7 Effectiveness of a Marine Education Program Applied in a Marine Protected Area Context and Designed with Science Education Strategies

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Abstract

The study examines the effectiveness of a marine education program in a Chilean marine protected area (MPA), designed using science education strategies to promote Ocean Literacy and sustainable decision-making. It involved 240 participants who engaged in activities illustrating ecosystem services, human impacts, and marine conservation, emphasizing interactive learning and practical application. A Teaching and Learning Sequence (TLS) was employed during a sustainable fishing game to connect theoretical knowledge with daily life decisions. The program significantly improved participants' understanding of the human-Ocean connection, reflected in an average 9% increase in correct responses on post-activity surveys. Notable gains included awareness of ecosystem services and the impact of human activities, such as overfishing. Six to twelve months later, 44% of surveyed participants reported applying their learnings in sustainable consumption practices and sharing knowledge with others.

This approach highlights the potential of TLS and experiential education to enhance Ocean Literacy and foster long-term behavioural change, which is critical for the success of MPAs and marine conservation efforts. Future research should explore broader applications of such educational strategies to create a more Ocean-literate society.

Keywords

Ocean Literacy (OL) · Marine conservation · Science education · Marine protected area · Learning-teaching sequence · Community engagement

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7.1 Introduction: Education for Marine Conservation

The Ocean is essential for life on our planet and provides us with numerous benefits known as Ecosystem Services (ES). However, many fail to recognise that the Ocean is vulnerable to degradation and its resources are not limitless. Human activities are affecting Oceans worldwide (Österblom et al. 2017), creating a considerable challenge for marine conservation and the management of those ES. In this context, we must also address one of the Ocean's most significant threats: the lack of information that promotes responsible decision-making (Pendleton et al. 2020).

One of the primary mechanisms for addressing the environmental risks currently impacting global coasts is the establishment of Marine Protected Areas (MPAs). MPAs are not solely created to protect marine habitats and shield endangered marine species but are also implemented to benefit local communities by supporting better fisheries management or boosting other economic activities, like tourism (Ban et al. 2019). Research shows that key stakeholders in protected areas are more likely to accept MPA rules when they are informed because they understand the rationale behind these conservation tools, and recognize their benefits, contributing to the long-term success of the MPA (Gall and Rodwell 2016).

Marine education is crucial for the long-term sustainable management of the coast and seas, motivating public involvement in governance (Katikiro 2016). During UNESCO's "Ocean Decade", Challenge 10 was proposed to restore society's relationship with the Ocean. One of its key Priority Outcomes is to use formal education in schools, colleges, universities, and nonformal experiential learning (e.g., citizen science, museums, aquariums, multimedia, etc.) to build connection (physical and emotional), deepen Ocean understanding, and motivate individual and community action (Glithero et al. 2024).

To increase knowledge, awareness and connection with the Ocean and MPAs, it is required that conservation incorporate Ocean Literacy (OL) methodologies to increase knowledge and raise awareness through education as key strategies for the success of MPAs (Bennett and Dearden 2014). Increasing evidence links sustainable behaviour to improvements in marine ecosystems (Ruckelshaus et al. 2013), with studies showing that such behaviour is often associated with participation in environmental education programs. Effective implementation of education and outreach programs, clear communication of rules and regulations, and activities to build confidence and resolve conflicts will enhance participation and integrate local values and knowledge into conservation planning (Bennett and Dearden 2014).

Despite efforts to enhance OL and promote responsible decision-making, considerable uncertainty remains about the best effective approaches to achieve these goals. Research emphasizes the need for more rigorous evaluations of educational tools used in these programs to validate their effectiveness and impact on marine conservation outcomes (Watson et al. 2014). Evaluations highlight the potential of education strategies to empower communities and contribute solutions. They also provide a means to measure success and offer valuable evidence for future projects (Veiga et al. 2016).

7.2 Science Education for Ocean Literacy (OL)

Marine education should prepare citizens to make responsible decisions regarding environmental issues. The challenge for marine educators is to link information with daily decisions which involves developing knowledge and attitudes at an individual level (McKinley and Fletcher 2012). Science education research suggests that a constructivist approach is a coherent strategy for marine education and sustainable

development (Walsh and McGowan 2017). This approach fosters higher-order thinking skills, enabling students to apply their knowledge to make responsible decisions (Robottom 2004). Current scientific education gives relevance to the use of meaningful contexts, the centrality of alternative ideas, and the participation of students in learning scenarios in which direct contact with the phenomenon under study, data collection and evidence analysis is possible (Vosniadou 2019).

In recent years, the purpose of scientific literacy has shifted from a contextual science approach to a critical scientific literacy aimed at societal transformation (Sjöström and Eilks 2018). This approach emphasizes that understanding science should empower responsible citizenship by tackling real socio-scientific issues. Consequently, marine education strategies need to address students' existing ideas and attitudes about specific issues (Hawkins and Stark 2016, while also considering social and cultural factors. Students develop ideas and understandings of their interactions and experiments with topics such as the Ocean (Marrero 2009), and meaningful learning occurs when their alternative views, often inconsistent with formal science, are acknowledged and addressed (Vosniadou 2019). In biology science learning, both children and adults face similar challenges in modifying their alternative ideas, as the differences lie not in the underlying conceptual structures but in the relevance and application of these structures in different contexts (Inagaki and Hatano 2013). Instructional planning should focus on activities encouraging students to question and refine their ideas (Robottom 2004). The teaching and learning sequences (TLS), which gained prominence in the early 2000s, offer a comprehensive framework for planning educational activities by detailing what, how, and why to teach. The learning cycle proposed by Sanmartí (2000) exemplifies TLS by considering context, prior knowledge, and student interests, facilitating the didactic transposition needed for effective learning. Additionally, TLS adopts a socio-constructivist perspective, positioning the educator as a mediator and fostering cognitive conflicts and peer learning opportunities (Leach and Scott 2002).

This study aimed to evaluate the impact of a TLS as a tool for promoting knowledge increase in marine conservation and the long-term application of learnings expected as a strategy to promote Ocean conservation.

7.3 Methodology

7.3.1 Educational Visits

Chile es Mar is a marine education program created in 2012 to share scientific information and promote marine conservation in Chile. The program was primarily developed in the *Estación Costera de Investigaciones Marinas* (a marine research and teaching laboratory of the Pontificia Universidad Católica de Chile), located in Las Cruces (Valparaíso). The research station was based there due to the creation of a marine and coastal protected area in 1982. The program aimed to increase knowledge and understanding of ecosystem services (ES), human impacts (HI), and marine conservation strategies (MC) through the lens of the OL sixth principle that "humans and the Ocean are inextricably connected." The program featured a variety of activities, but the most notable one was the visit to the research station. Initially, these visits were designed for schools, aligning some concepts with the national curriculum. However, due to high demand, family visits were introduced, typically held on weekends and during holidays. The visits were tailored to all age groups, attracting participants from diverse locations, ranging from nearby communities to visitors from Santiago, a city located 100 kilometers from the coast.

