

Gastropod relevance in predator–prey interactions on a benthic shallow sandy ecosystem at Mar del Plata, Argentina (38°S)

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The shallow sandy marine subtidal ecosystem off Mar del Plata, Argentina, is the scene of multiple fisheries activities, in particular the prawn–shrimp Artemesia longinaris and Pleoticus muelleri grounds. We examined the $\delta^{13}\text{C}$ vs $\delta^{15}\text{N}$ isotope signatures of 22 species commonly found in the area in order to understand how this ecosystem supports the fishery, with special emphasis on imposex-affected gastropod populations. Our results indicate that the main food source for Olivancillaria urceus and Buccinanops monilifer were bivalves and crustaceans. Buccinanops duartei and Olivancillaria carcellesi feed on bivalves and also on macroalgae. These findings indicate, for the first time, a slight selectivity of some of the gastropods studied for local drifted algal sources and how gastropods may scavenge available food from by-catch returned to the sea. The fishes Urophycis brasiliensis and Callorhynchus callorhynchus appeared to be the top predators of this area with B. duartei and O. carcellesi constituting important components of their diet.

Keywords: food web, gastropods, mixing models, stable isotopes

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INTRODUCTION

Information on trophic relationships among species is fundamental to understand how a marine ecosystem works as well as to anticipate the potential effects that anthropogenic activities have on an ecosystem. To elucidate the food web, analysis of stable isotope ratios is commonly used when direct observation and gut content analysis is not easy or possible (Fry & Sherr, 1984). This technique assumes that the isotopic composition of a consumer is directly related to the isotopic composition of its food source (DeNiro & Epstein, 1978). The nitrogen isotope ratio ($\delta^{14}\text{N}/\delta^{15}\text{N}$) determines the trophic position of a consumer in a food web because $\delta^{15}\text{N}$ tends to increase $\sim 3\text{--}4\text{‰}$ between any two trophic levels, apparently due to the loss of the light ^{14}N isotope in excretory products (Minagawa & Wada, 1984). Carbon signatures establish the trophic enrichment (usually 1‰, DeNiro & Epstein, 1978) and are mainly used to elucidate sources of primary production that support food webs (Persic *et al.*, 2004). Therefore, the dual isotope ratios can resolve ambiguities in food-web relationships, particularly for most benthic invertebrates where gut content analysis by stereoscopic microscope observation is difficult.

The sandy coastal ecosystem off Mar del Plata, Argentina, has supported a number of demersal and benthic fisheries for

many years. One of the most important fisheries is the ‘prawn–shrimp’, *Artemesia longinaris* Spence Bate, 1888 and *Pleoticus muelleri* (Spence Bate, 1888) fishing grounds (Scelzo *et al.*, 2002). The gastropod community associated with this fishery is dominated by the olive snails *Olivancillaria deshayesi-ana* (Ducros de Saint Germain, 1857), *Olivancillaria urceus* (Röding, 1798) and *Olivancillaria carcellesi* Klappenbach, 1965 as well as the whelk snails *Buccinanops monilifer* (Kiener, 1834) and *Buccinanops duartei* Klappenbach, 1961. These snail species are found buried in the sandy-silty bottom, living between 5 and 20 m depth, and little is known about their life history except for their direct development, presence of imposex (masculinization of the females caused by the presence of tributyltin in the water) (Penchaszadeh *et al.*, 2001; Teso & Penchaszadeh, 2009; Averbuj & Penchaszadeh, 2010; Teso *et al.*, 2012) as well as age and growth (Arrighetti *et al.*, 2012). These gastropods are important food sources for a number of species in this ecosystem (Penchaszadeh *et al.*, 2006) but their relative contribution to the food web is still not known.

The objective of this study was to characterize the trophic role of the gastropod community associated with the local prawn–shrimp fishery. This aim was achieved using a dual isotope approach ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) and a multiple-source mixing model to examine the relative contribution of potential food sources to gastropod diet, and the contribution gastropods make to the diet of the local predators. These results will increase understanding of trophic relationships within this exploited community and provide valuable baseline data to study future changes to the food web.

