California Fish and Game 101(3):178-183; 2015

Length-weight and length-length relationships, condition index, and trophic level of *Sphyraena idiastes* Heller and Snodgrass, 1903 (Teleostei: Sphyraenidae)

Adrian F. Gonzalez-Acosta*, Gorgonio Ruiz-Campos, Lloyd T. Findley, and Javier Romo-Rios

Instituto Politecnico Nacional-Centro Interdisciplinario de Ciencias Marinas, Av. Instituto Politecnico Nacional s/n, Col. Playa Palo de Santa Rita, La Paz, BCS, Mexico, 23096 (AFGA, JRR)

Facultad de Ciencias, Universidad Autonoma de Baja California, Carretera Tijuana-Ensenada km 103, Ensenada, BC, Mexico, 22860 (GRC)

Centro de Investigacion en Alimentacion y Desarrollo, Unidad Guaymas, Carretera al Varadero Nacional km 6.6, Col. Las Playitas, Guaymas, Sonora, Mexico, 85480 (LTF)

**Correspondent: aacosta@ipn.mx*

Key words: condition index, L-L relationship, L-W relationship, Mexico, Pacific Ocean, pelican barracuda, *Sphyraena idiastes*, Sphyraenidae, trophic ecology

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The pelican barracuda (*Sphyraena idiastes* Heller and Snodgrass, 1903) is a schooling pelagic species inhabiting waters as deep as ~100 m and is common throughout the southeastern Pacific and present at least occasionally along the western coast of the Baja California peninsula and in the Gulf of California (Merlen 1988, Sommer 1995, Grove and Lavenberg 1997, Robertson et al. 2010, Gonzalez-Acosta et al. 2013). This species is caught commercially in the southeastern Pacific using gill-net and hook-and-line fishing techniques (Jimenez-Prado and Bearez 2004); however, despite its commercial value in artisanal fisheries, its biology is poorly known (e.g., Froese and Pauly 2015). In this study we provide the first appraisals of its length-weight (L-W) and length-length (L-L) relationships, Fulton's condition index, and data on its trophic ecology based on specimens caught in the northernmost range of its distribution.

This study is based on specimens from different localities on the outer coast of the Baja California peninsula and in the Gulf of California (see Gonzalez-Acosta et al. 2013 for locality coordinates). Specimens were caught with gill nets of 7.5 cm and 15 cm mesh size (n = 7), trolling with artificial lures (n = 13), and with spear gun while scuba diving (n = 1). All specimens were identified using pertinent literature (Heller and Snodgrass 1903, Sommer 1995, Bearez 2008), measured to the nearest 0.1 cm (SL and TL), weighed (g), and sex was determined by macroscopic examination of gonads. Some food items were determined by inspection of a few stomachs.

The length-weight regression [LWR] (Ricker 1975) was calculated from 15 freshly collected specimens using the equation: log W = log ***a*** + ***b*** log L, where W is the weight (g) and L is the standard length (mm). The "***b***" value was derived by Student's *t*-test. The SL-TL relationship was calculated by simple linear regression. The condition index of Fulton (K) was estimated using the equation $K = [100*W/L^3]$.

The trophic-level of the pelican barracuda was based on the trophic determination of the difference between the isotope composition of the consumer and its food source, appraised through analysis of stable isotopes (SIA) of nitrogen ($\delta^{15}N$) and carbon ($\delta^{13}C$) (see Aurioles-Gamboa et al. 2013). Additionally, we estimated the isotopic contribution as a percentage of potential prey items in the diet through a multi-source SIA in R [SIAR] model, a Bayesian mixture model that allows incorporation of several sources and the estimation of the uncertainty associated with isotopic values from prey in relation to those of the predator (Parnell et al. 2008, 2010).

