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Research Article

Stomach contents of the Pacific sharpnose shark, *Rhizoprionodon longurio* (Carcharhiniformes, Carcharhinidae) in the southeastern Gulf of California

Yolene R. Osuna-Peralta[1], Domenico Voltolina[2]
Ramón E. Morán-Angulo[1] & J. Fernando Márquez-Farías[1]
[1]Facultad de Ciencias del Mar, Universidad Autónoma de Sinaloa
Paseo Claussen s/n, Col. Los Pinos, CP 82000, Mazatlán, Sinaloa, México
[2]Laboratorio UAS-CIBNOR, Centro de Investigaciones Biológicas del Noroeste
Ap. Postal 1132, CP 82000, Mazatlán, Sinaloa, México

ABSTRACT. The feeding habits of the sharpnose shark *Rhizoprionodon longurio* of the SE Gulf of California are described using the stomach contents of 250 specimens (135 males and 115 females) obtained weekly from December 2007 to March 2008 in the two main landing sites of the artisanal fishing fleet of Mazatlan. The mean total length (TL) was 77.7 ± 12.8 cm and the respective ranges for males and females were 60-120 cm and 52-120 cm. Size distribution showed two modal groups (juveniles: 52-80 cm, mode 72.5 cm, and adults: 85-140 cm, mode 92.5 cm). Out of the 395 preys identified in 235 stomachs with identifiable contents, the most important were cephalopods (Index of Relative Importance, IRI = 93.1%), mainly *Argonauta* spp. (IRI = 92.9%). The total IRI value for fish was 5.9%, mostly represented by *Oligoplites refulgens* and *Oligoplites* sp. (joint IRI value = 4.8%). The diversity of the stomach contents of males and females was not significantly different, and although the values of diversity, equitability and dietary breadth indexes were lower in juveniles than in adults, ANOSIM analysis did not show differences in dietary habits related to age and sex. The results indicate a specialized feeding behaviour, with *Argonauta* spp. as preferred prey. This behaviour does not agree with all previous information on *R. longurio*, and is probably due to local availability of this prey during the sampling period.

Keywords: *Rhizoprionodon longurio*, feeding habits, diversity, cephalopods, fish, Gulf of California.

Contenido estomacal del cazón bironche del Pacífico, *Rhizoprionodon longurio* (Carcharhiniformes, Carcharhinidae) en el sector suroriental del Golfo de California

RESUMEN. Se describen los hábitos alimentarios del cazón bironche, *Rhizoprionodon longurio* a partir del contenido estomacal de 250 especímenes (135 machos y 115 hembras) obtenidos entre diciembre 2007 y marzo 2008 en los dos mayores lugares de desembarque de la flota artesanal de Mazatlán (SE del Golfo de California). La longitud total (LT) media fue 77,7 ± 12,8 cm y varió entre 52 y 120 cm en hembras y 60 y 120 cm en machos. La distribución de tallas evidenció dos grupos modales (juveniles: 52-80 cm, moda 72,5 cm, y adultos: 85-140 cm, moda 92,5 cm). Se identificaron 395 organismos presa en los 235 estómagos con contenidos identificables; los más importantes fueron cefalópodos (IIR = 93,1%), principalmente *Argonauta* spp. (IIR = 92,9%). El IIR para los peces fue 5,9%, entre los cuales dominaron *Oligoplites refulgens* y *Oligoplites* sp. (IIR = 4,8%). No se encontraron diferencias entre la diversidad del contenido estomacal por sexo, y aunque los valores de diversidad, equitabilidad y amplitud de la dieta fueron menores para los juveniles que para los adultos, el análisis ANOSIM no mostró diferencias entre los hábitos alimenticios por edad y sexo. Según estos resultados *R. longurio* tendría una alimentación selectiva, con *Argonauta* como presa preferida, probablemente debido a su abundancia durante el periodo de estudio.

Palabras clave: *Rhizoprionodon longurio*, comportamiento alimentario, diversidad, cefalópodos, peces, Golfo de California.