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MATERIALS AND METHODS

Study area

Sampling was carried out in the coastal area off Mar del Plata, Argentina ($38^{\circ}01'S$ $57^{\circ}31'W$), during summer 2006 (Figure 1). Annual range of salinity and temperature are 33.5–33.8 and 8–21°C, respectively (Guerrero & Piola, 1997; Teso *et al.*, 2012). The area is dominated by sandy and sandy-silty bottoms (Olivier *et al.*, 1968). Rocky bottoms nearby support large amounts of macroalgae that may serve as allochthonous food sources for soft bottom benthic consumers and as a refuge for the associated community (Scelzo, 2016).

Sample collection and isotope ratio determination

Eight hauls were conducted at ~ 1 knot from a depth range of 5–10 m with a bottom trawl (2 cm mesh size at the cod end and 2 m mouth opening). The dominant species were selected for the isotope analysis. Broad species groups included macroalgae, benthic epifauna (bivalves, gastropods, sea anemones, shrimps, crabs and hermit crabs) and fishes. All samples were individually frozen at $-20^{\circ}C$ until further analysis.

Macroalgal fronds were rinsed with distilled water, all visible epibionts were removed from their surface and samples were pooled to create a representative composite sample. Pieces of body wall of cnidarians and muscle tissue from crustaceans' abdomen (shrimp and prawn) and legs (crabs) were taken for analysis. Molluscs were removed from shells and foot muscle was dissected. Muscle tissue samples were dissected from the dorsal musculature of fishes. All samples were dried at $60^{\circ}C$ until they reached a constant weight and then ground into a fine powder with mortar and pestle. The dried samples were stored in Eppendorf tubes and kept frozen until analysis to prevent rehydration prior to transportation. Samples were transported to the GeoBioCenter^{LMU}, University of Munich and then were acidified to remove inorganic carbonates by

adding 2 N HCl drop-by-drop until no more CO_2 was released, in order to make stable isotope data comparable between taxa with variable $CaCO_3$ content (Jacob *et al.*, 2005). The samples were re-dried at $60^{\circ}C$ without rinsing to minimize loss of dissolved matter and ground again to a homogeneous powder.

Mass-spectrometric measurement of stable nitrogen and carbon isotope composition was carried out at the GeoBioCenter^{LMU}, University of Munich (Thermo/Finnigan Delta Plus). Data were expressed in the standard δ unit notation according to the following equation:

$$\delta X = [(R_{\text{sample}}/R_{\text{standard}}) - 1] \times 1000$$

where X is ^{13}C or ^{15}N and R is the corresponding ratio $^{13}C/^{12}C$ or $^{15}N/^{14}N$ and are reported relative to the Vienna Pee Dee Belemnite standard (PDB) for carbon and to atmospheric N_2 for nitrogen. Experimental precision (based on standard deviation of replicates of a peptone standard) was better than $\pm 0.2\text{‰}$. Considering a mean trophic fractionation in $\delta^{13}C$ of $\sim 1\text{‰}$ (DeNiro & Epstein, 1978; Peterson & Fry, 1987) and a mean trophic enrichment in $\delta^{15}N$ of 3.4‰ (DeNiro & Epstein, 1981; Post, 2002), as a result of the assimilation of food, we can estimate the mean isotopic composition of the diet of the macrofauna.

Isotope analysis

To quantitatively assess the importance of gastropods as predators and food sources, we used the available biological information on the consumer and mixing models in order to determine the most plausible diet. The IsoSource Visual BasicTM program developed by Phillips & Gregg (2003) provides an indication of relative prey consumption when the number of potential sources exceeds the number of isotopes used by more than one. This program is designed to use isotopic signatures to determine the range of feasible source contributions to a mixture when there are too many sources. We followed the 'a priori source aggregation' technique as given by Phillips *et al.* (2005). This method relies on an iterative model that considers all possible combinations of source proportions (that sum 100%) by some small increment (in this case 1%). Then the predicted isotopic signature(s) for the mixture are computed as each combination is created and compared with the observed mixture signatures. If they are equal, or within some small balance tolerance (in this case 1%) this combination of source proportions represents a feasible solution. In order to reduce the uncertainty of the results, potential sources with different isotope values from each other and a high number of samples were included in the model. The results were reported as means and lower and upper ranges.

