Biology of the shrimp *Artemesia longinaris* Bate, 1888 (Decapoda: Penaeidae) from Mar del Plata coast, Argentina

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Abstract

Commercial exploitation of *A. longinaris* is semi-artisanal in coastal waters of the Buenos Aires and Chubut Provinces, Argentina. Total landings have been variable, with mean values of 200 mt/ year in the last 10 years. This paper updates biological information on the population of *Artemesia longinaris* between 1994-2002. Shrimp were obtained from commercial catches from the Mar del Plata coastal waters. Landing values peaked between January and May, started to decline until July and increased again in December. A total of 7701 specimens were analyzed. Sex ratio was skewed towards females in all years. Significant differences were recorded in 90% of the samples. Size range varied between 6-22 mm carapace length (CL) with 19.84 maximum mean CL for males, and between 5-30 mm CL and 23.91 maximum mean CL for females. Mean values from the size frequency distributions of *Artemesia longinaris* in the Mar del Plata coastal waters indicate that there has been an increase in the shrimp sizes captured in the years 2001-02 compared to those of 1966-67. Stomach contents of 349 individuals from 27 samples taken between May 1965 and June 1966, and 267 from 5 samples between April and October 1979 were analyzed. Detritus and benthic meiofauna are considered main components of *Artemesia longinaris* natural diet. Presence of sand grains in almost all stomachs studied indicates that this shrimp mostly feeds on soft substrates. A conceptual model of the trophic web for the Mar del Plata coastal community is proposed.

Key words: Penaeidae, *Artemesia*, population, diet, food web

Introduction

Crustacean penaeids are important marine resources of economic value. Two species, *Pleoticus muelleri* (Bate, 1888) and *Artemesia longinaris* Bate, 1888 are commercially exploited in Argentina. Landings of *A. longinaris* oscillated between 36 and 430 mt during the last 30 years, supporting a small-scale fishery. Fifty per cent of the shrimp captured is used for human consumption and the rest is sold as bait for sport fisheries (Boschi, 1997).

The shrimp *A. longinaris* is distributed in the southwestern Atlantic from Rio de Janeiro, Brazil (23° S) to Rawson, Argentina (43° S) (Boschi, 1969). Individuals are unevenly concentrated in fishing grounds with soft bottoms up to 68 meters depth on sandy or muddy substrates (Boschi, 1969, Olivier *et al.*, 1968). Temperature, salinity and depth are key factors affecting the distribution of *A. longinaris* in different areas of the Brazilian coast as Fortaleza Bay, Ubatuba (Fransozo *et al.*, 2004). As in all penaeids, the species is sexually dimorphic, being the females larger than males. An interesting feature is that shrimp size increase along their geographical distribution range. While in southern Brazil individuals are the smallest, in

Mar del Plata they are of medium sizes and those from Patagonia reach maximum dimensions. Measurements reported for females are in terms of carapace length: 22.5 mm in Brazil, 29 mm in Mar del Plata and 37 in Chubut, while males reached 18.5 mm in Brazil, 24 mm in Mar del Plata and 27 mm in Chubut) (Ruffino and Castello, 1992; Boschi, 1997).

In Argentina, commercial exploitation of *A. longinaris* is semi-artisanal in coastal waters of the Buenos Aires and Chubut Provinces. Total landings have been variable, with mean values of 200 mt/year in the last 10 years. Variations in landings are mostly associated with two main causes: on the one hand, environmental conditions that affect larval and post-larval instars. On the other, less interest of fishermen on this species because they target the red shrimp *P. muelleri*, a higher marketable species that shares the fishing ground with *A. longinaris* (Boschi, 1969). In Mar del Plata, both species are captured up to 1-2 km off shore and between 3-10 m depth.

The shrimp is captured daily using small fishing vessels of 9-12 m length, from early morning to the afternoon. They lack cooling systems and the catch is boiled and stored sheltered from the sun and heat during the summer, until their return to the fishing port. The shrimp is captured using bottom trawl net with small doors and the vessels have winches to load the net. Largest individuals are captured during spring and summer, and for that reason fishermen mix those shrimps with *P. muelleri*, while specimens of medium and small sizes are sold as bait. Sometimes, when catches are extremely large, small and medium size shrimps together with the by-catch are sold to the fish flour industry.

