EXPLORING OCEAN LITERACY AT THE FRENCH MEDITERRANEAN COAST
Information seeking, knowledge, awareness and concern about threats among residents and visitors in Port-Cros National Park

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With 11 figures and 5 tables
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Summary: The Mediterranean Sea is one of the world's most biologically diverse yet ecologically threatened marine ecosystems. In response to increasing environmental pressures, marine protected areas such as Port-Cros National Park in France play a crucial role in conservation efforts. However, effective marine protection requires more than legal frameworks. It demands an ocean-literate public that understands the interconnectedness of marine ecosystems and human activities, and has the capacity to engage in conservation efforts. This study investigates ocean literacy among 405 residents and visitors to Port-Cros National Park, with a particular focus on information seeking, knowledge of marine issues, and awareness and concern about environmental threats. Results indicate high awareness and concern about marine pollution but only moderate active information seeking, knowledge of ecological conditions and species population trends. Plastic and oil pollution were most frequently noted, with online sources as the primary information channel. Although residents reported more proactive information seeking and higher awareness of pollution, concern and knowledge levels were similar across residency groups, with visitors even demonstrating a better understanding of declining fish populations. The findings underscore the importance of place-based marine education initiatives that address passive information acquisition and knowledge gaps while leveraging existing emotional connections to the marine environment. Accessible, solution-oriented communication strategies that convey the full range of ecological threats seem essential to strengthen regional ocean literacy and promote sustained, informed engagement with marine ecosystems in Port-Cros National Park.

Keywords: Giens Peninsula, public perception, risk perception, marine conservation, ocean literacy, science communication

1 Introduction

The Mediterranean Sea basin is home to one of the world's most biologically diverse marine ecosystems, supporting a wide array of coastal and marine environments that are vital for local communities. These ecosystems provide critical services such as food and energy production as well as climate regulation (Liquete et al. 2016, Barbier 2017). Despite covering less than 1% of the world's ocean surface area, the Mediterranean Sea is home to an estimated 18% of known marine species, exhibiting the highest rate of endemism globally (UNEP/MAP 2020). Yet, it is also among the most heavily impacted large marine ecosystems worldwide, facing cumulative pressures from fishing, habitat loss, pollution, eutrophication, climate change, and non-indigenous species (Piroddi et al. 2020). This degradation reflects the long-term, simultaneous effects of these stressors, which are severely affecting regional biodiversity. A growing body of evidence indicates that the Mediterranean Sea may be approaching an ecological tipping point, characterised by notable declines in marine biodiversity. Over the past 50 years, marine mammal populations have decreased by 41%, while total fish biomass has declined by 34% (Piroddi et al. 2017). Alarmingly, 93% of assessed fish stocks in the region are currently overexploited (STECF 2023), and continued unsustainable fishing practices may soon render their recovery impossible (Demirel et al. 2020). Beyond overexploited fish stocks, marine mammals are heavily affected by intensified human activities, including fishing, pollution (e.g., microplastics, noise, industrial effluents, and urban wastewater), leisure activities, coastal urbanisation, and maritime traffic (IUCN 2023). The Mediterranean subpopulation of bottlenose dolphins (*Tursiops truncatus*), for example, is a cetacean species that has been subject to persistent environmental stressors, which have resulted in its recent classification as endangered. This is a notable development, given the species' historical prevalence in the region (McGuinness et al. 2021).

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To address some of these threats, France established the Port-Cros National Park in 1963 as Europe's first marine national park. The park plays a crucial role in the conservation of biodiversity along the French Mediterranean coastline, protecting both marine and terrestrial habitats. Its waters serve as a refuge for endangered species, including various marine mammals, such as the common and bottlenose dolphins. However, despite its protected status, this area faces the same significant ecological challenges as the whole Mediterranean Sea (Maes et al. 2018, Mérillet et al. 2020).

Protecting the natural environment of Port-Cros National Park requires understanding the opportunities and challenges of marine conservation, including the ocean literacy of key stakeholder groups. Ocean literacy, defined as "an understanding of the ocean's influence on you and your influence on the ocean" (Cava et al. 2005: 9), constitutes a critical prerequisite for fostering environmentally responsible behaviour and informed decision-making regarding marine environments. Particularly relevant groups for research on ocean-related perceptions are residents and visitors in coastal areas (Jefferson et al. 2021). As the principal users of Mediterranean coastal ecosystems, they depend on marine resources, contribute to local economies, and simultaneously exert significant ecological pressure (Portman & Camporesi 2020, Lucrezi 2022). Empirical evidence indicates that coastal residents often cultivate a stronger connection to marine environments owing to their pronounced sense of place and socio-economic interdependencies (McKinley & Fletcher 2010). Compared with inland populations, they have been found to display higher levels of environmental awareness and concern (Heck et al. 2018, Gkargkavouzi et al. 2020). However, other studies suggest that visitors may exhibit comparable levels of concern (Potts et al. 2016, Meo et al. 2021), indicating that they too can develop place attachment and a sense of responsibility for marine protection.

Given this context, there is a growing call for place-based research on ocean literacy that examines both residents and visitors together to develop more inclusive and effective conservation strategies (Meo et al. 2021). Assessing the ocean literacy of these groups could also provide valuable insights for conservation initiatives in the coastal region of Port-Cros National Park. Therefore, this study aims to assess the ocean literacy among visitors and residents of Port-Cros National Park, with a particular focus on their engagement with information, knowledge of marine issues, as well as awareness and concern about potential threats. The findings may help optimize information dissemination efforts, such as educational programs, communication strategies, or citizen-science initiatives, so that messages resonate with diverse audiences and can result in meaningful action (Stoll-Kleemann 2019, Jefferson et al. 2021). Finally, the insights are equally valuable for policymakers and park management as they can help inform marine conservation strategies that are better aligned with the knowledge levels, information-seeking behaviours, and threat perceptions of both residents and visitors. By shedding light on the public's engagement with marine conservation, this research can contribute to the long-term sustainability of the Mediterranean's unique and vulnerable biodiversity through improved ocean literacy.

2 Ocean Literacy

To mitigate adverse impacts on ocean health and to promote the transformation of human–ocean interactions toward sustainability, ocean literacy is a conceptual framework that aims to enable individuals to make informed lifestyle choices concerning the ocean (Fletcher & Potts 2007, Domegan et al. 2019, Buchan et al. 2023). According to Cavas et al. (2023: 1), ocean literacy "refers to the ability of citizens to understand and explain the concepts and phenomena related to the oceans, and leads them to positive behavioural change for the protection and sustainability of the oceans." Accordingly, an ocean-literate person is knowledgeable about ocean dynamics and the reciprocal interactions between humans and the ocean (Cava et al. 2005). Reflecting its recognized significance, the enhancement of ocean literacy has been established as a central objective of the United Nations Decade of Ocean Science for Sustainable Development (2021–2030), in line with the Sustainable Development Goal 14 ('Life below water'). Increasingly, ocean literacy is positioned as a pivotal mechanism for societal change (Kopke et al. 2019, Schwerdtner Máñez et al. 2023).

Ocean literacy was first introduced in 2004, initially as a concept primarily applied in informal education and training. Over time, it has evolved into a broader framework aimed at inspiring actions to protect the ocean and its resources (Ryabinin et al. 2019). This development signals a shift toward translating ocean education into observable behavioural change and concrete conservation outcomes, necessitating more effective tools and methodologies (McKinley & Burdon 2020, Stoll-Kleemann 2019). Contemporary ocean literacy frameworks thus

move beyond the traditional focus on knowledge and awareness. They now integrate dimensions such as emotional connection, communication, access and experience, or trust and transparency (McKinley et al. 2023). Together, these elements support a systems perspective that captures the complex relationships between people, societies, and the ocean (Brennan et al. 2019).

Understanding the factors that shape human cognition and behaviour, as well as how audiences relate to specific subjects, locations, or problems, is essential for designing effective behavioural interventions (Kollmuss & Agyeman 2002, Ashley et al. 2019, Borja et al. 2020). Although knowledge alone is rarely sufficient to trigger behavioural change, it can play an important role in fostering support for marine conservation. For example, Steel et al. (2005) found that citizens with higher knowledge about ocean conditions were more supportive of ocean and coastal protection. This indicates that strengthening knowledge may be a valuable component of ocean literacy, particularly when combined with approaches that address motivational and contextual barriers to action. However, as evidence on the 'value–action' or 'intention–behaviour gap' shows, knowledge alone rarely results in behavioural change (Kollmuss & Agyeman 2002), even though such change is ultimately the central aim of any ocean literacy initiative (Amel et al. 2017, McCauley et al. 2019, Stoll-Kleemann 2019). Behavioural interventions seem most effective when target audiences are explicitly defined, rewards and behavioural impediments are identified, and the main motivators and biases at work are understood (Stoll-Kleemann 2019, Schwerdtner Máñez et al. 2023). These requirements suggest that efforts to promote ocean literacy may benefit from taking regional variations into account, given that behavioural motivations and environmental perceptions can exhibit spatial variability shaped by exogenous factors, including prevailing social norms, infrastructural conditions, or the availability of resources (Stoll-Kleemann 2019). In this vein, research indicates that, for example, people's attitudes toward marine habitats differ considerably across regions, reflecting varying personal concerns and degrees of awareness (Lotze et al. 2018).

The regional groups of the European Marine Science Educators Association (EMSEA), designated after their respective seas (Mediterranean, Baltic, etc.), demonstrate how the ocean literacy community conceptualizes the value of acting regionally. Within this context, Mokos et al. (2020) developed the 'Mediterranean Sea literacy', with seven principles and 43 differing concepts, describing several specificities tailored to the Mediterranean Sea's unique environmental, cultural and socio-economic characteristics. The aim of this framework is to restore and protect the Mediterranean Sea while providing guidance for research, education, informed decision-making, and improved citizens' lifestyle choices. One example of a principle reflecting regional peculiarities is principle 6: "The culture, history, economy, lifestyle, health, and well-being of the peoples of the Mediterranean region are inextricably interconnected. The Mediterranean Sea affects all aspects of the lives of its inhabitants. Complex terrestrial and marine morphology, together with its distinctive hydrological cycle, have created the Mediterranean climate, which exerts a strong influence over human activities (e.g. agriculture, mariculture, tourism)" (Mokos et al. 2020: 596). These attempts by regional organizations support and work towards the universal ocean literacy framework endorsed by UNESCO in 2017, while concentrating on the specific conditions, challenges and opportunities of particular seas or ocean regions (Schwerdtner Máñez et al. 2023).

