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150 years of anthropogenic impact on coastal and ocean ecosystems in Brazil revealed by historical newspapers

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ABSTRACT

Human impact on coastal ecosystems is one of the greatest environmental threats of our times. An understanding of the scale and magnitude of species and habitat degradation requires a long-term perspective that incorporates historical information from a range of sources, including local newspapers. Here we provide a novel contribution to the historical ecology of marine organisms along the Brazilian coast by exploring evidence of anthropogenic impacts in digitized historical newspapers spanning 167 years, available from the Brazilian Digital Newspapers and Periodicals Library. Using the keyword *pesca* we analyzed over seven thousand matches published in 26 newspapers between 1849 and 2016 in the state of Santa Catarina, one of the largest fish producing territories in Brazil. We found evidence of anthropogenic impacts involving overfishing and bycatch as early as the 19th century, well before the commencement of scientific studies and collection of fisheries landing data in the region. Impacts were exacerbated by the expansion of commercial fishing beginning in 1930, a process that seemingly increased competition for resources, while from 1980 onward anthropogenic impacts were mostly reported in relation to habitat degradation due to urbanization (including tourism) and industrialization. The results reveal that historical newspapers are valuable sources of information on local stakeholder perceptions of environmental and resource changes, and thus can provide a deeper temporal perspective to studies involving local, traditional-citizen knowledge in conservation and management actions.

1. Introduction

Coastal areas are currently home to billions of people who directly or indirectly depend on ocean ecosystems for their livelihoods. These ecosystems are exposed to a range of natural and anthropogenic drivers of changes which affect marine biodiversity and ecosystem structure, function and services (Worm et al., 2006). Human activities, in particular, feature as prominent drivers of environmental changes but the scale, magnitude and pace of cumulative impacts is a matter of debate (Halpern et al., 2015). To complicate matters, our understanding of the origin and changing nature of anthropogenic pressures is often hampered by the lack of historical perspective of the human footprint on modern marine ecosystems, and its impact on coastal populations that depended on them.

The Atlantic Forest of Brazil and its surrounding coastal areas are hotspots of world biodiversity (Joly et al., 2014; Reis et al., 2016) and a global priority area for ecosystem restoration and the adaptation of biodiversity to climate change (Hannah et al., 2013; Strassburg et al., 2020). Its narrow coastal strip is home to a large portion of the Brazilian population and has experienced considerable levels of ecosystem alteration due to accelerated population growth, industrialization and urbanization during the 20th century (de Lima et al., 2020), especially in port areas (Bisi et al., 2012; Larcerda and Molisani, 2006; Benicá et al., 2012). Commercial and industrial fisheries have further contributed to environmental degradation by overexploiting several economically important marine species, such as *Genidens barbus*, *Pogonias cromis*, and

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Micropogonias furnieri (Haimovici et al., 2006; Haimovici and Cardoso, 2017). Overfishing, followed by coastal development, habitat loss and degradation, are considered the main causes of population decline for several red-listed marine species in Brazil (Reis et al., 2016).

While institutions and norms governing fisheries have been forged to deal with these and many other overfished stocks, the Brazilian state still faces severe limitations (e.g., political, institutional, financial, capacity, etc) in sustaining long-term fisheries stock assessments programs and generating even the most basic socioeconomic and demographic data (e.g., number of fishers, fleet size, technology and geographic operation, etc, Mattos et al., 2020). Moreover, even though biodiversity conservation in Brazil has been addressed through distinct mechanisms, such as regular assessments of the conservation status of marine species (REF) and in situ approaches such as the implementation of Marine Protected Areas (MPAs) with variable levels of access and use (Maretti et al., 2019), these remain limited in extension and resources, and are surrounded by socio-economic conflicts and political controversies (Gerhardinger et al., 2011; Magris and Pressey, 2018; Martins et al., 2014; Pereira da Silva, 2019; Silveira et al., 2018; Vieira et al., 2019). As a consequence, considerable uncertainties still exist regarding the true scale of marine population decline and loss of diversity along the Brazilian coast. Questions remain about conservation and restoration targets, as defining reference baselines is complex in ecosystems transformed by historical human activities (Lotze and Worm, 2009; Pauly, 1995; Worm et al., 2009).

As in most parts of the world, conservation studies in Brazil are based on information collected over the last few decades. Along with the pervasive lack of memory about past coastal ecosystems, the absence of a historical perspective in conservation debates can result in generation shifts in the acceptance of what are considered degraded systems, a phenomenon known as shifting baseline syndrome (Lovell et al., 2020; Pauly, 1995). Pauly (1995) noticed that each generation of scientists and/or fisheries consider as a baseline the abundance and composition of species observed at the beginning of their careers, and use this baseline to evaluate changes through time. This condition may result in the misleading perception of "pristine" or "natural" marine ecosystems, when in reality they are historically altered (Jackson et al., 2001; Sáenz-Arroyo et al., 2005) and thus deserve more informed and ambitious conservation strategies.

A long-term perspective on human interaction with coastal and ocean ecosystems is becoming increasingly relevant in conservation and restoration debates (Bonebrake et al., 2010; Engelhard et al., 2016). Such a perspective can be gained through the analysis of historical documents for time periods predating scientific observations (Ferretti et al., 2015; Marzin et al., 2015; McClenachan et al., 2012; Thurstan et al., 2015). Among historical documents, newspapers have been used to gain insights into the scale of human exploitation of aquatic resources in the past, bringing the outcomes to policy and scientific arenas in order to inform conservation actions (Friedlander et al., 2015; McClenachan, 2009; Thurstan et al., 2017). In the last two centuries, newspapers have been some of the most widely distributed sources of written information, with a great potential for the preservation of early editions due to the relatively large number of issues released at high frequencies (daily, weekly, monthly). The first newspaper in Brazil was published in 1808, and from the middle 19th century newspapers gradually became a consistent and reliable documentary source on the flow of information around public interest and commercial activities (Morel, 2005). Digitization has made historical newspapers readily accessible through online platforms, offering a relatively cost-effective approach for historical socio-ecological analysis (Allen and Sieczkiewicz, 2010; McClenachan et al., 2012; Perruci, 1978). Nevertheless, the potential of historical newspapers for providing information on past marine conservation issues in Brazil has never been systematically addressed.

