LENGTH-LENGTH RELATIONSHIPS FOR SIX PELAGIC SHARK SPECIES COMMONLY CAUGHT IN THE SOUTHWESTERN ATLANTIC OCEAN

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SUMMARY

This study reports length-length relationships between Fork Length, Precaudal Length and Total Length for the main six pelagic species (Prionace glauca, Carcharhinus brachyurus, Carcharhinus signatus, Sphyrna zygaena, Isurus oxyrinchus and Lamnanasus) captured by pelagic longline fisheries in the southwestern Atlantic Ocean. The length-length relationships provided in this contribution covers an extended portion of the reported size range of each species considered, and represents the first length-length conversions ever reported for these species in the region.

RÉSUMÉ

La présente étude décrit les relations longueur-longueur entre la longueur à la fourche, la longueur précaudale et la longueur totale pour les six principales espèces pélagiques (Prionace glauca, Carcharhinus brachyurus, Carcharhinus signatus, Sphyrna zygaena, Isurus oxyrinchus et Lamna nasus) capturées par les pêcheries palangrières pélagiques dans le Sud-Ouest de l'Atlantique. Les relations longueur-longueur fournies dans ce document couvrent une vaste portion de la gamme de tailles déclarées de chaque espèce étudiée et sont les premières conversions longueur-longueur jamais déclarées pour ces espèces dans cette zone.

RESUMEN

*Este estudio describe relaciones talla-talla entre longitud a la horquilla, longitud precaudal y longitud total para las seis especies principales de tiburones pelágicos (*Prionace glauca, Carcharhinus brachyurus, Carcharhinus signatus, Sphyrna zygaena, Isurus oxyrinchus y Lamna nasus*) capturados por la pesquería de palangre pelágico en el océano Atlántico suroccidental. Las relaciones talla-talla presentadas en este documento cubren una parte ampliada del rango de tallas comunicado para cada especie considerada, y representan las primeras conversiones talla-talla comunicadas para estas especies en la zona.*

KEYWORDS

Conversion factors, Longline fisheries, Elasmobranchs, Morphometry

1. Introduction

Biological information needed for stock assessment and conservation policies, among others, is lacking for many shark species in several regions of the world (Anon, 2013; ICCAT, 2013). Basic data such as average, minimum and maximum sizes, as well as length-length and length-weight relationships are often not available or reported, but are important for understanding population structure (Francis, 2006; ICCAT, 2013).

Sharks lengths have been reported worldwide using a variety of different measures (Francis 2006). Those most commonly used are total length (TL, from tip of snout to posterior end of dorsal caudal lobe in natural position), fork length (FL, form tip of snout to caudal fork) and precaudal length (PCL, from tip of snout to precaudal pit). Other measures such as alternate length (distance between the origin of both dorsal fins; e.g. Semba *et al.*, 2011), stretched total length (total length measured with the dorsal caudal lobe stretched along the main body axis; e.g. Harry *et al*., 2011), and total length as the sum of precaudal and dorsal caudal lobe lengths (Sadowsky, 1986) are also used.

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As different types of measures are used for sharks, a lack of length-length conversions factors often precludes direct comparisons among different studies (Francis, 2006). Moreover, in the absence of local or regional length-length conversions factors, researchers are forced to use length data gathered elsewhere, which most likely come from different shark populations and may not accurately describe the length-length relationship of the population under study.

In this contribution we present several length-length conversions factors for six shark species commonly caught by pelagic longline fisheries in the Southwest Atlantic Ocean, namely: blue shark (*Prionace glauca* Linnaeus 1758), shortfin mako (*Isurus oxyrinchus* Rafinesque 1810), bronze whaler (*Carcharhinus brachyurus* Günther 1870), smooth hammerhead (*Sphyrna zygaena* Linnaeus 1758), night shark (*Carcharhinus signatus* Poey 1868) and porbeagle (*Lamna nasus* Bonnaterre 1788).

