated based on either a direct measure of a single specimen (e.g., stingrays) or a "best guess" based on general scientific knowledge and from unpublished analyses from previous NBRs (e.g., molas).Minimum, maximum, , and sample sizes (N) are usually shown as reported from the source data for each available species (Table 1). Average weights (kg) were then estimated using the average length (cm) from observer data (Table 1).

Data Sources

Most of the data used to estimate parameters of the length-weight relationships were originally acquired in research by the Pacific Islands Fisheries Science Center (PIFSC), compiled by Christofer Boggs (Director, Fisheries Research and Monitoring Division), and amalgamated into a working data file (Boggs, 2015). The Boggs file includes information on data source notes, length vs. weight plots, length information, "best estimates" regression results, and the "a" and "b" coefficients for use in the NBR.For some species, (L) values were adjusted to convert fork length (FL) data to total lengths (e.g., Galapagos shark - *Carcharhinus galapagensis*). In some cases, Boggs combined a variety of data sources and analyses to derive the regression coefficients used in the NBR, this report only shows the primary source of the data utilized in these cases (e.g., yellowfin tuna).

Protocols in deciding which data sources to use aimed to utilize the most recent and relevant information available. Species specific length weight relationships collected from the Hawaii-based longline fishery (e.g., auction sampling from the United Fishing Agency in Honolulu, Hawaii) and on PIFSC research cruises were selected when available (e.g., Bigelow et al. 2012, Sundberg and Underkoffler 2011, Uchiyama and Boggs 2006, Uchiyama and Kazama 2003, and Uchiyama et al. 1999). These data sources provided length weight data for most species of commercial value in the pelagic longline fishery including tunas and billfish. Outside data sources were utilized for species where there was little or no information available from PIFSC research. These sources included Northeast Fisheries Science Center (NEFSC) for some shark species and FishBase for many species of little or no commercial value. FishBase is a web based relational database developed in collaboration with the Food and Agriculture Organization of the United Nations to provide information to research scientists and fisheries managers on available literature on all fish species.

Results

An average mean weight (kg) was estimated for all 73 species and species groupings (Table 1). For 37 of these species, species-specific regression coefficients and length to weight estimates were directly calculated. For 16 species, regression coefficients from a similar species were applied to estimate average weights. For 11 species groupings, a representative species was chosen to obtain an average weight estimate for that group (e.g., albacore *Thunnus alalunga* for unidentified tuna). For 9 species/species groups, not enough information was available to attempt a regression analysis and average weights were estimated based on general knowledge of that species or a similar species (e.g., Sharptail Mola *Masturus lanceolatus*) these are listed as "Best guess" in Table 1.

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Table1. Length to Weight regression coefficients ("a", "b") and estimated average weight (W) in kg per fish for 73 species/species groups of pelagic fish as reported in the Hawaii and American Samoa based pelagic longline fisheries. Sample size (N) and minimum (Min. length), maximum (Max. length), and Average lengths (L) are as reported in the source and observer data used to perform the regression analysis. Source data are shown as WW = whole weight (kg) and FL = fork length (cm) except where otherwise noted[1]: EFL = eye fork length, PCL = Pre-caudal length, SL = standard length, and TL = total length.

