



Enhancing recognition of seagrass ecosystems through communication planning based on historical and present social perception studies

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ABSTRACT

The knowledge of the NW Spanish population on the ecology of seagrass meadows and the recognition of the benefits and pressures provided by these ecosystems was evaluated by integrating the historical narrative and the current social perception, aiming at the implementation of management and communication strategies to achieve effective conservation policies. The results obtained in this study confirm the low visibility of seagrasses in the Galician media, as shown by the low number of news (110) registered on this topic over the last 160 years, as well as their low social profile. The current social perception of these habitats reflected an ample level of ignorance on their functions, converting them in one of the most forgotten coastal ecosystems in the region, despite their socio-ecological relevance. Thus, only a third knew that seagrass beds are not formed by algae and less than 20 % knew that there are flowering plants in the sea. Based on the historical and current social perception data focused on the conflict between shellfishing and seagrass beds, we applied Grunig's situational communication theory to identify the key environmental publics on which communication strategies should be focused. A further audience's assessment led to the proposal of a communication action plan which includes specific actions to be implemented by each one of the identified strategic audiences.

1. Introduction

The complex compatibility between seagrass meadows and human pressure derives into extended conflicts [1], as they coexist with coastal urbanization, artisanal fisheries, and tourism activities, making them highly vulnerable to water quality degradation and physical disturbances [2]. Consequently, accelerated seagrass loss and degradation rates have been reported worldwide [2,3], albeit recent investigations pointed out to signs of seagrass recovery in European waters [4].

Seagrasses are largely unknown for local populations, being commonly confused with seaweeds [5]. Although increasing social support on seagrasses is starting to be recognized, the benefits provided by these ecosystems to local communities are still poorly acknowledged [6,7]. When the public profile and appreciation of the main coastal ecosystems including coral reefs, mangrove forests, salt marshes and seagrass meadows were compared; the later were recognized to display a "charisma problem" [1,8]. Furthermore, a survey carried out to comparatively assess the attention received by different coastal

ecosystems by the social media, reported that news on seagrasses accounted for only 1.3 % of the total number of news published in newspapers, as compared to salt marshes (6.5 %), mangroves (20 %), or coral reefs (72.5 %) [8]. Published news, grants and public and private funds directed toward coral reefs exceeded by 1–2 orders of magnitude those devoted to seagrasses, mangroves and salt-marshes [3].

These low charismatic habitats and species, although may be of major significance to face climate and food security challenges, are also commonly ignored in ocean management policies and literacy programs [9]. To overcome this limitation, several studies identified the need to raise the profile of seagrass meadows to advance on seagrass conservation [9,10]. These studies recommended focusing efforts on improving communication on seagrass ecosystem services to the target publics by analyzing key effective messages to communicate, means to reach broader segments of society and the processes by which communication is established. Nevertheless, prior to the definition of communication plans, knowledge on the social perception on the benefits provided by seagrasses is required.

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Research focused on public perceptions of the marine environment and particularly on seagrass ecosystems is scarce, being mostly centered on coastal intertidal areas and mainly dedicated to threats to marine health and on measuring public concern [5]. When this kind of studies was performed, large differences in social perception among localities were detected [5,11]. As expected, a higher recognition of the relevance of seagrasses characterizes local communities with closer socioeconomic dependence on seagrass for livelihoods, whereas recognition is weaker in communities not directly linked to these ecosystems [5,11]. Differences in seagrass recognition were also related to the level of economic development, showing a strong inverse correlation between ecological knowledge and income levels in India, Indonesia, and the UK [12]. As communities become wealthier, and largely independent of local environmental livelihoods, ecological knowledge decreases and turns out to be concentrated in fewer people while losing social capital for environmental management as compared to resource-dependent communities.

Quantification of ecosystem services and analysis of their social perception are, therefore, required for the integration of sociocultural values into coastal management and conservation policies [13]. 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 [14] and loss of culture and traditions [15]. This has been suggested to be frequently the case of seagrass ecosystems [1]. In this context, knowledge on the historical narratives of ecosystem services provided by seagrasses may facilitate the societal transition towards a more conservation-based perception of ecosystems Wyllie-Echevarria et al. [16].

In conclusion, one of the crucial challenges for global seagrass conservation is to engage society and deliver behavior changes by designing and implementing more effective communication plans [17], which may eventually improve the effectiveness of conservation strategies [18,19]. Communication plans need to be supported by local studies on

social-ecological knowledge and perceptions and be oriented towards the design of informative techniques leading people to make up their own minds based on scientific evidence. For such, it is necessary to identify target audiences and their current knowledge level on the ecosystem services provided by seagrasses and to develop segmented communication actions, improved marketing, and education products to achieve the dissemination objectives that allow increasing recognition.

In this study we investigated the current social perception of the Galician population about the services, barriers to knowledge, pre-conceptions and the most relevant conflicts related to seagrass ecosystems as the basis to elaborate a social communication plan aimed at different audiences. The proposed plan addresses the main values, impacts, interactions, and conflicts identified in the study. We focus on the Galician region (NW Spain), where seagrass meadows constitute a well-represented ecosystem of high economic importance due to the provision of critical habitat for fish and invertebrate species with significant commercial and recreational values. They are mostly located within habitats included in the Natura 2000 network and exposed to the threats derived from the human activity, as untreated urban sewage, the alterations of the coastal margin associated to land reclamation or the mechanical impacts derived from shellfishing [20–24].

2. Methods

2.1. Social perception studies

The perception of the Galician population (Fig. 1) about seagrass meadows was carried out through a web-based questionnaire implemented in Google forms and was structured in 8 sections (see supplementary material: <https://docs.google.com/forms/d/e/1FAIpQLSfGtsZMJfeEuabScnhUtqFkDnpBtoVtOdkGzcH9e5CxumOUTA/viewform>), was disseminated through email and social media channels in