Pre-existing values of $\delta^{15}N$ and $\delta^{13}C$ of the same community between 10 and 18 m water depth published by Penchaszadeh *et al.* (2006) were included in this analysis, i.e. the fish species *Callorhynchus callorhynchus* Meuschen, 1778, *Urophycis brasiliensis* (Kaup, 1858), *Micropogonias furnieri* (Desmarest, 1823) (small), *Micropogonias furnieri* (big) and *Cynoscion striatus* (Cuvier, 1829).

Samples of individual macroproducers and macroconsumers were pooled to create representative composite samples (Corbisier, 2006).

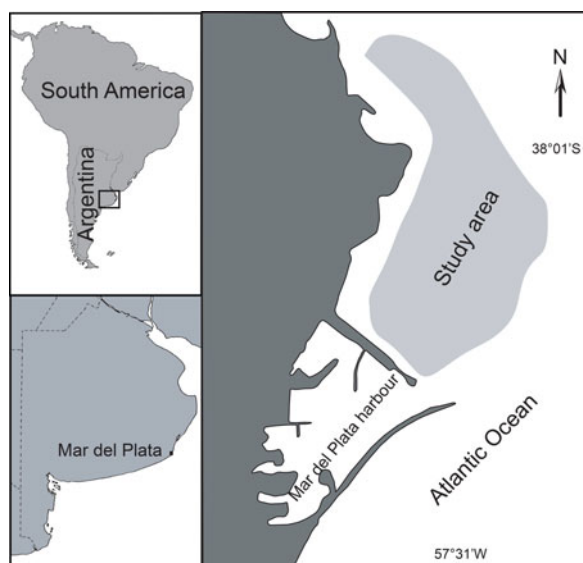


Fig. 1. Location map of the study area.

RESULTS

Macroalgae were at the base of the food web (Figure 2) with $\delta^{15}\text{N}$ values ranging from 7.3‰ (*Petalonia fascia* (O.F. Müller) Kuntze, 1898) and 10.2‰ (*Dictyota* sp.) (Table 1).

Filter feeder species had the lowest $\delta^{15}\text{N}$ values, with 10.88‰ for the bivalve *Solen tehueltchus* (D'Orbigny, 1843) and 11.1 ± 1.8 ‰ for the bivalve *Amiantis purpurata* (Lamarck, 1856). Among gastropods, *Olivancillaria carcellesi* had the lowest $\delta^{15}\text{N}$ signature (13.26 ± 0.88 ‰) and the Brazilian codling *Urophycis brasiliensis* was the species with the highest $\delta^{15}\text{N}$ value (17.1 ± 0.3 ‰) (Penchaszadeh *et al.*, 2006).

The corresponding $\delta^{13}\text{C}$ values for macroalgae, invertebrates and fishes are presented in Table 2. The ray *Sympterygia bonapartii* Müller and Henle, 1841 was relatively ^{13}C -enriched (-14.3 ± 0.02 ‰) while the macroalgae *Polysiphonia fucoides* was more ^{13}C -depleted (-20.0 ‰).