3 Description of the region

The Port-Cros National Park is located in the south-eastern part of France in the Provence-Alpes-Côte d'Azur region, more precisely in the Var department, about 16 km east of Toulon. Established in 1963, the Port-Cros National Park is the oldest marine park in Europe. The national park covers an area of about 17 km^2 (terrestrial core zone) on land and 29 km^2 at sea (marine core zone). It is an exceptional example of Mediterranean biodiversity protection. Since 2012, the national park has covered an extended area, including terrestrial and marine areas around the Giens Peninsula and the Hyères Islands. As shown in Figure 1, the extended area covers 1,200 km^2 from the coast to the edge of the continental shelf, containing a sustainable development project area developed with the municipalities of La Garde, Le Pradet, Hyères-les-Palmiers, La Croix-Valmer, and Ramatuelle (Parc National De Port-Cros n.d.). In addition, it is important to note the existence of an 'adjacent maritime area', a sea-based extension of the membership zone, which spans the waters from La Garde to Ramatuelle and extends up to three nautical miles south of the Hyères Islands.

The climate of the national park is typically Mediterranean, with mild, humid winters and hot, dry summers. It is one of the sunniest regions in

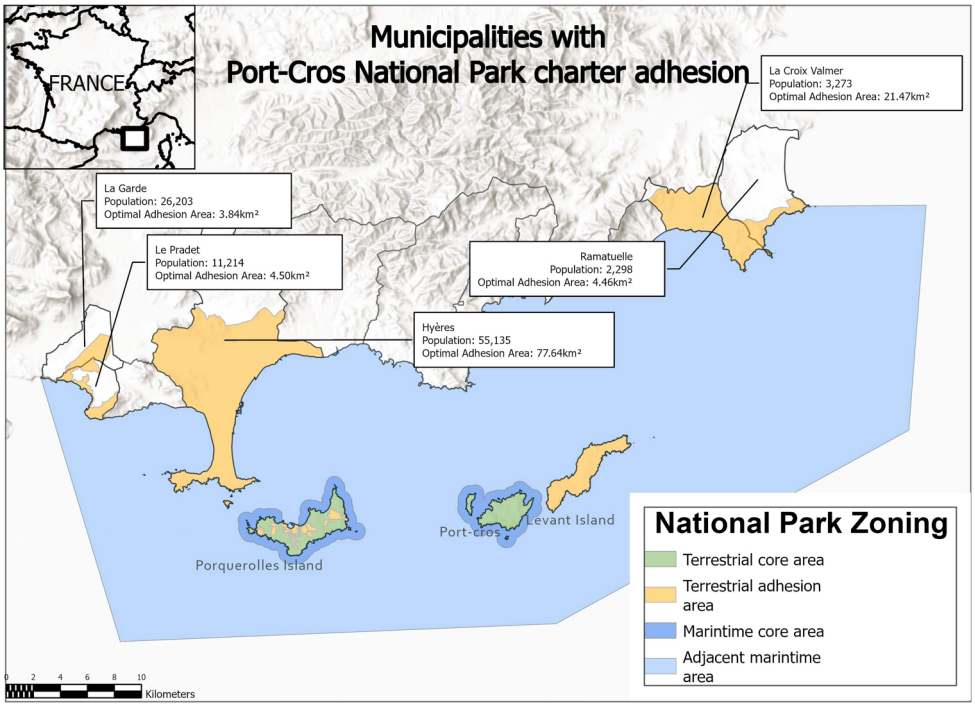

Fig. 1: Map of the Port-Cros National Park territory. Source: Adapted from Parc National de Port-Cros (n.d.).

France, with over 2,700 hours of sunshine annually. The weather is strongly influenced by the Mistral, a cold, dry north-westerly wind, which ensures clear air and stable weather, especially in winter and spring (Rey et al. 2020). This is why the rocky coasts of the peninsula are covered with Mediterranean maquis, a dense, shrubby vegetation, which takes on a distinctly dry appearance during the summer months (Aboucaya et al. 2016, Cadoret 2021). In general, the national park region is characterised by a varied topography, such as the hilly Massif des Maures, which reaches heights of up to 780 m, and a coastline with rocky coves, beaches and the offshore Hyères Islands, including Porquerolles, Port-Cros, and Île du Levant.

The Giens Peninsula itself forms a unique geomorphological structure with its narrow strip of land connected to the mainland by two tombolo-dune ridges. It extends for about 6 km and contains the Etang des Pesquiers, which is a shallow lagoon, also designated as a marine protected area. This and other lagoons and the salt marshes, formerly used for salt production, form important wetlands with resting and nesting sites for various bird species such as flamingos and herons (Faget et al. 2021). The marine reserves around the Giens Peninsula are home to an impressive variety of flora and fauna, including seagrass beds, coral reefs and numerous fish species. A notable example is the Mediterranean subpopulation of common bottlenose dolphins, characterised by a decreasing population trend, as discussed above (McGuinness et al. 2021).

Traditionally, the region was characterised by agriculture, in particular viticulture and olive growing. Hyères, where the headquarters of the national park is located, is one of the oldest tourist destinations on the French Mediterranean coast, known for the cultivation of ornamental plants and palm trees, which is why it is nicknamed 'Hyères-les-Palmiers'. Today, tourism plays a central role in the regional economy, with the Toulon metropolitan area attracting 45,514 tourists in 2024 (Provence Méditerranée Tourisme 2024). Water sports, especially kitesurfing and diving, well-marked hiking trails and underwater paths for snorkelers are key economic factors, as is sailing and yachting tourism. Current estimates for the Port-Cros National Park suggest that approximately 2 million people visit the park annually, with numbers peaking at 1.2 million during the summer months (Ben Ghazi 2024). In addition, the park is not only an important centre of sustainable tourism, but also a significant research area for biologists and ecologists. The park also has a particularly strong maritime identity with 122 SRAs (sea-related associations), which reflect the close connection of the population to the sea (Robert 2024).

In addition, since 1999, the Port-Cros National Park has been responsible for a coordination mission for the establishment and monitoring of the International Sanctuary for Pélagos, which is the result of a tripartite agreement between Italy, the Principality of Monaco and France. The role of the French party to the agreement, overseen by the Port-Cros National Park, is to organise and coordinate initiatives and actions aimed at supporting marine mammals, such as dolphins, in cooperation with a diverse set of stakeholders, including government departments, local authorities, transport, fishing and tourism professionals, scientists, and relevant associations.

Unfortunately, despite these conservation efforts, the park and its neighbouring areas face ongoing environmental threats. Among these, the climate crisis, as outlined above, constitutes a substantial threat, particularly through the ongoing rise in sea temperatures, which drives habitat alterations and increases the vulnerability of marine species. Additionally, the region is susceptible to pollution and habitat destruction, often exacerbated by tourism and coastal development. In particular, the increasing number of visitors and intense levels of activity during the summer months require a clear definition of stress limits in order to prevent the threat of irreversible environmental damage and a decline in the attractiveness of the region as a tourist destination (Cadoret 2021). Overall, while Port-Cros National Park has made significant strides in marine conservation, continuous adaptive management and community engagement are still essential to address the described evolving environmental threats in this Mediterranean region, which is important for ocean protection and restoration (Cadoret 2021).

4 Method

This study aims to contribute empirical evidence on knowledge and perception components of ocean literacy among residents and visitors to Port-Cros National Park, with a particular focus on identifying potential differences between the two groups. By collecting and analysing data on their information-seeking behaviour, knowledge of marine issues, concern and awareness of threats, the study identifies patterns that can inform the design of more inclusive and effective educational conservation strategies. Data were collected through face-to-face interviews conducted between 25 August and 10 September 2024 in a two-part large-scale investigation of ocean literacy in the Baltic and the Mediterranean Sea. The study was undertaken within the framework of a research project on regional ocean literacies and behavioural change at the Interdisciplinary Centre for Baltic Sea Region Research (IFZO) in Germany.

4.1 Sample and procedure

Participants were selected using convenience sampling and had to be at least 18 years old. Interviews were conducted in a one-to-one format in German, English, and French by a team of six interviewers. Data collection took place in public spaces such as city centres and markets, as well as within the national park at trails, beaches, and ports across the Giens Peninsula and Port-Cros National Park, including the island of Porquerolles. Interviews lasted approximately 17 minutes on average. During each interview, and immediately after, non-verbal cues and contextual information were documented in the form of notes.

The sample comprises individuals who either reside ('residents') or visit ('visitors') the specified sample region in close proximity to the Mediterranean Sea coast. In the context of this study, the distinction between residents and visitors is based primarily on self-identification. Respondents were asked to classify themselves as either residents or visitors of the Giens Peninsula and Port-Cros National Park. A person may be considered a resident if they subjectively perceive themselves as locally based and identify with the region as their primary place of living or belonging. Conversely, a visitor may be defined as someone who perceives their presence in the area as temporary, such as tourists, short-term travellers, or individuals staying for limited periods without long-term settlement intentions. By relying on participants' self-categorization, this study ensures a more context-sensitive and flexible identification of target groups, which is particularly useful in coastal Mediterranean settings with overlapping forms of place attachment and mobility. This approach further acknowledges that legal or administrative criteria, such as official registration, nationality, or duration of stay, are not always meaningful or available in social science research, particularly in areas characterized by high tourist activity, temporary migration, or seasonal labour.

