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Creating a scientific picture book of marine organism with natural history illustration: A case study in Japan

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ABSTRACT

In recent years, global concern has grown regarding the degradation of marine ecosystems. Humanity has greatly benefited from the oceans, underscoring the constant need for restoration and conservation of marine ecosystems. International cooperation is essential for protecting the oceans, with Japan, an island nation surrounded by the sea, playing a crucial role in marine environmental conservation. For the sustainable use of marine resources and the preservation of marine environments, comprehensive measures are important. Particularly, marine biology education for the next generation holds great importance. Here, we report a detailed case study on the creation of a scientific picture book about marine organisms in Japan and its feedback. The book explores the theme of mutual symbiosis among marine organisms, aiming through illustrations and storytelling to help children understand the complexities of marine life. It focuses on the symbiotic relationship between hermit crabs and sea anemones. The picture book was developed based on scientific literature survey and specimen observation. Positive feedback from readers highlights how effectively the picture book conveys educational content on marine biology, suggesting the potential of science picture books as powerful tools in educational outreach and environmental conservation efforts. This report discusses the creative process, the educational impact of the picture book, and offers valuable insights into the use of visual arts and narrative in science education.

Keywords: marine education, ocean natural history, natural history illustration, picture book, symbiosis

INTRODUCTION

In recent years, the global concern over the degradation of marine ecosystems, primarily due to ocean pollution, has intensified. Humanity benefits immensely from the oceans, highlighting the critical need for marine ecosystem restoration and environmental conservation (Danovaro et al., 2021). Therefore, conservation efforts require more than just scientific understanding but also requires the cultivation of a culture. Given its geographical nature, Japan, one of the maritime nations surrounded by seas, has a substantial role to play in these conservation efforts (Hioki & Niwa, 2020).

The sustainable utilization of marine resources and the preservation of marine environments require a comprehensive approach. As part of this, it is crucial to foster a deeper understanding of marine life among the younger generation (Omura, 2019a, 2019b). It is widely acknowledged that experiential learning is highly effective for understanding the natural sciences; however, opportunities for learning in marine environments are limited and less accessible compared to land-based observations (Hsieh, 2021; Kohno et al., 2016; Omura, 2019a). Moreover, systematic marine education is not implemented in Japan's school curricula, and references to the ocean are scarcely found in the national curriculum guidelines for elementary and junior high schools (Sasaki, 2023).

Given these circumstances, it has become essential to develop educational materials that can serve as substitutes for direct experiences, especially for children with limited access to marine environments. Among various biological education tools, science picture books have long been recognized for their effectiveness. A good example of integrating science with art and narrative storytelling is a science picture book, which combines both scientific content and artistic elements. The impact of colour schemes and the appeal of visual imagery on human perception are well-documented, underscoring the critical role of visual representation and aesthetic elements in educational settings (Gilbert & Stocklmayer, 2012). Especially, natural history illustrations used in picture books offer unique advantages by allowing creators to imbue their work with specific intentions and perspectives compared to photography frequently used to depict natural life (Orihara, 2015). Moreover, storytelling is an essential component that enhances the educational value of these materials (Negrete & Lartigue, 2004).

Considering this, this paper aims to contribute to marine education through a case study on creating a science picture book, themed around the mutual symbiosis of marine organisms. This endeavor aligns with the objectives of "Kagaku no Tomo," a monthly series published by Fukuinkan Shoten Publishers, Japan, designed to engage children aged 4-6 in the wonders of science. This report elaborates on 1) the process of developing a science picture book for publication in this series, 2) the feedback from readers, and discusses about the effectiveness of a scientific picture book for marine education.

MATERIALS AND METHODS

Picture Book Production

Story selection

One compelling topic in marine biology narratives is mutual symbiosis. Mutual symbiosis represents a biological interaction where different species coexist to their mutual benefit. Examples include the associations between hermit crabs and sea anemones (Gusmão et al., 2020; Ross & Sutton, 1961; Ross & von Boletzky, 1979), clownfish and sea anemones (De Jode et al., 2024; Fautin, 1991; Lubbock, 1981), and gobies with shrimps (Preston, 1978).

