



Historical evolution of the social perception on ecosystem services provided by seagrasses through analysis of the written press in North West Spain (1860–2020)

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ABSTRACT

The social recognition of the services delivered by ecosystems takes advantage from knowledge on the historical narratives of their uses and benefits and may facilitate the societal transition towards a more conservation-based perception of natural systems. Historical analysis of ecosystem services have been barely addressed, possibly because of the lack of available information, especially in the case of uncharismatic habitats such as seagrass meadows. In this investigation, we used the written press to reconstruct the historical narrative of seagrass ecosystems in Galicia (NW Spain), a region where this type of information is not stored in scientific publications or public archives. We assessed the social perception of the ecosystem services provided by marine angiosperms and inferred the main conflicts between seagrasses and users of the Galician estuaries over the last 160 years. The NW Spanish population perceived four provision and regulation ecosystem services from seagrasses throughout this period. A distinct temporal succession of the ecosystem services supplied by seagrasses and perceived by the Galician society was identified. Provisioning services, such as seagrass harvesting for fertilizer use or textile fiber, prevailed until the first quarter of the 1900s, whereas the perception of the nursery effect of *Zostera* meadows became dominant since the second half of the 1900s. The conflict between shellfishing and seagrasses was recurrent all through the past 160 years. New conflicts related to dredging, filling and navigation emerged in the present century. A positive perception of seagrasses is progressively growing mainly associated with an increasing importance of news referring to research, dissemination and conservation of seagrass ecosystems. Our results show that the information retrieved from the written press helps building the social-ecological memory of ecosystem services provided by seagrass meadows. The public outreach of local traditions associated with these habitats, dissemination of the services they delivered to previous generations and the diffusion of the interactions between *Zostera* and contemporary human populations may contribute to modify social perceptions on this ecosystem, providing valuable information for the design and implementation of social awareness programs encouraging seagrass conservation needed for ecosystem-based coastal management.

1. Introduction

Seagrass meadows deliver a diversity of ecosystem services, playing a significant role in human well-being (Norlund et al., 2016), revealing as one of the most valuable ecosystems on earth (Costanza et al., 2014). However, little attention has been paid to these ecosystems as compared to other coastal habitats (Unsworth et al., 2019). Seagrass ecosystems displayed a worldwide declining trend due to their exposure to different anthropogenic pressures, (e.g Waycott et al., 2009). Yet, a recovery

trend was recently reported for European seagrass meadows, largely due to water quality improvement (de los Santos et al., 2019).

The coexistence of seagrasses with numerous human-derived pressures such as urban expansion, eutrophication, sediment inputs, climate change, the impact of invasive species or physical damage caused by the exploitation of marine resources or recreative navigation (e.g. Barañano et al., 2017; Orth et al., 2006; Waycott et al., 2009), led to recurrent conflicts among uses and coexisting activities in seagrass-dominated littoral areas. Consequently, sustainable management regulations and

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conservation policies are needed (Unsworth et al., 2019).

The ecosystem-based approach for the implementation of an effective management of the coastal zone should consider relevant information from all sources of knowledge as they provide complementary perspectives to support management (CBD, 2004). In this regard, quantification of ecosystem services and analysis of their social perception are considered as missing layers for the integration of sociocultural values into coastal management and conservation policies (Pennino et al., 2021). It is also recognized that the decline of ecosystems worldwide is linked to a parallel reduction of the society's memory on their historical state (Jackson et al., 2001), of human health (Bratman et al., 2019), and loss of culture and traditions (IPBES, 2019). This has been suggested to be frequently the case of seagrass ecosystems (Unsworth et al., 2019). This knowledge gap is somewhat buffered where provision services dominate the social perception of a given society, but in those regions where people lack direct experience with respect to the meadow or when the ecosystem services provided are indirect (eg. seagrasses as nursery grounds for fishes), recognition of their benefits lowers (Newmaster et al., 2011).

The social recognition of the services delivered by ecosystems takes advantage from knowledge on the historical narratives of uses and benefits, that, in turn, tend to stimulate identity and sense of belonging with respect to the territories and help delivering evidence on the status of ecosystems (Unsworth et al., 2015). It has been also proposed that these historical narratives may facilitate the societal transition towards a more conservation-based perception of ecosystems (Willie-Echevarria et al., 2000) as awareness of past ecosystem states are frequently lost over the course of generations. In this context, they could bring a link between policy goals and public aspirations (McAfee et al., 2019).