In total, 405 individuals participated in the survey, of whom 402 completed it in full. As shown in Table 1, the demographic structure of the sample

Tab. 1: Sociodemographic characteristics of survey participants

Baseline characteristic	Full sample		Baseline characteristic	Full sample	
	n	%		*n*	%
Residency			**Education**		
Visitors	291	71.9	No school / still in school	3	0.7
Residents	105	25.9	Lower secondary school	11	2.7
Others	9	2.2	University entrance qualification	46	11.4
Gender			Vocational training	103	25.4
Male	213	52.6	Still studying	19	4.7
Female	189	46.7	Undergraduate degree	60	14.8
Missing	3	0.7	Graduate degree	123	30.4
Age	74	49.3	Doctorate	18	4.4
18-29	96	23.7	Other	16	4.0
30-39	71	17.5	Missing	6	1.5
40-49	93	23.0	**Country of origin**		
50-59	77	19.0	Germany	203	50.1
60-69	48	11.9	France	155	38.3
70-79	14	3.5	Italy	9	2.2
80-89	2	0.5	Switzerland	6	1.5
Missing	4	1.0	Austria	6	1.5
			UK	6	1.5
			Netherlands	5	1.2
			Belgium	2	0.5
			EU Single [a]	3	0.7
			Non-EU [b]	5	1.2
			Missing	5	1.2

(*N* = 405; [a] Country of origin occurs one single time: Croatia, Luxembourg, Sweden; [b] Countries of origin: Australia, Brazil, USA (*n* = 2), Pakistan).

somewhat corresponds to the composition of the region during the summer months. The sample was predominantly composed of visitors (*n* = 291), accounting for 71.9% of all respondents, while residents comprised 25.9% (*n* = 105). Given the high influx of up to 1.2 million visitors to the Port-Cros National Park area during the summer months, this proportion is reflective of the actual dominance of visitors in the region's population and mirrors the socio-ecological reality of the park and the Giens Peninsula at the time of data collection. An additional 2.2% of participants identified as *others*, indicating that they did not consider themselves either residents or visitors. Consequently, the effective sample size for analyses comparing residents and visitors was 396. The sample had a balanced gender distribution, with a slight majority of men, as 52.6% of valid responses identified as male and 46.7% as female. The age distribution reflected a diverse composition, skewed toward younger and middle-aged adults with an average age of 43.3 years (*SD* = 14.7). Respondents aged 18–29 comprised 23.7%, those aged 30–39 accounted for 17.5%, and 23% were aged 40–49. Individuals aged 50–59 made up 19%, while older participants (60+) represented 15.9% of the sample. The educational profile of respondents highlights a concentration of higher education qualifications, with almost half of the sample holding a university degree (49.6%). A quarter (25.4%) of the sample consisted of participants with vocational training, reflecting a practical rather than academic focus. Fewer respondents reported a high school diploma or less (14.8%). Germany and France dominated the country-of-origin distribution (88.4%), reflecting the study's geographical focus and potential regional accessibility biases. The majority of respondents originated from Germany (50.1%), followed by France (38.3%). Other European countries, like Austria, Belgium, Italy or the Netherlands contributed small proportions (less than 3% each). Non-European respondents were few (1.2%). The distribution of participants' countries of origin partly reflects the composition of international overnight guests in the Toulon metropolitan area, with Germany being the predominant country of origin, followed by Italy, Switzerland, the United Kingdom, and Belgium (Provence Méditerranée Tourisme 2024). Missing data across all sociodemographic variables was negligible.

4.2 Measures

The data were collected through structured interviews based on a questionnaire designed to capture a comprehensive understanding of participants' ocean literacy in the Mediterranean Sea region. The selection of measures was informed by a review of the relevant literature on ocean literacy and guided by the ten dimensions of ocean literacy proposed by McKinley et al. (2023). Wherever possible, validated instruments were employed. However, given the scarcity of established tools for assessing ocean literacy, dimensions lacking validated scales were addressed through self-developed, open-ended questions aimed at generating initial qualitative insights.

The questionnaire combined open- and closed-ended items to enable participants to articulate their views freely. This approach reveals nuances and unanticipated patterns, while also ensuring consistency and comparability for quantitative analysis when

validated scales were available. This mixed format further allowed for clarification of responses and facilitated the identification of potential biases. To maintain a clear and manageable scope, this study concentrates on four of the ten established dimensions of ocean literacy (communication, knowledge, and awareness in combination with an emotional component) which serve as fundamental building blocks for assessing participants' basic level of ocean literacy. The dimensions were assessed by measuring information-seeking behaviour, ecological knowledge, as well as awareness of and concern about environmental threats to the Mediterranean Sea. Following the pretests, adjustments were made to improve clarity and reliability, leading to refinements in the wording and deletion of several items.

The assessment of participants' information-seeking behaviour focused on whether they actively sought information on the state of the Mediterranean Sea and where they obtained this information from. Responses regarding information seeking were categorized according to frequency, providing insight into the extent to which participants engaged with issues related to the Mediterranean Sea. Participants were then asked to indicate the sources from which they obtained information, with the option to add further sources. Multiple answers were possible.

Respondents' knowledge of the Mediterranean Sea was assessed through three targeted survey items. The first item asked whether fish populations in the Mediterranean are endangered, and the second whether dolphin numbers have increased or decreased over the past decade. To reduce the risk of response option bias, both items were presented as open-ended questions. Responses were then systematically coded into four nominal categories: 'yes', 'no', 'partially', and 'I don't know'. The questions were selected as fish and dolphin populations serve as key indicators of marine ecosystem health, both under severe threat. Fish populations reflect broader biodiversity trends and the (un)sustainability of fisheries, while dolphins, as top predators, signal changes in the marine food web and environmental stressors (Carlucci et al. 2018). Additionally, both topics are highly visible in media discourse and central to the national park biodiversity, making them relevant touchpoints for public knowledge. Beyond these specific indicators, participants also rated the overall ecological condition of the Mediterranean Sea on a 6-point Likert scale. Together, these three measures capture different dimensions of ecological knowledge, reflecting knowledge of both general and specific Mediterranean marine issues (see Tab. 2). At the end, responses were coded for accuracy (correct/false) and aggregated into a composite overall knowledge score, with higher scores indicating greater familiarity with Mediterranean Sea-related issues.

Finally, threat awareness was assessed in three steps. First, participants were asked whether they

Tab. 2: Overview of measures and items

Ocean literacy dimension	Variable	Item	Item format
Communication	Information seeking	Do you inform yourself about the condition of the Mediterranean Sea?	Closed question
	Information sources	Where do you inform yourself about the condition of the Mediterranean Sea?	Closed question
Knowledge	Knowledge fish populations	Are the fish populations in the Mediterranean Sea endangered?	Open-ended question
	Knowledge dolphin populations	Is the number of dolphins in the Mediterranean Sea higher or lower than 10 years ago?	Open-ended question
	Knowledge condition	How would you rate the ecological condition of the Mediterranean Sea?	6-point Likert scale
	Knowledge total	Composite score of single knowledge variables	Total score (0-1)
Awareness	Pollution awareness	Have you heard about pollution in the Mediterranean Sea?	Closed dichotomous question
	Pollution sources	If "yes", which ones?	Open-ended question
Emotions	Pollution concern	On a scale from 1-6, how worried are you by information about pollution in the Mediterranean Sea?	6-point Likert scale

had heard about pollution in the Mediterranean Sea. Second, if they had, they were asked to specify the types of pollution they had heard about. Third, their level of concern about pollution to the marine environment of the Mediterranean Sea was measured on a 6-point Likert scale. This approach allowed for a nuanced understanding of both exposure awareness about threats to the marine environment of the Mediterranean Sea as well as the emotional responses, in the form of concern levels, assigned to perceived threats.

4.3 Data analysis

For the analysis of the quantitative data, statistical analyses were performed using SPSS version 30. First, frequency analyses and descriptive statistics provided an overview of the data and the distribution of key variables. Pearson's chi-squared tests then assessed differences in the distribution of nominal ocean literacy variables between residents and visitors. Finally, Mann-Whitney *U* tests compared continuous variables between the two groups. All tests were conducted at a significance level of 0.05.

Responses to the open-ended question on perceived sources of pollution were analysed using a quantitative content analysis. Answers recorded in French were translated into German by bilingual experts prior to analysis to ensure consistency. Coding was conducted in MAXQDA 24 by two coders, with discrepancies resolved through consensus discussions. A coding scheme was derived from the category system by Demmler & Stoll-Kleemann (2025) and adapted to the present dataset. Each response was coded according to the predefined subcategories, and the frequency of each category (e.g., litter) and subcategory (e.g., plastic) was counted. Multiple responses within a single statement were permitted, and distinct mentions were coded separately. For instance, if a participant made reference to waste, microplastics, and plastics, the response was coded as waste (1), microplastics (1), and plastics (1), respectively. To examine differences between residents and visitors, participant statements were categorized based on residency status, while retaining the original coding scheme used in the overall analysis. Participants categorized as having *other* residency ($n = 9$) were included in the overall analysis of variables but excluded from all comparative analyses between residents and visitors.

5 Results

The data analysis provided insights into the extent to which residents and visitors to Port-Cros National Park actively seek information about the ecological state of the Mediterranean Sea, the sources they use, their overall knowledge of its ecological condition and population dynamics, and their awareness of and concern about associated environmental threats.

5.1 Seeking information on the ecological condition of the Mediterranean Sea

The following chapter presents findings on how frequently participants seek information about the ecological condition of the Mediterranean Sea and the sources from which they obtain this information. Figure 2 illustrates the distribution of responses on the frequency of information seeking concerning the sea's ecological condition. The figure differentiates between four categories of information-seeking behaviour (active, occasional, incidental, and none) and compares these among residents and visitors. Slightly more than half of all participants (52.6%) reported engaging in deliberate or semi-regular efforts to obtain information about the ecological condition of the Mediterranean Sea, with 33.6% actively seeking information and 19.0% doing so occasionally. In contrast, 47.4% reported incidental or no information-seeking activity.

This divergence was especially pronounced between residents and visitors. A Pearson's chi-squared test (see Table 3) revealed significant group differences in information-seeking behaviour, χ^2 (3, $N = 396$) = 57.78, $p < .001$. When the responses of residents categorized as *active* or *occasional* were aggregated, 79.0% of the resident population reported deliberate or semi-regular engagement. In contrast, this proportion was 42.6% among visitors. Almost one-third of visitors (29.2%) indicated that they never sought information about the Mediterranean Sea, while this was the case for only 9.5% of residents. Conversely, 28.2% of visitors stated they encountered information by chance, compared to 11.4% of residents.

