Hydrobiologia (2005) 00: 1–7
DOI 10.1007/s10750-005-5446-x

Food and feeding habits of flounder *Paralichthys orbignyanus* (Jenyns, 1842) in Bahía Blanca Estuary, Argentina

A. Lopez Cazorla* & S. Forte
Departamento de Biología, Bioquímica y Farmacia – Universidad Nacional del Sur, San Juan 670, 8000 Bahía Blanca, Argentina
*(*Author for correspondence: Fax: +54-291-4595130; E-mail: acazorla@criba.edu.ar)*

Received 13 September 2004; accepted 29 March 2005

Key words: flounder, *Paralichthys orbignyanus*, feeding habits, AR, Buenos Aires, Bahía Blanca estuary

Abstract

Specimens of flounder *Paralichthys orbignyanus* (Jenyns, 1842) were collected in Bahía Blanca estuary between February 1997 and January 1998, and their feeding habits were examined in relation to season and size class. The stomach contents of 823 specimens, ranging from 70 to 875 mm total length, were analysed. Their diet included organisms from 17 taxa. The highest vacuity index values were found during autumn and winter. The stomach fullness index indicated that flounders increased their feeding activity between October and March, reaching a highest point in February and decreasing after February. Fish were the primary prey item in frequency, number and weight, followed by crustaceans, such as shrimps and crabs. A seasonal and size class variation was detected in the diet. During summer all-size flounders consumed mainly fish. In autumn, for all-size classes the main food were fish and crustaceans even though fish were dominant in terms of biomass. In spring, crustaceans (mysids *Arthromysis magellanica* (Cunningham), shrimps *Artemesia longinaris* Bate, and prawns *Pleoticus muelleri* (Bate)) were the dominant prey in terms of number and biomass for flounders ≤ 450 mm TL. Size classes larger than 451 mm TL fed on crustaceans and fish though the most important prey item in terms of biomass was fish. In Bahía Blanca estuary, *P. orbignyanus* evidenced mainly an ichthyophagou – carcinophagous diet. The results collected from the present study lead to conclude that *P. orbignyanus* shows, in this region, a clear preference for fish.

Introduction

The flounder *Paralichthys orbignyanus* (Jenyns, 1842) is commonly found in the area extending from Río de Janeiro, Brazil, to San Matías Gulf, Argentina (Fabré & Días de Astarloa, 1996). It is characterized by a wide spatial and temporal distribution within Bahía Blanca estuary and is mainly captured in areas near the coast (Lopez Cazorla, Unpublished). In addition, in this estuary, *P. orbignyanus* is categorized as an eurihaline and euritherm species (Lopez Cazorla, 2004). This benthic fish, which has a considerable value as a commercial resource, is one of the eight dominant species of this type registered to date among the 30 observed in Bahía Blanca estuary. The capture all along the year evidences intra-annual variations, and the highest volumes are registered during spring and summer (Lopez Cazorla Unpublished, 2004).

The aim of the present study is to describe the food and feeding habits of flounder *P. orbignyanus* in Bahía Blanca estuary as well as to determine whether or not there are seasonal and size variations within size classes.

Journal : HYDR
CMS No. : DO00015446
MS Code : HYDR950R2
Dispatch : 20-5-2005
☐ LE
☑ CP
Pages : 8
☐ TYPESET
☑ DISK

PDF-OUTPUT

Study area

Bahía Blanca estuary is located in the area between 38° 45′ 39° 25′ S and 61° 15′ 62° 30′ W (Fig. 1). It covers an area of 1900 km^2 at high tide, which is reduced to 750 km^2 at low tide and is classified as a salt marsh. This mesotidal estuary is formed by a North-West to South-East channel, it is separated by islands and wide tidal flats, with two well-defined zones: an inner zone which, in terms of salinity and temperature, can be described as vertically homogeneous, and an external one, which

