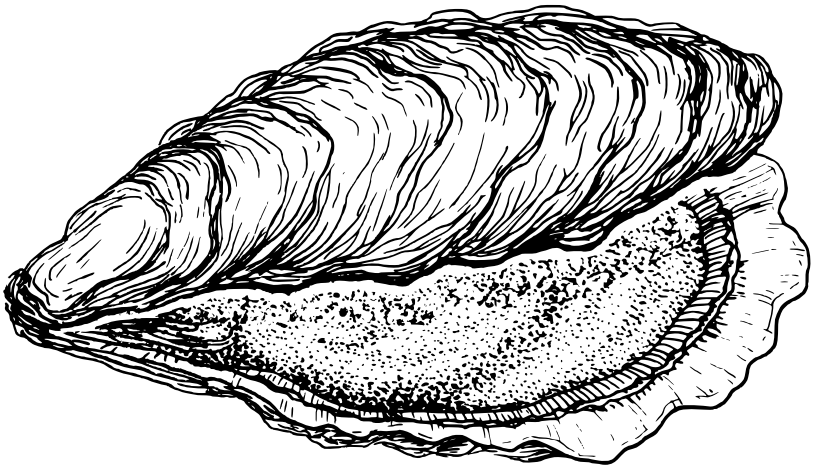
Enhancing the Port Phillip EcoCentre's Citizen Science Program For Mollusc Monitoring



Written By

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Port Phillip EcoCentre

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An Interactive Qualifying Project Report
submitted to the faculty of
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partial fulfillment of the requirements for
the Degree of Bachelor of Science.

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ABSTRACT

Citizen science invites ordinary citizens to participate in scientific studies. In the city of Melbourne, Australia, the Port Phillip EcoCentre specializes in facilitating citizen science programs. The goal of this project was to assist the EcoCentre with their mollusc citizen science program. Through literature reviews, interviews with mollusc experts, a workshop-based approach, and application of the citizen science rubric, our team developed recommendations to improve the EcoCentre's shoreline shell surveys. From this, our team recommended a citizen science program that balances scientific rigor while fostering community engagement.

ACKNOWLEDGEMENTS

First, we acknowledge the Kulin Nations, including the Yalukut Weelam clan of the Boon Wurrung language group, traditional owners of the land on which we are located.
We pay respects to their Elders past and present, and extend that respect to other Aboriginal and Elder members of our multicultural community.

We would also like to give our thanks to the following:

- Our sponsors from the Port Phillip EcoCentre, Mr. Neil Blake, Dr. Sabrina Trocini, Mr. Tyler King, and all the EcoCentre staff. Their insights and feedback throughout our time with the organization were instrumental in the success of our project.
- Our advisors, Stephen McCauley and Beth Eddy, for supporting our team throughout the 14 weeks of research, interviews, and completion of our project. Their perspectives and insight allowed our team to explore new ideas and processes.
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- Our interviewees, Dr. Gary Poore and Mr. Kade Mills. Their expertise within the field was beneficial to our understanding of molluscs and citizen science programs.

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Jack Duryea was primary contributor to the Authorship, List of Figures, Introduction, 3.3: Provide and Implement Recommendations to Update the Survey Process, 5.1: Species Identification Tools, 5.2: Standardized Area and Time, and 5.3: Clear and Precise Methods.

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Cooper Mann was primary contributor to the Acknowledgments, Table of Contents, Executive Summary, 2.3: The Port Phillip EcoCentre's Approach to Citizen Science, 3.4: Determine and Recommend Strategies to Increase Community Engagement in the Mollusc Citizen Science Program, 6.1: Media Inspires People to Engage, 6.2: Accessible Findings Incentivize Citizen Science Involvement, and Appendix A.

EXECUTIVE SUMMARY

PROJECT OVERVIEW

Known as environmental engineers, molluscs are one of the most important and diverse animal groups that inhabit aquatic and coastal ecosystems. Mollusca heavily contribute to structuring the bottom of aquatic ecosystems and offer habitats and food to a wide variety of species (Fortunato, 2015). By converting nutrients to food, they support higher-order species such as seals, birds, fish, dolphins, and even humans. While being a major food source and economically important for humans, mollusca are essential biological indicators regarding environmental changes. With this significant calcareous species having substantial fossil records, they can offer crucial details on past climate occurrences and oceanic shifts. Educating others about the roles molluscs play is vital for the environment and its battle against climate change.

The Port Phillip EcoCentre's mollusc citizen science program uses shoreline shell surveys to evaluate species populations within Port Phillip Bay. Facilitated by members at the Port Phillip EcoCentre, this program has been engaging the community since January 2009. At this stage, the EcoCentre's mollusc citizen science program does not currently have funding and is lacking community engagement and reliability of data. The EcoCentre is interested in improving their program because they want to increase community engagement with mollusc surveys, through the improvement of the current shoreline shell survey.

Figure ES-1: *Collecting shells from the shoreline shell survey*

One way samples of molluscs and shellfish are collected is through the use of citizen science. Citizen science serves a dual purpose of providing important scientific data while engaging and educating the community about various scientific subjects. Facilitators instruct citizen science participants to collect and submit environmental data through structured protocols.

PROJECT OBJECTIVES

The goal of this project is to review and improve the citizen science methods for the Port Phillip EcoCentre's shoreline shell survey. The proposed new survey methods will aim to meet the dual goals of providing the EcoCentre with efficient and reliable protocols for data collection, while also increasing community engagement through user-friendly surveys. To meet this objective, our team split the scope of the project into four primary goals:

INVESTIGATE THE ROLE OF MOLLUSC SPECIES IN PORT PHILLIP BAY AND REPORT ON KEY INFORMATION AND FINDINGS.

DETERMINE EFFECTIVE METHODS OF CITIZEN SCIENCE SURVEYS AND ANALYZE ASPECTS OF THE ECOCENTRE'S SHORELINE SHELL SURVEY.

DEVELOP AND PROVIDE RECOMMENDATIONS TO UPDATE THE ECOCENTRE'S SHORELINE SHELL SURVEY.

DETERMINE AND RECOMMEND STRATEGIES TO INCREASE COMMUNITY ENGAGEMENT IN THE MOLLUSC CITIZEN SCIENCE PROGRAM.

Figure ES-2: *Our four project objectives*

PERSPECTIVE

It was important for our team to consider the themes of scientific value and community engagement throughout our project. Balancing these two themes can be challenging in developing citizen science programs that meet both needs. In some instances, a program sacrifices scientific validity for community engagement, while others prioritize the opposite. Citizen science program facilitators must determine what that balance should be, based upon their priorities and the information that they are interested in gaining. The EcoCentre's initial goal was to engage the community in their mollusc monitoring citizen science program. Our team worked to value their goal, while also taking into account the need for scientific validity.

Our team has prioritized certain aspects of community engagement and scientific rigor, such as developing materials to engage more volunteers with the EcoCentre and improving scientific value by refining survey methods. From our evaluation of the current survey methods, our team found the survey to be very feasible and accessible to citizen scientists. However, there was less scientific value within the survey, due to the focus on community engagement.