The mixed model analysis (Table 2) indicated that *A. purpurata* and *S. tehueltchus* constitute the majority of the diet of *O. urceus* and *B. monilifer*. The spider crab *Libinia spinosa* Milne-Edwards, 1834 and the shrimp *A. longinarius* are an important secondary food source for *B. monilifer* while *B. duartei* feeds mainly upon *A. purpurata* with a small

component of the macroalgae *Codium fragile* (Suringar) Hariot, 1889 and *L. spinosa*. *Olivancillaria carcellesi* showed evidence of having *S. tehueltchus* as the main prey item with a secondary contribution of the macroalgae *P. fascia*. *Olivancillaria deshayesiana*, *O. carcellesi* and *B. duartei* are important items in the diet of the Brazilian codling *U. brasiliensis*. The plownose chimaera *C. callorhynchus* also feeds on *B. duartei* with the crab *Ovalipes trimaculatus* (De Haan, 1833) as an additional important prey (Table 2). The electric ray *Discopyge tschudii* Heckel, 1846 showed evidence of having *S. tehueltchus* as the main prey item.

DISCUSSION

Traditionally, for reconstructing food webs, identification of food sources is accomplished by underwater direct observation, stomach content, and/or faecal pellet analysis. High turbidity in the study area reduces visibility making it impossible to directly observe gastropod foraging habits. It is also difficult to interpret the stomach content of gastropods. Isotope analysis was therefore the best possible tool to study the trophic role of local gastropods.