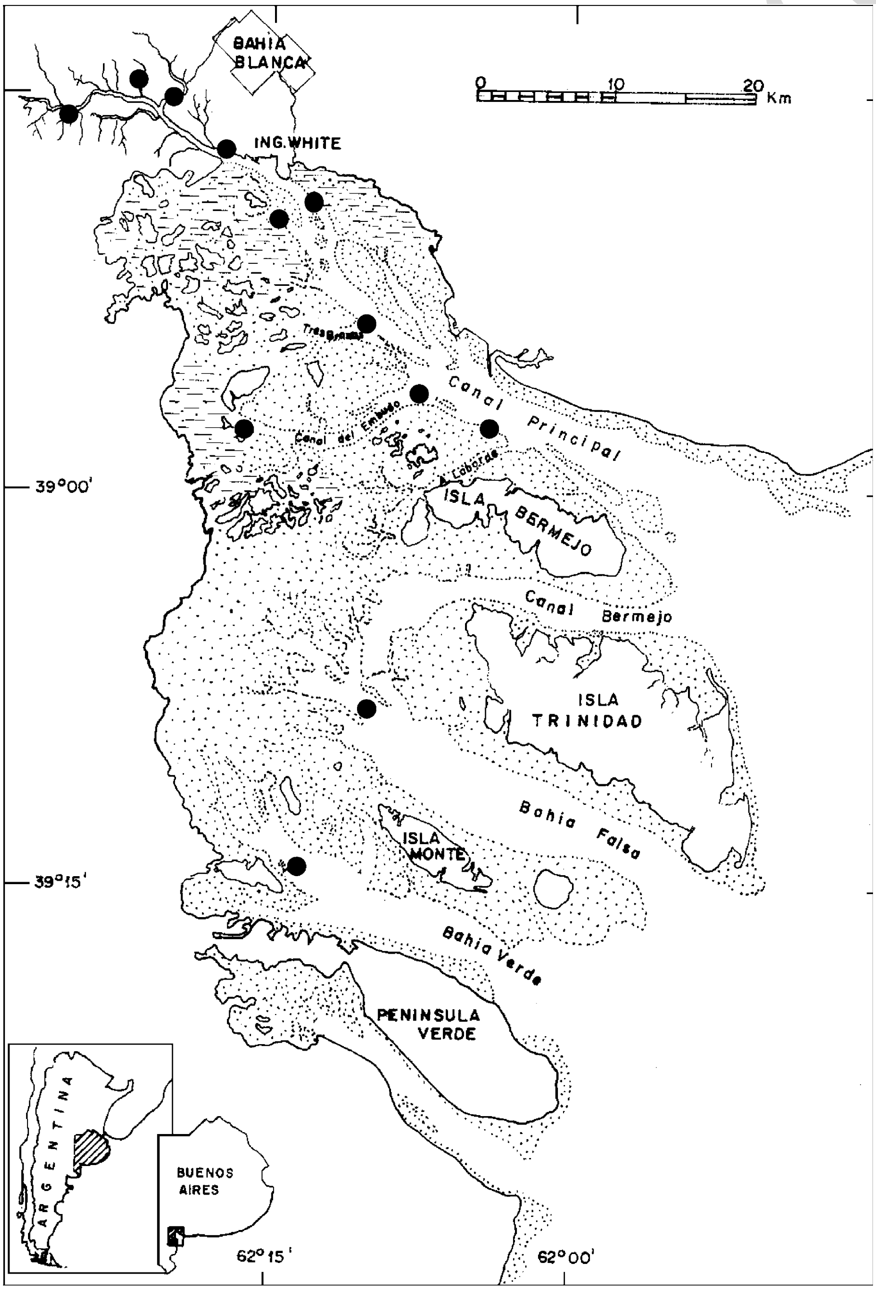

Figure 1. Map of Bahía Blanca estuary, Argentina, showing commercial fishing locations of *Paralichthys orbignyanus*.

Journal : HYDR | Dispatch : 20-5-2005 | Pages : 8
CMS No. : DO00015446 | ☐ LE | ☐ TYPESET
MS Code : HYDR950R2 | ☑ CP | ☑ DISK

extends from the vicinity of Puerto Belgrano to the mouth, and is characterized by an important exchange of waters (Piccolo & Perillo, 1990).

