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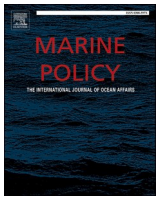

Association between ocean literacy and climate change mitigation efforts in the Republic of Korea

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ABSTRACT

Promoting ocean literacy can lead to numerous benefits, such as improved marine ecosystem comprehension, responsible environmental behavior, and support for marine conservation policies. However, past research focused on the contribution of ocean literacy to the public's support for marine policy and management, failing to expand the concept to broader issues like climate change. This study aims to assess people's ocean literacy and its association with climate change mitigation behaviors, using a nationally representative survey that collected 2000 responses in the Republic of Korea in November 2022. The results provide evidence that people with a better understanding of the ocean are more likely to follow recommendations for climate change mitigation, including reducing disposable products, using public transportation, and using eco-friendly products. This association was robust against varying levels of climate change risk perception. These findings imply that promoting public ocean literacy can be an effective strategy for encouraging people to engage in efforts to mitigate climate change in their daily lives.

1. Introduction

Addressing and adapting to climate change and global warming necessitates broad public engagement. Climate change is a global issue that affects almost every people and community [1,2]. While early discussions about climate change often treated it as a policy, future problem, recent years have seen a shift towards recognizing climate change as an immediate threat, considering dire predictions from climate models and reports and ever-increasing climate-related disasters, such as wildfires, hurricanes, and floods [3]. Such a shift has also been from a technical focus on reducing emissions to a significant emphasis on societal approaches, including adaptation strategies to build resilient communities, protect vulnerable populations and climate change victims, and engage stakeholders with diverse backgrounds [4–8]. Therefore, many strategies to combat climate change involve shifts in individual behaviors, community resilience, and business practice [9,10].

A similar paradigm shift has been made in the Republic of Korea (ROK) in recent years. Although different approaches have been taken by conservative and liberal administrations, the recognition of climate change as an existing threat has not evolved into a deeply polarized issue in the political landscape in the country [11]. In line with this, the Korean government's climate change policy has continuously expanded over the past few decades aiming to enhance public engagement. The government began to include action items to promote public engagement and participation in climate change adaptation efforts since the second 5-years national plan for climate change adaptation, released in 2015, while the first plan mainly focused on developing technologies and environmental interventions (pp. 7–31) [12]. The 2050 Carbon Neutral Strategy of the Republic of Korea and the 3rd 5-years national plan, which are the most recent ones, continued to suggest more tangible action items and enhanced public outreach programs to promote climate-friendly attitudes among the public through lifestyle changes and formal education [13,14].

In this study, we claim that promoting ocean literacy can be a crucial strategy for strengthening individual commitment to climate change mitigation. The ocean plays a key role in global ecosystems by providing homes to millions of marine species [15,16]. It is the largest carbon sink on Earth and has absorbed about 40 % of the anthropogenic carbon dioxide emissions since the late 18th century [17,18]. Therefore, there is growing recognition that climate change is closely related to marine ecosystems, emphasizing the need for conservation of the oceans

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[19–21].

Ocean literacy is a meaningful driver of climate-friendly perceptions and behaviors in several ways. First, ocean literacy implies the understanding of the interconnectivity between the ocean and the global climate. A broader definition of ocean literacy is multi-dimensional and goes further to embrace attitudinal components and capability in making responsible choices for the sustainable use of the ocean [22–24]. For example, the seven essential principles of ocean sciences, suggested by the Centers for Ocean Science Education Excellence (COSEE) in the United States, highlight the interconnectivity between the ocean and climate and the influence of the ocean on weather and ecosystems [25]. Furthermore, ocean literacy is a contextual concept with varying definitions and elements across regions and cultures rather than being a concept with a universal definition [24]. For example, in the context of the ROK that has one of the largest tidal flats (i.e., getbeol in Korean) worldwide, understanding the function and value of tidal flats in the ecosystem would be an essential component of ocean literacy. For another instance, understanding the Kuroshio Current (i.e., the Black Current) as part of the North Pacific Gyre is an important component of knowledge in understanding how environmental consequences around the Korean peninsula would affect the global ecosystem. In this sense, ocean literacy means understanding the ocean through both scientific evidence and relevant local knowledge and can lead to climate-friendly people [22].

Moreover, ocean literacy implies the understanding of the mutual influence between the ocean and us and the recognition of the impact of anthropogenic activities on the ocean, such as the use of fossil fuels, water use, and plastic consumption [22]. As people learn about the ocean's state and its importance to human life, they can develop a sense of personal responsibility to protect it [23,25]. Given that the concept of ocean literacy encompasses attitudes towards the ocean, it is reasonable to anticipate that people who have accurate knowledge of the oceans are more likely to engage in environmentally beneficial actions. Therefore, it serves as the foundation of climate-friendly lifestyles that consider a sustainable use of the environment and resources.

Empirical evidence demonstrates various benefits of promoting public ocean literacy. First of all, promoting ocean literacy can improve people's understanding of the complex interactions within marine ecosystems [26]. Two studies conducted in the United States and the United Kingdom, showed ocean-literate people were more likely to engage in environmentally responsible behaviors, such as reducing plastic waste, supporting sustainable seafood choices, and participating in coastal clean-up efforts [27,28]. Similarly, as shown in a study based in Hawai'i, people who better understand the ocean were more likely to support actions for marine biodiversity and the sustainable use of the ocean [29]. In light of these benefits of ocean literacy, there have been recent efforts to expand ocean education to global and national policy agendas and institutionalize it in the formal education system [30–33].

