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Chapter 8
Archaeology of Fishing of the Earthen and Shell Moundbuilders (Cerritos and Sambaquis) of the Patos Lagoon, Southern Brazil, 3200–200 Years BP

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Abstract Faunal remains deposited in archaeological sites are important sources for understanding the eco-historical processes and dialectic relations between human populations and the environment since Pre-Columbian times. They make it possible to present archaeologically framed models of biodiversity and an ecological past which, when compared to contemporary concerns, can drive political and technical decisions meant to solve current environmental problems. In this chapter, we analysed the data regarding long-term fisheries in the Patos Lagoon (located on the southern coast of Brazil) from 3200 years BP, based on the archaeological record of earthen (Cerritos) and shell (Sambaquis) moundbuilders of the Atlantic coast and Pampa biomes. By considering the data on captured fishes, radiocarbon dating, the position of the archaeological sites and the environmental and climate changes that occurred since the mid-Holocene, we inferred the role of fisheries in the societies and the climatic factors that drove the past practices. It was found that throughout the last three millennium fish were an important element in the diet of indigenous populations around Patos Lagoon year-round with emphasis on the spring and summer months, when adult specimens of some species enter the interior of the lagoon. Otoliths of small specimens of the sciaenid fishes *M. furnieri* and *Pogonias courbina* and catfish of the genus Genidens were dominant, suggesting fishing occurred

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mostly in shallow shoreside waters with fishing gear of limited efficiency. Although fishing was associated with the exploitation of the most abundant species, the data shows that the sizes of fish caught were smaller than those available in the environment due to the use of fishing gear that allowed the capture of mostly smaller specimens.

Keywords Patos Lagoon · Late Holocene · Earthen mounds (Cerritos) · Shell mounds (Sambaquis) · Coastal fisheries

8.1 Introduction

From a paleoenvironmental perspective, the remains of plants and animals in archaeological sites are an important source of information regarding the long-term dialectical relationship between human populations and the environment. By applying archaeology it is possible to access the record of human behaviour materialised in artefacts, bones of exploited and consumed animals, phytoliths, pollen grains and starches from managed and processed plants, coal and ash from bonfires and buried human bones, all arranged in a sedimentary package also composed of physical and chemical signatures of cultural activities and natural processes. This matrix of human-ecological information can be analysed to describe processes of environmental transformation, as well as to perceive the most dramatic moments of these changes over time. This information can be used not only to compose historical scenarios of interaction between humans and the environment, but also to understand long-term human-oriented ecological disturbances and serve as a point of departure to drive actions aimed at environmental and heritage conservation in the present (Balée, 2006).

The archaeological-ecological record is generally more complex, evident and significant among populations that lived in the same places for long periods. Behavioural recurrence in places with specific functions tends to make the record of human activities more archaeologically identifiable (Heckenberger, 2001). Archaeological sites intentionally built as mounds, for example, acquire a double importance as they are matrices of behavioural actions "sealed" in stratigraphic packages. This is the case of sites such as that of the earthen mounds (Cerritos) and shell mounds (Sambaquis). These two families of identifiable architectural forms were used and built by indigenous populations that inhabited the Pampa biome and the southern Brazilian Atlantic coast during the recent Holocene. Thus far, more than 3000 "*Cerritos de indios*" have been recorded in southern Brazil, Uruguay and northeastern Argentina between approximately 5000 and 200 years BP (López Mazz, 2001; Bracco et al., 2008; Milheira & Gianotti, 2018). They are earthen mounds ranging from 30 cm to 7 m in height, which occur singly or in groups of up to a hundred, usually arranged in grassland and wetland environments, such as fields and swamps. The sambaquis, in turn, are shell mounds reaching up to 6 m in height and appear on almost the entire Brazilian Atlantic coast. Similar to the

cerritos, they are found in both isolation and in groups of dozens of mounds. They generally are associated with marine and lagoon environments, and have been dated between approximately 8500 and 1000 years BP (Gaspar, 2000; Calippo, 2010; De Blasis et al., 2007). In this chapter, we did not include information on the Guarani indigenous groups due to the lack of quantitative zooarchaeological data regarded to diet and economy in the research area.

The Patos-Mirim complex that surrounds the watershed of Patos and Mirim Lagoons, between the southern coast of Brazil and Uruguay, is a one-of-a-kind environment to trace the ecological history of fishing populations from 3200 years BP, when the first recorded occupations took place (Schmitz, 1976; Milheira et al., 2017). In the Patos-Mirim complex, more than 400 cerritos and 11 sambaquis have been recorded, with zooarchaeological studies pointing to a wide significance of animal species in the composition of the sites, reflecting different pre-colonial indigenous strategies of capture, consumption and economic exploitation of the regional fauna. Through Abundance Index methods used in Zooarchaeology, such as the NISP (Number of Identified Specimens), the MNI (Minimum Number of Individuals) and the sizes of otoliths of fish in archaeological sites, it is possible to estimate the spectrum of ichthyological fauna, its relative abundance in the history of the sites and the sizes of fish captured.

In order to support such a historical-ecological approach to fishing in the Patos Lagoon, this chapter presents the main characteristics of the environment in which fishing was carried out and the information available on the ecology, diversity and abundance of species caught by the cerritos and sambaquis populations, between 3200 and 200 years BP. A synthesis of knowledge on pre-colonial indigenous occupation and use of food resources (including aquatic ones) is presented. Published and unpublished data on fish remains (notably otoliths) and radiocarbon dating from several archaeological sites in the region were considered, which supported the inference about the main species captured and the sizes of the specimens consumed over the more than 3000 year period under consideration. Finally, based on the interpretation of this data, discussions about the types of fishing practised, the artefacts used and the role of fish and fishing locations for these ancient indigenous populations are also presented.

8.2 The Estuary of Patos Lagoon and Its Ichthyological Biodiversity

The area under analysis in this project (Fig. 8.1) is located in the southern Coastal Plain of Brazil, and was formed from 400,000 years BP by a process linked to discontinuous sedimentary deposition events known as the Laguna-Barreira System (Tomazelli et al., 2017). This process is evidenced by the presence of at least four waves of sediment transported during the last marine transgressions and regressions that occurred between the Tertiary and Quaternary which isolated and formed

