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Feeding habits of the juvenile striped weakfish, *Cynoscion guatucupa* Cuvier 1830, in Bahía Blanca estuary (Argentina): seasonal and ontogenetic changes

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Abstract

The aim of this study was to analyze the feeding habits of the juvenile striped weakfish, *Cynoscion guatucupa* Cuvier, from Bahía Blanca estuary, Argentina. *C. guatucupa* is one of the most important regional fishing resources although in the last 10 years landings have greatly decreased. The year class strength of fish as well as stock size and yield are determined during the early life stages. Knowledge about the diet of young *C. guatucupa* may therefore contribute to our better understanding of the influence that the changes occurring in the biota of the estuary exert on the abundance fluctuations of this species. To this end, we investigated the ontogenetic and seasonal dietary changes of *C. guatucupa* between 1.00 and 12.99 cm total length (age 0+), and we related them to changes in habitat use and prey selection. Two dietary shifts were found during ontogeny. The first shift, at approximately 4 cm total length, involved a change from demersal-pelagic prey (mysid shrimps) to demersal-benthic prey (*Peisos petrunkevitchi* Burkenroad). The second shift, at approximately 8 cm total length, involved a progressive increase in ichthyophagy (mainly an increase consumption of the Argentine anchovy *Engraulis anchoita* Hubbs & Marini). Seasonal dietary changes were also found. They evidenced the changes in the availability of organisms. In autumn, the chaetognath *Sagitta friderici* Ritter-Zahoni, *P. petrunkevitchi,* and *E. anchoita* were the dominant prey items; in winter, the copepod *Labidocera fluviatilis* Dahl along with *S. friderici,* mysids, and *P. petrunkevitchi* constituted the majority of the diet; and, in summer, mysids were the most important prey item consumed. Selectivity data showed that whereas some prey items, such as the copepods *Acartia tonsa* Dana and *Paracalanus parvus* (Claus) and *S. friderici,* were consistently negatively selected by all size classes throughout the year, other prey items, such as fish larvae, mysids, and *P. petrunkevitchi,* were selected in one season and avoided in another. Additional dietary seasonal differences observed in our research indicate that the limited food supply and the low water temperatures are limiting factors for winter juveniles in Bahía Blanca estuary. These factors may also directly influence the more-than-10 cm total length seaward migration of large numbers of *C. guatucupa* that is registered at the end of every autumn.

Introduction

Many commercially important fish species common all along the Argentinean coast live in estuaries during either one or more life history stages. Many of these species, particularly members of the family Sciaenidae, use estuaries as nursery grounds where they seasonally dominate nekton assemblages. Estuaries have been reported to offer physiologically suitable physicochemical conditions, abundant prey resources, and low predation risk (Joseph, 1973). These features presumably increase survival, feeding, and growth rates of the juvenile fishes.

The striped weakfish *Cynoscion guatucupa* Cuvier is a commercially important coastal sciaenid all along the area that extends from central Argentina (ca. 41° S; Díaz de Astarloa et al., 1997) to Brazil (about 227°; S; Menezes & Figueiredo, 1980). *C. guatucupa* is one of the most important coastal Argentinean–Uruguayan fishing resources that is captured by bottom trawlers all along the year (Nion, 1985; Cordo, 1986). In Bahía Blanca estuary (Fig. 1), *C. guatucupa* accounts for the bulk of the catches by coastal fishing fleets (50% of the total annual catch in 1993). However, stock size and yield have undergone important fluctuations to the extent that in the last 10 years landings decreased in large proportions (15% of the total annual catch between 1994 and 1996) (Lopez Cazorla, 1997).

The Bahía Blanca estuary ecosystem underwent a severe perturbation throughout the 1980s and 1990s as a result of the industrial activity (oil refineries, petrochemical industries, plastic factories, leather plants, textile plants, meat factories), intensive marine traffic, dredging, and pollution (Hoffmeyer, 2004). Much of the waste derived from these activities ends up in the estuary with poor or no treatment at all, thus contaminating both the sediments and the biota (Ferrer, 2001). In this respect, a recent study has reported several changes in the zooplankton assemblage composition and structure in the inner zone of Bahía Blanca estuary during the period 1990–1991 compared to the period 1979–1980 (Hoffmeyer, 2004). Juvenile *C. guatucupa* consume zooplankton as its primary prey during estuarine residency (Lopez Cazorla, 1996). On account of the fact that year class strength as well as stock size and yield are determined during the early life stages (May, 1974; Salojarvi, 1987), the study about the diet of young fishes will contribute to our better understanding of the influence that the changes in the biota of the estuary exert on the abundance fluctuations of *C. guatucupa*.

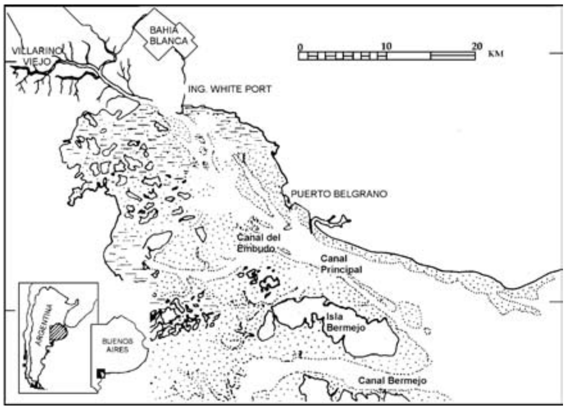

Figure 1. Bahía Blanca estuary, Argentina.

Previous studies on the feeding habits of juvenile *C. guatucupa* in Argentinean waters (Olivier et al., 1968; Ciechomski & Ehrlich, 1977; Cordo, 1986; Lopez Cazorla, 1996) have provided general baseline information. Based on these previous studies, our research aims at providing a detailed analysis of the diet changes during the ontogeny of this species as well as interpreting these changes in terms of morphology and habitat utilization. In addition, our research aims at contrasting stomach contents with simultaneously available prey offer in order to elucidate the feeding selectivity mechanisms of juvenile *C. guatucupa*.

In view of the above, the objectives of our study were (1) to assess the seasonal diet of juvenile *C. guatucupa* at the southern extreme of the species distribution range in Bahía Blanca estuary, (2) to analyze ontogenetic dietary changes, and (3) to study the feeding selectivity mechanisms of young *C. guatucupa* on zooplankton.

Materials and methods

Study area

Bahía Blanca estuary (Fig. 1), the second largest estuary in Argentina, is located between 38°30′–39° 25′ S and 61° 15′–63° 00′ W. It is a mesotidal system formed by a series of NW–SE major tidal channels separated by extensive tidal flats and islands. It covers an area ranging from 750 (low tide) to 1900 (high tide) km^2. The system is dominated by a semidiurnal, quasi-stationary tidal wave. Mean tidal amplitude varies from 2.2 m at the mouth to about 3.5 m at the head. The estuary is made up of two well-defined zones: the inner zone and the outer zone. The former extends between Ingeniero White Port and Villarino Viejo (Fig. 1); it receives the freshwater input of the Sauce Chico river and the Napostá Grande creek, and its waters show neither salinity nor temperature stratification. The outer zone, ranging from the vicinity of Puerto Belgrano to the mouth, is characterized by an important exchange of waters (Píccolo & Perillo, 1990). The estuary is very shallow, with a mean depth of approximately 10 m, and highly turbid due to the predominance of fine sediment and the turbulent mixing of waters. Temporal changes are complex, depending mainly on the generally low and variable freshwater input. Water temperature varies seasonally, with highest values in summer (approximately 21 °C from December to February) and lowest values in winter (approximately 8 °C from June to August). Normally, salinity varies around 30–35 ‰ although in summer values as high as >40 ‰ may occur (Freije et al., 1981).