However, previous research on ocean literacy largely focused on issues in the realm of marine policy and management. Other than the studies discussed above, there have been several international or national survey studies that assessed the current state of public ocean literacy in different locations [23,24,34]. Some other studies on the social benefits of ocean literacy focused on the contribution of promoting ocean literacy in improving public support of policy actions for marine conservation and restoration [35]. A study conducted in Canada found that ocean literacy tended to be higher among students who were interested in ocean-related jobs and had a higher-degree of scientific literacy [36].

This study aims to assess the state of ocean literacy among Korean adults and empirically examine the association between ocean literacy and climate change mitigation behaviors based on a nationally representative survey. We hypothesize that those who understand the marine environment and ecosystem and their impacts on the global climate are more likely to engage in pro-environmental behaviors, such as reducing energy use and utilizing public transport, and comply with recommendations for mitigating climate change. The ROK provides an interesting context for examining the research question, given the government's decade-long emphasis on public engagement in climate change adaptation. Despite these efforts, there is a notable gap in the empirical assessment of ocean literacy within the country.

2. Methods

2.1. Data

This study used an online survey distributed in November 2022 to collect 2000 responses from a nationally representative sample of Korean adults 18 or over. The survey was distributed through an online survey platform provided by Trend Research (www.trendmr.com). Trend Research's panel consists of about 720,000 people who have agreed to opt for e-mail notifications to participate in an online survey. The company regularly renews its panel by inviting about 5,000 new participants in March and September of every year. The variables used in this study did not include missing values.

The data collection was stratified by age, gender, and 17 metropolitan cities/provinces. However, when compared to the population benchmarks obtained from Statistis Korea, our data tended to undersample low-educated people (eSupplement 1). We applied post-stratification weights to account for this discrepancy in educational attainment using the 2020 Population Census of Statistics Korea between the ages of 20 and 79. As this benchmark data only provides aggregated population counts grouped by educational attainment and categorized into five-year age intervals, there is a slight difference in the age range between the study sample (18−80) and the benchmark (20−79).

The invitation to the survey was sent to randomly selected people in the panel. When respondents agreed to participate, they were brought to a page that contained the informed consent and instructions, including information about the objective, methods, potential risks and benefits, the respondent's rights, and confidentiality of the survey. As compensation for completing the survey, rewards that were equivalent to approximately 1.8 US dollars (2000 won in Korean currency) and could be tranferred to cash were given to respondents. The survey questionnaire was written in Korean and included 145 questions in ten sections on demographic information and perceptions of marine science and technology, climate change, government and experts, and media usage. The ocean literacy questions were part of the first section, whereas those related to climate change were positioned in the third section. The survey included two randomized experiments; however, these were provided after the ocean literacy and climate change questions before asking about education, employment, marital status, religion, and income. The project was approved by Seoul National University under protocol number SNU 22–10–042.

2.2. Variables

The outcome variables included five binary measures of climate change mitigation behaviors that have been frequently recommended in public outreach campaigns by the Korean Ministry of Environment. These include compliance with reducing power, reducing the use of disposable products (i.e., minimizing the consumption of single-use items, such as plastic bags, or using resuable products), saving water usage, using public transport instead of a private vehicle, and buying and using eco-friendly products (i.e., selecting items that are designed to minimize harm to the environment, such as biodegradable products and electric vehicles). These variables were measured by using a multiple choice question: "are you making personal efforts to mitigate global warming? If so, what type of actions are you taking among the following?" Respondents were instructed to select all applicable actions from six options, comprising the five climate change mitigation behaviors described above and an 'other' category. These variables were

coded as one if respondents answered that they complied with the recommendations, and coded as zero otherwise. There were seven responses that chose 'other' and provided open answers: three of 'travelling on foot for short distances,' two of 'growing and eating crops using eco-friendly methods,' one of 'reducing food consumption,' one of 'recycling,' and one of 'nothing.' These responses were not categorized under the five defined outcome categories because they were not aligned with the outcome measures.

We examined how the outcome variables were associated with the ocean literacy index, which was measured as a row mean of the seven essential principles of ocean sciences, originally suggested by the COSEE [22,23,25,31]. These were measured on a 5-Likert scale (*i.e.*, from one if strongly disagree to five if strongly agree) by using questions asking if respondents agree with each of the seven principles: "*the Earth has one big ocean with many features*," "*the ocean and life in the ocean shape the features of Earth*," "*the ocean is a major influence on weather and climate*," "*the ocean makes Earth habitable*," "*the ocean supports a great diversity of life and ecosystems*," "*the ocean and humans are inextricably interconnected*, " and "*the ocean is largely unexplored*." As each of these principles situates the ocean in a broader ecosystem and points to the interconnectivity of the ocean with other environmental components, we hypothesized that the degree of agreement with these principles would be an indicator of responsible behaviors for climate change mitigation.

The association between ocean literacy and climate-friendly behaviors can be accelerated when people are more cognizant of the risk of climate change. To examine this moderating effect, we further examined the association by decomposing respondents into three groups of how much they consider climate change as a serious issue. The question captured reactions to both climate change and global warming by considering that these terms may evoke differing degrees of concern, despite often being used interchangeably [37]: "*do you think that climate change or global warming is at a serious level currently?*" This was measured on a 5-Likert scale (*i.e.*, from one being very serious to five being not serious at all) and recoded into three categories: two if very serious, one if serious, and zero otherwise. We combined neutral, not serious, and not serious at all into one category because the original measure was highly right-skewed.