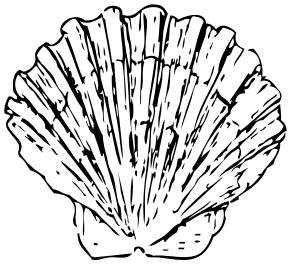
Figure ES-3: *Our team's interview with Dr. Poore*

METHODS

To meet our project objectives, our team utilized numerous research tools. First, we used literature reviews and interviews with field experts familiar with Port Phillip Bay's coastal ecosystem. Specifically, we consulted Baykeeper Neil Blake, Dr. Sabrina Trocini and Tyler King from the Port Phillip EcoCentre, and conducted interviews with Dr. Gary Poore, Principal Marine Biology Curator at Museums Victoria, and Mr. Kade Mills, Victorian National Parks Association Reefwatch Coordinator. These approaches allowed us to gather reliable information about the roles that molluscs play in the environment, the threats they face, and how they currently contribute to the health of Port Phillip Bay.

Next, we reviewed international citizen science programs, using this as a comparison to the current citizen science methods employed by the EcoCentre. In addition, we used our expert interview to gain knowledge about best practices related to citizen science surveying tools. This research aided us in our analysis of the current mollusc citizen science program. We also conducted the current shoreline shell survey with the EcoCentre, which gave us valuable insight into the current survey methodology and feedback from participants.

Our team then recommended a new survey methodology to improve the EcoCentre's current shoreline shell survey. Our team aimed to refine the surveys through two desired outcomes. The first outcome focused on improving the volunteers experience, while still keeping the survey feasible and enjoyable. Secondly, we focused on designing a survey to gain reliable and useful scientific data. One of our main methods to achieve this was a more precise and thorough methodology, reducing the potential confusion volunteers could face when participating in the program.



Lastly, our team used the previously mentioned interviews and case studies to analyze successful citizen science programs. In combination with these tools, the team performed an on-site workshop with EcoCentre staff. We used their Citizen Science Evaluation Rubric, developed by a previous Worcester Polytechnic Institute team, to evaluate the target outcomes of the current mollusc citizen science program. From the workshop, we received valuable feedback on how well the current program meets the rubric criteria and areas for improvement.

FINDINGS

Using the information from case studies, interviews, and personal experience, our team discovered four primary principles to use as criteria for refining the shoreline shell survey:

1. Citizen science programs must balance scientific value and community engagement.
2. Measuring metrics provide scientific value.
3. Consistent methodologies supported by identification resources ensure data reliability.
4. Standardized collection areas lead to reliable and comparable data.

Some of the key aspects of the shoreline shell survey updates included species identification, survey location and area considerations, and new methods. We developed a species identification guide which serves as a resource that can excite citizens about molluscs, aiding to our goal of increasing community engagement. To standardize survey study areas, the team created a shoreline survey location guide. With the EcoCentre's current survey locations, the team outlined boundaries at each beach to guide the participants' study. Standardized survey areas will allow the EcoCentre to monitor species population trends within these areas over time. Finally, we clarified the current survey methods, as well as developing a new methodology for participants.

Figure ES-4: *A page from our new Species Identification Guide*

We also developed a set of principles that guided our recommendations for a program website:

Figure ES-5: *Community engagement principles*

Within the recommendations, we include our informational report, *Molluscs Matter: A Guide to Molluscs*.

From all of our findings, the final project deliverables focus on providing the EcoCentre with materials to enhance and promote their citizen science mollusc program. Through updated survey methodology, supplementary resources, and a proposed website design, these deliverables serve to engage community members while providing important scientific value towards mollusc population trends. The EcoCentre can utilize this material to improve the impact of citizen science programs around Port Phillip Bay.

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INTRODUCTION

Known as environmental engineers, molluscs are one of the most important and diverse animal groups that inhabit aquatic and coastal ecosystems. Mollusca is a phylum of invertebrates that have soft bodies which are typically protected by a hard exoskeleton. They are categorized into four major groups: gastropods, bivalves, cephalopods, and scaphopods. Mollusca heavily contribute to structuring the bottom of aquatic ecosystems and offer habitats and food to a wide variety of species (Fortunato, 2015). By converting nutrients to food, they support higher-order species such as seals, birds, fish, dolphins, and even humans. While being a major food source and economically important for humans, mollusca are essential biological indicators regarding environmental changes. Being significant calcareous species with substantial fossil records, they can offer crucial details on past climate occurrences and oceanic shifts. This helps humans to improve their comprehension of anticipated future changes or events (Fortunato, 2015).

Climate change and overfishing directly threaten the status of mollusc populations. Contaminants, pollutants, pathogens, and organic and inorganic materials can all be detected through physiological sampling of molluscs (Comeau, 2017). The health status of aquatic ecosystems and the effects of climate change can be monitored and assessed through the status of molluscs. Scientists look to preserve species that are extremely valuable to monitoring and maintaining environmental health. Educating others about the roles molluscs play is vital for the environment and its battle against climate change.

Figure 1*: Sea snail, a surface deposit feeder (Cavallaro, 2020)*

One way samples of molluscs and shellfish are collected is through the use of citizen science. Citizen science serves a dual purpose of providing important scientific data while engaging and educating the community about various scientific subjects. Facilitators instruct citizen science participants to collect and submit environmental data through structured protocols. Volunteers are provided with long-lasting fulfillment and future learning opportunities within citizen science programs (Ryan et al., 2001).

The scientific value of citizen science projects has improved over time, contributing to numerous peer-reviewed publications on current environmental issues (Robinson et al., 2018). The protocols citizen scientists follow are created and maintained with the use of a citizen science rubric. These rubrics guide project facilitators to create and adjust project scope and deliverables, methods, participation, and communication. Citizen science rubrics are essential to understanding project limitations and areas for improvement by evaluating all aspects that go into a citizen science program (Golumbic & Oesterheld, 2023). The rubrics are also a key tool in evaluating the balance between community engagement and scientific rigor, which is a core theme of citizen science. Currently, numerous tools exist to facilitate citizen science projects. The digital age has brought about platforms like iNaturalist and ObsIdentify, which help identify and share data from citizen science projects.

***Figure 2**: Our project team with our sponsor, the Port Phillip EcoCentre staff*

At the Port Phillip EcoCentre, a diverse team of dedicated volunteers work together to address the effects of humans and climate change on Port Phillip Bay. The group currently hosts numerous citizen science projects through community and educational programs (Volunteer with Us | Get Involved, n.d.). With these programs, the EcoCentre makes a direct impact on the environment, while providing its volunteers with a sense of purpose and fulfillment. One such project, the mollusc citizens science program, uses shoreline shell surveys to evaluate species populations within Port Phillip Bay. This program has been engaging the community since January 2009. At this stage, the EcoCentre's mollusc citizen science program does not currently have funding, is lacking community engagement and reliability of data. The EcoCentre is interested in improving their program because they want to increase community engagement with mollusc surveys, through the improvement of the current shoreline shell survey. Our team focused on investigating the role of molluscs in Port Phillip Bay and determining effective methods of citizen science shell surveys and programs. We then provided recommendations to both the current shoreline shell survey and the EcoCentre's citizen science mollusc program through media content. These objectives meet our project goal to increase community engagement with their program, while also increasing the reliability of data with their shoreline shell surveys.

BACKGROUND

In this section, we discuss the current threats to Australia's coastal ecosystem, and locally the ecosystem in Port Phillip Bay. We elaborate on the contributions of citizen science to this issue, offering examples of tasks carried out by the Port Phillip EcoCentre.