All along our study, water temperature ranged from 6.8 to 22.4 °C, the lowest values being in winter (June–September) and the highest ones in summer (December–February). Salinities ranged from 31.9 to 37.3 ‰. Dissolved oxygen concentrations oscillated around 5.7–12.1%. All parameters were vertically uniform throughout the sampling period.

Field samples and laboratory procedures

Monthly samples of juvenile *C. guatucupa* were collected in diurnal net tows in Bahía Blanca estuary between March 2000 and February 2001. Samples were taken from the Canal del Embudo zone (Fig. 1) using shrimp nets of 1-cm-tail bag mesh (knot-to-knot). The sampling station was considered to be representative of the whole estuarine habitat as it constitutes the middle point of the species distribution inside the estuary. It is also the most frequently used fishing area by the coastal fleet from Ingeniero White Port.

All fish were frozen immediately after capture. Zooplankton samples were collected simultaneously with fish samples using a conical 200 μm mesh plankton net (0.3 m in diameter, 1.0 m long). Three horizontal 5 min tows at 2 knots were made prior to each fish collection, and samples were preserved in formaldehyde (5%). Water temperature, salinity, and dissolved oxygen concentration were recorded using a HORIBA U10 water analyzer. Surface and bottom (4 m) temperature, salinity, and dissolved oxygen concentration were measured to verify vertical profiles of these parameters.

In the laboratory, all fish were measured to the nearest mm total length (L_T) and grouped into 1-cm size classes. A subsample composed of ten randomly selected specimens of each size class was used for diet analysis. These fish were wet weighted to the nearest gram and their stomachs were removed and preserved in 10% formaldehyde. Mouth height (mouth fully open) and width (distance between angles of jaw with mouth opened) were measured in 180 randomly selected fish from a pooled yearly collection covering at least 10 animals per size class.

Stomach contents were sorted, counted, and identified to the lowest possible taxon. The maximum size (length or width depending on the prey) of intact dietary items was measured. Species identifications for a sizable fraction of the prey item were not possible due to their state of digestion. The copepod species *Acartia tonsa* Dana and *Paracalanus parvus* (Claus) were treated together as *A. tonsa*/*P. parvus* because of the difficulty in identifying digested materials.

Large food items were damp-dried on a paper towel and weighted whereas the mass of prey items too small to be weighted was assessed measuring and using appropriate size-to-biomass relationships (see below).

Mysid shrimps (*Arthromysis magellanica* (Cunningham) and *Neomysis americana* (Smith)) and chaetognaths (*Sagitta friderici* Ritter- Zahoni) were measured to the nearest 0.1 mm, grouped into 1-mm size classes, and weighted to the nearest 0.0001 g. A mean biomass for each size class was used to develop a regression equation relating length to wet mass (Table 1). The length–mass relationship reported by Fernandez Araoz (1991) and Hoffmeyer & Torres (2001) was used for *A. tonsa* and *Calanoides carinatus* Kröyer. The biomass for both *A. tonsa*/*P. parvus* was estimated from measurements of only *A. tonsa* as there are no published data on *P. parvus*. Ten groups of five adult individuals were weighted to obtain a mean

Table 1. Total number (N), size range (r) and regression slopes of total weight (W_T) and total length (L_T) of the mysid shrimps *Arthromysis magellanica* and *Neomysis americana,* and the chaetognath *Sagitta friderici* catched by means of horizontal net tows in Bahía Blanca estuary, Argentina

	N	r (mm)	Equation
A. magellanica	49	3–20	$W_T = 6 \times 10^{-6} L_T^{2.82} (r^2 = 0.98)$
N. americana	36	3–36	$W_T = 4 \times 10^{-6} L_T^{3.04} (r^2 = 0.99)$
S. friderici	131	4–11	$W_T = 3 \times 10^{-7} L_T^{3.66} (r^2 = 0.99)$

biomass value for the copepod *Labidocera fluviatilis* Dahl.

Stomach contents were compared to the zooplankton prey present at the time of collection. Zooplankters were identified to the lowest possible taxon and counted. Counts were standarized to individuals/m^3 (ind/m^3).

Data analysis

Diet assessment

In order to compensate for bias in the assessment of diet composition when prey items differed markedly in size and biomass, the following three complementary indices were used: numerical composition (N), biomass (W), and frequency of occurrence (FO). These indices were calculated by species, major zoological groups (chaetognaths, copepods, mysids, crabs, Penaeids, *Peisos petrunkevitchi* Burkenroad, amphipods and fish), and ecological groups. The ecological groups were defined according to Koen Alonso et al. (2001) as benthic (the prey species dwells at the bottom), demersal (the prey species dwells near the bottom), and pelagic (the prey species dwells in the upper layers of the water column). Demersal prey species include the demersal-pelagic (the prey exhibits a diel vertical migration pattern) and the demersal-benthic (the prey species does not migrate vertically).

Multidimensional scaling analysis (MDS) was used to pinpoint dietary size-related and seasonal shifts. Seasons were defined as follows: autumn (March, April, and May), winter (June, July, August, and September), and summer (December, January, and February). The data used were standardized prey numerical abundances per 1 cm predator size class (Bray & Curtis (1957) dissimilarity index). Results from the MDS analysis were validated through cluster analysis based on the same dissimilarity matrix and by means of the unweighted pair-group method using arithmetic averages (UPGMA) clustering procedure. The results of the cluster analysis are represented by dendrograms and those of MDS, by two-dimensional maps. Goodness of fit of the derived map was measured by a 'stress coefficient' (Field et al., 1982). Stress values <0.1 imply a good representation (Clarke & Warwick, 1994). Discontinuities in the diet between body sizes and seasons may be accepted as real when the results of the two methods agree (Field et al., 1982).

Prey diversity in the diet, which yields an estimate of dietary breadth (Marshall & Elliot, 1997), was calculated using Levin's standardized index, B_A (Krebs, 1998) for each class group obtained from the ontogenetic diet analysis described above, and for each season: $B_A = (B_i - 1)/(n - 1)$, where B_i is Levin's index and n is the total number of prey species. B_A was calculated on the standardized prey numerical abundances.

Two-way analyses of variance (2-way ANOVA) were carried out to test the significance of variation of mean vacuity (%V), mean prey number/stomach (MPN), and mean prey biomass/stomach (MPB) (dependent variables) as a function of fish size and season (independent variables). On account of the fact that only small and medium-sized *C. guatucupa* were captured in summer, two sets of comparisons were carried out. In the first one, differences between autumn and winter, and three size classes of *C. guatucupa* (see Results) were tested. In the second one, differences were tested among autumn, winter and summer, and two size classes of *C. guatucupa*. The normality of the data was verified using Lilliefors' test and the homogeneity of variances was verified using Barlett's test ($p > 0.05$). When data did not satisfy any of the assumptions of parametric tests, logarithmic transformations were applied.