This estuary is very shallow, with a mean depth of approximately 10 m. It is highly turbid as a result of the predominance of fine sediment and the turbulent mixing of waters. The behaviour of the estuary throughout the year is complex; it depends on fresh water from rivers and creeks with a reduced flow; this gives rise to a low and variable runoff. It is a seasonally mixed estuary with a tendency towards hypersalinity in summer (Hoffmeyer, 1994).

Materials and methods

Data collection and analysis

Paralichthys orbignyanus was sampled monthly from commercial catches during February 1997–January 1998 in Bahía Blanca estuary (Fig. 1). Captures were carried out with shrimp nets (Lopez Cazorla, 2004). The total sample size consisted of 823 specimens. Total length (TL) measured to the nearest mm and total weight (TW) in g were recorded for each fish.

Stomach contents were removed and preserved in 10% formaldehyde. Food items from stomach contents were identified under a binocular microscope to the lowest possible taxon and were subsequently weighted and counted.

The vacuity index (VI) was calculated as the number of empty stomachs divided by the total number of stomachs examined and multiplied by 100 (Molinero & Flos, 1992). The stomach fullness index (SFI) (Okach & Dadzie, 1988) was: (wet weight (g) of stomach contents/weight of fish (g)) $\times$ 100. Data analysis was carried out by means of the Index of Relative Importance (IRI) (Pinkas et al. 1971): IRI $=$ %O(%N $+$ %W), where %O is the frequency of occurrence of each item, expressed as a percentage, %N is the percentage of the total number of food items, and %W is the percentage of the total weight of the stomach contents (wet weight) calculated for each food category. IRIs were standardized to 100% by calculating the percentage of the total IRI contributed by each prey type (% IRI), and ranged from 0 (absent from diet) to 100 (the only prey consumed) (Barry et al. 1996). This method was used to analyse the general diet, seasonal and size variations. For the latter one (size variation in the diet), fish length was divided into four size classes: $\leq$350 mm TL (I), 351–450 mm TL (II), 451–500 mm TL (III) and $\geq$501 mm TL (IV). The significant difference in % IRI between seasons and flounder size classes were analysed by Spearman rank correlation (R_s) (Siegel, 1956). In order to group the four size classes obtained during spring, summer and autumn, a hierarchy cluster method with complete linkage was used, considering the inversely related distance ($d = 1 - R_s$) as one unit of measurement to R_s (Digby and Gower, 1986).

Trophic diversity was estimated by the Shannon–Wiener diversity index (H) (Wilson & Bossert, 1971).

Predator size distribution

The total length distribution of *P. orbignyanus* caught for stomach analyses at Bahía Blanca estuary ranged from 70 to 875 mm with a peak at 350–550 mm TL fish (Fig. 2).

Results

Twenty-eight per cent of the stomachs analysed in the present study were empty; the monthly vacuity index evidenced seasonal variations and the highest values were found in winter (June–August) (Fig. 3a). A decrease in the vacuity index with increasing length was also observed (Fig. 3b).

In addition, the stomach fullness index showed variations; the largest feeding activity was observed during spring and summer (October–March),

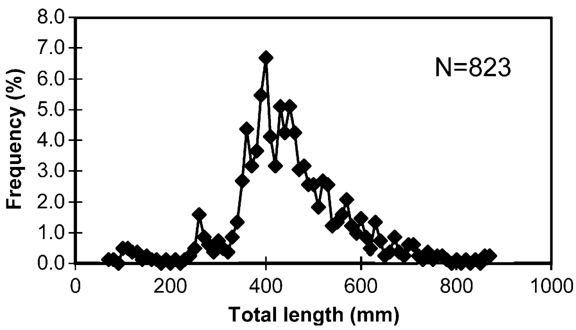

Figure 2. Length frequency of *Paralichthys orbignyanus.*

Journal : HYDR | Dispatch : 20-5-2005 | Pages : 8
CMS No. : DO00015446 | LE | TYPESET
MS Code : HYDR950R2 | CP | DISK

