

The biggest or the most abundant? Predation of the Black Drum *Pogonias cromis* (Perciformes, Sciaenidae) on benthic organisms in southern Brazil

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Abstract

Predators that consume larger prey acquire a greater net return of energy per individual, even though they are less abundant. The objective of this work is to analyze the feeding biology of *Pogonias cromis* in southern Brazil, in order to test for the occurrence of ontogenetic changes in diet as fish reach larger sizes, by consuming larger prey as they grow. Between August 2014 and May 2016, 347 specimens were collected from catches of the fishing fleet that operate in the Patos lagoon estuary and in the adjacent marine area of Cassino beach, that use artisanal fishing gillnets. The prey-specific relative importance index, food overlap, niche breadth and prey length preference were calculated for three length classes, class 1 (27.8–48.73 cm), class 2 (48.73–69.66 cm) and class 3 (69.66–90.60 cm). A total of 13 food items (6 species of crustaceans, 5 species of mollusks, fish fragments and non-animal fragments) were identified, where two species of mollusks (*Heleobia australis* and *Erodona mactroides*) represented 90.49% of the diet. The overlap index was moderate between classes 1 and 2, high between 2 and 3 and moderate between 1 and 3. There was a low niche breadth at the population level and for each length class. There were no significant differences in the length of prey consumed among classes. The data obtained here indicates that *P. cromis* can be classified as a predator specialized in mollusks, with low tendency to ontogenetic changes in southern Brazil. Considering information from the population of *P. cromis* from Argentina, it can be inferred that the species in the waters of southern South America is a benthic predator adapted to local conditions.

Keywords

feeding biology, food overlap, niche breadth, ontogenetic changes

Introduction

Animals exploit the available resources, adapting their strategies to the biotic and abiotic conditions of their habitats, within the range of possibilities imposed by their physiological and morphological conditions (Bolnick et al. 2002; Taylor et al. 2018).

In aquatic communities, niche enlargement, due to ontogenetic change in the diet, can be considered an adaptive response to certain environmental pressures (Abelha et al. 2001). As animals increase in length, there is often a shift from nursery areas to areas with a higher degree of competition (Carrier et al. 2012), which may lead to trophic generalization or specialization of populations (Bolnick et al. 2002).

The classical foraging models indicate that predators that consume larger prey acquire a higher net energy return per individual (Harper and Blake 1988). The maximization of benefits generates a positive energy balance, where the energy obtained can be invested in other activities, such as the development of gonads (Morse and Fritz 1987), increasing the possibilities of success of the population.

The black Drum, *Pogonias cromis* (Linnaeus, 1766), a demersal, estuarine-dependent fish distributed from the United States to Argentina (Nieland and Wilson 1993; Laiata and Aparicio 2005), can reach 150 cm of total length and 66 kg of total weight (Murphy and Taylor 1989). In southern Brazil, in the Patos lagoon estuary and the adjacent marine area of Cassino beach, this species is one of the largest teleost fish (Santos et al. 2016). This species is classified as Threatened in Brazil (MMA 2014), due to large catches in the 1970s. This led to intense population declines and the consequent collapse of fishing activity in southern Brazil (Haimovici et al. 2006; Haimovici and Cardoso 2017). Knowledge of population ecology of *P. cromis* in the subtropical climate of southern Brazil is scarce, hampering efficient sustainable management plans (Castello 2007; Santos et al. 2016; Santos and Velasco 2017).

Thus, this work aims to analyze the feeding biology of *P. cromis* in southern Brazil, in order to test for the occurrence of ontogenetic changes in diet as fish reach larger sizes, by consuming larger prey as they grow.

This study was performed on the Patos lagoon estuary and the adjacent marine region on Cassino Beach (Figure 1). The estuary extends for 900 km² and is characterized by the presence of islands, islets, channels and shallow inlets. Cassino beach has moderate to low sediment mobility (Figueiredo and Calliari 2006). The study area is one of the main national coastal fishing areas (Velasco et al. 2011).

