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Estuarine early life stage habitat occupancy patterns of whitemouth croaker *Micropogonias furnieri* (Desmarest, 1830) from the Patos Lagoon, Brazil

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ABSTRACT

The whitemouth croaker *Micropogonias furnieri*, inhabits marine and brackish waters, and is one of the main fishery targets along the Brazilian coast. The species uses different estuarine habitats as a nursery during its early life cycle. The main objective of this study was to investigate the estuarine spatial distribution pattern of *M. furnieri* in the Patos Lagoon Estuary (PLE) during different development stages. A non-continuous 11-year interval was used to understand development stage spatial variability and the influence of environmental variables in different sized abundance. Results demonstrated that each developmental stage is correlated with an estuarine habitat and is associated with different environmental variables that influence their occurrence. Eggs were associated with coastal environments, whereas larvae were abundant in the estuarine channel area. Juveniles of different sizes exhibited a different spatial pattern: post-settlement individuals (<30 mm TL) were associated with channel areas, individuals between 30 and 160 mm were related to shallow and deep environments; and, individuals larger than 160 mm were mainly associated with deep waters. These results revealed complex estuarine habitat occupancy by *M. furnieri* during its early life stages, with implications to the knowledge of its biology, conservation and management actions, such as the identification of the essential fish habitat.

1. Introduction

The whitemouth croaker *Micropogonias furnieri* (Desmarest, 1830) is a Sciaenidae which inhabits marine, brackish and freshwater environments. This species uses estuaries as a nursery ground and adults occur in shallow waters, usually around continental shelf areas, over muddy and sandy substrata (Nelson, 2006). The species can be found in the western Atlantic from the Gulf of Mexico (20°N) to Argentina (41°S) (Vazzoler, 1991). *M. furnieri* occurs year-around in the Patos Lagoon estuary (PLE), from its early stages (Muelbert and Weiss, 1991) to a size range of 10 to >250 mm TL (Vieira, 2006). The species ranks first in number in bottom trawl samples and also among the four dominant species in beach seine samples (Vieira, 2006), and depends on the PLE ecosystem to successfully recruit and maintain the adult population that supports local traditional fisheries (Abreu and Castello, 1997; Odebrecht et al., 2010). In Brazil, it is one of the main target species in fisheries (Haimovici and Ignácio, 2005) with annual catches over 40.000 tons (MPA, 2010).

In a recent review (Haimovici and Ignácio, 2005) the whitemouth croaker fishery was identified as in an overfishing status since 1960. Additionally to overexploitation, environmental changes caused by ENSO events can act in a synergic manner and influence local production (Moraes, 2011; Möller et al., 2009; Odebrecht et al., 2010; Schroeder and Castello, 2010). ENSO events have a direct effect in this ecosystem, influencing the salinity distribution in the estuary, with low salinity (associated with high river discharge and an increase with rainfall) during El Niño, and the highest values of salinity in La Niña years (Odebrecht et al., 2010). These conditions have a great influence on the distribution of early life stages of whitemouth croaker, therefore regulating the recruitment success of the species (Moraes, 2011; Muelbert et al., 2010; Vieira et al., 2010). This scenario reinforces the need to understand

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the importance of estuarine habitat for the different development stages during early life.

The Patos Lagoon (32°S, Brazil) is a warm subtropical river-dominated chocked lagoon with a significant relationship between total rainfall at the hydrographic basin and annual river discharge (Odebrecht et al., 2010). The estuarine region comprises about 1000 km^2, and represents 10% of the lagoon total area. Water exchange with the coastal ocean is controlled by wind forcing and freshwater discharge, resulting in variable geographic estuarine limits as this ecosystem is conditioned by climatic factors (Odebrecht et al., 2010; Seeliger, 2001). This ecosystem is predominantly shallow and composed of different estuarine habitats. Shallow waters (<1.5 m), intermediate waters (1.5–5.0 m), deep waters (>6.0 m), unvegetated subtidal flats (300 km^2), seagrass beds (120 km^2), marginal salt marshes (40 km^2) and artificial hard substrates represent the main habitat for marine invertebrates and fish species (Seeliger, 2001). Fish eggs, larvae and juveniles are transported into the PLE by deep channel currents; and retention and survival of these organisms in the estuarine region are dependent on the water exchange and prevailing winds (Martins et al., 2007; Muelbert and Weiss, 1991; Odebrecht et al., 2010; Sinque and Muelbert, 1997).