2.1: Threats to the Molluscs in Port Phillip Bay

Like many other nations, Australia is currently tackling the issue of climate change. Recently, Australia has been experiencing extreme weather conditions that cause damage to their natural ecosystems. The consistently high atmospheric temperatures have increased the temperature of the water, causing marine heatwaves. Marine heatwaves are long periods of excessively warm sea surface temperatures that lead to detrimental effects on the ocean and its inhabitants. Rising water temperatures have negatively affected mollusc populations. Molluscs are unable to adapt to warmer temperatures, and many species are unable to migrate to cooler water due to their lack of mobility. Bivalves, molluscs with a two-part hinged shell, are very sensitive and vulnerable due to heat stress. Their growth and filtration process is hindered by higher temperatures, leading to mortalities (Golumbic & Oesterheld, 2023).

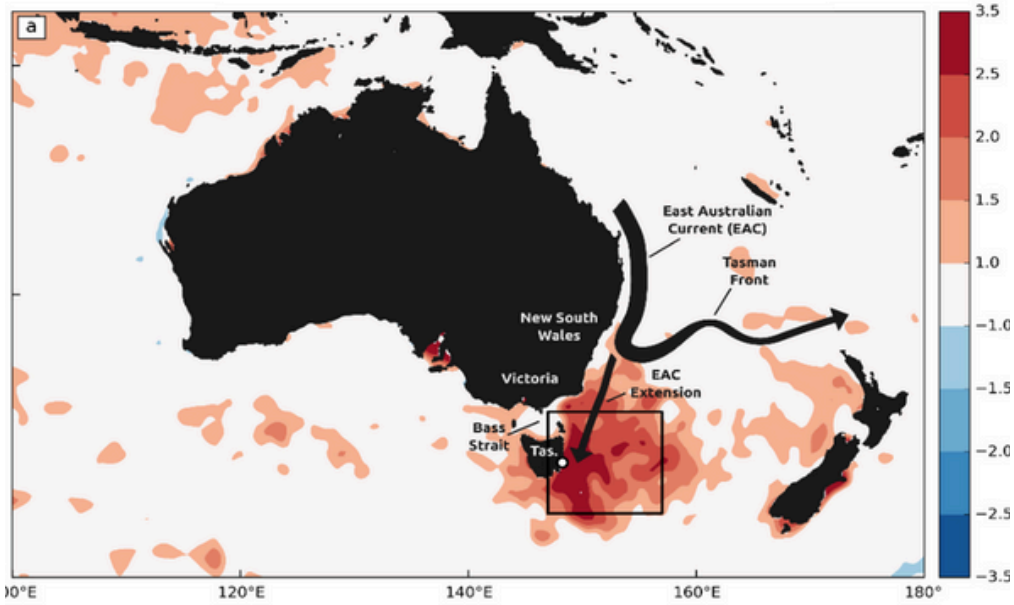


Figure 3 represents the seawater temperature increase due to marine heatwaves that affected Australia in 2015. As pictured, the intensity of the marine heatwaves is highest on the southern coast, in close proximity to Port Phillip Bay.

Figure 3: *Major marine heat waves around Australia in 2015 (Marine Heatwave News, n.d.)*

The intense climate is also affecting the potential of hydrogen (pH) of the water. As humans emit greenhouse gasses, atmospheric carbon dioxide (CO_2) levels continue to rise. When seawater absorbs atmospheric CO_2, a series of chemical reactions occur causing an increased concentration of hydrogen ions. This process causes the pH of the ocean water to decrease and is known as ocean acidification (Ocean Acidification, 2020). Molluscs are directly affected by this negative process. During ocean acidification, carbonate ions bond with the excess hydrogen created. This reduces the number of carbonate ions available for calcareous species, such as molluscs, to build and preserve their hard exoskeleton (Ocean Acidification, 2020). When the pH gets too low, the exoskeleton will weaken, break down, develop abnormalities, and potentially dissolve.

The State of Climate report published by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) stated that the pH of Australian surface waters has decreased by 0.12 units in the past 140 years. This represents a 30 percent increase in acidity (*State of the Climate*, 2022). This dangerous acidity creates conditions that will eat away at the mineral responsible for building the mollusca skeleton and shells. Climate change has and will continue to affect the state of these organically formed ecosystems. Figure 4 displays the continual rise in atmospheric and seawater carbon dioxide, and decrease in seawater pH. Since 1960, all of these values have trended in the wrong direction and will continue to threaten marine ecosystems.

At a local glance, Port Phillip Bay, located on the southern coast of Australia, hosts a diverse ecosystem. This bay demonstrates biodiversity within marine life by hosting a variety of species. For this reason, the health of this bay is deemed to be fair (Victoria, 2022). However, climate change and invasive species threaten the species of Port Phillip Bay. Just in 2021 alone, there were 160 invasive species located within Port Phillip Bay (*State of the Marine and Coastal Environment 2021 Report | CES*, 2021). Given the bay's diverse nature, the role of each species within this ecosystem is important. Especially with the issue of invasive species, shellfish face a decline in their populations.

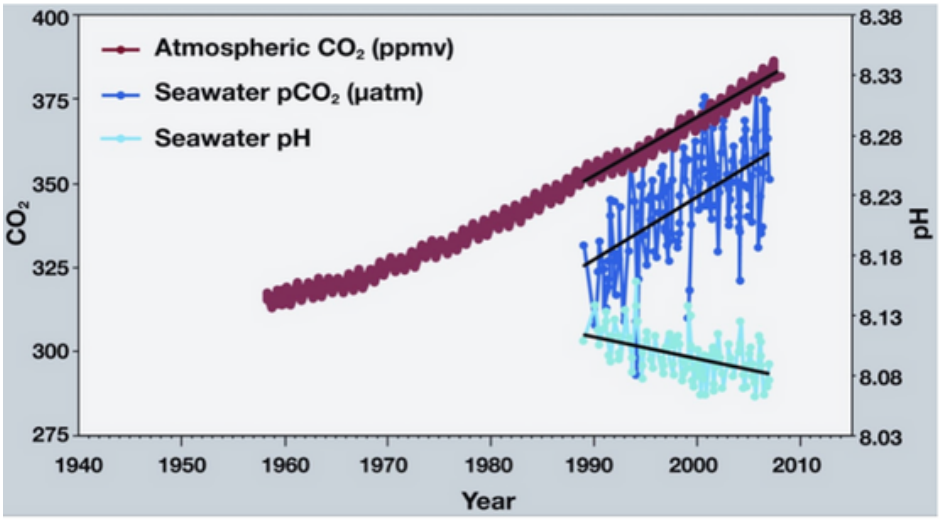


Figure 4: *Carbon dioxide and seawater pH levels by year (National Oceanic and Atmospheric Administration, 2020)*

Figure 5: *Northern pacific seastar (Marine Biosecurity Porthole, n.d.),*

The *Asterias amurensis*, also known as the Northern Pacific Seastar, is an invasive species that directly impacts the ecosystem. First spotted in 1995, the Northern Pacific Seastar is believed to have originated from Japan and migrated into Port Phillip Bay from Tasmania's Derwent Estuary (Volunteer with Us | Get Involved, n.d.). Females can carry up to 20 million eggs (Volunteer with Us | Get Involved, n.d.). The seastar is responsible for being an aggressive predator toward oysters, mussels, and scallops (Northern Pacific Sea-Star (*Asterias amurensis*), 2023). The seastar negatively affects the population by decimating native biodiversity within Port Phillip Bay. Due to their voracious nature and high spawn rate, mollusc and shellfish populations face a potentially unstoppable predator.