Corresponding author: Domenico Voltolina (voltolin04@cibnor.mx)

INTRODUCTION

The Pacific sharpnose shark, *Rhizoprionodon longurio* (Jordan & Gilbert, 1882) is a small shark (<1.5 m) of the eastern Pacific coastal waters. Its distribution ranges from California to Peru (Compagno, 1984), it is exploited by the artisanal fishing fleets operating along the Mexican coasts from Baja California to Chiapas, and it appears in the bycatch of industrial trawl fisheries (Márquez-Farías *et al*., 2005).

Its presence in Sinaloa coastal waters shows a strong, possibly temperature-related seasonal pattern, since it is present only between November and March-April of each year when *R. longurio*, as well as the pups and juveniles of the scalloped hammerhead, *Sphyrna lewini* (Griffith & Smith, 1834), are important target species for the artisanal fishery of the state of Sinaloa, where these species are the bulk of the captures of small sharks, and the 453 ton of cazón landed in 2011 (small sharks), were close to 20% of the total production of small sharks of the Mexican Pacific fishing fleets (SAGARPA-CONAPESCA, 2011).

Although it is fished intensively, studies on its general biology are scarce. In particular, information on its feeding habits is limited (Márquez-Farías *et al*., 2005) and is mostly confined to grey literature (Saucedo-Barrón *et al*., 1982; Alatorre-Ramírez, 2003; Conde-Moreno, 2009). Aiming to add information on its feeding ecology in the SE Gulf of California, we determined the stomach contents of specimens of this species caught by the artisanal fishing fleet operating off Mazatlán, Sinaloa, and NW Mexico.

MATERIALS AND METHODS

Samples were obtained between December 2007 and March 2008 in two important landing sites (Playa Sur and Chametla) for the local artisanal fishing fleet. This fleet operates on a gently sloping platform, in depths of 18 to 91 m with soft terrigenous sediments (Alba-Cornejo *et al*., 1979), between the locations Mármol (23°11'N, 106°30'W) and Chametla (23°45'25"N, 106°05'15"W). The boats (pangas) are fiberglass, 6 to 7.5 m long, with 75-200 HP outboard motors, and each boat operates two 1500-m bottom longlines with 300 hooks #4 or H5.

Both landing sites were visited once weekly, the total length (TL) and wet weight (WW) of the landed specimens of *R. longurio* were obtained with a measuring tape and a digital scale (±0.5 cm y 50 g), and their sex was determined from the presence/absence of claspers. The females and males of this species reach first maturity at 83 and 86 cm TL, respectively (Castillo *et al*., 1996). Consequently, specimens with values lower than these sizes were considered juveniles.

The whole stomachs were obtained through a longitudinal slit in the abdominal region and preserved frozen (-30°C) until analysis. Upon defrosting, the fullness of each stomach was assessed as: 0 = empty, 1 = 1-25%, 2 = 26-50%, 3 = 51-75% and 4 = 76-100% (Stillwell & Kohler, 1982). The contents were sieved through a 0.1 mm sieve to retain the prey items, which were counted, weighed to the nearest 0.1 g and identified to the lowest possible taxon depending on the state of digestion. This was evaluated as: 1: preys complete, undigested; 2: whole body, no skin, no eyes, bare muscles; 3: only parts of the body and axial skeleton present; 4: only hard structures present, and 5: organic material not identifiable (OMNI) (Galván-Magaña, 1999).

Complete, undigested fish were identified with the manuals by Miller & Lea (1972); Walker & Rosenblatt (1988); Allen & Robertson (1994) and Fischer *et al*. (1995). Fish remains (states of digestion 2 and 3) were identified by their vertebral characteristics with the keys by Clothier (1950) and Miller & Jorgensen (1973), using as reference the collection of fish skeletons of the Laboratory of Fish Ecology of the Centro Interdisciplinario de Ciencias Marinas (CICIMAR) of La Paz, BCS. State 4 items were fish otoliths, cephalopod beaks and crustacean exoskeletons (complete or parts), which were identified using the keys by Fitch & Brownell Jr. (1968), Clarke (1962, 1986), Iverson & Pinkas (1971) and Wolff (1982, 1984).