The biology of this species has been extensively studied by Boschi (1969), who considered some characteristics such as the population structure, recruitment, reproductive cycle, size at maturity, growth, feeding, distribution and migrations. That information was based on data collected during the years 1965-66-67, but sampling - despite its infrequency- continued to the present. This paper updates biological information on the population of *A. longinaris* in Mar del Plata between years 1994-2002. The feeding ecology of *A. longinaris* is analyzed and we propose a conceptual model of the trophic web for the Mar del Plata coastal community.

Materials and methods

Data on landings were obtained from the *Dirección Nacional de Pesca, Subsecretaría de Pesca of Argentina*. Shrimp were obtained from commercial catches from the Mar del Plata coastal waters. It must be stressed that some sorting of the catch by fishermen is a potential source of bias. Carapace length (eye socket to mid-posterior carapace edge) measured with vernier calipers to the nearest 0.1 mm was the dimension chosen for size determination. For graphic representation of the data, size frequency distributions were obtained by splitting size records in 1-mm classes. Parameters from the size frequency distributions (SFDs) were calculated using the method of Mac Donald and Pitcher (1979). The program (MIX) splits modes that correspond to polymodal distributions using maximum likelihood and calculate the components of each distribution. Data on SFDs published by Boschi (1969) were recalculated here, and mean CL values corresponding to years 1966 and 2001-02 were compared by ANOVA one-way test and the sex ratio by $\chi 2$ test.

Shrimps were dissected and the stomach contents of 349 individuals from 27 samples taken between May 1965 and June 1966, and 267 from 5 samples between April and October 1979 were analyzed. Prey items were identified to major taxonomic levels. The percentage frequency of occurrence for each prey taxon identified was calculated. The arcsine transformation was performed so that the resultant data have an underlying distribution nearly normal (Zar, 1984), and a two-way ANOVA was used to compare prey items between sexes and years. The α level considered for all tests was 0.05. Our results, together with those obtained

from the literature (Boschi, 1969; Ilzarbe, 1987; Aquino, 1996; Mancurti *et al.*, 1996; Abelando y Seo, 2002) were used to propose the conceptual model of the trophic web for the Mar del Plata coastal communities.

Results

Landings

Overall landings for Argentinean ports reached maximum values in 1992 with 380.08 mt, then between 1993–98 they were close to 200 mt/year, and declined in 1999-2000 reaching minimum values of 37.45 and 36.51 mt/year (Figure 1). However, in 2001-2002 there was a marked increase in landings with values of 271.68 mt. Main ports of landings are Bahia Blanca, Rawson and Mar del Plata; this last one accounts for 15-40% of the total landings. When landings along the year are considered, highest values are concentrated mainly from January to May, and then they start to decline until July. In August there is a small peak, but they start to increase again in December. This pattern was observed for all years considered (Figure 2).

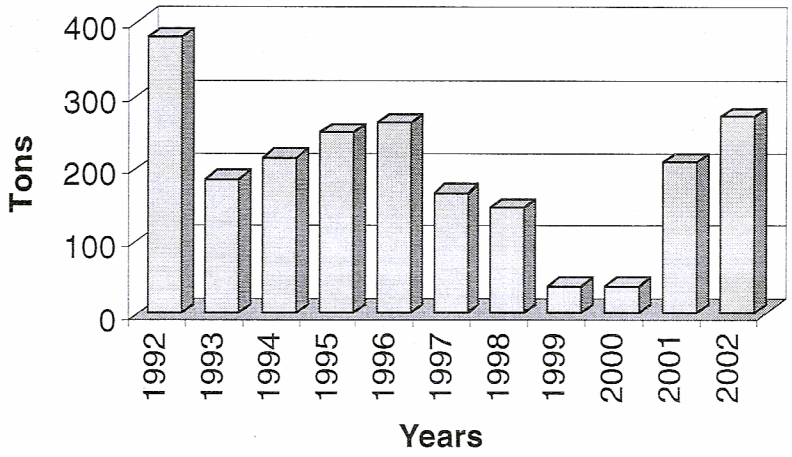

Figure 1: Total landings of *Artemesia longinaris* between years 1992-2002 in Argentina.