The fish were obtained from catches of the artisanal fishing fleet (using gill-nets) between August 2013 and May 2016. After landing, specimens were measured (TL – total length in cm), weighed (TW – total weight in g) and eviscerated for removal of the gastrointestinal tract. In the laboratory, the stomach contents were identified to the lowest possible taxonomic level. Subsequently, food items were counted, measured (maximum length) and weighed with a precision scale (0.01 g).

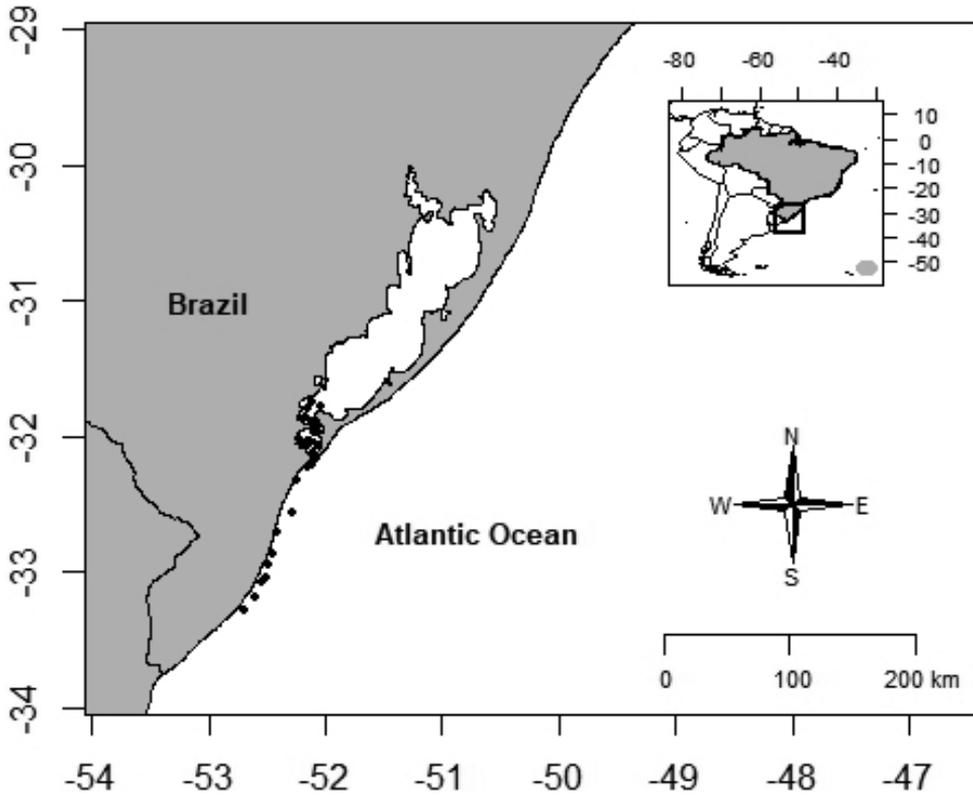


Figure 1. Study area and capture sites of the *Pogonias cromis* in southern Brazil.

To verify possible ontogenetic changes, three length classes were established, calculated from the division of the breadth of fish length into three equal parts, class 1 (27.8–48.73 cm), class 2 (48.73–69.66 cm) and class 3 (69.66–90.60 cm). Diet was quantified using numerical methods, such as percentage by frequency of occurrence (%FO), percentage by number (%P_{Ni}) and percentage by weight (%P_{Wi}) of food items (Hyslop, 1980). Subsequently, the Prey-Specific Index of Relative Importance (PSIRI) was calculated (Brown et al. 2012), by the formula:

$$PSIRI = \frac{\%FO \times (\%P + \%P_{Wi})}{2}$$

The food overlap between the length classes was analyzed according to the Pienka Index, ranging from 0 (no overlap) to 1 (total overlap).