Figure 3 presents the sources utilized by participants to acquire information about the environmental state of the Mediterranean Sea. Across a total of 703 sources referenced, *online searches* were the most frequently reported (22.8% of all mentions, $n = 160$), followed by *television* (15.6%, $n = 110$), *so-*

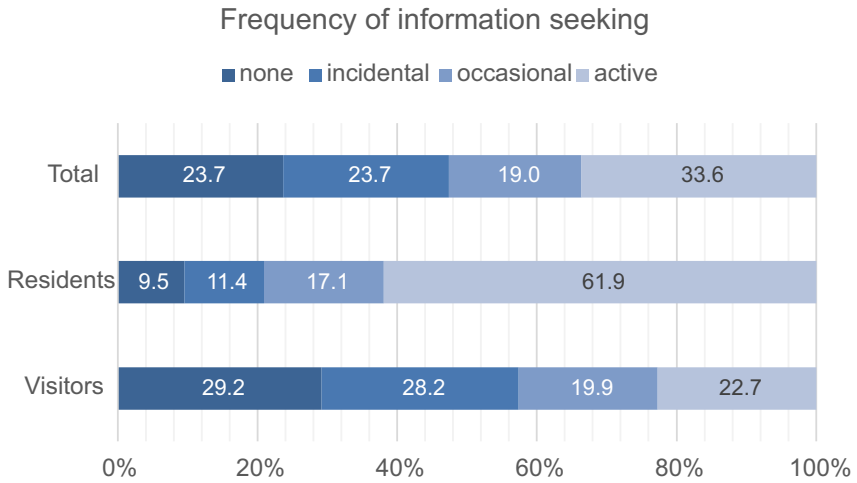

Fig. 2: Frequency of residents and visitors to engage with information about the environmental state of the Mediterranean Sea. *N* (total) = 405; *n* (residents) = 105; *n* (visitors) = 291.

cial media platforms such as Instagram or YouTube (14.2%, *n* = 100), and *print* media (14.1%, *n* = 99). *Local information* sources, including visitor centres, flyers, signage, municipal apps, beach flag systems and information provided by municipal administration offices, accounted for 12.9% (*n* = 91) of mentions. Local community sources (*people in my community*) contributed to 11.2% (*n* = 79) of all mentions and consisted of conversations with fishers or national park rangers, exchanges with locals at markets, memberships in clubs, and information from family and friends. The remaining 9.2% (*n* = 64) of mentions were attributed to *other* sources, with personal observations (3.8%, *n* = 27) emerging as the most prevalent subcategory, encompassing direct assessments of the condition of the sea and beaches. This was followed by work-related information from environmental protection or national park activities (1.3%, *n* = 9). The remaining sources, each accounting for less than 1% of mentions, included scientific publications and educational institutions (*n* = 6), voluntary work such as participation in beach clean-up campaigns (*n* = 4), books (*n* = 3), radio and events like trade fairs or the Ocean Film Tour (*n* = 2), and podcasts (*n* = 1).

Tab. 3: Results of Pearson's chi-squared tests of independence comparing variables between residents and visitors (*p* two-sided)

Variable	*N*	*Df*	χ^2	*p*
Information seeking	396	3	57.783	.001
Pollution awareness	392	1	17.204	.001
Knowledge fish populations	392	1	13.115	.001
Knowledge dolphin populations	392	1	1.765	.184

As shown in Figure 4, a comparative analysis of the use of information sources reveals differences and similarities between the two residential groups. Residents of the Port-Cros National Park region most frequently cited *people in my community* (18.2% of all mentions, *n* = 42) as their source of information about the ecological status of the Mediterranean Sea, followed by *television* and *print* (15.2%, *n* = 35) as well as *social media* (13.0%, *n* = 30). Visitors most often cited *online searches* (27.9%, n = 128), followed by *television* (15.7%, *n* = 72), *social media* (15.0%, *n* = 69), and *print* (13.9%, *n* = 64). Both population groups make similar use of *television*, *print*, and *social media*. Differences were evident in the higher use of community sources (18.2%, 7.6%) and personal observations (7.4%, 2.2%) by residents, while visitors more frequently used *online searches* (27.9%, 12.6%) and *local information* materials (13.1%, 11.7%).

5.2 Knowledge of the endangerment of marine animal populations and the ecological state of the Mediterranean Sea

This section examines participants' understanding of the marine environment of the Mediterranean Sea. Specifically, participants' knowledge of selected marine animal populations and of the general ecological status of the sea is assessed. These indicators are then summarized in an overall knowledge

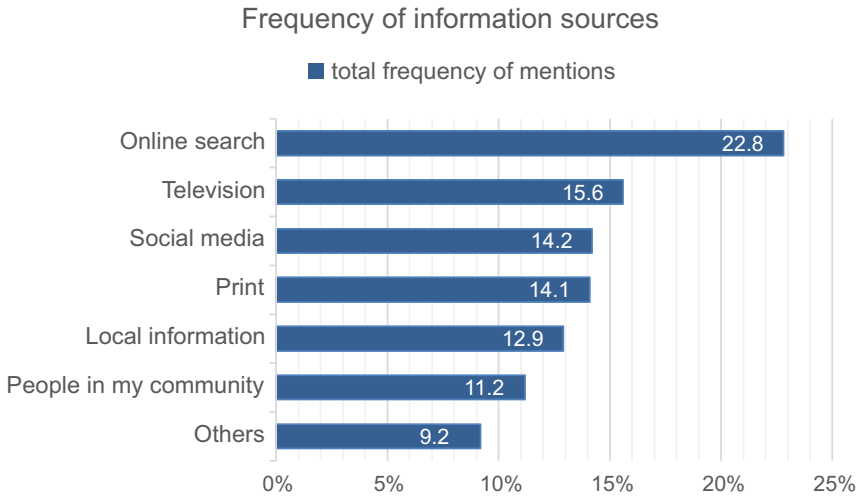

Fig. 3: Distribution of the frequencies of information sources participants used to acquire information about the environmental state of the Mediterranean Sea. Total number of sources mentioned: 703; *N* (total) = 309; multiple responses possible.

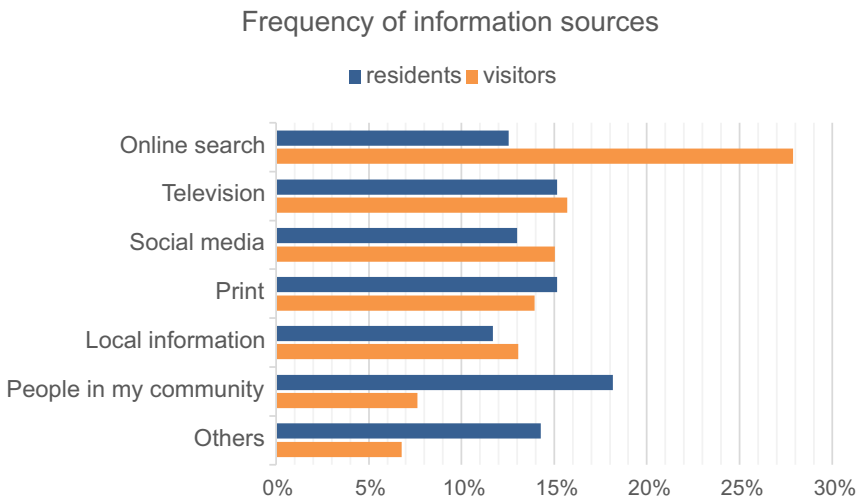

Fig. 4: Distribution of the frequencies of information sources residents and visitors used to acquire information about the environmental state of the Mediterranean Sea. Total number of sources mentioned: 690; *n* (residents) = 95; *n* (visitors) = 206; multiple responses possible.

score, with a focus on differences between residents and visitors. The majority of respondents (84.2%) correctly identified that fish populations in the Mediterranean Sea are endangered (see Figure 5). Table 3 shows that this assessment varies depending on place of residency, as a Pearson's chi-squared test revealed a statistically significant association between place of residency and knowledge of the endangerment of fish populations, χ^2 (1, N = 392) = 13.12, $p < 0.001$. Visitors provided a significantly higher proportion of correct answers (88.2%) than residents (73.1%).

The extent of knowledge concerning the trends in dolphin populations over the past decade was found to be less pronounced. Here, 62.0% of participants correctly reported a decline in population size, while 38.0% were either uncertain or provided an incorrect answer (see Figure 6). As indicated in Table 3, a Pearson's chi-squared test revealed no statistically significant association between residency status and knowledge of dolphin population trends, χ^2 (1, N = 392) = 1.77, p = .184. Although this difference was not significant, visitors showed a higher proportion of correct answers (67.5%) than visitors (46.6%).

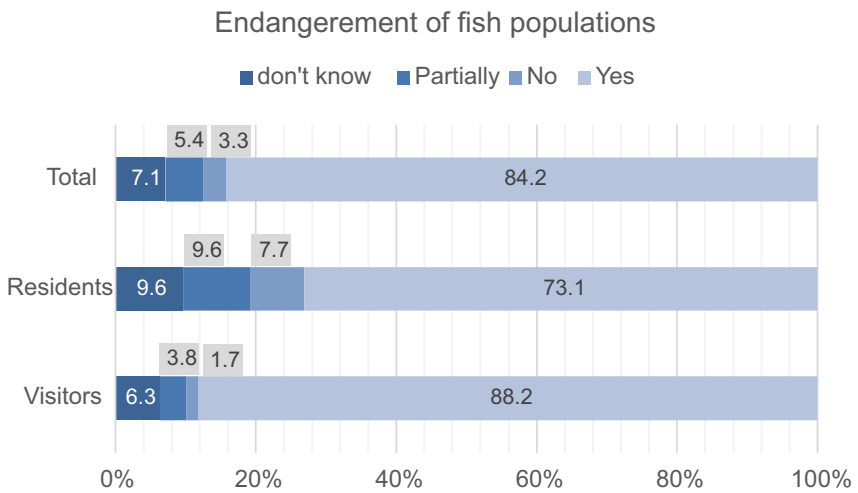

Fig. 5: Responses of residents and visitors to the endangerment of the fish population in the Mediterranean Sea. *N* (total) = 392, *n* (residents) = 104, *n* (visitors) = 288.