The importance of each prey was determined using the traditional numeric (%N), gravimetric (%W) and frequency of observation (%F) indexes (Hyslop, 1980), which were used to calculate the composite index of relative importance IRI = (%N+%V) %F by Pinkas *et al*. (1971), but using gravimetric (W%), rather than volumetric (V%) data, as suggested by Stevens *et al*. (1982).

The diversity of the diet as indicated by the stomach contents was estimated with the Shannon-Weaver diversity (H') and equitability (E) indexes $H' = -\Sigma(pi)\ln(pi)$ and $E = H'/MH'$, where pi is the proportion of species i, MH' is the index of maximum diversity: $-\ln(1/S)$, and S is the number of species (Pielou, 1975).

The dietary breadth was determined with the standardized version $B_A = (B-1)/(n-1)$ of Levin's index of niche breadth $B = 1/\sum Pj^2$ where B is Levin´s index, Pj is the proportion of the diet consisting in prey j, and n is the number of prey categories (Krebs, 1999; Navia *et al*., 2007). B_A ranges from 0 to 1: values close to 0 indicate dominance of few prey items (specialist feeder), and generalist feeders have values close to 1.0 (Hurlbert, 1978).

The presence of overlap of trophic habits of males and females and of organisms of different size (age) was determined using analysis of similarities (ANOSIM) tests, performed with the PRIMER Software package (Clarke & Gorley, 2006). The values of the resulting statistic (R) range from 1 to 0. R = 1 indicates that the samples are within the same groups (no overlap), and R values close to 0 indicate that similarities and dissimilarities are not related to the groups (overlap).

RESULTS

The total number of sharks used for this study was 250 (135 males and 115 females). Sizes ranged from 52 to 120 cm and from 60 to 120 cm TL for females and males, respectively. The common mean TL was 77.7 ± 12.8 cm and the TL distribution frequency diagram showed two clearly defined modal groups of equal size, hereinafter defined as juveniles (size range 52-80 cm TL, modal value 72.5 cm), and adults (TL 85-140 cm, modal value 92.5 cm) (Fig. 1).

The accumulated diversity curves reached close to asymptotic values after 25 to 30 stomachs for juveniles (both sexes) and male adults. The total number of female adults was 26, and the accumulated diversity increased by 0.25% between 20 and 26 stomachs (Osuna-Peralta, 2010). Most of the stomachs were in fullness class 1 (78.4%), and 6% were totally empty. Class 2 was 12.4% and classes 3 and 4 represented 1.2% y 2.0% of the total, respectively. The total number of preys found in the 193 stomachs with contents between stages of digestion 1 to 4 was 395. More than 73% were at stages of digestion 3 and 4, and OMNI was 17%.

Trophic spectrum

The preys identified were 395. Those identified at the specific level were 52 (13.2%), and 311 (79%) were identified at the generic level. The remaining 32 were identified at the family level, for a total of 11 species, 18 genera and 15 families (17 fish, 4 cephalopods and 1 crustacean) (Table 1).

Numeric index

Pelagic cephalopods and fish made up approximately 76.9 and 20.7% of the preys, while crustaceans were the remaining 2.3%. The most frequent and abundant cephalopods were *Argonauta* spp. (73.7%), this was followed by *Lolliguncula diomedae* and *Mastigoteuthis dentata*, which jointly represented <2.5%. The most common fish were *Oligoplites refulgens* (6.8%), *Oligoplites* spp. (3.3%) and *Chloroscombrus orqueta* (1.0%) (Table 1).