$$\theta_{jk} = \frac{\left(\sum_{i=1}^n p_{ij} \cdot p_{ik} \right)}{\sqrt{\sum_{i=1}^n (p_{ij})^2 \sum_{i=1}^n (p_{ik})^2}}$$

Where θ_{jk} = Pianka food overlap measure between j and k ; p_{ij} = proportion of the food resource i in total resources used by j ; p_{ik} = proportion of food item i in total resources used by k ; n = total number of items. This index may be indicative of competition or resource sharing. The results of the overlap are considered high (> 0.6), moderate (0.4–0.6) or low (< 0.4) (Novakowski et al. 2008).

The population food niche breadth was calculated using the Levins measure (Krebs, 1999), with the assumption that the breadth of the diet can be estimated by measuring the uniformity of the distribution of the items among the various food resources. It was calculated as follows:

$$B = \frac{1}{\sum (p_j)^2}$$

Where B is the food niche breadth, p_j proportion of item j in the total diet. To standardize the measurement of the trophic niche (0 to 1), the formula of Hubert (1978) was applied.

$$B_a = \frac{B - 1}{n - 1}$$

Where B_a is the breadth of the standardized food niche and n the total number of food items consumed. From the maximum length data of each food item, five length classes were produced to analyze the feeding by prey-length preference (PLP), as follows: 1) for items of maximum length < 0.5 cm; 2) from 0.5 up to 1.0 cm; 3) from 1.0 to 1.5 cm; 4) from 1.5 to 2.0 cm; and 5) for items > 2.0 cm.

To verify the possible differences between the PSIRI and PLP values, the Kruskal-Wallis test was used among the three length classes due to the non-parametric nature of the data.

A total of 347 fish were analyzed, being 200 females (27.8–90.6 cm / 275–8650 g) and 147 males (28.2–85.9 cm / 270–7435 g), of which 239 had stomach contents (122 females and 117 males). In total, 13 food items were identified, which included 6 species of crustaceans, 5 species of mollusks, fish fragments (scales, heads and vertebrae) and fragments of non-animal origin (FNA) such as stones, wood, ropes and plastic. Mollusks were the main group in the diet of *P. cromis*, responsible for 92.70% of the results, where two species, *Heleobia australis* (D'orbigny, 1835) and *Erodona mactroides* (Bosc, 1801), were responsible for 90.49%, followed by crustaceans (4.77%), FNA (1.59%) and fish (0.59%) (Table 1).

The predominance of mollusks, within the length classes, was similar to the general pattern. In class 1 the highest values of PSIRI were found in *H. australis* and *E. mactroides*, however, in classes 2 and 3 there were a greater participation of different species, including an increase of *E. mactroides* and *Glycymeris longior* (Soweby, 1833) and a considerable reduction of *H. australis*. Crustaceans had low PSIRI values in all three length classes, with the highest value found in class 3. This class had

Table 1. Food items consumed by *Pogonias cromis* in southern Brazil (%PSIRI = percentage of the Pre-Specific Relative Importance Index of class 1, 2, 3 and in population (P), * = crustaceans and ** = mollusks).

Food items	% PSIRI(1)	% PSIRI(2)	% PSIRI(3)	% PSIRI(P)
<i>Amphibalanus improvisus</i> *	0.45	1.81	0.00	0.61
<i>Callinectes sapidus</i> *	0.00	1.17	4.08	3.30
<i>Sergio mirim</i> *	0.00	0.05	0.00	<0.01
<i>Loxopagurus loxochelis</i> *	0.00	0.00	5.45	0.33
<i>Libinia spinosa</i> *	0.00	0.03	5.73	0.50
<i>Sphaeromopsis mourei</i> *	0.01	0.18	0.24	0.02
<i>Buccinanops gradatum</i> **	0.11	0.10	0.43	0.06
<i>Heleobias australis</i> **	83.98	26.84	23.10	53.98
<i>Erodona mactroides</i> **	8.63	43.34	45.99	36.51
<i>Glycimeris longior</i> **	3.57	20.21	11.66	1.85
<i>Mesodesmas mactroides</i> **	0.05	0.87	3.28	0.30
Fishes fragments	0.31	2.50	0.42	0.95
NAF	2.89	2.90	0.42	1.59

the highest number of food items, 11 out of 13. The Kruskal-Wallis test revealed no significant differences between the three classes ($H = 2.67$, $df = 2$, $p = 0.263$).