For the theme of mutual symbiosis, the example of hermit crabs and sea anemones was chosen for three main reasons. Firstly, their interaction is one of the most familiar examples of symbiosis in temperate seas (Gusmão et al., 2020). Secondly, hermit crabs and sea anemones are easily observable in public aquarium settings. Thirdly, while both hermit crabs and sea anemones are well-known, opportunities to learn about their symbiotic relationship are rare. For these three reasons, the story was crafted based on ecological literature, highlighting the mutual benefits of their symbiosis. Additionally, other species (predators and the types of shells carried by hermit crabs) were also chosen to feature in the story.

Thumbnail creation

Page layouts were decided according to the storyline, followed by rough sketches to conceptualize the overall image of the picture book.

Understanding morphology

To grasp the morphology of the featured hermit crabs and sea anemones, specimen research was conducted using preserved specimens from the Natural History Museum (**Figure 1**). We also conducted a literature survey for hermit crabs and sea anemones.

Drawing and painting production

Preliminary pencil sketches were drawn based on the information gathered in previous steps (story selection, thumbnail creation, understanding morphology) finalizing the composition. After creating the line draft, transparent watercolours (Winsor & Newton, UK) and acrylics (Liquitex, UK) were used on watercolour paper for the final illustrations.

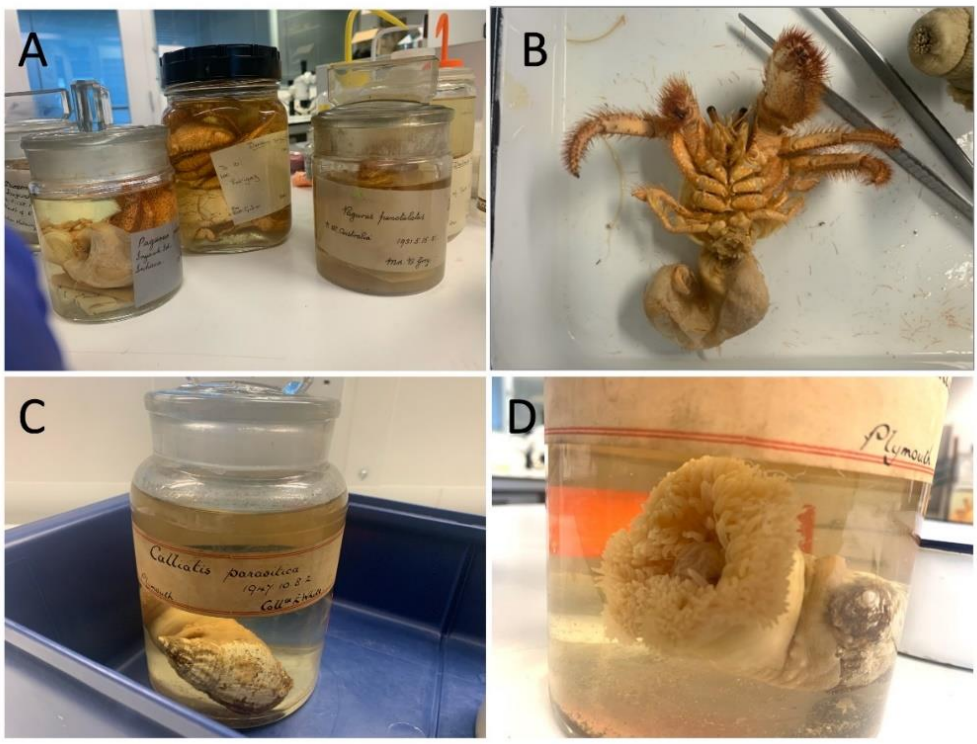

Figure 1. A) Museum Specimens of Hermit Crabs (*Dardanus* sp.); B) Ventral View of a Hermit Crab Specimen; C) Museum Specimen of Sea Anemone (*Calliatis paraitica*) attaching to a Shell; & D) Dorsal View of a Sea Anemone Specimen (Source: Field study)

Text insertion and colour proofing

The illustrations were digitized through Adobe Photoshop CS5, followed by text insertion. Preliminary prints were made to adjust the colours, undergoing two rounds of colour proofing before the final binding.

Supplementary Poster Production

The magazine includes a supplementary poster showcasing the diversity of sea anemone colours and forms, illustrated with watercolours (Winsor & Newton, UK) on paper. Each image was drawn separately, scanned, and then arranged in Photoshop for layout and text insertion.