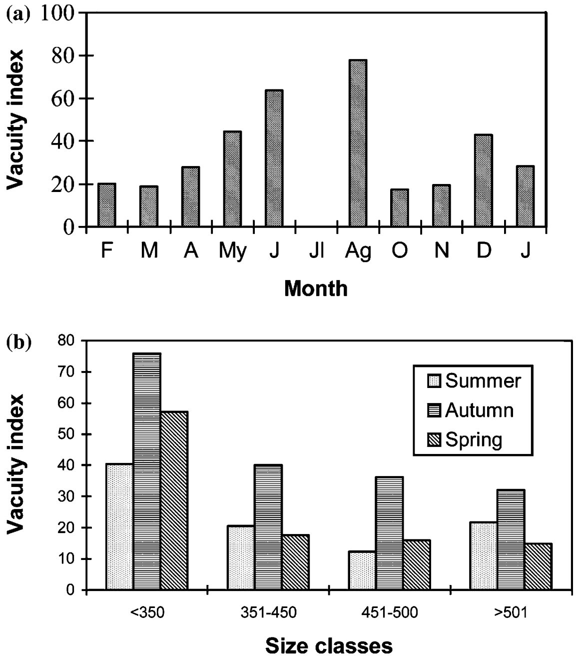

Figure 3. Vacuity index of *Paralichthys orbignyanus*, (a) per month and (b) by size class and season.

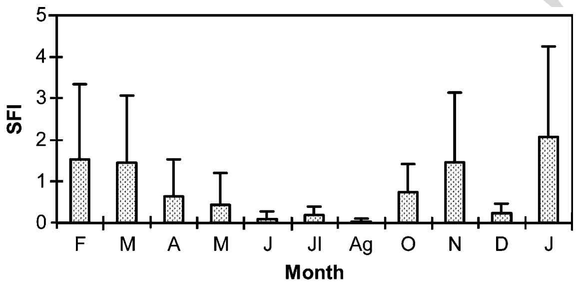

Figure 4. Monthly stomach fullness index (SFI) of *Paralichthys orbignyanus*.

reaching its highest peak in January. During autumn and winter this index slowly decreased to reach the lowest value, which was registered in August (Fig. 4). The diet consisted of 17 feeding items, of which 9 were fish, 7 were crustaceans, and 1 was Cephalopod (Table 1). Among them, the most important prey items according to the index calculated were weakfish *Cynoscion guatucupa* (Cuvier), menhaden *Brevoortia aurea* (Agassiz), shrimps *Artemesia longinaris* Bate, white croaker *Micropogonias furnieri* (Desmarest), and mysid *Arthromysis magellanica* (Cunningham).

Indexes of the relative importance of the preys (%IRI) by season and size classes are shown in Table 2.

During summer, all fish size classes mainly consumed more fish than crustaceans. In autumn, the same feeding habits were observed in fish that were larger than 501 mm. In smaller size classes, crustaceans – particularly *A. longinaris* – were the most important taxon. In spring, the stomach contents were mainly composed of crustaceans, especially *A. magellanica*, in all size classes even when this type of food was less important in fish over 501 mm in length. In terms of biomass, fish were the most important prey item during summer and autumn in all size classes. In spring, an increase in fish biomass and a decrease in crustacean biomass were observed in the diet as flounder size increased. Spearman rank correlation analysis indicated that there was a high positive correlation in the prey composition of *P. orbignyanus* between the size classes observed in summer (r = 0.60–0.91, $p > 0.05$) and in autumn (r = 0.53–0.90, $p > 0.05$) while there was no correlation in spring (r = −0.39–0.30, $p < 0.25$).

Cluster analysis at the %IRIs of prey items based on distance measurement (D) produced three clusters, which correspond to the seasons considered in the present study (Fig. 5).

Prey diversity index for flounder ranged from 1.23 to 1.72 (Table 3); the highest values were mainly found in summer. During summer and autumn, size classes showed the same behaviour in feeding diversity. During spring, diversity increased with size classes.