2. Methods

Length data were collected by scientific observers of the National Observer Program onboard the Uruguayan Tuna Fleet (Programa Nacional de Observadores a bordo de la Flota Atunera, PNOFA) operating in the Southwestern Atlantic Ocean. Measurements were taken to the nearest centimeter in a straight line fashion using a metal measuring tape. Sharks were also sexed whenever possible. Excluding *L. nasus*, all sharks measured and considered in the current study where caught within the Uruguayan Exclusive Economic Zone (UEEZ) between 1998 and 2009. Porbeagles were caught in a larger area of the Southwestern Atlantic between 1998 and 2010, including the UEEZ and international waters adjacent to Argentina, Brazil and Uruguay (28-42°S 53-27°W). Length-length relationships between FL, PCL and TL were performed by ordinary linear regressions fitted by the method of least squares. Total length was measured following Sadowsky (1968), while FL and PCL were measured as described above. For each species, an analysis of covariance (ANCOVA) was conducted in order to assess differences in length-length relationships among sexes. All statistical procedures were done with the statistical package R (R Development Core Team; www.r-project.org).

3. Results and Discussion

In total, 21,332 sharks where measured and used for the analysis. Conversion factors among different length measurements (FL, TL and PCL), as well as mean and range size for the six shark species considered are presented in **Tables 1-3**. All regressions were highly significant ($p < 0.001$). Conversion factors were statistically different or not among sexes depending on the pair of measurements and species considered. For those cases in which the sex factor had a significant effect we presented the conversion parameters for both sexes separately and for sexes combined as well, as it may be useful anyway for unsexed specimens.

Size ranges of the shark species caught and considered here were large, but might have not been representative of the full size range reported in the literature (**Table 4**). In the case of the bronze whaler and night sharks, the smaller sizes were not well represented in the data. Smaller night sharks up to a minimum of 68 cm LT have been occasionally caught by the Uruguayan longline fishery (Mas, 2012), but they were not considered here because information on other measurements was not available. Blue and shortfin mako sharks were fairly well represented in their small classes but lacked individuals from the larger ones. The smooth hammerhead was the less well represented species considering its total size range, although this might be consequence of the inherent spatial segregation of their different size classes (Vooren&Klippel, 2005; Amorim *et al*., 2011) and their overlap with the area operated by the longline fishery. According to the size range reported in the literature, the porbeagle shark is fully represented in the Uruguayan longline fishery captures (Forselledo, 2012; see **Table 4**). In any case, the lack of smaller and larger sizes in the capture of some of these species may be a consequence of low selectivity by the fishing gear or simply the fact that they do not occur in the fishing area.

Length conversion factors stands as an easy and practical tool not only to estimate in a rather conservative way several morphological measurements with limited information, but also to compare and contrast results of different studies that have used information which is not directly comparable. Some morphometric features like total length are difficult to measure accurately on board, especially when specimens are very large and/or are still alive (Francis, 2006). Around the globe most of shark species captured by longliners have large heterocercal caudal fins as in Carcharhinids and Sphyrnids, being the Alopiids the extreme case. In those cases, measures like fork length or precaudal length rather than total length are easier to get accurately, and ultimately length conversion avoid the loss of information.

Despite being incomplete in some cases, the length-length relationships provided in this contribution covers an extended portion of the reported size range of each species considered, and represents the first length-length conversions ever reported for these species in the Southwestern Atlantic Ocean.

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Table 1. Fork length (FL) – Precaudal length (PCL) conversion factors for six shark species from Southwest Atlantic. Mean size and range (in parenthesis) are also presented.

Species	Forklength (cm)	Precaudallength (cm)	n	FL = *a* + *b* * PCL		
				a	***b***	**R^2**
Carcharhinus brachyurus	179 (100–230)	161 (90–216)	683	7.022	1.072	0.976
males	182 (100–216)	164 (90–196)	421	6.185	1.074	0.977
females	175 (102–230)	156 (93–216)	239	7.352	1.074	0.977
Carcharhinus signatus	137 (88–215)	124 (79–196)	354	1.168	1.096	0.997
males	132 (90–202)	119 (80–182)	161			
females	142 (101–215)	129 (91–196)	187			
Prionace glauca	151 (64–259)	136 (52–235)	8572	1.956	1.091	0.992
males	159 (68–259)	144 (62–235)	3761	1.837	1.093	0.992
females	144 (64–228)	131 (52–209)	4707	1.837	1.086	0.992
Isurus oxyrinchus	150 (70–270)	135 (62–245)	1369	5.292	1.069	0.985
males	153 (75–264)	138 (64–245)	707			
females	147 (70–270)	132 (62–243)	646			
Lamna nasus	139 (66–226)	124 (54–203)	983	2.250	1.103	0.995
males	146 (66–226)	130 (54–203)	638	2.619	1.102	0.995
females	127 (67–214)	113 (56–190)	329	2.082	1.102	0.995
Sphyrna zygaena	131 (90–255)	118 (80–232)	560	5.043	1.064	0.988
males	128 (95–165)	116 (83–150)	199	4.908	1.063	0.988
females	132 (90–255)	119 (80–232)	351	5.222	1.063	0.988

Table 2. Total length (TL) – Fork length (FL) conversion factors for six shark species from Southwest Atlantic. Mean size and range (in parenthesis) are also presented.