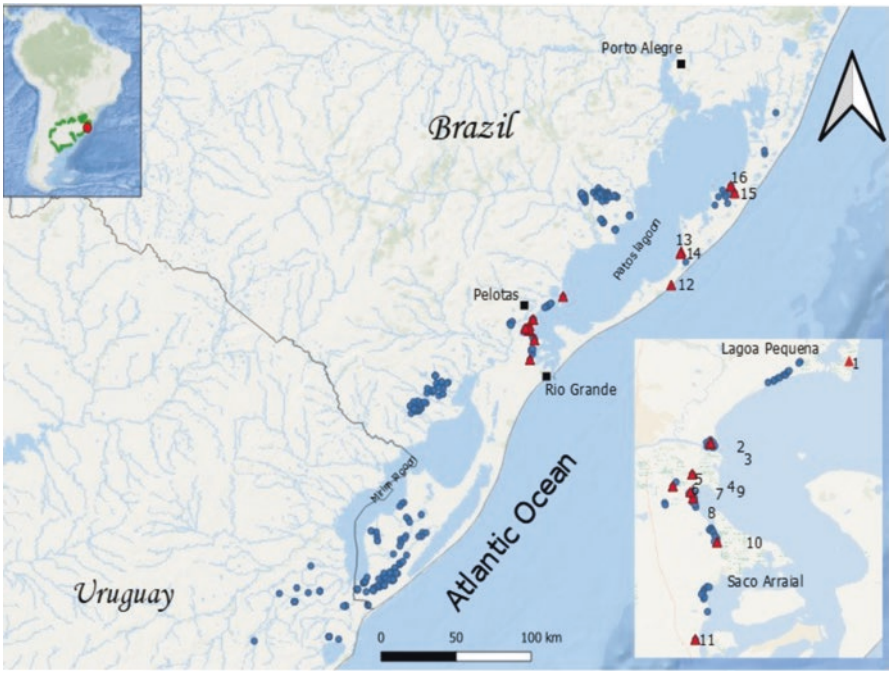

Fig. 8.1 Location of the research area between the Pampa biome and the Atlantic coast with the position of the cerritos in the Patos-Mirim complex (circles) and the studied sites (triangles) with emphasis on the area of the Patos Lagoon estuary. Studied archaeological sites: (1) PT-02-cerrito da Sotéia, (2, 3) Cerrito PSG-02 and Cerrito PSG-07, in Pontal da Barra, (4) RS-LS-11 Cerrito Ariano de Souza, (5) RS-RG-20, (6) RS-RG-21, (7) RS-RG-48, (8) RS-RG-49, (9) RG-8, (10) CI, (11) C-5 -II, (12) RS-LC-59 Sambaqui Capão D'areia, (13) RS-LC-16 Sambaqui Farol do Capão da Marca, (14) RS-LC-14 Sambaqui Capão da Marca, (15) RS- LC-42 Cerrito Nilton Dutra, (16) RS-LC-21 Cerrito Ondina Brazil

lagoon bodies (including the Patos-Mirim complex which appeared approximately 5500 years BP). The current geological structure of the Coastal Plain is composed of deposits of both marine and continental natures, modelled by weather, alongside alluvial and fluvial sedimentation. It results in a complex and diversified topography, which involves floodplains, terraces and deposits of fluvial network trough, flat terrain, dunes and paleodunes (Tomazelli et al., 2017).

As a result of these transgressive-regressive processes several lakes, supplied by river drainage from the mountains in the West, by the Atlantic Ocean in the East and by precipitation, were formed in the Coastal Plain. Laguna dos Patos (30°S and 32°S) is the largest obstructed lagoon in the world and one of the most voluminous bodies of water in southern Brazil, with an area of approximately 10,227 km^2. It is located between the state of Rio Grande do Sul and the east coast of Uruguay and is connected to Mirim Lagoon through the 75 km long São Gonçalo Channel (Simon & da Silva, 2015; Burns et al., 2019). The southern portion of the Patos Lagoon is home to an estuary zone, considered one of the greatest natural fisheries in Brazil.

This zone comprises approximately 963.8 km^2 (10% of the total lagoon area), between the Barra breakwater of the Rio Grande and an imaginary line between the island of Feitoria and Ponta dos Lençóis (Oliveira & Bemvenuti, 2006).

8.3 Fauna and Fishing in the Patos Lagoon and Adjacent Region

The estuarine portion of the Patos Lagoon is a large area for reproduction, spawning and breeding of a variety of organisms, such as fish and crustaceans that utilize the estuary throughout their life cycle, as well as more intermittent species, which inhabit the area for only a certain period, such as spawning and breeding seasons. The shallow (<2 m) and more protected areas (such as *Saco do Arraial* and *Lagoa Pequena*) (Fig. 8.1), stand out for the number of smaller fish. Meanwhile, in channels with a depth greater than 2 m, larger fish occur in more abundance, serving as movement corridors for the species (Oliveira & Bemvenuti, 2006).

The ichthyological fauna of the Patos-Mirim complex ranges includes over 300 marine, estuarine and freshwater species with different behaviours in habitat use (Chao et al., 1985). Among the most frequent species in the estuarine portion of the Patos Lagoon recorded in the post-colonial period are the whitemouth croaker (*Micropogonias furnieri*), the marine catfishes (*G. barbus* and *G. planifrons*), the black drum (*Pogonias courbina*), the silverside (*Odontesthes bonariensis*), the mullet (*Mugil liza*), the red flounder (*Paralichthys orbignyanus*), pink shrimp (*Farfantepenaeus paulensis*), blue crab (*Callinectes sapidus*), the menhaden (*Brevoortia pectinata*), and the small clupeid (*Lycengraulis grossidens*). In addition, there are common species in the environs of the São Gonçalo Channel, such as the trahira (*Hoplias malabaricus*) and the freshwater silver catfish (*Rhamdia* sp.). More frequent marine species in the coastal strip occasionally penetrate the lagoon by means of the wedge of salt water that flows through the channel and spreads to the deepest areas. In periods of low flow, this saltwater influx can reach as far as the shore of *São Lourenço beach*, nearly 100 km from the mouth. The presence of marine mammals such as the porpoise (*Tursiops truncatus gephyreus*) and the sea lion (*Otaria flavescens*) are also recorded in the Patos Lagoon (Castello & Pinedo, 1977; Pinedo, 1990).

The weights recorded by species in the available fisheries statistics indicate the most abundant species in the Patos Lagoon and adjacent coastal region. The percentages of the main species in the total landings of artisanal fisheries in the period of 1945–1975 were: croaker 35.3%, catfish 23.3%, menhaden 8.5%, mullet 8.4%, yellow hake 7.2%, black drum 4.7% and anchovies 1.5%. This period was chosen because it represents a time before the sharp decline and even the collapse of the main fisheries in the last four decades (D'Incao et al., 2002; Haimovici & Cardoso, 2017; Thykjaer et al., 2020). We observed that, together, croaker and catfish, which were also the most common taxa in zooarchaeological studies, represented 63.4%

of landings from contemporary fisheries in the Patos Lagoon, of which three species have their life cycle linked to the estuarine region.

The whitemouth croaker reaches relatively large lengths at up to 70 cm in total length and over 35 years of age in Rio Grande do Sul populations. It is considered mature between 2–4 years old at 25–40 cm and spawns between November and April in coastal waters close to the mouth of the Patos Lagoon (Haimovici et al., 2021). Adults enter the lagoon in spring, and young specimens appear throughout the year in the channel and coves of the estuarine region, where they find the ideal conditions for growth and feed preferentially on benthic invertebrates (Costa et al., 2014).