Family visits were performed for guided groups of 20 participants. All Guides participated in in-person training covering the educational methodology behind the activities and the activities themselves. Sessions lasted 2.5 h and were structured into four stages, each set in a different environment to enhance learning through varied experiences. The stages were as follows:

1. Stage 1—MPA Visit: Understanding MPA Values and Benefits
   The first stage took place within the MPA, where participants explored the ecological and social benefits of these protected areas. The marine coastal landscape is visibly divided between protected and non-protected zones, with a fence restricting community access to the protected area. This demarcation highlights the contrast between accessible and restricted coastal sites. From an elevated vantage point at the Research Center, visitors observed and compared the biological richness of both zones, even quantifying visible differences in biodiversity. Extending their perspective beyond directly observable, allowed participants to grasp the broader impact and critical importance of protecting marine ecosystems. This activity emphasized how MPAs play a pivotal role in preserving biodiversity and supporting the sustainability of human communities.
2. Stage 2—Aquarium: Learning About Biodiversity
   In the second stage, participants visited an aquarium room featuring a touch pool. The activity began with educators emphasizing the importance of respecting and caring for the animals involved, guiding the group throughout the experience. This setting provided a unique opportunity to introduce new marine species, many of which were unfamiliar to the visitors, showcasing the richness of Chilean coastal biodiversity and its vulnerabilities. Participants learned about various organisms inhabiting the region, with a focus on how human activities, such as habitat destruction and overfishing, can threaten these species and disrupt marine ecosystem balance. This stage fostered meaningful connections between visitors and marine biodiversity. For some, the close observation of the animals and their movements sparked curiosity and surprise, while for others, emotional bonds emerged as they engaged with the marine life during the activity.
3. Stage 3—Open Air: Interactive Game About Responsible Fishing
   The third stage took place outdoors and featured an interactive game focused on responsible fishing (Fig. 7.1a). This stage fully implemented the TLS approach, making it a cornerstone of the educational program. The activity was designed to enhance participants' understanding of overexploitation in Chilean fisheries and to promote informed, responsible decisions about marine resource consumption. To achieve these goals, the activity was divided into four phases:
   (i) Exploration Phase: Participants were asked key questions (Table 7.1) to challenge their existing ideas and misconceptions about marine resources, overfishing, and the concept of fish reproduction sizes. This discussion helped to establish a baseline understanding in preparation for the following stages. The end of this activity includes the interaction with cards (Fig. 7.1b) that show the primary marine resources used in Chile (on this coast) and their reproduction sizes.
   (ii) New Knowledge Introduction Phase: Participants were introduced to conservation strategies, including closed seasons (no-fishing seasons) and the importance of reproductive sizes for sustainable fishing. They learned how choosing fish based on their size could support marine conservation.
   (iii) New Knowledge Structuring Phase: Participants took on the role of fishermen in this phase. Having a pool of mock-up fish as options to fish, they had to decide what to catch or not, using the information they had about reproduction sizes, closed seasons, and overexploited species. They used tape measures (Fig. 7.1c) and species information cards (Fig. 7.1b) to make informed decisions, applying the knowledge gained in the previous phase.
   (iv) New Knowledge Application Phase: Participants reflected on their decisions after the game and discussed whether they were sustainable. They were given

tape measures as a takeaway (Fig. 7.1c) to use in real-life markets, encouraging them to apply what they learned daily by verifying fish sizes before purchasing.

4. Stage 4—Lab: Conclusions. The final stage occurred in the conference room, where participants reflected on the day's activities. This was an opportunity to synthesise the knowledge gained across all stages while self-evaluation and explicit learning occurred. The discussion focused on the importance of responsible consumption, conservation strategies, and how participants could contribute to marine sustainability in their daily lives. Educators facilitated this conversation through questions but avoided sharing information to encourage participants to lead the reflections, allowing them to connect personally with their learnings and the broader marine conservation goals.

7.3.2 Survey Design, Validation and Application

This study utilized both qualitative and quantitative analyses to assess participants' knowledge and perceptions before and after their educational visits. From 40 family groups who participated during the summer, 12 groups were randomly selected to complete in situ tests before and after the activity (Table 7.2). This resulted in 240 of the 790 in-person participants being included in the pre-post-test. Among these, 90 participants consented to share their contact information for follow-up, and they were subsequently invited to participate in an online survey conducted 6–12 months later. Of these, 44% responded, representing 17% of the initial 790 participants.

Table 7.1 Questions used for the exploration phase during stage 3 (Interactive game about responsible fishing)

Questions
Are marine resources limited?
Do you know any strategies for marine conservation?
How do we contribute to marine conservation at the same time that we eat marine resources?
Do Chilean people eat a lot or a few amounts of fish? Has this consumption had an impact on the marine ecosystem?
Have you eaten young or old fish? Can we know that information?
What is your favourite fish? What fish is eaten most in your family?
Is a fish's size connected to its reproduction?
What size would you say that a fish must be to be reproductive?
Can some fish reproduce even if they are tiny?
How old is a reproductive fish?
Have you observed any differences in sizes at fish markets?

While the study was limited by the self-selecting nature of the follow-up participants and the relatively small sample size for long-term evaluation, efforts were made to mitigate potential biases and enhance validity. These efforts included random selection of groups for initial testing, the use of validated survey instruments, and pre-testing of the questionnaires to ensure clarity and consistency. Additionally, the multi-phase design—combining immediate pre-post assessments with long-term follow-ups—allowed for a more comprehensive evaluation of knowledge retention and application, strengthening the reliability of the findings despite the study's constraints.

7.3.2.1 Survey A: Before and After the Activity (Appendix 1)

Survey A, conducted in situ, consisted of a 5-page questionnaire that gathered socio-demographic data, including 2 open-ended questions, and 14 multiple-choice questions. The open-ended questions were categorized based on three key topics outlined in the introduction: Ecosystem Services (ES), Human Impact (HI), and Marine Conservation (MC). To ensure consistency and reliability, two researchers independently categorized responses, achieving 82% agreement in Survey A and 85% in Survey B. Each response could represent one or more categories.