Fish morphology and prey size

Mouth gape was estimated as follows: mouth gape = mouth height × mouth width × π. This equation, which is the area of an ellipse, was used mainly for two reasons. Firstly, we consider it the best way to estimate the mouth opening of the species. Secondly, it involves both the mouth height and width.

Regression equations were calculated to evaluate the relationship between fish L_T and mouth gape, and the size of the largest preys found in the gut contents.

Prey selection

Feeding selectivity was evaluated using Vanderploeg & Scavia's (1979a, b) relativized electivity index $E = (W_i - 1/n)/(W_i - 1/n)$, where n is the number of prey types and W_i is Chesson's (1978, 1983) index. Values of E range from $E = 1$, indicating strong selection for a particular prey type, to $E = -1$, indicating strong avoidance. E values around 0 indicate random use of a resource (Lechowicz, 1982). E was calculated separately for each group of size classes during each season.

Results

C. guatucupa was captured from March to September 2000, and from December 2000 (2 animals) to February 2001 (Table 2). In total, 2398 juveniles ranging between 1 and 16 cm L_T were collected, 833 of which – between 1 and 12 cm L_T – were used for the diet analyzes (Table 3). Mysid shrimps dominated the diet in terms of numbers of individuals (44.0%) and in terms of frequency of occurrence. They were followed by the sergestid *P. petrunkevitchi*, the calanoid copepod *L. fluviatilis*, and the chaetognath *S. friderici*. In terms of biomass, *P. petrunkevitchi* and fishes, mostly the Argentine anchovy *Engraulis anchoita* Hubbs & Marini (Engraulidae), were the most important, and both represented 77.3% in the total diet, being followed by mysids and epibenthic penaeid prawns (*Artemesia longinaris* (Bate) and *Pleoticus muelleri* Bate).

Table 2. Total junveniles collected (*N*), size range (*r*), mean total length ± standard deviations (L_T ± st. dev.), and total number of stomachs analyzed (*n*) of *Cynoscion guatucupa* captured in Bahía Blanca estuary between March 2000 and February 2001

	N	*r* (cm L_T)	L_T ± st. dev.	*n*
March	242	2–11	4.26 ± 1.75	112
April	318	2–12	6.19 ± 2.04	150
May	42	1–7	5.21 ± 1.71	40
June	331	2–13	4.95 ± 1.96	140
July	105	2–15	5.10 ± 2.08	74
August	517	3–16	5.95 ± 1.68	128
September	55	2–5	3.52 ± 0.63	36
October	0	–	–	–
November	0	–	–	–
December	2	–	7.25 ± 0.63	2
January	283	1–5	2.91 ± 0.64	61
February	503	2–7	4.60 ± 0.95	90
TOTAL	2398	1–16	4.93 ± 1.88	833

Stomach contents allowed the identification of three-size groups in *C. guatucupa* plus one odd class (1.00–1.99 cm L_T; see Fig. 2). The resulting stress for the MDS two-dimensional plot was 0.02, indicating an excellent representation. This grouping was subsequently validated by the cluster analysis, thus strongly supporting the MDS results.

Members of the first group (small juveniles from 2.00 to 4.99 cm L_T Fig. 2) ate almost exclusively mysid shrimps. The second group (medium juveniles from 5.00 to 8.99 cm L_T) was characterized by the dominance of mysids in terms of frequency and numbers, whereas *P. petrunkevitchi* was dominant in terms of biomass (Table 3). For the third group (large juveniles from 9.00 to 12.99 cm L_T), mysids and *P. petrunkevitchi* were the most frequent prey items, *P. petrunkevitchi* became dominant in terms of numbers whereas the highest biomass values were shared by this sergestid and small fishes, mainly *E. anchoita* (these two items represented 90.6% in the total diet biomass; see Table 3).

In terms of ecological groups, these changes in the diet implied a change in habitat utilization, i.e., small juveniles were characterized by a demersal-pelagic diet whereas large juveniles ate mainly demersal-benthic prey items (Fig. 3). Pelagic organisms were present all throughout the three size classes but their species composition changed, i.e. *S. friderici* and *L. fluviatilis* were dominant in the diet of small juveniles while *E. anchoita* was dominant in the diet of medium and large individuals.

Levin's index of diet width was narrower in small and large *C. guatucupa* ($B_A = 0.31$ and 0.33, respectively), and wider in medium-sized animals ($B_A = 0.45$). Results of the 2-way ANOVAs are shown in Table 4. Both analyses yielded no interaction between size of the fish and season.

Table 3. Diet composition of *Cynoscion guatucupa* from Bahía Blanca estuary in relation to body size groups indicated by multivaried analysis (for grouping see Fig. 2)

		Total			Small			Medium			Large		
Cm L_T			2.00–12.99			2.00–4.99			5.00–8.99			9.00-12.99	
Total stomachs			833			361			390			82	
Empty stomachs			109			61			41			7	
	EG	%FO	%*N*	%*W*	%FO	%*N*	%*W*	%FO	%*N*	%*W*	%FO	%*N*	%*W*
Prey items													
Sagitta friderici	P	16.30	13.4	0.93	21.3	21.8	7.1	14.0	9.1	0.6	6.7	6.6	0.2
Acartia tonsa/*Paracalanus parvus*	P	2.21	0.99	0.00	3.3	1.4	0.01	1.7	1.0	0.02	–	–	–
Labidocera fluviatilis	P	20.17	12.6	0.38	23.7	10.4	1.1	20.3	15.5	0.5	5.3	9.0	0.1
Calanoides carinatus	P	3.45	1.3	0.07	2.3	0.7	0.2	4.6	2.0	0.1	2.7	0.5	0.0
Copepods*	NA	1.24	1.07	0.06	1.0	0.7	0.5	1.4	0.4	0.0	1.3	3.7	0.04
Total			16	0.51		13.2	1.81		18.9	0.62		13.2	0.14
Arthromysis magellanica	DP	20.30	8.22	3.51	25.0	11.8	18.5	18.9	7.5	4.0	8.0	2.0	0.4
Neomysis americana	DP	39.64	20.9	3.43	41.3	25.9	14.5	38.7	18.9	3.6	37.3	15.6	1.2
Mysids*	DP	39.50	14.9	3.49	50.3	21.3	21.7	34.4	13.1	3.3	20.0	5.6	0.5
Total			44.0	10.4		59	54.7		39.5	10.9		23.2	2.1
Penaeids	DB	8.15	2.92	6.31	1.0	0.3	1.5	12.6	4.5	8.4	16.0	4.4	4.9
Peisos petrunkevitchi	DB	26.38	14.3	45.4	7.7	2.8	20.2	35.2	16.3	45.6	60.0	35.4	49.6
Crabs	B	1.24	0.4	0	1.0	0.3	0.0	1.7	0.6	0.0	–	–	–
Amphipods	B	2.62	0.91	0.01	1.3	0.4	0.0	4.0	1.4	0.0	1.3	0.7	0.0
Crustacea*	NA	8.15	2.45	4.22	3.3	1.1	5.1	10.6	3.4	6.2	16.0	2.9	2.0
Sciaenidae	DP	3.31	1.19	5.88	1.0	0.3	3.9	3.4	1.2	5.5	12.0	3.2	6.6
Engraulidae	P	4.56	2.09	19.8	–	–	–	4.0	1.4	10.9	25.3	8.8	32.9
Fish*	NA	6.63	1.98	6.22	2.0	0.7	5.6	10.6	3.2	10.7	6.7	1.2	1.5
Total			5.26	31.9		1.0	9.5		5.8	27.1		13.2	41
Other taxa	NA	0.83	0.28	0.24	–	–	–	1.4	0.4	0.5	1.3	0.5	0.0

*Unidentified.