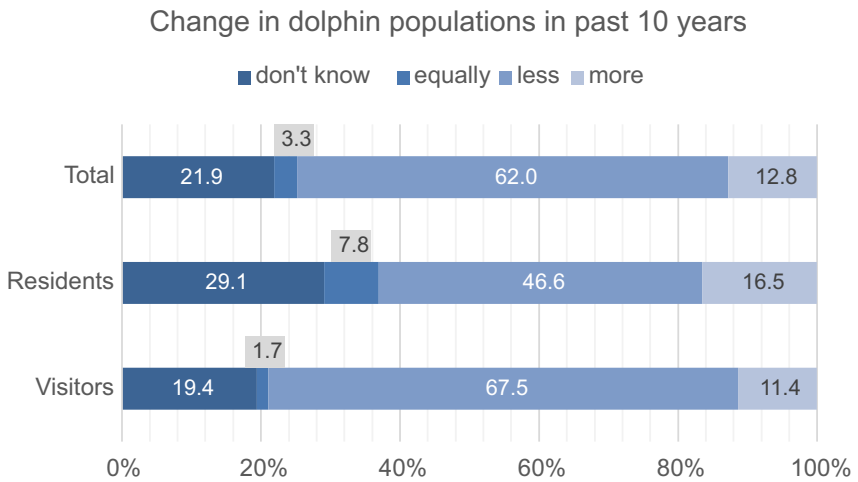

Fig. 6: Responses of residents and visitors to the change in dolphin populations over the last ten years in the Mediterranean Sea. *N* (total) = 392; *n* (residents) = 103; *n* (visitors) = 289.

Figure 7 presents respondents' assessments of the overall ecological condition of the Mediterranean Sea. Ratings averaged between moderate and good ($M = 3.43$, $SD = 1.14$, see Table 4), with the majority of participants (59.7%) having selected mid-range categories from rather poor to rather good. 19.2% of all participants described the ecological status of the Mediterranean Sea as good to very good, while 21.0% described it as poor or very poor. The difference between residents and visitors in their assessment of the ecological condition was examined using a Mann-Whitney *U* test, due to the ordinal scale of measurement and non-normal distribution of the score. The test revealed that there was no significant group difference between residents and visitors in the assessment of the ecological condition of the Mediterranean Sea ($U = 13921.00$, $\tilde{r} = 0.06$, $p = .953$) (see Table 5). Nonetheless, residents were found to be more inclined to select mid-range categories of rather poor to rather good (66.7%) than visitors (55.9%) and did not rate the ecological state of the Mediterranean Sea as very good.

Finally, to bring the three knowledge indicators together, responses on fish population decline, shifts in dolphin population dynamics, and overall ecological condition were combined into a single composite knowledge score. For overall knowledge, the descriptive statistics in Table 4 show a mean total score of $M = 0.51$, ($SD = 0.24$), pointing to a moderate level of knowledge across the entire sample. A subse-

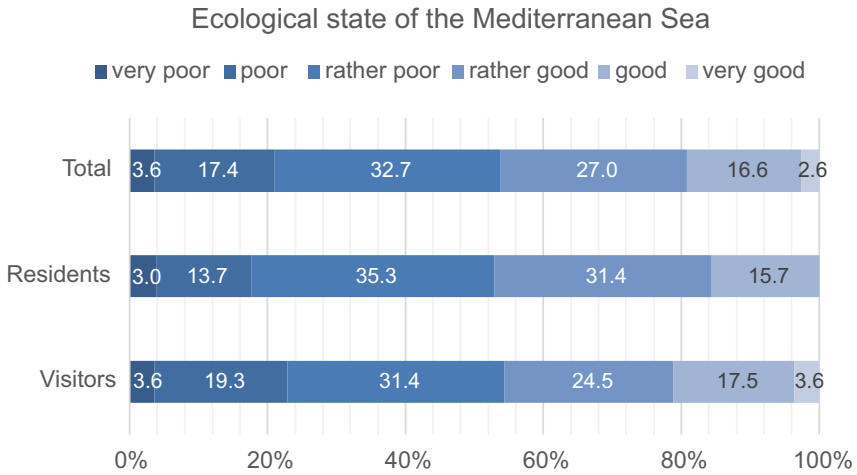

Fig. 7: Responses of residents and visitors to the ecological state of the Mediterranean Sea.
N (total) = 376; *n* (residents) = 102; *n* (visitors) = 274.

Tab. 4: Descriptive statistics for ordinal study variables

Variable	*N*	*M*	*SD*	*Range*
Ecological condition	385	3.43	1.14	1-6
Knowledge total [a]	380	0.51	.24	0-1
Pollution concern	351	4.45	1.21	1-6

[a] only cases without missing values included

quent Mann-Whitney *U* test (see Table 5) indicated that there was no statistically significant difference in overall knowledge between residents and visitors, $U = 14249.00$, $z = -1.10$, $p = 0.272$. However, visitors exhibited marginally higher median rank scores (*Mdn* = 202.03) compared to residents (*Mdn* = 188.70).

5.3 Awareness and concern about threats posed to the Mediterranean Sea

The final chapter focuses on participants' awareness and concern regarding marine pollution in the Mediterranean Sea. This includes an assessment of their general awareness and concern, as well as the specific sources of pollution they have identified. Overall, respondents in the region of the Port-Cros National Park reported a high level of awareness regarding marine pollution in the Mediterranean Sea. The vast majority (86.3%) of participants indicated that they were aware of pollution in the sea. This awareness varied depending on the residential group, as a Pearson's chi-squared test revealed a significant association between residential status and awareness of environmental pollution, χ^2 (1, $N = 392$) = 17.20, $p < 0.001$. The differences are shown in Figure 8, where 98.1% of residents reported awareness of pollution in the Mediterranean Sea, compared to 81.6% of visitors, suggesting a higher level of awareness among the local population than among visitors.

In accordance with the findings indicating a high level of overall awareness, an elevated average level of concern was also found ($M = 4.45$, $SD = 2.21$), as illustrated in Table 4 above. Over half of all participants (53.0%) expressed strong to very strong concern about pollution in the Mediterranean Sea and only a small minority reported little (5.4%) to no

Tab. 5: Results of Mann-Whitney *U* tests comparing variables between residents and visitors

Variable	Residents		Visitors		*U*	*z*	*p*
	n	Mean rank	*n*	Mean rank			
Ecological condition	102	189.02	274	188.31	13921.0	0.06	.953
Knowledge total [a]	105	188.70	291	202.03	14249.0	-1.10	.272
Pollution concern	98	183.51	244	166.68	10779.5	1.47	.142

p two-sided; [a] only cases without missing values included

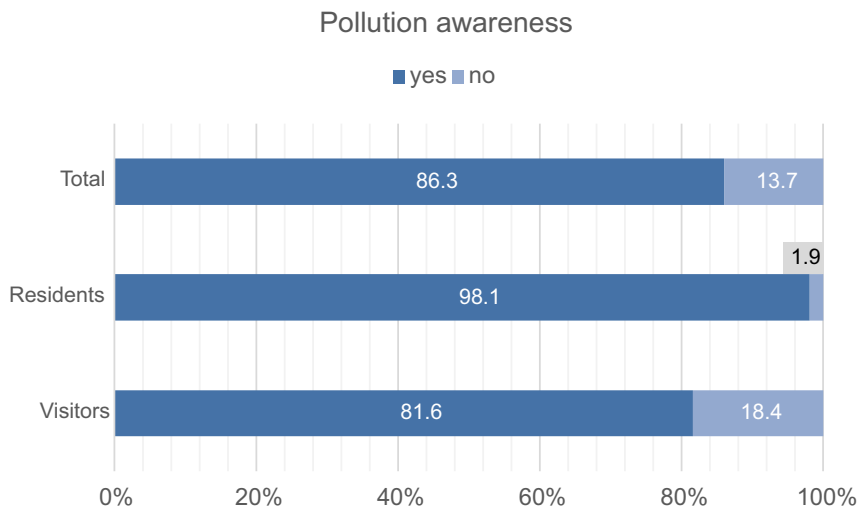

Fig. 8: Responses of residents and visitors to awareness about pollution in the Mediterranean Sea. *N* (total) = 401; *n* (residents) = 104; *n* (visitors) = 288.

concern (1.4%) (see Figure 9). To assess differences in pollution concern between residents and visitors, a Mann–Whitney *U* test was conducted, the results of which are shown in Table 5 above. The analysis revealed no statistically significant difference between the two groups, $U = 10{,}779.5$, $z = 1.46$, $p = .142$. However, residents reported a marginally elevated median rank of 183.51, while visitors reported a median rank of 166.68.

To further explore the topic of pollution, participants were asked to report specific types of pollution in the Mediterranean Sea's marine environment they were aware of. A total of 750 coded mentions of perceived sources of pollution affecting the Mediterranean were recorded by 342 participants. Figure 10 illustrates that the most frequently cited category was *litter* (33.7%, *n* = 253), with plastic (22.9%, *n* = 172) as the dominant subcategory, followed by unspecified litter (7.5%, *n* = 56) and microplastics (2.0%, *n* = 15). Subcategories in the *litter* category with a frequency of less than 1% of mentions included unspecified waste deposits (*n* = 4), cigarettes (*n* = 2), transport waste, food, and household waste (*n* = 1 each). The second most frequently cited category was *industrial pollution and accidents* (19.1%, *n* = 143), most commonly oil (7.7%, *n* = 58), ship accidents, industri-

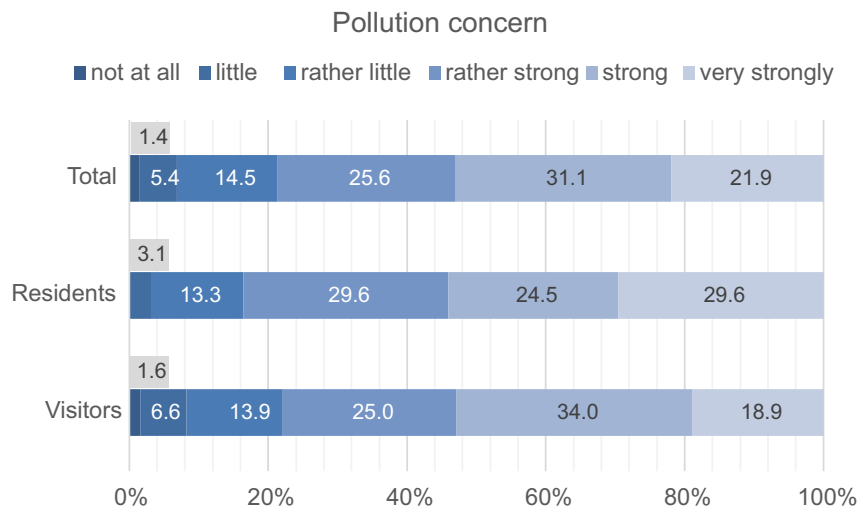

Fig. 9: Responses of residents and visitors to the intensity of concern about pollution in the Mediterranean Sea. *N* (total) = 351; *n* (residents) = 98; *n* (visitors) = 244.