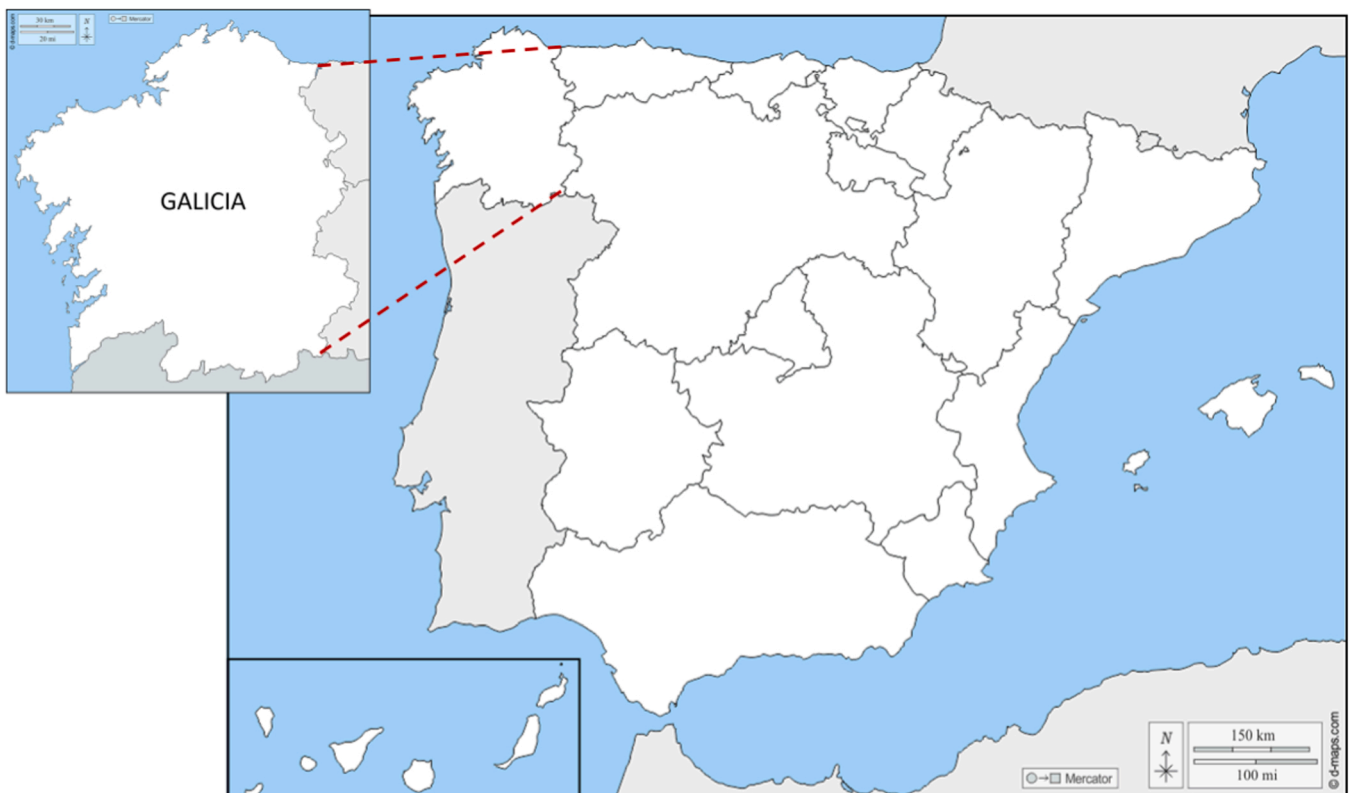


Fig. 1. Map of the study area (Galicia, Spain).
Source: d-maps.com.

February 2020. The questionnaire first addressed the sociodemographic characteristics of the participants (sex, age, educational level), and then focused on different social ecological aspects related to seagrass dynamics, threats, and management. Information was gathered on the respondents' general knowledge on seagrass ecosystems and how they perceive the differences with algae and on the level of familiarity about the representative Atlantic seagrass species (*Zostera spp.*) and the Mediterranean *Posidonia oceanica*, including the information channels whereby that information was acquired. Questions about the spatial and temporal dynamics and growth scales of seagrass beds and about the benefits that *Zostera* meadows bring to society followed. The three last sections of the questionnaire dealt with the respondents' awareness about threats and the interaction of uses and conflicts between human activities and seagrass conservation and on the governance and management of seagrass ecosystems.

The survey was completed by a total of 823 people, what represented 0.03 % of the > 18 years Galician population. Both the age structure of the Galician and the population sample show low percentages of young people (18–29 years) with a notable fraction of the middle-aged population (between 40 and 60 years), which in both cases represented approximately 50 % of the population. In the case of the gender structure, women represented 55 % of the sample, compared to a value of 52 % provided by the Galician Institute for Statistics (IGE) in 2020, so it is considered that the sample is representative of the current population of Galicia (Fig. 2).

The exception to this was detected in the significant bias of the sample towards people with higher education. This group represented almost 82 % of the total, whereas the value reported by the IGE for Galicia for 2018 was 29.5 %.

To overcome this limitation, a new database was generated to adjust the education level structure to that characteristic of Galicia, that is, 11.7 % of primary school level studies, 53.1 % with secondary education and 29.5 % with higher education. To this end, the number of people who should be included in each class to build up the adjusted database was calculated considering that the limiting class in our sample was the one formed by people with primary education. From this exercise it turned out that the new database should be composed, in addition to all the people with primary and secondary education in the sample, by 71 with higher education out of the 674 who answered the survey. A random sampling of this group was carried out on the original database resulting in a new database made up of 225 people, whose structure of educational levels reproduced the characteristic distribution of the Galician population.

Both databases, the total and the adjusted one, were processed in the same way to compare the results obtained from both samples. The estimated sampling errors calculated from z-score values (95 % confidence interval) and the standard error of the mean were 3.4 % for the

complete database and 6.5 % for the adjusted database. Although the results of both databases are comparable, the adjusted version was used in all the results presented in this study.

2.2. Review of historical narratives related to seagrass meadows

In this study, we also used the information derived from a review of all the available news published in Galician newspapers since mid 1850–2020, which was performed by searching selected keywords on the historical archives of the Galician digital library, the Spanish National Library, Google and the historical archives of the two major newspapers of the region: La Voz de Galicia and Faro de Vigo, as shown in Fernández et al. [25]. A total of 158 references were obtained and analyzed.

We also explored the quantitative relevance and the main topics addressed by scientific publications focused on seagrass research through a bibliographical search. References to in situ studies were extracted from previous reviews, in particular the Spanish seagrass distribution Atlas [26], as well as from specific authors who studied these ecosystems from different disciplines, adopting a snow-ball approach. In addition, a search was performed using the Scopus and Google Scholar databases and the keywords 'seagrass'; 'Galicia'; 'NW Iberian'; 'Zostera'. All references were classified based on the scientific topics addressed. A total of 63 scientific works have been published since 1950, with a clear focus on seagrass fauna (44 %), flora (22 %) and seagrass threats (19 %), whereas seagrass distribution assessments and social-ecological evaluations only represented 14 % and 3 %, respectively.

2.3. Communication plan

Based on the knowledge obtained from the historical and present perception studies, a SWOT analysis on communication in the context of human-seagrass interactions was performed. Then, an audience map was developed following three consecutive phases. After a first identification of the potential audiences, these were classified according to Grunig's situational theory of audiences [27]. This theory tries to determine the communicative behavior of individuals by addressing the challenge of explaining why people communicate and when they are most likely to do so. Although some authors consider this approach as obsolete, others defend its validity and usefulness, especially through the most recent developments [28]. In this regard, we decided to follow this methodology as previous studies [29], have shown the reliability of using the situational theory in conjunction with the Van Liere and Dunlap, Kent [30] scale of environmental concern and because it has been applied in recent environmental studies (Lim et al., 2014; Jiang et al., 2019).

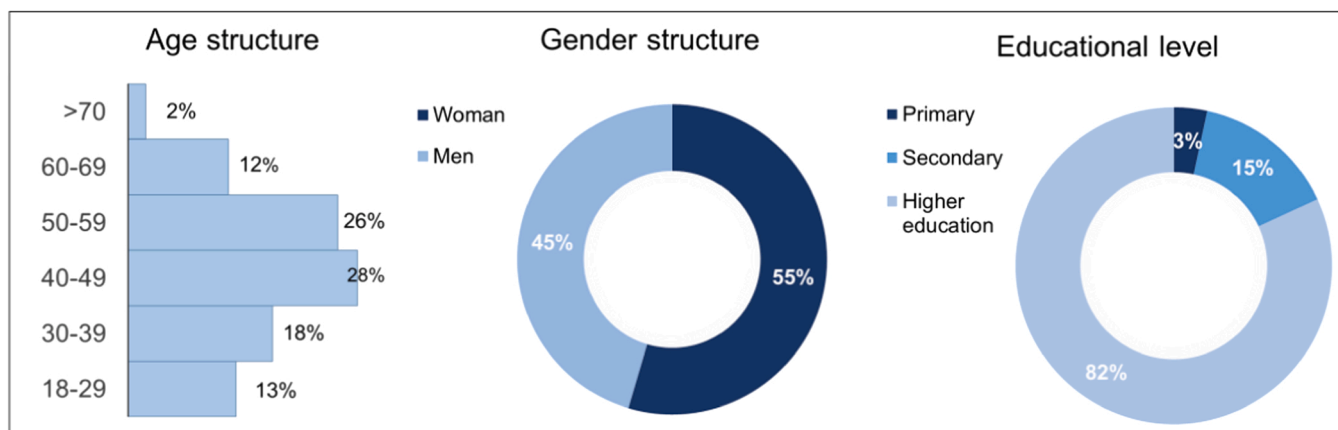


Fig. 2. Demographics of the population sample used in the survey: age structure, gender structure and educational level (n = 823).