Historical analysis provided significant contributions to ecological research and ecosystem management. However, they have been barely addressed in studies on ecosystem services (Renard et al., 2015) and historical studies on the uses of seagrasses (Newmaster et al., 2011) or on their contribution to quality of life based on library research and interviews, are still scarce (McKenzie et al., 2021).

In this investigation, we aim at analysing the social perception of the ecosystem services provided by marine angiosperms in the Galician region (NW Spain) throughout history using the information drawn from the written press, and to infer from this analysis, the main conflicts between seagrass uses and ecosystem services occurring in this region over the last 160 years. To our knowledge, this is the first attempt to reconstruct the historical narrative of seagrass ecosystems in a region where this information is not stored in scientific publications or public archives, drawing on the information gathered in the written press. We stem from the assumption that the frequency a given news typology appears in newspapers, might reasonably reflect the perception or interest of the society.

2. Material and methods

2.1. Study area

The present study is centred in the Galician region (NW Spain). Two species of marine angiosperms, *Zostera marina* and *Zostera noltei*, inhabit sheltered areas of the Galician estuaries (Cacabelos et al., 2015). *Z. noltei* dominates in the intertidal inner part of the estuaries over muddy or sandy substrates, sometimes coexisting with *Z. marina*, a species that resides in the central or external parts of the estuaries on shallow subtidal sand-dominated bottoms. *Ruppia maritima* is also present in brackish waters of some estuaries showing an extremely low spatial coverage (Cacabelos et al., 2015). The extension of Galician estuaries covered by seagrasses is estimated as 28 km²; 87% of this area being occupied by *Z. noltei*. The conservation status of seagrasses in NW Spain is generally unfavourable showing a progressive decrease in spatial cover over the last 20 years as shown by the results of the NANO project (<https://nano.ihcantabria.com/resultados/visor-nanozostera/>). The

high biological productivity associated with the coastal wind-driven upwelling process occurring at the NW Spanish waters (Álvarez-Salgado et al., 2010), supports a particularly intense harvesting activity of shellfish species, mainly clams and cockles, in the inner parts of the Galician Rias, where seagrasses dominate. The interaction between shellfishing and seagrass meadows in this region exerts a significant impact on seagrass populations (Barañano et al., 2017), frequently leading to conflicts between users and seagrass conservation.

2.2. Review of the written press and categorization of news

The information used in this research derive from a systematic review of all the available news published in Galician (NW Spain) newspapers since the mid 1800s until December 2020. We used all known denominations of seagrasses in the region: “*Zostera*”, “seba”, “xebra”, “cebal” and “cebales”. In a further phase of the searching process, the term “*Zoostera*” was also selected, as this mistaken denomination was frequently used in the newspapers.

We first searched in the Galician digital library (<https://biblioteca.galiciana.gal/gl/inicio/inicio.do>) and the digital archive of the Spanish National Library (<http://hemerotecadigital.bne.es/index.vm>). We further explored the digital archive of the newspaper with the larger circulation in Galicia: La Voz de Galicia (<https://www.lavozdegalicia.es/hemeroteca/>). Finally, a Google search of news related to *Zostera* during the 1900s and 2000s was undertaken.

The selected news were categorized from the uses, ecosystem services or conflicts they refer to. The Common International Classification of Ecosystem Services (CICES V5.1) was used. Interactions between seagrasses and marine uses or activities that result in disagreements between social actors were identified as conflicts. As different categories may be mentioned in the same article (ie. two services or conflicts can be addressed in the same news), the results are expressed as a number of references referring to a given use, service or conflict identified in a particular time period.

3. Results

A total of 158 references published in 23 newspapers were retrieved; 60% of them were published in the two major newspapers of the region: La Voz de Galicia and Faro de Vigo. A considerable number of media, 18, only contributed with one reference. The news were filtered to only include those referring directly to social perceptions, uses, ecosystem services or conflicts between users and seagrasses, resulting in 110 articles that set up the database used in this study. The selected news showed a wide spatial coverage over the Galician coastal region, with the Rias of Ferrol and Vigo showing the highest number of reports (Fig. 1).