EG = ecological group of the prey, (B = benthic, DB = demersal-benthic, DP = demersal-pelagic, P = pelagic and NA = not assigned); %FO = percent frequency of occurence, %*N* = percent number, and %W = percent wet weight.

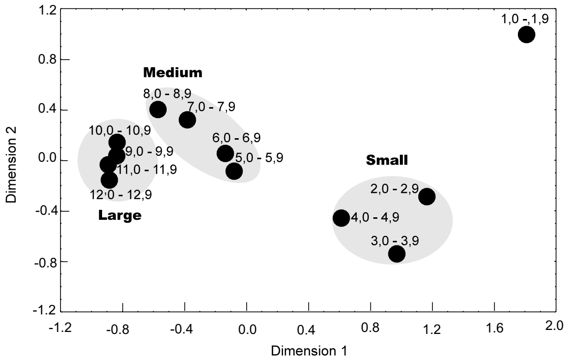

Figure 2. Two-dimensional multidimensional scaling configuration (MDS, stress = 0.02) based on the standarized numerical abundances of prey found in the stomach contents of *Cynoscion guatucupa* ($n = 833$) from Bahía Blanca estuary, showing the classification by size into three main groups: Small, Medium and Large. Numbers indicate cm total length (L_T): 1.00–1.99 cm L_T; 2.00–2.99 cm L_T, and so on.

Therefore, principal effects are presented (Table 4). Mean vacuity (%V) decreased with fish size, although significant differences were only found between small and large *C. guatucupa*. Mean prey number/stomach (MPN) increased with fish body size. However, statistical differences were only found between small and large fishes. Also, mean prey biomass/stomach (MPB) significantly increased across the three-size groups (Table 4).

Fish morphology and prey size

The size of the largest prey items found in the stomach contents increased linearly with both fish L_T and mouth gape ($p < 0.01$, Fig. 4). Prey sizes varied from 1 mm for *A. tonsa*/*P. parvus* to 40 mm for the largest penaeid (*P. muelleri*) found in gut contents. The differences between prey and mouth size became progressively more evident with increasing fish length. That is, the largest preys approached mouth gape size in smaller juveniles but were much smaller than the mouth gape size in larger individuals (e.g., in 2 cm L_T *C. guatucupa*, the largest prey found in the gut contents was 11 mm and the mouth gape was 12.61 mm^2; in contrast, in 12 cm L_T *C. guatucupa*, the largest prey measured was 38 mm for a fish having a mouth gape of 285.44 mm^2). Also, the overall prey size range was larger in larger fishes. In small *C. guatucupa*, preys ranged from 1 to 16 mm, whereas in large *C. guatucupa,* preys ranged from 1 to 38 mm. As a result, whereas small food items were eaten by fishes of all sizes, large food items were eaten only by large predators.

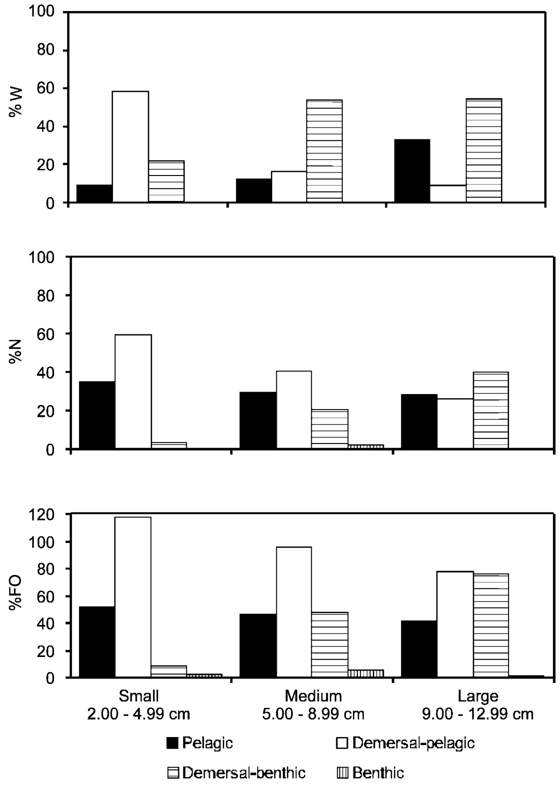

Figure 3. Size-related variations in the importance of the ecological groups of prey of *Cynoscion guatucupa* from Bahía Blanca estuary, based on the three size groups considered: Small = 2.00–4.99 cm total length, Medium = 5.00–8.99 cm total length and Large = 9.00–12.99 cm total length. %W = percentage of the total wet weight, %N = percentage by number and %FO = percent frequency of occurrence.

Seasonal feeding changes

MDS was carried out on each group of size classes identified from the ontogenetic analysis (see above) for each season. Three seasonal groups and two ungrouped seasons (small *C. guatucupa* from autumn and winter) were identified (Fig. 5, stress = 0.07). Consistency of these groups was subsequently confirmed by cluster analysis.

Group I was represented by medium and large *C. guatucupa* from autumn, with their diets dominated by *P. petrunkevitchi* in terms of frequency and numbers as well as by this sergestid and

Table 4. ANOVA results for the two set of comparisons (a and b) of season and fish size differences in mean vacuity (%V), mean prey number/stomach (MPN) and mean prey biomass/stomach (MPB) in the diets of *Cynoscion guatucupa* captured in Bahía Blanca estuary between March 2000 and February 2001

	p		
	%V	MPN	MPB
(a)			
Size, Season	0.96	0.18	0.74
Size	0.05*	0.03*	0.000**
Season	0.3	0.009**	0.01**
Effect: Size			
Small	23.4 ± 11.40 a	2.74 ± 1.44 a	0.01 ± 0.005 aa
Medium	9.50 ± 8.15	2.99 ± 1.11	0.06 ± 0.04 aa
Large	5.80 ± 6.74 a	4.93 ± 2.04 a	0.18 ± 0.14 aa
Effect: Season			
Autumn	7.94 ± 8.27	4.29 ± 1.28 aa	0.11 ± 0.14 aa
Winter	16.91 ± 12.46	2.82 ± 1.94 aa	0.05 ± 0.06 aa
(b)			
Size, Season	0.88	0.21	0.25
Size	0.14	0.61	0.000**
Season	0.03*	0.003**	0.004**
Effect: Size			
Small	11.95 ± 13.25	3.16 ± 1.41	0.01 ± 0.004 aa
Medium	13.15 ± 10.98	3.6 ± 1.69	0.04 ± 0.03 aa
Effect: Season			
Autumn	10.56 ± 9.5	3.73 ± 0.77 aa	0.05 ± 0.04 aa bb
Winter	20.67 ± 12.22 a	2.12 ± 1.12 aa bb	0.02 ± 0.01 aa
Summer	3.94 ± 5.44 a	4.47 ± 1.56 bb	0.02 ± 0.007 aa bb

In (a) two seasons (autumn and winter) and three size classes (small = 2.00–4.99 cm total length, medium = 5.00–8.99 cm total length, and large = 9.00–12.00 cm total length) were tested. In (b) three seasons (autumn, winter and summer) and two size classes (small and medium) were compared. Mean ± standard deviations and principal effects for each set of comparisons are shown. Statistical differences were found between factors with the same letter: single letter, $p < 0.05$; double letter, $p < 0.01$.