The aim of this study was to investigate historical anthropogenic impacts on coastal and ocean ecosystems along the southern Atlantic Forest coast of Brazil through newspapers. In this context, we intend to evaluate the applicability of this method to obtain information on ecosystem baselines, impacts and management in a data-poor country like Brazil. We focused on newspapers published in the state of Santa Catarina, one of the largest fish producing regions in the country, between 1849 and 2016. This time interval covers the transition from largely subsistence fishing and farming to commercial and industrial fisheries in the region in response to policy incentives, urbanization and market development. We scrutinized thousands of digitized editions available at the Brazilian Digital Newspapers and Periodicals Library (*Hemeroteca Digital Brasileira*) and found evidence for anthropogenic impacts on coastal ecosystems and organisms as early as the 19th century. Historical newspapers contained information on local community perceptions of environmental and resource changes, thus potentially providing complementary data for studies involving local, traditional-citizen knowledge in conservation and management programs.

2. Material and methods

2.1. Data source and mining

Historical newspapers were sourced from the digital collection of the Brazilian Digital Newspapers and Periodicals Library (*Hemeroteca Digital Brasileira, BNDigital)*, made available by the National Library Foundation (*Fundação Biblioteca Nacional,* https://bndigital.bn.gov.br/hemeroteca-digital/). Using Optical Character Recognition, news items (e.g. articles, opinion pieces, regulations and sanctions) were sourced using the single keyword "*pesca*" (fishing) for the region (*Locality*) of Santa Catarina (SC) by single decades (*Period*), including all newspapers for the selected decades. The keyword *pesca* was able to capture a diversity of information related to the impact on coastal and marine ecosystems and the affected species. A search test was carried out with the word "*impacto*" (impact) and, as could be expected, a variety of subjects were found (e.g. financial, political) not directly associated with the environmental perspective of marine ecosystems. Details of the searching facilities are available through the *BNDigital* can be found at https://www.bn.gov.br/en/explore/heritage/bndigital.

Single items were screened for duplicate results and non-relevant information (e.g. commercial advertisements) which were then excluded. To ensure consistency in data collection, evidence of anthropogenic impact was searched in single items using two rounds of analysis. First, single items were read by two authors (SS and ACC) in order to assess the content and quality of information based on two inclusion criteria: 1) the items focused on coastal and ocean areas, including estuaries and coastal lagoons, or rivers where anadromous/catadromous fish were reported; and 2) the items focused on aquatic species that spent all or part of their life in seawater/brackish water (e.g. oceanodromous, anadromous, catadromous, Frose and Pauly, 2020). An analytical framework was then created and a new round of analysis for each item was performed to systematically collect the information (Supplementary Information 1A). The newspapers published in Santa Catarina also contained information from other states (Rio Grande do Sul, Paraná, São Paulo, Rio de Janeiro, Espírito Santo), which were also considered in our analysis (Fig. 1).

2.2. Identifying and quantifying evidence of impact

Our analytical frameworks consisted of a checklist (presence/absence) of variables that could be contextually associated with anthropogenic impacts. The variables included: 1 - reports of illegal/detrimental fishing gear (fishing gear that were reported as illegal or detrimental to aquatic organisms and environments); 2 - fishing restrictions and sanctions; 3 - reports of overfishing; 4 - reports of bycatch (undesirable taxa accidently caught and discarded); 5 - reports of habitat degradation/destruction (with the nested variables: "industrial and urban pollution and infrastructure", "habitat destruction by removal of mangroves"). Whenever possible, we associated evidence of impact with

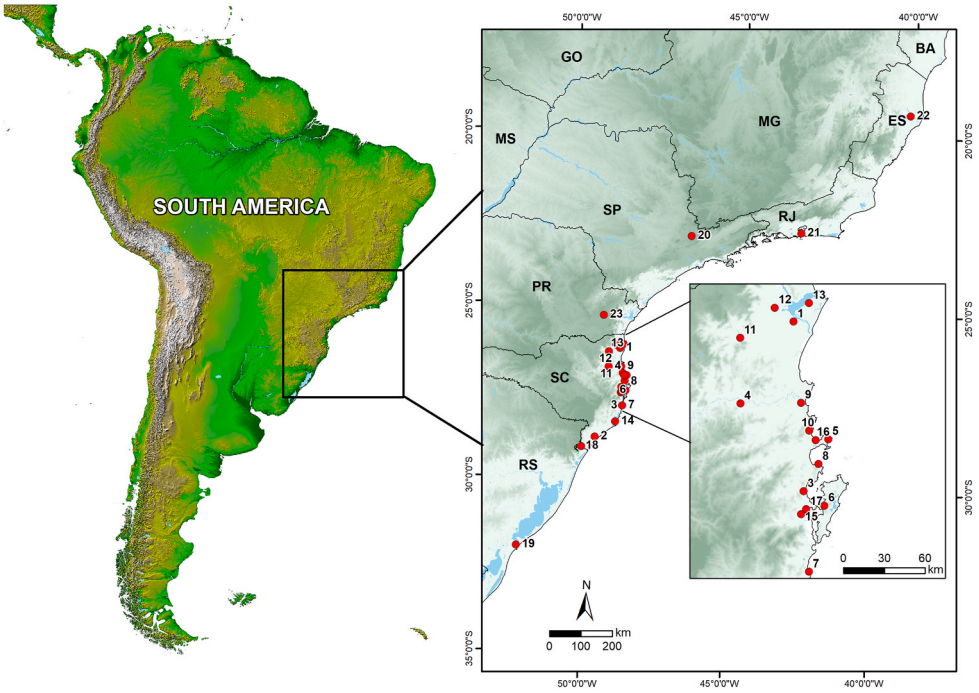


Fig. 1. Map showing localities (municipalities) reported in the newspapers. Santa Catarina: 1) Araquari, 2) Araranguá, 3) Biguaçu, 4) Blumenau, 5) Bombinhas, 6) Florianópolis, 7) Garopaba, 8) Governador Celso Ramos, 9) Itajaí, 10) Itapema, 11) Jaraguá do Sul, 12) Joinville, 13) São Francisco do Sul, 14) Laguna, 15) Palhoça, 16) Porto Belo, 17) São José. Rio Grande do Sul: 18) Mampituba, 19) Rio Grande. São Paulo: 20) Atibaia. Rio de Janeiro: 21) Rio de Janeiro. Espírito Santo: 22) Linhares. 23) Paraná state (unknown locality). Maps generated using ArcGIS 10.7 (https://desktop.arcgis.com/en/) on data publicly available from NASA/JPL/NIMA (South America), free spatial data from DIVA-GIS (http://www.diva-gis.org/Data), the Brazilian Institute of Geography and Statistics (IBGE), and the National Institute for Space Research (DPI/INPE).

inshore (coast or close to the coast) and offshore (several miles from the coast, but depending on jurisdiction) environments, based on multiple contextual information (fishing gear, resources, locations). The collected variables were then quantified for their absolute and relative (%) frequency of occurrence over the number of items aggregated per decade.