2.2: Current Mollusc Survey Methods in Port Phillip Bay

The coastal ecosystem within Port Phillip Bay is currently being monitored through the use of shoreline shell surveys. Current research shows that there are six main feeding types of soft-bottom molluscs within this bay: epifaunal and infaunal suspension feeders, surface deposit feeders, grazers, predators, and scavengers (Poore & Rainer, 1974). The general distribution of major mollusc species within this area is known, but scientists are interested in monitoring the general distributions to observe any changes, especially with the rise of climate change. Distributions of molluscs are mainly based on food supply and various external factors, so changes can serve as an indicator for unhealthy circumstances (Murphy, 2015).

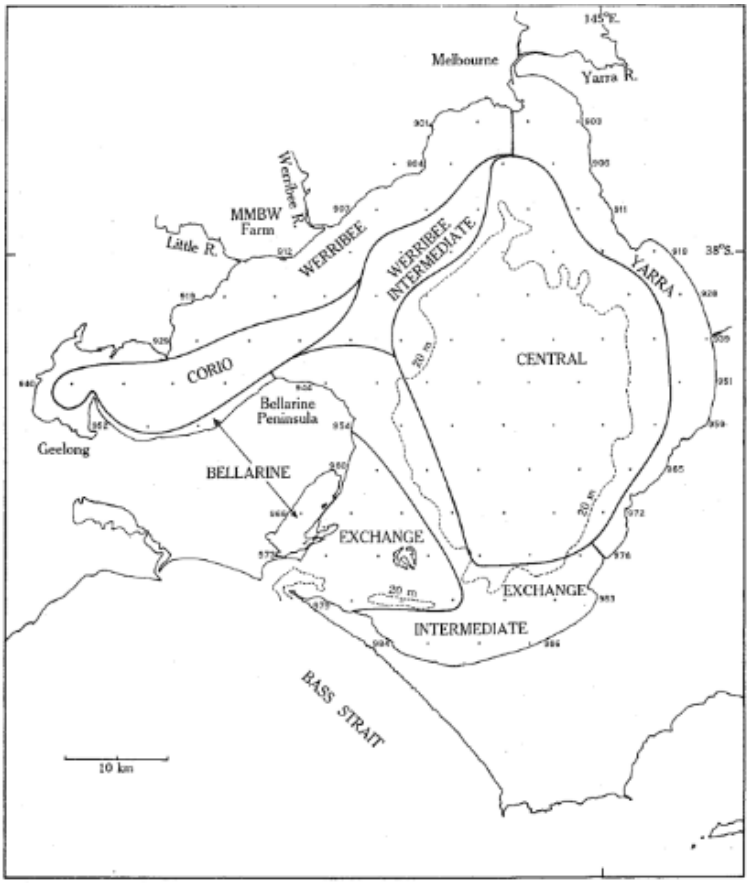


Figure 6: *Sampling protocol for Poore and Rainer 1974 study of molluscs in Port Phillip Bay (Poore & Rainer 1974)*

Besides the factor of distribution, scientists study molluscs to investigate any patterns of diversity. If a specific mollusc species is decreasing at a higher rate than average, scientists can witness the potential effects of invasive species in real-time. The current methods of collection consist of applying a grid on the Bay's total area, with a total of 86 separate stations labeled from 901-986. It spans across the majority of the bay and accounts for mollusc regions (Poore & Rainer, 1974). With this grid method set in place, surveyors completed the data collection of species samples at the floor of the bay over a defined area. These surveyors collected samples with two main methods: grab sampler or suction sampler (Poore & Rainer, 1974).

Both methods are useful to get an overall scope of the distribution. Using the collected data, statistical analysis showed the abundance and biomasses of mollusc populations. However, several limitations come with data collection. Surveyors failed to collect the majority of mollusc data at an efficient rate while accounting for most of the area, due to the lack of sufficient resources.

Also, most shells found in beach-based sampling areas have already died. This leads to confusion as to whether scientists should include the counting of dead shells, also known as fresh kills, within the species inventory. With the inclusion of fresh kills in data collection, scientists can gain more information on biodiversity, compared to live sampling. On the other hand, limiting the data to only include the true lifespan of molluscs can result in more accurate data about their actual living population. Another limitation with shoreline data collection includes the timing of sampling. Low-tide periods on the beach provide a reliable sampling window for analyzing beach ecosystems, but the timing acts as a constraint for overall data (Schlacher et al., 2008). A balance between feasibility and reliability provides sufficient amounts of information without expending too much effort in sampling. Even with these limitations, scientists determined that surveying systems are the best practice for beach data collection.

2.3 The Port Phillip EcoCentre's Approach to Citizen Science

Currently, the Port Phillip EcoCentre is undertaking the task of improving shoreline shell surveys within the Port Phillip Bay. In order to improve public knowledge about the effects that climate change has on mollusc communities, the EcoCentre conducts citizen science within their survey guidelines. Their citizen science program aids environmental education, emboldening the community to participate in numerous fields including marine science. In 2023, the EcoCentre had approximately 14,000 individuals participating in its various citizen science programs. The result of this participation led to 96% of participants having an increased knowledge of local ecosystems, and 88% of participants feeling more involved within the community (*Volunteer with Us | Get Involved*, n.d.). Using effective methods for citizen science will strengthen environmental awareness of endangered ecosystems affected by climate change. Despite all of this, the shoreline shell surveys have been completed only very sporadically, and data has not been collected and recorded since 2019.