E. anchoita in terms of biomass (Table 5). Group II included medium and large juveniles from winter, with the stomachs being characterized by low quantity of food with *L. fluviatilis*, *S. friderici* and mysids as dominant species in terms of frequency and numbers, and *P. petrunkevitchi* in terms of biomass. Group III included juveniles from summer and was characterized by the dominance of mysids in their diets (Table 5).

In small *C. guatucupa* from autumn, *S. friderici* and mysids were the most important prey items in terms of frequency and numbers, whereas *P. petrunkevitchi* was the most important one in terms of biomass (Table 5). On the other hand, in small *C. guatucupa* from winter, mysids, *L. fluviatilis*, and *S. friderici* were dominant in terms of frequency and numbers, while mysids (mainly *A. magellanica)* were dominant in terms of biomass.

Levin's index of diet breadth was wider in winter ($B_A = 0.38$) than in the rest of the year ($B_A = 0.29$ and 0.23 in autumn and summer, respectively). %V was higher in winter than in the other two seasons (Table 4 and Fig. 6). Statistical differences were only found between winter and summer. MPN was significantly lower in winter than in autumn and summer. MPB was always higher in autumn than in winter and summer (see Table 4).

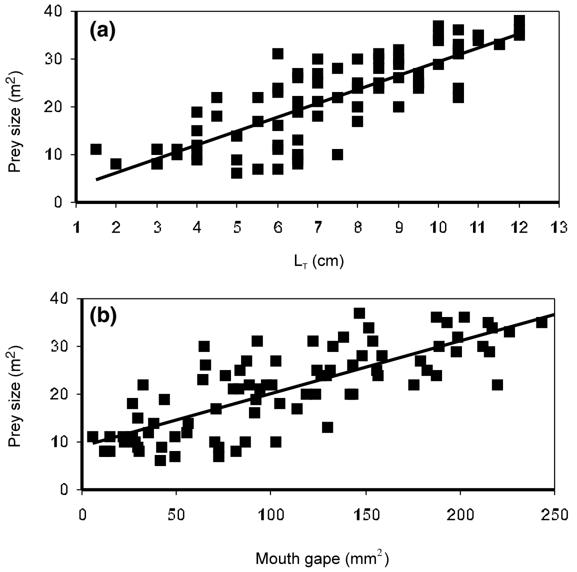

Figure 4. Size of the largest preys found in the gut contents as a function of (a) fish total length (Max.PreySize = 2: 91L_T+ 0.34; $r^2 = 0.67$; $n = 88$) and (b) fish mouth gape (Max. PreySize = 0.11MouthGape + 9.24; $r^2 = 0.61$; $n = 85$) of *Cynoscion guatucupa* from Bahía Blanca estuary.

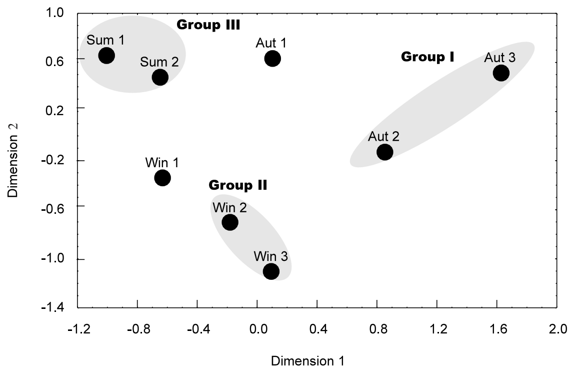

Figure 5. Two-dimensional multidimensional scaling configuration (MDS, stress = 0.07) based on the standarized numberical abundances of prey found in the stomach contents of *Cynoscion guatucupa* ($n = 833$) from Bahía Blanca estuary, showing the classification by season into three main groups. 1 = small *C. guatucupa* (2.00–4.99 cm total length), 2 = medium-sized *C. guatucupa* (5.00–8.99 cm total length), 3 = large *C. guatucupa* (9.00–12.99 cm total length).

Zooplankton abundance and prey selection

Mean zooplankton density ranged from 192.05 ± 88.70 ind/m^3 in winter to 1000.00 ± 295.06 ind/m^3 in summer (Table 6). There was a clear dominance of copepods all throughout the year (77–98% of the monthly total abundances), *A. tonsa*/*P. parvus,* and the harpapticoid *Euterpina acutifrons* (Dana) being the dominant species. As to the zooplankton taxa that contributed to juveniles' diets, mysids increased in summer whereas *P. petrunkevitchi* was more abundant in autumn. *S. friderici* was present all along the year and was more abundant in autumn and summer. Similarly, fish larvae were found during the three seasons considered in the present study although the highest numbers were registered in summer (Table 6).

In autumn, all *C. guatucupa* strongly selected mysids and large juveniles moderately selected fishes. The remaining prey items were avoided, including *P. petrunkevitchi,* even though it was the dominant prey item in the diets of medium and large specimens during that season (Table 5). In winter, the only prey item selected was *L. fluviatilis* (Table 6). Mysids were avoided by all size groups although they were important dietary components in winter (Table 5). In summer, small *C. guatucupa* positively selected *L. fluviatilis*, mysids, and *P. petrunkevitchi* whereas medium-sized individuals positively selected *P. petrunkevitchi* and avoided all other prey taxa (Table 6).

The copepods *A. tonsa*/*P. parvus* and *C. carinatus*, *S. friderici*, and crabs were negatively selected by the three-size groups in all the seasons considered in the present study (Table 6).

Discussion

C. guatucupa supports important commercial fisheries in Bahía Blanca estuary, although historical data show dramatic variability in its population in the last 10 years (Lopez Cazorla, 1997). Ruarte et al. (2000) indicate that the zone located outside the estuary, called El Rincon, is one of the most important fishing grounds of *C. guatucupa* in the country, and Lopez Cazorla (1997) claims that the observed declines are probably due to the fishing pressure exerted on this species.