Grunig [27] defines the public as a group of people who a) face a similar problem, b) recognize that the problem exists, and c) organize to do something about it. According to these premises, four types of audiences are defined:

- Non-public: individuals who do not meet any of the three previous criteria
- Latent audiences: individuals who face a problem, but do not detect it
- Informed or aware publics: individuals that are affected by a similar problem and acknowledge its existence
- Active audiences: individual that are affected by the problem, recognize it, and do something about it.

The Situational theory considers three independent and two dependent variables. The independent variables are: a) problem recognition, b) constraint recognition, that is, the degree to which people perceive the limitations to plan their behavior in a situation and c) level of involvement. The independent variables determine to what extent the two dependent variables will occur: a) the information processing or passive communication behavior and b) the search for information or active communication behavior, that is, the individual in addition to receiving information is mobilized to obtain more information.

Thus, audiences with a behavior to confront the problem will tend to seek information and process it, especially if they are involved. In the case of restricted behavior (high problem and constraint recognition), information will only be sought and processed if involvement is high, as is the case with routine behavior (low problem and constraint recognition). There will be no search for information in the case of individuals with fatalistic behavior (low problem recognition and high constraint recognition).

Based on the above information, an assessment of audiences was carried out by assigning weights to each of those considered relevant, either because they are active or conscious publics or because they are "not audiences" or "latent audiences" today but have a significant potential to become active audiences in the future. Valuation assessment of the classified audiences was performed on five characteristics: strategic importance, accessibility, influence on the public opinion, dissemination capacity and cost of communication, and weighted from 1 to 5, according to the conclusions derived from a panel of experts composed by relevant stakeholders (NGOs, Artisanal fishers organizations, scientists, public administration and tourism and leisure organizations). An overall rating close to 1 indicates a strategically very unimportant audience, very expensive communication cost and low influence on public image, while ratings close to 5 represent strategically very important audiences, with very cheap communication cost and high influence on public image. Based on the identified target audiences, a roadmap was designed with concrete actions that may contribute to upgrading the level of knowledge and social perception of the population about seagrass ecosystems.

3. Results

3.1. Perception of the Galician society on seagrass ecosystems

Most of the population surveyed in this study confirmed they knew about seagrass beds (74 %). However, 26 % of the respondents did not know what these plants are, and only 36 % distinguished them from algae. Only 7 % of the respondents knew that, unlike algae, they have roots and flowers and only 18 % know that there are flowering plants at sea. Of these, 65 % were not able to identify any type of flowering plant in marine waters, only 11 % recognized *Zostera* and *Posidonia* and 3 % mentioned seagrass beds.

When the knowledge of the Galician population about the most representative genera of seagrasses in the Atlantic and Mediterranean was explored, more than 50 % of the sample acknowledged *Posidonia*,

while only 32 % knew *Zostera*, the dominant seagrass species in the Atlantic, the regional oceanic environment of the population surveyed (Fig. 3). Up to 8 types of communication media were recognized to provide information on *Posidonia*, while only 4 were registered in the case of *Zostera*. Most of the surveyed population was informed on *Zostera* through Internet, which requires an active search, while television was the main information channel for *Posidonia*. Transmission by acquaintances is 20 % more important in *Zostera* than in *Posidonia*. Reports, literacy programs and research were reported as information sources in the case of *Posidonia*. None of these media were mentioned in the case of *Zostera*.

Only 17 % of the people surveyed recognized the seasonal variability of the abundance of these plants, while 32 % knew the time scale of growth, which indicates a considerable lack of knowledge about the temporal variability of these species. Almost 60 % of the population knows some of the types of habitats inhabited by *Zostera*, and up to 10 % associate them with rocky bottoms, which in turn is related to the confusion identified between marine plants and algae. The respondents showed a better level of knowledge about its geographical and bathymetric distribution. More than 50 % are aware of their wide distribution and only 7 % restricted them to our coast. More than half of the respondents associate the distribution of these species to shallow waters, and 22 % believed that they are only intertidal or extend down to 1 m depth, which may be related to the lack of knowledge of the population about the vertical distribution of light in the sea.

In general, the results of the survey revealed a positive perception about the ecosystem services that seagrasses provide to society (Fig. 4). More than 50 % of the population valued these services as important or very important, except for their relevance as habitat for the collection of bivalves such as clams and cockles or for the maintenance of water quality for recreational use, which showed lower valuations, since only 30–40 % of the respondents valued them with a high or very high level. The most valued services were their role as indicator of water quality, its value for marine research and its importance as breeding area for other species, which obtained high or very high recognition by almost 70 % of the people consulted. 30–40 % of the surveyed population was not aware on the importance of *Zostera* to provide ecosystem services, a value similar to those initially recognizing that they had not heard of seagrasses before.

More than 70 % of the respondents considered that seagrasses are threatened and only 1 % did not identify pressures on these ecosystems. Among the people who identified seagrasses as a threatened ecosystem, more than 90 % mentioned pollution as the main threat, followed by anchoring boats (75 %) and climate change (65 %). On the contrary, tourism and shellfishing received the same attention with about 40 % of the respondents identifying these activities as the main pressures. Almost 20 % of the consulted people identified sport diving as a threat and less than 1 % recognized parasites (Wasting disease) or landfills as drivers for seagrass loss.

However, it is noteworthy that the percentage of people who believe that the presence of *Zostera* affects shellfishing (44 %) is similar to those who think that shellfishing is a threat to this ecosystem (43 %).

Most of the people surveyed (> 70 %) believed that seagrass meadows should be protected and less than 1 % considered that they should not have any specific protection (Fig. 5).

The activity receiving the largest support to its reduction was boat anchoring, where more than 75 % of those surveyed consider that measures should be taken. In the case of shellfishing, about 60 % considered that this activity should be reduced when it interacts with seagrass habitats, but 18 % believe that it should be maintained. It is noteworthy that more people advocate a reduction of underwater fishing (45 %) as compared to reducing tourism activities (35 %).