A total of 20 individuals of the pelican barracuda was examined (Table 1): three males (277–560 mm SL, 315–640 mm TL, and 319–961 g), six females (353–541 mm SL, 412–598 mm TL, and 278.2–860 g), and eleven immature (57–455 mm SL, 64–515 mm TL, and 0.5–440 g). Immature fish were the most abundant group in this study, comprising 57.1% of the total sample, their predominance perhaps a consequence of the sampling methods employed. A previous record of total length (910 mm) reported for an "unsexed fish" from the Galapagos Islands (Merlen 1988, Froese and Pauly 2015) contrasts with the maximum total length of one of our male specimens (640 mm) from Punta Diablo (Table 1).

Table 1.—Biometry and meristics from 6 females (F), 3 males (M) and 11 immature (I) specimens of pelican barracuda from the outer coast of the Baja California peninsula and Gulf of California (see Gonzalez-Acosta et al. 2013). Values in parentheses are proportion of the standard length and values in brackets expressed as proportion of head length; *n* = number of individuals.

	Location										
Measurements (mm)	Bahia Asuncion		Punta Diablo		Guaymas area			Puerto San Carlos	Guerrero Negro	Isla San Esteban	
& meristics	F	M	F	M	I	F	M	I	F	I	F
Standard length	353.0-376.0	363.0	470.0	560.0	57.0-365.0	397.0	277.0	359.8	541.1	390.0-455.0	423.3
Total length	412.0-440.0	428.0	545.0	640.0	64.0-433.0	466.0	315.0	379.4	598.3	470.0-515.0	495.6
Weight (g)	278.2-349.5	319.4	860.0	891.0	0.5-286.0	396.0	96.1	271.0	779.0	300.0-440.0	487.0
Head length	112.0-116.0 (30.8-31.7)	111.0 (30.6)	143.0 (30.4)	170.0 (30.3)	22.2-112.1 (30.7-38.6)	117.6 (25.2)	87.1 (31.4)	108.9 (30.3)	154.8 (28.6)	113.4-128.0 (27.0-29.8)	123.9 (29.3)
Body depth	46.0-64.0 (13.0-17.0)	51.0 (14.0)	79.0 (16.8)	64.0 (11.4)	4.5-40.0 (10.9-11.2)	42.3 (10.6)	31.1 (11.2)	44.6 (12.4)	59.4 (10.9)	43.0-54.9 (11.0-13.4)	48.7 (11.5)
Snout length	47.5-48.0 [41.4-42.4]	49.0 [44.1]	69.0 [48.2]	82.0 [48.2]	8.1-49.4 [34.9-44.0]	51.4 [43.7]	35.1 [40.3]	47.5 [43.6]	71.9 [46.4]	51.1-56.4 [44.0-45.3]	59.9 [48.3]
Orbit diameter	13.0-14.0 [11.6-12.1]	14.0 [12.6]	16.5 [11.5]	18.0 [10.6]	3.5-18.1 [13.4-16.8]	19.8 [16.8]	12.5 [14.3]	17.0 [15.6]	15.9 [10.3]	14.8-17.1 [12.9-13.4]	18.7 [15.1]
Postorbital length	43.0-47.0 [38.4-40.5]	46.0 [41.4]	59.5 [41.6]	68.0 [40.0]	7.3-47.9 [31.5-42.7]	48.6 [41.3]	33.2 [38.1]	46.0 [42.3]	62.7 [40.5]	46.2-54.9 [40.7-43.0]	52.3 [42.2]
Pectoral fin length	34.0-38.0 [30.5-32.7]	32.0 [28.8]	43.0 [30.0]	54.0 [31.7]	2.3-34.4 [9.4-30.7]	40.3 [34.2]	26.0 [28.9]	35.2 [30.9]	42.5 [27.4]	35.0-42.3 [30.0-33.6]	37.0 [29.8]
Pelvic fin length	30.0-34.0 [26.8-29.3]	31.0 [27.9]	39.5 [27.6]	48.0 [28.2]	4.6-31.0 [19.8-28.9]	36.3 [30.8]	25.2 [28.9]	31.1 [28.6]	43.8 [28.3]	34.2-42.9 [27.8-36.8]	37.1 [29.9]
Dorsal fin elements	V-I, 9	V-I, 9	V-I, 9	V-I, 9	V-I, 9	V-I, 9	V-I, 9	V-I, 9	V-I, 9	V-I, 9	V-I, 9
Anal fin elements	II, 9	II. 9	II, 8	II, 8	II, 8	II, 8	II, 8	II, 8	II, 8	II, 8	II, 8
Pectoral fin rays	14	14	14	13	13	13	13	13	13	13	13
Lateral line scales	133	135	148	146	134-139	136	136	135	135	135-138	141
n	2	1	1	1	6	1	1	1	1	4	1