The oldest article corresponded to a reference to the use of *Zostera* as textile material published in “Revista de Economía” in 1862. The temporal distribution of the obtained references followed a clear trend mainly characterized by a relatively high number of news published in the early 1900s followed by a sharp drop in the 1940-80 period, associated with the Spanish Civil War and the posterior military dictatorship which limited the possibility of social media to reflect social-ecological conflicts. With the advent of democracy, the number of references rose considerably (Fig. 2).

A clear temporal trend was also observed in the typology of the articles selected (Fig. 2). References to ecosystem services appearing in the news accounted for 29% of the total and were relatively more frequent in the second half of the 1800s and in the 21st century. The social media reflected conflicts related to seagrasses in any period, except when the number of news was very low (1920–1980 period). Conflicts represented 25% of the total number of references. News on seagrass conservation or focused on research or dissemination activities first appeared in the 1970s. Since then, the number of articles corresponding to these typologies grew exponentially accounting for a notable fraction

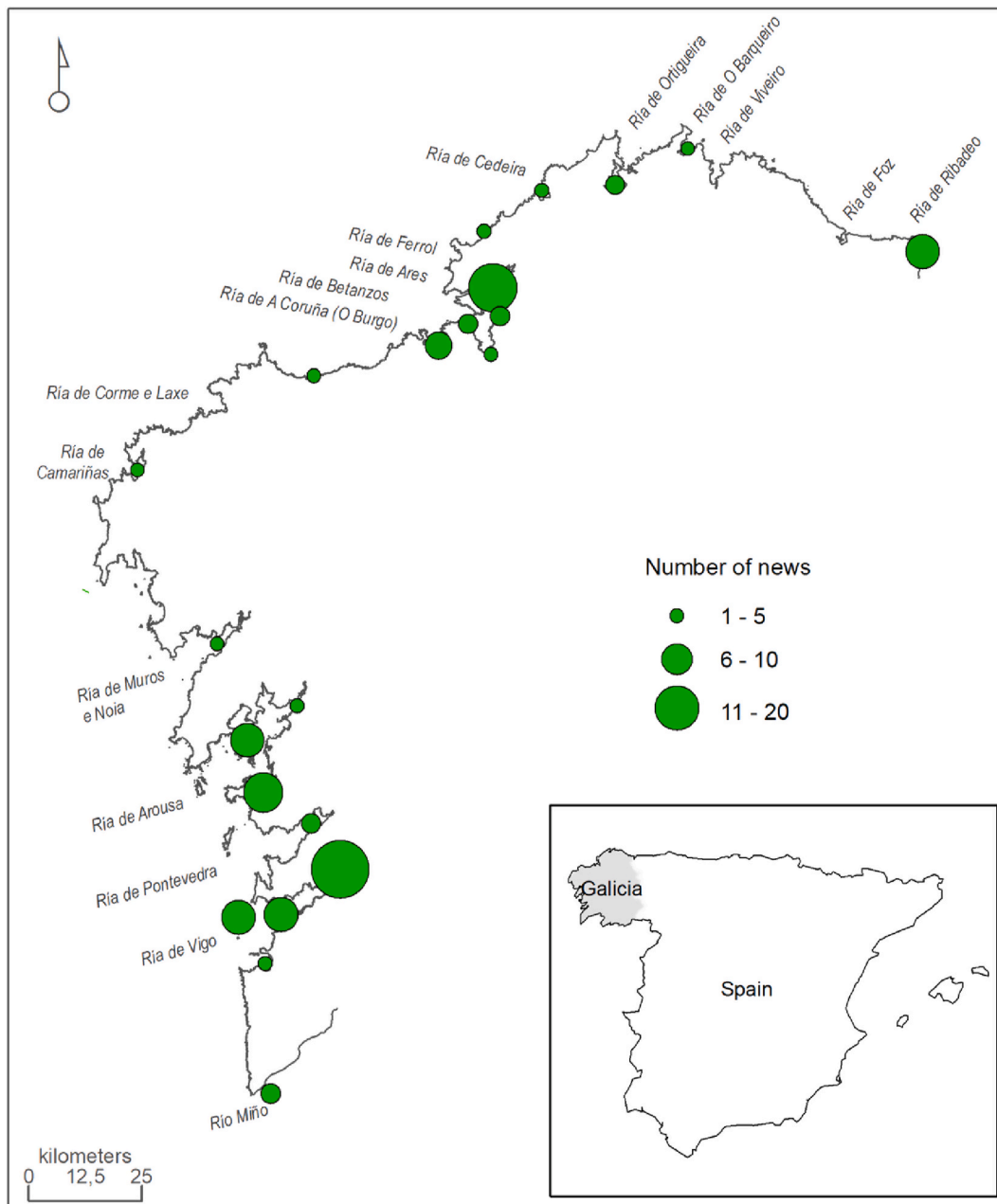


Fig. 1. Spatial distribution of the Galician locations referred to in the news selected from newspapers over the 1860–2020 period.

(>56%) of the total number of articles considered in the last two decades.