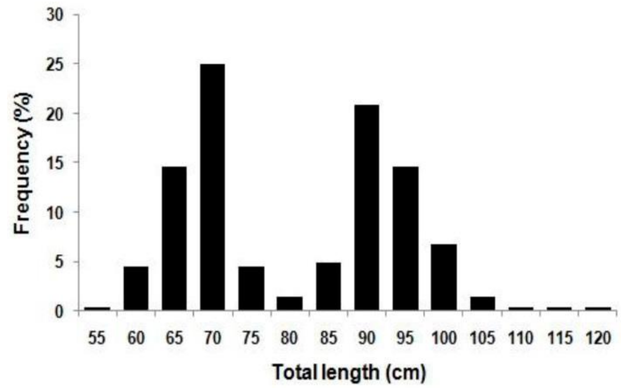

Figure 1. Size class structure of *Rhizoprionodon longurio* landed by the Mazatlán artisanal fishing fleet between December 2007 and March, 2008.

Gravimetric index

The total weight of the preys identified was 570.3 g; 506.4 g (88.8%) were fish, cephalopod beaks were 10.8% and crustaceans 0.4%. Additionally, 317 g of OMNI were found in 83 stomachs (Table 1).

Gravimetrically, the most important prey items were the belonid fish *Tylosurus crocodrilus fodiator* (25.7%) and the carangid *O. refulgens* (13.9%). The beaks of *Argonauta* spp. were only 10.8%, which was closely followed by fishes *Opisthonema libertate*, *Oligoplites* spp. and *Caranx* spp. (9.7%, 8.4% and 7.8%, respectively) (Table 1).

Frequency of occurrence

The most frequent prey items were molluscs (46.8%), followed by fishes and crustaceans (26.0 and slightly less than 3% of the stomach contents examined, respectively). Among molluscs, the most frequent were *Argonauta* spp. (43.4%), followed by *L. diomedae* and *M. dentata*, with 2.1 and 1.7%. Among fish, *O. refulgens*, *Oligoplites* spp. and *C. orqueta* were 6.8%, 4.3% and 1.7% respectively (Table 1).

Index of relative importance

The main preys were cephalopods, with IRI values >3600 (>93%). Among these, the most important were *Argonauta* spp. (92.9%), followed by *O. refulgens* (3.6%) and *Oligoplites* spp. (1.3%). All remaining preys were <1% (Table 1). The relative importance of *Argonauta* spp. was similar for males and females (91.0 and 92.8%, respectively), but the value calculated for juveniles (95.4%) was almost 12% higher than for adults (83.7%). As a consequence, the relative importance of other preys such as *Oligoplites* spp. was higher for adults than for juveniles (8.8% and 2.9%, respectively).

Table 1. Absolute and relative (%) number of specimens (N, N%), mass (grams: G, G%), frequency of occurrence (FO, FO%), and absolute and relative indexes of relative importance (IRI, IRI%) of preys identified in the stomach contents of *Rhizoprionodon longurio*, landed in Mazatlán, Sinaloa, Mexico.