3.2. Historical perception of galician population

The main ecosystem services and benefits supplied by seagrasses and

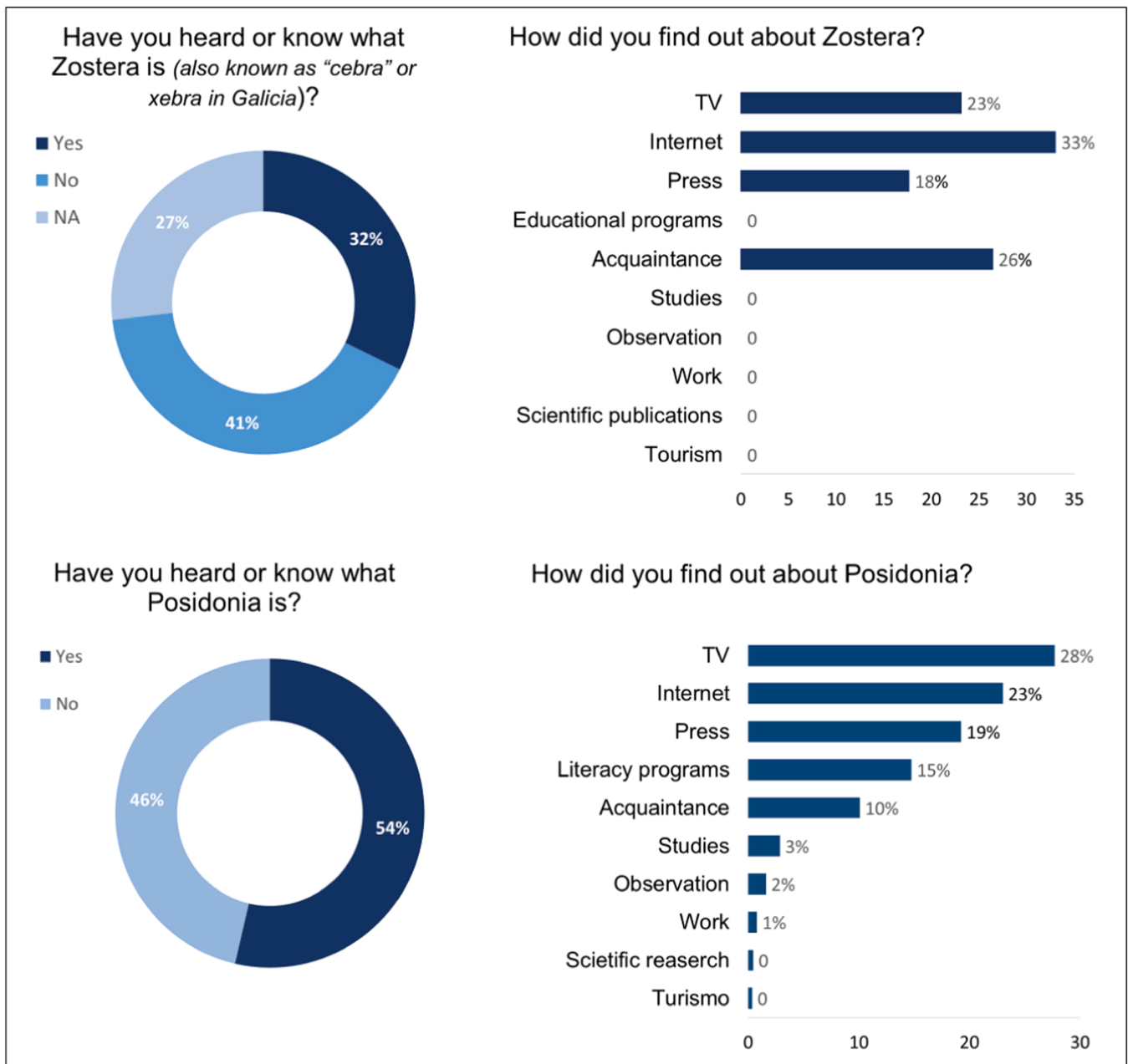


Fig. 3. Perception of the Atlantic (*Zosteria*) and Mediterranean (*Posidonia*) dominant seagrass species and information channels used to obtain information on these species.

perceived by the society, showed a distinct temporal succession during the last 160 years as inferred from the analysis of the written press (Fig. 6). Articles published in the XIX century and the first quarter of the XX century only referred to activities related to provisioning services such as seagrass harvesting (56 %), the supply of fertilizers for agriculture (30 %) or textile material (15 %). There was not any explicit mention to the role of seagrasses as habitats for marine animals until the last quarter of the XX century, then showing a drastic increase until the most recent period, when numerous news referred to the function of seagrasses as nursery for populations of *Sepia officinalis*, which constitutes a significant economic resource for regional coastal populations. The contribution of seagrasses to climate change mitigation through carbon sequestration has been reported in newspapers only very recently.

Conflicts between harvesting of seagrasses for their use as fertilizers, fishers and the Galician administration that tried to regulate this

extractive activity concentrated > 60 % of the references to conflicts in the early 1900 s. The interaction between shellfishing and the conservation of *Zosteria* meadows extended throughout the study period, although it was more frequent since 1980. Similarly, the conflict between seagrasses and leisure activities, mainly sea bathing and use of beaches, was also recurrent in the period under study. Disputes between conservationists and administrations derived from dredging and filling activities only occurred in the XXI century.

The scientific literature on Galician seagrass ecosystems was relatively modest until the 1980 s. Only five scientific publications were registered from 1920 to 1970, focused on new records of Galician seagrass beds and the accompanying flora. The number of publications increased exponentially since 1980 onwards, with 19 new scientific investigations registered until the end of the XX century.

The main research topics addressed by the reviewed scientific publications were related to the associated faunal assemblages, which

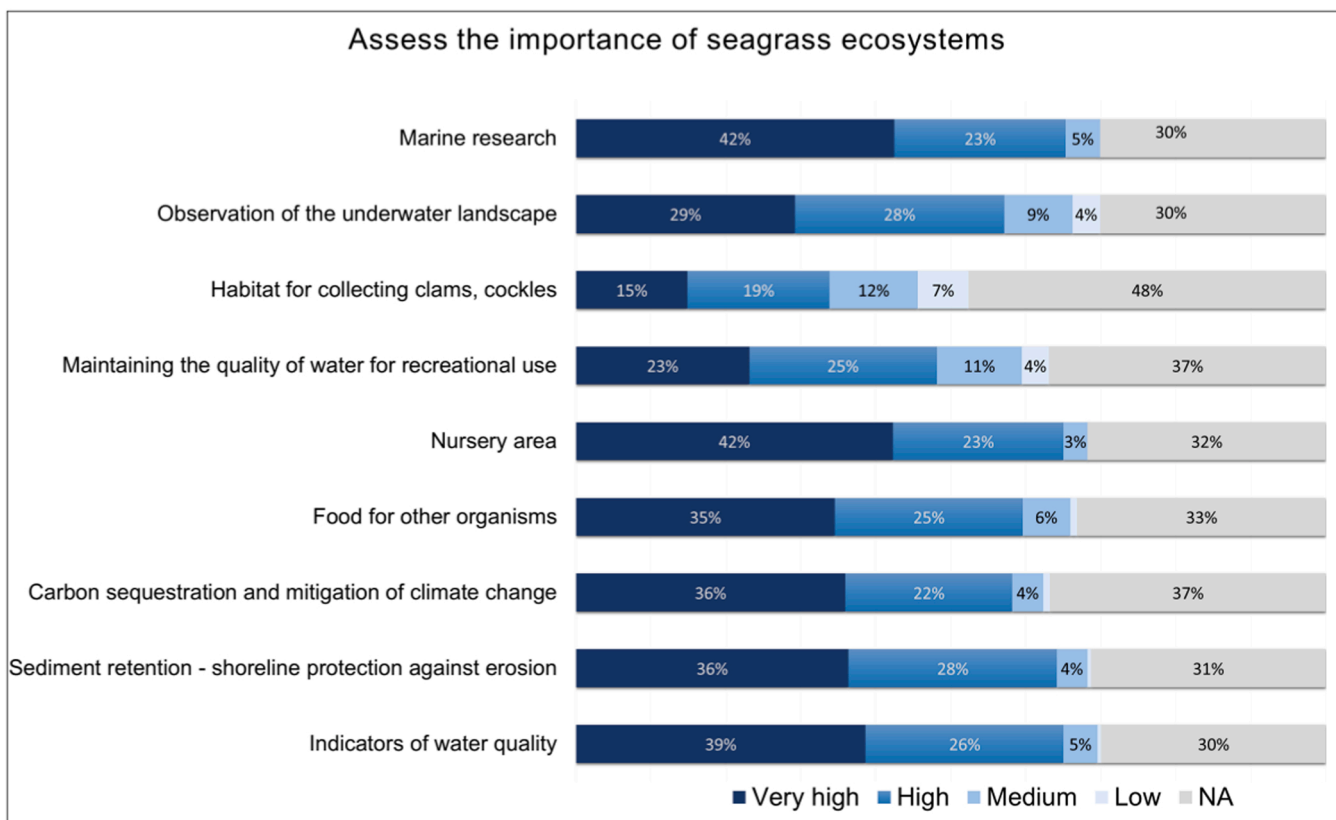


Fig. 4. Social perception of the services provided by seagrass ecosystems.