References with a distinct negative perception, generally associated with leisure activities (e.g. bad smell), or with intense interactions between seagrass harvesters and fishers or between shellfishing and conservation regulations, appeared throughout the complete study period and accounted for 26% of the total number of references (Fig. 2). The relative contribution of positive with respect to negative social perceptions of seagrasses displayed a clear increasing temporal trend, with more than 90% of the references reflecting a positive perception in the two first decades of this century.

Four main provision and regulation ecosystem services supplied by seagrasses and perceived by society were identified: provision of fibres for direct use or processing, in this case textile (CICES code 1.1.1.2), harvesting of seagrass for the supply of fertilizers (CICES code 1.1.2.1), maintenance of nursery populations and habitats (CICES code 2.2.2.3) and regulation of the chemical composition of the atmosphere

associated to carbon sequestration (CICES code 2.2.6.1). These services showed a distinct temporal succession during the period of study (Fig. 3).

Articles published in the 1800s and the first quarter of the 1900s only referred to activities related to provisioning services such as seagrass harvesting to supply fertilizers for agriculture (78%) or to deliver textile material (17%). There was only one mention of the role of seagrasses as habitats for marine animals in that period.

The references to the nursery effect of *Zostera* meadows on invertebrate populations displayed a drastic increase until the most recent period, when references to this ecosystem service became dominant. Most of these news mentioned the nursery function for the cephalopod *Sepia officinalis*, which constitutes a significant economic resource for coastal populations. Newspapers recently invoked the relevance of *Zostera* meadows for the carbon sequestration over extended temporal periods.