Prey	N	N%	G	G%	FO	FO%	IRI	IRI%
Mollusca Cephalopoda								
Argonauta spp.	291	73.67	61.51	10.770	102	43.40	3665.82	92.93
Lolliguncula diomedae	5	1.26	0.14	0.020	5	2.13	2.75	0.07
Mastigoteuthis dentata	4	1.01	0.05	0.010	4	1.70	1.74	0.04
Onychoteuthis banksii	3	0.76	0.03	0.005	3	1.28	0.98	0.02
Remains, unidentified	1	0.25	0.01	0.002	1	0.43	0.11	0
Subtotal	304	76.95	61.74	10.810	115	48.94	3671.4	93.06
Crustacea Decapoda								
Pleuroncodes planipes	3	0.76	0.39	0.07	1	0.43	0.35	0.01
Remains, unidentified	6	1.52	1.73	0.30	6	0.43	4.65	0.12
Subtotal	9	2.28	2.12	0.37	7	0.86	5.00	0.13
Pisces Osteichthyes								
Opisthonema libertate	2	0.51	55.22	9.680	2	0.85	8.67	0.22
Anchoa spp.	1	0.25	1.49	0.260	1	0.43	0.22	0.01
Carangidae	3	0.76	2.26	0.400	2	0.85	0.98	0.02
Caranx spp.	2	0.51	44.22	7.750	2	0.85	7.03	0.18
Chloroscombrus orqueta	4	1.01	7.61	1.330	4	1.70	4.00	0.10
Decapterus spp.	1	0.25	7.00	1.230	1	0.43	0.63	0.02
Engraulis mordax	1	0.25	1.85	0.320	1	0.43	0.25	0.01
Fistularia spp.	1	0.25	24.74	4.340	1	0.43	1.95	0.05
Gerreidae	1	0.25	5.09	0.890	1	0.43	0.49	0.01
Menticirrhus undulatus	1	0.25	11.41	2.000	1	0.43	0.96	0.02
Mugil spp.	1	0.25	24.16	4.240	1	0.43	1.91	0.05
Oligoplites refulgens	27	6.83	79.09	13.870	16	6.81	140.96	3.57
Oligoplites spp.	13	3.29	47.99	8.410	10	4.26	49.81	1.26
Sciaenidae	1	0.25	0.01	0.002	1	0.43	0.11	0
Serranidae	1	0.25	0.01	0.002	1	0.43	0.11	0
Sphoeroides annulatus	1	0.25	7.14	1.250	1	0.43	0.64	0.02
Sphoeroides spp.	1	0.25	6.00	1.050	1	0.43	0.56	0.01
Trachinotus spp.	1	0.25	34.29	6.010	1	0.43	2.67	0.07
Tylosurus crocodilus fodiator	1	0.25	146.50	25.690	1	0.43	11.04	0.28
Remains, unidentified	18	4.56	0.34	0.060	18	7.66	35.36	0.91
Subtotal	82	20.72	506.42	88.800	61	28.57	268.35	5.91
Total	395	100	570.28	100	235	78.37	3944.75	100

Diversity, equitability, dietary breadth and trophic overlap

There were no significant sex-related differences in the mean diversity of the stomach content of both sexes, although the mean diversity values calculated for juveniles were significantly lower than those of the respective adults. In all cases, the low values of the accumulated diversity, equitability and dietary breadth indexes indicated a monotonous diet, strongly dominated by a small number of prey items, and the global R value obtained with the ANOSIM routine was 0.02, indicating similar dietary habits for juveniles and adults of the two sexes (Table 2).

DISCUSSION

All information available on the trophic habits of *R. longurio* was obtained in southern Sinaloa waters during winter months, when samples are available from the local artisanal fishing fleets. According to these previous data, the most important preys of this species are fish (Saucedo-Barrón *et al*., 1982; Castillo *et al*.,

Table 2. Diversity (H'), equitability (E) and diet breadth (B_i) indexes calculated from the stomach contents of juveniles and adults (J and A) of the males and females (M and F) of *Rhizoprionodon longurio* landed in Mazatlán between December 2007 and March 2008. F + M = indexes calculated jointly for both sexes. The different letters indicate significant differences between juveniles and adults, in either case with no difference between males and females (two ways ANOVA, α = 0.05, a < b).

		H'	E	B_i
J	F	0.619a (0.149)	0.26	0.049
	M	0.696a (0.133)	0.27	0.045
	F+M	0.796a (0.112)	0.30	0.033
A	F	1.053b (0.266)	0.48	0.102
	M	0.947b (0.202)	0.38	0.085
	F+M	1.283b (0.179)	0.44	0.055

1996; Alatorre-Ramírez, 2003; Márquez-Farías *et al*., 2005), which does not coincide with our results, since the frequency, abundance and high IRI value of the pelagic octopod *Argonauta* spp. beaks indicate that, in spite of their low %W due to the advanced degree of digestion of these preys, this was the most important prey in all our samples.

Argonauta spp. are epipelagic organisms of tropical and subtropical oceanic waters (Roper *et al*., 1984; Heeger *et al*., 1992), although they may appear in high numbers in coastal areas, generally associated with the presence of oceanic water masses (Demicheli *et al*., 2006). They are frequent in the vicinity of floating objects, and are known to form long chains of up to 20 specimens (Nesis, 1977; Walton & Houston, 2001), which might explain the high numerical and relative importance indexes (>70 N% and >90% IIR), although their frequency of occurrence was below 45%.