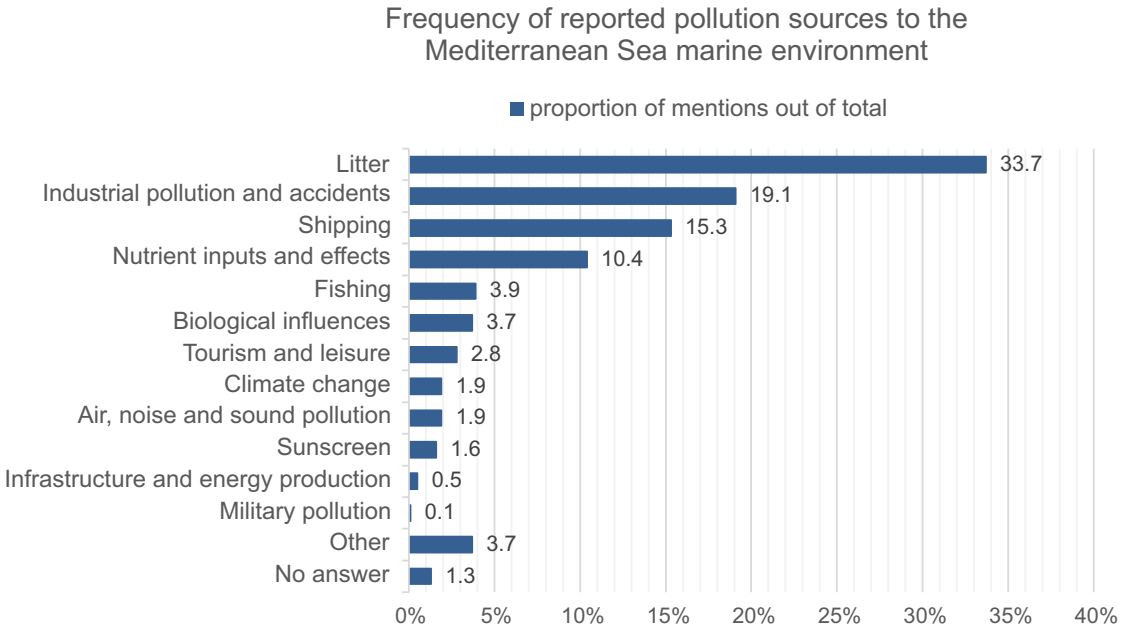

Fig. 10: Distribution of the frequencies of the types of pollution in the Mediterranean Sea mentioned by the participants. Total number of sources mentioned: 750; *N* (total) = 342; multiple responses possible.

al accidents or war involving oil (4.0%, *n* = 30), fuels (1.7%, *n* = 13), unspecified industrial pollution (1.6%, *n* = 12), and chemical pollution (1.3%, *n* = 10). Less frequently mentioned (all < 1.0%) in this category were aluminium production in Marseille (*n* = 7), industrial waste (*n* = 7), heavy metals (*n* = 3), refineries (*n* = 2), and surfactants (*n* = 1). Following litter and industrial pollution, *shipping* was mentioned 115 times (15.3%), including unspecified shipping traffic (5.7%, *n* = 43), ship waste and wastewater (2.8%, *n* = 21), cruise ships (2.4%, *n* = 18), tanker ships (1.5%, *n* = 11), and motorboats (1.5%, *n* = 11) as well as ferries (n = 4), ports (n = 2), sailing, container ships and warships, ship anchors, and shipwrecks (*n* = 1 each). Mentions of *nutrient inputs and their effects* accounted for 10.4% of all references (*n* = 78). The most frequently cited subcategories were unspecified algae (3.7%, *n* = 28) and unspecified wastewater or discharges (3.1%, *n* = 23). Less frequent mentions included excrements (*n* = 7), river inputs (*n* = 5), seaweed (*n* = 3), pesticides (*n* = 3), agriculture (*n* = 3), and wastewater treatment plants (*n* = 2). The following sources were each mentioned once: animal farming, sewage, overfertilization, and blue-green algae (*n* = 1 each). Pollution categories below five percent of all mentions included *fishing* (3.9%, *n* = 29), *biological influences* (3.7%, *n* = 28), such as invasive species (1.3%, *n* = 10), jellyfish (*n* = 9), or bacteria (*n* = 5), *tourism and leisure* (2.8%, *n* = 21), *climate change* (1.9%, *n* = 14), *air, noise, and light pollution* (1.9%, *n* = 14), and *sunscreen products* (1.6%, *n* = 12). Least frequently mentioned categories (< 1.0%) were *infrastructure and energy production* (0.5%, *n* = 4) and *military pollution* (0.1%, *n* = 1). Various *other* factors, like unspecified pollution, 'humans' or 'bad water quality' together accounted for 3.7% (*n* = 28), and responses categorised as *no answer* accounted for 1.3% (*n* = 10) of all mentions.

Figure 11 distinguishes between the reported sources of pollution for the two residential groups. Both residents and visitors most frequently cited *litter* as a source of pollution (residents: 30.8%, visitors: 35.2%), followed by *industrial pollution and accidents* (18.3%, 19.4%), *shipping* (12.1%, 16.1%), and *nutrient inputs and effects* (9.4%, 11.0%). Similar proportions (defined as differences of one percentage point or less) were observed between the two groups for *fishing* (3.6%, 4.1%), *biological influences* (4.5%, 3.5%), *tourism and leisure* (3.1%, 2.8%), *climate change* (2.2%, 1.8%), *sunscreen* (2.2%, 1.4%), *infrastructure and energy production* (0.9%, 0.4%), *military pollution* (0.0%, 0.2%), and *no answer* (1.8%, 1.2%). More substantial differences (greater than one percentage point) between residents and visitors emerged in the following categories: the largest difference was observed for *litter* (4.4 percentage points), which was cited more frequently by visitors than by residents, followed closely by *air, noise, and light pollution* (4.3), reported more often by residents. Residents also more frequently mentioned *other*

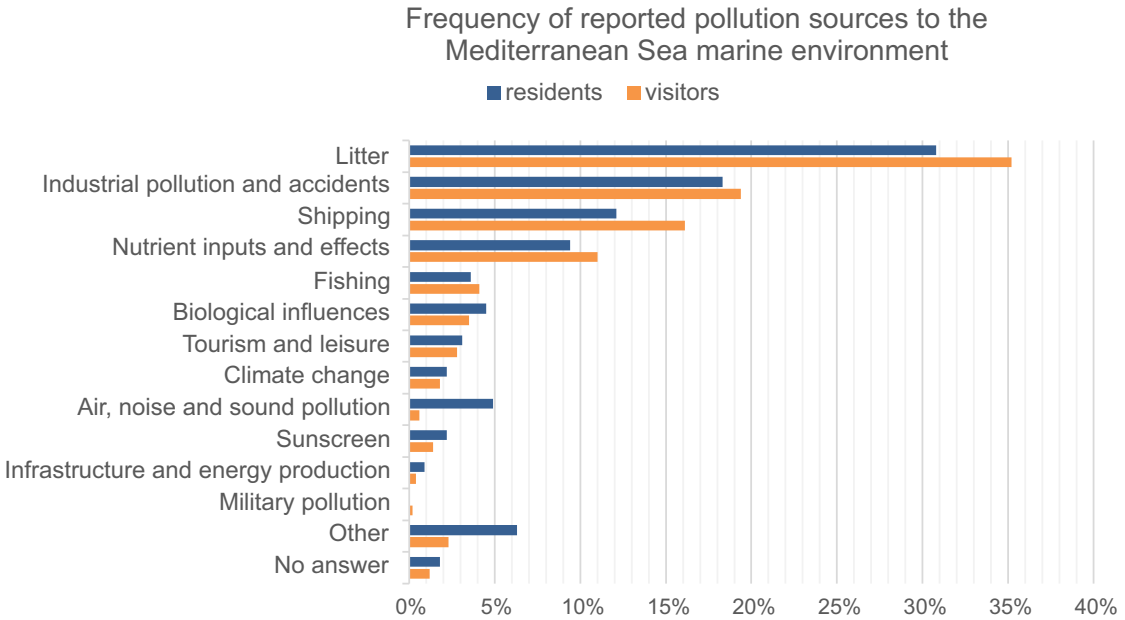

Fig. 11: Distribution of the frequencies of the types of pollution in the Mediterranean Sea mentioned by the residents and visitors. Total number of sources mentioned: 733; *n* (residents) = 100; *n* (visitors) = 233; multiple responses possible.

sources (3.0), such as unspecified pollution, whereas visitors more often identified *shipping* (4.0), *nutrient inputs and effects* (1.6), and *industrial pollution and accidents* (1.1) as sources of pollution to the marine environment of the Mediterranean Sea.

6 Discussion

This study examined key dimensions of ocean literacy among residents and visitors in Port-Cros National Park, focusing on information seeking, ecological knowledge, awareness of and concern about environmental threats to the Mediterranean Sea. The findings show that although participants expressed high levels of awareness and concern regarding the Mediterranean's ecological challenges, they did not comprehensively identify the full spectrum of pollution sources. Likewise, knowledge about the ecological condition and population dynamics of the Mediterranean was moderate, and participants reported only medium engagement in seeking ecological information.