Marine catfish are fished both in the lagoon and on the adjacent coast, while juveniles are commonly found in the estuary and near ocean beaches (Reis, 1986a; Chao et al., 1985). Catfish are considered long-lived and slow growing species. *G. barbus* reaches sexual maturity at 40–43 cm in total length and between 8 and 9 years of age (Reis, 1986b). According to Reis (1986c), sexually mature *G. barbus* and *G planifrons* enter the Patos Lagoon from the sea in August and September before spawning, which takes place in November and December. Later the females return to the ocean, while the males remain orally incubating the eggs until their release between January and February. Recent studies indicate that adults of *G. barbus* return to spawn preferentially in the environments where they were born (Avigliano et al., 2017a). However, Avigliano et al. (2017b) suggest that the species shows great variety in relation to the environments where it completes its life cycle, with individuals that migrate annually between the estuary and the sea or that reside permanently in their habitat of birth, either in the sea or in sweet water. The "guri" catfish *G. genidens* is a freshwater and estuarine species that completes its life cycle in Patos Lagoon as evidenced in a recent study of stable isotopes by Pereyra et al. (2016).

The black drum is a species that can reach up to 140 cm in length, weigh up to 40 kg, and can live beyond 55 years of age, occurring both in the marine and estuarine environments. In the Patos Lagoon and adjacent region, spawning takes place between November and March, amongst individuals with 2–5 years of life, and with sizes between 40 and 70 cm. Food, both in the estuary and in adjacent waters, consists predominantly of bivalve molluscs, small gastropods, and crabs (Haimovici, 1997; Santos et al., 2019).

8.4 Earthen Mounds (Cerritos) and Shell Mounds (Sambaquis), Fishing Peoples of the Pampas and Atlantic Coast

The potential for catching fish in the lagoon environment has certainly attracted fishing populations since pre-colonial times, as attested by more than 400 cerritos (Milheira et al., 2019a, b), at least 11 sambaquis (Ribeiro & Calippo, 2000) and dozens of Guarani occupations (Milheira & Wagner, 2014), almost all showing

evidence of the exploitation of aquatic resources. Both cerritos and sambaquis, while sharing some characteristics, also have differences in terms of architectural structure and material culture.

In terms of economy, the earthen moundbuilders (cerriteiros), at the end of the Mid-Holocene, exploited a wide spectrum of animal and plant resources through hunting, fishing, gathering and also planting botanicals such as corn (*Zea mays*), beans (*Phaseolus* sp.) and pumpkin (*Cucurbita* sp.) (Iriarte, 2006; del Puerto, 2015). From 2500 BP onwards, a certain specialisation in the exploitation of some animals (deer and cavy) is known, which is accompanied by incipient experiences in animal management, associated with changes in the ownership of the territory and resources in general (Moreno, 2016). From 2500 years BP, there is also an economic diversification evidenced by the significance of fishing, especially in the environment of the Patos and Mirim Lagoons, where the cerritos demonstrate a meaningful exploitation of marine and estuarine-dependent species (Schorr, 1975; Ulguim, 2010, 2018; Sens, 2020; Chanca et al., 2021).

In this sense, if in the interior of Uruguay the cerriteiros seem to have been sustained by the fauna of mammals typical of wetlands, in the estuary of the Patos Lagoon, fishing seems to have played the central role (Milheira et al., 2019a). Pottery, invented around 3000 BP, was also an important technological improvement, reflecting new ways of processing, cooking, consuming and storing food. Animals and plants, therefore, were structuring resources of the economy of the earthen moundbuilders – a society that could be classified as a mixed economy of hunter-gatherers specialised in flooded environments (Iriarte, 2006) and oriented to fishing in some contexts (Chanca et al., 2021; Milheira et al., 2019a).

In the estuary of Patos Lagoon, approximately one hundred cerritos were recorded between the municipalities of Rio Grande, Pelotas, Capão do Leão, Mostardas and Tavares, since the first half of the twentieth century (Figs. 8.1 and 8.2). Between the 1960s and 1980s, a narrative (currently contested) was constructed regarding the Cerriteiro groups, defining them as populations with a low level of cultural complexity, a system of wide mobility determined by the abundance of seasonal species, existing between approximately 2500 and 200 years BP. An exhaustive identification work of species allowed Schorr (1975) and Schmitz (1976) to understand fishing and the exploitation of aquatic resources as the central factor in the social organisation of the cerriteiros, in which the estuary of the Patos Lagoon acted as a central area of seasonal encampments occupied during the hottest seasons of the year (spring and summer), given the abundance of estuarine-dependent species such as croakers, catfish and black drums. On the other hand, the rarity of mullet in the archaeological record, a species most present in the autumn and winter periods in the estuary, was suggested as an indicator that the indigenous occupations did not occur in the winter.

However, more recently, in the municipalities of Pelotas and Capão do Leão, a survey of 43 cerritos was carried out in the wetlands of Pontal da Barra, Lagoa do Fragata, and Lagoa Pequena (Fig. 8.2). Excavations at six of these sites have provided the most robust chronological information for cerritos in southern Brazil to date, with radiocarbon dates ranging from approximately 2400 to 800 years BP