In determining the importance of estuaries for marine animals it is noteworthy that these ecosystems consist of a complex mixture of many habitat types and that these habitats are subjected to physical, chemical and biological interactions (Pihl et al., 2002). Habitat selection by fish species in an estuary may be associated to availability and structural complexity, prey and predator abundance, physical transport process and local environmental conditions (Blaber and Blaber, 1980; França et al., 2009). In this sense, the degradation and losses of these estuarine habitats can potentially affect fishes and fisheries that depend on them to survive. Knowledge of estuarine habitat usage during life cycle can serve as a conservation basis for species as the concept of Essential Fish Habitat, which encloses "those waters and substrate necessary for a fish for spawning, feeding or growth to maturity" (Minello, 1999).

The estuarine spatial and temporal patterns and variations of distribution of *M. furnieri* abundance during the juvenile stage is recorded for a variety of ecosystems (Costa and Araújo, 2003; Giannini and Paiva Filho, 1990; González-Sansón et al., 1996), including Patos Lagoon estuary (Castello, 1986; Vieira, 2006). Indeed, these spatial variation reflect ecological requirements of each development stage, and associated environmental features (Figueiredo and Vieira, 1998; Gonçalves et al., 1999). Despite the existing information about *M. furnieri* in the PLE and other environments as the Rio de La Plata estuary (Acha et al., 2012; Braverman et al., 2009; Giberto et al., 2007; Jaureguizar et al., 2003, 2008; Militelli et al., 2013), an integrated study that combines information on eggs, larvae and juveniles is still lacking. This is the first study that analyzes the occupational pattern of the species in an estuarine ecosystem covering from eggs to individuals larger than 160 mm. The integrated approach is important to better comprehend the ecology and to determine the pattern of use of the PLE by whitemouth croaker during its early life cycle, and can be considered as a first step to the identification of essential fish habitats for the species. So, the main objective of this study was to comprehend the estuarine habitat occupancy patterns of whitemouth croker *M. furnieri* in the PLE during different development stages (e.g. eggs, larvae and juveniles), and understand stage variability and the influence of environmental variables in stage abundance.

2. Materials and methods

2.1. Sampling methods

The analysis of the estuarine habitat occupancy pattern of the whitemouth croaker was based on abundance data of eggs, larvae and juveniles sampled in PLE (Fig. 1) during a non-continuous 11-year interval (1975–1984), composed by two sampling periods (1975–1978, and 1979–1984). Table 1 summarizes information for both ichthyoplankton sampling periods. Samples were taken with a conical plankton net (500 μm, 60 cm mouth diameter) equipped with a flow-meter, which was towed for about 3 min in surface water during the first sampling period. During the second sampling period, three depth strata (surface, mid-water and bottom depths) were sampled using the same net without a closing system. All samples were preserved in a 4% formalin solution. Water for salinity and temperature measurements were collected at each sampling station and depth strata with a Niskin bottle. Salinity was registered using an American Optical refractometer. Temperature was recorded in degrees Centigrade and was obtained with a thermometer. Since the aim of the present study is not the vertical variability of ichthyoplankton, mean egg and larval abundance, temperature and salinity data was used for each sampling station.

Data for juvenile abundance also covered two periods. The first coincided with the first ichthyoplankton sampling period (from

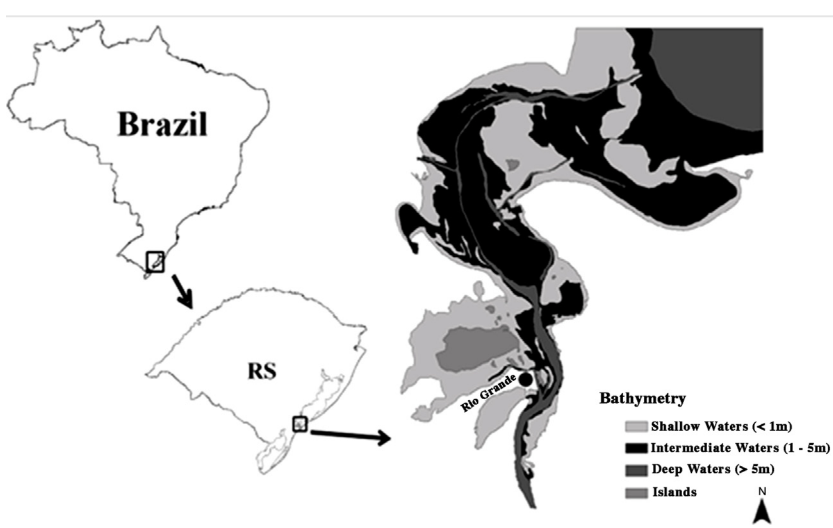

Fig. 1. Location of Patos Lagoon estuary in Rio Grande do Sul State (RS, Brazil) and bathymetry in the estuarine area.

Source: *C. Tagliani*.