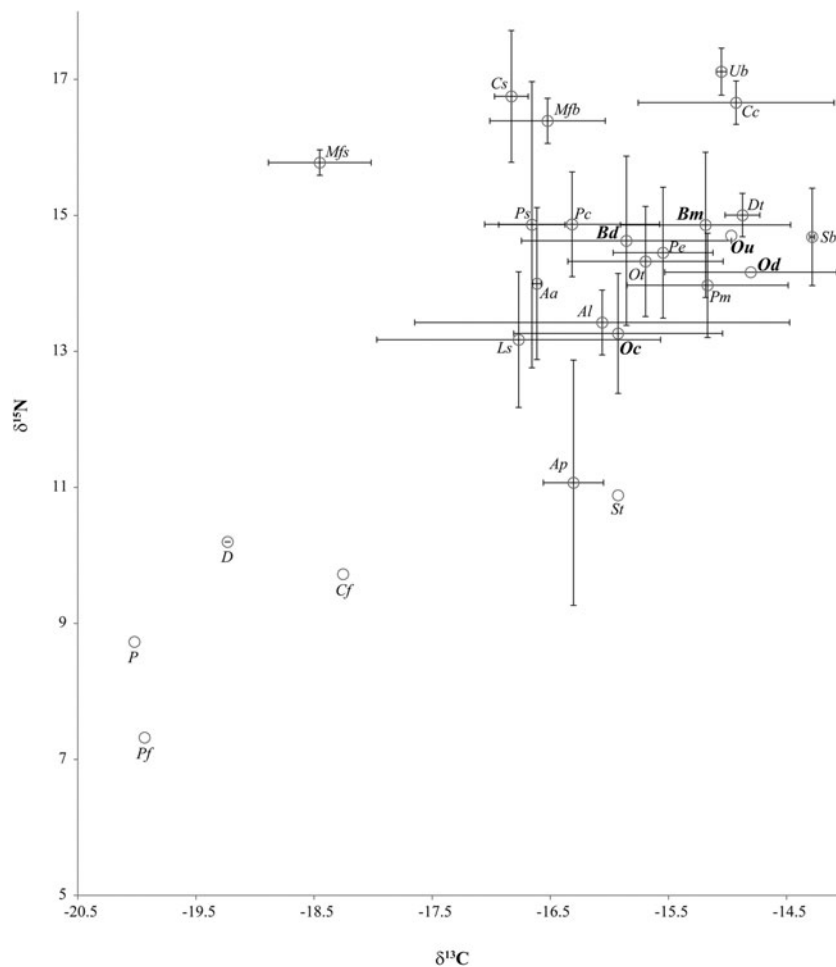


Fig. 2. Distribution of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ stable isotope ratio values (mean \pm standard deviation). D – *Dictyota* sp.; Pf – *Polysiphonia fucoides*; Cf – *Codium fragile*; P – *Petalonia fascia*; Aa – *Antholoba achates*; Ap – *Amiantis purpurata*; St – *Solen tehueltchus*; Ps – *Parona signata*; Pe – *Pagurus exilis*; Bm – *Buccinanops monilifer*; Bd – *Buccinanops duartei*; Od – *Olivancillaria deshayesiana*; Oc – *Olivancillaria carcellesi*; Ou – *Olivancillaria urceus*; Ls – *Libinia spinosa*; Ot – *Ovalipes trimaculatus*; Pc – *Platyxanthus crenulatus*; Pm – *Pleoticus muelleri*; Al – *Artemesia longinarius*; Sb – *Sympterygia bonapartii*; Dt – *Discopyge tschudii*; Cs – *Cynoscion striatus*; Cc – *Callorhynchus callorhynchus*; Ub – *Urophycis brasiliensis*; Mfs – *Micropogonias furnieri* small; Mfb – *Micropogonias furnieri* big.

Table 1. $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ stable isotope range of values of coastal food web and corresponding feeding strategy.

Species	Feeding type	N	$\delta^{15}\text{N}$	$\delta^{13}\text{C}$
ALGAE				
<i>Dictyota</i> sp.	Autotroph		10.2	-19.2
<i>Polysiphonia fucooides</i>	Autotroph		8.7	-20.0
<i>Codium fragile</i>	Autotroph		9.7	-18.2
<i>Petalonia fascia</i>	Autotroph		7.3	-19.9
CNIDARIA				
<i>Antholoba achates</i>	Omnivorous	3	12.7 to 14.7	-16.6 to -16.5
BIVALVIA				
<i>Amiantis purpurata</i>	Filter feeder	5	9.3 to 12.9	-16.5 to -16.0
<i>Solen tehuelchus</i>	Filter feeder	1	10.9	-15.9
GASTROPODA				
<i>Buccinanops monilifer</i>	Benthic invertebrate feeder	16	13.0 to 16.5	-16.9 to -14.4
<i>Buccinanops duartei</i>	Benthic invertebrate feeder	3	13.3 to 15.7	-16.9 to -15.2
<i>Olivancillaria deshayesiana</i>	Benthic invertebrate feeder	12	13.4 to 14.3	-15.7 to -13.9
<i>Olivancillaria urceus</i>	Benthic invertebrate feeder	3	14.6 to 14.7	-15.0 to -14.9
<i>Olivancillaria carcellesi</i>	Benthic invertebrate feeder	3	12.4 to 14.1	-16.9 to -15.1
CRUSTACEA				
<i>Pagurus exilis</i>	Omnivorous	3	13.3 to 15.1	-15.8 to -15.1
<i>Libinia spinosa</i>	Omnivorous	6	11.9 to 14.1	-18.2 to -15.2
<i>Ovalipes trimaculatus</i>	Benthic invertebrate feeder	6	13.0 to 15.2	-16.4 to -14.7
<i>Platyxanthus crenulatus</i>	Omnivorous	3	14.3 to 15.4	-16.8 to -15.8
<i>Pleoticus muelleri</i>	Detritivorous-omnivorous	13	12.5 to 15	-16.2 to -13.3
<i>Artemesia longinaris</i>	Detritivorous-omnivorous	14	12.8 to 14.2	-21.5 to -14.9
PISCES				
<i>Sympterygia bonapartii</i>	Benthic invertebrate feeder/Piscivore	2	14.2 to 15.2	-14.3 to -14.2
<i>Parona signata</i>	Benthic invertebrate feeder/Piscivore	2	13.7 to 16.3	-16.8 to -16.5
<i>Discopyge tschudii</i>	Benthic invertebrate feeder	2	15.0	-14.9
<i>Cynoscion striatus</i> *	Benthic invertebrate feeder/Piscivore	4	16.3 to 19.9	-17 to -16.6
<i>Callorhynchus callorhynchus</i> *	Benthic invertebrate feeder	2	16.3 to 16.9	-15.8 to 14.2
<i>Urophycis brasiliensis</i> *	Benthic invertebrate feeder	6	16.4 to 17.4	-15.42 to -14.4
<i>Micropogonias furnieri</i> (s)*	Benthic invertebrate feeder	3	15.6 to 16.0	-18.8 to -18.0
<i>Micropogonias furnieri</i> (b)*	Benthic invertebrate feeder/Piscivore	3	16.1 to 16.9	-17.0 to -16.0

*Refers to Penchaszadeh *et al.* (2006).