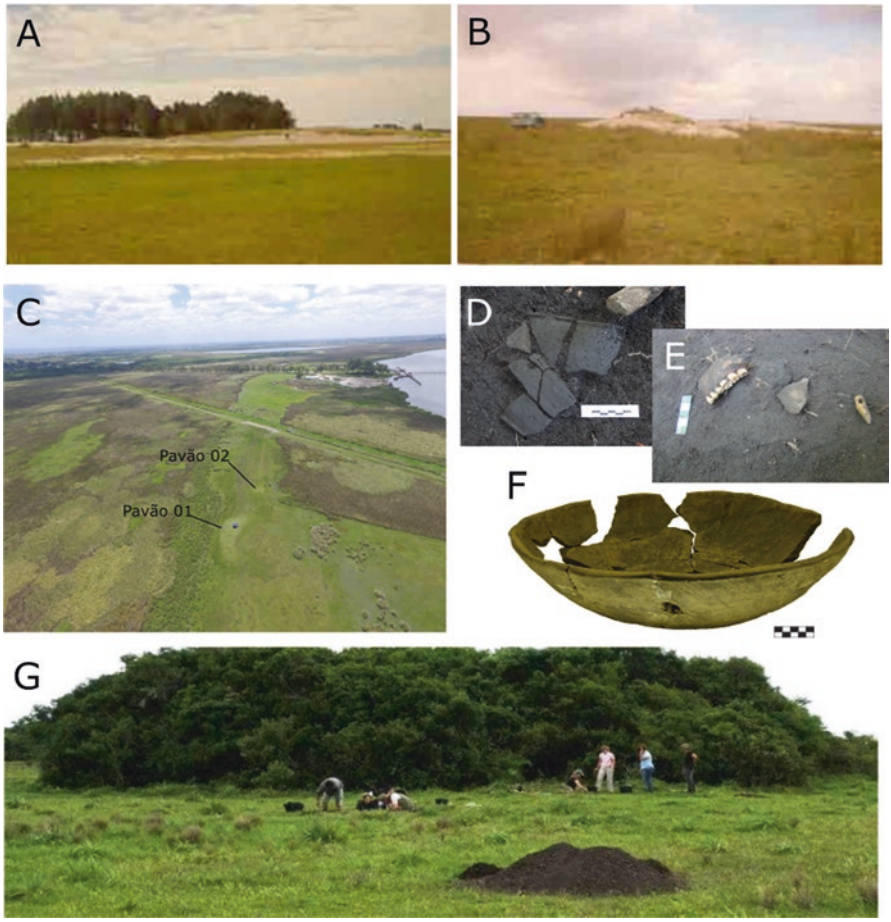

Fig. 8.2 Archaeological sites and material culture of cerritos and sambaquis in the Atlantic coast and Pampa region: (**a**) Sambaqui RS-LS-16, located in Mostardas; (**b**) sambaqui RS-LS-59, located in Tavares; (**c**) Cerritos Pavão 01 and 02, located on the banks of the São Gonçalo channel; (**d**); Ceramic sherd with suspension hole located in the cerrito PSG-07, Pontal da Barra; (**e**) Human jaw associated with a pendant made from a dolphin tooth and ceramics, located at cerrito PSG-02, Pontal da Barra; (**f**) Cerrito's ceramic vessel located at the CH2D01 site, Uruguay; (**g**) Cerrito PSG-06, Pontal da Barra in Pelotas

(Milheira et al., 2017, 2019a). The combination of radiocarbon dating, analysis of material culture and faunal remains suggests long-term occupation may have been compatible with the development of semi-sedentary villages, in which the estuarine environment would be stably and permanently occupied throughout the entire periods of the year and not just in the summer, as previously suggested by Schorr (1975) and Schmitz (1976). Oliveira (2006), Ulguim (2010, 2018), and Sens (2020), in turn, identified traces of mullet at the RG-48, PT-02, PSG-02, and PSG-07 sites respectively, which also suggests that fishing would have taken place permanently throughout all seasons of the year.

The cerritos of the estuary of the Lagoon of Patos are mounds with circular and elliptical shape, dimensions that vary from 20 to 120 m in the major axis (average of 26 m of radius), between 0.45 and 1.20 m in height (average of 0.85 m in height), and are generally located in riparian forests along rivers and lakes. A complex stratigraphic record is a distinguishing feature of these sites. Archaeological deposits are dark, rich in charred plant and fauna remains and artefacts, including a large number of ceramic, lithic and sometimes human bone fragments. Human remains normally occur disjointed, highly fragmented and spatially dispersed, following the same distribution pattern as the rest of material culture. The excavations were carried out from the top to the base of the mound structures, at artificial levels of 5 cm, 10 cm or 20 cm, with individual spatial recording of areas of activities and materials. The excavations at the sites covered between 1 and 4.5 m^2 of excavated area (average of 3.5 m^2), corresponding to 0.9 m^3 and 5.4 m^3 (average of 2.94 m^3) of excavated volume. Dating was performed in 13 cerritos with dates ranging from approximately 2500 to 200 years BP.

Among the sambaquis, for many years the inferred economic model was based on the premise of a heavy mollusc exploitation. However, this idea was revised in the 1990s, when it was realised that the marine, lacustrine and mangrove fauna, derived from fishing, had a much more important role in the economy than simple shell collecting (Figuti, 1992). Fishing would have been a foundational practice in the life of the shell moundbuilders (sambaquieiros) since the beginning of the occupations, around 8500 years BP. It was certainly a factor that allowed for significant demographic densification, especially during the Mid-Holocene, when there was a process of expansion of the sambaquieiro's territory denoted by the construction of gigantic mound structures and their functional diversification. The variation in the types of structures is evidence of important social transformations and practices. For example, it is now known that the species that were fished not only served to feed the body at the dietetic level, but also had a symbolic dimension, since fished animals became commonly associated with funerary deposits (Gaspar, 2000; Klokler, 2010).

As fishing societies, the sambaquieiros' centre of daily life were the lagoon, sandbanks, and the mangroves environments. The groupings of sites, the visibility between them and the notion of territory amongst these ecosystem would offer greater resource predictability (DeBlasis et al., 2007; Colonese et al., 2014; Scheel-Ybert & Boyadjian, 2020). Domesticated and managed plants were also important sources of food and certainly played a major role in the diet and economy of sambaquieiros societies. Species such as sweet potato (*Ipomoea batatas*), squash (*Cucurbita* sp.), yam (*Dioscorea* sp.) and corn (*Zea mays*) have been variably consumed since approximately 4000–3000 years BP, and this consumption of plants is also indicated by the stone milling tools and by dental marks that denote a carbohydrate-based diet, suggesting dietary diversity and complementarity between exploited fauna and flora; a typical case of mixed economy (Wesolowski et al., 2007; Scheel-Ybert & Boyadjian, 2020).

8.5 Spectrum of Zooarchaeological Fauna

The Patos Lagoon is a privileged region for zooarchaeology studies, with extant indexes of several animal and, specially, fish species identified from bones and otoliths. Regarding the cerritos studied in the estuary, located in the municipality of Rio Grande (RG-21, RG-49, RG-20, C-1, RG-08, C-5-II and RG-48), dated between approximately 2500 and 200 years BP (Table 8.1), Schorr (1975) and Oliveira (2006) identified and tallied a series of mammal species, such as cavy (*Cavia aperea*), raccoon (*Myocastor coypus*), armadillo (*Dasypus* sp.), armadillo (*Novemcinctus novemcinctus*), opossum (*Didelphis* sp.), deer (*Mazama* sp.), birds, reptiles, crustaceans, molluscs and fish such as *Cynoscion leiarchus, Hoplias malabaricus, Rhamdia* sp*., Mugil* sp*., Pimelodella* sp*., Pimelodus maculatus, Loricariichthys anus, Cichlidae, Sinbranchus marmoratus, P. courbina, M. furnieri, Genidens* sp., demonstrating that the ichthyological fauna is the most abundant and corresponds to the highest index of consumed and exploited biomass. In the RS-LS-11-Ariano de Souza cerrito, dated between approximately 2150 and 2050 years BP, the recorded fauna spectrum is more reduced, with catfish, croakers, black drums and pejerrey (Chim, 2016).

