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Ocean literacy in managing marine protected areas: bridging natural and cultural heritage

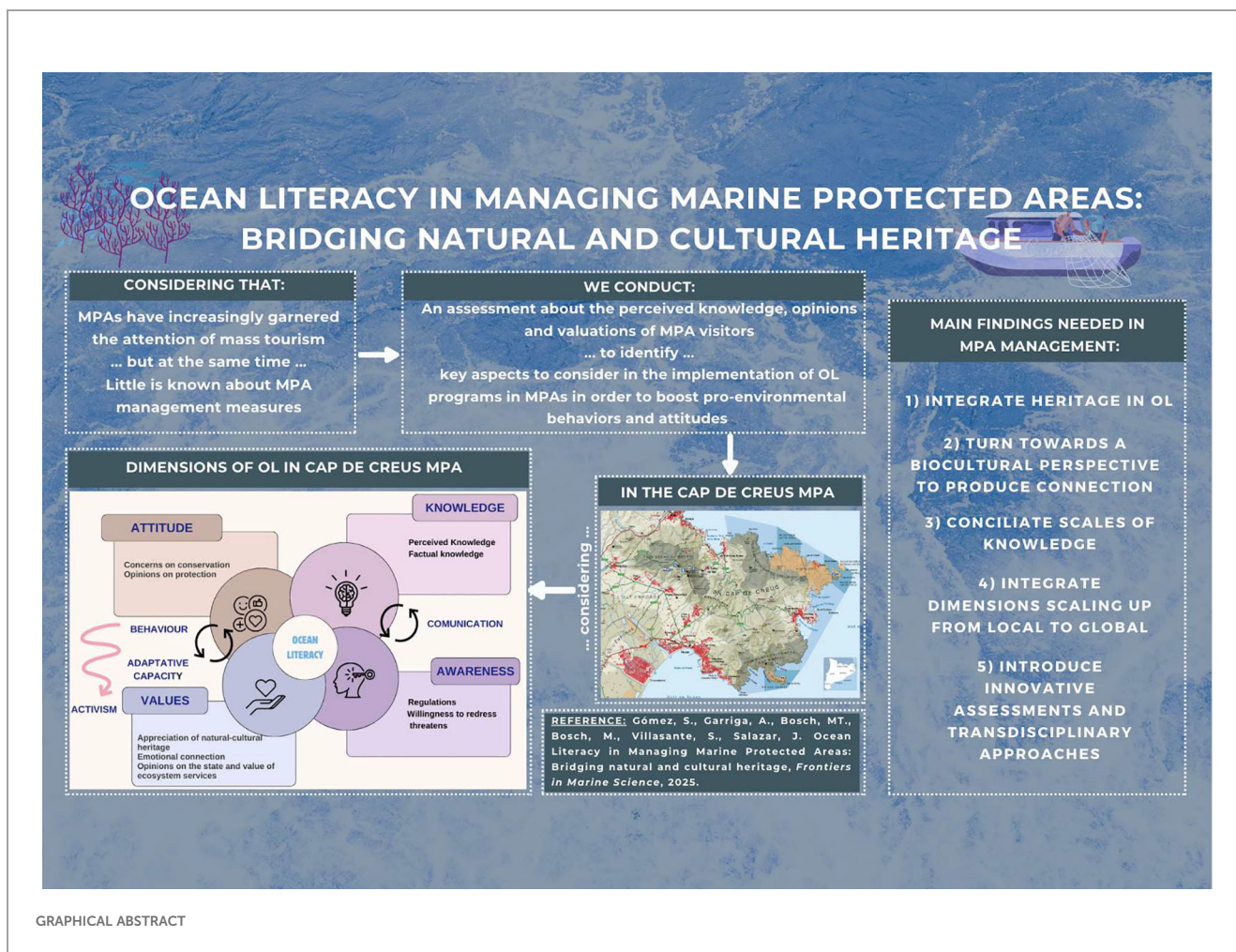
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This study explores the factors driving the integration of ocean literacy into the management of Marine Protected Areas, highlighting its role as a powerful tool to transform the human–ocean relationship to improve conservation efforts. A survey was completed by 197 visitors in Cap de Creus (Northeastern Catalonia, Spain). The findings show that visitors who were more willing to pay for conservation valued cultural and natural heritage more highly, and held more positive opinions about protection, regardless of their knowledge and despite their lower income and educational level. These results show us that knowledge does not necessarily indicate greater environmental awareness. The need to consider the marine environment as a cultural-natural embedded heritage is highlighted to foster a cultural connection, inspire commitment to its protection and promote conservation that ensures human well-being and health. Finally, some recommendations are offered to improve the integration of OL in MPA policies.

KEYWORDS

marine management, knowledge - attitude - behavior, conservation, contingent valuation (CV) method, human-ocean relationship, tourism



1 Introduction

Mediterranean coasts are among Europe's top tourist destinations, attracting visitors worldwide, with marine protected areas (MPAs) at the forefront of the most visited places in the region (Randone et al., 2017). An MPA is "a clearly defined geographical space, recognized, dedicated, and managed through legal or other effective means to achieve the long-term conservation of nature with its ecosystem services and cultural values" (Dudley, 2008). Between 2012 and 2021, the surface area of MPAs in the EU more than doubled, to 12.1% (European Environmental Agency, 2023). Whereas in the Mediterranean Sea, they have increased almost threefold over the past 20 years and cover more than 1,000 designated areas (8.33%) (United Nations, 2024; MedPan, 2020). Nevertheless, for most sites, little is known about the management measures in place and whether they are effective at maintaining or restoring the biodiversity they aim to protect (MedPAN and SPA/RAC, 2023).

In the last 15 years, there has been an exponential increase of mass tourism and unregulated offshore recreational activities in the Mediterranean Sea, such as recreational boating (Carreño and Lloret, 2020). Several studies point out that sustainable, non-

motorized marine recreational activities provide cognitive and physical benefits (Lloret et al., 2021). However, scholars have also observed that nature could become a new recreational industry adapted to "green" and "blue" discourses that follow consumer market logic, disregarding the ways people relate to the environment and whether they truly respect nature (Margaleff, 2022). MPAs are increasingly recognized for their value and attractiveness, and this is reflected in the growing number of visitors seeking outdoor activities. The situation has escalated since the onset of the COVID-19 pandemic, overloading the carrying capacity of natural parks beyond previous levels. This has raised awareness and concerns about the environmental impact of the frequency of visits at the local level (Margaleff, 2022).

In order to achieve ocean sustainability United Nations (UN) Decade of Ocean Science for Sustainable Development highlights Ocean Literacy (OL) within an interdisciplinary and crosscutting nature of ocean science to fuel more responsible and informed behavior change towards sustainable oceans (UN, 2018). Ocean Literacy (OL) can empower individuals to meet environmental protection goals by aiding the effectiveness of environmental management (McRuer et al., 2025). Knowledge is recognized as a powerful tool to influence ocean transformation and the

environment through actions aligned with the vision of the Ocean We Want (<https://oceandecade.org/>). The term Ocean Literacy was originally coined in 2004 by a group of ocean scientists and education professionals in the USA who recognized a lack of ocean-related subjects in formal education and developed a comprehensive framework to encourage inclusion of ocean sciences in national and state standard education (De Santoro et al., 2017; UNESCO, 2017). It was defined as “an understanding of your influence on the ocean, and its influence on you” (UN, 2018).

Afterward, it was incorporated into UNESCO’s priorities since it aligned with its environmental education goals. Since then, “Ocean Literacy as a concept and approach is radically evolving from being a tool to be applied in formal education and training contexts to a tool and approach for society as a whole, aimed at triggering actions towards ocean sustainability” (Buttigieg, 2020). According to McKinley et al. (2023) and adapted from the initial principles proposed by Brennan et al. (2019), OL encompasses 10 dimensions: knowledge, awareness, attitude, behavior, activism, communication, emotional connections, access, and experience, adaptive capacity, trust, and transparency. These dimensions shift the focus beyond knowledge to a more comprehensive framework central to recent OL studies.