Species	a	b	Source data Min. length (cm)	Source data Max. length (cm)	Observer data L=Avg. length (cm)	N	W= Avg. weight (kg)	Equation	Primary source of data (and alternate species, if any, used for regression analysis)
Albacore *Thunnus alalunga*	2.60E-05	2.95	56	127	86.9	200	13.6	W=a*(L^b)	Uchiyama and Kazama, 2003 WW (lb), FL (cm)
Bigeye Thresher *Alopias superciliosus*	9.10E-06	3.08	100	228	144.2	55	40.6	W=a*(L^b)	Boggs, 2015 WW (g), PCL (cm)
Bigeye Tuna *Thunnus obesus*	3.51E-05	2.91	65	193	106.8	11579	28.1	W=a*(L^b)	Bigelow et al., 2012
Bigeye Sand Tiger Shark *Odontaspis noronhai*	1.39E-06	3.29	106	227	200	15	52.3	W=a*(L^b)	Boggs, 2015 WW (lb), FL (in)
Unidentified Billfish	1.30E-05	3.07	82	202	150	166	63.4	W=a*(L^b)	Boggs, 2015 WW (kg), EFL (cm)
Black Gemfish *nesiarchus nasutus*	1.90E-06	3.22	80	80	80	1	3.0	W=a*((L/0.95)^b)	FishBase WW (g), TL (cm)
Blue Marlin *Makaira nigricans*	2.72E-06	3.31	110	303	172.7	154	69.1	W=a*(L^b)	Uchiyama and Kazama, 2003 WW (kg), EFL (cm)
Blue Shark *Prionace glauca*	1.82E-06	3.13	87	250	189.1	181	24.9	W=a*(L^b)	Strasburg, 1958Uchiyama and Kazama, 2003 WW (lb), TL (cm)
Identified Uncoded Fish (Bony fishes, other)	6.01E-06	2.76			105		2.3	W=a*(L^b)	NOAA (avg. of longnose lancetfish and dolphinfish)
Unidentified Fish (Bony fishes, unidentified)	6.01E-06	2.76			105		2.3	W=a*(L^b)	NOAA (avg. of longnose lancetfish and dolphinfish)
Brama Pomfret *Brama japonica*	2.60E-05	2.90	12	53	32.8	2500	0.6	W=a*(L^b)	Boggs, 2015
Lustrous Pomfret *Eumegistus illustris*	2.60E-05	2.90	12	53	48.1	2500	2.0	W=a*(L^b)	Boggs, 2015(Brama pomfret)
Cigarfishes *Decapturus spp.*							0.6		Boggs, 2015

Common Mola *Mola mola*	4.54E-05	3.05	46	213	155	13	217.6	W=a*(L^b)	FishBase WW (g), TL (cm)
Common Thresher *Alopias vulpinus*	9.10E-06	3.08	100	228	207.2	55	124.0	W=a*(L^b)	Boggs, 2015(Bigeye thresher shark)
Cookie Cutter Shark *Isistius brasiliensis*	1.82E-06	3.13	45	45	45	1	0.5	W=a*((L/0.84)^b)	Uchiyama and Kazama, 2003 (Blue shark)
Cottonmouth Jack *Uraspis secunda*	2.96E-05	3.00	29.3	29.3	29.3	1	0.9	W=a*((L/0.95)^b)	FishBase WW (g), TL (cm)
Crestfishes *Lophotus spp.*	2.70E-06	3.00	123.1	123.1	123.1	1	5.0	W=a*(L^b)	FishBase WW (g), TL (cm)
Crocodile Shark *Psuedocarcharius kamoharai*	1.82E-06	3.13	87	250	94.8	181	2.9	W=a*(L^b)	Uchiyama and Kazama, 2003 (Blue shark)
Dagger Pomfret *Taractes rubescens*	2.60E-05	2.90	12	53	63.6	2500	4.4	W=a*(L^b)	Boggs, 2015(Brama pomfret)
Deepwater Dogfishes *Centroscymnus spp.*	1.82E-06	3.13	87	250	94.8	181	2.9	W=a*(L^b)	Uchiyama and Kazama, 2003 (Blue shark)
Dolphinfish *Coryphaena hippurus*	3.69E-06	3.17	65	137	95.8	2482	7.0	W=a*(L^b)	Uchiyama and Boggs, 2006
Escolar *Lepidocybium flavobrunneum*	1.18E-05	3.00	40	140	57.1	103	2.2	W=a*(L^b)	Sundberg and Underkoffler, 2011
Galapagos Shark *Carcharhinus galapagensis*	1.36E-05	3.00	130	173	157.4	2	92.8	W=a*((L/0.83)^b)	FishBase WW (g), TL (cm)
Great Barracuda *Sphyraena barracuda*	9.80E-06	2.88	19	160	97.8	198	5.2	W=a*(L^b)	FishBase WW (g), FL (cm)
Unidentified Hammerhead *Sphyrna spp.*	7.80E-06	3.07	79	243	196.4	390	84.2	W=a*(L^b)	FishBase (scalloped hammerhead)
Hammerjaw *Omosudis lowii*							1.0		Boggs, 2015(Best guess)
Longfin Escolar *Scombrolabrax heterolepis*	1.90E-05	3.22	24.3	24.3	24.3	1	0.6	W=a*((L/0.95)^b)	Boggs, 2015
Longfin Mako Shark *Isurus paucus*	1.12E-05	2.93	60	162	161.1	80	42.1	W=a*((L/0.91)^b)	Strasburg, 1958 (Shortfin mako shark)
Longnose Lancetfish *Alepisaurus ferox*	6.01E-06	2.76	27	152	93.4	200	1.6	W=a*(L^b)	Uchiyama and Kazama, 2003
Unidentified Mako Shark *Isurus spp.*	1.12E-05	2.93	60	162	161.1	80	42.1	W=a*((L/0.91)^b)	Uchiyama and Kazama, 2003 (Shortfin mako shark)
Manta Ray *Manta birostris*							40.0		Boggs, 2015(Best guess)