The cerritos of Pontal da Barra and Lagoa Pequena (PSG-02, PSG-07 and PT-02), in the municipality of Pelotas, dated between approximately 2400 and 800 BP, offered up a similar array of species such as the the mammals cavy (*Cavia aperea*), raccoon (*Myocastor coypus*), armadillo (*Dasypus* sp.), armadillo (*Novemcinctus novemcinctus*), domestic dog (*Canis lupus familiaris*), opossum (*Didelphis* sp.), deer (*Mazama* sp.) and water rat (*Holochilus* sp.). Reptiles are represented with specimens of the order *Testudines* (turtles and tortoises). Bony fish included *M. furnieri*, *P. courbina*, *Cynoscion* sp., *Mugil* sp., *Hoplias malabaricus* and *G. barbus; G. genidens; G. planifrons* (Ulguim, 2010, 2018; Sens, 2020; Milheira et al., 2019a). In the biomass calculation performed for the PT-02-Cerrito da Sotéia site, the Osteichthyes class presented the highest values, at 93% of the total, followed by the Mammalia class with 4%, Reptilia with 2% and Malacostraca with 1% (Ulguim, 2010).

The sandbank sites are located between 100 and 9000 m from the Laguna and 600 to 4000 m from the ocean. They are located on depositional barriers from 1 to 10 m in height, formed in the Holocene-Pleistocene ages where currently predominant vegetation of grasses and shrubs is typical of dune formation (Ribeiro et al., 2004). The structures of the cerrito and the three sambaquis are composed of shells of *Erodona mactroides* and *Mesodesma mactroides* (Ribeiro et al., 2004). In two sambaquis, Bager (2013) identified the euryhaline fish *P. courbina, M. furnieri and Genidens* sp. *Mugil* sp., freshwater *Hoplias* sp., *Rhamdia* sp. and marine *Carcharias taurus* and *Chondrichthyes*; the marine molluscs *Mesodesma mactroides, Amiantis purpurata, Phacoides pectinatus, Tivela zonaria, Adelomelon* sp*., Olivancillaria* sp*.,* and the terrestrian *Megalobulimus* sp. In addition to fish and molluscs, he also identified specimens of the deer (*Dasypus* sp.), some unidentified birds, animals of the order *Squamata*, marine mammals, small rodents and scarce fragments of crustacean claws.

Table 8.1 Number of specimens (NISP) identified in the sambaquis and cerritos of the Patos Lagoon, with values adjusted for the volume of 1 m^3 of excavation

Archeological site	RS-RG-21	RS-RG-49	RS-RG-20	C-1	RG-8	C-5 II	PSG-02	PSG-07	PT-02	RS-LS-11	RG-48	RS-LC-16	RS-LC-21	RS-LC-42	RS-LC-59	Total (inferred to one cubi meter)	%
Age of the site (years BP)	845 ± 85	2020 ± 50	–	1080 ± 90	–	200 ± 80	Between 1280 ± 20 and 1859 ± 29	Between 1214 ± 22 and 2340 ± 150	Between 1360 ± 40 and 1400 ± 40	Between 2056 ± 84 and 2147 ± 65	1355 ± 45	Between 1350 ± 50 and 2090 ± 60	–	3210 ± 60	Between 1070 ± 60 and 1090 ± 40		
Excavated volume (m3)	0.90	2.70	4.80	1.80	5.40	1.50	0.90	1.00	0.80	5.40	10.80	0.42	2.02	1.20	1.35		
Taxon																	
Genidens sp.	44	1023	64	641	5	359	1309	480	6084	58	578	629	99	620	426	12,417	36.3%
Micropogonias furnieri	40	284	5	9406	51	2269	830	228	3040	672	253	860	72	393	346	18,749	54.9%
Pogonias cromis	3	99	3	36	3	22	249	81	1921	4	5	24	57	134	24	2666	7.8%
Mugil sp.								4	4		1					9	0.0%
Cynoscion leiarchus								1								1	0.0%
Hoplias malabaricus									28		49					76	0.2%
Menticirrhus sp.																0	0.0%
Pimelodella sp.											1					1	0.0%
Pimelodus maculatus																0	0.0%
Rhamdia sp.											250					250	0.7%
Loricariichthys anus											1					1	0.0%

(continued)

Table 8.1 (continued)

Archeological site	RS-RG-21	RS-RG-49	RS-RG-20	C-1	RG-8	C-5 II	PSG-02	PSG-07	PT-02	RS-LS-11	RG-48	RS-LC-16	RS-LC-21	RS-LC-42	RS-LC-59	Total (inferred to one cubi meter)	%
Age of the site (years BP)	845 ± 85	2020 ± 50	–	1080 ± 90	–	200 ± 80	Between 1280 ± 20 and 1859 ± 29	Between 1214 ± 22 and 2340 ± 150	Between 1360 ± 40 and 1400 ± 40	Between 2056 ± 84 and 2147 ± 65	1355 ± 45	Between 1350 ± 50 and 2090 ± 60	–	3210 ± 60	Between 1070 ± 60 and 1090 ± 40		
Excavated volume (m3)	0.90	2.70	4.80	1.80	5.40	1.50	0.90	1.00	0.80	5.40	10.80	0.42	2.02	1.20	1.35		
Taxon																	
Geophagus brasiliensis											8					8	0.0%
Sinbranchus marmoratus											4					4	0.0%
Total	88	1406	71	10,083	59	2651	2388	794	11,076	733	1149	1512	229	1148	796	34,182	

Site ages (BP): Radiocarbon dating intervals

8.6 Faunal Composition of Fishing Resources

The numbers of identified fish (NISP) were collected at 15 archaeological sites located around Patos Lagoon (Schorr, 1975; Schmitz, 1976; Calippo, 2000; Oliveira, 2006; Ulguim, 2010, 2018; Chim, 2016; Milheira et al., 2019a; Sens, 2020). From these sites, 33 radiocarbon datings are available from human bone samples, fish otoliths, charcoals, shells and a domestic dog tooth (Schmitz, 1976; Loureiro, 2008; Chim, 2016; Milheira et al., 2017). Of these, five are still unpublished, and include the base of the Nilton Dutra-RS-LC:42 cerrito (3210 ± 60 years BP/Cal BP 3700 to 3420 – Beta 258667), the sambaquis Farol do Capão da Marca-RS-LC:16 (top: 1350 ± 50 years BP/Cal BP 1390 to 1240 – Beta 25865; base: 2090 ± 60 years BP/Cal BP 2300 to 1970 – Beta 258664) and Capão D'Areia-RS-LC:59 (top: 1070 ± 60 years BP/Cal BP 1180 to 920 – Beta 25866; base: 1090 ± 40 years BP/Cal BP 1220 to 970 – Beta 258668).

Taxonomic identifications of the species compiled in the specialised literature corresponded with the originals, except in two cases. Due to their similarity, it was not possible to discriminate among the otoliths of catfish of the genus *Genidens* present in the region (*G barbus; G genidens, G. planifrons and G. machadoi*) (Marceunik, 2005). In the set of sites, five euryhaline genera and seven genera of freshwater fish were recorded (Table 8.1). Secondly, *Umbrina* sp. (cited in Schorr, 1975) was not included as Oliveira (2006) recently reanalyzed the same collection of cerrito RG-48 and showed it did not include *Umbrina* sp., thus correcting the previous research bias.