The overall high levels of self-reported awareness and concern among both residents and visitors align with previous studies on environmental perceptions in Mediterranean populations (Gkargkavouzi et al. 2020, Lucrezi 2022) and reflect similar patterns documented in other European sea basins (Hynes et al. 2014, Hawkins et al. 2016, Potts et al. 2016, Tonin & Lucaroni 2017, Demmler & Stoll-Kleemann 2025). As in other European studies, visible and tangible threats, such as plastics and oil pollution, were reported far more frequently than less visible or diffuse issues including climate change or biological changes, like invasive species (Gelcich et al. 2014, Buckley et al. 2017, Lotze et al. 2018, Lucrezi 2022). This focus is likely reinforced by mass media attention and conservation campaigns which also emerged here as participants' main sources of information. In the present sample, litter and industrial pollution together accounted for over half of all mentions (52.8%), while biological influences, climate change, tourism, or air, noise, and sound pollution made up only 10.3% together. Notably, mentions of nutrient inputs and effects constituted 10.4% of all mentions, a proportion that was higher than in other European samples, whereas fishing accounted for less than 4%, a frequency that was lower than in other regions (Buckley et al. 2017, Garcia-Bustos 2025).

In addition to this imbalanced perception of marine threats, participants exhibited deficiencies in their marine-related knowledge, a finding that is similarly consistent with the results of other European studies (Tonin & Lucaroni 2017, Lotze et al. 2018, Garcia-Bustos 2025). While the majority of respondents correctly identified a decline in fish populations, indicating awareness of general biodiversity loss, a

substantial proportion were either uncertain or misinformed about the decline of a more specific species. Moreover, respondents evaluated the ecological condition of the Mediterranean Sea as moderate to good, a perception divergent from that of scientific assessments (UNEP/MAP 2020, Briciu 2024). The overestimation of ecological health and underestimation of biodiversity loss, also observed in other European studies (Gkargkavouzi et al. 2020, Spoors et al. 2021, Demmler & Stoll-Kleemann 2025), may reflect a broader tendency to underestimate ecological degradation (Engel et al. 2021). Explanations for such knowledge gaps point to both sociodemographic factors, such as education, income, or unequal access to information (Lotze et al. 2018, Jefferson et al. 2021, Wootton et al. 2024), as well as motivational factors, including environmental attitudes and values (Gkargkavouzi et al. 2020). These deficiencies in knowledge and perception have the capacity to influence the evaluation of risks. When threats are perceived as less severe or less imminent, a sense of urgency is diminished, and the motivation to adopt pro-environmental behaviours can be reduced (Leiserowitz 2006, Roeser 2012, van der linden 2015). Therefore, a lack of knowledge or misperceptions regarding the ecological issues of the Mediterranean Sea may act as a cognitive barrier to behavioural change, even among individuals who express a high level of awareness and concern for the marine environment.

The discrepancy between self-reported awareness and actual knowledge may partially be explained by participants' information-seeking behaviour. In line with their moderate knowledge scores, respondents on average reported only medium levels of deliberate or semi-regular engagement with marine information. This limited engagement may have contributed to participants' incomplete understanding of critical marine issues in the Mediterranean Sea. Participants' reliance on mass media, such as online searches, television and social media, as their main sources of information may have further influenced this divergence. Mass media tend to emphasize prominent or sensational issues while underrepresenting diffuse yet ecologically critical processes, including climate change, eutrophication, and biodiversity decline (Hartley et al. 2015, Buckley et al. 2017, Lotze et al. 2018, Lucrezi 2022). As a result, individuals may develop a sense of awareness about marine issues without necessarily gaining a comprehensive understanding of the underlying complexities and interconnections. Individuals may feel broadly concerned yet remain unable to translate this concern into specific knowledge about causes, consequences, or potential solutions (Potts et al. 2016). This discrepancy can hinder the development of a more robust ocean literacy, which requires not only basic knowledge but also the capacity to link global ecosystems, economic production, and consumption patterns, and individual choices with local ecological impacts (Brennan et al. 2019, Buchan et al. 2023). Such an ability is crucial for engaging in informed communication and decision-making regarding the ocean (Cava et al. 2005, Stoll-Kleemann 2019, Paredes-Coral et al. 2021).

Furthermore, knowledge and perceptions can be influenced by regional or local contexts. In the Mediterranean Sea in Greece and Italy, for example, respondents reported higher frequencies of indirect threats such as jellyfish blooms, invasive species, and rising sea temperatures, as they were phenomena that could be directly observed in local environments (Buckley et al. 2017). This direct observability may also explain the elevated references to nutrient inputs and their effects, which are predominantly associated with algae and wastewater dumping. By contrast, diffuse system inputs, such as phosphorus and nitrate enrichment or agricultural runoff, were mentioned less frequently in this category. Unlike these less perceptible influxes, which operate over broader spatial and temporal scales, harmful algal blooms often occur in sheltered areas such as harbours, bays, and lagoons near human activity, making them far more visible to local populations (Marampouti et al. 2021). Similarly, shipping was more frequently mentioned in the Mediterranean than in a comparable Baltic Sea study (Demmler & Stoll-Kleemann 2025), likely due to the greater visibility of cruise ships and leisure vessels in the Port-Cros area. These patterns may be substantiated by the observation that some participants reported being informed about ecological issues in the Mediterranean Sea based on their personal observations. In turn, issues such as infrastructure and energy projects or military pollution received negligible attention. These topics were prominent in the Baltic Sea sample by Demmler & Stoll-Kleemann (2025), where they were regionally salient or linked to ongoing controversies, such as LNG terminals, but did not appear in the Mediterranean responses. Instead, participants more often cited sunscreen as a source of pollution, reflecting concerns tied to local recreational practices and the region's more southern geographical context.

Overall, the findings underscore a notion that public awareness does not necessarily reflect public knowledge. Awareness and concern may be shaped by media influences, the visibility of threats, and by

the geographical, economic or political contexts in which people experience the marine environment. Knowledge, however, may be rather shaped by the acquisition, extent, and kind of information sources and their effectiveness in displaying the comprehensive sources and impacts of threats to marine environments.

6.1 Residential differences

Beyond the identification of general patterns, this study also revealed distinctions between residents and visitors to the Port-Cros National Park region. Residents reported significantly higher awareness of pollution in the Mediterranean Sea and more frequent active or occasional information seeking. This heightened awareness could plausibly be linked to their proximity to and daily interaction with the marine environment. Regular exposure to environmental change, potentially stronger place attachment, and socio-economic dependence on the sea have elsewhere been associated with heightened sensitivity to marine issues (Rangel et al. 2015, Lucrezi, 2022). In line with this, residents more often mentioned less visible, chronic stressors such as air, noise, and light pollution, which may become more salient through long-term exposure. Residents also demonstrated a greater reliance on community networks and personal observation for their information gathering, along with mass media sources.

However, despite these higher self-reports of awareness and more diverse information sources, residents did not exhibit greater factual knowledge of ecological conditions, marine species, or pollution dynamics. With the exception of somewhat more frequent mentions of air, noise, and light pollution, as well as bacteria, no clear advantage in identifying pollution sources emerged. This discrepancy between perceived awareness and actual knowledge among residents may have several explanations. Residents could be more susceptible to social desirability bias, given the expectation that proximity, exposure, and interdependence with the ocean should translate into greater awareness. They may have also overestimated their own awareness, or their differing information sources may have provided data that is inaccurate or incomplete, leading to a sense of being informed without necessarily possessing comprehensive knowledge.

Visitors, by contrast, reported lower awareness and less active information seeking, which was often incidental or entirely absent. Assuming that information seeking is tied to perceptions of personal relevance, individuals living far from the Mediterranean coast may not view the marine environment as directly affecting their daily lives and thus lack incentives to actively and consistently seek detailed information. Yet, their concern levels did not differ significantly from those of residents. In fact, visitors' mean ranks ($Mdn = 166.68$) were only slightly lower than those of residents ($Mdn = 183.51$), suggesting that visitors may show equal concern despite lower self-reported awareness. This finding is consistent with the results by Potts et al. (2016), who found that concerns about the marine environment across seven European countries did not significantly vary by proximity to the coast. Thus, concern may have also been influenced by a number of other social and personal factors, such as social norms, sociodemographic profile, personality, environmental attitudes and values, or feelings of responsibility and place attachment (Gelcich et al. 2014, Gifford & Nilsson 2014). The finding of comparatively similar levels of concern, further supports the idea that emotional connections to marine environments, such as place attachment, are not simply determined by proximity or residency. It can also arise from individual experiences and the development of personal bonds and values with an environment (Ahtiainen et al. 2019, Diamond et al. 2024). In a study of place attachment at the Baltic Sea, for example, the sample region was associated with personal memories such as childhood experiences and recurring visits, as well as functional or health-related values like accessibility and well-being due to favourable environmental and climatic conditions (Stoll-Kleemann & Demmler in press).

In line with the observation that levels of concern were equivalent, visitors demonstrated comparable knowledge to that of the residents. They even reported declines in fish populations more often and evaluated the ecological condition of the Mediterranean Sea less positively (albeit not reaching statistical significance). Additionally, they identified litter, shipping, and nutrient inputs as pollution sources with greater frequency than residents, which may reflect the salience of visible maritime activities in tourist areas as well as global media attention to marine litter. Alternatively, visitors' greater reliance on local information materials may have provided a wider range of perspectives than the community- and observation-based sources relied on by residents, leading to more scientifically-backed knowledge. The prominence of nutrient inputs in visitor responses further suggests that targeted local outreach may have effectively increased knowledge of complex or indirect forms of pollution.