Feedback from Readers

We systematically gathered public feedback on the picture book from a variety of sources within the first two months following the book's release (from 1st December 2023 to 31st January 2024). We also searched for mentions of the book's title on social media platforms (Twitter and Instagram). Direct feedback to the publisher and posts on a review site (reading meter, KADOKAWA group, Japan) were also analyzed.

The feedback collected through these channels was analyzed based on three primary evaluation criteria designed to gauge the book's effectiveness. These criteria were:

1) increasing scientific knowledge and interest
2) overall appeal of the story
3) impressions of the illustrations.

In our analysis, each mention within the comments that pertained to these specified criteria was counted. Some comments addressed multiple criteria, resulting in certain overlaps in our tallying process.

RESULTS

Literature Research and Story

The story utilized knowledge about the symbiotic relationship between hermit crabs and sea anemones. The main theme of the symbiotic relationship is as follows: Some species of hermit crabs form symbiotic relationships with sea anemones (this term is rather species-specific). The sea anemone can deter predators like octopuses, which avoid the anemones' cnidocyte toxins, allowing the hermit crabs to avoid predation. On the other hand, the sea anemones get motility and food scraps (Brusca et al., 2022; Gusmão et al., 2020).

Deciding on Featured Species

We chose *Dardanus pedunculatus* commonly referred to as the anemone hermit crab, and *Calliactis polypus* as the sea anemone, which can be observed in Japan, for their symbiotic relationship. In the picture book, we selected the common octopus, *Octopus vulgaris*, as a predator. For the shells, we chose *Tonna marginata* (**Figure 2A** - left side) for its round shape and *Pleuroploca trapezium* (**Figure 2A** – right side) for its elongated shape, allowing readers to easily recognize the difference in shell types (ex. **Figure 2B** to **2D**).

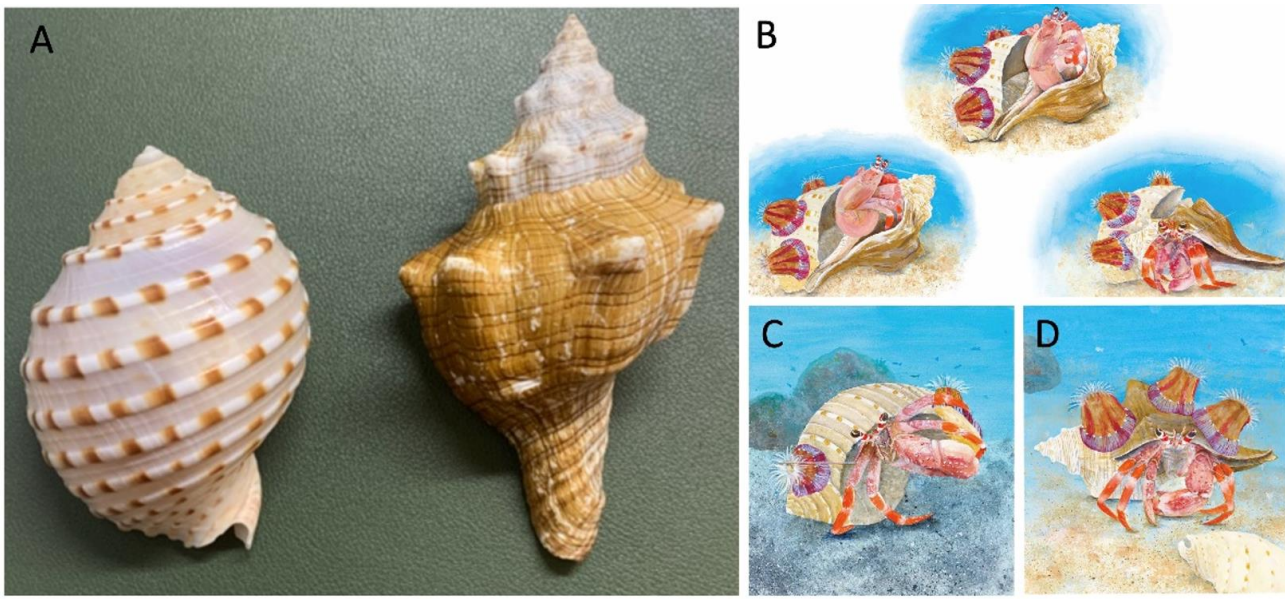

Figure 2. Shells carried by the hermit crab in the picture book. A) Photo images of shells - left: *Tonna marginata* shell specimen; right: *Pleuroploca trapezium* shell; B) Colour painting - A scene of the hermit crab transferring from the previous shell to the new shell; C) A hermit crab in the *Tonna marginata* shell; & D) A hermit crab in the *Pleuroploca trapezium* shell (Omura, 2024)