The presence of *Argonauta* in the stomach contents of *R. longurio*, caught in the southeast of the Gulf of California, was reported only by Conde-Moreno (2009), but it has been mentioned by several authors as a common and sometimes important food item for other predators, such as billfish (Abitia-Cárdenas *et al.*, 2002, 2010; Arizmendi-Rodriguez *et al.*, 2006; Amezcua-Gómez, 2007) and dolphinfish (Amezcua-Gómez, 2007), among others.

R. longurio has been considered a generalist predator by all authors who described its feeding habits (Saucedo-Barrón *et al*., 1982; Castillo *et al*., 1996; Alatorre-Ramírez, 2003; Márquez-Farías *et al*., 2005), but the low value of Levin's index obtained in this study suggests the feeding behaviour of a specialist predator.

However, as is the case for electivity indices which may be influenced by external food availability (Strauss, 1979; Gras & Saint-Jean, 1982), this is probably due to a high dominance in the pelagic community of the more frequent and abundant prey items found in the stomachs of this species. As suggested for other sharks, by Wetherbee *et al.* (1990), this feeding strategy combines maximum consumption with minimum energy used for its capture. This is consistent with the suggestion by Conde-Moreno (2009), that *R. longurio* should be considered an opportunistic, rather than a generalist feeder.

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REFERENCES

Abitia-Cárdenas, L.A., A. Muhlia-Melo, V. Cruz-Escalona & F. Galván-Magaña. 2002. Trophic dynamics and seasonal energetics of striped marlin *Tetrapturus audax* in the southern Gulf of California, Mexico. Fish. Res., 57: 287-295.

Abitia-Cárdenas, L.A., D. Arizmendi-Rodríguez, N. Gudiño-González & F. Galván-Magaña. 2010. Feeding of blue marlin *Makaira nigricans* off Mazatlan, Sinaloa, Mexico. Lat. Am. J. Aquat. Res., 38: 281-285.

Alatorre-Ramírez, V.G. 2003. Análisis del contenido alimenticio del tiburón *Rhizoprionodon longurio* en Mazatlán, México. B.Sc. Thesis, Universidad Autónoma de Sinaloa, Mazatlán, 33 pp.

Alba-Cornejo, V.M., A. Machado-Navarro, J. González-Millán, C. Herrera-Santoyo, J. Ledesma-Vázquez, R. Rico-Domínguez, E. Rosales-Contreras & A. Vera-Morán. 1979. Estudio sedimentológico de la bahía de Puerto Viejo, Mazatlán, Sinaloa. An. Inst. Cien. Mar Limnol. UNAM México, 6(1): 97-120.

Allen, G.R. & D.R. Robertson. 1994. Fishes of the Tropical Eastern Pacific. University of Hawaii Press, Honolulu, 332 pp.

Amezcua-Gómez, C.A. 2007. Relaciones tróficas entre el pez vela (*Istiophorus platypterus*) y el dorado (*Coryphaena hippurus*) en la costa de los estados de Jalisco y Colima, México. M.Sc. Thesis. Centro Interdisciplinario de Ciencias Marinas, La Paz, Mexico (available online: http://itzamna.bnct.ipn.mx:8080/dspace/handle/123456789/3879), 93 pp.

Arizmendi-Rodríguez, D.I., L.A. Abitia-Cárdenas, F. Galván-Magaña & I. Trejo-Escamilla. 2006. Food habits of sailfish *Istiophorus platypterus* off Mazatlán, Sinaloa, Mexico. Bull. Mar. Sci., 79: 777-791.

Castillo, L., F. Márquez, J. Uribe, R. Bonfil, D. De Anda, R. Vélez & D.O. Mendizábal. 1996. La pesquería de tiburón en México. Pesquerías relevantes de México. Vol. 2. Instituto Nacional de la Pesca, México D.F., pp. 365-415.

Clarke, M.R. 1962. The identification of cephalopod beaks and their relationship between beak size and total body weight. Bull. Brit. Mus. Nat. Hist. Zool., 8: 422-480.

Clarke, M.R. 1986. A handbook for the identification of cephalopod beaks. Clarendon Press, Oxford, 273 pp.