The Bahía Blanca estuary ecosystem underwent a severe perturbation throughout the 1980s and 1990s as a result of pollution sources corresponding to industrial activities, maritime traffic, dredging, and domestic sewage (Ferrer, 2001;

Table 5. Seasonal diet composition by body size groups of *Cynoscion guatucupa* from Bahía Blanca estuary

	Autumn									Winter									Summer					
Size groups	1			2			3			1			2			3			1			2		
Total stomachs	105			156			41			157			180			41			99			54		
Empty stomachs	19			8			2			42			30			5			0			3		
	%FO	%*N*	%P	%FO	%*N*	%P	%FO	%*N*	%P	%FO	%*N*	%P	%FO	%*N*	%P	%FO	%*N*	%P	%FO	%*N*	%P	%FO	%*N*	%P
Prey items																								
Sagitta friderici	35.6	46.2	13.6	15.6	9.4	0.4	–	–	–	24.8	21.2	5.0	15.9	13.6	1.4	14.3	17.5	0.9	3.2	1.0	0.6	4.2	0.8	0.2
Acartia tonsa/ *Paracalanus parvus*	4.6	1.5	0.0	0.7	0.2	0.0	–	–	–	–	–	–	0.7	0.2	0.0	–	–	–	6.4	2.0	0.0	8.3	4.1	0.0
Labidocera fluviatilis	13.8	3.5	0.5	12.2	4.6	0.1	–	–	–	22.3	16.7	1.6	24.5	29.9	1.6	14.3	33.8	0.9	34.0	13.2	3.4	31.3	12.0	1.4
Calanoides carinatus	–	–	–	–	–	–	–	–	–	5.5	3.4	0.5	10.6	5.5	0.5	5.7	1.3	0.1	–	–	–	–	–	–
Copepods*	1.1	0.3	0.0	3.4	1.0	0.0	–	–	–	0.8	0.5	0.0	–	–	–	–	–	–	1.1	1.3	0.0	–	–	–
Total	–	5.3	0.6	–	5.8	0.1	–	–	–	–	20.7	2.1	–	35.6	2.0	–	35.1	0.9	–	16.5	3.4	–	16.1	1.4
Arthromysis magellanica	5.7	1.8	3.3	7.5	2.6	0.7	7.9	2.0	0.4	19.0	12.3	23.0	19.9	7.8	10.8	8.6	1.9	0.3	50.0	20.3	34.1	52.1	17.4	16.1
Neomysis americana	46.0	24.6	12.8	36.1	19.5	1.4	44.7	18.7	0.7	16.5	10.3	11.9	28.5	11.3	8.9	28.6	9.7	3.4	69.1	34.9	20.7	81.3	31.8	10.3
Mysids*	46.0	13.7	7.6	34.0	11.8	1.0	26.3	7.2	0.4	41.3	26.6	33.8	22.5	8.0	8.5	14.3	3.2	1.2	62.8	25.1	25.3	70.8	24.4	9.0
Total	–	40.1	23.8	–	33.9	3.0	–	27.9	1.5	–	49.3	68.7	–	27.1	28.3	–	14.9	5.0	–	80.3	80.0	–	73.6	35.4
Penaeoidea	2.3	0.6	3.2	15.0	4.6	6.9	7.9	1.2	1.2	0.8	0.5	0.8	12.6	6.2	11.9	25.7	9.7	21.3	–	–	–	2.1	0.4	0.8
Peisos petrunkevitchi	14.9	4.4	34.2	57.1	29.5	50.1	89.5	49.0	48.0	6.6	4.4	16.7	19.2	8.0	38.5	28.6	12.3	54.7	2.1	0.5	4.6	20.8	4.1	27.8
Crabs	1.1	0.3	0.0	1.4	0.4	0.0	–	–	–	0.8	0.5	0.0	2.6	1.1	0.0	–	–	–	1.1	0.3	0.0	–	–	–
Amphipods	–	–	–	1.4	0.4	0.0	–	–	–	2.5	1.5	0.0	6.6	2.8	0.0	2.9	1.9	0.0	1.1	0.3	0.0	4.2	0.8	0.0
Crustacea*	3.4	0.9	4.8	8.8	2.8	3.1	10.5	1.6	0.8	2.5	1.5	2.5	11.3	3.9	11.1	20.0	4.5	7.4	4.3	1.0	9.3	12.5	2.9	23.5
Sciaenidae	3.4	0.9	10.2	8.2	2.8	7.9	18.4	4.4	7.0	–	–	–	–	–	–	5.7	1.3	5.3	–	–	–	–	–	–
Engraulidae	–	–	–	9.5	3.4	15.6	50.0	14.3	40.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Fish*	5.7	1.5	9.6	19.7	6.0	12.7	10.5	1.6	0.8	0.8	0.5	4.2	3.3	1.1	5.3	2.9	0.6	4.7	1.1	0.3	1.9	6.3	1.2	10.8
Total	–	2.3	19.8	–	12.2	36.2	–	20.3	48.5	–	0.5	4.2	–	1.1	5.3	–	1.9	9.9	–	0.3	1.9	–	1.2	10.8

*Unidentified.

1 = small *C. guatucupa* (2.00–4.99 cm total length), 2 = medium-sized *C. guatucupa* (5.00–8.99 cm total length) and 3 = large *C. guatucupa* (9.00–12.99 cm total length).
%FO = percent frequency of occurrence, %*N* = percent number and %*W* = percent wet weight.

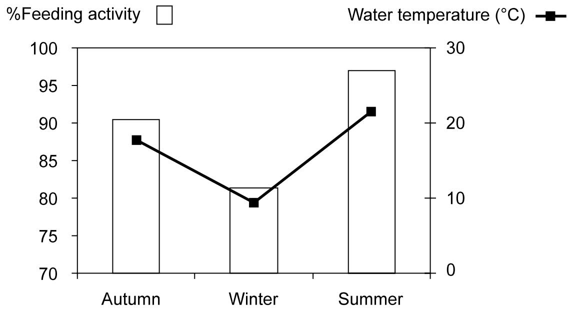

Figure 6. Monthly variation in water temperature and in feeding activity (1 – %Vacuity) of *Cynoscion guatucupa* ($n = 833$) from Bahía Blanca estuary.

Hoffmeyer, 2004). A recent study has, in fact, found severe alterations in the zooplankton assemblage composition and structure in the inner zone of the estuary. In this respect, three main changes were observed in the period 1990–1991 with respect to the period 1979–1980: (1) the dominance, during winter–spring, of two new invading species (the copepod *Euritemora americana* Williams and the cirriped *Balanus glandula* Darwin), which caused a decrease in the autochthonous key copepod *A. tonsa*, (2) seasonal changes in diversity and species richness, and (3) a decrease in the community stability (Hoffmeyer, 2004). In addition, and since this estuary is very shallow and mixed, the plankton–benthos relationship is very strong to the extent that dredging and its effects on the benthos community probably also affected the plankton community (Hoffmeyer, 2004).

One of the major changes in the composition of zooplankton assemblages after a decade (1980–1990) was a decrease in the frequency and abundance of *P. petrunkevitchi,* the principal food item in the diet of juvenile *C. guatucupa*. Other important food items for *C. guatucupa* also showed changes. In this respect, an increase in frequency and abundance was detected for the chaetognath *S. friderici* and the mysid shrimps *A. magellanica* and *N. americana*, and it was attributed to dredging effects (Hoffmeyer, 2004).

It is seems likely that the estuarine habitat loss and degradation could have affected fish populations in the last years, particularly during the early life stages. It is worthy of note that all the juveniles analyzed in this study were found to be in good feeding conditions (P. Sardiña & A.C. Lopez Cazorla, unpublished data). Long-term changes in the environmental conditions and in the biota of the estuary represent a combination of factors that could have impacted recruitment levels and are likely to account, in some degree, for the decline in *C. guatucupa* adult stock. Further declines should be expected if an integral habitat and fishery management are not to be implemented.