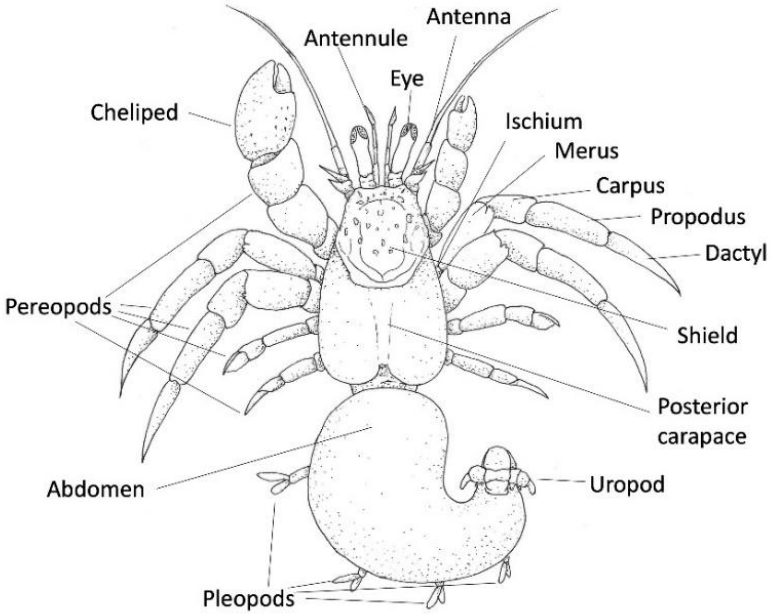

Figure 3. Diagram of hermit crab (Adapted from Brusca et al., 2022)

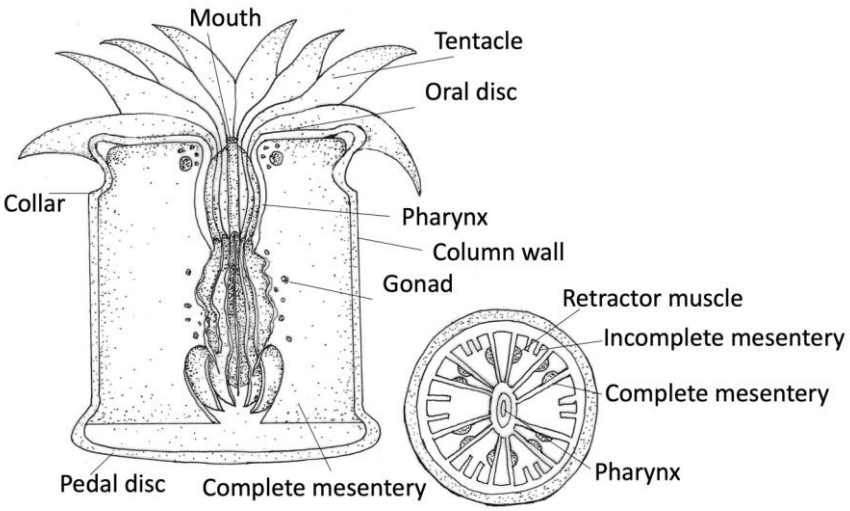

Figure 4. Diagram of sea anemone (Source: modified by Brusca et al., 2022)

Basic Classification and Morphology

Hermit crab

Hermit crabs belong to the phylum Arthropoda, class Malacostraca, order Decapoda, suborder Pleocyemata, infraorder Anomura, superfamily Paguroidea. They carry and live in empty scavenged molloca shells to protect their soft abdomen. There are five pairs of pereopods. The first pereopods are cheliped, which are often asymmetrical. The second and third pairs of pereopods are walking limbs, while the fourth and fifth pairs are shorter and used to hold the Molluscan shell. The abdomen is spirally curved and soft. Most frequently, hermit crabs carry the empty Molluscan shells for protect their soft abdomen. The pereopods remain only on the left side. The uropods are hook-like shape and act as an anchor for the body into the Molluscan shell (**Figure 3**) (Brusca et al., 2022).