Whenever reported, the type of fishing gear associated with evidence of impact was also documented. The identification of fishing gear was aided by the list of fishing implements published by Brazil's National Center for Research and Conservation of Marine Biodiversity in the Southeast and South (CEPSUL-ICMBio; https://www.icmbio.gov.br/cepsul/artes-de-pesca.html) and the Fishing Gear Type Fact Sheets of the United Nations' Food and Agriculture Organization (http://www.fao.org/fishery/geartype/search/en). Organisms associated with evidence of impact were also recorded. Taxa were predominantly reported as vernacular names, with conversion to scientific names based on information in Begossi et al. (2019), Ramires et al. (2018), Ramires and Barrella (2003), and from Magda Bartz's personal communication. The taxonomic diversity by decade was assessed using Shannon Index (SHI) in PAST 4.03 (Hammer et al., 2001). SHI varies from 0 for communities with only a single taxon to high values for those with many taxa. We also explored changes in trophic level of identified taxa through time. Trophic positions were attributed according to FishBase (Frose and Pauly, 2020). For taxa where only genus and/or family were identified we used the average values of the main local species in the region, or the range of trophic level reported in the literature (Arreguín-Sánchez and Manickchand-Heileman, 1998; Cortés, 1999). In order to investigate links between historical exploitation and current conservation status, we classified the statuses of species that could be taxonomically identified according to the IUCN Red List of Threatened Species, the Decrees 444/2014 (Brazil, 2014a) and 445/2014 (Brazil, 2014b) of Brazil's Ministry of the Environment (Ministério do Meio Ambiente - MMA), and of Brazil's updated Red List of Threatened Species (https://www.icmbio.gov.br/portal/component/content/article/10187). Finally, fishing gear and organisms were quantified for their frequency of occurrence (absolute count, %) over the number of items aggregated per decade (Supplementary Information 1B–C). For example, if the fishing gear X (or an organism Y) were mentioned more than once in a single item (e.g. article), its absolute frequency in the given item was counted as 1.

3. Results and discussion

3.1. Qualitative and quantitative data distribution

The keyword "*pesca*" (fishing) generated a total of 7564 matches, representing 6120 items, covering a period of 167 years between 1849 and 2016 (Fig. 2). The year 1849 refers to that of the first record of newspapers in Santa Catarina, while 2016 is the year in which the series in question ends in the Brazilian Digital Newspapers and Periodicals Library. Items were printed in 26 newspapers representing 2.8% of the total newspapers available in the HBD for Santa Catarina over the studied time period (total 931). The total number of newspapers and the number of newspapers reporting fishing were unevenly distributed, with a high and significant positive correlation ($r = 0.89$; $R^2 = 0.80$; $p < 0.001$) revealing that the distribution of newspapers reporting fishing depended on the amount of newspapers in the HDB by decade. The majority of articles reporting fishing were distributed between 1910 and 1969 (74% of the data), and in particular from 1930 to 1939. While we recognize that gaps in the database may influence the amount and temporal distribution of evidence of impact, we highlight that the time interval covered herein is highly relevant as it predates many larger incentives for the commercial/industrial fishing sector (from the 1960s) and the beginning of fish stock assessments, which have received cursory attention in conservation studies in Brazil.

Evidence of anthropogenic impact was found in 192 of the items, representing 3.13% of all newspaper items reporting fishing (Fig. 2). The majority of information was obtained for the state of Santa Catarina; however, because of the regional scope of the newspapers, other regions were also sporadically documented and thus this information was also considered in our analysis. We documented evidence of impact in areas currently belonging to 23 municipalities in the states of Santa Catarina, Rio Grande do Sul, Paraná, São Paulo and Rio de Janeiro and Espírito Santo. The majority of the evidence was reported for coastal areas of Santa Catarina (78%), and primarily for Florianópolis (formerly Desterro, 51%), the capital of Santa Catarina state. This indicates that newspaper data is biased towards economic, administrative and touristic centers, which may give the impression that other regions were less affected by anthropogenic activities.

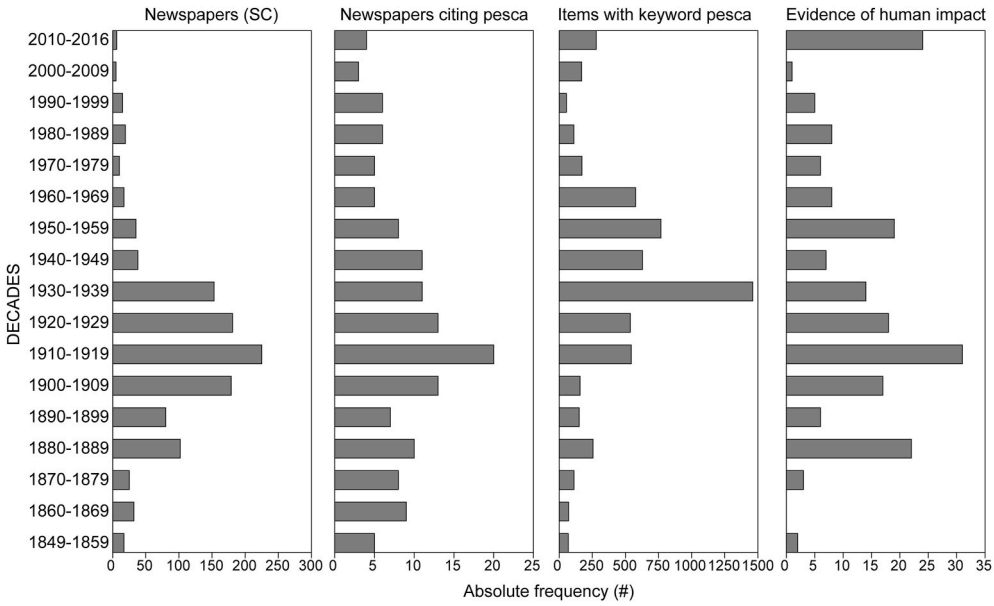


Fig. 2. Absolute frequency distribution of data available in Hemeroteca Digital of Biblioteca Nacional, Brazil.