The numbers of identified specimens (NISP) adjusted for a standard 1 m^3 excavation volume were calculated for each of the 15 sites (Table 8.1). Among all standardised pooled records, the most frequent eurialine fishes were *M. furnieri* 54.9%, *Genidens* sp. 36.3%, and *P. courbina* 7.8%, and together they were dominant in 14 of the 15 sites. *Rhamdia* sp. 0.7% and *H. malabaricus* 0.2% were the most frequent freshwater fish and were dominant in site RG-48 (Table 8.1).

The historical sequence of NISP in the 15 sites analysed around Patos Lagoon shows that catfish, croaker and, to a lesser extent, black drum were the most conspicuous fish caught throughout the time period under purview (Fig. 8.3). The lowest relative abundances occurred between 3200 and 1800 years BP. The maximum was reached between 1100 and 400 years BP, decreasing again until 200 years BP. Catfish were the most abundant in 1400 years BP and croakers between 1000 and 200 years BP.

8.7 Size Composition of Caught Fish

In the sambaquis (RS-LC-16 and RS-LC-59) and cerritos RS-LC-42 and RS-LC-21 (Calippo, 2000), located on the sandbank, between Laguna dos Patos and the ocean, it was possible to calculate the total lengths (TL) and total weights (TW) of croaker,

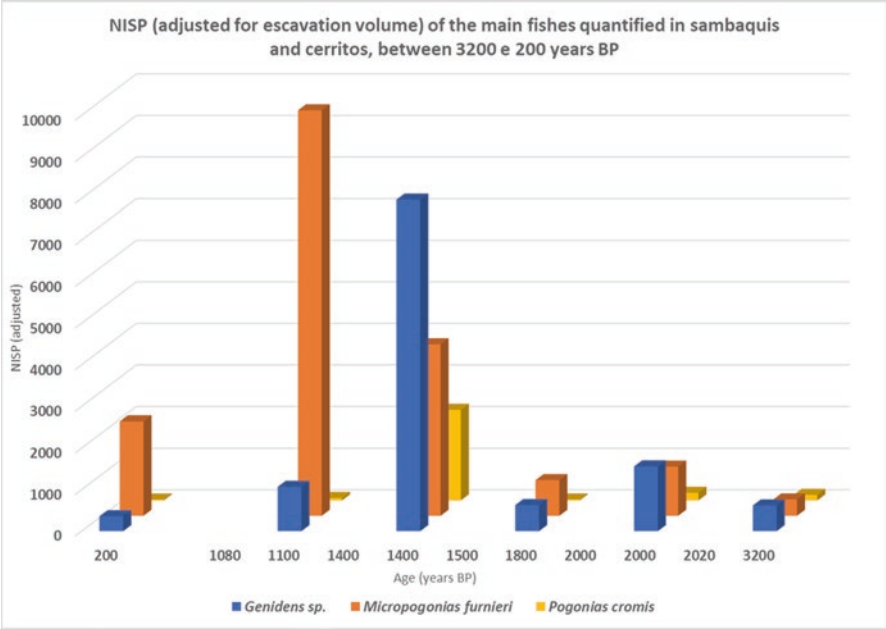

Fig. 8.3 Total number of NISP specimens from each analyzed site, adjusted for a 1 m^3 of excavation

catfish and black drum based on the otolith sizes (OS) of 1446 *M. furnieri* (13.6–77.0 cm), 1783 *Genidens* sp. (11.3–115.8 mm) and 320 *P. courbina* (13.6–104.9 cm) (Fig. 8.4), according to Bastos (1990), Calippo (2000), and Haimovici and Velasco (2000).

Figure 8.4 shows the estimated length compositions for all three species at the four sites. Croaker from the RS-LC-16 and RS-LC-21 sites showed shorter average lengths in the range of 20–25 cm, while in the RS-LC-42 and RS-LC-59 sites the average occured in the range of 30–35 cm (sites where the largest sizes for croakers were also identified). At cerritos RS-LC-21 and RS-LC-42, the most frequent catfish lengths are between 25 and 30 cm. In sambaquis, the most frequent catfish occur between 30 and 45 cm (lacustrine sambaqui RS-LC-16) and 30–35 cm in the marine site RS-LC-59. Black drum of the entire length spectrum occurred in the RS-LC-21 and RS-LC-42 and RS-LC-59 sites, while in the RS-LC-16 site only smaller black drums (from 20 to 45 cm) were present. Considering these fish as a whole, it is observed that the catches predominantly include small fish (which are included in the size spectrum of catfish and croaker caught in contemporary fisheries). In contrast, large black drums, measuring more than 120 cm and weighing over 20 kg, quite frequent in fisheries until the 1970s, were completely absent from the sites.

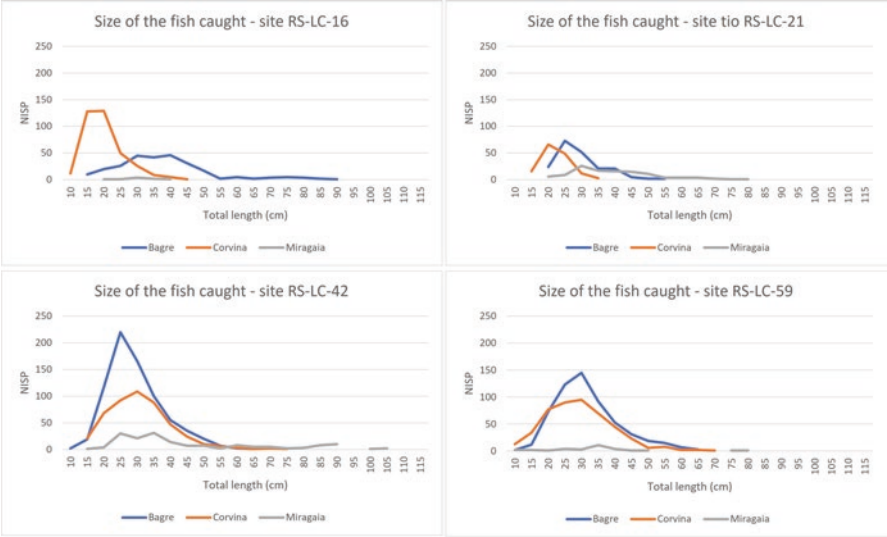

Fig. 8.4 Number and size estimate of catfish, croaker and black drum identified in archaeological sites RS-LC-16, 21, 42 and 59

8.8 Discussion

The spectrum of fauna identified in the cerritos and sambaquis of the estuary and sandbank of the Patos Lagoon indicates that the animal resources captured and recorded in the archaeological sites represent the fauna in local wetland environments such as swamps, lakes and rivers. The data indicates that fish are the most significant fauna in terms of abundance, representing up to 93% of the biomass consumed among the moundbuilders, as indicated in the case of the PT-02-Cerrito da Sotéia cerrito (Ulguim, 2010). The remaining 7% would be represented by the other species of mammals, turtles and birds. The relative calculation of abundance shows that there are two most representative taxa at the sites: the croaker represents around 49.9% of the total weighted NISP in all the sites and the catfish (*Genidens* sp.) with approximately 36.3%. Black drum occurs in only 7.8% of the total weighted NISP. The other taxa do not reach even 0.5%.