Other sociodemographic characteristics included the distance to the ocean, age, sex, educational attainment, and monthly household income. We controlled for the distance to the ocean because people who live in a coastal area are more likely to have more accurate knowledge of the ocean and, regardless of the degree of knowledge, have different patterns in complying with recommendations for climate change mitigation, compared to others. This variable was coded as one if respondents lived within a 10-kilometer radius of the ocean. Other demographic control variables were also included, considering that they can cause differences in both the degree of ocean knowledge and patterns in taking actions to mitigate climate change.

2.3. Statistical analysis

The analysis used weighted ordinary least squares (OLS) regression to identify the effects of the independent variables on the outcome variables (Fig. 1), and weighted logistic regression to calculate predicted probabilities (Fig. 2). Individual behavior to mitigate climate change is defined as $y_{ij} \in \{0,1\}$, where one indicates 'Yes' and zero indicates 'No.' Here, $i = 1,\ldots,n$ denotes individual respondents, while $j = 1,\ldots,17$ denotes provinces and metropolitan cities in the ROK. In the first part of the analysis, OLS regression was used to provide intuitive interpretations of the results based on marginal effects. The equation is:

$$Y_{ij} = \beta O_i + \gamma CC_i + \delta O_i{*}CC_i + \vartheta X_i + \sigma_j + \varepsilon_{ij}$$

In the equation, δ explains the interaction effects of ocean literacy and the risk perception of climate change. Therefore, β denotes the effects of ocean literacy among those who do not think that the impact of climate change is serious, while γ denotes a coefficient vector of the risk perception categories when the ocean literacy score equals 0. In OLS models, robust standard errors were used to reflect the heterogeneity among people from different provinces and metropolitan cities.

A logistic specification was used to calculate predicted probabilities. Pearson's chi-squared test and ANOVA test were conducted to check if there are significant differences among the groups divided by the degree of climate change risk perception in Table 1. Statistical significance was determined at a 95 % confidence level and based on 2-taled tests. Analyses and visualizations were conducted by using Stata version 17 (StataCorp LP, College Station, TX).

3. Results

Table 1 presents the weighted sample characteristics broken down

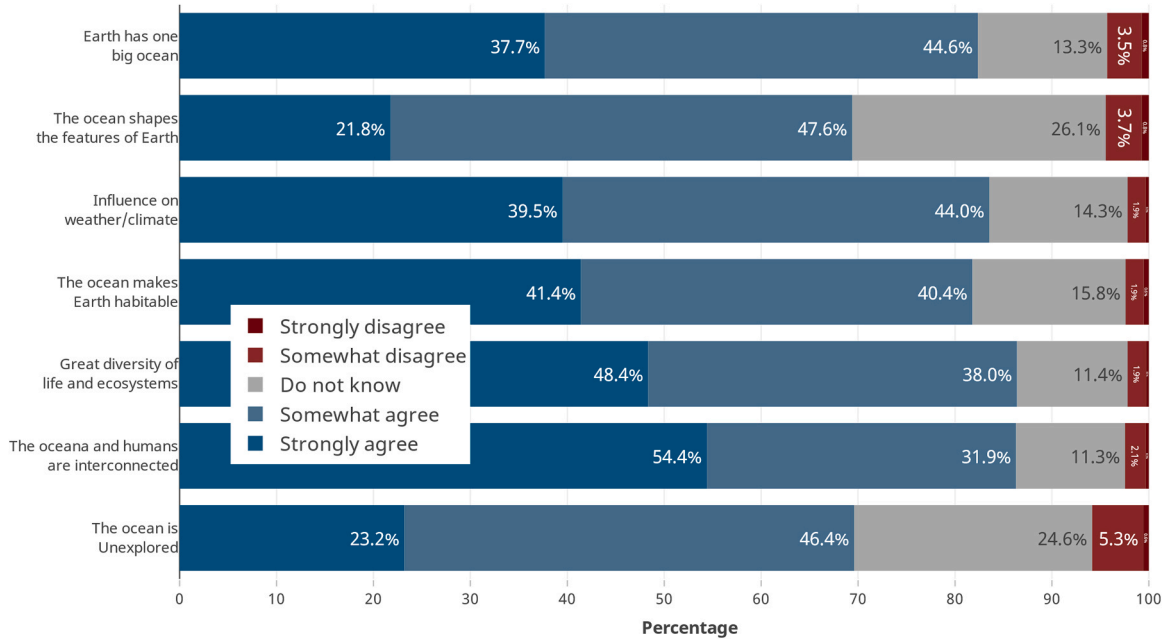

Fig. 1. Distributions of Answers to Questions Asking About the Knowledge of the Ocean. Note: Bars indicate percentage.