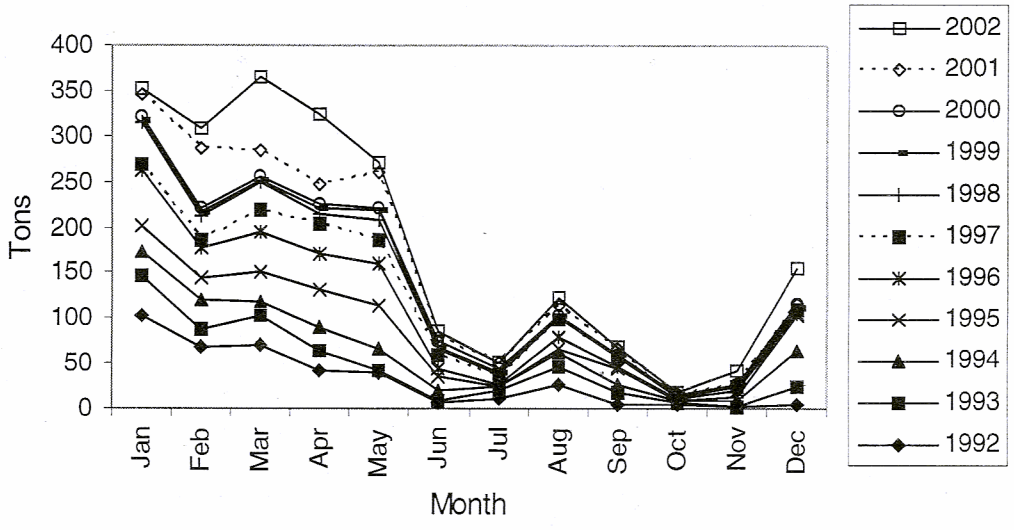

Figure 2: Monthly variations in landings of *Artemesia longinaris* along the year, all years compared.

Population structure.

A total of 7701 specimens were analyzed from which 78.48% were females and 21.52% males. Sex ratio was skewed towards females in all years and significant differences were recorded in 90% of the samples (n=17, $P < 0.0001$) (Figure 3). Size range of males captured varied between 6 -22 mm CL, and females between 5-30 mm CL. Maximum mean CL was 19.84 for males and 23.91 for females (Tables I and II). Adult shrimps were dominant in the samples, while younger ones were sporadically recorded throughout the study period. Size frequency distributions were uni- or bimodal along the study period except for the males in 1994, for which three components were detected (Table II, Figure 4). There was an increase in mean sizes among the years compared: in 1966-67 mean sizes of the smallest shrimps were less than 10 mm and the largest 21-mm. The opposite occurred in the '90s, in which mean values of the smallest shrimp were 12 mm and the largest > 25 mm. Mean CL of females were significantly different between years 1966 and 2001-2002 (ANOVA test, $F= 5.95$, $P< 0.05$).

Table I: Parameters obtained by MIX program from size frequency distributions of *Artemesia longinaris* females in Mar del Plata coast. Prop: proportion; S.D. standard deviation; df: degrees of freedom; $\chi 2$: Chi square test.

Date	Prop.	Mean	S.D.	Prop.	Mean	S.D.	$\chi 2$	df	P
10/11/94	1.00	17.66	1.59				4.8	2	0.09
01/12/94	0.42	16.92	2.42	0.58	23.11	2.30	18.9	12	0.09
08/12/94	1.00	22.09	2.48				17.5	11	0.09
22/12/94	1.00	21.85	2.31				10.1	9	0.35
29/12/94	0.59	16.52	1.30	0.41	22.67	2.29	7.0	9	0.64
31/01/95	1.00	18.74	1.74				8.7	7	0.27
27/02/95	1.00	19.58	1.76				26.7	10	0.02
28/03/95	0.66	17.48	2.72	0.34	21.62	0.85	7.2	7	0.41
24/11/95	0.40	19.35	3.47	0.60	22.68	2.43	19.0	11	0.06
28/11/97	0.40	12.75	1.72	0.60	21.42	1.74	28.5	11	0.02
27/02/98	0.77	14.88	2.54	0.23	20.31	1.08	10.5	8	0.23
24/05/98	1.00	16.07	2.32				9.1	8	0.34
09/07/98	1.00	17.69	2.76				20.2	10	0.03
24/05/01	0.34	14.62	2.60	0.66	18.96	1.96	7.0	8	0.54
10/08/01	1.00	23.91	1.82				12.0	6	0.06
08/11/01	0.60	15.23	2.73	0.40	24.93	2.17	14.4	17	0.64
12/02/02	1.00	22,28	2.50				33.0	13	0.01
01/03/02	1.00	23,00	1.86				24.9	10	0.01