Length-weight (L-W) and length-length (L-L) relationships calculated from 15 of our specimens using a logarithmic transformation of the linear regression equation, showed good fit for the linear regression for the overall population ($r^2 > 0.911$, $P < 0.001$; Figure 1, Table 2). These data represent the first assessment of LWR and LLR for the species, and may prove useful in future regulation of its artisanal fishery. At this time, this fishery in the southeastern Pacific is currently assessed as not overfished (Jimenez-Prado and Bearez 2004).

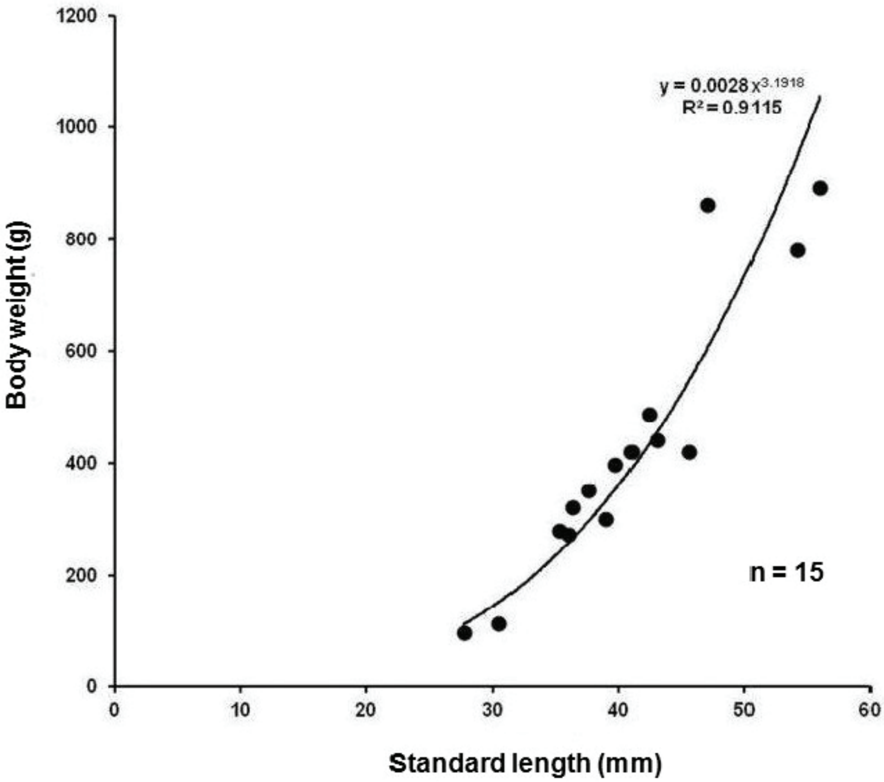

Figure 1.—Length-weight relationships of pelican barracuda (*Sphyraena idiastes*) from the northeastern Pacific Ocean.

Table 2.—Parameters of length-weight (LW) and length-length (L-L) relationships from 15 freshly collected specimens of pelican barracuda from the outer coast of the Baja California peninsula and in the Gulf of California.

Length (mm)				95% CI of *b*		
Min.	Max.	*Log a*	*b*	Min.	Max.	r^2
277	560	-2.556	3.192	2.596	3.787	0.911

Parameters of length-length relationships to convert SL to TL
a = 3.034 *b* = 1.075 *r* = 0.934

The determined *b*-value (3.19) (Table 2) is within the range of 2.5 to 3.49 reported for other barracuda species, such as the great barracuda, *S. barracuda* (e.g., Froese and Pauly 2015). The Student's *t*-test indicates isometric growth ($b = 3.19$; $t = 0.695$, $d.f. = 13$, $P < 0.001$) for the pelican barracuda. Isometric growth assumes that body shape and proportions do not change with increase in length (Ricker 1975); alternatively, it may be due to homogeneity in body form and condition of the 15 specimens analyzed herein (e.g., Grupta et al. 2011).