The multiple-choice questions were analyzed to identify correct and incorrect answers, both before and after the activity. Responses were evaluated independently and grouped according to the themes from OL Principle 6. To determine whether there were significant differences between pre- and post-activity correct answers,

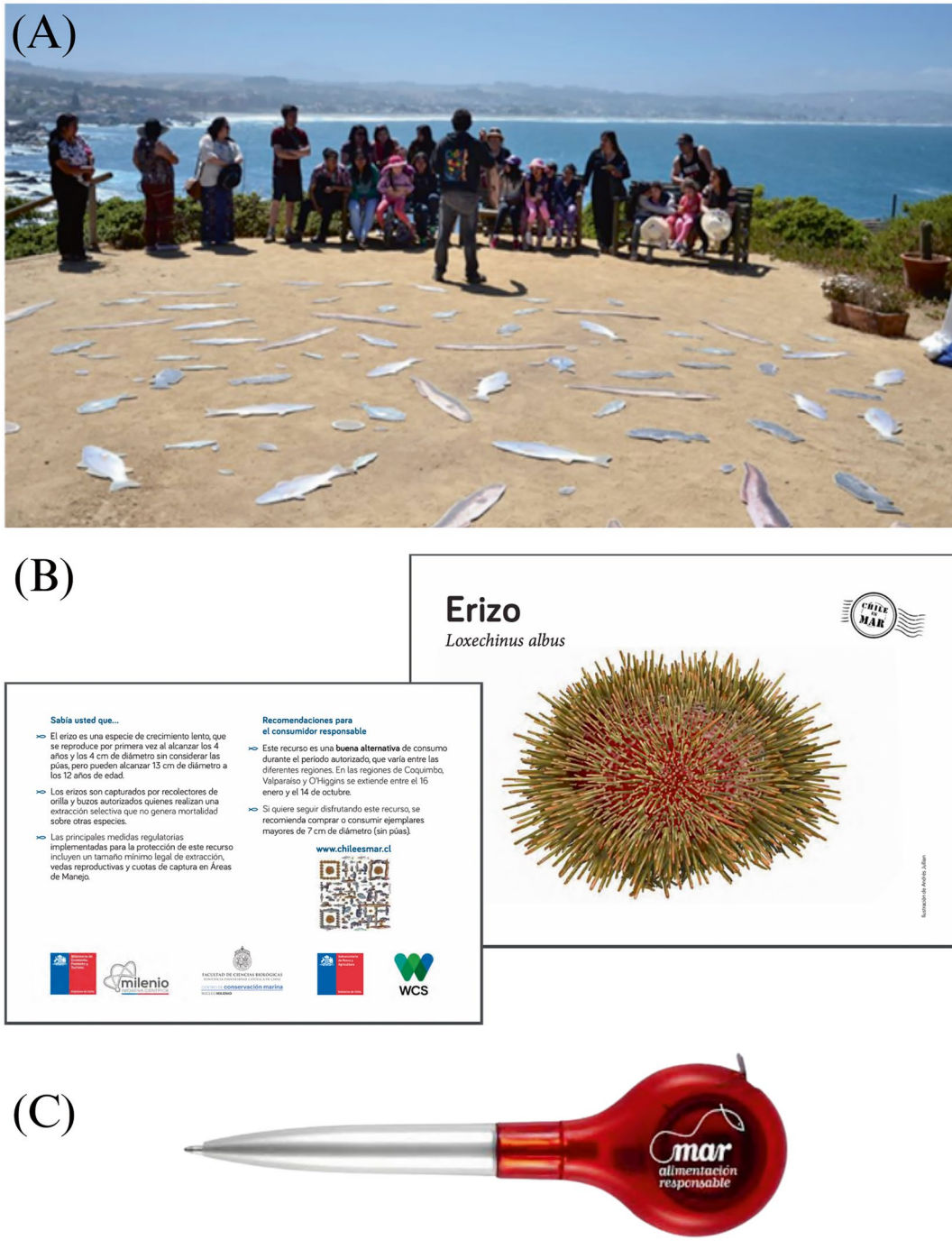

Fig. 7.1 (**a**) Interactive game taking place close to the MPA. (**b**) Educative cards of species and (**c**) Pen with measure tape was provided to the visitors as a takeaway

Table 7.2 Summary of surveys conducted before, after, and 6–12 months post-visit to assess participant misconceptions, experiences, and application of knowledge from the educational program

Stage	Survey	Description	Objectives	Design	Application
1	A (Appendix 1)	Before the visit, a 5-page survey with socio-demographic data, 2 open-ended questions, and 14 multiple-choice questions.	Identify misconceptions reiterative in the participants and compare it with other studies.	Studies on various aspects of marine education were adapted to inform the survey questions, while new questions were developed to address previously identified misconceptions.	Socio-demographic and open questions first and retired.
	After the visit, a 5-page survey with socio-demographic data, 2 open-ended questions, and 14 multiple-choice questions.	Diagnostic OL initial level from principle 6.	Additional questions were designed by the author, drawing on her experience in marine education programs.		Multiple choice test later, to avoid possible influence on the first stage test.
3	B (Appendix 2)	Between 6 and 12 months after the visit. Compounded by short answer questions.	Open questions were designed to reflect about her/his experience during the visit, thinking about what activity is more remembered and what information has been used during their daily life.	Open questions were designed based on main goals from the program.	Implemented online. Link for the questionnaire was sent to 90 participants from Survey A and B (those who shared with us their email address to be contacted). Answers were received from 6 to 12 months after the visit.

statistical tests include the "t-student" ($p < 0{,}001$) and Wilcoxon test ($p < 0{,}001$).

7.3.2.2 Survey B: 6–12 Months After the Activity (Appendix 2)

Survey B was administered online 6–12 months after the visit. It focused on short-answer questions to reflect participants' long-term recollections of the visit, including which activities were most memorable and how the information influenced their daily lives. The questions in this survey were directly aligned with the program's primary objectives.

A panel of two marine education experts, two marine biologists, and two science education teachers reviewed and validated both Survey A and Survey B. Their recommendations were incorporated into the final design. The instruments were pre-tested on an initial group of 20 participants to evaluate internal consistency, eliminating one poorly worded question.

7.3.3 Results

Among the 240 visitors, we found a similar proportion of men and women. The most frequent age groups were children between 8 and 12 years old, and adults between 35 and 45, although participants ranged from 7 to 85 years old. 68% of the visitors came from inland areas, while only 32% were residents who live year-round in the coastal area. The occupation and educational level of each visitor were also recorded. However,

no significant differences were found in any of the previously described parameters, with very similar results both in initial knowledge and in the increase after the visit when comparing place of residence, age, gender, education, and occupation.