Clarke, K.R. & R.N. Gorley. 2006. User manual/tutorial. PRIMER-E, Plymouth, 6: 192 pp.

Clothier, C.R. 1950. A key to some southern California fishes based on vertebral characters. Fish. Bull., 79: 1-83.

Compagno, L. 1984. FAO species catalogue. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. FAO Fish. Synop., 4(1-2): 1-655.

Conde-Moreno, M. 2009. Ecología trófica del tiburón bironche, *Rhizoprionodon longurio* (Jordan & Gilbert, 1882*)*, en dos áreas *del* Pacífico Mexicano. M.Sc. Thesis. Centro Interdisciplinario de Ciencias Marinas, La Paz, Mexico, 80 pp. (available online: http://www.repositoriodigital.ipn.mx/bitstream/handle/123456789/13670/condem1.pdf?sequence=1).

Demicheli, M., A. Martínez, L. Ortega, F. Scarabino, S. Maytía & A. Demicheli. 2006. Mass stranding of *Argonauta nodosa* Lightfoot, 1786 (Cephalopoda, Argonautidae) along the Uruguayan coast (south-western Atlantic). Rev. Biol. Mar. Oceanogr., 41: 147-153.

Fischer, W., F. Krupp, W. Schneider, C. Sommer, K.E. Carpenter & V.H. Niem.1995. Guía FAO para la identificación de especies para los fines de pesca. Pacífico Centro-Oriental. Vol. II and III. Vertebrados, Parte 1 y 2. FAO, Rome, pp. 647-1813.

Fitch, J.E. & R.L. Brownell Jr. 1968. Fish otoliths in cetacean stomachs and their importance in interpreting feeding habits. J. Fish. Res. Bd. Can., 25: 2561-2574.

Galván-Magaña, F. 1999. Relaciones tróficas interes-pecíficas de la comunidad de depredadores epipelágicos en el Océano Pacífico Oriental. Ph.D. Thesis. Centro de Investigación Científica y de Educación Superior de Ensenada, Ensenada, 212 pp.

Gras, R. & L. Saint-Jean. 1982. Comments about Ivlev's electivity index. Rev. Hydrobiol. Trop., 15(1): 33-37.

Heeger, T., U. Piatkowski & H. Moller. 1992. Predation on jellyfish by the cephalopod *Argonauta argo*. Mar. Ecol. Prog. Ser., 88: 293-296.

Hurlbert, S. 1978. The measurement of niche overlap and some relatives. Ecology, 59(1): 67-77.

Hyslop, E.J. 1980. Stomach contents analysis-a review of methods and their application. J. Fish Biol., 17: 411-429.

Iverson, L.K. & L. Pinkas. 1971. A pictorial guide to beak of certain eastern Pacific cephalopods. Fish. Bull., 152: 83-105.

Krebs, C.J. 1999. Ecological methodology. Addison Wesley Pearson, Menlo Park, 620 pp.

Márquez-Farías, J.F., D. Corro-Espinosa & J.L. Castillo-Géniz. 2005. Observations on the biology of the Pacific sharpnose shark (*Rhizoprionodon longurio*, Jordan & Gilbert, 1882), captured in southern Sinaloa, Mexico. J. Northw. Atlantic Fish. Sci., 35: 107-114.

Miller, D.J. & R.N. Lea. 1972. Guide to the coastal marine fishes of California. Fish. Bull., 157: 249 pp.

Miller, D.J. & S.C. Jorgensen. 1973. Meristic characters of some marine fishes of the western Atlantic Ocean. Fish. Bull., 71: 301-312.

Navia, A.F., P.A. Mejía-Falla & A. Giraldo. 2007. Feeding ecology of elasmobranch fishes in coastal waters of the Colombian Eastern Tropical Pacific. BMC Ecology, 7: 8 <doi:10.1186/1472-6785-7-8 (available online: http://www.biomedcentral.com/1472-6785/7/8).