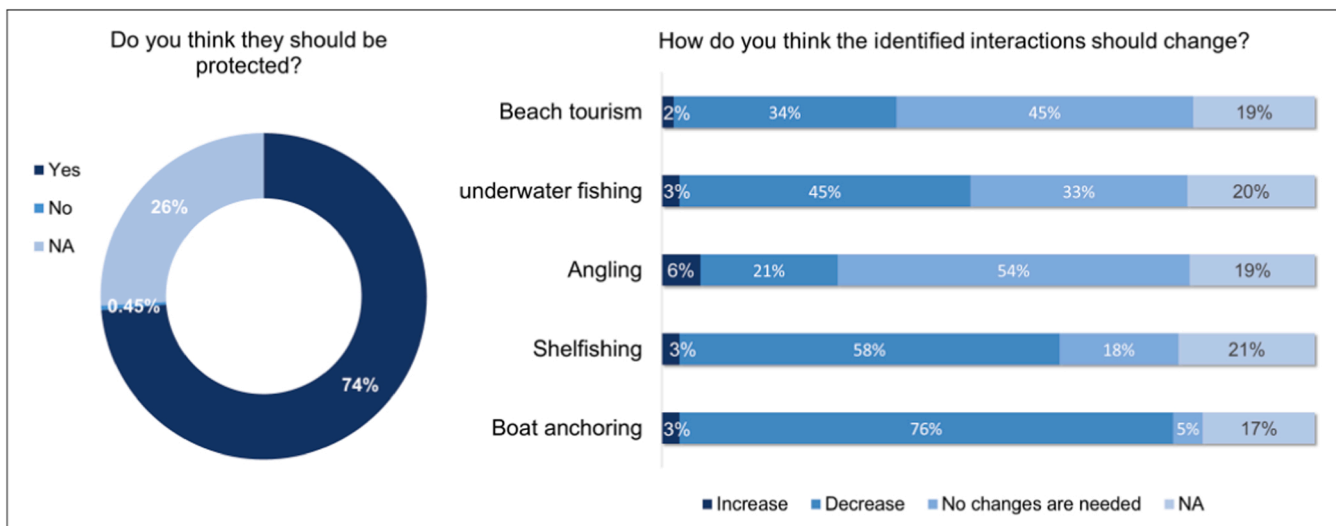


Fig. 5. Social perception of seagrass management uses.

accounted for almost half of the papers, followed by studies on the flora associated with seagrasses (22 %), and, to a lesser extent, studies focused on pressures and impact assessment (20 %) and reporting seagrass habitats characterization and distribution (14 %). It was not until 2018 when the first social ecological assessment of seagrass interactions and stakeholder perceptions was published.

3.3. Communication plan on seagrass ecosystems

A SWOT analysis was performed based on the perception studies presented above to identify the strengths, weaknesses, opportunities,

and threats on which the communication plan should anchor its main actions. The main elements that articulate the SWOT analysis are presented in Table 1.

The results of the perception analyses carried out either on the present Galician population or derived from the historical study combined with the literature review, revealed the lack of knowledge of the Galician society about the biology and ecology of these ecosystems. This illiteracy is especially evident when basic concepts about its nature and spatial and temporal dynamics were explored and is clearly illustrated by their frequent confusion with algae.

The perception of these ecosystems is conditioned by their low

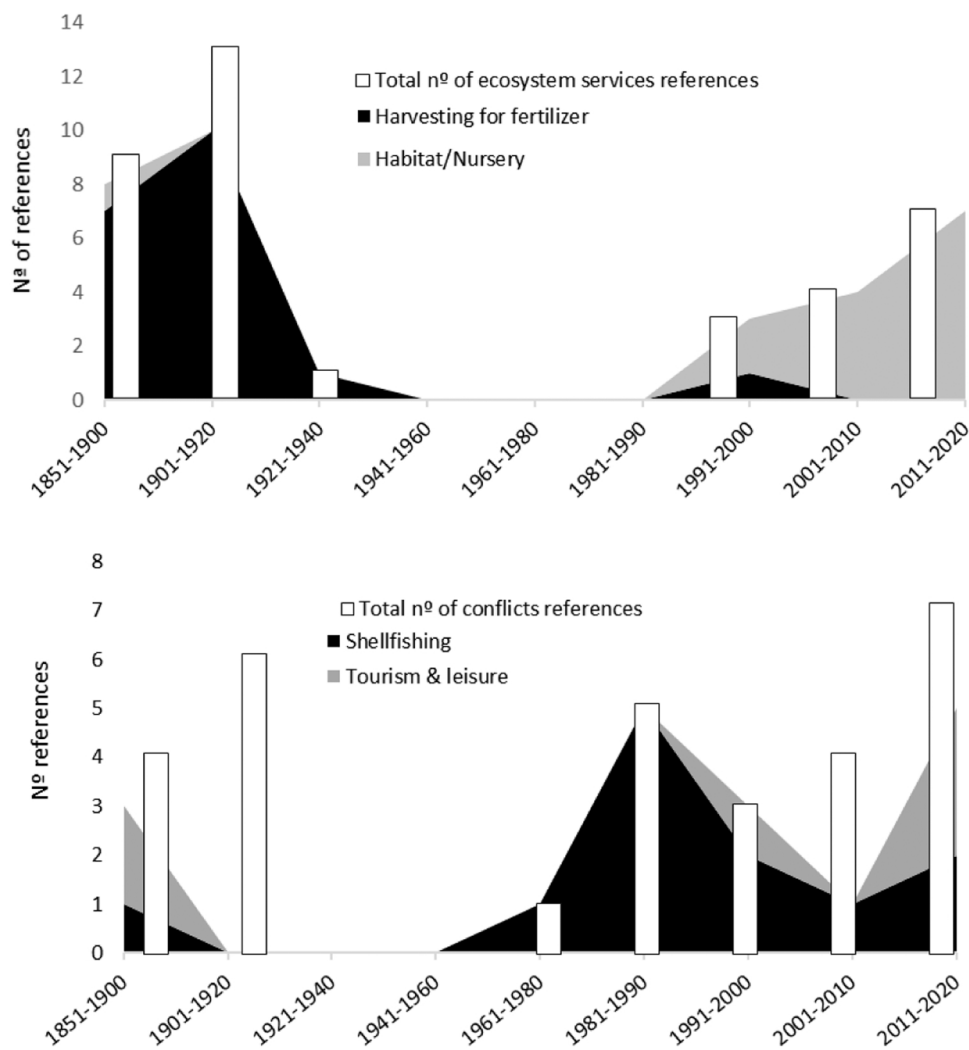


Fig. 6. Temporal variation of the number of news referring to A) ecosystem services and B), conflicts associated with seagrass meadows.

aesthetic appeal. They are responsible for the common phenomena of summer arrival on the beaches, causing disgusting odors and a source of discomfort for bathers to enjoy the coastline. In addition, they inhabit coastal areas interacting negatively with many coastal economic activities, such as shellfishing and leisure or commercial port activities. They have been, consequently, a historical source of conflicts, still persistent, with consolidated economic sectors of the blue economy. In spite of this, the absence of regulations and the lack of recognition as a priority habitat within the Natura 2000 Network, illustrates the lack of a specific protection of the Atlantic species.