7.3.3.1 Ocean-Human Relationship According to Open-Ended Questions

Survey A included open-ended questions about people's influence on the Ocean and, in turn, the influence people identify the Ocean has on their lives. These responses were classified according to the same three main groups from Principle 6: ecosystem services, human impact, and marine conservation. This classification encompasses all Ocean-human relationships (the types of benefits received from the sea, the types of impact caused by extraction and use, and the measures in place to minimize these impacts). The same questions were applied pre and post activity. Figure 7.2 presents pie charts of the most common responses at entry (left) and exit (right). At entry, nearly 70% of visitors recognized that their influence on the Ocean is related to pollution. In comparison, approximately 12% mentioned the consumption of marine resources, and another group stated they do not influence the Ocean in any way. When comparing the pre-and post-activity responses, the most significant result was, first, the reduction from 12.5% to less than 4% in the responses, indicating that individual actions 'do not influence' the Ocean at all. Secondly, it is essential to mention that the 'Food' category, which included all responses related to understanding that humans extract marine resources and that this has an environmental impact, increased from only 30 mentions at the beginning (12.9% of responses) to 128 mentions (more than 44% of responses). This was linked to Stage 3 of the visit, where we implemented the sustainable fishing game using the teaching and learning cycle. As previously defined, this activity goes through the stages of the TSL so that participants can understand their role as consumers of marine resources and their individual responsibilities. Interestingly, the reduction in the percentage of pollution-related responses is likely due to participants diversifying their answers about their influence on the Ocean.

Figure 7.3 shows the results regarding the question: 'How does the Ocean influence you?' Before the educational activities (left pie chart), respondents identified Food (30.9%) and Tourism (22.8%) as the two primary sources of the Ocean's influence on their lives. After the intervention, participants identified climate regulation as the second significant influence of the Ocean in their lives, giving greater importance to oxygen (O_2) production (14%). This again suggests greater diversification in participants' responses, indicating increased knowledge of the ecosystem services they benefit from.

7.3.3.2 Ocean-Human Relationship According to Closed-End Questions

We observed that, on average, participants in the educational activities provided nearly 10% more correct answers to the closed-ended questions of Survey A after the visit (Table 7.3). Regarding topics associated with ecosystem services, all responses improved at the exit. Notably, understanding the oxygen contribution from algae increased from 18% correct answers to 50%, which is significant as it indicates the presence of a prior misconception and its possible conceptual change. Another prior understanding that improved was the Ocean's importance in the water cycle, with correct responses increasing from 58% to 79% at the exit.

Regarding questions related to understanding human impact on the Ocean, the most notable change in this category was the increased understanding of the connection between pollution in Santiago (an inland city) and the Ocean. The misconception that Santiago's waste is unrelated to the Ocean decreased from 47% to 34%. Another change observed was the improvement in correct responses (from 24% to 37%) regarding the understanding that most of the population lives near the coast, as well as the longevity of plastics (from 55% to 62%) and the state of fisheries in Chile (from 61% to 71%). Another significant improvement was seen in the awareness of

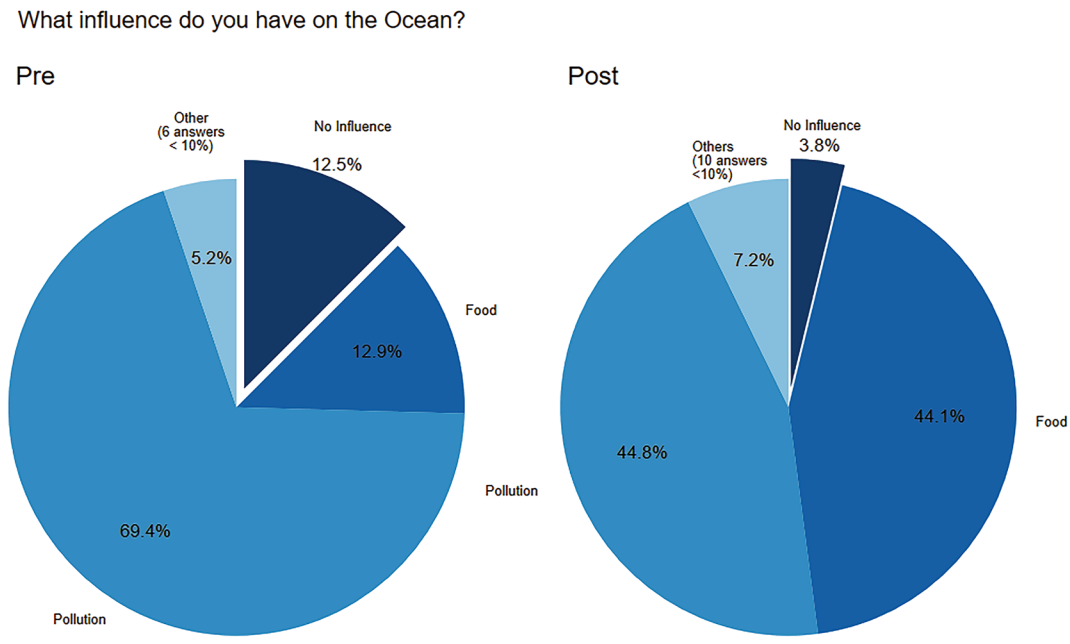

Fig. 7.2 Pie plot with percentage (%) of answers for the question: What influence do you have on the Ocean? *Note:* Total N = 240

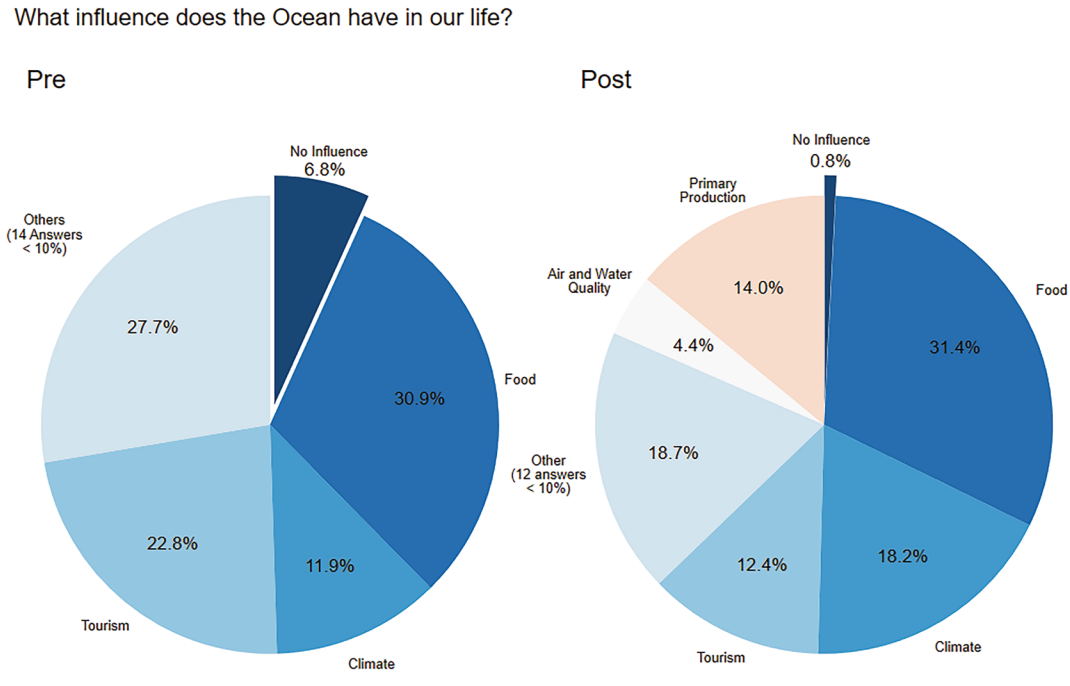

Fig. 7.3 Pie plot with percentage (%) of answers for the question: What influence does the Ocean have in our life? *Note:* Total *N* = 240