Nesis, K. 1977. The biology of paper nautiluses, *Argonauta boettgeri* and *A. hians*, in the Western Pacific and the seas of the East Indian Archipelago. Zool. Zh., 56: 1004-1014.

Osuna-Peralta, Y.R. 2010. Hábitos alimenticios del tiburón bironche *Rhizoprionodon longurio* (Jordan & Gilbert, 1882) (Chondrichthyes: Carcharhinidae) en el puerto pesquero de Mazatlán, Sinaloa 2007-2008. B. Sc. Thesis, Universidad Autónoma de Sinaloa, Mazatlán, 52 pp.

Pielou, E.C. 1975. Ecological diversity. John Wiley, New York, 165 pp.

Pinkas, L., S. Oliphant & I. Iverson. 1971. Food habits of albacore, bluefin tuna, and bonito in California waters. Fish. Bull., 152: 1-105.

Roper, C.F.E., M.J. Sweeney & C.E. Nauen.1984. FAO species catalogue. Cephalopods of the world. An annotated and illustrated catalogue of species of interest to fisheries. FAO Fish. Synop., 3: 125-277.

Saucedo-Barrón, J.C., G. Colado-Uribe, G.J. Martínez-Adrián, S. Burgos-Zazueta, J.G. Chacón-Cortez & J. Espinoza-Fierro. 1982. Contribución al estudio de la pesquería del tiburón en la zona sur de Sinaloa.

Memoria de Servicio Social Universitario. Universidad Autónoma de Sinaloa, Mazatlán, 80 pp.

Secretaria de Agricultura, Ganadería y Desarrollo Rural, Pesca y Alimentación-Comisión Nacional de Pesca (SAGARPA-CONAPESCA). 2011. Anuario estadístico de acuacultura y pesca 2011. Secretaria de Agricultura, Ganadería y Desarrollo Rural, Pesca y Alimentación. Comisión Nacional de Pesca, Mazatlán, 219 pp.

Stevens, B., D. Armstrong & R. Cusiano. 1982. Feeding habits of the Dungeness crab, *Cancer magister*, as determined by the index of relative importance. Mar. Biol., 72: 135-145.

Stillwell, E. & E. Kohler. 1982. Food, feeding habits, and estimates of daily ration of the shortfin mako (*Isurus oxyrinchus*) in the northwest Atlantic. Can. J. Fish. Aquat. Sci., 39: 407-414.

Strauss, R.E. 1979. Reliability estimates for Ivlev's electivity index, the forage ratio, and a proposed linear index of food selection. T. Am. Fish. Soc., 108: 344-352.

Walker, H.J. Jr. & R.H. Rosenblatt. 1988. Pacific toadfishes of the genus *Porichthys* (Batrachoididae) with descriptions of three new species. Copeia, 4: 887-904.

Walton, D.W.II & W.W.K. Houston. 2001. Zoological catalogue of Australia. Vol. 17.2. Mollusca: Aplacophora, Polyplacophora, Scaphopoda, Cephalopoda. CSIRO Publishing, Collingwood, 355 pp.

Wetherbee, B.M. & E. Cortes. 2004. Food consumption and feeding habits. In: J.C. Carrier, J.A. Musick & M.R. Heithaus (eds.). Biology of sharks and their relatives. CRC Press, Boca Raton, pp. 223-244.

Wetherbee, B.M., S.H. Gruber & E. Cortes. 1990. Diet, feeding habits, digestion and consumption in sharks, with special reference to the lemon shark, *Negaprion brevirostris*. In: H.L. Pratt Jr., S.H. Gruber & T. Taniuchi (eds.). Elasmobranchs as living resources: advances in the biology, ecology, systematics, and the status of the fisheries. NOAA Washington NMFS Tech. Rep., 90: 29-47.

Wolff, C.A. 1982. A beak key for eight eastern tropical Pacific cephalopod species, with relationship between their beak dimensions and size. Fish. Bull., 80: 357-370.

Wolff, C.A. 1984. Identification and estimation of size from the beaks of eighteen species of cephalopods from the Pacific Ocean. NOAA NMFS Technical Report, 17: 50 pp.

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