The interpretation that croakers, catfish and black drums are the most important estuarine-dependent species in the diet of the populations that inhabited the Patos Lagoon is also supported by isotopic analyses. Chanca et al. (2021) demonstrated that there is a predominance of marine and estuarine fauna captured and consumed by cerriteiros in the region, whose values of collagen samples from human individuals of $\delta^{13}C$ and $\delta^{15}N$ range from −21.3‰ to −10.7‰ and from +5.8‰ to +18.3‰ respectively, which coincides with the zooarchaeological data compiled in the present work.

As a hypothesis, it is suggested that the other species with low frequency may have been consumed occasionally or used as bait. It is common among the fishermen of Patos Lagoon, for example, to use shrimp meat and small fish species as bait. As an alternative hypothesis, the low frequency of some fish species, shrimp and cartilaginous species could have happened due to taphonomic, preservation and/or sampling. An interesting topic that should be considered in future research is the role of the large sized black drum in the diet which, despite its lower frequency (NISP below 10%) may have been important in the diet, due to its large amount of meat-to-size ratio.

From the point of view of the almost 3000 years of fishing history of catfish, croaker and black drum in the area, it is clear these have been the most exploited key-species in the estuarine and sandbank environment, from the pre-colonial period until the present day. The predominance of these species can be inferred considering four non-exclusive questions:

1. They were the most captured species due to food choices inherent to the socio-cultural systems of both indigenous groups. Catfish and croaker are the most abundant taxa in several archaeological sites of fishermen-hunters-gatherers on the south Atlantic coast, such as in the sambaquis located in Babitonga Bay, on the northern coast of Santa Catarina (Fossile et al., 2019), in the sambaqui Jabuticabeiras II (Klokler, 2010), at the Lagoa dos Freitas site (Pavei et al., 2019), on the south coast of Santa Catarina, and the sambaqui Sereia do Mar (Wagner et al., 2020), on the north coast of Rio Grande do Sul. The frequency of catfish and croaker on a large coastal scale suggests standardised consumption behaviour and interaction between different coastal fishing groups, which lasted over millennia of occupation of the lagoon and sandbank environments. Note that local frequency variations may be linked to opportunistic behaviours driven by the ecological availability of species, typical of mixed-economy societies, whose food choices oscillate between animal, and plant species complementary (Iriarte, 2006; Scheel-Ybert & Boyadjian, 2020).
2. Fishing tackle were preferably used to capture these species, masking the frequency of smaller species. It is interesting to note that the most captured species occurred in shallow waters close to the coast, which may indicate that they could be captured with fishing gear that does not necessarily require the use of boats. The use of boats would facilitate fishing of species along their migratory circuits, such as mullet, which occur less frequently in the archaeological record. However, although there are no direct records of vessels in the archaeological contexts of the Patos and Mirim Lagoons, the occurrence of traditional indigenous canoes made of a tree trunk (monoxyls) in other locations along the Pampa, such as the Uruguay River, is well-documented. In addition, there are a considerable number of chroniclers' who mention the use of boats by indigenous populations, which strongly suggests that vessels were a common-place technology (D'Olwer, 1963; Saccone, 2022). Carvalho (2004), when analysing the modification of the insertion structures of the muscle bundles and the irregular bone wear present in individuals buried in sambaquis in Rio de Janeiro, identified anomalies associated with activities related to swimming, handling harpoons or

long spears (the latter also involved in propulsion and canoes and rafts), the use of oars (standing and sitting) and axes (which, indirectly, could also be linked to the manufacture of canoes and rafts) (Calippo, 2010, 2011). The fishing and canoe-using behaviour was also evidenced by physical pathologies identified in human burials found in earthen mounds located in the *cerrito* RS-LS-85: Oscar Erocildo Abreu, located in Rio Grande. There, three individuals' osteoarchaeological analysis showed skeletal pathologies associated with repetitive and intensive activities such as trauma to the head of the ulna (affecting the elbow), flattening of the tibia (indicative of squatting for long periods), and clavicle bones with enthesopathy and arthrosis (Ferreira, 2012). Exploitation of aquatic resources is also evidenced by human remains from the *cerritos* of Pontal da Barra, which show dental wear potentially related to daily activities such as the handling of nets and fibres for the production and use of fishing implements (Ulguim & Milheira, 2017). Such a diagnosis led these researchers to interpret these as chronic symptomatic consequences of the intensive canoe-rowing related to the fishing and transportation activities of the aquatic lifestyle.

3. The choice of these species could have been determined by their ready availability in the estuarine and sandbank environment. It is worth remembering, in this sense, that the sea level would be around 0.5–1 m above current levels, offering an environment with a greater marine influence (Angulo et al., 2006). Bearing in mind that the coastal dynamics and the estuary have changed over the last few thousand years, if the location of the sites were the result of environmental availability alone, there would be a more homogeneous distribution of sites around the lagoon. If the location of the sites followed the environmental conditions (of greater availability or biomass of fish) that would form as a result of the lowering of the sea level, the result would be the occurrence of sites of shorter duration, in which the composition of sizes would be very similar. On the other hand, the data show that fishing over these periods was also not just a direct response to ecological availability. The interpretation of the quantities and sizes of black drums showed that, even though they were fished in smaller numbers than catfishes and croakers, the capture of the largest specimens (verified in three of the four sites in the sandbank) is also associated with specific points within the Patos Lagoon and consumption requires specific/differentiated fishing gear (such as the slingshot, harpoon, spear or bow and arrow), it occurs in all sites throughout the analysed period. The capture of black drums may not have been predominant for the selection of settlement sites, but their presence in the archaeological record certainly indicates a cultural bias, indicated by the need to perceive and identify their capture sites; by the energy supply provided by a single specimen; and by the symbolic aspects and status involved in fishing a larger animal.
4. Analysis of the otoliths sampled in the sambaquis of the sandbank of the Patos Lagoon indicates that fishing occurred throughout the year. The otoliths of many fish, including the croaker, show alternating, more opaque or more translucent growth bands that form at different times (Schwingel & Castello, 1990; Cotrina, 1998). Both types of bands were observed in the sections of croaker otoliths (90 opaque edges and 30 translucent) of the two sites. At the site RS-LC:42 41 (46%) opaque edges and 49 (54%) translucent edges were found. In the RS-LC:59 23

(77%) were opaque and 7 (23%) translucent. Analysing the actual specimens the numbers were 39 (59%) opaque and 26 (41%) translucent specimens in all. This data seems to indicate that fishing, at least for *M. furnieri*, was not seasonal, happening throughout the year, including spring and summer, when these species were more abundant in the estuarine environment (Calippo, 2000). It suggests that the territorial practices of the groups that build cerritos and sambaquis were more stable than the high mobility system suggested by Schorr (1975) and Schmitz (1976). Annual fishing would probably include mullet in the spectrum of captured and consumed fauna. However, little direct archaeological evidence of this species has been identified, which raises the question whether there was a social phenomena regarding food taboo or whether it is simply a question of conservation of bone remains or *in situ* sampling due to the reduced size of the otoliths.