Table 7.3 Comparison of correct answers in pre-and post-tests using t-test and Wilcoxon test

	%Correct answers		Mean difference tests (t-test)			Wilcoxon test	
Questions	Pre	Post	Difference	Est. t	P-Value	Est. Z	P-Value
Overall	56.7%	65.9%	9.2%	−5.40	0.001	8.64	0.001
Ecosystem Services	62.3%	72.1%	11.1%	−6.7	0.001	6.68	0.001
Human Impact	46.6%	54.8%	8.3%	−5.3	0.001	5.05	0.001
Conservation	61.5%	71.1%	7.1%	−5.8	0.001	5.03	0.001

marine resource overexploitation in Chile, with correct responses increasing from 61% to 71%. However, there was a 2% decrease in correct responses related to the extent of resource consumption.

Finally, in analysing responses related to marine conservation, understanding the benefits of marine conservation is one of the objectives of this education program. At entry, 40% of participants correctly answered the question about the benefits of marine conservation. In contrast, at the exit, 62% identified that protected areas benefit not only the ecosystem but also fishermen and consumers. The most notable change in this section was the increase from 72% to 90% responding correctly regarding individual responsibility in marine resource consumption. However, we observed a 4% decrease in correct responses related to the description of marine conservation.

We found that the increase in the percentage of correct responses in the post-test occurred predominantly overall (Table 7.3 and Fig. 7.4a) and within each of the question categories: Ecosystem Services, Human Impact, and Conservation (Table 7.3 and Fig. 7.4b). For the overall count, there was an increase of more than 9% in correctly answered questions at the exit compared to the knowledge at the entry. When the questions were analyzed by group, the largest change was observed in the 'Ecosystem Services' group (questions 2, 3, 4, 5, and 8), where only about 64% of the questions were answered correctly at the entry, compared to 75% at the exit. Additionally, the groups of questions on 'Human Impact' and 'Conservation' also showed positive changes (greater knowledge), from 47% to 55% and from 58% to 65%, respectively.

There was a statistically significant increase in correct responses overall and also within each group of questions (Table 7.3). The p-values for all statistical tests are less than 0.05, indicating that we can reject the null hypothesis of equal means with a 95% confidence level.

7.3.3.3 Learning Persistence and Application

As highlighted throughout the theoretical framework, this type of marine education program's main objective is to convey information to participants and promote future decision-making using the information provided. To evaluate this, participants were contacted several months after the activity and asked about their experience (Table 7.2). The most prominent question was about the key learning they remembered from the activity (Fig. 7.5a). A total of 40 visitors responded to the survey, indicating a 44% participation rate from the total number of participants who received the questionnaire. Almost 50% of the survey responses referred to Stage 3 of the activity, which was associated with sustainable consumption fishing. This was followed by 40% of respondents who mentioned that their most significant learning experience was linked to the biodiversity activity (aquarium visit). Less than 15% of respondents referenced MPA, the importance of learning about these topics, and other general marine conservation themes.

Despite knowing that the aquarium visit was always the most anticipated and emotional part for participants, the fishing game was the most frequently remembered activity (Fig. 7.5b). Activities such as talks and debates were the least mentioned in these results. Of the 40 participants who voluntarily responded, only one indicated that they could not apply anything they learned during the visit. As for the rest, all applied what they had learned in one way or another. The most repeated responses (60% of respondents,

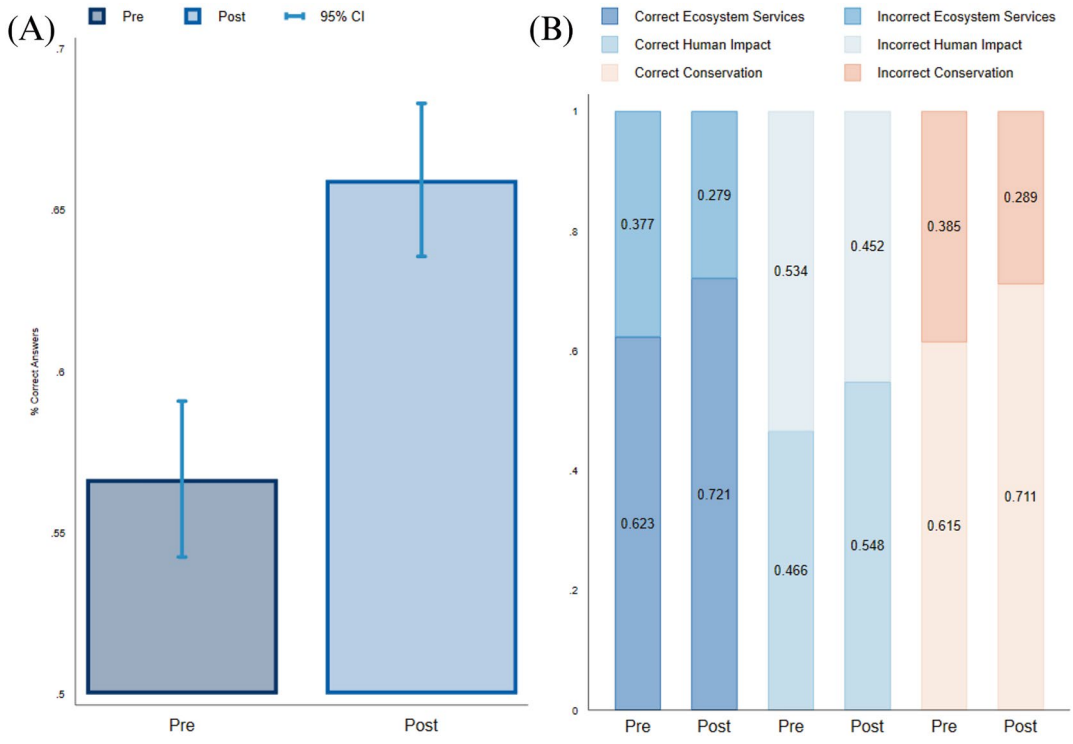

Fig. 7.4 Bar plots with percentage (%) of correct answers before (pre) and after (post) for the overall (**a**) and within each of the categories (**b**)