Species composition in the catches

Artemesia longinaris was captured together with a number of fish and other invertebrate species whose presence varied along the year. Species that were present in most samples during the whole year were the red shrimp *P. muelleri*, the fish *Cynoscion guatucupa* and the ray *Atlantoraja cyclophora*. Species that were recorded only once were the crab *Corystoides abbreviatus* and the

hermit crab *Loxopagurus loxochelis*, the fish *Conger orbygnanus*, the angelfish *Squatina argentina* and other invertebrates such as the ctenophor *Mnemiopsis leidyi* (Table III). Other species were recorded at different moments, as shown by the fish *Percophys brasiliensis* and *Porichthyes porosissimus* in the spring. *Potamonotus saltatrix, Anchoa marini,* and *Engraulis anchoita* were absent from winter samples. 64.6% of the taxa correspond to finfish, 26 % were crustaceans and the rest, algae, squid and jellyfish.

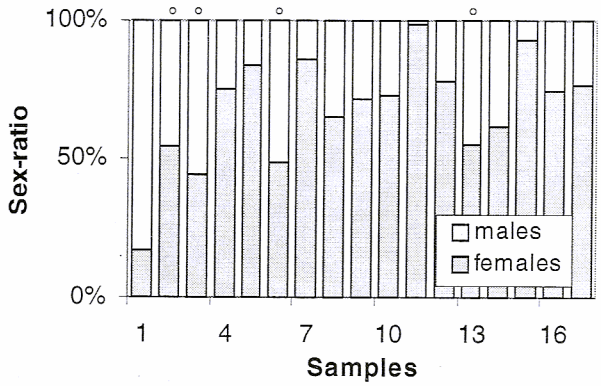

Figure 3: Sex ratio in *Artemesia longinaris*. Statistically significant differences respect an hypothetized 1:1 ratio was determined for 90% of the samples. ° Indicate no significant differences.

Table II: Parameters obtained by MIX program from size frequency distributions of *Artemesia longinaris* males in Mar del Plata coast. Prop: proportion; S.D. standard deviation; df: degrees of freedom; $\chi 2$: Chi square test.

Date	Prop.	Mean	S.D.	Prop.	Mean	S.D	Prop.	Mean	S.D	$\chi 2$	df	P
10/11/94	0.03	13.88	1.70	0.50	19.84	1.53	0.47	24.31	1.29	4.52	6	0.61
01/12/94	1.00	16.13	2.55							7.65	10	0.66
08/12/94	1.00	17.86	1.36							10.46	4	0.03
22/12/94	1.00	16.80	1.44							6.72	4	0.15
29/12/94	1.00	17.12	1.46									
27/02/95	1.00	16.30	1.59							0.50	4	0.97
28/03/95	1.00	16.08	0.65							7.36	1	0.01
24/11/95	1.00	17.86	1.11							1.96	2	0.37
28/11/97	1.00	12.73	2.26							2.29	5	0.81
27/02/98	1.00	13.70	1.94							5.86	5	0.32
24/05/98	1.00	14.98	1.29							5.58	5	0.35
09/07/98	1.00	14.57	1.48							6.77	5	0.24
24/05/01	0.34	12.30	1.79	0.66	15.78	1.09				5.26	4	0.26
10/08/01	1.00	18.90	1.62							0.88	3	0.83
08/11/01	0.39	11.57	0.60	0.61	16.22	3.22				3.80	7	0.80
12/02/02	0.44	15.47	1.46	0.56	19.73	0.88				2.49	4	0.65