Discussion

In Bahía Blanca estuary, *P. orbignyanus* evidenced mainly an ichthyophagou – carcinophagous diet. The results collected from the present study lead to conclude that *P. orbignyanus* shows, in this region, a clear preference for fish, a habit which was also observed in previous studies by Minami & Tanaka (1992) in Fonds et al. (1995) who report that mysids are part of the natural food for the early demersal stages, while adult flounders feed on fish, mainly on *C. guatucupa*, *B. aurea* followed by *M. furnieri* and *Ramnogaster arcuata* (Jenyns, 1842). Diet composition analysis indicates that

Journal : HYDR Dispatch : 20-5-2005 Pages : 8
CMS No. : DO00015446 LE TYPESET
MS Code : HYDR950R2 CP DISK

Table 1. Diet composition of *Paralichthys orbignyanus* in Bahía Blanca estuary

Food item	Diet composition				
	%O	%N	%W	IRI	%IRI
Crustaceans	54.16	63.84	21.97	4648	38
Arthromysis magellanica	6.11	37.60	1.07	236	8.55
Peisos petrunkevitchi	0.68	2.73	0.13	2	0.07
Artemesia longinaris	22.58	10.70	4.85	351	12.70
Pleoticus muelleri	7.64	2.05	7.05	70	2.51
Chasmagnathus granulata	13.92	6.76	5.41	169	6.12
Cyrtograpsus altimanus	2.04	0.31	0.19	1	0.04
Cyrtograpsus angulatus	10.19	3.40	3.10	66	2.39
Unidentified	1.70	0.29	0.17	1	0.03
Cephalopods	1.02	0.14	0.19	0	0.00
Loligo sp.	1.02	0.14	0.19	0	0.01
Pises	66.55	36.02	77.83	7577	62
Ramnogaster arcuata	9.68	4.14	4.27	81	2.94
Lycengraulis olidus	0.17	0.02	0.53	0	0.00
Brevoortia aurea	17.32	13.41	19.17	564	20.40
Odonthestes bonariensis	8.66	1.54	6.35	68	2.47
Cynoscion guatucupa	18.68	5.88	32.07	709	25.62
Micropogonias furnieri	16.98	5.80	10.33	274	9.90
Parona signata	0.68	0.10	0.34	0	0.01
Mustelus schmitti	0.17	0.02	0.11	0	0.00
Symphurus jenynsi	1.70	0.23	0.38	1	0.04
Unidentified	18.68	4.88	4.28	171	6.19

IRI = index of relative importance and its components.

Table 2. Seasonal and size variation of the index of relative importance of the prey (% IRI) for *Paralichthys orbignyanus* in Bahía Blanca estuary

Food item	Summer				Autumn				Spring			
	< 350	351–450	451–500	> 501	< 350	351–450	451–500	> 501	< 350	351–450	451–500	> 501
A. magellanica	0	0	0	0	0	0	0	0	47	55	52	0
A. longinaris	38	12	10	0	63	48	26	2	27	15	1	1
P. muelleri	2	1	8	7	0	0	0	0	13	0	0	1
Ch. granulata	0	0	0	0	9	4	4	8	0	19	9	37
C. angulatus	0	0	0	0	0	2	13	12	3	4	9	7
R. arcuata	1	12	5	6	0	0	0	0	0	0	0	0
B. aurea	11	41	22	35	0	0	0	4	9	1	4	17
O. bonariensis	1	1	1	2	0	0	0	1	0	0	2	11
C. guatucupa	12	14	39	41	0	0	1	2	0	5	20	26
M. furnieri	14	10	10	2	15	36	38	51	0	0	2	0
Others	21	9	5	7	13	8	18	20	0	0	1	0

flounder *P. orbignyanus* behaves as an opportunistic species because dominant fish preys in all size classes during summer and autumn have a correlation with those species that reproduce either within or near the estuary during spring while the juveniles of the latter species remain in the region

Journal : HYDR Dispatch : 20-5-2005 Pages : 8
CMS No. : DO00015446 ☐ LE ☐ TYPESET
MS Code : HYDR950R2 ☑ CP ☑ DISK