The existence of conflicts between different uses of the estuarine

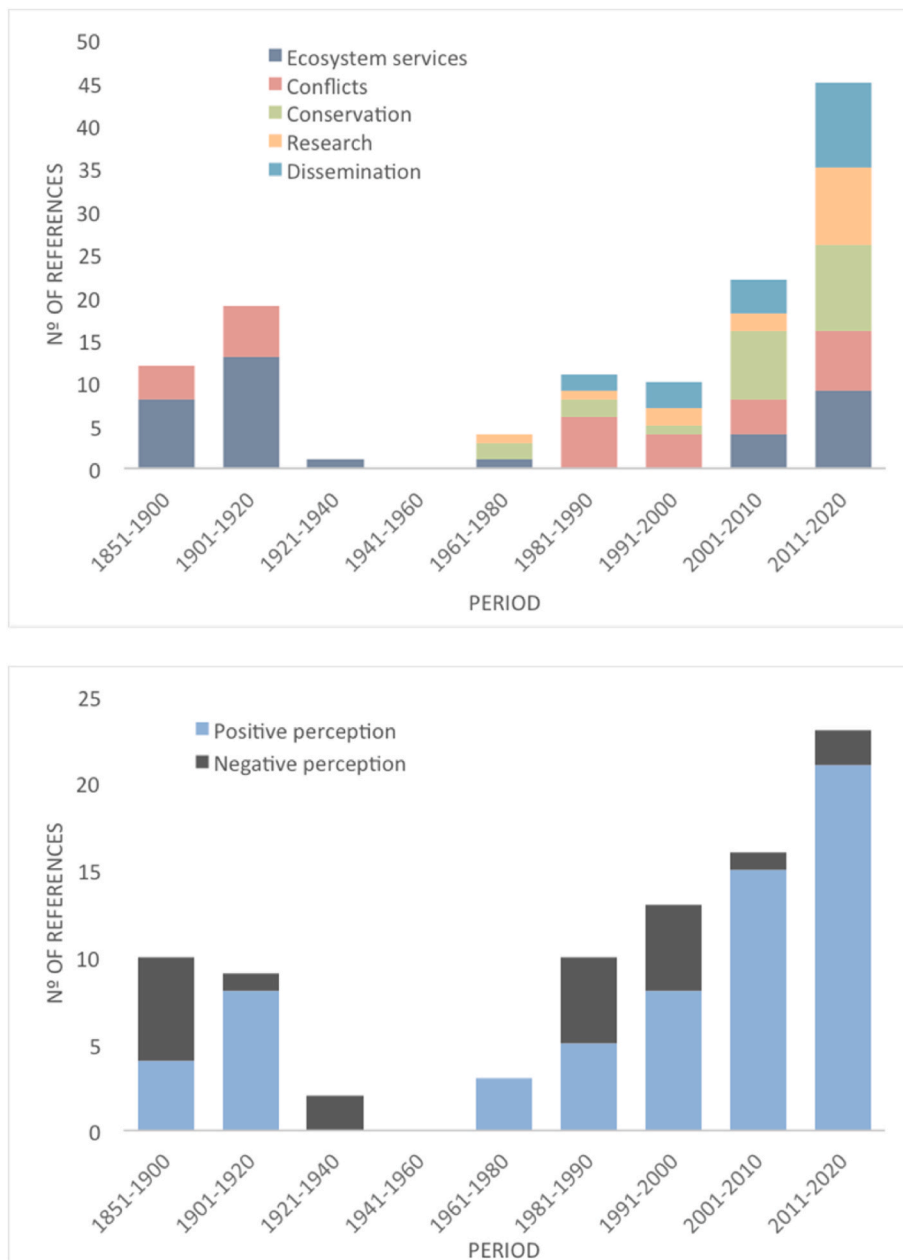


Fig. 2. Temporal trend of the number of references related to seagrass meadows published in Galician newspapers used in this study classified from their typology (upper panel) and social perception (lower panel). News are aggregated into 20 year periods except in the case of the 1800s when they correspond to a 50-years period. From 1980 onwards they are clustered into decades. Note that the 1936–1975 period corresponds to the Spanish civil war and the posterior military dictatorship.

environment and the presence of seagrasses was reflected in the written media for the first time in 1881 and persisted thereafter, with the exception of the central decades of the 1900s (Fig. 4).

This early report shows the conflict between seagrass harvesters for fertilizer use and artisanal fishers who claimed the role of *Zostera* as habitat for small pelagic fishes (e.g. sardines). Conflicts between seagrass harvesters, fishers and the Galician administration that tried to regulate this extractive activity aiming at the coexistence of uses occurred in the northern Ría of Ferrol (see Fig. 1) and concentrated more than 60% of the references mentioning conflicts in the early 1900s (see Fig. 5).

The interaction between shellfishing and the conservation of *Zostera* meadows was reported even by the end of the 1800s and extended throughout the study period, although it became more frequent from the second half of the 1900s onwards. Similarly, the conflict between seagrasses and leisure activities, mainly sea bathing and use of beaches, was present both in old and recent dates. Conversely, contrasting arguments between environmental advocates and administrations as a result of

dredging and filling activities only emerged in the 2000s.

4. Discussion

Our results show that ecosystem services provided by seagrasses and the conflicts associated with them were recognized by the Galician society since the 1800s. Nevertheless, the low number of news related to *Zostera* meadows published in local newspapers throughout the last 160 years is consistent with the recognized “invisibility” of seagrasses as compared with other coastal ecosystems (Orth et al., 2006) and confirm that social perception on the ecological relevance of these ecosystems “is still in its infancy” (Norlund et al., 2016).