More recently, OL has gained prominence as a global framework for integrating natural and social sciences, supported by the UN Decade of Ocean Science for Sustainable Development (UN, 2018). The roadmap for this initiative highlights the importance of incorporating social dimensions and coordinating research efforts across disciplines, particularly in the social sciences, identifying it as a high-priority research area for sustainable development (UN, 2018).

Despite calls to promote a more integrated approach between natural and social sciences, few studies explore how to achieve this or which disciplines should be incorporated into Ocean Literacy at the intersection between natural and social sciences (McReur et al., 2025). Additionally, research on reconciling different scales of knowledge remains scarce (Ferreira et al., 2021), even though knowledge is primarily applied through local actions to address global challenges, as highlighted by Hylland Eriksen (2016) and Reyes-García et al. (2016).

Furthermore, while past OL efforts within marine research institutions have been significant, they have often been voluntary or disconnected from institutional strategies. As such, much remains to be done in building the capacity of marine research centers and universities -where most scientific marine knowledge is generated-to effectively align OL programs with marine conservation goals (Salazar et al., 2022).

Understanding the human dimensions of the ocean - how they interact with the physical environmental aspects studied in the natural sciences - is essential for advancing ocean sustainability (Liu et al., 2023). This study follows the approach of Liu et al. (2023) to evaluate OL within an integrated natural and social science framework. It considers the unique spatial, ecological, and cultural factors shaping the human dimensions of MPAs (Gómez and Lloret, 2017).

These human dimensions encompass the social, economic, and institutional considerations of MPAs, as highlighted by Charles and Wilson (2008). Recognizing both natural and cultural elements as integral to MPAs underscores their role in shaping seascapes and ecosystems. These elements define a place’s unique character and value, and their preservation supports broader environmental conservation efforts.

MPAs provide an ideal setting for applying an integrated OL framework that combines natural and social science approaches. While research has explored incorporating diverse stakeholder perspectives into MPA decision-making, little attention has been given to OL’s role as a bridge between society and environmental management, particularly in achieving protection goals outlined in the UN Sustainable Development Goals.

Few studies have examined OL integration in MPA management plans (Cavas et al., 2023; Ferreira et al., 2021; Perry et al., 2014) and research on OL among MPA visitors is almost inexistent (Garcia and Cater, 2022; Shellock et al., 2024). This gap persists despite OL’s recognized value in shaping effective policies, conservation initiatives, and tools, including MPA designation (McRuer et al., 2025).

Integrated cultural and natural heritage plays a crucial role in sustainable development, particularly in rural planning and management. Its preservation not only supports ecological integrity but also serves as an economic asset (Bonenberg, 2019).

MPAs like Cap de Creus are celebrated for their exceptional biodiversity and rich cultural heritage, making them valuable both ecologically and culturally (see Law 4/1998, March 12, on the protection of Cap de Creus). However, this heritage often receives little attention in maritime conservation policies and regulations, such as the European Union Common Fisheries Policy or comprehensive MPA management plans (Gómez and Maynou, 2021; Kenterelidou and Galatsopoulou, 2021).

MPAs offer a unique opportunity to integrate heritage values into conservation strategies, positioning them as essential components of OL. While OL has been studied in the context of fisheries in Cap de Creus (Biel-Cabanelas et al., 2023; Salazar et al., 2024), its role in engaging other societal groups, such as tourists, remains largely unexplored.

Collaborative efforts between fishers and biologists, along with anthropological studies and recommendations, have contributed significantly to the conservation and restoration of marine benthic ecosystems in Cap de Creus (Gómez et al., 2006; Gómez and Lloret, 2017; Montseny et al., 2021; Santin et al., 2022). These experiences underscore the importance of cooperation in MPA management and the need to develop strategies that actively involve fishers in environmental conservation (Salazar et al., 2024).

Recognizing the heritage value of artisanal fisheries has led to proposals for fishers to act as sea stewards, promoting sustainable practices within MPA co-management frameworks (Gómez and Lloret, 2017; Gómez et al., 2006). Community-based management, which integrates cultural heritage and local ecological knowledge, is inherently sustainable, blurring the traditional divide between natural and cultural heritage (Boccardi and Duvelle, 2013). The significance of heritage in environmental sustainability is also

reinforced in the 2030 Agenda for Sustainable Development, with multiple Sustainable Development Goals (SDGs) highlighting its roles (SDG 5, 8, 9, 10, 11, and 13).

Given this context, this study assesses visitors' perceptions of the of the Cap de Creus MPA, their opinions on its protection, and their perceived knowledge¹, focusing on both natural and cultural heritage. The underlying hypothesis is that a greater appreciation of heritage correlates with stronger pro-environmental attitudes. This relationship is reflected in indicators such as visitors' willingness to pay for the conservation of protected areas, which in turn may encourage environmentally responsible behavior.

This evaluation is especially appropriate in the context of the Cap de Creus MPA, given the area's cultural and natural wealth, which has contributed to the formation of its landscape and seascape. This is reflected by numerous sources, encompassing literature and art, among others. Given its biodiversity and the pressures of increasing human activity, the Cap de Creus area serves as a representative laboratory for assessing OL among visitors in the Mediterranean. However, it could also be relevant for other regions with similar patterns, such as MPAs in California (USA), despite contextual differences.

Therefore, this study aims to: 1) Assess visitor's perceived knowledge, opinions, and valuations of the MPA; 2) Identify key factors for implementing OL programs in MPAs to promote pro-environmental behaviors and attitudes among visitors.

2 Materials and methods

The Contingent Valuation Method (CVM) is an effective approach for assessing willingness to pay (WTP) in natural parks, allowing for the valuation of non-use benefits and has been validated for reliability. [Xiao et al. \(2021\)](#) confirmed the existence of non-use values, highlighting CVM's effectiveness in prioritizing conservation funding. Additionally, [Ramdas and Mohamed \(2014\)](#), emphasize that environmental literacy -including knowledge and attitudes- shapes pro-environmental behaviors, such as willingness to pay. This suggests that enhancing OL can positively influence tourists' willingness to support financially conservation efforts.

This study employs CVM to analyze how stakeholders value environmental protection, their knowledge and valuation of the cultural and natural heritage associated with the Cap de Creus MPA, and their perceptions of conservation needs. The goal is to identify key aspects to integrate into OL programs as part of MPA management plans.

While WTP is commonly used to estimate the economic value of marine ecosystem goods and services, research on valuing cultural and natural heritage as embedded dimensions of conservation in MPAs remain scarce. Apart from studies focusing on maritime buildings, underwater archaeology, and recreational activities ([Baez and Herrero, 2012](#); [Duran et al., 2015](#); [Eftec, 2014](#);

[Whitehead and Finney, 2003](#)), the value of heritage, and maritime heritage in particular, is largely unexplored.

In general terms, WTP for environmental protection has been used in studies on nature-based tourism to assess taxation feasibility for funding MPA conservation ([Laarman and Gregersen, 1996](#)) to fund the conservation of MPAs ([Brathwaite et al., 2021](#); [Gravestock et al., 2008](#); [Gelicich et al., 2013](#); [Thur, 2010](#); [Uyarra et al., 2010](#)) or to reduce overtourism and improve environmental carrying capacity ([Casey and Schuhmann, 2019](#); [Sorice et al., 2007](#)). Other applications include WTP assessments to measure both non-use values (bequest) and use values (communication media) associated with conservation according to the countable value stated by stakeholders ([Togridou et al., 2006](#)). Furthermore, placing a value on nature has been highlighted as a potentially effective strategy ([Laarman and Gregersen, 1996](#)) for gaining efficiency in environmental protection. Consequently, willingness to make economic sacrifices for environmental protection has been identified as an indicator of pro-environmental behavior and mediating individuals' moral obligation toward the environment. Accordingly, in this study, we use WTP as an indicator of pro-environmental attitudes linked to ecosystem services.