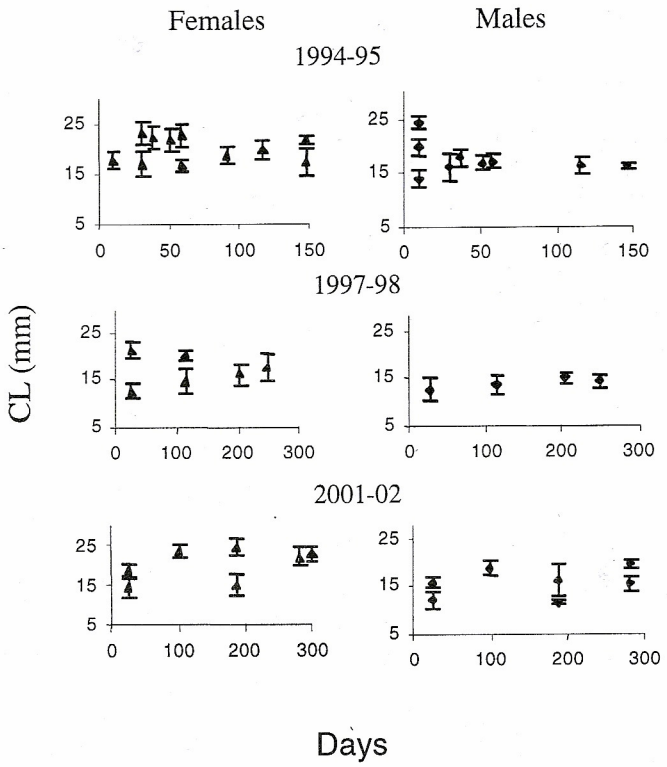

Figure 4: Mean carapace length (CL) and standard deviations of *Artemesia longinaris* in the years 1994-95, 1997-98, and 2001-02 sampled at the Mar del Plata coast.

Table III: Species present in the *Artemesia longinaris* sampling area year-round, during the sampling period 1965-66 and 1979.

	Common name	Species	J	F	M	A	M	J	J	A	S	O	N	D
Algae	Benthic algae				o						o		o	
Ctenophora	Comb jelly	*Mnemiopsis leidyi*		o										
Cnidaria	Jellyfish													o
Mollusca	Longfin inshore squid	*Loligo sanpaulensis*		o	o								o	
Crustacea	Argentine stiletto shrimp	*Artemesia longinaris*	o	o	o		o	o		o	o	o	o	o
	Argentine red shrimp	*Pleoticus muelleri*	o	o	o		o	o		o	o	o	o	o
	Shrimp	*Peisos petrunketvichi*						o		o	o			o
	Crab	*Corystoides abbreviatus*							o					
	Crab	*Cyrtograpsus angulatus*								o	o			
	Crab	*Pachychaeles laevidactylus*								o	o			
	Spider crab	*Libinia spinosa*			o			o		o	o			o

	Hermit crab	*Loxopagurus loxochelis*			o									
Osteichthyes	Blue fish	*Potamotonus saltatrix*												o
	Anchovy	*Anchoa marini*	o		o					o		o		
	Argentine anchovy	*Engraulis anchoita*									o			
	Brazilian codling	*Urophycis brasiliensis*	o		o			o			o	o	o	o
	Argentine conger	*Conger orbignyanus*							o					
	Whitemouth croaker	*Micropogonias furnieri*					o	o				o	o	o
	Brazilian menhaden	*Brevortia aurea*			o				o					o
	Bastard Halibut	*Paralichthys orbignyanus*			o		o					o	o	o
	Parona leatherjack	*Parona signata*								o	o			
	Butterfish	*Stromateus brasiliensis*	o		o									
	Stripped weakfish	*Cynoscion guatucupa*		o	o		o	o	o	o	o	o	o	o
	King weakfish	*Macrodon ancylodon*					o						o	
	River anchovy	*Lycengraulis olidus*			o									
	Brazilian flathead	*Percophys brasiliensis*							o				o	
	Atlantic midshipman	*Porichthys porosissimus*												o
Chondrichthyes	Patagonian smoothhound	*Mustelus schmitti*	o				o		o					o
	Argentine angel shark	*Squatina argentina*					o							
	Skate	*Dipturus chilensis*		o	o									
	Skate	*Atlantoraja cyclophora*	o		o		o	o				o	o	o
	Electric ray	*Discopyge tschudii*							o	o				

Note: The list of organisms represents the major species found in the sampled years

Natural diet

None of the stomachs analyzed were found empty, and the major components were sand grains (>80% in all samples), crustacean remains, sponge spicules and diatoms (approximately 60%), radiolarians and fish scales. Detritus was present only in 15% of the 1965-66 samples but in more than 88% of the 1979 ones (Table IV). There were no differences between males and females in their stomach contents (ANOVA test, F= 0.34, P>0.5) and between years compared (ANOVA test, F= 2.65, P>0.1).