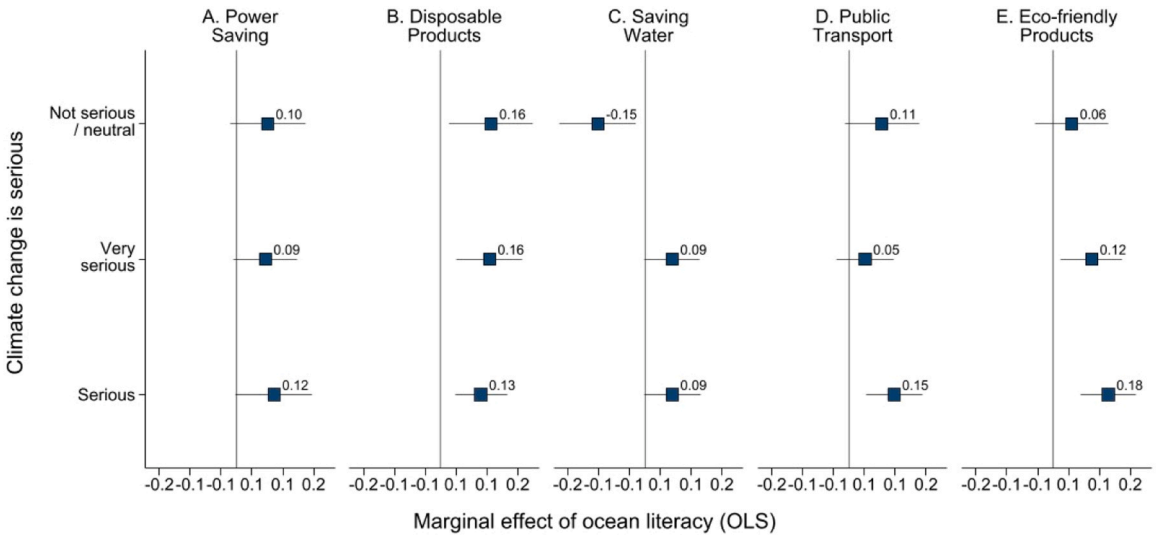

Fig. 2. Marginal Effects Ocean Literacy on Climate Change Mitigation Behaviors by the Threat Perception of Climate Change. Note: Blue markers indicate the marginal effects based on OLS models. Horizontal spikes indicate 95 % confidence intervals of marginal effects.

into the three groups divided by the degree of perceived seriousness of climate change. After applying post-stratification weights, the initial discrepancies in educational attainment between the study sample and the national benchmark were successfully adjusted. See eSupplement 2 for the unweighted descriptive statistics.

In the study sample, the majority of respondents (81 %, weighted percentage) answered that climate change is very or somewhat serious. The percentage of complying with climate change mitigation behaviors greatly varied across the outcomes. The majority of respondents answered that they had tried reducing disposable products (74 %). However, the percentage of following other behaviors – i.e., saving power, reducing water usage, using public transport, and using eco-friendly products – was less than 50 %. These percentages generally increased along with the perceived seriousness of climate change, except for reducing water usage (X^2 = 1.53; P=0.464). The percentage of reducing water usage was slightly lower among those who think climate change is a threat than among others.

The ocean literacy index also increased along with the perceived seriousness of climate change ($F_{2,1997}$ = 197.56; P<0.001). The average score was 4.10 for all respondents. Compared to those who think that climate change is somewhat serious, it was 0.23 higher among those who think that the threat from climate change is very serious, while it was 0.53 lower among those who disagreed with the threat from climate change.

Among other characteristics, the perceived seriousness of climate change tended to be higher among those who live closer to the ocean. It was also lower among male, younger, low-educated, and low-income respondents. These differences were statistically significant.

Fig. 1 presents the distributions of answers to questions used to construct the ocean literacy index. The majority of respondents agreed with the suggested statements about the ocean, 69–84 %, although there was still a substantive portion of respondents who chose 'somewhat agree' or 'did not know.' Among the statements, the percentage of agreement was lower for two statements, compared to other statements: the influence of the ocean in shaping the features of Earth and the ocean being an unexplored area.

Fig. 2 presents the marginal effects of ocean literacy on the five types of climate change mitigation behaviors in each group of climate change threat perception (see eSupplement 3 for the full regression output). Overall, the likelihood of reducing disposable products, using public transport, and using eco-friendly products significantly increased along with the degree of the ocean literacy score. Specifically, a one point increase in the ocean literacy score increased the likelihood of reducing disposable products by 13 percentage points in the highest threat perception group [95 % CI = 0.05–0.21; P=0.002] and by 16 percentage points in the moderate threat perception group [95 % CI = 0.05–0.27; P=0.004] and among others [95 % CI = 0.03–0.30; P=0.018]. A one point increase in the ocean literacy score increased the likelihood of using public transport by 15 percentage points in the highest threat perception group [95 % CI = 0.05–0.24; P=0.002], however, it did not make a significant difference in the other groups. A one point increase in the ocean literacy score increased the likelihood of using eco-friendly products by 18 percentage points in the highest threat perception group [95 % CI = 0.09–0.27; P<0.001] and by 12 percentage points in the moderate threat perception group [95 % CI = 0.03–0.22; P=0.014].

The increase by the ocean literacy score was marginal and insignificant for saving power and water. Rather, the ocean literacy score was associated with a 15 percentage points decrease in the likelihood of reducing water usage in the lowest threat perception group [95 % CI = −0.28 to −0.03; P<0.017].

Fig. 3 decomposes the predicted probability of following climate change mitigation behaviors by the perceived seriousness of climate change. The likelihood generally increased along with the degree of the ocean literacy score for most of the outcomes in all groups of threat perception, except for the lowest threat perception group in terms of reducing water usage. In particular, the predicted probability was lower than 0.2 for most of the groups at the 0 of the ocean literacy score but increased to 0.42 or above (Fig. 3A-E and 3E). The pattern in the effects of ocean literacy on reducing water usage was different from the other outcomes, however. Among those who disagreed that the threat from climate change is serious, the predicted probability was the highest at the 0 of ocean literacy and decreased to 0.29 at the highest score of ocean literacy, which is 5.

4. Discussion

In the presented analysis, we examined the effects of ocean literacy on climate change mitigation behaviors by using an online survey collected in the ROK in November 2022. The results showed that a significant majority of survey respondents in the ROK correctly answered questions regarding the basic characteristics of the oceans, with the proportion ranging from 69 to 84 %. People who had more correct knowledge of the ocean were significantly more likely to follow three types of climate change mitigation behaviors, including reducing the use of disposable products, using public transport, and using eco-friendly products. On the other hand, we also found that the predicted

Table 1
Climate Chage Mitigation Behaviors, Ocean Literacy, and Sociodemographics of Survey Respondents, by the Degree of Climate Change Threat Perception: Republic of Korea, November 2022 (Weighted).