Seagrasses constitute highly resilient ecosystems that are recognized to provide important benefits and services to society what contributes to reverse its initially negative social image. The informative and political path already advanced in the Mediterranean with *Posidonia oceanica* is an opportunity to open a space of awareness for the Atlantic species. There is a broad consensus about the key role of this ecosystem in mitigating climate change, positioning them as allies in political and corporate strategies for sustainability. Although it is necessary to advance in the planning and management of these habitats, there are normative tools on which to build and improve the management and protection of these ecosystems. The fact that seagrass meadows have been identified as one of the key components of various habitats subjected to conservation and considered in the EU Water Framework Directive, represents a solid base on which to advance in the consolidation of measures that ensure the conservation and social recognition

of these ecosystems.

A prominent opportunity to catalyze the needed change in social perception with respect to these ecosystems is that artisanal fishers recognized them as a key habitat for the reproduction and nursery of species of commercial interest, as is the case of cuttlefish (*Sepia officinalis*), what illustrates the economic benefits for local communities derived from seagrass beds. The contribution of seagrasses to improve water quality by reducing both nutrients and pathogens is among the most easily recognizable benefits provided by these ecosystems, as they help mitigating one of the main environmental social concerns: "pollution". They also support shelter and protection to one of the most charismatic marine species in the region, "seahorses", and are a source of food for umbrella species such as turtles and manatees in tropical areas.

Among the opportunities identified, it is worth mentioning the growing social awareness and concern for the marine environment, which, added to the accessibility and proximity of these coastal ecosystems favors their use for learning and dissemination initiatives, particularly for the implementation of environmental education and citizen science programs.

In this context, the following objectives for the communication plan are specified:

1. Increase the knowledge of the various audiences about seagrass meadows, their characteristics, and their relevance in the Galician environmental and economic context.

Table 1

Strengths, weaknesses, opportunities and threats on which the communication plan should anchor its main actions. PPS, HPS and LR indicates whether the conclusion derived from the Present Perception Study, from the Historical Perception Study or from the Literature Review.

STRENGTHS	WEAKNESSES
The ecosystem benefits associated with seagrasses are important and socially recognized (PPS)	Knowledge about its existence and dynamics is scarce (LR)
Seagrass meadows dominated by <i>Zostera</i> are identified as one of the key components of Habitats of Interest by the EU Habitats Directive (cod. 1110) (LR)	Low number or ineffectiveness of outreach programs focused on seagrasses (PPS and LR)
They are part of the Natura 2000 Network as Special Conservation Areas (LR)	Existence of misconceptions about its nature (confusion with algae) and population dynamics (PPS)
The EU Water Framework Directive designates as protected areas those occupied by <i>Zostera</i> meadows in Galicia (LR)	Ignorance of its spatial and temporal variability (PPS)
Advances in the Mediterranean with the dissemination of <i>Posidonia</i> (PPS, LR)	Absence of seagrass, and in general of the marine environment, in the educational curriculum of Galicia (PPS, LR)
Ecosystem highly resilient to physical disturbances. Sign of recovery in several European locations (LR)	Negative interaction with relevant economic activities in the territory, such as shellfishing and aquaculture (PPS, LR)
	It is not socially recognized as an ecosystem with high aesthetic quality (LR)
	Very little visibility in the media (PPS, LR)
	Banquet on the beaches causes discomfort to bathers (LR)
	Unlike other species (<i>Posidonia</i>), the genera <i>Zostera</i> does not appear specifically as a priority species in the Red Natura, but as a component of a priority habitat (PPS)
OPPORTUNITIES	THREATS
Use of cuttlefish nursery as a justification for the economic benefits derived from seagrass beds (HPS)	The area they occupy is in regression in many localities (LR)
Use of seahorses as a “flag” species that justifies their conservation (LR)	It has been a source of conflict since the XIX century (HPS)
Capacity to sequester carbon, related to their potential in climate change mitigation strategies (LR)	Geographical location is close to urban settlements (LR)
Use of its ability to purify water, both nutrients and pathogens (LR)	They coexist with areas where discharges of human origin enter the marine environment (LR)
Positive assessment of seagrass beds as indicators of good water quality (LR)	Tourist or leisure activity tends to trample seagrasses (bird watchers) (LR)
Growing societal awareness favorable to environmental conservation (PPS)	There is a socially recognized interaction between shellfish extraction and the presence of <i>Zostera</i> (PPS)
Its distribution (accessible areas) and ecology allow environmental education and citizen science activities with limited means / resources (LR)	Global change scenarios forecast a pessimistic future for their conservation (LR)
	The ecological integrity of these ecosystems is not included in the exploitation plans in the areas where they coexist with shellfishing (LR)

2. Generate a favorable attitude towards the protection and conservation of seagrass meadows, especially in key groups directly related to the sea and audiences with a high dissemination capacity.
3. Transfer to the media agenda the relevance of seagrass meadows and the need for their conservation, to encourage the development of protection measures by public and private entities.

In addition to considering the general population as a final target of the plan, we developed an specific audience map following three consecutive phases. After a first identification of the potential audiences, they were classified and finally an evaluation assessment was undertaken. These audiences were initially classified from their direct or indirect relationship to the coastal area dominated by seagrass beds. We then classified the audiences according to Grunig and Hunt [31], consulted in Míguez-González [28] (Table 2). Based on the above information, a valuation assessment was developed by assigning weights to each of the audiences considered as relevant either because they are active or conscious publics or because they are “non-public” or currently “latent public” but with significant potential to become active audiences in the future (Table 2).

Six key audiences were selected based on the weight analysis on which to focus communication and training actions: Shell fishers and Artisanal fishers, Administration, Journalists, Environmental associations, Students and Teachers. Considering the characteristics of the key audiences, specific actions were designed and temporalized for each of the audiences, as shown in Table 3. There is not any specific organization responsible for the implementation of proposed road map in NW Spain, but it could be led by different organizations with the involvement of the identified interest groups.

Shellfishers and artisanal fishers, both strategic audiences with restricted behavior, will require an approach aimed at reducing misconceptions and transmitting the benefits that the presence of the

seagrass meadows exert on the populations on which they act. Journalists, as an active public with routine behavior, are considered of special relevance as an intermediate audience due to their great capacity to influence opinion and their ability to disseminate. In this sense, contact with professional associations as well as with some journalists from the region who frequently cover topics related to the environment, the marine domain or scientific research is proposed. Environmental associations, as an active public with behavior to confront the problem, are essential actors in the achievement of the objectives due to their accessibility and influence on the public opinion.

Administrations responsible for environmental policies and those dealing with marine resources are part of the strategically relevant active public as they are ultimately responsible for the management of protected areas. They used to identify themselves as an active public with restricted conduct, where the limitations of its action are indeed related to the socioeconomic and environmental conflicts derived from the coexistence of resource extractive activities with habitats of interest for conservation. Specifically, elaboration of a synthesis document “Brief policy” gathering the conclusions of the workshops and dialogue tables developed with the different groups involved is suggested. This document should include proposals for the improvement of the management of the natural spaces where they coexist.