Table 2. Probable contribution of each potential food source based on IsoSource mixing model. Values are given as the mean per cent contribution, and 1st and 99th percentiles of the distribution of feasible solutions of each source to prey diet. Dashes indicate that the potential prey were not included in the analysis.

Dietary source	Gastropod diet			
	<i>O. carcellesi</i>	<i>O. urceus</i>	<i>B. duartei</i>	<i>B. monilifer</i>
<i>L. spinosa</i>	1 ± 0.3 (0-1)	4.3 ± 3.7 (0-18)	22.3 ± 3.2 (16-29)	11.6 ± 7.1 (0-29)
<i>P. muelleri</i>	-	5.2 ± 3.3 (0-33)		
<i>A. longinaris</i>		5.5 ± 4.2 (0-20)	-	9.6 ± 5.7 (0-24)
<i>S. tehuelchus</i>	70.3 ± 2.3 (64-74)	67.7 ± 11.4 (25-89)		39.2 ± 18.6 (0-79)
<i>A. purpurata</i>	2.3 ± 2.4 (0-9)	17.3 ± 12.4 (0-62)	54.7 ± 5.1 (44-65)	39.6 ± 20.6 (0-88)
<i>P. fascia</i>	26.1 ± 0.7 (25-27)	-	-	-
<i>C. fragile</i>	1.2 ± 1.3 (0-4)	-	23 ± 2.9 (20-27)	-
Dietary source	Fish diet			
	<i>U. brasiliensis</i>	<i>C. callorhynchus</i>	<i>D. tschudii</i>	
<i>O. carcellesi</i>	25.9 ± 13.3 (0-52)	-	-	
<i>O. deshayesiana</i>	6.8 ± 4.9 (0-20)	-	-	
<i>B. duartei</i>	10.9 ± 8.3 (0-33)	23.3 ± 15.8 (0-58)	-	
<i>P. crenulatus</i>	11.2 ± 8.4 (0-34)	-	-	
<i>O. trimaculatus</i>	-	37.3 ± 17.7 (0-76)	9.7 ± 5.8 (0-22)	
<i>L. spinosa</i>	-	6 ± 5 (0-20)	2 ± 1.9 (0-7)	
<i>P. muelleri</i>	-	-	6 ± 4.6 (0-18)	
<i>A. longinaris</i>	27.9 ± 19.4 (0-72)	-	6.2 ± 5.4 (0-22)	
<i>S. tehuelchus</i>	-	15.6 ± 8.1 (0-32)	70.1 ± 5 (48-79)	
<i>A. purpurata</i>	-	11 ± 7.9 (0-30)	6.1 ± 5 (0-20)	
<i>A. achates</i>	17.3 ± 11.2 (0-45)	6.8 ± 5.5 (0-22)	-	

In recent years, a common application is to use linear mixed models (Fry & Sherr, 1984). The isotopic composition of the consumer reflects their diet, so this mathematical model could calculate the proportion of each source after correcting for diet-tissue fractionation. Dietary mixing models, traditionally, have been developed to determine the diet proportion for $n + 1$ different food sources (n is the isotope value). However, when interpreting a food web, the most common situation is to have more food sources than potential isotopes. For this reason, Phillips & Gregg (2003) developed the IsoSource software, which determines multiple feasible solutions based on a mass-balanced approach. However, some controversial aspects arise from this model; one of them is that mixing models are sensitive to missing sources and the results may be interpreted erroneously if some sources are not included. The other limitation is the degree of uncertainty in diet proportion that the model provides (Philips *et al.*, 2014). According to Phillips (2012), the most important factor that affects the estimation on the uncertainty is the isotopic differences among sources. In our study, to reduce this uncertainty, sources with different isotope values from each other and a high number of samples were included in our analysis, with the exception of the bivalve *S. techuelchus*. This species is an important component of the food web (Penchaszadeh *et al.*, 2006) and we consider that by excluding it from the analysis we would lose valuable information. Moreover, the life-history parameters of each individual were used to interpret the probable food sources.