The earliest evidence of human impact was documented in 1853 (*O Correio Catharinense*, 02 February 1853), and most of the information refers to items published in the first half of the 20th century. This distribution was not correlated with the number of items reporting fishing ($r = 0.38$, $R^2 = 0.15$; $p = 0.12456$), but significant positive correlations were found with the number of newspapers available for the region ($r = 0.65$, $R^2 = 0.42$; $p = 0.004$). In some cases an item was published over several consecutive editions or by distinct newspapers, which was mostly the case for fishing regulations enforced by municipal, state or federal governments.

3.2. Trends in anthropogenic impact

The majority of items (94%) reported evidence for impacts on inshore organisms and environments (estuaries, lagoons, bays, coastal areas in general), while only a small fraction (6%) were associated with offshore impacts. This is not surprising given the importance of coastal areas to emerging urban centers, and because historical small-scale fisheries in the region operated mostly inshore (Alvarez Perez et al., 2009; Diegues, 1983; Seixas and Troutt, 2003). Nevertheless, such localized impacts are highly relevant because it is at the local scale that most vulnerable, small-scale coastal communities secured their livelihoods (Diegues, 1983).

3.2.1. Fishing restrictions and sanctions

Fishing restrictions and sanctions were particularly common at the end of the 19th (e.g. 1880–1890) and the first half of the 20th centuries (e.g. 1910–1919) (Fig. 3), and indirectly indicate that some anthropogenic-driven environmental degradation was already occurring more than a century ago. The earliest restrictions and sanctions were imposed through Municipal Regulation Codes (*Código de Posturas da Câmara Municipal*), a set of municipal laws aimed at regulating and inspecting the function and structure of urban centers between 1822 and 1889 (Santos, 2020). We found that the earliest regulations focused on relatively small and confined water ecosystems such as inland rivers; however over time, they became more complex, targeting habitats considered breeding grounds (bays, lagoons, rivers, estuaries) for economically important taxa (Supplementary Information 1B–C), and a range of fishing gear (trawl/gillnet [colloquially "*redes*"], drift nets, cast nets, dynamite, toxic substances, etc.; Fig. 4) associated with the capture

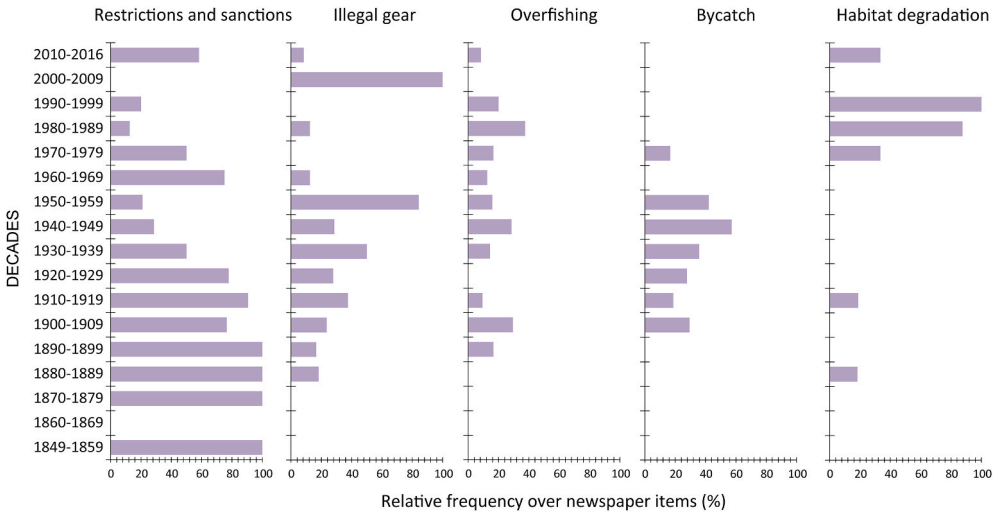


Fig. 3. Relative frequency (%) of evidence of impact over newspaper items per decade.

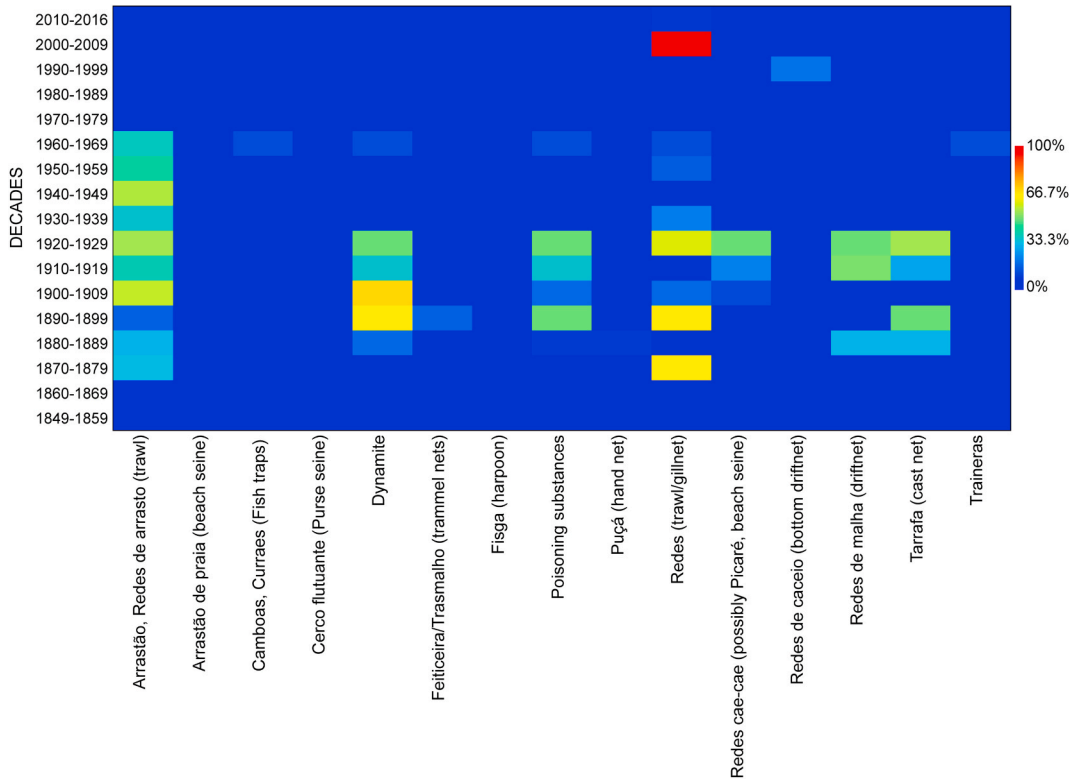


Fig. 4. Two-dimensional plot of the relative frequency (%) of fishing gear over newspaper items per decade.