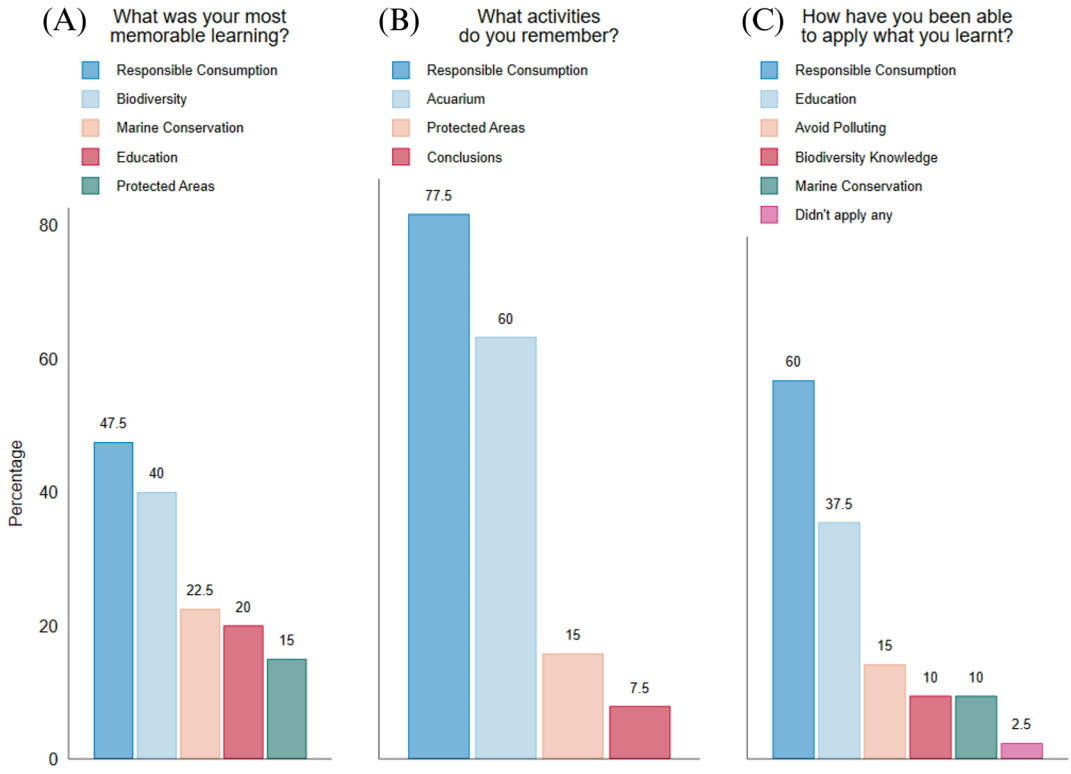

Fig. 7.5 Bar plots with percentage (%) of different types of answer to 3 questions: (**a**) What was your most memorable learning? (**b**) What activities do you remember? and (**c**) How have you been able to apply what you learnt?

Fig. 7.5c) were related to making decisions for responsible consumption of resources (respecting fishing bans, ensuring resources are above their first reproduction size, avoiding consumption of overexploited resources, etc.). In second place (37%), participants indicated they used the information acquired to share it with their immediate environment and encourage behaviours aligned with marine conservation. Finally, a smaller number of responses were related to marine pollution.

7.4 Discussion

Our results demonstrate a significant improvement in Ocean Literacy, particularly in questions related to Principle 6, with a marked increase in correct answers after participation in the activity. This aligns with the challenges identified in the literature, where students' understanding of the Ocean has often been described as limited and inconsistent, even when interest is present (Ballantyne 2004). These findings further support previous evidence that non-formal marine educational activities can enhance knowledge effectively (Joyce et al. 2019).

Only two questions showed a decrease in correct answers after the visit. The first was related to the concept of marine conservation, with correct responses declining by 4%. This decrease may be attributed to visitors potentially conflating the definition of conservation with the institution's name, *Marine Conservation Station*, leading to confusion between the general concept and a specific location. The second decrease, by 2%, was observed in a question regarding marine resource consumption and the size at first reproduction. This could reflect a misunderstanding; while the activity emphasized the importance of respecting the first reproduction size, participants might have been influenced by additional discussions about the greater reproductive capacity of larger specimens, leading to conflicting interpretations. Nonetheless, in both cases, the t-test results indicated that these differences were not statistically significant.

Despite these results, the program achieved significant success by improving participants' ability to identify a broader range of ecosystem services, illustrating their connections to the Ocean even from distant locations, and deepening their understanding of the benefits of marine conservation. To effect a change in decision-making, it is necessary to introduce participants to new content that helps them understand the Ocean's functioning, natural phenomena, and the science behind it (Ballantyne 2004). In this sense, having more knowledge after the activity demonstrates that in just 2 h and 30 min, it is possible to convey relevant information about the connection between humans and the Ocean.

While our results suggest a significant increase in Ocean Literacy following the educational activities, the study lacked sufficient data to establish a definitive causal relationship. Nevertheless, we analysed whether those activities with a stronger didactic focus might have been related to long-term changes. Considering the activity design, it is essential to highlight that while didactic strategies are incorporated throughout the entire visit, a complete TLS is fully implemented only during the sustainable fishing activity. Implementing this TLS aims to provide visitors with the tools needed to apply the new content in their daily lives. During this activity, participants engaged in debates about different strategies for sustainably consuming marine resources and the responsibilities of all actors involved in extracting, legislating, and consuming these resources. Up to this point, the activity is similar to other visit stages, even incorporating additional information from the guide. However, after the debate, each participant is assigned a fisherman's role and asked to decide which resources they would fish from a wide range of options. By engaging in the activity this way and being required to make decisions, participants need to use the newly acquired information and the ability to apply it. As previously mentioned, this stage was designed based on a teaching and learning cycle, with the final step being the application of new content in different contexts. This is what differentiates it from the design of other stages. At the end of the activity, participants realised that the

same decisions they made as fishermen can be applied as consumers when selecting marine resources at the market. This becomes a new, accessible tool in their daily lives to contribute to Ocean and resource conservation.

Although information related to individual conservation tools (such as not littering beaches, avoiding the extraction of marine animals from rocks in summer, respecting MPA, etc.) is provided throughout the visit, in the open responses collected online months after the activity, nearly 80% of the responses mentioned the tools for responsible consumption, which were covered during the TLS of Stage 3, despite the opportunity to mention other learnings from the visit. This suggests that integrating the TLS positively impacted visitors, as applying the new content in their contexts when consuming marine resources was the most frequently mentioned response. This fulfils the program's objective of providing information to the community and promoting using that information for responsible decision-making.

7.5 Conclusions

The marine educational activities designed with specific didactic strategies promote the incorporation of new content related to the relationship between humans and the Ocean, increasing levels of OL knowledge component. This highlights the effectiveness of these strategies in enhancing participants' understanding of the human-Ocean connection.