Seagrass ecosystems have been considered of great cultural value, either as food provider, housing and isolation, medicine or ceremonial (see e.g. Judson Kenworthy et al., 2006 and references therein). *Zostera* populations of the temperate North Atlantic provide 19 out of the 24 services globally considered for these ecosystems, being absent the provision of raw materials and several others remaining unknown

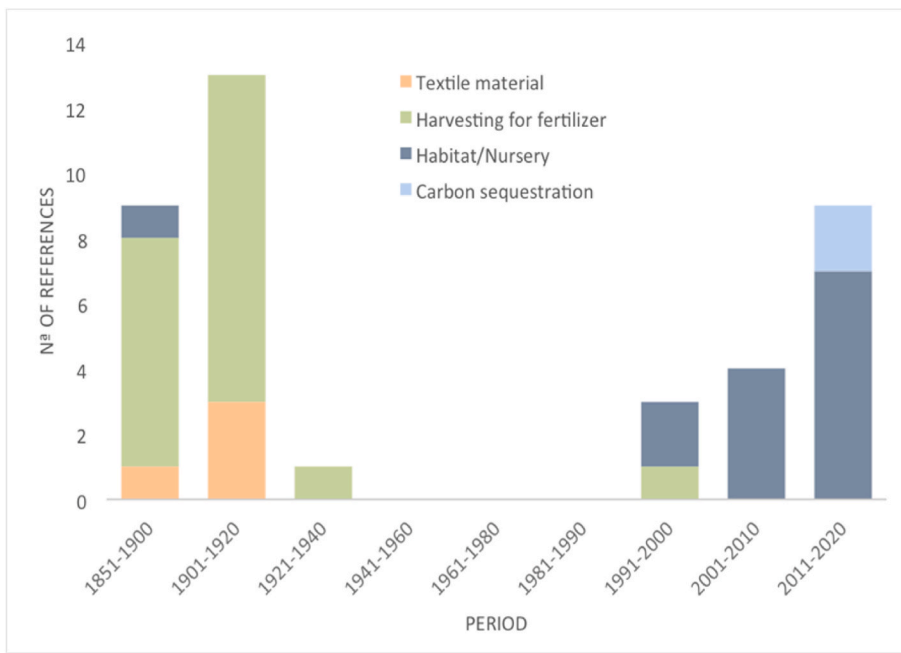


Fig. 3. Temporal variation of the number of references referring to ecosystem services. Services such as the provision of textile material or fertilizers from *Zostera* biomass harvesting, their role as habitat or nursery for animals or their capacity to sequester carbon were considered. News are aggregated into 20 year periods except in the case of the 1800s when they correspond to a 50-years period and in the 2000s when they are clustered into decades. Note that the 1936–1975 period corresponds to the Spanish civil war and the posterior military dictatorship.

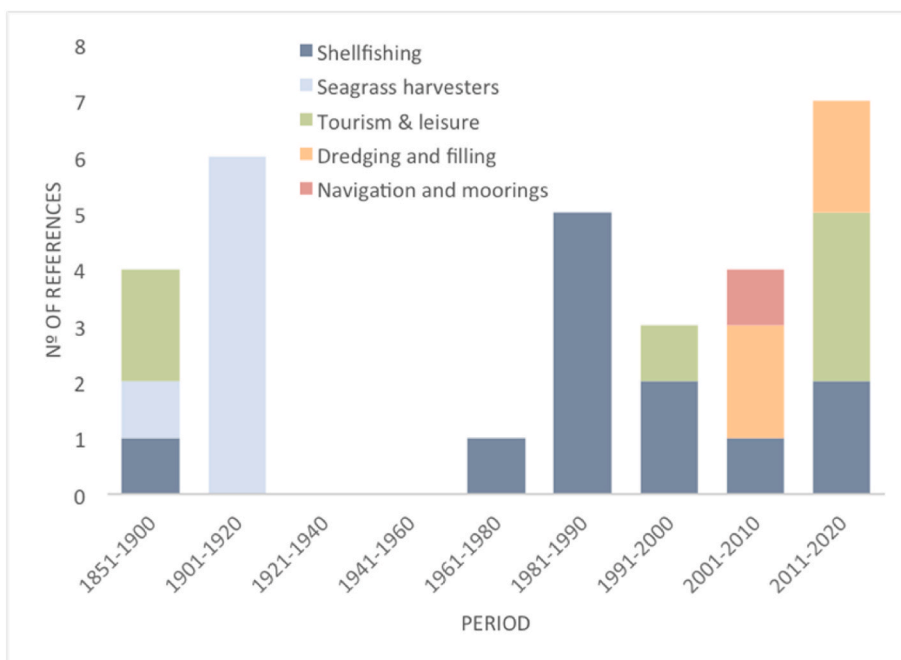


Fig. 4. Temporal variation of the number of news referring to conflicts associated with seagrass meadows. Conflicts between *Zostera*, shellfishing, seagrass harvesters, tourism and leisure, dredging and filling and navigation and moorings were considered. News are aggregated into 20 year periods except in the case of the 1800s when they correspond to a 50-years period and in the 2000s when they are clustered into decades. Note that the 1936–1975 period corresponds to the Spanish civil war and the posterior military dictatorship.