Mobula *Mobula mobular*							30.0		Boggs, 2015(Best guess)
Oceanic Whitetip Shark *Carcharhinus longimanus*	1.70E-05	2.98	80	200	149.4	32	51.3	W=a*(L^b)	FishBase WW (g), FL (cm)
Oilfish *Ruvettus pretiosus*	9.60E-06	3.00	188	188	87.3	36	7.4	W=a*((L/0.95)^b)	FishBase WW (g), TL (cm)
Opah *Lampris guttatus*	1.16E-04	2.73	64	120	104	1117	37.1	W=a*(L^b)	Sundberg and Underkoffler, 2011
Pelagic Puffer *Lagocephalus lagocephalus*	2.69E-05	3.00	59	59	59	1	5.5	W=a*(L^b)	FishBase WW (g), TL (cm)
Pelagic Stingray *Pteroplatytrygon violacea*	2.73E-05	2.95	36	69	59.8	157	4.8	W=a*(L^b)	FishBase
Pelagic Thresher Shark *Alopias pelagicus*	9.10E-06	3.08	100	228	136	55	33.9	W=a*(L^b)	Boggs, 2015(Bigeye thresher)
Pompano Dolphinfish *Coryphaena equiselis*	7.68E-06	3.14	28	63	58	8	2.6	W=a*(L^b)	Uchiyama and Kazama, 2003 WW (g), SL (mm)
Unidentified Puffer (Puffer unidentified)	2.69E-05	3.00	59	59	59	1	5.5	W=a*(L^b)	Boggs, 2015(Oceanic puffer)
Rainbow Runner *Elagatis bipinnulata*							2.0		Boggs, 2015(Best guess)
Unidentified Ray (Rays unidentified)						1	3.0		Boggs, 2015(one sample)
Razorback Scabbardfish *Assurger anzac*	1.20E-05	2.53	221.5	221.5	221.5	1	10.4	W=a*(L^b)	Uchiyama and Kazama, 2003 (Snake mackerel)
Roudi Escolar *Promethichthys prometheus*	3.13E-05	3.14	21	69	57.1	38	10.1	W=a*(L^b)	Uchiyama and Kazama, 2003
Rough Pomfret *Taractes asper*	2.60E-05	2.90	12	53	50	2500	2.2	W=a*(L^b)	Boggs, 2015(Brama pomfret)
Rough Triggerfish *Canthidermus maculata*							2.0		Boggs, 2015(Best guess)
Sailfish *Istiophorus platypterus*	6.90E-05	2.52	88	184	107.3	35	9.2	W=a*(L^b)	Uchiyama and Kazama, 2003 WW (kg), EFL (cm)
Salmon Shark *Lamna ditropis*	1.12E-05	2.93	60	162	233.5	80	94.6	W=a*(L^b)	Uchiyama and Kazama, 2003 (Shortfin mako shark)
Sandbar Shark *Carcharhinus plumbeus*	3.13E-06	3.17	51	249	144.9	3734	22.3	W=a*(L^b)	NEFSC WW (lb), TL (in)
Scalloped Hammerhead *Sphyrna lewini*	7.80E-06	3.07	79	243	152.9	390	39.1	W=a*(L^b)	FishBase WW (g), FL (cm)