	All	Threat perception of climate change			Difference among A, B, and C (p-value of X^2 and ANOVA)
		Very serious (A)	Somewhat serious (B)	Not serious / neutral (C)	
Number of observations	2000	852	799	349	-
Climate change mitigation behaviors					
% Saving power	47.17	56.88	47.29	24.93	<0.001
% Reducing disposable products	74.49	83.08	76.75	50.48	<0.001
% Reducing water usage	41.25	41.36	37.47	48.61	0.464
% Using public transport	38.57	42.16	37.71	32.14	0.046
% using eco-friendly products	34.22	42.62	31.60	20.47	<0.001
Ocean literacy index	4.10	4.33	4.10	3.57	<0.001[a]
Living near the coast (<= 10 kilometers)	67.08	69.76	68.43	58.27	<0.001
% Female	51.30	60.26	45.10	43.48	<0.001
Age					
% 18–29	19.14	13.66	19.58	30.65	
% 30 s	18.79	18.29	15.80	25.93	
% 40 s	19.26	22.18	17.80	15.60	
% 50 s	20.91	21.35	24.25	13.17	
% 60+	21.90	24.52	22.56	14.64	<0.001
Education					
% <High school	43.84	43.11	40.47	52.25	
% Bachelor or less	51.69	51.96	55.66	43.07	
% Graduate	4.48	4.93	3.87	4.68	0.09
Income					
% <₩2 M	14.30	14.47	9.15	24.31	
% ₩2 M-₩3.99 M	39.10	36.36	38.71	46.08	
% ₩4 M-₩5.99 M	24.60	26.15	27.32	15.61	
% ₩6 M-₩7.99 M	12.96	15.00	13.69	6.86	
% >₩7.99 M	9.04	8.03	11.13	7.14	0.003

[a] p-value of ANOVA. Otherwise, the figures in this column indicates p-value of Chi-squared test.

probability of willingness to engage in these behaviors was very low when the level of ocean literacy was low but increased along with the score.

These findings add to the literature on ocean literacy by demonstrating that promoting public ocean literacy can be an effective strategy for encouraging people to take action to mitigate climate change [24,27–29,38]. As many scholars emphasized already, ocean education involves understanding the inter-connectivity between the ocean and climate, as well as the mutual impacts of climate change on marine ecosystems [24,27,39]. The strong correlation between ocean literacy and climate change mitigation behaviors demonstrated in this study implies that such efforts to enhance public knowledge about the oceans can foster responsible actions for the environment at the individual level. Therefore, policies focused on increasing public ocean literacy could lead to greater public participation in lifestyle changes to mitigate climate change.

Promoting public ocean literacy can also yield positive outcomes in other environmental areas. Being conscious of the ocean's significance can encourage behaviors that are more conducive to broader environmental conservation, such as reducing pollution, protecting marine life, and preserving natural habitats [27,28]. This spillover effect is not confined to environmental issues. By understanding the impacts of marine ecosystems and pollution on health, people can develop a stronger sense of communal responsibility and involvement, contributing to community well-being. Similarly, these suggest that a holistic and integrated approach to ocean education can have multifaceted benefits, enabling people to contribute positively to various aspects of societal challenges. Therefore, the implications of our study extend beyond the immediate realm of marine policy and climate change, highlighting the potential of ocean education as a transformative tool for broader social and environmental progress.

More specifically, there are several practical strategies to promote public ocean literacy in the ROK. One option would be integrating ocean literacy into formal educational curricula. By educating students from a young age, such as primary and secondary education, about the ocean's role in the climate system and how to protect it, we can foster a generation that is more conscious about climate change and global warming. This could involve incorporating ocean science into school subjects, promoting experiential learning opportunities, such as field trips to coastal areas or aquariums, and developing educational materials that focus on the interconnectedness of oceans and climate change. For instance, emphasizing the ocean's role in absorbing heat and carbon dioxide from the atmosphere could help people comprehend the relevance of ocean activities in controlling the climate of Earth [34]. Educators can also illustrate the effects of climate change on marine ecosystems, such as coral bleaching, ocean acidification, and sea level rise, to foster a sense of urgency and relevance of climate change to people [35]. When considering the contextual nature of ocean literacy, it is essential to highlight the unique characteristics of the country. For example, around the Korean peninsula, which has an extensive coastline, diverse marine species, and the challenges posed by regional environmental pressures like overfishing and land reclamation, educational programs could focus on the specific impacts of these issues on the country's coastal ecosystems and communities. Such efforts can also assist learners in developing a feeling of ownership of the ocean and connection to the climate change issue [22,26,40].

Lastly, the findings from this study provide a new piece of evidence that demonstrates the benefits of promoting ocean literacy in the new context of the ROK, where the state of the public's ocean literacy has not yet been examined systematically. While there has been a growing body of literature on ocean literacy, evidence that sheds light on this country has been very rare. By investigating the Korean public, this study demonstrated that the level of that the majority of the Korean public has correct knowledge of the basic characteristics of ocean literacy is associated with differences in engaging in climate-friendly behaviors in the country, where the level of public ocean literacy and the public's risk perception of climate change (84 %) are high. Further research is necessary to examine this relationship and conduct comparative analyses across countries and various contexts. Such efforts will improve our understanding of ocean literacy and help develop tailored initiatives and public outreach programs to utilize ocean literacy for climate change adaptation.