(Norlund et al., 2016). We found that the NW Spanish society explicitly perceived 8 of the ecosystem services defined by this author: compost fertilizer, fish habitat, invertebrate habitat, nursery (juvenile habitat), raw materials, carbon sequestration, cultural artifacts, education and research.

Zostera leaves were used as raw material in our region, mainly as filling for mattresses, at the very early 1900s. In this regard, a newspaper report from 1902 stressed the superiority of *Z. marina* child mattresses over those filled with cotton or feather. The review of historical archives in the United States, Canada and several Northern European countries concluded that by the early 1900s, coastal societies recognized the use of seagrasses for insulation, bedding and green mulch (Wyllie-Echeverria et al., 2000), albeit no reference was made to

Southern European countries.

Furthermore, newspaper reports on the use of *Z. marina* as textile fibre appeared much earlier, in 1862, when the shortage in cotton supply due to the North American civil war fostered the search for alternatives to this raw material. The use of seagrass quilts for domestic insulation, namely Cabot’s quilts, was described for Nova Scotia, during the first three decades of the XX century (Wyllie-Echeverria and Cox, 1999). These quilts were used extensively in all types of buildings in Canada, USA and Great Britain. Yet, this prosperous industrial activity declined in the 1930’s partly due to the “wasting disease” and the appearance of fiberglass insulation (Wyllie-Echeverria and Cox, 1999).

We did not find any reference to the use of *Zostera* for human or animal feeding, as opposed to reports in the Gulf of California where the



Fig. 5. Photograph taken in the first two decades of the 1900s showing the transport of *Zostera* and crabs collected from the beach using ox-carts (from Galicia Única: <http://www.galiciaunica.es/el-patexo-y-la-xebra/>).

Seri Indians harvested *Z. marina* to produce flour from seeds (Felger and Moser, 1973) or in the Southwest coast of Canada where the Kwakwaka'wakw harvested rhizomes of *Zostera marina* in spring for food (Cullis-Suzuki et al., 2015). By contrast, reference to its use as fertilizer for agriculture was frequent in Galician newspapers. The use of storm cast seagrasses in agriculture was reported for the Orkney Islands almost two centuries ago (Urquhart, 1824) and the provision of compost fertilizer by these species was recognized in the temperate Atlantic (Norlund et al., 2016), and is still common in the tropical East African coast (de la Torre-Castro and Rönnbäck, 2004) and in the Pacific Islands (McKenzie et al., 2021). *Zostera marina* was intensively harvested in the Galician estuaries at the transition from the 1800s to the 1900s, mainly for nutrient amendments for crops and grasslands and references describing conflicts between seagrass collectors, fishermen and the administration were frequent. The existence of litigations derived from the extraction and distribution of marine plants, mainly algae, were described in Galicia as early as 1629 (Dosal, 2007) and pointed out to the relevance of this economic activity for the subsistence of northern Galician coastal communities at the early 1900s. However, those data do not discriminate between seaweeds and seagrasses.

We found a transition from the almost exclusive recognition of *Z. marina* provisioning services to the predominance of reports on habitat generation services, mainly nursery for fishes and cephalopods, probably due to increasing research activity and societal ecological awareness occurring from 1980 onwards. A similar temporal shift in ecosystem services provision was reported for the Quebec region where an increasing trend in cultural services was found since 1971, and the interaction between animal production and cultural services changed from a trade-off or no interaction at the start of the study period to an apparent synergistic relationship by the end (Renard et al., 2015).