Figure 7: *Participants engaged with shoreline shell survey*

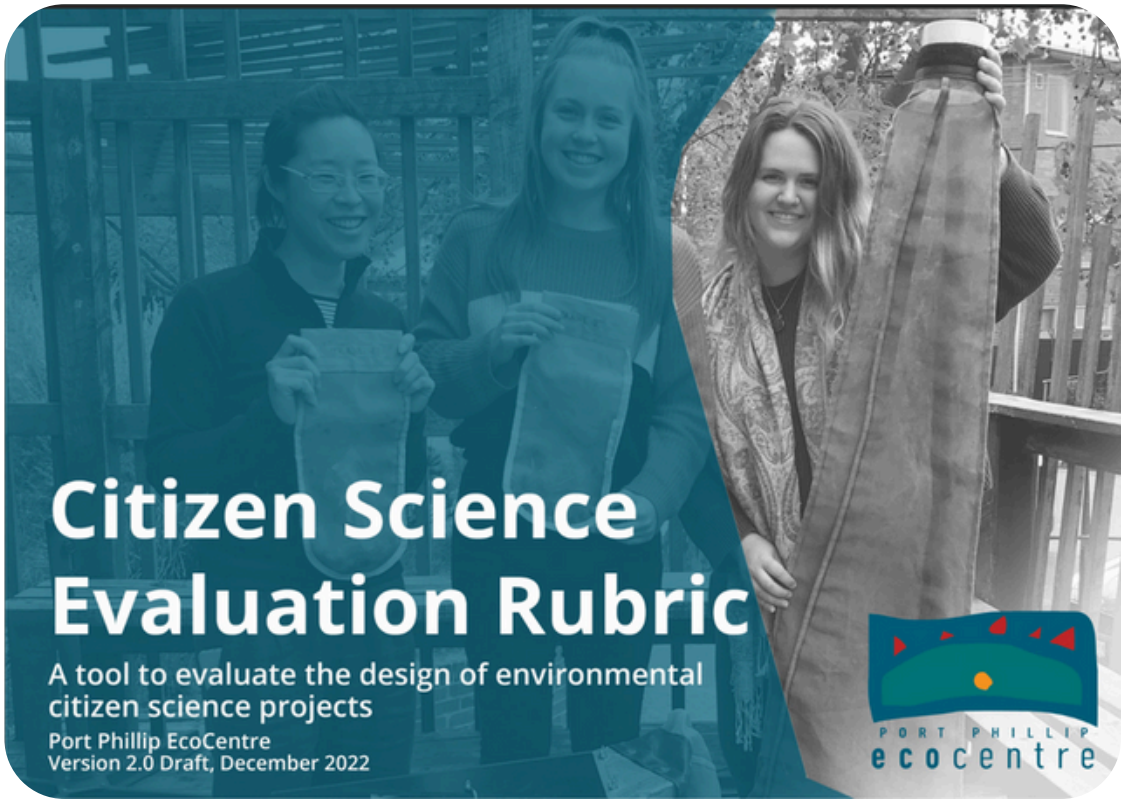


Figure 8: *Citizen Sceince Evaluation Rubric (Volunteer with Us | Get Involved, n.d.)*

In December of 2022, another student project team from Worcester Polytechnic Institute (WPI) had the opportunity to work with the Port Phillip EcoCentre. In 2017, the EcoCentre developed an evaluation rubric to assist citizen science facilitators with improving the design of their projects. The 2022 WPI team's goal was to improve the EcoCentre's rubric and promote citizen science. They researched literature, worked with the EcoCentre staff and conducted interviews with citizen scientists all in an effort to improve the rubric for participation in citizen science.

Now, the EcoCentre's citizen science rubric acts as a good resource for evaluating citizen science projects, and our team intended to use this rubric for the shoreline shell survey. The citizen science rubric helps with the trade offs associated with the balance between scientific reliability and community engagement.

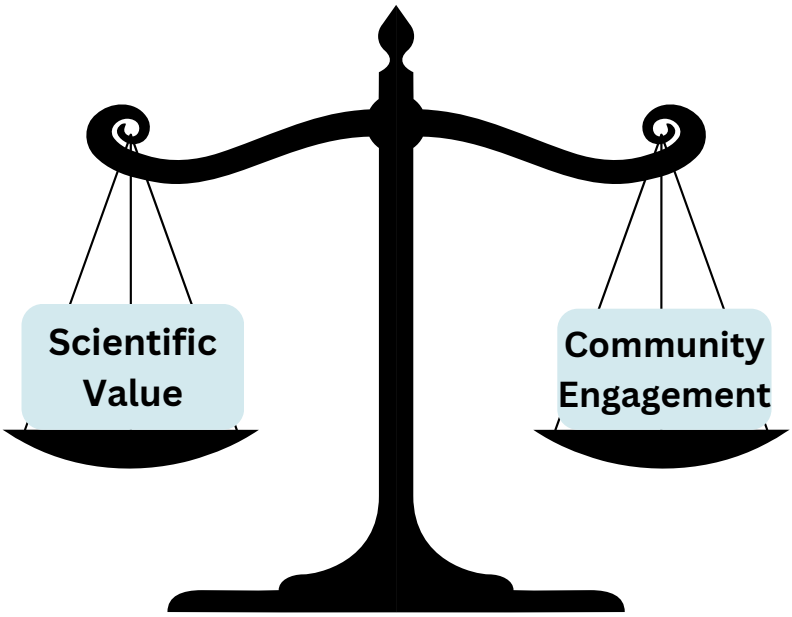


Figure 9: *Balance of scientific value and community engagement*

METHODOLOGY

The goal of this project is to review and improve the citizen science methods for the Port Phillip EcoCentre's shoreline shell survey. The proposed new survey methods will aim to meet the dual goals of providing the EcoCentre with efficient and reliable protocols for data collection, while also increasing community engagement through user-friendly surveys. To meet this objective, our team split the scope of the project into four primary goals:

1. Investigate the role of mollusc species in Port Phillip Bay and report on key information and findings.
2. Determine effective methods of citizen science surveys and analyze aspects of the EcoCentre's shoreline shell survey.
3. Develop and provide recommendations to update the EcoCentre's shoreline shell survey.
4. Determine and recommend strategies to increase community engagement in the mollusc citizen science program.

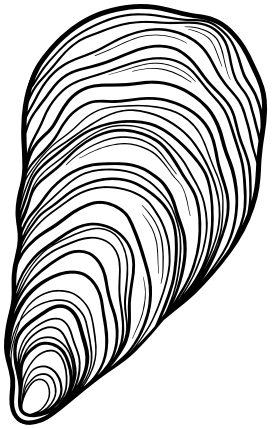
In the following sections, we describe the methods used to reach our research goals. This research took place between March and May 2024. (*Appendix A* details the timeline for implementing these methods).

Figure 10: *Blue mussel bed (Marine Life Information Network, Keith Hiscock, 2024)*

3.1 Assessing the Status of Port Phillip Bay Mollusc Species

Molluscs play a crucial role in Port Phillip Bay, shaping the aquatic ecosystems by providing habitats and sustenance for diverse species. As significant food sources and biological indicators, they hold environmental and economic importance. For this reason, our team needed to be conscious of the status of mollusc species in Port Phillip Bay. Our first deliverable is an informational report that will review and discuss the environmental roles and importance of molluscs in the bay. This report also summarizes current research information, and is targeted for citizens interested in learning more about molluscs in the bay. The team conducted literature reviews and interviews to meet this objective.

First, our team performed literature reviews. These reviews allowed our team to gather reliable information about the roles that molluscs play in the environment, and ultimately how they currently contribute to the health of Port Phillip Bay. Our team also conducted semi-structured interviews with field experts familiar with Port Phillip Bay's ecosystem. Specifically, we have consulted Baykeeper Neil Blake, Dr. Sabrina Trocini and Tyler King from the EcoCentre, and conducted interviews with Dr. Gary Poore, Principal Marine Biology Curator at Museums Victoria and Mr. Kade Mills, Victorian National Parks Association Reefwatch Coordinator. These interviews were conducted through an expert interview approach. We created a few research questions to help us achieve this objective:



1. In what specific ways do molluscs contribute to their surrounding coastal ecosystem?
2. With your experience, what do you think are the most current threats in Port Phillip Bay?

3.2 Determine Effective Methods of Citizen Science Survey Execution and Data Collection

Citizen science in the form of shoreline shell surveys is an essential source of data collection for the Port Phillip EcoCentre. Our project focused on evaluating their mollusc citizen science program. The research allowed the project team to determine effective and ineffective strategies and methods of citizen science. Understanding the factors that make citizen science reliable, and more accessible was important to develop recommendations to the EcoCentre's program. Before adjusting the EcoCentre's citizen program, the project team needed to be proficient in what makes a citizen science program successful.

Figure 11: *Aspects of strong citizen science programs*

To achieve this objective, our team reviewed international citizen science programs and compared findings to the current citizen science methods employed by the EcoCentre. Analyzing the approaches used from the citizen science case studies was a key component of this method. In addition to the case studies, the group had citizen science-related questions prepared for our consultations with Neil Blake, Dr. Sabrina Trocini, Tyler King, and our interviews with Dr. Gary Poore and Kade Mills. In *Appendix B*, the logistics of the interviews are explained. Their experience with Museums Victoria and the Victorian National Parks Association provided valuable insight into current data collection methods through citizen science. We developed research questions to reach this objective:

1. How do human error and lack of background knowledge impact citizen science-driven data collection?
2. What are some current key pieces of information that your organization uses from citizen science surveys?
3. How do you ensure the quality and reliability of data collected through citizen science projects?
4. How do you engage and retain participants in citizen science projects for the long term?
5. What are some methods that you are familiar with for monitoring population trends with aquatic life?