of juvenile specimens (fish and notably shrimp; Fig. 5). For example, in 1854 Municipal Regulation Code 363 forbade fishing with *redes* (trawl/gillnet/seine) at Rio Ratones, in Desterro (present day Florianópolis). Two decades later in 1876, the same regulation was extended to other rivers in the region and included new restrictions on fishing gear and timing (*O Despertador*, 28 March 1876). By 1881,

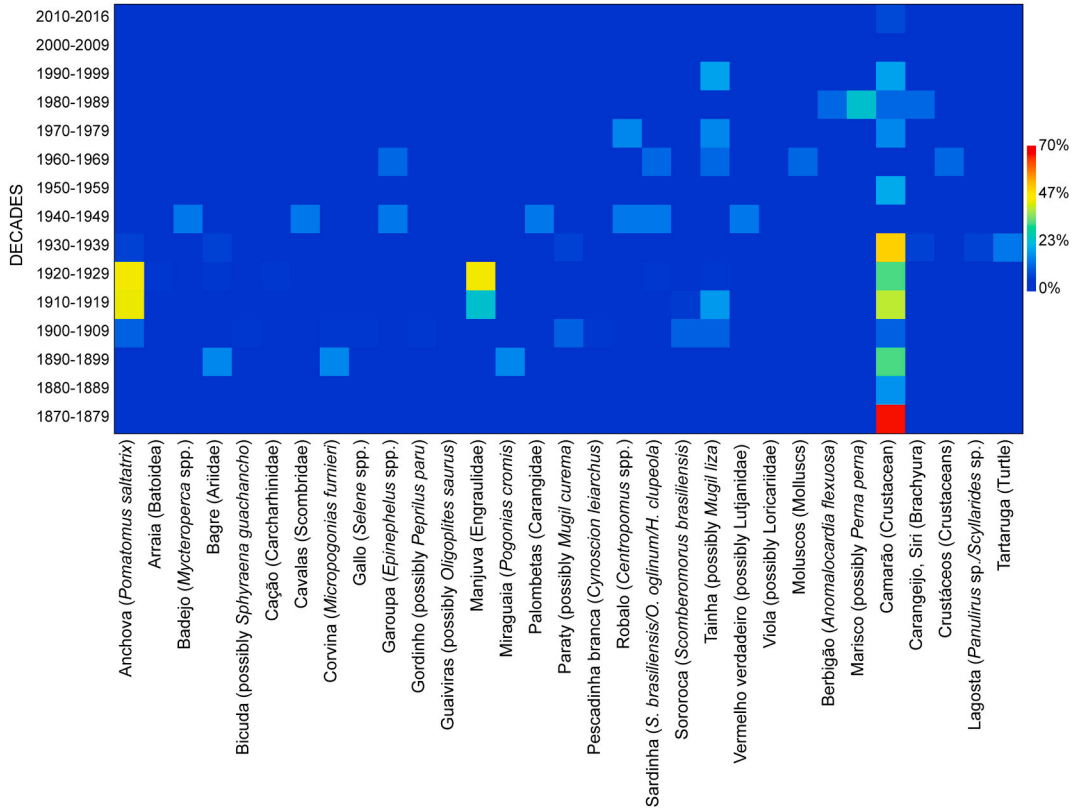


Fig. 5. Two-dimensional plot of the relative frequency (%) of impacted organisms over newspaper items per decade.

newspapers reported a number of regulations prohibiting nets, but also cast nets in many of the state's lagoons (e.g. Barra da Lagoa) and rivers (e.g. Rio Itajahy-Assú and Rio Mirim). The high frequency of these regulations suggests that by the end of the 19th century several inshore environments were under some level of anthropogenic pressure and that local ecosystem users (fishers, communities) were perceiving declining catches.

Conflicts between local fisheries due to illegal/detrimental fishing gear (e.g. beach trawls [*arrastão]*) also became more frequent at the end of the 19th and beginning of the 20th centuries, coinciding with increased nationalization and institutionalization of fishing (Filho, 2016a,b). For example, Decree 876 of 10 September 1856, authorized the incorporation of companies for catching, salting and drying fish along the coast and rivers of the Brazilian Empire. Later on, Decree 9672 of 17 July 1912, created the Fisheries Agency (*Inspetoria da Pesca*, implemented between 1913 and 1915), aimed at organizing and promoting commercial fishing in Brazil. From June to September 1915, the newspaper *O Estado* reported nine items on illegal fishing and the actions taken by local authorities following complaints by fishing communities at several localities in Florianópolis (Praia do Ingleses, Ribeirão, Pantano do Sul, Cannarvieras, Lagoinha, and Ponta das Canas) and Porto Bello (present day Porto Belo). Most actions were against fishing with driftnets (*redes de malha)*, in some cases operated by non-local residents (*O Estado*, 22 July 1915). The most affected resources were the winter schools of lebranche mullet (*tainha*, *Mugil liza*), white mullet (*pataty*, *Mugil curema*) and bluefish-enchova (*anchova*, *Pomatomus saltatrix*).