Although the choice of fishing sites and the techniques and technologies were responsible for the selection of species captured and the size of the fish, the importance of the availability of croaker, catfish and black drum must be emphasised. The exploitation of these resources must have been one of the attractions for the establishment and continuity of the occupation of this territory. When comparing the fishing carried out by cerriteiros and sambaquieiros with the data from the artisanal fisheries carried out between 1945 and 1975 that focused on the most abundant resources (Thykjaer et al., 2020), in both the past and present these three species represent the bulk of captured fishing resources. This suggests that over the last few millennia fishing has been directed towards the most abundant species (Fig. 8.5).

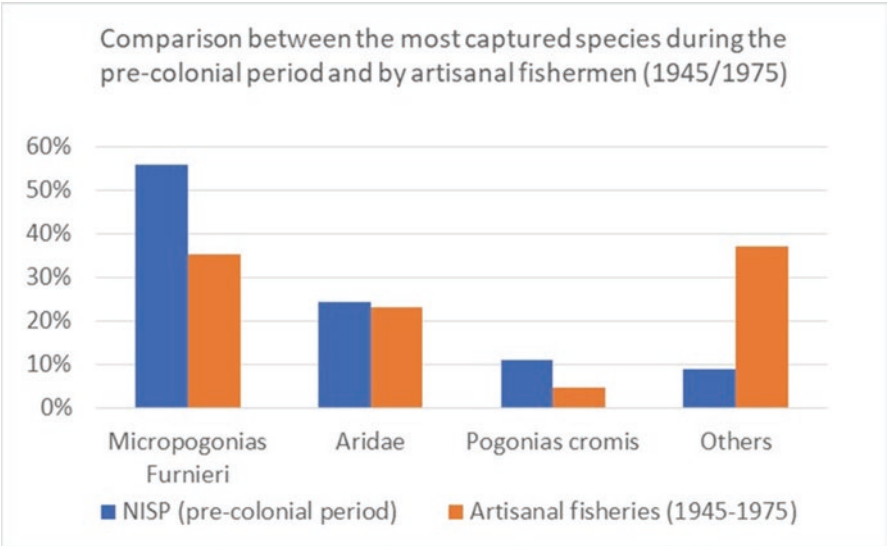

Fig. 8.5 Percentage of species caught by pre-colonial fisheries and artisanal fisheries in the Patos lagoon between 1945 and 1975. (Thykjaer et al., 2020)

In the case of artisanal fishing, the larger presence of other species is justified by the diversification of vessels, the fishing gear used, and contemporary commercial demands, offering access to resources that would not have been used by indigenous peoples for this purpose. As most of the fish recorded in the sambaquis were smaller than the fish landed in the recent artisanal fisheries in the Patos Lagoon, we estimate that the equipment available made it difficult to fish for larger specimens.

To discuss the predominance of catfish, croaker and black drum, it has to be taken into account that the Patos Lagoon has relatively little planktonic productivity and its trophic webs are mostly based on detritus and benthic algae, the food source for all three species. The life strategy of these species under moderate exploitation ensure the maintenance of their. Croakers and black drums that spawn high numbers of eggs in the marine environment or in thermohaline fronts (assuring planktonic food for the pelagic larval stages), which later penetrate estuaries where they find abundant food at the bottom. This explains why these species are abundant in estuarine environments and why, in turn, the location may have been attractive to human occupation. Catfish of the Aridae family, despite their low fecundity, are mouth breeders with large eggs and developed parental care, which reduces juvenile mortality.

Data from nearly 3000 years of exploitation of lagoon resources by indigenous populations show a pattern of sustainable fishing for croaker, black drum and catfish in the Patos Lagoon which has continued to the present day. It is noteworthy that the fishing carried out by the indigenous populations was not based on the commercialization of the surplus; they maintained, for more than three thousand years, an exploitation of fishing resources that did not impact diversity and abundance. Many of the species caught in the past are still the same ones consumed and traded by contemporary populations. However, the decrease in production in recent decades, as pointed out by Thykjaer et al. (2020), demonstrates that commercial fishing, within only a few decades, has dramatically altered the ecological balance and that the resilience of the estuarine and lagoon environments of Patos Lagoon may be at its limit.

8.9 Conclusion

The compilation of ichthyoarchaeological faunal data from 15 archaeological sites of the sambaquis and cerritos, located around the Patos Lagoon and dated between 3200 and 200 years BP, indicates that the most frequently captured and consumed species by pre-colonial indigenous populations are *M. furnieri* (49.9%), *Genidens* sp. (36.3%) and *P. Courbina* (7.8%). Although the predominance of temporal variations, these estuarine species are the basis of the diet, as was also indicated through isotopic studies in human individuals from the sites studied by Chanca et al. (2021), and are also the most consumed species in other wetlands environments as the coastal and estuarine lagoons of the warm temperate region of the south-western Atlantic (Fossile et al., 2019; Klokler, 2010; Pavei et al., 2019; Wagner et al., 2020).

Despite the lack of quantitative zooarchaeological data of the Guarani groups in the Patos Lagoon, the same three species of fish were captured and registered in the sites PS-02-Camping and PS-03-Totó, representing the main aquatic resources in the daily diet, which seems to be the tendency of the coastal indigenous economy on the estuary (Milheira & Ulguim, 2008).

The Total Lengths of the species, measured by otolithometrics, indicate that relatively small specimens of these species predominated in fishing hauls (young and young adults, probably), suggesting limitations in the efficiency of fishing technology to capture larger specimens. In addition, the average size also indicates that fishing could have been carried out from the beach, without the use of fishing gear or capture techniques in the deeper waters of the Patos Lagoon.

The species composition and sizes of the captured fish were influenced both by the greater ecological availability of these species and by specific aspects of the sociocultural systems of the sambaquis and cerritos peoples (environmental knowledge about the species, mastery of preparation techniques and artefacts used in the fishing), which denotes a dialectical relationship between environment and society. The lagoon environment has been economically exploited in a sustainable way for more than three thousand years by indigenous populations, and studies on recent fisheries show changes in species and sizes caught, which may be demonstrating that, according to Thykjaer et al. (2020), the resilience of the Patos Lagoon may be at a tipping point.

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