Figure 12: *Shoreline shell survey completion with Baykeeper Neil Blake*

Lastly, the project team also performed the EcoCentre's shoreline survey under the supervision of Baykeeper Neil Blake. The project team evaluated the process through the first-person user experience of the shoreline surveys. Performing the survey allowed the project team to experience the shoreline surveys firsthand. In Figure 12, our team determined what survey features were effective and enjoyable. On the other hand, our team looked for areas for improvement and recommended new features. The combination of case studies, interviews, and our experience gave us an overarching view of the current mollusc citizen science program and international survey methods.

3.3 Provide and Implement Recommendations to Update the Survey Process

Following the research and analysis of citizen science, we developed new methodology to improve the EcoCentre's shoreline shell surveys. Our team aimed to refine the surveys to achieve the desired outcomes. The first desired outcome was to improve the experience for the user, by ensuring data collection is feasible and enjoyable for the citizens partaking in the surveys. The volunteer experience is important to the EcoCentre for promoting community engagement. Maximizing the volunteers' participation will not only increase their enjoyment but will advance their education. The project team hoped to increase involvement in shoreline shell surveys and expand awareness of the roles molluscs play to citizens and the community. A refined survey with clearly outlined protocols and methods will lead to a more accessible survey for citizen science participants.

The second desired outcome was to gain reliable and useful scientific data. Clarity within methods are vital, as volunteers should be able to comprehend every step of the survey without confusion. This allows the volunteer to complete the survey process without any mistakes in data collection. In some cases, supplementary resources are necessary in aiding the volunteers survey process. A refined shoreline survey could produce data that will help monitor mollusc population trends throughout Port Phillip Bay. Standardizing survey efforts will produce more comparable data between surveys done over time. Survey area and time are the two main factors that should be standard for every survey.

The core of strong citizen science studies balances community engagement and scientific validity. The survey methodology adjustments aimed to provide both reliable scientific data and new material to engage participants.

Figure 13: *Mr. Blake identifying molluscs during shell survey*

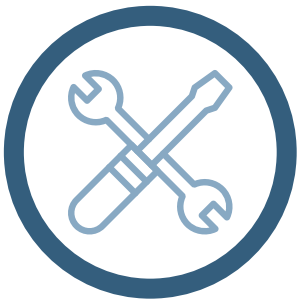
3.4 Determine and Recommend Strategies to Increase Community Engagement in the Mollusc Citizen Science Program

Educating the community about the Port Phillip Bay molluscs and the EcoCentre's mollusc citizen science program was a key component of the project. The EcoCentre prioritizes connecting people to nature through their citizen science programs. Utilizing different platforms and outreach strategies, the project team hopes to increase involvement in the mollusc citizen science program and promote environmental advocacy. This will provide volunteers with an outlet to maintain a strong and healthy ecosystem by connecting them to nature.

The interviews conducted with Dr. Poore and Mr. Mills, as well as the case study analysis performed in previous objectives were used here to analyze successful citizen science programs. Our interviews focused on community engagement, specifically advertising strategies and solutions to connect the community. The case studies, however, focused on the connections between participation and community engagement within citizen science programs, and on tools to strengthen this connection.

INTERVIEWS

CASE STUDIES



WORKSHOP

To gain further knowledge about the current effectiveness of the mollusc citizen science program, our team conducted an on-site workshop with EcoCentre staff and past shoreline shell survey participants. The participants analyzed the shoreline shell survey through the lens of the Port Phillip EcoCentre's Citizen Science Evaluation Rubric, developed in December 2022 by a previous WPI student project team. This rubric uses four major categories to evaluate a successful citizen science program. Those themes are Project Scope and Deliverables, Scientific Methods, Participant Recruitment and Retention, and Communication. At the workshop, the participants provided our team with their input on how well the survey meets the criteria of the rubric, and if there are areas for improvement within the current program. That input was used by our team to further evaluate and provide recommendations.

FINDINGS

Throughout our research, discussion, and interviews, we identified key findings that connect directly to our objectives. In the following section, we will detail our findings and analysis of the evidence collected.

4.1 The Status of Port Phillip Bay Mollusc Species

Throughout the project, we have performed desktop research, literature reviews, and interviews in order to gain significant knowledge on the role molluscs play in Port Phillip Bay. The combination of these research tools aided the development of our informational report, *Molluscs Matter: A Guide to Molluscs*. The main purpose of this report was to provide casual citizen scientists with background knowledge on the role of molluscs in Port Phillip Bay. The report primarily discusses the different types of molluscs, their environmental roles, and threats that they face. We found that providing this information through an organized report addressed the knowledge gap between citizens and the role molluscs play in the coastal ecosystem.