The questionnaire is composed of questions that aim to measure the perceived knowledge and opinions visitors have of MPA biodiversity and cultural heritage (maritime and fishing heritage) and its protection, as well as their valuation of the environmental protection, assessed by the level of WTP to curb over-frequentation (which has environmental impacts). Finally, it also includes questions on the natural and cultural heritage valuation of MPAs. Heritage valuations are not only catalysts for valuing educational opportunities and recreational activities, but also for enhancing coastal economic development and fostering community participation in management ([Claesson, 2011](#)).

2.1 Study area

It is estimated that the Mediterranean Sea contains between 4% and 18% of the world's marine species at the macroscopic level, although it represents only about 0.3% of the total volume of the world's oceans ([Bianchi and Morri, 2000](#)). MPAs have been recognized as playing a central role in addressing environmental degradation and challenges. Yet, only 8.9% of the Mediterranean is currently under some form of protection status ([UNEP/MAP and Plan Bleu, 2020](#)), falling well short of the 30% protection target set for 2030 at the 2022 UN Biodiversity Summit (COP15). It represents approximately 1,215 ha of MPAs and OECMs (other effective area-based conservation measures) covering a total of 171,362 km². Nevertheless, there is a great variety of conservation designations of great complexity. Over 72% of the protected surface is in the western Mediterranean, with 90% of the total surface protected by MPAs and OECMs found in European waters.

We focused on the Natural Park of Cap de Creus (NPCC) ([Figure 1a](#)), a representative MPA in the Mediterranean, as it is an important biodiversity hotspot. It is located in northeast Catalonia, flanked by picturesque fishing villages such as Roses, Cadaqués, Port de la Selva and Llançà. These villages are renowned tourist

¹ According to [Perry et al. \(2014\)](#), "self-assessed or perceived knowledge is where a person believes that he or she is knowledgeable and providing the correct answer" (2024: 108).

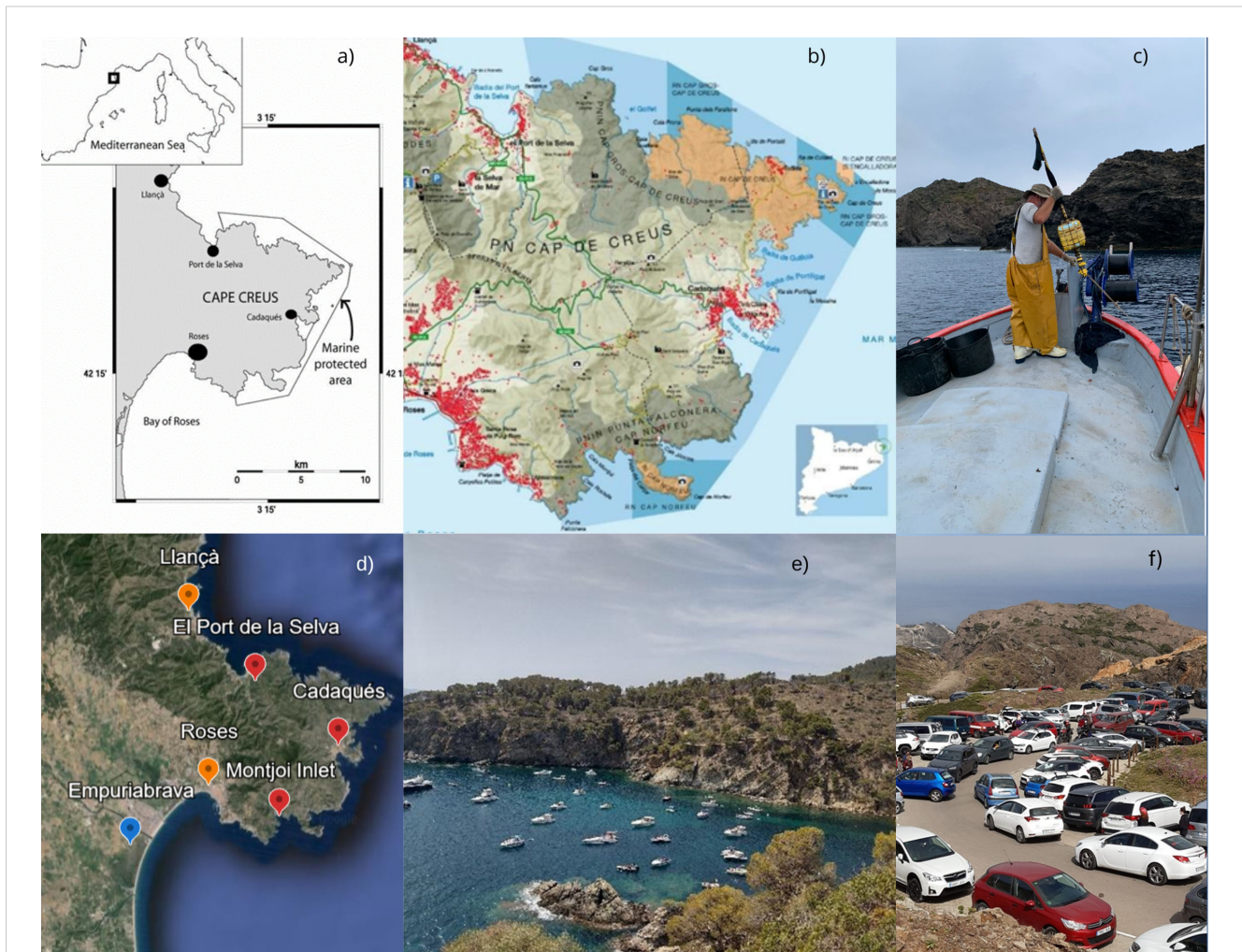


FIGURE 1

(a) Cap de Creus Natural Park (CCNP), Northeast Catalonia (Spain); (b) CCNP zoning. Only professional small-scale fishing and recreational fishing (spearfishing and angling) are allowed in the light blue zone. In the partial natural reserve (dark blue zone), only small-scale professional fishing and angling are permitted. All activities are prohibited in the Integral reserve (orange zone); (c) A fisher in Cap de Creus hauling trammel nets; (d) Roses and Llança (in orange) are towns bordering Cap de Creus. Empuriabrava at the adjacent area of Cap de Creus (in blue) is 30 minutes from Roses. The villages within the Cap de Creus Natural Park are indicated in red: Cadaqués, and Port de la Selva, and the Montjoi Inlet (which belongs to the Roses municipality); (e) Leisure boating in a Cap de Creus inlet (August 2023); (f) Cars parked in Cap de Creus in summer season.

attractions, popular for being the birthplace of famous international artists and writers, well-known for their beaches and natural beauty, as well as their long history of fishing. The Cap de Creus area ($42^{\circ}19'12''$ N, $03^{\circ}19'34''$ E) is in the northwestern region of the Mediterranean Sea, and the Cap de Creus submarine canyon system cuts into the continental shelf off the cape. This is one of the most productive places in the Mediterranean as a result of the rivers, currents and wind effects. The general water circulation in the area is from the northeast to the southwest, driven by the northern current (DeGeest et al., 2008). The dominant winds are Tramontana and Mistral, northern winds that are continuous, cold, and dry, causing an increase in the density of coastal waters that then translates into coastal downwelling in the Cap de Creus area (Ulises et al., 2008). The Rhône River provides 80–90% of the continental shelf sediments (Coup and Monaco, 1990), it being the primary source of hemipelagic sediments in the area (DeGeest et al., 2008; Ulises et al., 2008). Consequently, it is one of the largest and most

important biodiversity hotspots in the Mediterranean. In that region (both in the continental shelf and in the submarine canyon system), nearly all of the Mediterranean benthic communities are represented (Madurell et al., 2012; Sardà and Company, 2012), including cold-water corals, octocoral gardens, sponge grounds, and echinoderm aggregations. The area has optimum ecological conditions for being dominated by suspension and filter-feeding species (Dominguez-Carrio et al., 2022).