Reports of illegal fishing practices gradually increased from 1900 to 1959, coinciding with increasing fishing efficiency (Diegues, 1983) and large state incentives for the commercial sector (Filho, 2016a,b), such as the establishment of fish landing, processing and commercialization sites (*entreposto de pesca*, Decree 23348 of 14 November 1933). A relative spike in regulations and sanctions were detected in the 1960s and 1970s, coinciding with increased volumes of commercial catches (*O Estado,* 22 February 1963, but see also Freire and Pauly (2010); Haimovici and Cardoso (2017)) and considerable political and financial support to the industry (Abdallah and Sumaila, 2007). During this time, several coastal communities intensified fishing in response to the expansion of the local market and the incipient development of tourism (Seixas and Troutt, 2003), facilitated by technological improvements in the sector such as monofilament nylon or polyamide nets, motorized vessels, and butane gas lamps (Diegues, 1983; Seixas and Troutt, 2003).

3.2.2. *Overfishing, bycatch and habitat degradation/destruction*

Overfishing, bycatch and habitat degradation/destruction are the most common threats to marine organisms today and in the past (Harnik et al., 2012). Bycatching (prevalently juvenile specimens and small fish) and notably overfishing were commonly documented throughout the 20th century (Fig. 3). Habitat degradation was more consistently reported only from the 1970's, as a result of increased urbanization (including tourism) and industrialization in coastal areas.

The earliest evidence of impact was documented in a series of articles published by Pedro Soares Caldera in 1889 (entitled "Health Degeneration"), where the author attributed the "*notorious declining of fish abundance and increase in fish diseases*" to the widespread destruction of mangroves and the use of "rudimentary" fishing methods (*O Conservador*, 25 June to 14 August 1889). At roughly the same time (1899), the first complaint of fishing during spawning season was documented, in this case of lebranche mullet (*tainha*, *Mugil liza*) and catfish (*bagre*, Ariidae). According to the news item, this catching of breeding individuals could have been responsible for the decline in numbers of lebranche mullet (*tainha, M. liza*) that was seen at that time compared to previous years (*Republica*, 19 February 1899). We considered this as potential evidence for recruitment (catching of parent stock during breeding individuals) and growth overfishing (recruits are captured before they can replenish population; Pauly 1983). Similarly, in 1904, an article in *O Dia* argued that regulations were of extraordinary importance to avoid declining fish populations due to the "*constant devastation of our seas and rivers*", citing as an example the lack of bluefish-enchova (*anchova*, *P. saltatrix*) blamed on capture outside the season (possibly spawning season) with detrimental techniques (*O Dia*, 15 April 1904). Some techniques such as *redes cae-cae* (possibly *Picaré*, beach seine) were often associated with the destruction of "*criação miúda*" or young individuals (recruits). The first such mention was documented in 1905 (*O Dia*, 01 June 1905), and was attributed to bycatch and overfishing (recruitment overfishing).

It is worth noting the increasing number of items dated to the beginning of the 20th century reporting population declines due to the captured juvenile individuals. In 1909, an article in *O Dia* (28 July 1909) reported declining fish abundance at Porto Bello compared to the previous 30 years due to overfishing and bycatching through the use of drift nets (*redes de malha*) and trawls (*redes de arrasto*). Impacted species included bluefish-enchova (*anchova*, *P. saltatrix*), serra Spanish mackerel (*sororoca, Scomberomorus brasiliensis*), lebranche mullet (*tainha, M. liza*), white mullet (*paraty, M. curema*), smooth weakfish (*pescadinha branca,* possibly *Cynoscion leiarchus*), whitemouth croaker (*corvina, Micropogonias furnieri*), barracuda (*bicuda,* possibly *Sphyraena guachancho*), American harvestfish (*gordinho,* possibly *Peprilus paru*), and Atlantic moonfish (*gallo, Selene* sp.). In 1916, an article in *O Dia* revealed that public institutions (Ministry of Agriculture) were concerned about the decline of shrimp stocks due to the use of *puçá* (hand net) and *tarrafa* (cast net) with a mesh size of 3 mm, which impacted mostly juvenile individuals (*O Dia*, 3 August 1916).

By the 1940's, fish was reportedly a scarce item in several urban markets, including Rio de Janeiro. The causes of fish shortages seemed multifactorial, and possibly involved overfishing according to a member of the Executive Fishing Commission (*Comissão Executiva da Pesca*):

"*The main reason* [for the scarcity of fish at the market in Rio de Janeiro]*, however, is the lack of fish and, in my opinion, the devastation that has been taking place. The presence of fine fish on our coastline, at least from Maricá to Tijucas, is insignificant. There was a time that good fish was abundant, such as robalos* [*Centropomus* spp.]*, garoupas* [*Epinephelus* spp.]*, and badejo* [*Mycteroperca* spp.]*, cavala* [Scombridae]*, vermelho verdadeiros* [possibly Lutjanidae]*, etc. Today with the devastation that has happened and is still happening, but will not continue, there is little fish in our waters. It is pure illusion to assume that the seafront of this city is full of fish*" (*A Noticia,* 03 September 1943).

Bycatching was the most reported cause of population decline between 1920 and 1959, and largely attributed to non-local fishing companies (e.g. from Santos, São Paulo state) operating along the coast of Santa Catarina. For example, according to *O Estado* (13 January 1944), thousands of small *palometas* (Carangidae) and sardines (*Sardinella brasiliensis/Ophistonema oglinum/Harengula clupeola*) were found discarded everyday on the beaches of Florianópolis due to the extensive use of trawls. Few decades later, an item published in *Correio do Norte* in 1976 reported that:

"*Otair Becker [senator, ARE-NA/SC] pointed out that large fishing boats invade the area of these fishermen* [in Santa Catarina]*, causing the extinction of juvenile fish and shrimp. And he pointed out as the ideal formula to solve the serious problem, the indispensable help of the Brazilian Navy, which would also protect the fauna and the marine flora of our country*" (Correio do Norte, 17 January 1976).

Overall, conflicts among users due to invasion of fishing areas by distinct actors (local and non-local fishers) were documented over a century by newspapers, from 1915 (*O Estado*, 22 July 1915) to 2013 (*O Municipio*, 10 May 2013). Other than overfishing and bycatching, non-local fishing companies were also accused of persuasively acquiring the catches from local fishers and diverting the product to markets outside the region of origin, inflating local prices and affecting local livelihoods (e.g. *O Estado*, 09 July 1925; 13 September 1928, 06 October 1946, 25 June 1951, 25 August 1951; *A Noticia*, 23 February 1931). These continue to be ongoing issues in local small-scale fisheries in

Brazil (Begossi, 1995), and newspaper items reveal that they are strongly rooted in the past.