The results found in this study are indicative of important ontogenetic changes in the diet and prey selectivity mechanisms of the three-size classes of *C. guatucupa* studied. Shifts in habitat use and behavioral constraints related to morphological features interact to determine the diet and the actual availability of prey items in the environment for each size class of *C. guatucupa*. Young *C. guatucupa* have three different size-related feeding mechanisms. Small juveniles (2.00–4.99 cm L_T) strongly favor mysid shrimps over the other food items consumed, thus showing a narrow diet width ($B_A = 0.31$). In medium-sized juveniles (5.00–8.99 cm L_T), the preference for mysids is less marked and the contribution of other prey items is larger ($B_A = 0.45$). In large *C. guatucupa* (9.00– 12.99 cm L_T), trophic specialization increases ($B_A = 0.33$) mainly because of the marked preference for *P. petrunkevitchi.* In these large juveniles, the sergestid was eaten by more than half of the collected fish and represented 50% of the total diet biomass.

Published data on the diet of juvenile *C. guatucupa* are scarce. In general, our results are in agreement with previous studies in the region (Lopez Cazorla, 1996) and in other Argentinean coastal areas (Olivier et al., 1968; Ciechomski & Ehrlich, 1977; Cordo, 1986). All these studies report shrimps (*P. petrunkevitchi* and *P. muelleri*) and fishes (*E. anchoita*) as dominant food items. Amphipods (Gammaridea) have been reported to be an important prey of Mar del Plata coast (approx. 38° S; Ciechomski & Ehrlich, 1977). One peculiarity in the diet of *C. guatucupa* in Bahía Blanca, is the dominance in small juveniles of mysid shrimps, which usually represent a small proportion in the diet in populations located farther north along the coast (Ciechomski & Ehrlich, 1977; Cordo, 1986). *A. magellanica* and *N. americana*, together with *A. tonsa*, are the most frequent species in Bahía Blanca estuary all along the year (Hoffmeyer, 1983, 1994). This suggests that their higher proportions in the stomachs

Table 6. Seasonal zooplankton densities (mean ind/m^3 ± st. dev.) and selectivity values (*E*) for zooplankton taxa that were found in the diet of three size groups (1 = 2.00–4.99 cm total length, 2 = 5.00–8.99 cm total length and 3 = 9.00–12.99 cm total length) of juvenile *Cynoscion guatucupa* from Bahía Blanca estuary

	Autumn				Winter				Summer		
Zooplankton taxa	ind/m^3	*E*			ind/m^3	*E*			ind/m^3	*E*	
		1	2	3		1	2	3		1	2
Acartia tonsa + *Paracalanus parvus*	719.24 ± 631.09	−1	−1	−1	37.68 ± 35.35	−1	−1	−1	763.87 ± 345.15	−1	−1
Euritemora americana	–	–	–	–	0.42 ± 0.52	–	–	–	–	–	–
Labidocera fluviatilis	0.62 ± 0.75	–	–	–	0.04 ± 0.05	0.67	0.69	0.7	4.07 ± 1.23	0.34	−0.2
Calanoides arinatus	0.52 ± 0.90	−1	−1	−1	0.45 ± 0.73	−0.8	−0.8	−0.9	0.20 ± 0.34	−1	−1
Ctenocalanus vanus	7.48 ± 10.54	–	–	–	0.69 ± 0.57	–	–	–	12.64 ± 5.31	–	–
Euterpina acutifrons	104.34 ± 89.39	–	–	–	71.52 ± 84.36	–	–	–	77.30 ± 57.97	–	–
Oithona sp.	–	–	–	–	0.53 ± 0.90	–	–	–	7.49 ± 2.21	–	–
Monstrilla sp.	–	–	–	–	0.19 ± 0.25	–	–	–	1.09 ± 1.42	–	–
Cyclopoids	–	–	–	–	0.16 ± 0.31	–	–	–	0.60 ± 0.54	–	–
Copepod nauplii	0.89 ± 0.61	–	–	–	0.55 ± 0.52	–	–	–	4.72 ± 2.87	–	–
Cirripedia nauplii	–	–	–	–	2.23 ± 2.40	–	–	–	0.23 ± 0.41	–	–
Crab zoeae and megalopae	1.93 ± 1.08	−1	−1	−1	–	–	–	–	23.86 ± 8.83	−1	−1
Gammarids	–	–	–	–	–	–	–	–	0.43 ± 0.38	–	–
Mysids	0.05 ± 0.09	0.74	0.7	0.66	1.78 ± 1.75	−0.3	−0.7	−0.8	16.28 ± 6.86	0.42	−0.3
Peisos petrunkevitchi	0.22 ± 0.38	−0.96	−0.7	−0.6	–	–	–	–	0.01 ± 0.01	0.51	0.74
Crustacea eggs	13.30 ± 8.70	–	–	–	0.11 ± 0.22	–	–	–	9.25 ± 4.92	–	–
Sagitta friderici	5.70 ± 5.93	−0.69	−0.9	–	0.64 ± 0.30	−0.5	−0.8	−0.7	2.59 ± 0.11	−0.6	−1
Veliger larvae	11.21 ± 7.17	–	–	–	0.15 ± 0.15	–	–	–	56.70 ± 51.63	–	–
Tintinids	–	–	–	–	71.24 ± 82.55	–	–	–	0.61 ± 0.61	–	–
Conopeum sp.	1.65 ± 1.12	–	–	–	0.53 ± 0.44	–	–	–	4.97 ± 2.59	–	–
Bivalve larvae	1.18 ± 1.07	–	–	–	0.05 ± 0.1	–	–	–	1.90 ± 0.85	–	–
Polychaete larvae	1.15 ± 1.10	–	–	–	2.56 ± 2.35	–	–	–	4.30 ± 2.96	–	–
Hydromedusae	0.14 ± 0.24	–	–	–	0.13 ± 0.27	–	–	–	1.18 ± 0.52	–	–
Fish larvae	0.01 ± 0.02	−0.68	0.02	0.29	0.02 ± 0.03	−0.9	−0.9	−0.9	0.68 ± 0.54	−0.7	−0.7
Other taxa	0.15 ± 0.002	–	–	–	0.36 ± 0.35	–	–	–	3.98 ± 3.00	–	–
Total	869.78 ± 82.30	–	–	–	192.05 ± 88.70	–	–	–	1000.00 ± 295.06	–	–

contents of *C. guatucupa* from Bahía Blanca with respect to that in other areas results from a higher availability rather than from interpopulational differences in feeding preferences. Data on prey abundance were not collected in any of the above-mentioned studies although observations on the coast of Mar del Plata suggest that mysids are less abundant in that area than in Bahía Blanca estuary (Scelzo, pers. comm.).

Literature indicates that the diet of young *C. guatucupa* in South Atlantic coastal waters is similar to that of other *Cynoscion* species elsewhere. In fact, *N. americana* is the dominant prey item of *Cynoscion regalis* (Bloch & Schneider) <90 mm SL in Delaware Bay (Grecay & Targett, 1996), and, together with copepods, it is the main food item of *Cynoscion nebulosus* Cuvier between 3 and 28.8 mm SL from the Barataria-Caminada Bay (Baltz et al., 1998).