At the same time, it is one of the sites with the highest anthropogenic pressures. This is partly a widespread problem of the Mediterranean that is one of the world's top tourist destinations (AAVV, 2018). This has boosted increasing coastal urbanization processes that, together with agricultural changes and land-based activities, has turned the Mediterranean into one of the world's most highly affected basins by marine litter (UNEP/MAP and Plan Bleu, 2020), particularly by microplastics (UNEP/MAP & Plan Bleu, 2020). These pressures on marine benthic ecosystems lead to several

alterations including depletion of key species, an increase in the number of invasive species and other changes in the structure of benthic communities. This leads to biodiversity loss and other disruptions in their normal functioning (Halpern et al., 2008; Worm et al., 2006) and a need for marine benthic restoration actions (Grinyó et al., 2022).

Despite Cap de Creus having been recognized between 1976 and 1985 by various land management and nature conservation institutions of the Spanish Government and expert committees in Catalonia as a biodiversity hotspot, it was not declared a Natural Park until after approximately 10 years of grassroots efforts (1995–1998) [Law 4/1998 (Official State Gazette, 1998)] (AAVV, 2018). The demands of social movements denounced the growing urbanization process that threatened the landscape, the irreparable damage to the seabed from trawling in the coastal area, and recreational fishing competitions having impacts on vulnerable species and fragile ecosystems in the area (AAVV, 2018; Salazar et al., 2024).

Today, the NPCC covers a total area of 13,886 ha, of which 3,073 are maritime, and it is the first terrestrial-maritime Natural Park in the Mediterranean. The declaration in 1998 led to the creation of the zoning system for the Marine Protected Area, dividing it into three protection zones that restrict fishing activities. Within the Natural Park, which comprises most of the hectares, recreational and artisanal fishing is allowed, while in the three partial reserves only artisanal fishing is allowed (Figure 1c), and in the integral reserve (s'Encalladora) all activities are forbidden, with only scientific activities allowed with prior authorization (See zoning Figure 1b).

Further, in 2014, the Cap de Creus area was also declared a Special Protection Area (SPA) (Area ES5120007 of the Natura 2000 Network [Order AAA/1299/2014 (Official State Gazette, 2014)], Site of Community Importance (SCI) and “Sistema de cañones submarinos occidentales del Golfo de León” (submarine canyons system of the Gulf of Lions), which belongs to the European Union Natura 2000 Network [Area ESZZ16001 (Official State Gazette, 2014)] (See Salazar et al., 2024). Despite an initial attempt in 2005, and a second one in 2023, a Master Plan of Uses and Management is still lacking but pending approval expected by summer 2025. On both occasions, 2005 and 2023, there was opposition from certain socio-economic sectors, particularly the leisure boating sector.

For over 20 years, great efforts to meet conservation goals have been made in collaboration with small-scale fishers, scientists, NGOs, and local managers from the NPCC. Recently, given the accelerated growth in visits, in 2021, the NPCC introduced new measures to curb overcrowding, restricting vehicle access between June and September², at the peak of season when it receives the most visits (Figure 1f). In addition, being a very windy area (affected by the Tramontana wind), access to the NPCC inlets and beaches is

occasionally completely forbidden to avoid forest fires, which affects the normally free circulation of visitors by land to the NPCC during the summer. While restrictions on land are easier to enforce, restricting access by sea remains a challenge, especially due to the lack of a Master Plan of Uses and Management regulating free circulation by sea (leisure boating, jet skis, etc.) (Figure 1e), which causes significant environmental impacts (e.g., anchoring).

2.2 Data collection and analysis

A structured face-to-face questionnaire was administered to a simple random sample of 197 visitors of Cap de Creus, in the towns bordering the Natural Park (Llançà and Roses) and within Cap de Creus: Cadaqués at the entrance of the Pla de Tudela site, the Montjoi inlet in the municipality of Roses, and El Port de la Selva. We also collected data on visitors to Empuriabrava, a municipality 30 minutes from Cap de Creus with a significant number of visitors (Figure 1d).

The data was collected during the summer period, between June and August 2021, when tourism in this area is highest with visitors outnumbering residents. Throughout 2019, a total of 51,974 visitors were recorded at the four information points of the park, 12,840 of whom visited the Cap de Creus area³. It is important to note that in the summer of 2021, the tourism sector was still heavily affected by mobility restrictions due to the pandemic, which also explains the small sample size. However, the structure of the sample corresponds to the actual population distribution of the area where most surveyed tourists are French (Europarc, 2024). Therefore, the sample analyzed is significant and representative of the typical profile of tourists visiting the Natural Park. We employed a convenience sampling strategy, approaching visitors at strategic entry points to the park. A surveyor strategically placed at those data collection points gathered data from all visitors who agreed to be surveyed. They were asked for their consent to be interviewed.

A contingent valuation method focusing on “what if” questions was used to collect individuals’ contingent responses in hypothetical scenarios, clearly stated and described by the interviewer. Participants were also asked closed-ended questions about their knowledge and valuation of natural and cultural ecosystem services, with response options based on a five-point Likert scale analysis (see Supplementary Materials).

Nevertheless, while CVM provides valuable insights, it is important to note that respondents were asked to express their willingness to pay in a hypothetical scenario, which could introduce bias if no actual fees were ever implemented for access to the MPA. Additionally, the study’s sample size and timeframe present potential limitations. For example, the relatively small sample may restrict the generalizability of our findings to other MPAs or visitor populations. Nevertheless, the efficacy of the sample stems

² To give an example, in the final stretch of the peninsula of Cap de Creus with a capacity of only 85 vehicles, up to 1,200 vehicles were counted who sought access to the site at the peak of the summer season in 2019. Overcrowding causes a significant environmental impact and has always been a problem for the Natural Park. We thank P. Feliu, director of the Natural Park of Cap de Creus, (personal communication, November 2024) for providing this data.

³ We would like to thank P. Feliu, director of the Cap de Creus Natural Park, and M. Pascual, technician on environment who provided us with this unpublished data from the Natural Park’s records (personal communication, February 2025).

from the fact that respondents evaluate the case *in situ*, experiencing the real situation within the real environment.

We also recognize concerns raised by economists and ecologists, who argue that the economic valuation of nature risks equating environmental value with market-based value (Nature Editorial, 2019). This issue is particularly relevant when considering the irreplaceable nature of cultural artifacts and ecosystem services that cannot be adequately measured in economic terms (Chiesura and De Groot, 2003). In contrast, in-depth interviews and longitudinal studies that track changes in OL over time could offer qualitative insights, capturing a broader range of visitor perceptions and motivations, as shown by Myers et al. (2013) in global warming studies and Sobkow et al. (2017) in flood research. In the field of OL research, such studies remain scarce and limited, highlighting the need for further investigation (see Ashley et al., 2019, and Stoll-Kleemann, 2019). However, these approaches were beyond the scope of this study.

The structured face-to-face questionnaire was tailored for this study in order to meet the specific research goals. The different

questions were intended to capture the different dimensions of OL suggested by McKinley et al. (2023), which have been adapted to the context. For that purpose, in some instances, these dimensions were combined into a set of questions making up a block (see schema of OL dimensions in Figure 2). This combination is the result of the fact that, in contextual adaptation, several dimensions are contained in a single block because they are interrelated, and others at the intersection between blocks. The blocks were organized into five sections, as described below:

Block 1. Assessment of environmental protection knowledge. The knowledge section included questions related to perceived visitors' knowledge of the NPCC (whether they knew that it had been declared a Natural Park, the boundaries of the park, the type of activities permitted and prohibited, and its natural and cultural values). The "awareness" dimension was partly included here inasmuch as it referred to the regulations for the preservation and conservation of the MPA. Also, the "communication" dimension between knowledge and awareness was drawn upon, as it assessed the extent to which citizens were aware that they were in a Natural Park.