General food web structure

The diverse algae, invertebrate and fish species considered are broadly representative of the community present in the benthic shallow-water ecosystem off Mar del Plata (Olivier *et al.*, 1968; Scelzo *et al.*, 2002; Mantelatto *et al.*, 2007; Scelzo, 2016).

Among crustaceans, the spider crab *L. spinosa* is known to feed mainly on detritus, with a small proportion of crustaceans, molluscs and macroalgae (Acuña *et al.*, 2003). However, its $\delta^{13}\text{C}$ values were lower than expected unless the unidentifiable detritus found by Acuña *et al.* (2003) in its stomach content was composed mainly of macroalgal matter. The sea anemone, *A. achates*, is an epibiont of the spider crab and the volutid gastropod *Adelomelon brasiliense* (Lamarck, 1811) with a probably mutualistic relationship (Acuña *et al.*, 2003). The crab uses the anemone as camouflage while the latter benefits from the mobility and food availability of the crab, which is why the $\delta^{13}\text{C}$ values of both species were similar to those of the spider crab (Acuña *et al.*, 2003). *Adelomelon brasiliense* is a large snail up to 1 kg wet weight which is known to prey on *A. purpurata* (Penchaszadeh *et al.*, 2006). The shrimps *A. longinaria* and *P. muelleri* are considered to be detritivorous-omnivorous (Olivier *et al.*, 1968) as is the hermit crab *Pagurus exilis* (Benedict, 1892) (Roberts, 1968). Our results show great variation in the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of these three species, which suggests a considerable inter-individual variability in diet.

The whitemouth croaker *M. furnieri* (small) displayed the most depleted $\delta^{13}\text{C}$ values suggesting food sources that were not included in our analysis, probably polychaetes and small crustaceans, while adult specimens showed values more consistent with a diet based on bivalves (Penchaszadeh *et al.*, 2006; Botto *et al.*, 2011). The $\delta^{15}\text{N}$ values for *P. signata* were lower than expected for a species that feeds on benthic

invertebrates and fishes (Perrota *et al.*, 2006). The isotopic data were taken from juvenile individuals of *P. signata* (84 and 90 mm total length) with a limited range of prey compared with larger-sized individuals, that are able to feed on larger prey and select from a greater variety of prey species (Hobson & Welch, 1992; Davenport & Bax, 2002).