Ontogenetic diet shifts in the juveniles of *C. guatucupa* in Argentinean waters have not been studied to date although diet changes in other *Cynoscion* species elsewhere are well documented. In this respect, Sheridan (1979) reported ontogenetic changes in the feeding habits of the sand seatrout *Cynoscion arenarius* Ginsberg from Apalachicola Bay, Florida. The latter fish <40 mm SL prey heavily on mysids whereas larger ones are mainly piscivorous. Baltz et al. (1998) found that *C. nebulosus* <2 cm SL eats mainly *A. tonsa* and that subsequently shifts to mysid shrimps.

Dietary shifts are common in fish. These changes are usually related to modifications in the environmental conditions, habitat use, size-related morphological constraints, and the energetic requirements of the animals. In the latter case, changes in the diet are often related to the optimization of resource usage (Stephens & Krebs, 1986). In the case of *C. guatucupa*, the diet changes described in our research are related to changes in habitat use (from demersal-pelagic to demersal-benthic and a progressive increase in ichthyophagy) and morphology. These changes involve an increase in the quality of the diet (in terms of biomass), in which small crustaceans like mysid shrimps are replaced by large crustaceans, such as *P. petrunkevitchi*, and fishes.

In relation to these observations, prey selectivity analysis showed that for small prey items, e.g., *S. friderici* and mysids, selectivity values decreased with fish size, whereas for large prey items, e.g., *P. petrunkevitchi* and fish larvae, the opposite pattern occur. These findings are indicative of the fact that prey selection seems to be related not only to prey size but also to fish energy requirements. In fact, as *C. guatucupa* grew, net prey biomass (and therefore the nutritional value of the diet) also increased (see Table 4). *S. friderici* represented an important dietary item in terms of frequency and numbers, but it constituted a minor part of the diet in terms of biomass. In contrast, although fishes were numerically less important, they always represented an important part in the total dietary biomass.

On the other hand, prey size has been shown to be determined by changes in the feeding apparatus (Peterson & Mclntyre, 1998). Our data support this relationship for small *C. guatucupa* although it is less obvious for larger juveniles. This may indicate that mouth gape is not a limiting factor for the ingestion of larger prey items among larger juveniles, and that, although larger prey may provide fish with more energy, other factors such as handling time and capture success may represent higher costs to this species when preying on larger food items. The preference for prey items that are substantially smaller than those presumably permitted depending on mouth-size has been observed elsewhere in other fish species (Boubée & Ward, 1997; Gaughan & Potter, 1997).

Other aspects in the diet of *C. guatucupa* also varied during ontogeny. As fish grew, feeding activity (inferred from the proportion of empty stomachs) became increasingly higher and the amount and weight of prey eaten also increased. These patterns have been reported for many young fishes (Grossman, 1980; Stergiou & Fourtouni, 1991; Milton et al., 1994; Kleanthidis & Sinis, 2001) although other studies (Jones, 1984; Gillanders, 1995; McCormick, 1998; Lukoschek & McCormick, 2001) described a marked decrease in feeding rates with increasing fish size. This observation was reported for *C. guatucupa* between 75 and 138 mm L_T from Mar del Plata (Ciechomski, 1981). The author found through laboratory experiments that the smallest specimens evidenced the highest feeding rates whereas the largest animals evidenced the lowest ones. In our study, the increased feeding rates observed in large *C. guatucupa* is most probably related to an increase in the energetic requirements, as pointed out above.

Seasonal *C. guatucupa* diet shifts evidenced the changes in the availability of organisms. Our results show that mysids and *P. petrunkevitchi* represented the major part of the diet and that, although they were consumed all along the year, their representation was higher when they increased in the environment, i.e., mysids in summer and *P. petrunkevitchi* in autumn, respectively. Similarly, *S. friderici* and *L. fluviatilis* always represented an important part of the diet (in terms of frequency and numbers) when they were present in the estuary. On the other hand, and although their overwhelming numerical abundance in the water column, *A. tonsa*/*P. parvus* were minor components of the diets and were always strongly negatively selected by all size classes.

Selectivity data showed that *C. guatucupa* selected certain prey items whereas other ones were avoided. Also, whereas some prey items were consistently negatively selected by all size classes all along the year, other prey items were selected in one season and avoided in another. *S. friderici* was always negatively selected even when it was a major component of the diets (autumn and summer). For mysids, electivity values showed that even though they were the predominant food item for *C. guatucupa* in winter, all size groups ate fewer mysids than expected from their availability in the water column (Table 6). In contrast, the calanoid *L. fluviatilis* was always positively selected. Similarly, even though *P. petrunkevitchi* was dominant in the diets of *C. guatucupa* during autumn, it was avoided by all size classes during the same season and it was always selected for by all juveniles in summer.

Differences in prey selection mechanisms could be related to differences in the vertical distributions of predator and prey, prey morphology, relative abundance, and availability of other prey taxa. For example, negative values for *S. friderici* and *P. petrunkevitchi* in autumn, are likely to be related to their high availability to all size classes during that season. Abundance values shown in Table 6 for *P. petrunkevitchi* are probably underestimated (because of net avoidance during sampling). Our observations in the field and previous published data (Hoffmeyer, 1983) indicate that this sergestid is very abundant in the estuary during autumn. In this respect, and although during autumn juveniles consumed fewer *P. petrunkevitchi* than expected from their availability in the environment, this crustacean represented the major component of their diets (Table 5). Lukoschek & McCormick (2001) reported similar results for the carnivorous fish *Parupeneus barberinus* (Lacépéde), which was found to negatively select polychaetes, the dominant prey in their diet, because of their high availability to all size classes. On the other hand, differences between *C. guatucupa* (a mid-water feeder) and *P. petrunkevitchi* (an epibenthic crustacean) depth distributions could have also influenced selectivity. In addition, values for mysids in winter are probably related to the increased availability of the copepod *L. fluviatilis* in the estuary. In fact, this copepod was the only prey item positively selected by all size classes in winter and was also the most important one in the diets during this season.

Additional seasonal differences were found in the feeding behavior of *C.guatucupa*. The reduced feeding activity and the lower MPN and MPB registered in winter are likely to indicate that limited food supply and water temperature are limiting factors for winter juveniles in the estuary. This could be indicative of the fact that juveniles reduce their feeding activity as the temperature decreases (7 °C in July and August, see Fig. 6) as described for many demersal fishes (Tyler, 1971; Caragitsou Papaconstantinou, 1988). Also, in winter mean zooplankton density decreased to 192 ind/m^3 (compared to 870 and 1000 ind/m^3 registered in autumn and summer, respectively), suggesting that the decreased availability of prey was also limiting feeding.

The importance of *C. guatucupa* as forage for larger coastal fishes, including adult *C. guatucupa* (Lopez Cazorla, 1996) magnifies the potential significance of this species as exporters of estuarine production to the ocean during winter seaward migrations. Given that a significant portion of emigrating fish populations does not survive to return to estuaries the following spawing season, the net balance of biomass and energy transfer strongly favor export to the coastal ocean (Gillanders, 1995).

As a result, and in view of the data collected from our research, it can be concluded that juvenile *C. guatucupa* plays an important trophic role as major consumer of zooplankton during estuarine residency and represents a major transfer of energy to the relatively low production areas outside the estuary, when large numbers of *C. guatucupa* >10 cm L_T emigrate seaward from Bahía Blanca estuary every autumn.

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