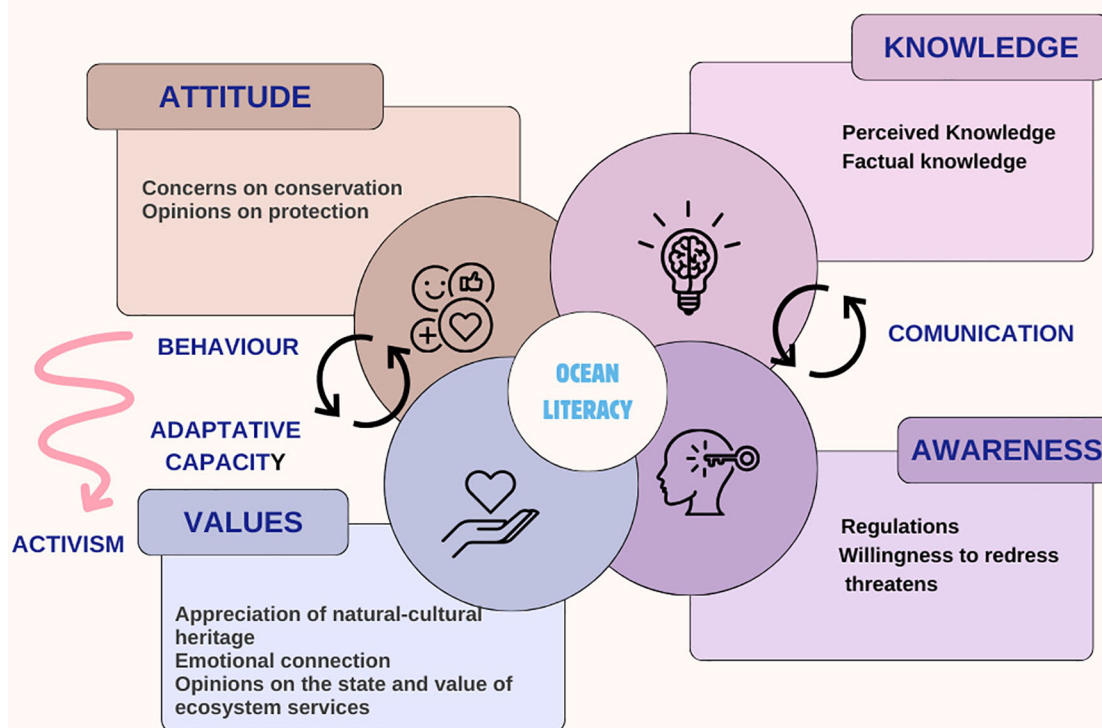


FIGURE 2

Dimensions of the OL in the Cap de Creus MPA. The *knowledge* (corresponding to Block 1 of the survey, which refers to the perceived knowledge of visitors about the PNCC), the *values* (Block 2 on the valuation of the natural and cultural heritage), *awareness* (Block 1 on the perceived knowledge of visitors about the regulations, and Block 4 on the willingness to pay to repair the threats. That is to say, the environmental impacts produced by overcrowding) and *attitude* (block 3 which refers to opinions and perceptions about conservation and protection). *Communication*, *behavior* and *adaptive capacity* were reflected in the intersection between the blocks. *Activism* is reflected in questions at Block 3 and 4. Design by Silvia Gómez.

Block 2. Natural and cultural heritage valuation. This block made it possible to gauge the level of appreciation of natural and cultural heritage, and underlying emotions that could be expressed through senses such as sound and smell. The “emotional connections” dimension was reflected throughout this block.

Block 3. Opinions and perceptions on conservation and protection. The questions in this block reflected the “attitude” dimension, as visitors had to express the level of agreement or concern in relation to conservation issues.

Block 4. Economic valuation. This section dealt with visitors’ willingness to pay in order to enjoy nature without overcrowding.

Blocks 3 and 4 showed the “awareness” dimension, highlighting to what extent visitors were willing to redress a situation that needs improvement, as well as the value they placed on the environment, reflecting potential drivers of societal change. In addition, it reflects the “behavior” and “adaptive capacity” dimensions, contextually understood as the willingness of visitors to adjust their behavior to potential constraints in order to meet conservation goals. This refers to choices according to individuals’ decisions regarding their behavior. Questions in Block 3 and 4 also inquired about the potential of the “activism” dimension and visitors’ willingness to take action and engage in actions for the protection and conservation of the NPCC.

Block 5. Visitors’ income. In this section, visitors were asked about their level of income.

The dimensions “Access and experience” and “Trust and transparency” were not assessed since visitors were not asked about aspects concerning the visit (frequency, transportation, etc.) nor about sources of information and quality. We considered that this type of evaluation would involve a more specific and in-depth questionnaire, which did not fit with the exploratory nature of the study.

The data was statistically analyzed using regression analysis, examining the relationships between the variables: (1) degree of knowledge in relation to sociodemographic indicators (sex, age, education, and income); (2) rating of natural and cultural values in relation to sociodemographic indicators; (3) opinion of topics related to the protection of the NPCC in relation to sociodemographic indicators; (4) willingness to pay, or not pay, according to Blocks 1 (knowledge), 2 (valuation), and 3 (opinion), and sociodemographic indicators (sex, age, education, and income); (5) amount informants are willing to pay according to Blocks 1 (knowledge), 2 (valuation), 3 (opinion), and sociodemographic indicators (see [Supplementary Material](#)).

To analyze the relationship between knowledge and sociodemographic factors, we used a linear regression model with knowledge as the dependent variable and age, gender, education level, and income as independent variables. A primary descriptive analysis led us to consider the formulation of multiple regression models to evaluate the significance of the different explanatory variables.

Correlation analyses were also performed to explore the relationships between key variables, including age, education level, income, and valuation of natural and cultural heritage.

These analyses help determine whether associations exist between sociodemographic characteristics and visitors’ perceptions, opinions, and knowledge. The results provide additional insights into the underlying factors that may influence pro-environmental attitudes and behaviors.

For the first regression model (1) the answer YES in the questionnaire was given the value 1, and NO the value 0 (see [Supplementary Material](#)). The variable *knowledge* was obtained by adding up the answers to the questions in the first section of the questionnaire for each individual. The minimum value is therefore 0 and the highest value is 5. In the second regression (2), the variable score (point) in the ranking of natural and cultural values was obtained by adding up the scores given for the 23 questions making up the second section of the questionnaire. The results of the sum for each individual gave the highest possible score of 115 points, and the lowest possible score of 23 points. In the third regression (3), the following numbers were assigned to possible answers: 2=agree, 1=partly agree, 0=disagree. Only questions 3.3, 3.5, and 3.8 were considered (see [Supplementary Material](#)). The opinion variable (3_opinion) was obtained by adding the answers given by each individual to the questions. The variable willingness to pay (“WTP”), regression (4), was obtained from question 5.1 of the questionnaire, giving a 1 for YES and a 0 for NO. The variable amount visitors were willing to pay (quant) (5) was obtained from question 5.2 of the questionnaire, with a 1 for yes and a 0 for no (see [Supplementary Material](#)).

The variability of the answers to these questions was analyzed for the sociodemographic indicators mentioned above (sex, education, income, and age). In this regression, we also added individuals’ evaluations of the NPCC as a regressor. This variable was obtained from sections 1, 2, and 3 of the questionnaires and comprises the sum of the values obtained in the following sections: Block 1 (questions 1 to 5), Block 2 (questions 1 to 23), Block 3 (questions 3, 5 and 8).

Model 1 aims to measure the influence of socioeconomic variables on the level of knowledge (*Knowledge*). The socioeconomic variables are defined as follows: Sex (binary: 0,1), Age (continuous variable), Education level (four categories: no education, basic education, secondary education, university degree), Income (nine categories, ranging from less than €600/month to more than €5000/month). Given the nature of the dependent variables, some dichotomous (sex, for example) and others continuous [*Knowledge+Valuation+(Opinion+Perception)*], we employed linear and logistic regressions.