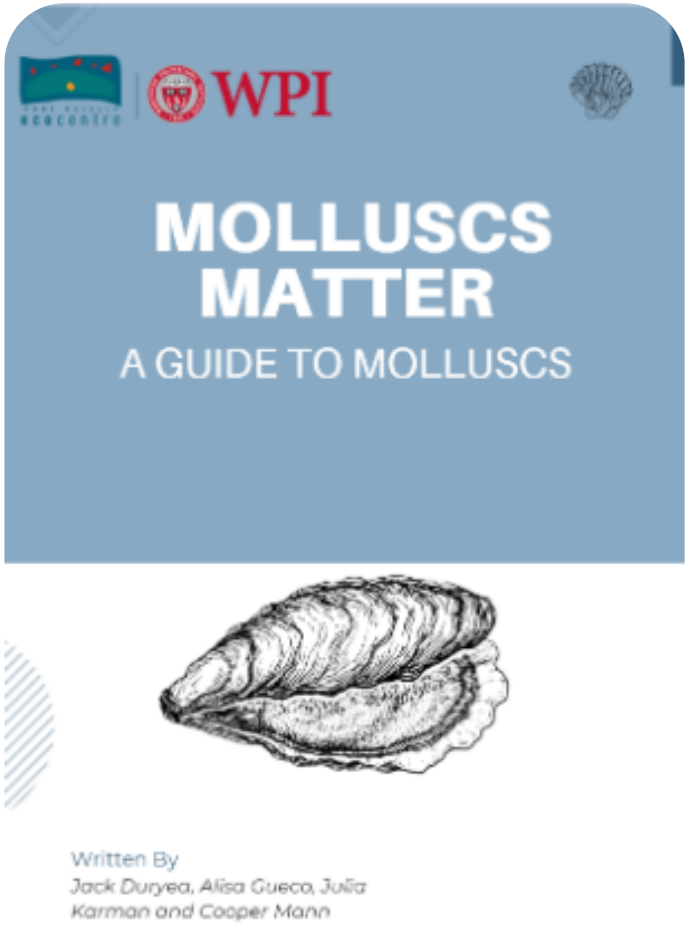


Figure 14: *Molluscs Matter Cover*

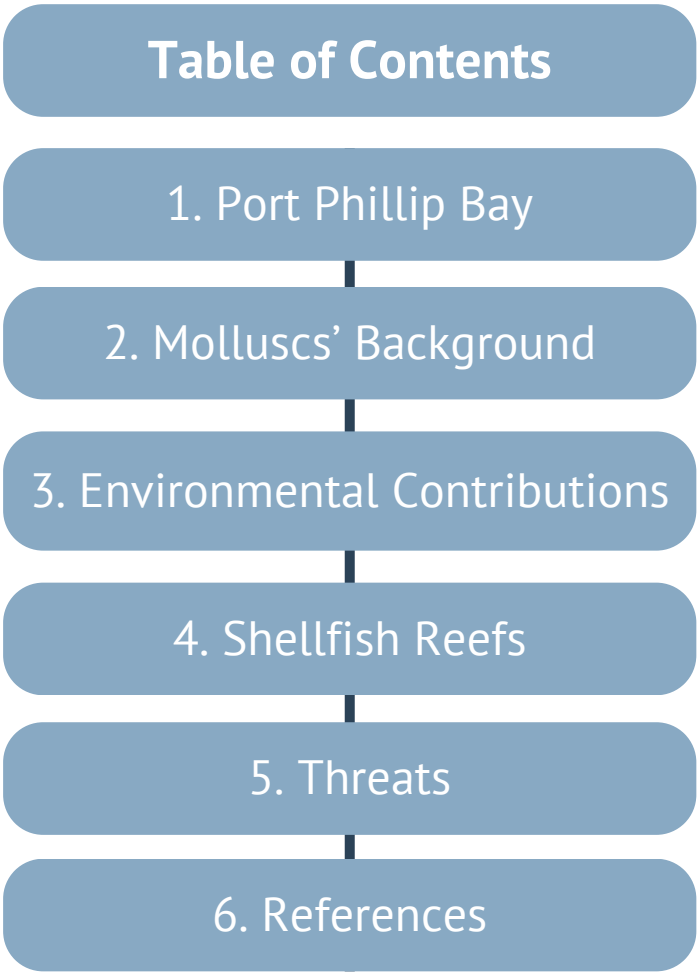
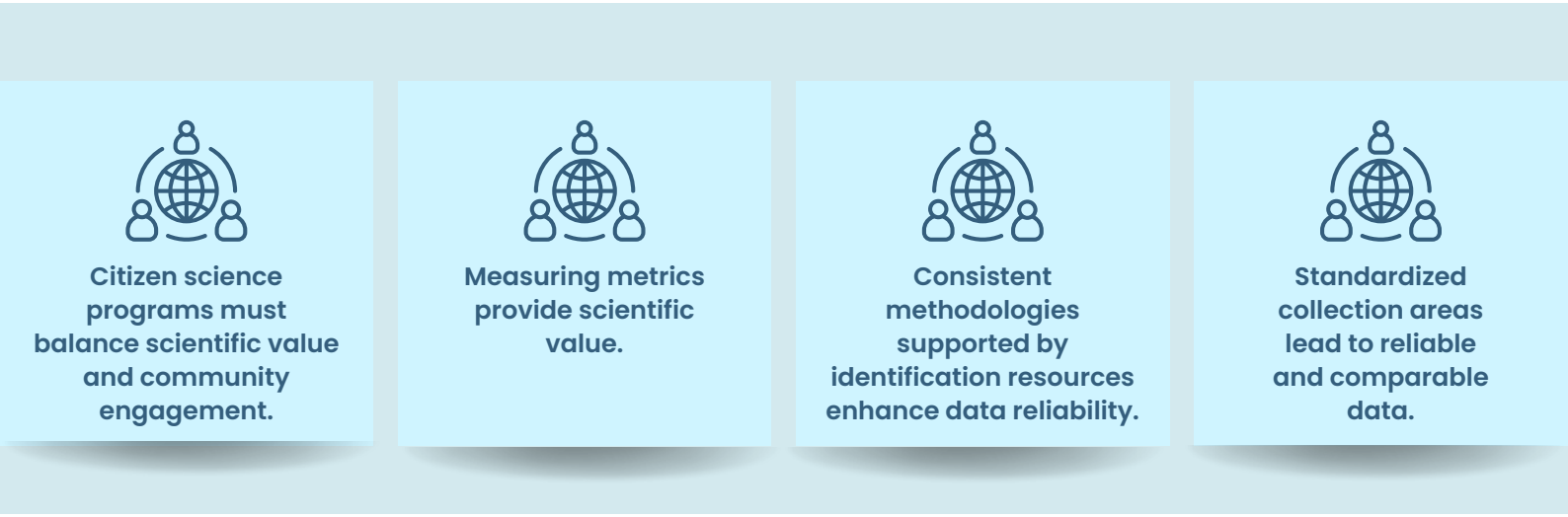


Figure 15: *Molluscs Matter Table of Contents*

4.2 Effective Methods of Citizen Science Survey Execution and Data Collection

Using the information from case studies, interviews, and personal experience, we discovered important principles of citizen science surveys. Our team discovered four primary principles to use as criteria for refining the shoreline shell survey:



Figures 16: *Criteria for survey evaluations*

In the following sections, we describe the development of these principles.

4.2.1: Citizen science programs must balance scientific value and community engagement.

For the duration of our project, our team has balanced aspects of community engagement and scientific rigor, such as developing materials to engage more volunteers with the EcoCentre and improving scientific value by refining survey methods. After conversations with Dr. Trocini and Mr. Blake, who each have unique perspectives on this topic, our team learned how the EcoCentre values community engagement, such as school programs and youth groups conducting projects. In addition, both hope that future data collected by citizen scientists can be used for research purposes, with clearly defined protocols and regulations by the EcoCentre's Citizen Science Evaluation Rubric. While analyzing various articles, a common research question regarding citizen science was, "how can the design of citizen science projects lead to higher quality data?" (Ellwood et al., 2017) We made sure to take scientific validity seriously, while honoring the EcoCentre's goal of connecting people to nature. Balancing these two themes can be challenging in developing citizen science programs that meet both needs. In some instances, a program sacrifices scientific validity for community engagement. In other instances, they do the opposite. Citizen science program facilitators must determine what that balance should be, based upon their priorities and the information that they are interested in gaining.

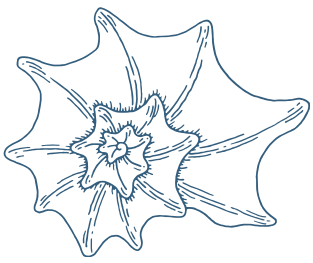
4.2.2: Measuring metrics provide scientific value

After studying shoreline shell surveys from international standpoints, our team analyzed how different countries performed their mollusc surveys. Specifically, we studied three shoreline shell methods around the world, all of which have measuring metrics in place. Each citizen science program has a different scale at how useful their data is, and this all depends on the strength of those measuring metrics. After discussion, our team found that it was necessary to have measuring metrics in place for citizen science surveys in order to provide a level of scientific value.

Figure 17: *The Big Sea Shell Survey (EOS, 2024)*

Every year, LifeWatch Belgium organizes the Big Seashell Survey, a successful approach to conducting citizen science surveys. In 2024 alone, participants collected 114,093 shells throughout the survey. (EOS Science, 2024). The overall purpose of the Big Seashell survey is to encourage citizen science engagement rather than to have a high degree of scientific value. For Belgium's methodology, facilitators instructed citizens to collect 100 shells in premarked quadrants of the beach. Belgium takes the number of shells identified in each species and divides the value by 100. For example, if there are 2 specific shells out of 100, then they determine that the abundance is 2%. This method was understandable for citizens to perform, but in turn, the collected data held a low degree of scientific value.