Limitations. This study has some limitations. First of all, we utilized an online survey panel to collect survey responses from people who willingly consented to receive invites. Thus, it is possible that our sample might not well represent people without internet access. However, given that the ROK has great internet accessibility and nearly 98 % of the population uses the internet [41], the study sample can still be representative of the country's population. Second, since we tested by using a limited number of ocean literacy questions and climate change mitigation behaviors, this study provides a preliminary understanding of the

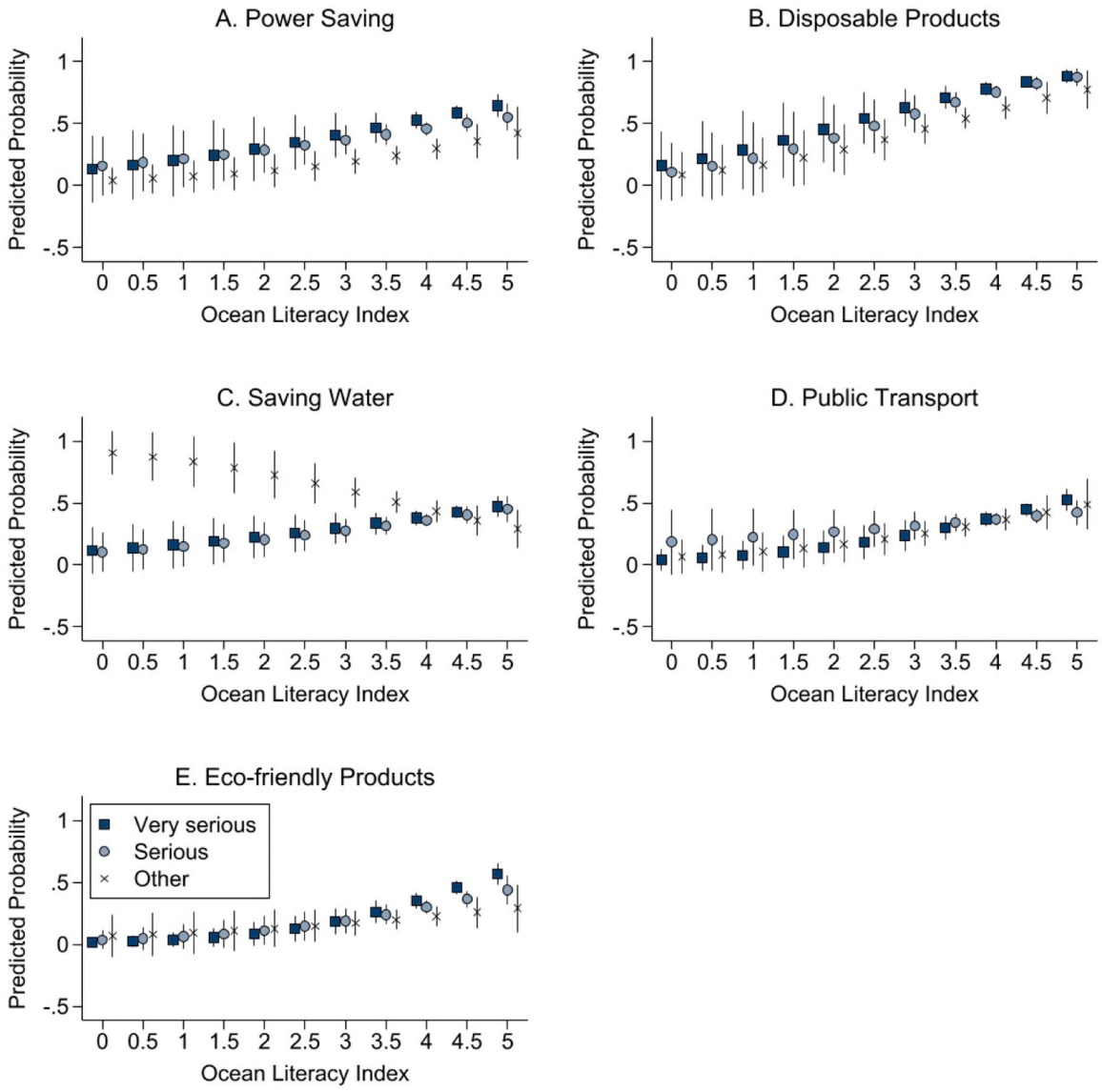

Fig. 3. Predicted Probability of Climate Change Mitigation Behaviors by the Degree of Ocean Literacy and by the Threat Perception of Climate Change. Note. Markers indicate predicted probabilities based on logistic models. Vertical spikes indicate 95 % confidence intervals of predicted probabilities.

association between people's knowledge of the ocean and their engagement in climate change mitigation behaviors. Therefore, further research with a comprehensive assessment is needed to draw more definitive conclusions and uncover potential nuances in this association. Lastly, although existing research conceptualizes ocean literacy as a concept that is contextualized to specific environments, this study did not tailor the ocean literacy index to align with the Korean context. Moreover, we acknowledge that our measures of ocean literacy and the climate change threat perception may be susceptible to certain forms of response bias, potentially steering respondents to lean towards agreement with the statement. Therefore, future research can attempt to develop context-specific ocean literacy assessments tailored to the unique context and encourage unbiased responses. Such efforts will enable a more precise assessment of ocean literacy's benefits and guide the customization of educational and training programs to promote ocean literacy.