Sea anemone

Sea anemones belong to the phylum Cnidaria, class Anthozoa, subclass Hexacorallia, order Actiniaria. A typical sea anemone is a single polyp. It attaches to hard substrates using its pedal disc. The polyp has a columnar trunk. The top of its trunk is an oral disc with a ring of tentacles surrounding a central mouth. The body plan of sea anemones is radially symmetrical (body-axes being in an aboral plane) (**Figure 4**). A ring of tentacles encircling the body can collect food from any direction. Sea anemones possess cnidae tubular structures contained within cellular capsules for prey capture, defence, locomotion, and attachment (Brusca et al., 2022).

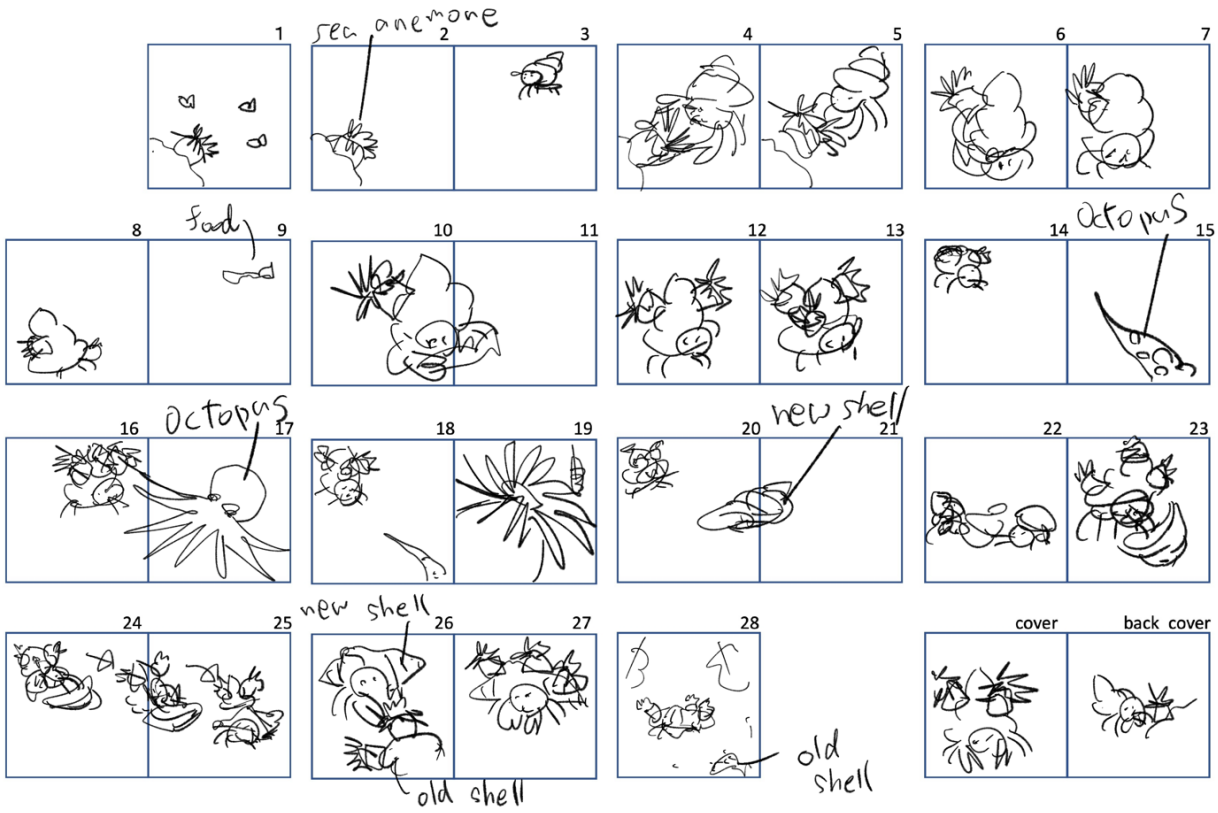

Figure 5. Thumbnail for the picture book (Omura, 2024)

Production Content

This book constructs 28 pages as shown in the **Figure 5**. Based on the story, the pages were assigned as follows:

- A hermit crab finds a sea anemone and attaches it to a molluscan shell carried by the hermit crab (p. 1-7).
- Benefit to the symbiotic anemone: Increasing mobility with the hermit crab and eating hermit crab food spills (p. 8-11).
- The hermit crab carries more sea anemones (p. 12-13).
- Benefit to hermit crabs of symbiosis; when attacked by an octopus, the hermit crab is protected by the cnidarian of the sea anemone (p. 14-19).
- The hermit crab finds a new mollusca shell and fights for the shell against another hermit crab (p. 20-22).
- The hermit crab moves from its molluscan shell (p. 23-25).
- The hermit crab moves the sea anemones from the previous shell to the new shell (p. 26-27).
- Ending (p. 28).

Based on the thumbnail, line drawings, colour paintings (**Figure 6**), and text insertion (**Figure 7**) were created.

Figure 6. A: Line drawing; B: Colour painting with specimens and ecological photos (Omura, 2024)

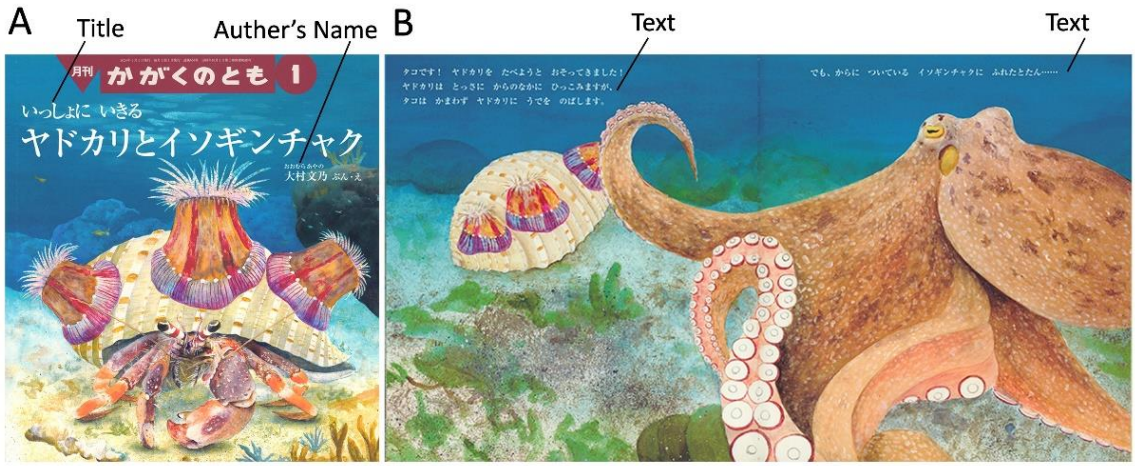

Figure 7. Colour page with interesting texts. A: The cover page; B: A scene of being attacked by an octopus (Omura, 2024)