From the 1970's to 2010's, the nature of human impact in newspaper items was dominated by habitat degradation in the context of urban development and industrialization, and by the growing tourism industry (*Zero*, February 1983, September–October 1986). Domestic and urban sewage (*Zero*, May–June 1988), industrial pollutants (*Correio do Povo*, 06 May 1978), along with public infrastructure works involving dams, bridges and landfills (*Correio do Povo*, 27 October 1979; *Zero*, April 1990) were some of the most reported drivers of stock declines along the coast, as documented by others (Seixas and Troutt, 2003).

3.2.3. Species affected

A total of 31 types of fish, molluscs, crustaceans and reptiles were reported in newspaper items in relation to anthropogenic impacts. We identified 11 fish and two molluscs to species level, and several fish to the levels of genus and/or family (Fig. 4, Supplementary Information 1C). The most commonly reported taxa was shrimp (*camarão*, crustacean), followed by lebranche mullet (*tainha*, *M. liza*), bluefish-enchova (*anchova, P. saltatrix)*, catfish (*bagre*, Ariidae), whitemouth croaker (*corvina*, *M. furnieri*), and others. While this is a limited number of species when compared to the variety of marine resources currently exploited by local communities in this region (Bastos and Petrere, 2010; Begossi et al, 2017, 2019; Castro et al., 2016; Herbst and Hanazaki, 2014; Martins et al, 2018, 2019; Ramires and Barrella, 2003), their frequency suggests these taxa were historically of primary importance in market and household consumption. Shrimp and lebranche mullet are prime examples of this, as they featured almost continuously in news items from the 19th and 20th centuries, and are currently cultural keystone seafoods in Santa Catarina (Berkström et al., 2019; Diegues, 2004; Machado et al., 2019).

The diversity of impacted organisms fluctuated over the time interval covered, with the highest diversity between 1900 and 1969 (SHI 2.25 to 1.44) and the lowest from 1970 to 2016 (SHI 1.33 to 0.69). Similarly, the weighted average trophic level of impacted organisms declined from 4.1 in the 1880s, through 3.1 in the 1970s, to 2 in the 1990s and in the 2010s. Taxa reported from 1900 to 1969 included species of high trophic levels, such as bluefish-enchova (*anchova, P. saltatrix)*, barracuda (*bicuda*, possibly *S. guachancho*), American harvestfish (*gordinho*, possibly *P. paru*), Atlantic moonfish (*galo*, *Selene* sp.), leatherjacket (*Guaiviras*, possibly *Oligoplites saurus*), as well as species feeding at lower trophic positions, including whitemouth croaker (*corvina, M. furnieri*), smooth weakfish (*pescadinha branca*, *C. leiarchus*), serra Spanish mackerel (*sororoca*, *S. brasiliensis*), lebranche mullet (*tainha*, *M. liza*), white mullet (*paraty*, *M. curema*), and shrimp (Supplementary Information 1C). They were reported as being affected by overfishing and bycatching, through the use of *arrastão* and *redes de arrasto* (trawl), *redes* in general (trawl/gillnet), *redes de malha* (drift net), *tarrafa* (cast net), but also dynamite and poisoning substances such as the *Timbó*, plant-based toxins widely used by indigenous groups in tropical South America (Soentgen and Hilbert, 2016) (Fig. 5).

Taxonomic diversity and trophic levels attained the minimum values from 1980 onward, represented by lebranche mullet (*tainha*, *M. liza*), carib pointed venus clam (*berbigão*, *Anomalocardia flexuosa*), shrimp and crab (*siri,* Brachyura) associated with overfishing and habitat degradation. This coincided with accelerated urban development and tourism along the coast from the 1970s (Jouffray et al., 2020; Pereira, 2011). Newspaper items expressed growing concerns over the potential loss of legitimacy and identity of small-scale coastal communities in the face of these new drivers of change (*Zero*, February 1983; 6 October 1995; September 2013) which were affecting organisms of high cultural and nutritional importance in the region (de Abreu-Mota et al., 2018; Gaspar et al., 2011; Herbst and Hanazaki, 2014; Reis-Filho, 2020; Seixas and Troutt, 2003). For example, shrimp (possibly Atlantic seabob, *Xiphopenaeus kroyeri*), one of the most exported fish products in Brazil (Lopes, 2008), was progressively overexploited to the point that coastal stocks almost completely disappeared between 1970 and 1990, although the population apparently recovered later on due to the eventual easing of fishing pressure (*A Ponta*, July 1993).

Several taxa identified here are currently threatened or vulnerable (Supplementary information 1C) and were subject to intensive capture over the last two to four decades (Haimovici, 1998; Vasconcellos and Haimovici, 2006). Their historical decline has been perceived by local communities in more recent times. Martins et al. (2018) have documented that modern fishers from the north Santa Catarina coast (Tijucas) perceived decreasing catches of catfish (*Genidens barbus*, Ariidae), mullet (*M. liza/M. curema*) and whitemouth croaker (*M. furnieri*) in relation to industrial fishing, shrimp trawling bycatch, and the overall increase in fishing efforts over the last five decades. Bender et al. (2014) has shown that fishers from the state of Rio de Janeiro (Arraial do Cabo) noticed a sharp decline in abundance of bluefish-enchova (*P. saltatrix*) and several grouper species (Epinephelinae) over the last six decades. The data collected from newspapers suggest that local fishers' baselines for perceiving population decline may have already been affected by long-term anthropogenic impacts, even before the intensive commercial fishing of the last decades.

Moreover, the declines in the weighted average trophic levels and in the overall diversity of impacted organisms might reflect the phenomena of fishing down the marine food web, whereby large predators are preferentially removed from the system (Christensen, 1996; Pauly et al., 1998). Fishing down the food web has been proposed for the Brazilian coast at the end of the 20th century (1978–2000), where a high rate of trophic level decline has been documented (Freire and Pauly, 2010). We suspect that newspapers indirectly captured expressions of fishing down the marine food web along the coast and among small-scale coastal fisheries of Santa Catarina due to the increased fishing efforts of the last decades. However, because the data in hand is too small to lead to conclusive interpretations, further research is necessary to confirm this hypothesis.