The overall mean of Fulton´s condition index (0.574) for our specimens appears to indicate unsuitable environmental conditions for the pelican barracuda in the northern part of its range, perhaps relating to state of sexual maturity or fitness (e.g., Williams 2000, Froese 2006). Information on the L-W and L-L relationships and Fulton's index of condition has not been reported previously for pelican barracuda (e.g., Froese and Pauly 2015). Thus, our results represent the first appraisal of its population parameters. These should be considered as preliminary and need to be corroborated in future population surveys throughout its wide distributional range.

Stomach contents of nine specimens were examined for food material. However, only three contained food items: two (male 560 mm SL and female 376 mm SL) had semi-digested remains of fishes; the third (female 470 mm SL) contained an individual (~190 mm SL) Pacific sardine (*Sardinops sagax*) identified by means of its urohyal bone morphology (Figure 2; Burnes-Romo 2007). Pacific sardine is a pelagic-neritic species occurring between the surface and ~200 m (Whitehead 1985). This finding corroborates this sardine in the diet reported for pelican barracuda by Grove and Lavenberg (1997) and also suggests a preference of pelican barracuda for pelagic-neritic habitats.

Figure 2.—Urohyal bone of Pacific sardine (*Sardinops sagax*) from the stomach contents of a pelican barracuda (*Sphyraena idiastes*; 470 mm SL) from the northeastern Pacific Ocean.

Based on four of our specimens caught off Isla San Esteban in the north-central Gulf of California (see Gonzalez-Acosta et al. 2013), Aurioles-Gamboa et al. (2013) estimated a trophic-level of 4 for pelican barracuda, which falls within values ($\bar{x} = 4.5 \pm 0.8$ [*SE*]) reported for this species (Froese and Pauly 2015) and is similar to other large predatory pelagic fishes such as bonito, swordfish and tunas (Stergiou 2005). The isotopic analyses of 30 specimens considered as potential prey species for pelican barracuda indicate that the highest percentages of contribution (33 ± 13%) to the diet are likely provided by Panama lanternfish (*Benthosema panamense*) and flatiron herring (*Harengula thrissina*) whereas Pacific sardine and the jumbo squid (*Dosidicus gigas*) contribute with lower percentages (21 ± 12%). The isotopic signature of the pelican barracuda depicts the contribution of its potential prey species over long periods of time, as well as the complex interaction between them via the assimilation of energy or mass flux through different pathways (Post 2002). Our results stress the importance of further population surveys on pelican barracuda to provide additional data on its life history throughout the tropical eastern Pacific.

Acknowledgments

We thank L.A. Burnes Romo for assistance in collecting and processing specimens. H. J. Walker and P. A. Hastings (SIO-UCSD) provided useful information on the species. D. Aurioles Gamboa and C. Hernandez Camacho (CICIMAR-IPN) supported collecting in the Gulf of California via the project REDMA-IPN ("Estado de salud, uso sustentable y conservacion del Golfo de California"). Many thanks to A. H. Andrews (NOAA Fisheries-PISFC), M. Love (MSI-UCSB) and an anonymous reviewer for comments that improved this paper. AFGA and GRC are grateful for research grants from SNI-CONACyT, EDI and COFAA-IPN.

Literature Cited

Aurioles-Gamboa, D., M. Y. Rodriguez-Perez, L. Sanchez-Velasco and M. F. Lavin. 2013. Habitat, trophic level, and residence of marine mammals in the Gulf of California assessed by isotope analysis. Marine Ecology Progress Series 488:275-290.

Bearez, P. 2008. Occurrence of *Sphyraena qenie* (Sphyraenidae) in the tropical eastern Pacific, with a key to species of barracudas occurring in the area. Cybium 32:95-96.