5. Conclusion

As the study has alluded, higher levels of understanding about the ocean's role in global climate and the impact of climate change on marine ecosystems are not just academic exercises; they should manifest in tangible climate action. This should serve as a call for educators, policymakers, and communicators alike to innovate and collaborate in crafting ocean literacy curricula and campaigns that resonate with and engage the public at every level. This endeavor is more than a measure for environmental conservation; it is an investment in cultivating a generation imbued with the knowledge and values needed to navigate and protect our planet. Through such dedication to education and outreach, we can hope to see a ripple effect of positive change, safeguarding our oceans and climate for generations to come.

CRediT authorship contribution statement

Duckhee Jang: Writing – review & editing, Data curation. **Moon-Suk Lee:** Writing – review & editing, Funding acquisition. **Yongjin Choi:** Writing – original draft, Software, Methodology, Formal analysis. **Se-Jun Jin:** Writing – review & editing, Conceptualization.

Declaration of Competing Interest

The authors have no conflicts of interest to declare.

Data availability

Data will be made available on request.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.marpol.2024.106157.

References

[1] O. Hoegh-Guldberg, J.F. Bruno, The impact of climate change on the world's marine ecosystems, Science vol. 328 (5985) (2010) 1523–1528, https://doi.org/10.1126/science.1189930.
[2] B.A. Swinburn, et al., The global syndemic of obesity, undernutrition, and climate change: the Lancet commission report, Lancet vol. 393 (10173) (2019) 791–846, https://doi.org/10.1016/S0140-6736(18)32822-8.
[3] C. Taylor, The discourses of climate change. Climate Change and Global Policy Regimes: Towards Institutional Legitimacy, in International Political Economy Series (IPES), Palgrave Macmillan, London, UK, 2013, pp. 17–31.
[4] D.A. Farber, Basic Compensation for Victims of Climate Change, Univ. Pa. Law Rev. vol. 155 (6) (2007) 1605–1656, https://doi.org/10.2139/ssrn.954357.
[5] V. Popovski, K.G. Mundy, Defining Climate-Change Victims, Sustain. Sci. vol. 7 (1) (2012) 5–16, https://doi.org/10.1007/s11625-011-0138-0.
[6] R. Few, K. Brown, E.L. Tompkins, Public participation and climate change adaptation: avoiding the illusion of inclusion, Clim. POLICY vol. 7 (1) (2007) 46–59.
[7] S. Kais, M. Islam, Community capitals as community resilience to climate change: conceptual connections, Int. J. Environ. Res. Public. Health vol. 13 (12) (2016) 1211, https://doi.org/10.3390/ijerph13121211.
[8] B. Neumann, A.T. Vafeidis, J. Zimmermann, R.J. Nicholls, Future coastal population growth and exposure to sea-level rise and coastal flooding - a global assessment, PLOS ONE vol. 10 (3) (2015) e0118571, https://doi.org/10.1371/journal.pone.0118571.
[9] B. Biagini, A. Miller, Engaging the private sector in adaptation to climate change in developing countries: importance, status, and challenges, Clim. Dev. vol. 5 (3) (2013) 242–252, https://doi.org/10.1080/17565529.2013.821053.
[10] F.S. Khatibi, A. Dedekorkut-Howes, M. Howes, E. Torabi, Can public awareness, knowledge and engagement improve climate change adaptation policies? Discov. Sustain. vol. 2 (1) (2021) 18, https://doi.org/10.1007/s43621-021-00024-z.
[11] B.-K. Cho, J.-B. Chung, C.-K. Song, National climate change governance and lock-in: Insights from Korea's conservative and liberal governments' committees, Energy Strategy Rev. vol. 50 (2023) 101238, https://doi.org/10.1016/j.esr.2023.101238.
[12] Intergovernmental Consortium of the Republic of Korea (2015), "The 2nd National Climate Change Adaptation Plan".
[13] Intergovernmental Consortium of the Republic of Korea, "The 3rd National Climate Change Adaptation Plan 2021-2025", 2020.
[14] The Government of the Republic of Korea, "2050 Carbon Neutral Strategy of the Republic of Korea," Dec. 2020. Accessed: Dec. 20, 2023. [Online]. Available: https://unfccc.int/sites/default/files/resource/LTS1_RKorea.pdf.
[15] E. Sala, N. Knowlton, Global marine biodiversity trends, Annu. Rev. Environ. Resour. vol. 31 (1) (2006) 93–122, https://doi.org/10.1146/annurev.energy.31.020105.100235.
[16] B. Worm, et al., Impacts of Biodiversity Loss on Ocean Ecosystem Services, Science vol. 314 (5800) (2006) 787–790, https://doi.org/10.1126/science.1132294.
[17] S. Khatiwala, et al., Global ocean storage of anthropogenic carbon, Biogeosciences vol. 10 (4) (2013) 2169–2191, https://doi.org/10.5194/bg-10-2169-2013.
[18] T. DeVries, M. Holzer, F. Primeau, Recent increase in oceanic carbon uptake driven by weaker upper-ocean overturning, Nature vol. 542 (7640) (2017) 215–218, https://doi.org/10.1038/nature21068.