Yet, not all the interactions identified in this study showed a distinct temporal pattern. The conflict between shellfishing and seagrasses was persistent all through the past 160 years, although it was more frequent in the last four decades. The first report to this conflict referred to the removal of *Zostera* leaves from an oyster park in the Ria of Ferrol in 1885. However, the nature of the conflict identified in the second half of the 2000s resides in the difficulty imposed by *Zostera* rhizomes to the digging or raking for clams procedures typically adopted by local shellfishers and to their believe that seagrasses are responsible for the accumulation of mud, which “absorbs the available oxygen” and suffocate bivalve molluscs, suppositions frequently supported by the fisheries administration. Consequently, authorities backed shellfisher’s claims

and eventually boosted initiatives that were disseminated in the newspapers, consisting of substrate ploughing using tractors that removed *Zostera* plants from the meadow. The growing presence of this conflict in Galician newspapers from 1979 onwards may be interpreted as a result of the higher importance of shellfishing in the second half of the century associated to the decline of the sardine fishery in the region (Silva et al., 2015), and also to the dawning of Spanish democracy in 1977 that allowed the expression of social dissatisfactions previously suppressed by the military dictatorship.

In spite of the negative impact of shellfishing on *Zostera* meadows (see e.g. Barañano et al., 2017), a window of opportunity can be envisaged. The growing attention by the media on the importance of this ecosystem as nursery for species of commercial interest, and the expanding reference to the association between *Zostera marina* and flagship species, such as seahorses, may highlight the habitat provision service and give support to on-going and future conservation initiatives (Norlund et al., 2018).

Among the multiple overlapping management strategies that may enhance resilience of seagrass ecosystems, policy and legislation have been reported to play a relevant role (Unsworth and Unsworth, 2016). *Zostera marina* and other marine angiosperms were identified as strictly protected species in the Bern convention on the conservation of European wildlife natural habitats. However, neither the EU habitats directive 92/43/EEC nor the Spanish law 42/2007 on Natural Heritage and Biodiversity explicitly mention any Atlantic species of marine angiosperms but they protect the habitats they occupy, such as estuaries, sand banks, intertidal mudflats and coastal lagoons. In Galicia, *Zostera* spp. species are present in 20 protected natural areas. However, the Decree 37/2014, which declared special conservation zones and adopted the Natura 2000 master plan, did not refer to these species.

Contrary to some countries that recognized the ecological sensitivity of seagrass meadows and developed the necessary legislation for their protection (e.g. Ramesh et al., 2018), environmental Spanish administrations relied seagrass conservation on management plans based on non-prescriptive approaches (Kenworthy et al., 2006), driven by general consensus and supported on community based and participatory management approaches. In this context, raising awareness of the benefits seagrasses provide and the threats they suffer is one of the key actions managers may boost to effectively protect these ecosystems (Bjork et al., 2008; Unsworth and Unsworth, 2016).

To our view, historical narratives derived from the written press, such as those presented in this investigation, may induce a feeling of

resource pride and stewardship as well as a sense of place, which may facilitate the societal transition towards a more conservation-based perception of ecosystems (Wyllie-Echeverria et al., 2000), as traditional ecological knowledge and awareness of past ecosystem states are frequently lost over the course of generations. Written press can also contribute to maintaining the social-ecological memory of individuals and collective groups around seagrasses, carrying practices and knowledge from the distant past (Reyes-García, 2021). Consideration of these social and cultural values is not only essential to achieve sustainability goals and improve human well-being, but also for the implementation of ecosystem-based approaches to coastal management (IPBES, 2019). Among them, the under researched human cultural heritage value has been the most frequently identified (Domínguez-Tejo et al., 2016).

5. Conclusions

In conclusion, our results show a distinct temporal succession of the ecosystem services supplied by seagrasses and perceived by the Galician society. Provisioning services prevailed until the first quarter of the 1900s, whereas the perception of the nursery effect of *Zostera* meadows became dominant since the second half of the 2000s. The conflict between shellfishing and seagrasses was recurrent all through the past 160 years. New conflicts related to dredging, filling and navigation emerged in the present century. A positive perception of seagrasses is progressively growing mainly associated with an increasing importance of news referring to research, dissemination or and conservation of seagrass meadows. The public outreach of local traditions associated with these habitats, dissemination of the services they delivered to previous generations and the diffusion of the interactions between *Zostera* and contemporary human populations may contribute to modify social perceptions and associated behaviour around this ecosystem, providing valuable information for the design and implementation of social awareness programs, thereby encouraging seagrass conservation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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