The choice between logistic and linear regression is based on whether the dependent variables are continuous or binary/categorical. Linear regression applies to continuous dependent variables, while logistic regression applies where the dependent variables are binary or categorical. Application of this method ensures that the analysis is well tailored to capture variations in knowledge levels and valuation among visitors. Logistic regression also enables better modeling of relationships with binary responses such as willingness to pay.

3 Results

The questionnaire gathered the opinions of 197 visitors, of which 73% were French⁴, 17% were Spanish (with only five being residents of the NPCC), and 10% from other nationalities.

The first section of the survey begins with the question: *Did you know that Cap de Creus is a Natural Park?* A total of 64% of respondents answered no. Even more striking is the fact that, among those surveyed in Cadaqués—right in the heart of the park—89.6% were unaware of this designation. This clearly indicates that the tourism market does not incorporate the environmental, cultural, and heritage value of the area. The various questions in the survey further confirm this high degree of unawareness regarding the Natural Park. Specifically, 75.5% of respondents stated that they were unfamiliar with the regulations, 87.2% did not know the boundaries of the Natural Park, and 80.6% were unaware of its flora and fauna. In summary, these exceptionally high percentages reveal a significant lack of knowledge among tourists regarding the Park's existence. This simple descriptive analysis suggests that the variable *knowledge* is unlikely to be statistically significant, necessitating the formulation of multiple regression models to evaluate the significance of the different explanatory variables. When asked: *Would you be willing to pay to enjoy the environment without congestion?* 82% of respondents answered yes. Among the 18% who stated they would not be willing to pay, the majority reported having no income (such as students) or very low income. This finding is particularly relevant because those who responded negatively fall within the typical categories eligible for public service fee exemptions. Therefore, excluding this population, all others should be expected to pay for the opportunity to enjoy the natural environment free from congestion.

In the first regression model, we tested the degree of knowledge in relation to sociodemographic indicators. We can see the coefficients in [Table 1](#). The adjusted R-squared is equal to 0.05251. This tells us that sociodemographic data explain 5.2% of the variability in the degree of knowledge. The P-value of the overall significance test is 0.01728. Therefore, at the 5% and 10% significance levels, we reject the null hypothesis that all β can be equal to 0. Thus, we can conclude that there is no significant variable that explains the variability in the degree of knowledge within the tested population.

Despite low correlations and regression coefficients not being statistically meaningful, they indicate meaningful trends in visitors' perceptions and willingness to pay. For instance, while the adjusted R-squared values suggest that socioeconomic variables explain only a small portion of the variability in knowledge levels, the observed trends still provide useful information on how different visitor groups perceive the Cap de Creus MPA.

In the individual significance test, we find that the only null hypothesis we can reject is that the β coefficient of the variable *age* equals 0. This is the case at all standard significance levels.

When testing the second and third models (see [Table 1](#)), the results do not differ significantly. However, the fourth model provides more interesting insights. Across all four models, the variable *age* is statistically significant, which, as expected, reflects its relationship with income and education level, leading to the typical multicollinearity issue found in socioeconomic variables. In all regression models, the *income* variable is not significant, a result that was already anticipated in the previous descriptive analysis.

Notably, two significant correlations were found ([Table 2](#)). First, the correlation between knowledge and age is negative, with a value of -0.186, and is significant at a 95% confidence level. This means that younger members of the population possess knowledge about the protection of the natural park and its existence. This tendency is observed more frequently in individuals aged 47–50 and younger.

The other variable showing significant correlation is income. In this case, the correlation is positive, which implies that respondents with a higher income have a higher level of knowledge about the existence and protection of the NPCC. This result represents a 90% confidence level. Note that 75.5% of those surveyed said they were unaware of the regulations, and 87.2% lacked knowledge about the delimitation of the NPCC.

The other two sociodemographic variables (education and gender) are positively correlated with the degree of knowledge, but this is not significant at any standard level.

Furthermore, we found a positive correlation between the age variable and the score for cultural and natural heritage valuation (rating) with a value of 0.54, significant at all standard confidence levels. This means that older respondents give higher scores to heritage. Nevertheless, the regression of the second model shows an adjusted R-squared value of 0.2453. The sociodemographic data explain 24.53% of the variability of the score given to the cultural and natural heritage of the NPCC.

Ratings in [Table 2](#) show a negative correlation between heritage and gender, with a significant confidence level of 90%. This implies that female respondents give the cultural and natural heritage of the NPCC lower scores. Moreover, the correlation between education and rating is negative, with a significant confidence level of 95%. Regarding opinions on MPA protection and conservation measures, findings indicate that the correlation between age and opinion is positive and significant at all standard significance levels. However, the correlation between opinion and education is negative, and significant at a 90% confidence level.

The correlation between age and opinion on preservation and protection (See Block 3, [Supplementary Material](#)) is positive and significant at all standard significance levels. In contrast, the correlations between opinion and income, and opinion and gender are negative and not significant at any standard level of significance.

Nevertheless, when we focused on the correlation between WTP and valuation, we observed that this is positive at 0.445 and significant at all standard confidence levels. With this data, we conclude that, on average, individuals who value the park more

⁴ French people represent more than half of daily tourist visitors in the area (See [Europarc \(2024\)](#) Diagnosi de la carta europea de turisme sostenible al cap de creus, 2020–2024. Report. CETS-Cap de Creus)

TABLE 1 Regression models.

	Model 1: Knowledge	Model 2: Rating	Model 3: Opinion	Model 4: Willingness to pay
Intercept	2.209365 (0.921683)	64.81440 (8.80153)	4.239594 (0.660760)	-0.030433 (0.197736)
Sex	0.052467 (0.296031)	-0.40564 (2.82692)	-0.041283 (0.212226)	0.004533 (0.054278)
Age	-0.024464* (0.009738)	0.55127*** (0.09299)	0.015742* (0.006981)	0.006981*** (0.001959)
Educational level	-0.104106 (0.184429)	-2.44602 (1.76119)	-0.215044 (0.132218)	0.025664 (0.034039)
Income	0.090500 (0.071713)	1.33885 (0.68482)	0.019630 (0.051411)	0.014625 (0.013329)
K+O+P				0.004232** (0.001532)
Adjusted R-Squared	0.05251	0.2453	0.06644	0.2049
P-value	0.01728	2.578e-09	0.006637	2.331e-06

The significance codes (shown by asterisks) are intended for quickly ranking the significance of each variable's coefficient, according international standard.