Species	Total length (cm)	Forklength (cm)	n	TL = *a* + *b* * FL		
				a	***b***	**R^2**
Carcharhinus brachyurus	218 (123–280)	180 (100–230)	670	5.801	1.181	0.974
males	222 (123–257)	182 (100–216)	411	7.419	1.176	0.975
females	212 (126–280)	176 (102–230)	236	5.359	1.176	0.975
Carcharhinus signatus	167 (110–256)	137 (90–215)	347	3.862	1.188	0.995
males	160 (110–243)	131 (90–202)	158			
females	173 (122–256)	143 (101–215)	185			
Prionace glauca	183 (78–309)	151 (64–259)	8391	1.631	1.201	0.987
males	193 (84–309)	159 (68–259)	3688	2.045	1.200	0.987
females	175 (78–282)	144 (64–228)	4609	1.694	1.200	0.987
Isurus oxyrinchus	167 (88–264)	148 (74–238)	1020	0.000	1.127	0.982
males	170 (88–264)	151 (75–238)	516			
females	163 (98–244)	144 (85–216)	490			
Lamna nasus	153 (78–245)	133 (67–214)	700	0.742	1.147	0.997
males	164 (78–245)	142 (67–211)	461			
females	133 (78–245)	115 (67–214)	223			
Sphyrna zygaena	167 (114–330)	131 (90–255)	547	0.000	1.279	0.982
males	164 (119–212)	128 (95–165)	194	0.000	1.280	0.983
females	168 (114–330)	132 (90–255)	344	-0.616	1.280	0.983

Table 3. Total length (TL) – Precaudal length (PCL) conversion factors for six shark species from Southwest Atlantic. Mean size and range (in parenthesis) are also presented.

Species	Toltallength (cm)	Precaudallength (cm)	n	TL = *a* + *b* * PCL		
				a	***b***	**R^2**
Carcharhinus brachyurus	221 (123–280)	163 (90–216)	931	10.270	1.289	0.986
males	224 (123–257)	166 (90–196)	615	13.997	1.268	0.987
females	214 (126–280)	158 (93–216)	292	7.301	1.306	0.985
Carcharhinus signatus	163 (107–256)	121 (73–196)	488	4.889	1.304	0.995
males	160 (107–243)	119 (73–182)	226			
females	167 (110–256)	124 (85–196)	253			
Prionace glauca	180 (78–309)	135 (55–235)	16542	3.549	1.313	0.989
males	186 (81–309)	139 (59–235)	6010	3.943	1.312	0.989
females	177 (78–282)	132 (55–209)	10256	3.554	1.312	0.989
Isurus oxyrinchus	167 (87–264)	133 (64–215)	1021	2.651	1.239	0.988
males	170 (88–264)	135 (64–215)	516			
females	163 (87–244)	130 (66–195)	491			
Lamna nasus	154 (78–245)	118 (58–190)	706	2.034	1.282	0.998
males	164 (78–245)	126 (58–189)	465			
females	133 (78–245)	102 (59–190)	225			
Sphyrna zygaena	166 (114–330)	118 (80–232)	795	5.440	1.361	0.983
males	164 (119–315)	117 (83–228)	272			
females	167 (114–330)	119 (80–232)	505			

Table 4. Size ranges captured by the Uruguayan pelagic longline fleet and reported in the literature for the six species considered in the study. TL: total length; FL: fork length.

Species	Size range of captures (cm)	Size range reported in the literature	
		Range (cm)	Reference
Carcharhinus brachyurus	123–280 TL	59–294 TL	Ebert et al. (2013)
Carcharhinus signatus	110–256 TL	60–280 TL	Ebert et al. (2013)
Prionace glauca	79–309 TL	35–383 TL	Nakano& Stevens (2008)
Isurus oxyrinchus	88–264 TL	70–400 TL	Stevens (2008)
Lamna nasus	66–226 FL	58–228 FL	Francis et al. (2008)
Sphyrna zygaena	114–330 TL	50–400 TL	Ebert et al. (2013)