Table IV: Stomach contents of *Artemesia longinaris* as number of items found by sex and percentage of 27 monthly samples between May 1965 and June 1966, and 5 samples between April and October 1979.

	1965-1966				1979			
	Females		Males		Females		Males	
Stomach content	N	%	N	%	N	%	N	%
Sand grains	207	80.2	77	84.6	105	84.0	41	97.6
Crustacean remains	163	63.2	54	59.3	85	68.0	34	80.9
Sponge spicules	157	60.8	72	79.1	70	56.0	15	35.7
Diatoms	153	59.3	65	71.4	74	59.6	16	38.0
Radiolarians	56	21.7	28	30.8	-	-	-	-
Fish scales	51	19.8	9	9.9	11	8.8	-	-
Macrophytes	43	16.7	5	5.5	-	-	-	-
Detritus	39	15.1	9	9.9	111	88.8	42	100
Tintinids	37	14.3	9	9.9	-	-	-	-
Undetermined eggs	30	11.6	6	6.6	-	-	-	-
Foraminifers	18	7.0	10	11.1	1	0.8	-	-
Ostracods	0	0	16	12.8	-	-	-	-
Others	30	11.6	18	19.7	-	-	-	-
Size (CL) mm	15.4-25.9		9.6-18.5		9.6-23.8		6.2- 3.6	
Nº of shrimps	258		91		125		42	
Total Nº of food items	984		258		473		148	

Discussion

The population biology of *A. longinaris* in the coast of Mar del Plata has been investigated by Boschi (1969) on the basis of samples mostly obtained during the years 1965-66 and 67. That study was conducted utilizing more than 30.000 specimens which provided the known information on recruitment, growth and mortality. In our analysis we compare parameters of the size frequency distributions and population structure between those early studies and from years 1994-2002. Sex ratio was strongly biased favoring females in most samples. Boschi (1969) also observed this pattern in the same area of the Mar del Plata coast and similar records were obtained in southern Brazil (Tremel, 1968; Nascimento, 1980; Ruffino and Castello, 1992). This could probably be related to natural and artificial causes. In the first level we include reproductive migrations as was documented in the population of *A. longinaris* at Bahía Blanca, in which there were unequal distribution of males and females (Boschi and Scelzo, 1977, Boschi, 1969). The major unnatural cause related to the biased sex ratio is due to two types of selectivity. There is a first selectivity from the gear and the other is done by the fishermen on the catch because they retain only shrimps which attain commercial size (Boschi, 1969). It is important to mention that in other studies in which the shrimp were not obtained from commercial catches the sex ratio was closely 1:1 (Carriquiriborde, 1984), pattern showed by other Penaeidae species (Ruffino and Castello, 1992).

The mean size composition of shrimps in the samples ranged from 12 to 25 mm CL. They were significantly larger than the mean sizes recorded in the first years of study in which the largest females reached 21 mm mean CL. Our results on the SFDs of *A. longinaris* in the Mar

del Plata coastal waters, indicate that there has been an increase in the shrimp sizes captured in the years 2001-02 compared to those of 1966-67, considering that the fishing ground is the same. One reason that could be determining this situation is that in the ´60s, the gear used in this fishery was mainly a beam trawl ("raño" in Spanish) in which the aperture was rigid and relatively small, approximately 5.0 m (Angelescu and Boschi, 1959). It was efficient in capturing small shrimps but larger individuals which could probably escape more easily. The gear used today, a bottom- trawl with doors, has an aperture significantly larger, near 15 m and is used for coastal fishing. It is similar to the net used in high fisheries but smaller in size. Probably, it is mostly difficult for the shrimp to escape from this net, resulting in the large sizes captured. Our results on the larger size attained by shrimp let us infer that this population is only moderately exploited.