3.3. Invoking the past to inform conservation debates

Coastal and ocean ecosystems have been affected by anthropogenic activities over long time scales (Jackson et al., 2001). As a response, scholars are highlighting the importance of historical information in order to establish accurate reference baselines for conservation and restoration targets (Bonebrake et al., 2010; Engelhard et al., 2016; Ferretti et al., 2015; Lotze et al, 2006, 2015; McClenachan et al., 2012). This is particularly the case of regions where long-term fishing statistics are missing and resources for monitoring programmes are limited, such as the Atlantic Forest coast of Brazil. Despite the inherent challenges in extracting and interpreting ecological data from historical archives (Bonebrake et al., 2010; Ferretti et al., 2015; Pooley, 2018), documents such as newspapers are valuable sources of information for conservation studies yet to be explored in Brazil. Gaps in digital databases are common and may introduce uncertainties in statistical analyses. However, as digital archives grow, their use becomes more attractive and their information more easily integrated with other historical and environmental sources (historical, archaeological, palaeontological, molecular, etc).

From an ecological perspective, our study demonstrates that historical newspapers from Santa Catarina documented evidence of anthropogenic impacts on coastal environments and organisms in southern Brazil at least since the end of the 19th century. Some items provided more explicit accounts of the nature and effects of anthropogenic impacts, for example by attributing the decline in abundance of some species to overfishing, bycatching, and habitat degradation. Others instead alluded to the existence of degraded environments, without providing specific details of the nature and effects of anthropogenic activities. This was the case of fishing regulations (restrictions and sanctions), which can be interpreted as attempts by local authorities to avoid, mitigate, control and/or restore existing environmental

degradation (McManus, 2009).

A large portion of information on stock fluctuations derived from local community and stakeholder perceptions of environmental and resource changes, emphasizing the potential of historical newspapers for expanding fish stock assessment to periods not covered by landing data (Haimovici, 1998; Haimovici and Cardoso, 2017; Vasconcellos and Haimovici, 2006), scientific observations (Barbosa-Filho et al., 2020; Cergole et al., 2002; Haimovici et al., 2006; Matsuura, 1977, 1996; Sunye and Morisson, 2006), and deliberative-participatory approaches (Begossi et al, 2016, 2019; Castro et al., 2016; Gerhardinger et al., 2006; Herbst and Hanazaki, 2014; Martins et al, 2014, 2018). The latter is particularly important because this work confirms that local ecological knowledge held by users (e.g. fishers) and stakeholders (e.g. communities) was produced and transmitted in environmental contexts that were historically modified by human actions. As a consequence, there is a potential for long standing and pervasive generational shifts on the perceptions of the conservation status of organisms and ecosystems in this region.

The information contained in historical newspapers also offered clues to the socio-economic and political circumstances of past anthropogenic impacts on coastal ecosystems and communities, which must be acknowledged in inclusive and participatory management strategies. Detrimental processes during the late 19th century and most of the 20th century responded to increasing market demand, nationalization and institutionalization of fishing, and were seemingly facilitated by centralized top-down management approaches and incentives that benefited actors with greater capital investment and regional market strategies (see also Diegues, 1983). The appropriation and deterioration of resources that were crucial for the food security and livelihood of local coastal communities by non-local actors (often referred to as "invaders") are examples of resilient drivers of socio-ecological stress that persisted throughout most of the 20th century (Diegues, 1983; Herbst et al., 2020). Increased fishing efficiency and the large incentivising policies of the last 60 years (Abdallah and Sumaila, 2007; Filho, 2016a, b) exacerbated ecological impacts and extended them to offshore environments, while urbanization (including industry and infrastructures; Lacerda and Molisani, 2006) and tourism accounted for most of the detriment of marine ecosystem along the coast (da Silveira and Rodrigues, 2015; Pereira, 2011; Widmer and Hennemann, 2010).

Top-down regulations are still the subject of conflicts with local populations and function as barriers for the advancement of integrated systems of governance, management, and conservation (Lopes et al., 2013). Governance, management, and conservation are, among others, part of an integrated system that encompasses culture, gender, co-production and exchange, autonomy, and include recognition of territorial rights and respect for local forms of tenure (Lopes et al., 2021). However, for most of the 20th century these elements developed in a landscape of conflict and relative marginalization. Scholars and managers must be familiar with these historical processes to comprehend their impact on the collective memories of fisheries and the challenges contemporary communities face when interacting with institutions.

The role of newspapers in shaping public opinion and the willingness of fisheries authorities to adopt much needed (and often unpopular) fisheries governance reforms during the 20th century remained unclear. Our analysis detected changes in narratives around issues affecting fisheries, notably during decades of incentivising policies such as in the 1960s and 1970s. In several cases local small-scale fisheries were associated with backwardness, poverty, and destitution, and accountable for negative impacts on local stocks (e.g. *O Estado*, 14 August 1964). Stereotypes of this kind have certainly affected the capacity of local communities to raise their voices around issues such as the legitimacy of property rights and power asymmetry. Future research should investigate to what extent the public opinion around fisheries and the shifting ecological baselines syndrome can be politically manipulated over time to benefit historically privileged actors to the detriment of less capitalized and less politically influential players, such as small-scale fishers.

4. Conclusion

The newspapers published in Santa Catarina captured evidence of human impact on coastal environments and organisms as early as the end of the 19th century. These were mainly documented for inshore environments which are areas of ecological importance for the feeding, reproduction and nursery of many coastal species, and where most small-scale coastal communities (both past and present day) secure their livelihoods. Since the end of the 19th century, the reported human-induced environmental changes mostly took the form of overfishing and bycatching, with urban and industrial development and tourism later heavily influencing habitat degradation. Reference baselines for conservation and restoration targets must consider the drivers of anthropogenic impact, and their antiquity, on coastal and ocean ecosystems, and on the populations that depended on them. This study also highlights the utility of local newspapers in attempting to understand changes in local traditional-citizen knowledge in relation to public policy, the development of institutions, and other drivers of change (e.g. market, tourism). In particular, newspapers revealed that some drivers of socio-ecological stress were resilient in historical contexts governed by top-down centralized management strategies. Adaptive co-management of small-scale fisheries in Brazil should consider the legacy of these processes on user-stakeholder-manager interactions.

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Contributors

ACC and SS conceived and designed the study, acquired data, analyzed and interpreted the data; ACC and SS drafted the article; TF, DFH, AB, LGS revised it critically for important intellectual content; all authors approved the final version to be submitted.

Declaration of competing interest

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Appendix A. Supplementary data

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