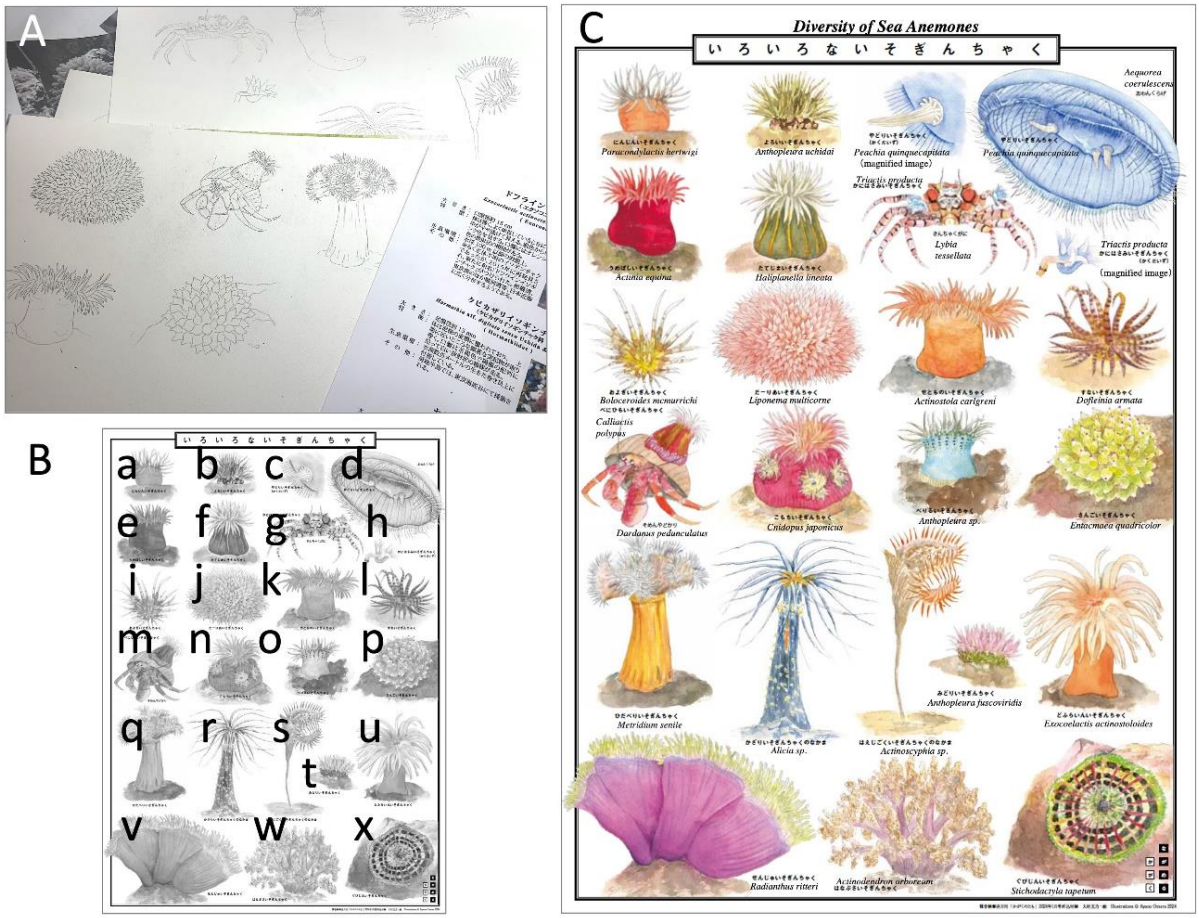

Figure 8. Appendix poster of sea anemone. A: Line drawing; B: Grayscale poster; C: Finished colour poster (Omura, 2024)

Appendix Sea Anemone Poster

The poster features 20 species of painted sea anemones, showcasing their colour and form diversity (*a: Paracondylactis hertwigi, b: Anthopleura uchidai, c,d: Peachia quinquecapitata, e: Actinia equina, f: Haliplanella lineata, g,h: Triactis producta, i: Boloceroides mcmurrichi, j: Liponema multicorne, k: Actinostola carlgreni, l: Dofleinia armata, m: Calliactis polypus, n: Cnidopus japonicus, o: Anthopleura sp., p: Entacmaea quadricolor, q: Metridium senile, r: Alicia sp., s: Actinoscyphia sp., t: Anthopleura fuscoviridis, u: Exocoelactis actinostoloides, v: Radianthus ritteri, w: Actinodendron arboretum, x: Stichodactyla tapetum*) showing the variation of colour, shape, and life history (**Figure 8**). It includes species that have symbiotic relationships with other animals, such as *Peachia quinquecapitata*, which parasitizes jellyfish larvae (ex. *Aequorea sp.*) (**Figure 8B: c & d**), and *Calliactis polypus*, which attaches to the shell of *Dardanus pedunculatus* (**Figure 8B: m**). The poster also highlights other symbiotic relationships, such as boxer crabs using sea anemones for defence and feeding (**Figure 8B: g**).

Reader Feedback

There were 22 positive comments from many sources (Twitter: 5, Instagram: 8, direct feedback to the publisher: 4, posts on a review site: 8).

Increasing scientific knowledge and interest

There were 11 positive feedback comments about increasing scientific knowledge and interest.

- I learned for the first time that hermit crabs and sea anemones live together.
- I found out that hermit crabs carry molluscan shells.
- I discovered there are many types of sea anemones.
- I learned that mutualism is a win-win relationship.

Overall appeal of the story

There were 10 positive feedback comments about the overall appeal of the story.