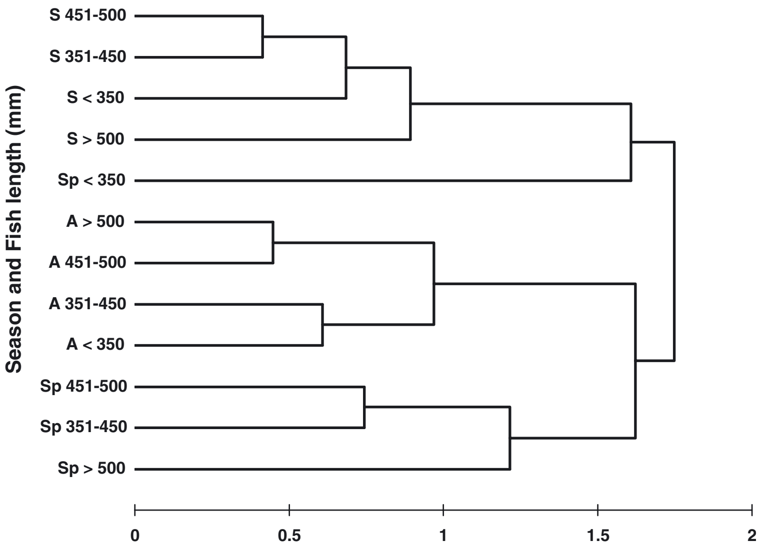

Figure 5. Dendrogram of fish length clustered by the % index of relative importance (% IRI) of food items using Distance measure (D).

Table 3. Size and seasonal variation of prey diversity (*H*) of *Paralichthys orbignyanus* in Bahía Blanca estuary

Size classes TL (mm)	Diversity index (*H*)		
	Summer	Autumn	Spring
<350	1.67	1.71	1.31
351–450	1.71	1.23	1.32
451–500	1.72	1.55	1.50
>501	1.49	1.51	1.56

until winter starts (Lopez Cazorla, 1983; Unpublished; 1996; 2000; 2004). The crustacean dominance observed in the diet of juveniles shorter than 500 mm in length can be interpreted as an environmental deficiency of the adequate size of fish to be eaten by *P. orbignyanus*. In agreement with previous studies by Wyngaard & Bertuche (1982), Cervellini (1986), and Mallo & Cervellini (1988) we also observed that crustaceans, the main diet components for the first three length classes in spring, are present and abundant during the whole year.

The trophic spectrum found in *P. orbignyanus* does not differ significantly from that reported by García (1987) in flounder *P. isosceles* Jordan which was captured in the coast of Buenos Aires Province and which was also reported to have a diet mainly integrated by fish. Even though *P. orbignyanus* showed an ichthyophagou feeding habit, we did not register cannibalism, a common behaviour in other flounder species according to observations reported by Michalsen and Nedreaas (1998).

Acknowledgements

We are grateful to Domingo Casserma for his assistance and cooperation in carrying out the present study. This research was funded by the *Comisión de Investigaciones Científicas de la Provincia de Buenos Aires* (CIC), the *Instituto Argentino de Oceanografía*, and the *Universidad Nacional del Sur* (UNS), Project N° 24/B046.

References

Barry, J. P., M. Y. Yoklavich, G. M. Cailliet, D. A. Ambrose & B. S. Antrim, 1996. Trophic ecology of the dominant fishes in Elkhorn Slough, California, 1974–1980. Estuaries 19 115–138.

Cervellini, P., 1986. Larvas y postlarvas de crustáceos Decapoda del estuario de Bahía Blanca (Argentina). I. Aspectos cualitativos. Spheniscus 3: 1–23.

Digby, P. G. N. & J. C. Gower, 1986. Ordination and classification. Séminaire de mathématiques supérieures No. 98. Les presses de L'Université de Montreal, Canada 87 pp.

Fabré, N. N., J. M. Díaz & de Astarloa, 1996. Pleuronectiformes de importancia comercial del Atlántico Sudoccidental, entre los 34°30′ y 55° S. Distribución y consideraciones sobre su pesca. Revista Investigación y Desarrollo Pesquero 10: 45–55.