Trophic role of gastropods

Species of the family Nassariidae have been considered to be carrion feeders (Harasewych, 1998), nevertheless Penchaszadeh (1971) and Averbuj *et al.* (2013) demonstrated that *Buccinanops monilifer* and *B. cochlidium*, primarily feed on living bivalves and crustaceans respectively. In our mixing models *B. monilifer* feeds on bivalves (*A. purpurata* and *S. techuelchus*) which coincides with previous findings (Penchaszadeh *et al.*, 2006). However, *B. duartei* is likely to feed on macroalgae such as *Codium fragile*, in addition to bivalves (*A. purpurata*) and crustaceans (*L. spinosa*). This sandy-bottom environment is characterized by drifting algae on which small invertebrates inhabit, especially crustaceans (Scelzo, 2016). It is possible that *B. duartei* prey on crustaceans and associated algae as a food source. Therefore, the differences found in prey items between these two *Buccinanops* species may indicate micro-habitat partitioning. Small-scale trophic plasticity is a common mechanism in consumers, allowing them to adjust their diet to environmental availability of food items (Dubois *et al.*, 2007). The same occurred for the *Olivancillaria* species. For *O. carcellesi*, our mixing models showed that among all the feasible potential food sources considered, their diet is likely to include bivalves with a small proportion of macroalgae. However, according to the mixing model procedure, no feasible solution could be modelled for *O. deshaysiana*, although the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values (-13.8 and 17.5‰ respectively) are close to the corresponding values obtained for a diet based on filter feeder species. *Olivancillaria vesica* (Gmelin, 1791) and *Olivancillaria auricularia* (Lamarck, 1811) in Brazil consumed the bivalves *Donax hanleyanus* Philippi, 1847 and *Mesodesma mactroides* Reeve, 1854 and the crustacean *Emerita brasiliensis* Schmitt, 1935 (Rocha-Barreira, 2002). Hence, it is possible that *O. deshaysiana* feeds on small bivalves or crustaceans not captured by the mesh size employed in this study.

Our data indicate that gastropod species probably feed on carrion or on severely injured organisms rather than directly catching healthy prey. Since the study area is an important fishing ground, it is possible that food sources include by-catch returned to the sea after a fishing haul. Our isotopic analysis also showed that gastropods contribute to the diet of several important commercial fish species in the area. Fish species with isotopic values that match with gastropods as a food source were mainly demersal species, such as *U. brasiliensis* and *C. callorynchus*. *Callorynchus callorynchus* predation on bivalves and gastropods has been reported from several areas (Orensanz *et al.*, 1991; Di Giacomo *et al.*, 1994) while *U. brasiliensis* is known to feed mainly on crustaceans (Olivier *et al.*, 1968; Acuña Plavan *et al.*, 2007). Another fish associated with the gastropod community studied in this work was the electric ray *D. tschudii* whose diet was dominated by bivalves, also reported by Arrighetti *et al.* (2005).

This study was focused in a highly vulnerable environment due to anthropogenic activities. On one hand, all the gastropod species included in our study are taken as by-catch in the fisheries of the prawn *A. longinaria* and shrimp *P. muelleri*

(Arrighetti *et al.*, 2012). In this fishery context, it is important to understand the trophic interactions between target and non-target organisms. The overexploitation of the dominant species could change these interactions and in the last instance modify the biodiversity of this ecosystem. In addition, high concentrations of butyltins (BTs) have been found in surface sediments, gastropod tissues and egg capsules in the studied area (Goldberg *et al.*, 2004; Cledón *et al.*, 2006; Bigatti *et al.*, 2009; Laitano *et al.*, 2015). Gastropods and bivalves have the ability of incorporate and accumulate organotin compounds, attaining in some cases 30 times the concentration found in sediments (Horiguchi *et al.*, 1995; Cledón *et al.*, 2006). Consequently, several gastropod species of the region developed imposex (Penchaszadeh *et al.*, 2001; Cledón *et al.*, 2006; Bigatti *et al.*, 2009; Teso & Penchaszadeh, 2009; Averbuj & Penchaszadeh, 2010). Since many of the exploited fishes studied here feed on bivalves and gastropods, further studies should evaluate butyltin bioaccumulation along the food chain with a view on the possible human dietary exposure to butyltins.

CONCLUSION

Our study confirms most of the previous information on feeding habits of the species investigated, although some hitherto unknown feeding relationships were identified. The bivalves *A. purpurata* and *S. tehuelchus* play an important role in this trophic web contributing to a variable extent to the diet of most of the gastropods studied. The prawn–shrimp fishery indirectly supports the diet of the gastropod community by returning by-catch to the sea. According to our results, only *B. duartei*, *O. deshayesiana* and *O. carcellesi* contribute substantially to the diet of the economically important fishes of the area. As this investigation was mainly concerned with large epifauna, meiofauna and demersal species, further studies need to focus on the sedimentary fraction, including meiofauna and microinvertebrates.

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