The study period was characterized by the presence of dominant species such as the red shrimp *P. muelleri* and the fish *Cynoscion guatupuca* together with *A. longinaris* year-round. Scelzo *et al.* (2003) studying the seasonal variation of the diversity in the same fishing ground 25 years after, reported the same associations mentioned here. The presence of other species fluctuated along the study period, so those demersal- benthic components are considered occasional species. The presence of other taxa is reported in the study done by Scelzo *et al.* (2003) such as polychetes, gastropods, bivalvia, and ascideans. Our results are also similar to those reported for Brazil, in Sao Paulo, in shrimp fisheries in which crustaceans and fish are the most abundant when compared to other invertebrates (Severino- Rodrigues *et al.*, 1997).

The main components of the diet of *A. longinaris* are detritus and benthic meiofauna. It has been recorded the presence of sand grains in almost all stomachs studied, which indicates that *A. longinaris* mostly feeds on soft substrates. However, in a study on the trophic relationships on the shrimp fishing ground, Capítoli *et al.* (1994) do not mention the presence of sand grains in the specimen's stomach contents. These authors perhaps underestimated the presence of sand grains and so, their conclusions were based on the fraction analyzed. We consider that although sand grains are inert material, they have a film composed of bacteria which are utilized as nutrient source (Moriarty, 1977). This was shown for other *Penaeus* species with diet composition similar to *Artemesia.* The same accounts for the remains of crustacean appendices and detritus, which are mostly colonized by dense colonial bacteria, protozoos and fungi, which are the main diet components of these species. Moriarty (1977) indicates that the highest values of bacterial carbon in the stomach contents, compared to those of the sediment, demonstrate that the shrimp select pellets rich in bacteria but in a smaller proportion that was formerly proposed (Moriarty, 1981).

Artemesia longinaris feeds also on detritus, algae, foraminifers, ostracods and copepods, and for that reason we propose that it is a detritivorous- omnivorous species with some tendency to be carnivorous. In this topic, our conclusions differ from those of Capítoli *et al.* (1994). Based on experimental conditions in tanks reported by Boschi (1969), these authors concluded that the species mostly feed on plankton in the water column, but this assumption is misleading at least for the Buenos Aires coastal ecosystem.

Food web

The trophic significance of shrimps in the fishing grounds of *A. longinaris* in the Mar del Plata coast has been already stressed by Olivier *et al.*(1968) and Boschi (1969). A large number of carnivorous fish which integrate the Buenos Aires Province coastal web select *A. longinaris* as their main food item (Boschi, 1969; Capítoli *et al.,* 1994; Scelzo *et al.*, 1993). Presence of juvenile and adult shrimp was recorded in the stomach contents of pelagic, demersal and benthic fish, which are top predators in the coastal web (Table V).

Based on the results obtained here and information from other authors (see Material and Methods), the feeding relationships of the species studied are summarized in a topological food web in which qualitative interactions are proposed (Figure 5). We considered functional groups and determined the following categories: [a] detritus and sand grains (with a film composed of bacteria utilized as nutrient source), which is the main food component of *A. longinaris*, [b] phytoplankton, [c] zooplankton, preyed by the small shrimp *Peisos petrunkevitchi.* [d] micro-, meio- and macro- benthic fauna, from which both *A. longinaris* and *P. muelleri* feed on the microbenthos.

Our diagram shows descriptive relationships on feeding among species guilds especially on fish from which some of them are commercially exploited. There are a number of problems in fisheries management that require characterization of food webs as an early step in formulating management solutions (Winemiller and Polis, 1996). For that reason, our diagram synthesizes present knowledge of feeding relationships among species of interest in the Mar del Plata coast.

Table V: List of fish species with juveniles and adults of *Artemesia longinaris* in their stomach contents.

Chondrichthyes	*Mustelus schmitti*
	Galeorhinus galeus
	Squatina argentina
	Callorhynchus callorhynchus
	Discopyge tschudi
	Psamobatis bergi
	Atlanotraja cyclophora
	Sympterigia bonapartii
	Myliobatis goodie
Osteichthyes	*Pomatomus saltarix*
	Macrodon ancylodon
	Umbrina canosai
	Paralichthys patagonicus
	Paralichthys orbignyanus
	Cynoscion guatucupa
	Micropogon furnieri
	Urophysis brasiliensis
	Percophis brasiliensis
	Engraulis anchoita (Larvae)
	Lycengraulis olidus (Larvae and juveniles)
	Porichthys porosissimus
	Anchoa marini