Finally, a pollution source that received little attention from either group, despite its immediate and well-documented interconnections with the coastal environment in the Port-Cros area, is tourism and leisure. Visitors, as direct agents of tourism-related pressures, rarely acknowledged it, while residents, who are more directly exposed to these impacts, only marginally reported tourism-related activities (2.8% vs. 3.8%). This underrepresentation is consistent with findings from Greece (Gkargkavouzi et al. 2020), where coastal users similarly underestimated tourism's environmental impacts, as well as with findings by Lucrezi (2022), who argues that such blind spots warrant stronger management attention. Comparable results have also been reported for the Baltic Sea, where tourism and leisure activities were cited even less frequently (1.7%) than in the present study (2.8%). Taken together, these results provide another example of the gap between perceived and actual environmental pressures: even highly visible and locally significant impacts such as tourism may remain underestimated, thereby limiting the perceived urgency for action.

Ultimately, while this study provides initial insights into regional dimensions of ocean literacy and residential differences in Port-Cros National Park, the sample composition shapes the interpretation of the findings. With a predominance of visitors and German respondents, the results primarily reflect short-term and culturally homogeneous perspectives at the time of data collection. Although this pattern aligns with the region's seasonal tourist profile, it still creates a linguistic and cultural concentration that foregrounds certain viewpoints and underrepresents others. Future research could build on this study by recruiting more balanced samples with a higher proportion of residents or visitors from more diverse origins, integrating seasonal waves of data collection to reflect shifts in visitor composition. Additionally, the statistical analyses conducted in this study were constrained to comparisons between residents and visitors. The use of open-ended questions to assess some of the ocean literacy constructs enabled nuanced responses and provided an initial understanding of the target group, while also compensating for the absence of validated instruments. This approach, however, limited the depth of statistical analyses because the variables could not be captured on equivalent scales. Findings and interpretations of underlying mechanisms are therefore descriptive in nature, and suggested connections should be regarded as informed indications rather than substantiated relationships. Designing and incorporating a selection of standardized metrics alongside open-ended inquiries can facilitate the enhancement of these preliminary findings in subsequent research endeavors. Such methodological approaches would allow for analyses that extend beyond group differences, including the role of additional sociodemographic features and the measurement of further influencing factors.

6.2 Implications for communication strategies and park management

The results have several practical implications for communication strategies and management practices, such as for Port-Cros National Park. First, the discrepancy between elevated levels of awareness and concern on one side, and only moderate ecological knowledge on the other, underscores the notion that perceived awareness does not inherently translate into a comprehensive understanding of the issues facing the marine environment of the Mediterranean Sea. Consequently, communication strategies may not only aim to raise awareness but also focus on broadening and deepening knowledge and understanding. This seems particularly necessary for complex, diffuse, or less visible threats, such as nutrient inputs and their effects, climate change, or biodiversity decline, all of which remain underrepresented in this sample and in the broader European public perception. The overly positive assessment of the Mediterranean Sea's ecological state further indicates a need for strategies that clearly convey the reality of ecological decline and its consequences for both marine ecosystems and human well-being. To this end, drawing upon the work of Halpern et al. (2012), who advanced an ocean index as a visual tool to communicate the state of the ocean, a map of the Mediterranean Sea basin could display up-to-date indicators of ecological conditions. Using colour codes and potentially interactive features that link pressures, causes, and solutions, such a tool could make complex dynamics more accessible to the public. An example of such a map is the COMMON Project Map (2020), which visualizes data from beach cleanups and marine litter monitoring across the Mediterranean Sea in an interactive format, allowing users to see how individual behaviours and local actions contribute to broader ecological impacts. Another facet of this perceptual gap is the underestimation of tourism-related impacts by both residents and visitors, underscoring the need for more targeted communication on how tourism affects the Mediterranean Sea environment. The Côte d'Azur France Regional Tourism Committee, for ex-

ample, implements a range of outreach programs to raise public awareness of tourism's impacts on both marine and terrestrial environments. These initiatives include educational campaigns, interactive workshops, and partnerships with local communities, all aimed at fostering responsible tourism practices that reduce disturbances to marine ecosystems (Côte D'azur France 2025). Additionally, national park communication could, for example, link recreational practices to their ecological consequences in brochures, visitor centres, guided tours or art installations. Thereby, invisible or systemic threats can be explicitly connected to visible pollution through impact–effect visualizations, showing, for example, how individual food choices (e.g., meat consumption) can affect water quality in local recreational areas, helping individuals understand the wider system dynamics and their personal role beyond residency and vacation.

Second, the consistently high levels of concern across both residency groups suggest that emotions may serve as an entry point for communication strategies. Concern, as shown in previous research, plays a critical role in moral decision-making and environmentally responsible behaviour (Kollmuss & Agyeman 2002, Landmann 2020, Stoll-Kleemann 2019, Brosch 2021, Stoll-Kleemann et al. 2022) and emotional engagement has been found to increase the effectiveness of conservation messaging (Roeser 2012). Thus, interpretive activities, storytelling and experiential or art-based education could help strengthen emotional bonds with the Mediterranean Sea and foster more durable engagement and comprehensive knowledge (Matias et al. 2023). In Italy, the One Ocean Foundation, for example, offers a wide range of initiatives to engage individuals emotionally and actively with marine environments, including workshops in art, painting, and music, as well as open-air cinema screenings of ocean-related documentaries (One Ocean Foundation n.d.). At the Oceanographic Institute in Monaco, visitors can explore a marine protected area through virtual reality, simulating direct contact with the marine environment and its species. This immersive experience showcases how a healthy, well-protected ecosystem would appear, providing a tangible understanding of the positive impact of conservation measures (Oceanographic Institute n.d.). Cappelletto et al. (2021) further suggest creating opportunities for active social engagement, such as marine citizen-science actions, to enable communities to engage with the Mediterranean Sea and collect information themselves. In France, numerous citizen-science initiatives already engage the wider public, including stakeholder groups such as visitors and divers, in hands-on monitoring of biodiversity or algal blooms, thereby translating concern into active participation and engagement (NATURAGIS 2024). Notably, concern was not tied to residency alone. This points to the value of integrating broader notions of place attachment and environmental identity into communication, focusing on how people feel connected to a place and its environment rather than on residency status alone.

Third, the data suggest that incidental knowledge acquired passively through everyday encounters with information may be just as influential as targeted information seeking. This is evidenced by the fact that residents' greater engagement in active information seeking did not result in higher proficiency compared to visitors. Educational materials might therefore be made easily accessible and clearly visible in public spaces to support passive learning, for example through installations, signage, or digital formats, so that they reach a wide audience. Thereby, communication efforts should adopt a solution-oriented approach, involve credible advocates, and provide practical, actionable behaviour recommendations (Lubchenco & Gaines 2019, Moss & Norgren 2021). A study on motivational communication strategies for climate protection at the Great Barrier Reef, for instance, found that the most effective messages highlighted iconic locations, reinforced positive social norms, emphasized collective efficacy, and combined these elements with calls for public action (Waters et al. 2024). Moreover, local information sources, which already appear effective among visitors, could be extended to broader audiences including residents. At the same time, mass media remain powerful for highly visible or sensational issues (e.g., plastic pollution), but their communication potential may be harnessed more systematically to address less tangible yet ecologically critical threats. Given that online sources were found to be the most frequently used by all participants, they may be employed more strategically. Linking on-site information to online platforms, for instance through QR codes, can provide additional material or immersive experiences, such as interactive games, quizzes, contests, or videos. This can enable both visitors and residents to engage more deeply with conservation topics regardless of time or place. Finally, the findings suggest that communication strategies do not necessarily require narrowly defined target groups based on residency, as knowledge gaps are evident across both groups. Regardless of differences in awareness or information seeking, broad and inclusive strategies may therefore prove equally effective.

The results underscore the potential role of marine protected areas as laboratories for ocean literacy. By integrating environmental education with conservation management, these areas can offer residents and visitors opportunities to deepen their ecological knowledge, foster emotional connections with marine environments, and ideally translate concern into informed, sustainable actions (Lucrezi 2022, Stoll-Kleemann et al. 2022). However, the question of whether short- and long-term educational initiatives and communication strategies in national parks can effect lasting changes in knowledge and behaviour remains an open issue for further research. Ultimately, providing individuals with the opportunity to understand and experience their personal connection to the ocean may reduce feelings of distance and unfamiliarity, thereby enabling a more tangible and relevant understanding of marine issues in their everyday lives.

7 Conclusion

This study underscores the importance of examining ocean literacy as a basis for strengthening conservation efforts in marine protected areas such as Port-Cros National Park. The results show that although residents and visitors both express high awareness and concern about marine issues, their knowledge remains only moderate and often diverges from scientific assessments. While patterns of information-seeking behaviour and awareness levels differed between the two groups, these differences did not translate into substantial variations in knowledge or recognition of marine threats.

The findings provide valuable insights for park administrators, pointing to opportunities for enhancing ocean literacy initiatives. They suggest that (Mediterranean) ocean literacy is shaped less by residency status than by broader public perceptions and information flows. Communication strategies may therefore address both residents and visitors simultaneously, while targeting specific knowledge gaps, particularly regarding less visible ecological threats such as biodiversity decline and climate change. Effective conservation communication should be accessible, emotionally engaging, collaborative, and solution-oriented, combining threat information with clear behavioural guidance.

A range of initiatives, encompassing artistic and storytelling approaches, digital access to marine environments, citizen-science projects, and indicator-based mapping, have emerged as promising avenues for marine communication. Such approaches hold potential to render diffuse, distant, and complex issues more tangible and engaging for diverse audiences. Future research should evaluate whether these initiatives can foster not only greater knowledge but also measurable shifts in protective behaviour. Expanding analyses to additional dimensions of ocean literacy, including behavioural intentions, access and experience, or trust and transparency, would offer a more comprehensive understanding of human–ocean relations. Moreover, comparative studies are needed to establish whether the observed patterns are specific to Port-Cros or reflect wider dynamics across the Mediterranean and other European sea basins. Such studies could inform large-scale ocean literacy initiatives and guide policy strategies that support marine conservation beyond the local level. By situating Port-Cros and the Giens Peninsula within this wider Mediterranean and European context, the study contributes to a more nuanced understanding of how ocean literacy can serve as a tool for effective marine governance in an era of accelerating ecological change. In this role, marine governance can link environmental education with conservation practice and support sustained, informed engagement with vulnerable marine ecosystems.

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