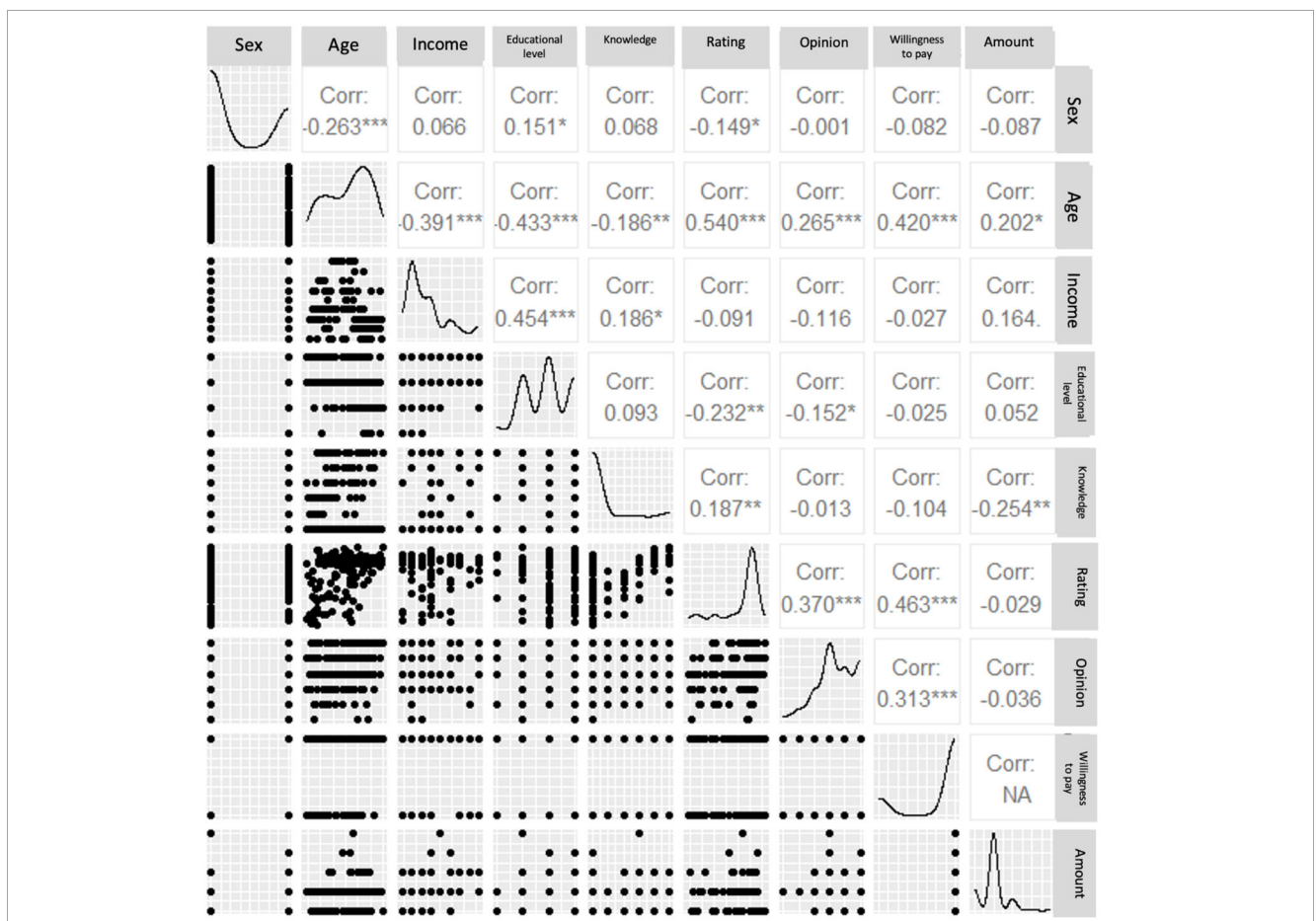
highly are more willing to pay for a congestion-free environment (See Block 4, [Supplementary Material](#)). The correlation between WTP and age is positive at 0.420 and significant at all standard confidence levels.

Finally, the correlation between the sex, valuation and income variables is negative (Table 2) and non-significant at any standard significance level. Therefore, we consider valuations and individuals' sex to be unrelated to the amount they are willing to

pay. The correlation between income and age is positive at 0.202 and significant at a confidence level of 10%.

The positive coefficient for age in the logistic regression model indicates that older visitors are more likely to express a willingness to pay for conservation. With this data, we found that the older individuals surveyed are willing to pay more for an environment that is not overcrowded. The variables studied and level of income reported present positive correlations with visitors' WTP, but none

TABLE 2 Correlation analysis between variables.



The significance codes (shown by asterisks) are intended for quickly ranking the significance of each variable's coefficient, according international standard. NA, Not available.

of them are significant at any standard significance level. Therefore, we consider that having a higher or lower income or being educated does not influence the amount that individuals are willing to pay. On the contrary, it is a pro-conservation opinion toward the protection of the MPA and valuation of cultural and natural heritage that determines the WTP for the protection of the environment, irrespective of age, income, and education level.

Furthermore, the analysis points out that, in general, there is a significant lack of knowledge or even ignorance about the Natural Park. This indicates that although the conservationist discourse of preserving the natural and cultural coastal landscape is generally assumed, people do not know where it applies locally. Additionally, this suggests that people are attracted by the beauty of internationally popular towns such as Cadaqués, the beaches, and landscapes, but not by the maritime culture and marine biodiversity. It is especially striking that visitors do not generally agree with the regulations or admit to not knowing about them, highlighting that regulations should be better communicated.

Our results point to a general willingness of citizens to pay for decongesting natural areas (Block 4), regardless of their knowledge of natural parks (Block 1), their level of education, or their income (see sociodemographic data). For decades, economic thinking had held that households with higher incomes place a higher value on environmental quality, something that recent studies have questioned. We believe that this approach may change with the spread in society of concerns about global change and the need to preserve the environment. In this sense, the results illustrate this change: the willingness to pay (WTP) to enjoy the park environment is not correlated with the income levels declared by visitors. The vast majority, regardless of their income, express their willingness to pay for access to the environment. This is a significant result.

Thus, WTP is correlated with a greater appreciation of natural and cultural heritage and with a favorable opinion of environmental protection (represented by the questions in Blocks 2 and 3). The results confirm that knowledge alone is neither sufficient nor significant in driving the possible pro-environmental attitudes represented by the questions in Blocks 2 and 3, awareness in Blocks 3 and 4, behavior and adaptive capacity in Blocks 3 and 4, or activism in Blocks 3 and 4. Therefore, the most conclusive finding in the fourth model is that WTP (Willingness to Pay) is explained by the variable $K+V+(O+P)$ [*Knowledge + Valuation + (Opinion + Perception)*], which is statistically significant. The coefficient indicates a positive relationship, meaning that knowledge, combined with a better opinion and perception of the park, leads to a greater WTP among the population which is correlated with higher valuation of heritage. In view of this, it could be concluded that it would be pivotal for public policies to evaluate the costs and benefits of maintaining the environment and cultural heritage linked to marine protected areas. Furthermore, the results are relevant in light of the scarcity of social, cultural and economic data on the marine protected area. In this sense, our exploratory study also functions as an experiment to illustrate the need for continuous improvement in data collection and analysis.

4 Discussion

According to the results, we align with studies stating that the knowledge variable is not the fundamental catalyst for driving the balanced transformation of the human–ocean relationship (Evans et al., 2021; Perry et al., 2014), but neither are variables such as awareness, proximity, and attachment (Evans et al., 2021; Perry et al., 2014), which furthermore depend on contextual social and political factors. For example, whether local stakeholders have been consulted or have participated in the MPA creation process, which may influence the level of awareness of MPA establishment and MPA attachment, expressed as an integrated link to the territory through the protective purpose of an MPA. Attachment as a “sense of place” is not a vehicle for knowledge or attitude change (Stoll-Kleemann, 2019 in Evans et al., 2021). Therefore, knowledge should be evaluated by considering other variables as “knowledge transmitters.” Likewise, it is necessary to review the content of variables such as “attachment,” usually employed as “sense of place” or “proximity to place,” which may only work in the case of local actors.

Considering that most respondents in this study are visitors and not locals, it seems unlikely that attachment is what drives the high valuation of the natural and cultural heritage of the place (Block 2) and the favorable opinion toward environmental protection (Block 3). Connection to place would seem a more appropriate factor to explain the motivation for positive opinions. In this line, several scholars (Evans et al., 2021; Ferreira et al., 2021; Kelly et al., 2022) have identified “connectedness” as an important trigger of action-oriented knowledge for social change. Kelly et al. (2022) expresses it as “cultural connections” referring to the cultural relationship with the ocean that involves identity, values, but also practices (music, paintings, poetry, cinema, theatre, traditions, beliefs, mythology, etc.). Cultural connectivity in this study is difficult to assess, but it could be understood as aesthetic values of environmental assets that, together with awareness of their environmental functions, create a kind of connection that translates into appreciation of the natural–cultural heritage and opinions about its protection. Our study points out that heritage that integrates natural and cultural assets is a key dimension to foster pro-environmental behaviors in MPAs. Therefore, it would be appropriate to integrate social and cultural science into conservationist principles through heritage.