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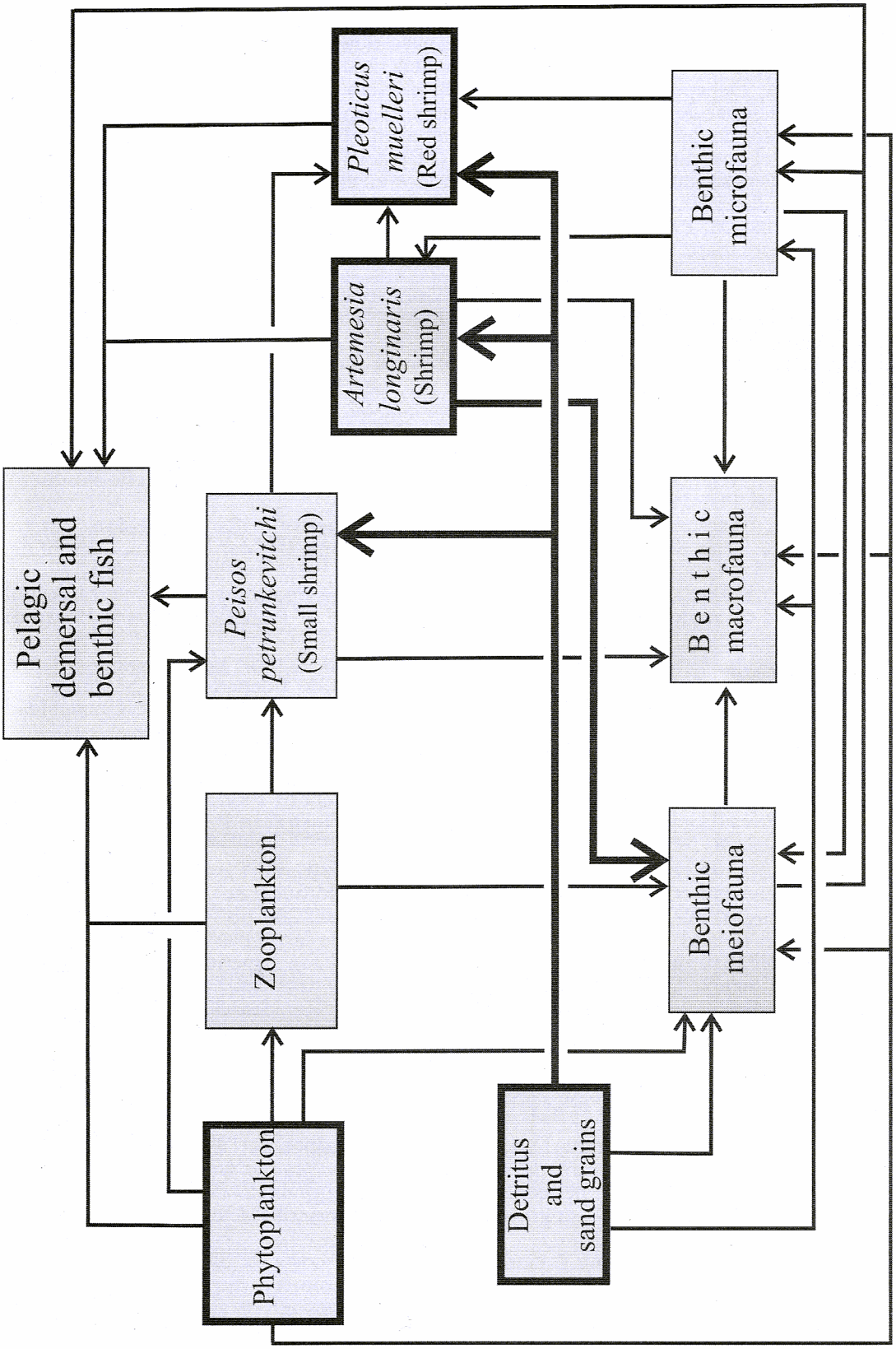

Figure 5: Graphic model indicating the qualitative trophic relations in the Buenos Aires Province coastal ecosystem. Wide lines show trophic relations of the shrimp and red shrimp. Sand grains are present in most individuals analyzed, so are included as substrates for bacterial growth.

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