Journal : HYDR | Dispatch : 20-5-2005 | Pages : 8
CMS No. : DO00015446 | ☐ LE | ☐ TYPESET
MS Code : HYDR950R2 | ☑ CP | ☑ DISK

Fonds, M., M. Tanaka & H. W. Van der Veer, 1995. Feeding and growth of juvenile Japanese flounder *Paralichthys olivaceus* in relation to temperature and food supply. Netherlands Journal of Sea Research 34: 111–118.

García, M., 1987. Pleuronectiformes de la Argentina, IV. Alimentación de Paralichthys isosceles (Bothidae, Paralichthinae). Revista Museo de La Plata (N.S.) Zool. 21 111–125.

Hoffmeyer, M. S., 1994. Seasonal succession of Copepoda in the Bahía Blanca estuary. Hydrobiologia 292/293: 303–308.

Lopez Cazorla, A., 1983. Edad, Crecimiento y Comportamiento migratorio de *Brevoortia aurea* (Agassiz, 1829) (Osteichthyes, Clupeidae). Investigación Pesquera 49(2): 297–313, Barcelona, Spain.

Loppez Cazorla, A., 1987. Contribución al conocimiento de la ictiofauna marina del área de Bahía Blanca. Tesis doctoral, Facultad de Ciencias Naturales y Museo, Univ. Nac. La Plata, Buenos Aires, Argentina, unpublished.

Lopez Cazorla, A., 1996. The food of *Cynoscion striatus* (Cuvier) (Pisces: Sciaenidae) in the Bahía Blanca area, Argentina. Fisheries Research 28: 371–379.

Lopez Cazorla, A., 2000. Age structure of the population of weakfish *Cynoscion guatucupa* (Cuvier) (Pisces: Sciaenidae) in the Bahía Blanca waters, Argentina. Fisheries Research 46: 279–286.

Lopez Cazorla, A., 2004. Peces del estuario de Bahía Blanca. pp.191–201. In El ecosistema del estuario de Bahía Blanca. Píccolo, M. C., Hoffmeyer, M. S. (eds), Instituto Argentino de Oceanografía (CONICET-UNS), Bahía Blanca, Argentina, 233 pp.

Mallo, J. & P. Cervellini, 1988. Distribution and abundance of larvae and postlarvae of *Artemesia longinaris, Pleoticus muelleri* and *Peisos petrunkevitchi* (Crustacea: Decapoda: Penaeidae) in the coastal waters of the Blanca bay, Argentina. Journal of Aquaculture in the Tropic 3: 1–9.

Michalsen, K. & K. H. Nedreaas, 1998. Food and feeding of greenland halibut (*Reinhardtius hippoglossoides*, Walbaum) in the Barents sea and east Greenland waters. Sarsia 83: 401–407.

Molinero, A. & R. Flos, 1992. Influence of season on the feeding habits of the common sole *Solea solea*. Marine Biology 113: 499–507.

Okach, J. I. O. & S. Dadzie, 1988. The food, feeding habits and distribution of a siluroid catfish, *Bagrus docmac* (Forsskal) in Kenya waters of Lake Victoria. Journal of Fish Biology 32: 85–94.

Píccolo, M. C. & G. M. E. Perillo, 1990. Physical characteristics of the Bahía Blanca estuary (Argentina). Estuarine, Coastal and Shelf Science 31: 303–317.

Pinkas, L., M. S. Olophant & I. L. K. Iverson, 1971. Food habits of albacore, bluefin tuna, and bonito in California Waters. California Fish Game Fish Bulletin, 152: 1–105.

Siegel, S., 1956. Nonparametric Statistics. McGraw-Hill, New York, 312 pp.

Wilson, E. O. & W. H. Bossert, 1971. A Primer of Population Biology. Mass, Sinaeuer, 192 pp.

Wyngaard, J. G. & D. A. Bertuche, 1982. Algunos aspectos de la biología pesquera del langostino (*Pleoticus muelleri*) de la Bahía Blanca y un análisis del desembarco comercial del período 1955–1979. Revista Investigación Pesquera INIDEP, Mar del Plata 3: 77–94.