- I really enjoyed this story.
- It's cute how hermit crabs take sea anemones with them when they move.
- It's easy to understand and interesting.
- It was explained very clearly, and I understood it well

Impression of the illustrations

There were 15 positive feedback comments about the impression of the illustrations.

- The colours of sea creatures are vivid and beautiful.
- It feels like being inside the ocean, which is enjoyable.
- Colourful and pretty!
- The hermit crab face is adorable!

There was no negative feedback.

DISCUSSION

This report reflects on the creation of a picture book aimed at enhancing the understanding of marine natural history through the engaging story of hermit crabs and sea anemones. The positive feedback received from readers serves as a testament to the book's success in achieving its educational and aesthetic goals.

Considering the feedback, the book contributed to increasing scientific knowledge, especially about symbiotic relationships in marine life, with 11 responses providing insights into the mutualistic "win-win" relationships and diversity of sea anemones. This suggests the book effectively conveyed complex ecological concepts in an accessible way, sparking curiosity and a deeper interest in marine biology.

The narrative structure and storytelling approach have also been successful, with 9 positive responses emphasizing the overall appeal of the story. Comments mentionin the story as 'cute,' 'easy to understand,' and 'interesting' support the idea that the narrative structure made the scientific content both relatable and engaging, integrating educational information into an enjoyable experience. Storytelling is recognized for its power to captivate young readers by presenting information in a memorable, resonant way (Dudley et al., 2023; Naul & Liu, 2020; Negrete & Lartigue, 2004).

The illustrations further enhanced the book's impact by immersing readers in the underwater world of hermit crabs and sea anemones. With 15 positive comments, readers appreciated the vivid, colourful depictions that made them "feel like being inside the ocean" and highlighted the beauty and diversity of marine ecosystems. Visual elements improved aesthetic appeal and engagement, reinforcing readers' connection to the content (Gilbert & Stocklmayer, 2012; Hildebrand, 2004; Ramadas, 2009).

The positive feedback from readers about the book's scientific content, narrative appeal, and illustrative quality confirms its effectiveness as an educational resource. This picture book succeeded in achieving its objectives of educating young readers about marine life, fostering an interest in science, and highlighting the symbiosis of marine species.

Creating science picture books requires a blend of accurate biological insights and compelling illustrations. As discussed in this report, illustrations require a deep understanding of both taxonomy and functional anatomy. Given the importance of specimen observation for morphological insights, the contributions of museums and aquariums, which curate such specimens, are invaluable. For example, Sugiura, who is one of the famous Japanese illustrator specializing in crustaceans, was informed by meticulous studies of museum specimens (Orihara, 2015). Thus, collaboration between science and art is essential.

As a scientific picture book, leveraging art and science as dual conduits for marine education proves to be highly effective. Art captivates visual interest and facilitates information dissemination in an engaging manner, making learning enjoyable, especially for children, and reducing aversion to studying. Studies in Britain and Japan reveal overlapping audiences for museums and art galleries (Kato-Nitta, 2013) and there is an affinity for art among those typically disinterested in science. This suggests that presenting science through an artistic lens can attract a broader audience. Vygotsky (1962) posited that art's impact extends beyond cognitive to emotional realms, enriching the encounter with the world through emotional engagement. The global

initiative to blend science and art in marine education, exemplified by Monaco's Oceanographic Museum's foundational ethos of "science-art integration," highlights the universal appeal and effectiveness of this approach (Abbott, 2011).

CONCLUSION

This project demonstrated the efficacy of using science picture books as a medium for marine education, receiving positive feedback for its educational impact. Cultivating interest in marine life among children is vital for the preservation of sustainable resources. Given the relative invisibility of marine compared to terrestrial life, and the inherent challenges in observing the marine environment firsthand, innovative educational approaches are essential. While this study did not engage in quantitative analysis, future investigations should aim to identify the most effective educational tools for marine literacy.

Author contributions: AO: designed the study, created the picture book and the poster, analyzed the data, and wrote the manuscript; **ML:** provided critical biological information; **DF & MK:** aided in data collection and wrote the manuscript. All authors agreed with the results and conclusions.

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Ethical statement: The authors stated that the research did not involve procedures requiring special ethical approval. Any feedback collected from readers was conducted anonymously, ensuring their privacy and confidentiality.

Declaration of interest: All authors declare that they have no conflict of interest.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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