[19] J. Chilvers, I. Lorenzoni, G. Terry, P. Buckley, J.K. Pinnegar, S. Gelcich, Public engagement with marine climate change issues: (Re)framings, understandings and responses, Glob. Environ. Change vol. 29 (2014) 165–179, https://doi.org/10.1016/j.gloenvcha.2014.09.006.
[20] K. Sherman, Toward ecosystem-based management (EBM) of the world's large marine ecosystems during climate change, Environ. Dev. vol. 11 (2014) 43–66, https://doi.org/10.1016/j.envdev.2014.04.006.
[21] M.R. Payne, et al., Uncertainties in projecting climate-change impacts in marine ecosystems, ICES J. Mar. Sci. vol. 73 (5) (2016) 1272–1282, https://doi.org/10.1093/icesjms/fsv231.
[22] S. Schoedinger, F. Cava, C. Strang, P. Tuddenham, Ocean Literacy Through Science Standards. Proceedings of OCEANS 2005 MTS/IEEE, IEEE, Washington, DC, USA, 2005, pp. 1–5, https://doi.org/10.1109/OCEANS.2005.1639840.
[23] G. Fauville, C. Strang, M.A. Cannady, Y.-F. Chen, Development of the International Ocean Literacy Survey: measuring knowledge across the world, Environ. Educ. Res. vol. 25 (2) (2019) 238–263, https://doi.org/10.1080/13504622.2018.1440381.
[24] E. McKinley, D. Burdon, R.J. Shellock, The evolution of ocean literacy: a new framework for the United Nations Ocean Decade and beyond, Mar. Pollut. Bull. vol. 186 (2023) 114467, https://doi.org/10.1016/j.marpolbul.2022.114467.
[25] National Oceanic and Atmospheric Administration (NOAA), "Ocean Literacy: The Essential Principles and Fundamental Concepts of Ocean Sciences for Learners of All Ages," National Oceanic and Atmospheric Administration (NOAA), Washington, DC, 2020.
[26] F. Cava, S. Schoedinger, C. Strang, and P. Tuddenham, "Science Content and Standards for Ocean Literacy: A Report on Ocean Literacy," 2005. [Online]. Available: http://www.coexploration.org/oceanliteracy/documents/OLit2004-05_Final_Report.pdf.
[27] S. Fletcher, J. Potts, Ocean citizenship: an emergent geographical concept, Coast. Manag. vol. 35 (4) (2007) 511–524, https://doi.org/10.1080/08920750701525818.
[28] S. Gelcich, et al., Public awareness, concerns, and priorities about anthropogenic impacts on marine environments, Proc. Natl. Acad. Sci. vol. 111 (42) (2014) 15042–15047, https://doi.org/10.1073/pnas.1417344111.
[29] M.D. Needham, B.W. Szuster, Situational influences on normative evaluations of coastal tourism and recreation management strategies in Hawai'i, Tour. Manag. vol. 32 (4) (2011) 732–740, https://doi.org/10.1016/j.tourman.2010.06.005.
[30] K. Koutsópoulos, J.H. Stel, Ocean literacy: understanding the ocean, 1st ed. 2021. in Key Challenges in Geography, EUROGEO Book Series, Springer, Cham, 2021.
[31] S. Costa, R. Caldeira, Bibliometric analysis of ocean literacy: An underrated term in the scientific literature, Mar. Policy vol. 87 (2018) 149–157, https://doi.org/10.1016/j.marpol.2017.10.022.
[32] R. Jefferson, E. McKinley, S. Capstick, S. Fletcher, H. Griffin, M. Milanese, Understanding audiences: Making public perceptions research matter to marine conservation, Ocean Coast. Manag. vol. 115 (2015) 61–70, https://doi.org/10.1016/j.ocecoaman.2015.06.014.
[33] M. Ashley, S. Pahl, G. Glegg, S. Fletcher, A change of mind: applying social and behavioral research methods to the assessment of the effectiveness of ocean literacy initiatives, Front. Mar. Sci. vol. 6 (2019) 288, https://doi.org/10.3389/fmars.2019.00288.
[34] H.K. Lotze, H. Guest, J. O'Leary, A. Tuda, D. Wallace, Public perceptions of marine threats and protection from around the world, Ocean Coast. Manag. vol. 152 (2018) 14–22, https://doi.org/10.1016/j.ocecoaman.2017.11.004.
[35] B.S. Steel, C. Smith, L. Opsommer, S. Curiel, R. Warner-Steel, Public ocean literacy in the United States, Ocean Coast. Manag. vol. 48 (2) (2005) 97–114, https://doi.org/10.1016/j.ocecoaman.2005.01.002.
[36] H. Guest, H.K. Lotze, D. Wallace, Youth and the sea: ocean literacy in Nova Scotia, Canada, Mar. Policy vol. 58 (2015) 98–107, https://doi.org/10.1016/j.marpol.2015.04.007.
[37] L. Whitmarsh, What's in a name? Commonalities and differences in public understanding of 'climate change' and 'global warming, Public Underst. Sci. vol. 18 (4) (2009) 401–420, https://doi.org/10.1177/0963662506073088.
[38] A. Mogias, T. Boubonari, A. Markos, T. Kevrekidis, Greek pre-service teachers' knowledge of ocean sciences issues and attitudes toward ocean stewardship, J. Environ. Educ. vol. 46 (4) (2015) 251–270, https://doi.org/10.1080/00958964.2015.1050955.
[39] S.C. Doney, et al., Climate change impacts on marine ecosystems, Annu. Rev. Mar. Sci. vol. 4 (1) (2012) 11–37, https://doi.org/10.1146/annurev-marine-041911-111611.
[40] E. McKinley, S. Fletcher, Improving marine environmental health through marine citizenship: a call for debate, Mar. Policy vol. 36 (3) (2012) 839–843, https://doi.org/10.1016/j.marpol.2011.11.001.
[41] The World Bank, "Individuals using the Internet (% of population)." Accessed: Feb. 21, 2023. [Online]. Available: https://data.worldbank.org/indicator/IT.NET.USER.ZS.