The Pianka index showed moderate overlap between classes 1 and 2 (0.58), high between 2 and 3 (0.87) and moderate between 1 and 3 (0.43). The calculation of the Levins measure for the population resulted in a low niche breadth (0.13), and the same was found for classes 1 (0.03), 2 (0.19) and 3 (0.24).

The mean of the PLP of the three classes studied was 1.75, being 1.74 for class 1, 1.85 for class 2 and 1.85 for class 3. The Kruskal-Wallis test revealed no significant differences between the PLP of the three studied classes ($H = 0.054$, $df = 2$, $p = 0.973$).

Generalist populations tend to be more frequent in ecosystems as they allow more options for evolutionary success (Bolnick et al. 2002; Wilson et al. 2008; Layman et al. 2015). However, when prey availability is low, morphological adaptations to capture certain food items may be more advantageous, thus allowing the success of specialist populations and reducing ontogenetic changes within these populations (Hahn and Loureiro-Crippa 2006). This second scenario seems to be occurring with the population of *P. cromis* in southern Brazil.

In the study area, the main prey for *P. cromis* are the mollusks, *H. australis* and *E. mactroides*. These animals are among the most abundant benthic organisms in the area, inhabiting coves, zones with vegetation and deep regions of the navigation channel (Bemvenuti et al. 1978). During periods of high river discharge, in the Patos lagoon estuary, *H. australis* and *E. mactroides* suffer a significant population reduction, where *H. australis* emigrates due to low levels of salinity and *E. mactroides* is detached from the substrate by the force of the stream discharge (Bemvenuti et al. 1992). In this same period, the marine and estuarine-dependent fish move out of the estuary (Garcia and Vieira 2001). Thus, the times of greatest abundance of *P. cromis* and their main prey coincide, allowing intense predation.

Morphological adaptations for capture and digestion of mollusks are present in *P. cromis*. Enlarged olfactory canals, extensive lateral line and sensory barbels are used for prey detection. The mollusks are ingested in the oral cavity and transported to powerful pharyngeal jaws filled with large molariform teeth, which grind the ingested food before being sent to the stomach (Grubish 2005).

The largest food items found in the diet of *P. cromis* were crustaceans. The small participation of this group is possibly related to the low overlap between the fishing areas with the occurrence areas of the species. The most abundant crustaceans, such as *Callinectes sapidus* (Rathbun, 1896) (Garcia et al. 1996), are concentrated in low depth regions, such as marshes (Garcia et al. 1996; Bemvenuti and Colling 2010); in turn the fishing fleet operates in the deeper regions where there is greater fishing yield (Reis et al. 1994; Santos et al. 2016).

The ingestion of small prey by large fish has already been reported in some studies (Mittelbach and Persson 1998; Scharf et al. 2000). The high abundance of smaller prey attempts to balance the relationship between capture effort and final energy gain (Kerr 1974; Platt and Denman 1978). Slatyer et al. (2013) mention that a low niche breadth and the consequent alimentary specialization, is related to a low environmental tolerance and low habitat diversity. The data obtained in the present study suggest an attention to the conservation of *P. cromis* in southern Brazil, considering the degree of food specialization and low niche breadth. Although the local scenario needs attention, considering the data of Blasina et al. (2010) in a study in Argentina, which found a greater participation of crustaceans and seasonal changes in the diet, we can conclude for the present study that *P. cromis* is a benthonic predator adaptable to local conditions.

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