Finally, both students and teachers emerge as key actors, particularly those from coastal municipalities. Although these two groups are classified as “latent publics” or “non-publics”, they present a strategic importance with a view to the medium-long term achievement of the proposed objectives, together with some very notable characteristics of accessibility and dissemination capacity. This justifies the implementation of a specific and innovative educational program that increases their problem recognition and their level of involvement, turning them into active audiences that help increase knowledge and awareness in other audiences.

Table 2

Classification of audiences on the basis of the Grunig situational theory [31] and Valuation assessment of the classified audiences. Weights equal to or greater than 4 are displayed in green and those between 3 and 4 in yellow. In the case of communication cost, 0 means maximum cost and 5 minimum cost. Finally, those audiences that exceed an average weight of 3 are marked with a gray frame.

AUDIENCE	PROBLEM RECOGNITION	CONSTRAINT RECOGNITION	INVOLVEMENT	TYPE OF AUDIENCE	RELATION	STRATEGIC IMPORTANCE	ACCESSIBILITY	INFLUENCE ON OPINION	DISSEMINATION CAPACITY	COMMUNICATION COST	TOTAL
SHELLFISHERS	HIGH (most recognize the effects of their activity)	HIGH (alters their work dynamics)	HIGH	ACTIVE Restricted conduct	Direct	5	3	3	2	4	3,4
ARTISANAL FISHERS	HIGH (They recognize that the loss of these habitats)	HIGH (conflicts between sectors)	HIGH	ACTIVE Restricted conduct	Direct	5	3	3	2	4	3,4
ENVIRONMENTAL ASSOCIATIONS	HIGH (Most recognize the consequences of these conflicts)	HIGH (lack of coordination-means to act)	HIGH (although they do not act, they feel involved)	CONSCIOUS / ACTIVE Restricted conduct	Direct	2	5	4	3	3	3,4
DIVERS	HIGH (Most recognize the consequences of these conflicts)	LOW (not limited)	HIGH (active in restoration / monitoring actions)	ACTIVE Behavior to confront with the problem	Direct	3	3	1	1	3	2,2
BAIT COLLECTORS	HIGH (They recognize the loss of these habitats)	HIGH (conflicts between sectors)	LOW	CONSCIOUS Restricted conduct	Direct	1	3	1	2	4	2,2
RIPARIAN NEIGHBORS	LOW (little perception of conflicts)	LOW (not limited)	HIGH (They feel involved with the actions in their "area")	ACTIVE Routine behavior	Direct	3	3	2	1	2	2,2
ADMINISTRATION OF NATURAL SPACES	HIGH (They recognize that the loss of these habitats)	HIGH (conflicts between sectors)	HIGH (are part of the solution)	CONSCIOUS / ACTIVE Restricted conduct	Direct	5	2	3	4	2	3,2
RESEARCHERS	HIGH (They recognize problem)	LOW (not limited)	HIGH (are part of the solution)	ACTIVE Behavior to deal with the problem	Direct	1	4	3	3	3	2,8
TEACHERS	LOW	LOW (not limited)	LOW	NOT PUBLIC / LATENT	Indirect	4	5	3	4	3	3,8
STUDENTS	LOW	LOW (not limited)	LOW	NOT PUBLIC / LATENT	Indirect	4	5	2	4	3	3,6
COMPANIES RELATED TO MARINE SERVICES	LOW	HIGH (alters their work dynamics)	LOW	NOT PUBLIC / LATENT	Indirect	3	2	2	3	2	2,4
JOURNALISTS	LOW (little perception of conflicts)	LOW (not limited)	LOW	NOT PUBLIC / LATENT	Indirect	4	4	5	5	3	4,2
NON-RIPARIAN NEIGHBORS	LOW (little perception of conflicts)	LOW (not limited)	LOW	NOT PUBLIC / LATENT	Indirect	2	3	1	1	1	1,6

4. Discussion

Seagrass ecosystems contribute significantly to the socioeconomic development of coastal communities [6], but still need to be better approached as coupled social ecological systems by recognizing the multiple services they provide. The results presented in this investigation combine the historical narrative and the current social perception of the Galician population, a component largely unexplored in seagrass-related studies, thus providing key knowledge to support effective management, conservation policies and communication strategies.

We are aware of the bias of our data base due to the greater response obtained from people with a higher education degree. However, the random subsample procedure performed, as in Almahsheer and Duarte

[32], which yielded very similar results from the total and adjusted data bases, make us feel confident that our results were robust and provide a representative portrait of the perception of the sampled population.

To the best of our knowledge, only eight studies have been carried out to evaluate perceptions and awareness level of seagrass ecosystems; four of them focused on Asian countries ([33,34,11,35]), one technical report in Africa [36], one in North America [37] and two in Europe [38, 39], together with the seven case studies covering Asia, Africa, Central America and Europe integrated by Cullen-Unsworth et al. [6]. Only five of these perception and awareness assessments were directed to local communities and residents and not specifically focused on seagrass experts or key stakeholder’s groups ([6,39,34,11,35]).

Our results suggest that knowledge on the basic biology and ecology of seagrasses by the Galician society is limited, which reflects the low

Table 3

Road map for the communication plan corresponding to the 6 selected key target audiences.

PHASE	TARGET AUDIENCE	ACTION	TIMING
1	Shellfishers and artisanal fishers	Participatory workshops to obtain the ecological knowledge of the users and the identification of conflicts	Months 1–3
1	Environmental Associations	Joint design of a mixed dissemination and citizen science project aimed at the general population	Months 1–4
1	Teachers	Design and implementation of an advanced training course on seagrass beds specifically aimed at teachers	Months 2–4
2	Shellfishers and artisanal fisher	Preparation of a decalogue on the relevance of seagrass beds in the sustainability of the provision of services, including its contribution to the provisioning services that translate into the extraction of species of commercial interest	Month 2–5
2	Students	Design of an educational innovation program aimed at the training of students of different levels of secondary education	Months 3–4
3	Students	Execution of an educational innovation program aimed at training seagrass ambassadors, with sufficient training to lead volunteer groups that may add to the program aimed at citizens.	Months 5–7
4	Journalists and general population	Design and execution of an advanced training course on seagrass beds specifically aimed at journalists	Months 6–12

attention that marine ecosystems received in the formal education. Similar results were reported for the Saudi population, where respondents showed an overall weak environmental knowledge, which was also related to the low attention to environmental issues in the Saudi official science curriculum [32]. The importance of the media is reflected in the fact that the Galician population recognizes *Posidonia oceanica*, a Mediterranean species, better than the species inhabiting their own estuaries.

The ecosystem services provided by seagrasses and the conflicts associated with them were recognized by the Galician written press since the XIX century. It was also shown a distinct temporal shift from the almost exclusive recognition of *Z. marina* provisioning services, either as raw material or for its use as fertilizer, during the late XIX century and the two first decades of the 2000's to a growing number of reports on habitat generation services, mainly nursery for fishes, cephalopods and invertebrates. At present, most of the respondents acknowledged the benefits that seagrasses provide to human wellbeing, with marine research, nursery area, coastal protection and sediment retention and water quality indicator showing higher valuations.