Scalloped Ribbonfish *Zu cristatus*	6.01E-06	2.76	27	152	120	200	3.3	W=a*(L^b)	Uchiyama and Kazama, 2003 (Longnose lancetfish)
Unidentifed Shark (Shark unidentified)	9.10E-06	3.08	100	228	144.1	55	40.5	W=a*(L^b)	Boggs, 2015(Bigeye thresher)
Identifed Uncoded Shark (Shark other)	9.10E-06	3.08	100	228	144.1	55	40.5	W=a*(L^b)	Boggs, 2015(Bigeye thresher)
Sharptail Mola *Masturus lanceolatus*							60.0		Boggs, 2015(Best guess)
Shortbill Spearfish *Tetrapturus angustirostris*	1.89E-04	2.31	89	153	140.5	80	16.9	W=a*(L^b)	Uchiyama and Kazama, 2003 WW (kg), EFL (cm)
Shortfin Mako Shark *Isurus oxyrinchus*	1.12E-05	2.93	60	162	160	80	31.3	W=a*(L^b)	Uchiyama and Kazama, 2003 WW (lb), TL (cm)
Sickle Pomfret *Teractichthys steindachneri*	1.50E-03	2.03	50	90	62.7	88	6.6	W=a*(L^b)	Sundberg and Underkoffler, 2011
Silky Shark *Carcharhinus falciformis*	1.90E-05	2.93	60	250	138.1	54	35.4	W=a*(L^b)	FishBase WW (g), FL (cm)
Skipjack Tuna *Katsuwonus pelamis*	4.82E-06	3.37	42	79	59.6	1298	4.6	W=a*(L^b)	Uchiyama and Kazama, 2003 WW (lb), FL (mm)
Shortnose Lancetfish *Alepisaurus brevirostris*	6.01E-06	2.76	27	152	93.4	200	1.6		Uchiyama and Kazama, 2003 (Longnose lancetfish)
Slender Mola *Ranzania laevis*							5.0		Boggs, 2015(Best guess)
Smooth Hammerhead *Sphyrna zygaena*	7.80E-06	3.07	79	243	152.9	390	39.1	W=a*(L^b)	FishBase (Scalloped hammerhead)
Snake Mackerel *Gempylus serpens*	1.20E-05	2.53	70	124	96.5	11	1.3	W=a*(L^b)	Uchiyama and Kazama, 2003
Unidentified Snake Mackerel *Gempylus spp.*	1.20E-05	2.53	70	124	96.5	11	1.3	W=a*(L^b)	Uchiyama and Kazama, 2003 (Snake mackerel)
Striped Marlin *Kajikia audax*	2.12E-03	2.02	89	198	109	1427	14.0	W=a*(L^b)	Uchiyama and Kazama, 2003WW (kg), EFL (cm)
Swordfish *Xiphias gladius*	1.30E-05	3.07	82	202	90.9	166	13.6	W=a*(L^b)	Uchiyama et al., 1999 WW (kg), EFL (cm)
Tapertail Ribbonfish *Trachipterus fukuzakii*	6.01E-06	2.76	27	152	178	200	9.7	W=a*(L^b)	Uchiyama and Kazama, 2003 (Longnose lancetfish)
Unidentified Thresher Shark *Alopias spp.*	9.10E-06	3.08	100	228	189	55	93.4	W=a*(L^b)	Boggs, 2015(Bigeye thresher)
Tiger Shark *Galeocerdo cuvier*	2.53E-06	3.26	92	339	284.5	187	253.2	W=a*(L^b)	FishBase

Unidentified Tuna (Tunas)	2.60E-05	2.95	56	127	86.9	200	13.6	W=a*(L^b)	Uchiyama and Kazama, 2003 (Albacore)
Wahoo *Acanthocybium solandri*	1.35E-06	3.31	108	160	104.4	1158	6.6	W=a*(L^b)	Uchiyama and Boggs, 2006 WW (kg), EFL (cm)
Yellowfin Tuna *Thunnus albacares*	1.48E-05	3.06	47	166	92.1	4822	15.0	W=a*(L^b)	Boggs, 2015 WW (lb), FL (cm)

[1] Lengths, weights, and coefficients in this table were converted to kg and cm when source data were in other units.