Burnes-Romo, L. A. 2007. Urohiales de especies selectas de peces del Pacifico oriental. Bachelor of Science Thesis, Universidad Autonoma de Baja California Sur, La Paz, Mexico.

Froese, R. 2006. Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. Journal of Applied Ichthyology 22:241-253.

Froese, R., and D. Pauly (editors.). 2015. Fishbase [Internet]. World Wide Web publication [version 02/2015]. Available from: www.fishbase.org

Gonzalez-Acosta, A. F., L. T. Findley, G. Ruiz-Campos, L. A. Burnes-Romo, and H. Espinosa Perez. 2013. Extreme northern range extension of the Pelican barracuda *Sphyraena idiastes* (Perciformes: Sphyraenidae) in the eastern Pacific. Journal of Applied Ichthyology 29:655-657.

Grove, J. S., and R. J. Lavenberg. 1997. The fishes of the Galapagos Islands. Stanford University Press, Stanford, California, USA.

Grupta, B. K., U. K. Sarkar, S. K. Bhardwaj, and A. Pal. 2011. Condition factor, length-weight and length-length relationships of an endangered fish *Ompok pabda* (Hamilton 1822) (Siluriformes: Siluridae) from the River Gomti, a tributary of the River Ganga, India. Journal of Applied Ichthyology 27:962-964.

Heller, E., and R. E. Snodgrass. 1903. Papers from the Hopkins Stanford Galapagos Expedition, 1898-1899. XV, New fishes. Proceedings of the Washington Academy of Science 5:189-229.

Jimenez-Prado, P., and P. Bearez. 2004. Peces marinos del Ecuador continental. SIMBIOE/NAZCA/IFEA, Quito, Peru.

Merlen, G. 1988. A field guide to the fishes of Galapagos. Wilmot Books, London, United Kingdom.

Parnell, A., R. Inger, S. Bearshop, and A. L.Jackson. 2008. SIAR: stable isotope analysis in R. Available at http://cran.rproject.org/web/packages/siar/index.html

Parnell A. C., R. Inger, S. Bearshop, and A. L. Jackson. 2010. Source partitioning using stable isotopes: coping with too much variation. PLoS ONE 5:e9672.

Post, D. M. 2002. Using stable isotopes to estimate trophic position: models, methods, and assumptions. Ecology 83:703-718

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Department of Environment, Fisheries and Marine Service, Ottawa, Ontario, Canada.

Robertson, R., B. Collette, H. Molina, A. G. Guzman-Mora, and E. Salas. 2010. *Saphyraena idiastes*, *in* IUCN 2013 [Internet]. IUCN Red List of Threatened Species; Version 2013.2 [Accessed 22 June 2015]. Available at: www.iucnredlist.org

Sommer, C. 1995. Sphyraenidae. Barracudas, picudas. Pages 1618-1621 *in* W. Fischer, F. Krupp, W. Schneider, C. Sommer, K. E. Carpenter and V. Niem, editors. Guia FAO para identificacion de especies para los fines de la pesca. Pacífico Centro-Oriental, Vol. 3. FAO, Rome, Italy.

Stergiou, K. I. 2005. Fisheries impact on trophic levels: long-term trends in Hellenic waters. Pages 326-329 *in* E. Papathanassiou and A. Zenetos, editors. State of the Hellenic marine environment. Hellenic Centre for Marine Research, Athens, Greece.

Whitehead, P. J. P. 1985. FAO Species Catalogue. Vol. 7. Clupeoid fishes of the world (suborder Clupeioidei). An annotated and illustrated catalogue of the herrings, sardines, pilchards, sprats, shads, anchovies and wolf-herrings. Part 1. Chirocentridae, Clupeidae and Pristigasteridae. FAO Fisheries Synopsis 125:1-303. FAO, Rome, Italy.

Williams, J. E. 2000. The coefficient of condition of fish. Pages 1-2 *in* J. C. Schneider, editor. Manual of fisheries survey methods II: with periodic updates. Fisheries Special Report 25. Michigan Department of Natural Resources, Ann Arbor, USA.

Submitted 9 February 2015
Accepted 23 May 2015
Associate Editor was N. Kogut