Similarly, studies that assessed ocean knowledge among Mediterranean middle school students pointed out that knowledge was moderate or low despite existing positive correlations with pro-environmental behavior and attitudes, which have since heightened (Ashley et al., 2019; Leitão et al., 2018; Sakurai et al., 2019) from an eco-centric perspective (Koulouri et al., 2022). This has been attributed to recent global communications on the need for environmental education and awareness, aimed at enhancing environmental protection in the context of the socioecological crisis, which have proved particularly effective in raising awareness (Koulouri et al., 2022).

It is evident that communication channels can influence responses based on self-assessed knowledge and perceptions.

These responses can also be influenced by social desirability and prevailing social discourse. For instance, the responses do not differentiate between stated preferences and revealed preferences, which corresponds to distinct frames for understanding payment decisions. The revealed preferences are highly sensitive to contextual and structured constraints, and as such are more closely linked to a pragmatic relationship with what is possible. In contrast, stated preferences are more linked to “what if” scenarios and aspirational desires within the cultural and social context of what is possible (Fisher, 2014: 64). In light of this, in order to go a step further in the results of this exploratory study, questions capable of capturing stated preferences should be included.

Our study aligns with research by Heimlich and Ardoin (2008); Hungerford and Volk (1990), and Hines et al. (1987), which shows that knowledge of MPAs alone does not lead to pro-environmental attitudes and behavioral change. Alternatively, the findings may be indicative of the potential influence of other variables, such as values, beliefs, and social norms, in general shaping pro-environmental behaviors. Therefore, we must consider different variables to understand socioecological interactions, as De Juan et al. (2023) and Jones et al. (2023) point out. Understanding how society connects with nature and produces emotions and non-material values is a necessary step alongside this. That is, to cultivate relational values through OL (Uheara et al., 2020) as well as emotions (Rölfér et al., 2021) to influence behavioral change that may impact and encourage ocean conservation actions. As Fox et al. (2021) state, “the deep sense of connection to the ocean is an equivalent of Ocean Literacy” (2022, p. 11), or in other words, understanding the health benefits of nature helps to encourage pro-environmental behaviors (Fox et al., 2021, p. 11).

Finally, the overall low percentage of perceived knowledge about the NPCC and its regulations reflects the lack of a Master Plan of Uses and Management. Furthermore, it demonstrates the failure to effectively disseminate and enforce the regulations to engage visitors in complying with the current zoning regulations, the activities permitted in each zone, and the measures recently adopted to restrict free movement in the summer season (see zoning of Cap de Creus, Figure 1b).

This exploratory study identified a number of key questions and methodologies that should be explored in future research to deepen our understanding of OL in Marine Protected Areas (MPAs). These include examining the role of values, beliefs and social norms in pro-environmental behavior, investigating motivations, using revealed preferences to inform these behaviors, and developing methods to capture these preferences to better understand their impact on environmental actions.

Qualitative approaches, such as open-ended questions and in-depth interviews, combined with methodologies that facilitate the capture of diverse perspectives in accordance with local contexts, e.g., Qmethodology, would enable the conduct of comparative studies across different MPAs. These studies could be based on general statements, while being adapted to specific contexts, deeper insights into the influence of sociocultural and socioeconomic factors on OL at the local level. These approaches are essential to fulfilling the principles of Global Ocean Literacy.

5 Moving forward: policy implications

Our results show that educational programs and OL initiatives should embed the environment as natural and cultural heritage, emphasizing its beauty and value for human well-being. The findings demonstrate the importance of integrating natural and cultural heritage into OL frameworks. However, they also highlight the need to go beyond knowledge-based approaches and address the complex interplay of values, attitudes, and behaviors that shape pro-environmental actions. The main findings state that knowledge alone does not produce pro-environmental attitudes, whereas awareness and attitude must be present in any knowledge process so that it is action-oriented. The environment, culturally embedded as heritage, produces cultural connection, commitment to its protection, and conservation to ensure human well-being and health. Based on these findings, we urge researchers, practitioners and policymakers to implement the following recommendations to integrate OL in MPAs management plans to advance in conservation:

1. **Integrate heritage in OL:** Major effort is required to raise awareness of natural–cultural heritage values that can transform the relationship between society and the ocean. The value of cultural heritage should be considered as embedded and constitutive of the environment to preserve essential, life-supporting ecosystem functions. Sustainable outcomes, as outlined by Kenterelidou and Galatsopoulou (2021), derive from the acknowledgement that marine ecosystems interact with socioecological systems, understanding that human practices originate in interaction with and from the ecosystems.
2. **Turn toward a biocultural perspective to produce connection:** OL actions should embrace a biocultural approach that is focused on the nexus between biology and culture, and focus on framing connectedness through experiences with the ocean. Actionable knowledge must emerge from action, the experience that connects and produces values. Consequently, behavioral change that transforms human–ocean relationships is deployed when the ocean is lived, and “OL is an intrinsic benefit” (Fox et al., 2021, p.10) of social practices at sea. Biocultural knowledge as heritage should be considered in management plans.
3. **Conciliate scales of knowledge:** This is necessary to produce localized lived experiences that promote care for the vulnerability of the ocean in local systems, which are interconnected globally. As such, OL in MPAs should integrate the often lacking cultural and social dimensions of the ocean that contextualize the ecological dimensions into the immediate realities that can be experienced, comprehended and that are rarely synthesized from a global perspective. OL programs should articulate sociocultural and natural local knowledge with global equivalents to scale up environmental awareness within

meaningful frameworks of knowledge for individuals, communities, and all humanity.

4. **Integrate dimensions scaling up from local to global:** The integration of social, cultural, and socioeconomic dimensions that require an interdisciplinary approach is also crucial, since ocean vulnerabilities and marine threats are a result of economic, social, and cultural factors. Integration of these dimensions, considering the different layers of acting, help to broaden the range of contexts of ocean connections in scaling up from the local to the global.
5. **Introduce innovative assessments and transdisciplinary approaches:** Nevertheless, we agree that OL is complex and multidimensional, and as [Paredes-Coral et al. \(2022\)](#) point out, it must go beyond cognitive and awareness approaches to include statements of willingness to evaluate attitudinal and behavioral dimensions. This also includes incorporating innovative assessment instruments and approaches and using social science methodologies ([Cavaleri Gerhardinger et al., 2024](#)) to evaluate cultural changes among stakeholders, the span of communication networks, and their role as channels of influence on beliefs and opinions in familial and community circles. Assessments should be based on empirical data and be grounded in transdisciplinary collaboration between natural and social scientists by integrating scientific, lay, and local knowledge ([Salazar et al., 2024](#)). Innovative tools such as social media ([Fauville et al., 2013](#)) and information technologies (e.g., smartphone applications), as well as co-creative processes (<https://www.naturcap-empowerus.eu/>) could enhance the span of communication and OL initiatives. Also, as Salazar et al. stated in 2022, improving the capacity-building of marine research centers and universities to ensure the effective transfer of updated scientific knowledge, rather than relegating this task to voluntary efforts, is crucial.

In conclusion, visitors' connection with MPAs can be effectively conveyed through natural and cultural heritage, thus generating the necessary stewardship mindset toward marine conservation. Greater efforts and investments in OL programs is essential, ensuring that natural and cultural heritage serve as effective tools for enhancing visitors' commitment to MPA protection.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors after request to the Generalitat de Catalunya where they are stored.

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Author contributions

SG: Conceptualization, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. AG: Data curation, Formal analysis, Funding acquisition, Writing – review & editing. MTB: Formal analysis, Writing – review & editing. MB: Formal analysis, Writing – review & editing. SV: Validation, Writing – review & editing. JS: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The author(s) declare that no Generative AI was used in the creation of this manuscript.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fmars.2025.1540163/full#supplementary-material>

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