The results suggest that the TLS facilitate participants' ability to apply the acquired information to their daily decision-making processes. This indicates that educational interventions can impact how individuals use knowledge practically and meaningfully.

The participants in this study voluntarily attended the marine education activities, demonstrating a prior interest in learning about the Ocean. However, despite their interest, many participants shared their need for more information about basic OL concepts. This suggests that more than interest alone is required to have the necessary information to make responsible decisions regarding the Ocean.

There is a need to encourage, develop, and support research in this area of marine education to create programs that foster an Ocean-literate community capable of protecting the Ocean and its resources. It is crucial to test if the educational activities design proved effective in improving understanding of ecosystem services, human impacts, and conservation strategies, as the individual use of this knowledge to make responsible decisions which are critical for the success of MPA. It is not sufficient to simply continue implementing marine education programs; we must demonstrate their effectiveness in fostering the Ocean-human connection necessary to cultivate individual leadership in Ocean conservation.

7.5.1 Summary

Key concepts explored in this chapter include:

- The study demonstrates that integrating Teaching and Learning Sequences (TLS) into marine education significantly improves Ocean Literacy by linking scientific knowledge to real-life decision-making in a Marine Protected Area (MPA) context.
- Participants showed a measurable increase in understanding of ecosystem services, human impacts, and marine conservation.
- Stage 3 of the program, which involved a participatory fishing game based on TLS, was most effective in promoting conceptual change and fostering long-term behavioral shifts toward sustainable seafood consumption.
- Six to twelve months after participation, surveyed individuals reported applying their

learning in everyday life, primarily by making more sustainable consumer choices and sharing knowledge within their communities.
- The findings underscore the importance of evaluating educational interventions not only in terms of knowledge gain but also for their capacity to encourage persistent, actionable change that supports the objectives of MPAs and marine conservation efforts.

7.5.2 Recommended Resources

The following resources provide further insights and support on this topic:

- *Chile es Mar*: https://chileesmar.cl
- Red de Educación Latinoamericana para el Océano (RELATO) www.relatoceano.org

Acknowledgements from Lead Author

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Appendix 1

Questionnaire 1: Entry and Exit

Name: _____

Age: _____ ID Number: _____

Email: _____

Address: _____ Commune: _____ Region: _____

Level of education completed: (circle all that apply)

Primary Secondary Technical and professional University None

Occupation: _____

How often do you visit the sea? (circle one)

Once or twice a year Very frequently I live by the sea.

What kind of activities do you like to do related to the sea?

Fishing, sports, vacations, artistic inspiration, others _____

Have you done this visit before? No__ Yes__

When? _____

Mark the following options where you learned about the sea:

- In class
- In aquariums
- In museums
- At science camps
- During personal experiences (e.g., visiting the beach)
- Through conversations with friends and family
- Watching television, movies, documentaries, etc.
- Through the internet
- Reading magazines, newspapers, and books
- Others: _____

_____

Write examples of how the Ocean influences your daily life. If you believe it doesn't, please indicate so.

_____

Write examples of how your daily life and decisions might affect the Ocean. If you believe they don't, please indicate so.

_____

Can you name a Marine Protected Area in Chile? Indicate where it is located.

_____

Tell us what you expect from this visit.

_____

_____

1. Which of the following definitions of marine conservation do you think is most accurate?
   a. Marine conservation refers to protecting the marine environment above all else, avoiding the use of the sea and its resources to prevent human damage.
   b. Marine conservation is about caring for the marine environment while including human use and understanding interactions, requiring collaboration between scientists, fishers, institutions, communities, etc.
   c. Marine conservation solely depends on marine scientists, who manage areas to cultivate marine flora and fauna and ensure their survival over time.
   d. Marine conservation solely depends on the navy, which must constantly ensure the protection of marine resources.

2. Imagine our planet without Oceans. What would the global temperature be like?
   a. Temperature changes would be more extreme (warmer summers, colder winters).
   b. Seasonal changes would be less extreme, with no difference between seasons.
   c. The Ocean does not affect the planet's temperature.
   d. The Ocean only affects coastal areas, and the absence of Oceans would not change the planet's temperature.

3. What benefits do humans obtain from the Ocean?
   a. The Ocean is a source of energy and transportation.
   b. The Ocean is essential to national security.
   c. The Ocean is a source of inspiration for artists, rejuvenation, and recreation.
   d. All of the above.

4. Most rainfall on land comes from:
   a. Freshwater rivers.
   b. Saltwater Oceans.
   c. Lakes, ponds, and glaciers.
   d. Ice from snowy mountain ranges.

5. We've always been taught that trees provide the oxygen we breathe, but in the sea, algae also produce oxygen. What percentage of the oxygen we breathe comes from algae?
   a. Only about 5%.
   b. Approximately 25%.
   c. Nearly 50%.
   d. More than 75%.

6. If you were a fisher wanting to fish responsibly to help conserve resources:
   a. You would fish older resources because they can no longer reproduce, minimizing ecosystem impact.
   b. It's best to leave older fish as they are key reproducers and fish those that haven't reproduced yet, as their removal causes less damage.
   c. The best decision is to wait until they reproduce at least once before fishing them.
   d. Responsible fishing is impossible; to be responsible, we must stop fishing.

7. Which statement is FALSE regarding marine pollution:
   a. Most beach trash consists of plastics left behind by tourists.
   b. Chile's most plastic-polluted beach is on Easter Island.
   c. Trash discarded in Santiago does not affect the sea.
   d. One of the most abundant wastes on Chilean beaches is cigarette butts.

8. How is humanity connected to the sea?
   a. Through freshwater and the oxygen we breathe.
   b. Through the food and medicine we use.
   c. Through the planet's temperature.
   d. All of the above.

9. Globally, most people live:
   a. Far from the sea, as it is risky due to tsunamis, hurricanes, etc.
   b. Close to the sea, due to its resources and water availability, modifying beaches and coastal areas.
   c. Indifferently; populations are equally distributed near and far from coasts.
   d. Far from the sea for economic and job-related reasons.

10. You're enjoying a summer day at the beach, and without realizing it, the wind carries your plastic bag into the sea. How long do you think plastic remains in the Ocean?
    a. Thousands of years.
    b. Between 20 and 30 years.
    c. Less than 5 years.
    d. Between 100 and 150 years.

11. Chile is one of the most productive countries in terms of marine resources:
    a. Therefore, there are no fishing quotas limiting resource extraction.
    b. Despite its productivity, nearly 50% of fisheries are in critical overexploitation.
    c. Resources like loco or hake are overexploited but represent less than 10% of fisheries; most remain abundant.
    d. Resource overexploitation has reached such extremes that we must import all fish we consume from other countries.