A similar awareness evaluation targeted at UK citizens also showed a low perception of seagrass ecosystems [39]. However, our results show a positive assessment about the functions and benefits seagrass ecosystems provide to society, what somehow contrasts with the results reported for the UK population, where respondents were unclear on what services are provided by seagrass meadows. Similarly, a study carried out in Berau Regency, Indonesia, showed that residents were unaware of most of the ecosystem services provided by seagrass meadows [34]. In contrast with our results, the best-valued ecosystem service was the potential of seagrass meadows as recreational (tourism) or educational site, followed, as in our study case, by its role for coastal protection.

As expected, a higher level of knowledge and recognition on seagrass services was found in the case of target stakeholder perception

evaluations both in developed and developing countries [38,33,36], whereas citizen perceptions, even when they belong to coastal communities, showed a lower ecological knowledge and consequently, lower awareness of the benefits and threads associated with these ecosystems [34,39]. In our region, target stakeholders, including policy-makers, academics and users mainly related to tourism and fishing activities, were able to acknowledge what seagrasses are, and even to distinguish them from other species also present in the seascape (algae). Similar results have been reported in the case of Cambodian local fishers [33], who showed a considerable understanding of provisioning services but low awareness of cultural services [35] or in the Selayar Archipelago (Indonesia), where coastal communities highly dependent on seagrasses recognized them as valuable resources, being able to identify threats and interactions [40].

The controversial valuations of seagrass beds as a clam breeding area (the worst valued service) can be interpreted when the historical evolution of uses and conflicts registered in these ecosystems were investigated. Shellfishers claimed that high-density meadows reduce the abundance of clams, while low-density meadows support high abundance of resources [38]. As this evaluation was intended for the general public, it is inferred that these conflicts have permeated to the local population through publications in the written press that have systematically collected these tensions throughout history. Likewise, the second less valued ecosystem service (tourism) can be also interpreted from the historical data, where the negative perception of these ecosystems was frequently associated with the unhealthiness characteristics of estuaries. This is consistent with the perceptions recorded by Cullen-Unsworth et al. [6] and from tourism stakeholders interviewed by Bas et al. [38] in our region, who noted the negative effect due to its visual impact in intertidal zones and the accumulation of seagrass leaves close to the bathing areas, disturbing also other recreational uses such as windsurfing due to the accumulation of seagrass leaves on the sea surface.

The communication platforms through which the participants were informed implies that awareness on *Zostera* is mainly associated with communication channels that require the active search by the population, underlining that no respondent has received specific training through informative programs, unlike the case of *Posidonia*. We conclude that, in our region, television largely ignores this ecosystem, educational programs do not exist or do not reach the civil society, scientific research in this field is not recognized by the society and that observation is not considered as a means to acquire knowledge, which confirms the invisibility of these habitats. This statement is consistent with the low number of news related to *Zostera* meadows published in local newspapers throughout the last 160 years and with the very low number of scientific papers on Galician seagrasses over the last seven decades (less than 1 paper per year).

Considering the global challenges for seagrass conservation [3] and the major topics that have been identified as key banners for contemporary scientific research on seagrasses, our results stress the need to foster the positive feed-back loop that establishes between increasing information to the public and further demand for more social ecological information catalyzed by scientists. Scientific works should be accompanied with media releases and supplementary materials to improve the social impact of the published research. Fortunately, a growing interest on publication outlets, such as journals, blogs, etc. have been reported since 2000, with positive news related to restoration and recovery, and their role in ecosystem function and provision services exceeding by 50 % those referring to negative outcomes (e.g. decline or loss) [41]. Previous research on this topic [8] already pointed out to the need to develop general-interest publications in cultural and environmental dissemination magazines, which provide an effective vehicle to translate scientific knowledge into public awareness.

In this research we analyzed the communicative behavior of audiences applied to seagrass ecosystems in Galicia using the Situational Theory of publics described by Grunig [27]. By adopting this

methodology, we aimed at improving the social perception of these ecosystems from the understanding of which are the motivations of people to communicate and when they are most likely to do, thereby designing actions that ultimately lead to better management and conservation procedures.

We identified six key audiences on which communication and training actions should be focused. Involvement of direct users, mainly local fishers and shellfishers, is essential to gather their ecological knowledge and to remove barriers, so that facilitating the creation of a shared understanding of how degradation of seagrass meadows can impact the economic, cultural and ecological values of exploitable marine resources. In this regard, participatory workshops held with these groups are recommended, as well as the development of a decalogue that summarizes and clearly gathers key messages to promote the benefits that the conservation of these ecosystems provide to the users.

Our analysis also suggests that an evidence-based communication course for journalists should be designed to establish the basic references and the minimum explanatory contents to rigorously address broad communication on seagrasses. The course will be focused on addressing the most common misunderstandings, the conflictive interactions in the territory and the technical terminology for their dissemination. In this context, it is worth mention that environmental communication has been traditionally focused on reporting negative effects of human activities and impacts which seems to have turned that the ocean in the eyes of many people is already irreversibly degraded, which has the risk to demotivate to action. Seagrass communication should take advantage from the climate change key communication findings [42].

ONGs and environmental associations and scientists should be encouraged to collaborate to facilitate their advocacy role for seagrass dissemination. Scientists can generate and convey information on the status of ecosystems to be integrated and transmitted by non-governmental organizations to the general public and local associations. Thus, the joint design and implementation of environmental volunteering programs is proposed to encourage human–nature interactions (seagrass citizen science).

Finally, students and teachers are considered key target publics due to their potential to act as focal points for dissemination. In this case, the design and implementation of an innovative educational program jointly elaborated by scientists and secondary school teachers is recommended. The aim of the program should be to achieve significant learning, both theoretical and practical, about the coastal environment and the socio-economic interactions taking place in these estuarine ecosystems. This has been stated as one of the best strategies to reach a vast audience [43,44]. To successfully increase awareness, it is fundamental to stimulate the student's interest by addressing local threats to ecosystems that are on the daily agenda, and by discussing solutions to improve and maintain their healthy status.

In conclusion, our results demonstrate that the public outreach of local traditions associated with seagrass ecosystems, dissemination of the services they delivered to previous generations and the diffusion of the interactions between *Zostera* and contemporary human populations provide valuable information for the design and implementation of social awareness programs needed for ecosystem-based coastal management, thereby encouraging seagrass conservation. This is particularly important in the case of seagrasses as they are among the least protected coastal marine ecosystems [45,46]. In the case of our region, neither the EU habitats directive nor the Spanish law 42/2007 on Natural Heritage and Biodiversity or the regional Decree 37/2014, which declared special conservation zones and adopted the Natura 2000 master plan, refer specifically to the protection of these species. This stresses the importance to develop an ambitious communication plan to improve social perceptions and associated behavior around this ecosystem, as already stated by Unsworth et al. [3], thereby guiding our society towards a more harmonious coexistence with coastal ecosystems, rescuing the perception of our ancestors and ultimately encouraging seagrass

conservation.

Statements

All the authors agreed to be listed and have approved the submitted version of the manuscript. The manuscript is not submitted elsewhere and is original.

CRediT authorship contribution statement

Carlota Barañano: Conceptualization, Data curation, Writing – original draft. **Gonzalo Méndez:** Reviewing, Editing, Validation. **María Isabel Míguez:** Reviewing, Editing, Validation. **Emilio Fernandez:** Supervision, Writing – review & editing, Validation.

Authors contribution

CB collected the data, performed the data analysis, interpreted the results and wrote the article. **EF** reviewed the data analysis and interpreted and discussed the results. **GM** contributed to the historical press review. All authors reviewed the article and contributed to the final manuscript. **MI** reviewed and improved the audiences assessment.

Data availability

Data will be made available on request.

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