12. Regarding the benefits of Marine Protected Areas (MPAs) where fishing is prohibited:
    a. MPAs solely benefit the marine ecosystem and its conservation.
    b. Fishers are only negatively impacted because they cannot fish in those areas, losing opportunities.
    c. Fishers benefit from MPAs as they lead to increased available resources.
    d. The Ocean is so vast that MPAs have no impact on fishers (positive or negative).

13. In recent years, many documentaries about the sea and seabed have been made. What percentage of the Ocean does humanity know about?
    a. Only about 5%.
    b. Approximately 25%.
    c. About 50%.
    d. More than 75%.

14. As consumers of marine resources:
    a. By the time we reach the market, resources have already been extracted, so it's not our responsibility.
    b. We are responsible for protecting the resources we consume and can contribute individually when purchasing marine resources.
    c. Marine resources are not our responsibility; only fishers and the government determine what is extracted and regulated.
    d. Our individual consumption is so small it doesn't impact conservation; it's the responsibility of large supermarkets.

Appendix 2

Questionnaire 2

1. What was the most significant learning experience for you during this visit?
2. Do you remember any of the activities?

   Which ones do you recall?

3. Have you been able to apply anything in your daily life over the past few months from what you learned during your visit to *Chile es Mar*?

   In what way have you been able to apply it? Please share your experience with us.

4. In your opinion, which aspect of the *Chile es Mar* program is more successful: teaching about the Ocean or changing attitudes toward the Ocean?

   Why?

References

Ballantyne R (2004) Young students' conceptions of the marine environment and their role in the development of aquaria exhibits. GeoJournal 60:159–163

Ban NC, Gurney GG, Marshall NA, Whitney CK, Mills M, Gelcich S, Bennett NJ, Meehan MC, Butler C, Ban S, Tran TC, Cox ME, Breslow SJ (2019) Well-being outcomes of marine protected areas. Nat Sustainability 2(6):524–532. https://doi.org/10.1038/s41893-019-0306-2

Bennett NJ, Dearden P (2014) Why local people do not support conservation: Community perceptions of marine protected area livelihood impacts, governance and management in Thailand. Mar Policy 44:107–116. https://doi.org/10.1016/j.marpol.2013.08.017

Gall SC, Rodwell LD (2016) Evaluating the social acceptability of Marine Protected Areas. Mar Policy 65:30–38. https://doi.org/10.1016/j.marpol.2015.12.004

Glithero L, Bridge N, Hart N, Mann-Lang J, McPhie R, Paul K, Peebler A, Wiener C, Yen C, Kelly R (2024) Ocean Decade Vision 2030 white papers—Challenge 10: restoring society's relationship with the Ocean. UNESCO-IOC. https://doi.org/10.25607/ekwn-wh61

Hawkins AJ, Stark LA (2016) Bringing climate change into the life science classroom: Essentials, impacts on life, and addressing misconceptions. CBE—Life Sciences Education 15(2):fe3. https://doi.org/10.1187/cbe.16-03-0136

Inagaki K, Hatano G (2013) Conceptual change in naïve biology 1. In: International handbook of research on conceptual change. Routledge, pp 195–219

Joyce J, Dromgool-Regan C, Burke N (2019) Creating marine outreach programmes that work—The Marine Institute Explorers Education Programme™. In: Fauville G, Payne DL, Marrero ME, Lantz-Andersson A, Crouch F (eds) Exemplary practices in marine science education: A resource for practitioners and researchers. Springer International Publishing, pp 171–189. https://doi.org/10.1007/978-3-319-90778-9_11

Katikiro RE (2016) Improving alternative livelihood interventions in marine protected areas: A case study in Tanzania. Mar Policy 70:22–29. https://doi.org/10.1016/j.marpol.2016.04.025

Leach J, Scott P (2002) Designing and evaluating science teaching sequences: An approach drawing upon the concept of learning demand and a social constructivist perspective on learning. Stud Sci Educ 38:115–142

Marrero MEC (2009) Uncovering students' conceptions of the Ocean: A critical first step to improving Ocean Literacy. Doctoral dissertation, Columbia University

McKinley E, Fletcher S (2012) Improving marine environmental health through marine citizenship: A call for debate. Mar Policy 36(3):839–843. https://doi.org/10.1016/j.marpol.2011.11.001

Österblom H, Jouffray J-B, Folke C, Rockström J (2017) Emergence of a global science–business initiative for Ocean stewardship. Proc Natl Acad Sci 114(34):9038–9043. https://doi.org/10.1073/pnas.1704453114

Pendleton L, Evans K, Visbeck M (2020) We need a global movement to transform Ocean science for a better world. Proc Natl Acad Sci 117(18):9652–9655. https://doi.org/10.1073/pnas.2005485117

Robottom I (2004) Constructivism in environmental education: Beyond conceptual change theory. Aust J Environ Educ 20(2):93–101. https://doi.org/10.1017/S0814062600002238

Ruckelshaus M, Doney SC, Galindo HM, Barry JP, Chan F, Duffy JE, English CA, Gaines SD, Grebmeier JM, Hollowed AB, Knowlton N, Polovina J, Rabalais NN, Sydeman WJ, Talley LD (2013) Securing Ocean benefits for society in the face of climate change. Mar Policy 40:154–159. https://doi.org/10.1016/j.marpol.2013.01.009

Sanmartí N (2000) El diseño de unidades didácticas. In: Perales Palacios FJ, Cañal de León P (eds) Didáctica de las ciencias experimentales. Editorial Marfil, pp 239–276

Sjöström J, Eilks I (2018) Reconsidering different visions of scientific literacy and science education based on the concept of Bildung. In: Dori YJ, Mevarech ZR, Baker DR (eds) Cognition, metacognition, and culture in STEM education: Learning, teaching and assessment. Springer International Publishing, pp 65–88. https://doi.org/10.1007/978-3-319-66659-4_4

Veiga JM, Vlachogianni T, Pahl S, Thompson RC, Kopke K, Doyle TK, Hartley BL, Maes T, Orthodoxou DL, Loizidou XI, Alampei I (2016) Enhancing public awareness and promoting co-responsibility for marine litter in Europe: The challenge of MARLISCO. Mar Pollut Bull 102(2):309–315. https://doi.org/10.1016/j.marpolbul.2016.01.031

Vosniadou S (2019) Teachers' beliefs and knowledge. In: Problem solving for teaching and learning. Routledge, pp 99–111

Walsh EM, McGowan VC (2017) 'Let your data tell a story': Climate change experts and students navigating disciplinary argumentation in the classroom. Int J Sci Educ 39(1):20–43. https://doi.org/10.1080/09500693.2016.1264033

Watson JEM, Dudley N, Segan DB, Hockings M (2014) The performance and potential of protected areas. Nature 515(7525):67–73. https://doi.org/10.1038/nature13947

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