In New Zealand, the Ministry for Primary Industries (MPI) has funded Northern New Zealand surveys since 1992. Their shoreline shell survey emphasizes scientific reliability. The organization has used the survey results to provide fisheries with important information about changes to shellfish populations and to compare population counts across the years (Ministry for Primary Industries, 2014). Within these surveys, molluscs are counted and measured from marked quadrants in each shellfish bed. These quadrants were predetermined randomly, based upon a combination of a "systematic design and a two-phase stratified random design" (Berkenbusch & Neubauer, 2017). In simple terms, a two-phase stratification sampling method involves collecting a large sample in the first phase, classifying the selected sampling units, and then using those classified units as marked lots in the second sampling phase. This method is effective because it is statistically sound. However, a flaw within their method is that it is too complicated for citizen scientists to apply to their surveys. The program was developed as a scientific initiative, not a citizen science program meant to engage community members.



In Tasmania, scientists follow a similar method as those in New Zealand. The Institute for Marine & Antarctic Studies conducts biomass surveys for mollusc observation. This involves random sampling of quadrants within the shellfish beds (Keane, 2019). The shoreline shell survey uses the information to determine their fishery's size structure, and if there are enough smaller-sized clams and oysters to populate the fishery in years to come. The program is focused on collecting reliable data, rather than prioritizing community engagement since their purpose was to gain important information about changes to shellfish populations.

Figure 18: *Tasmania*

From our case study analysis, all three shoreline shell surveys had varying standards in regard to measuring metrics. Because of this, each project had varying levels of scientific value. From our experience in conducting the EcoCentre's shoreline shell survey, we learned that there are instances where unclear measuring metrics can make it hard to record data. For example, estimating the abundance of shells on a beach could be different for individuals, since there is no standard to base their estimation on. Ultimately, it is up to each program to determine how much scientific value they want their measuring metrics to have.

4.2.3: Consistent methodologies supported by identification resources enhance data reliability

After first-hand experience with surveys and expert input, our team found that it was necessary to update the shoreline shell survey methodology. A uniform survey instruction procedure will benefit the results because it will ensure that each participant will be performing the survey in similar ways. The survey methods should also be thorough and precise. Clear methodology reduces confusion while participating in the survey, ensuring data reliability through repeatable results.

4.2.4: Standardized collection areas lead to reliable and comparable data

Our team's main focus is to adjust the survey methodology to ensure the EcoCentre receives reliable data from citizen scientists. One of the important data trends to monitor is the mollusc population. The standardized area is a key tool to monitor population trends, as we found from both the Great Victorian Fish Count and the study conducted by Dr. Poore.

A strong citizen program engages the surrounding community and provides reliable scientific data. Mr. Mills stated that, "in order to monitor population trends, area needs to be standardized." When the Great Victorian Fish Count is completed each year, the same locations and areas are studied. There is no variance in the defined study areas. In addition, during Dr. Poore's interview, he reinforced Mr. Mills's idea of a well-defined survey area. In conclusion, these interviews emphasized the importance of including the standardization of area within our team's shoreline shell survey recommendation.

4.3: Key Aspects to Current Survey Methods

While participating in the shoreline shell survey, our team identified key aspects within the EcoCentre's survey methods. The directions in the EcoCentre's current survey entail choosing two landmarks about 40 paces apart at any beach around Port Phillip Bay. The first key aspect of this was that the participants taking the survey were the ones responsible for determining those two landmarks, allowing area at any survey location to vary between volunteers. Different shells could be present in different areas, which could lead to biased results from data collection. Through participant observation, our team found that there was confusion in ensuring correct shell identification. Confirmation on specific shell species was necessary from Mr. Blake or an expert in the field, before recording the data. Because of this, a casual volunteer with minimal mollusc knowledge could not correctly identify all species found without assistance. This limits the surveys to only being completed with the supervision of a mollusc expert from the EcoCentre. The third key aspect involved the estimated number for abundance. In the survey, participants were instructed to determine the abundance of a specific shell species. This was done by estimating the population from a scale of 1-3, 4-10, 11-30, etc., increasing for different, unequal increments. The estimating was primarily done by Mr. Blake, as many of the volunteers, including our team, had little confidence in estimating the abundance correctly. In conclusion, all three key aspects contributed to the evaluation of our survey criteria.

Following the development of these four principles and the evaluation of the current survey, our team used them as criteria to refine the shoreline shell survey. After completing the survey, we found that when being performed by the EcoCentre staff, the current abundance estimation was a viable method. However, it proved difficult for a casual volunteer, as there was some confusion about this method in terms of what metric to estimate by.

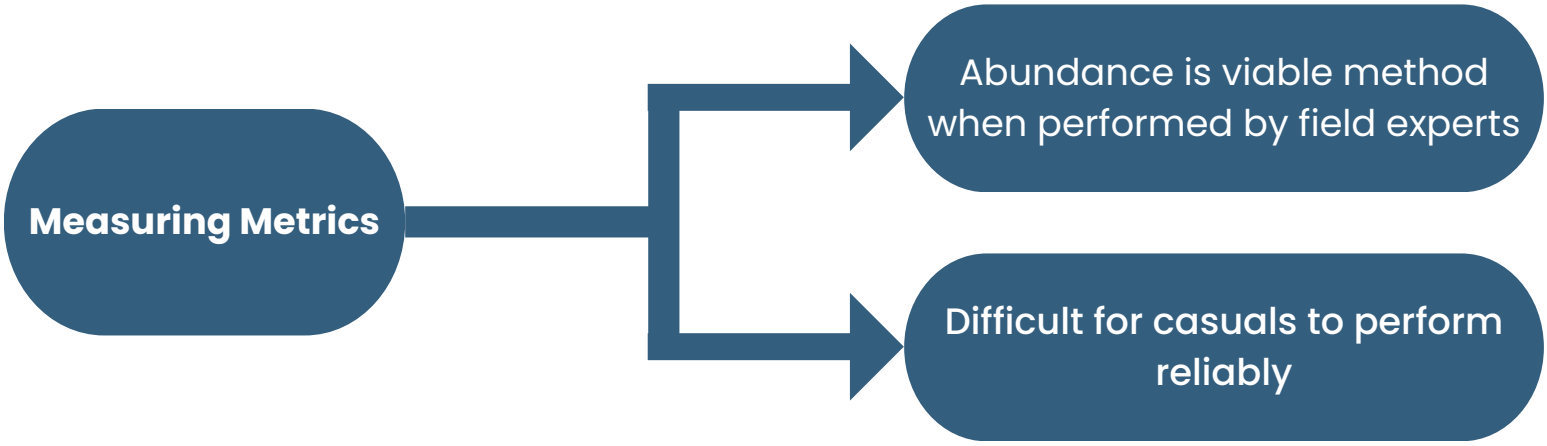


Figure 19: *Measuring metrics evaluation*

The next principle has been an overarching theme throughout our project in balancing scientific value and community engagement. From our evaluation of the current survey methods, our team found the survey to be very feasible and accessible to citizen scientists. However, there was less scientific value within the survey, due to the focus on community engagement. An example of this was the data storage system, not being updated with the most current survey data.

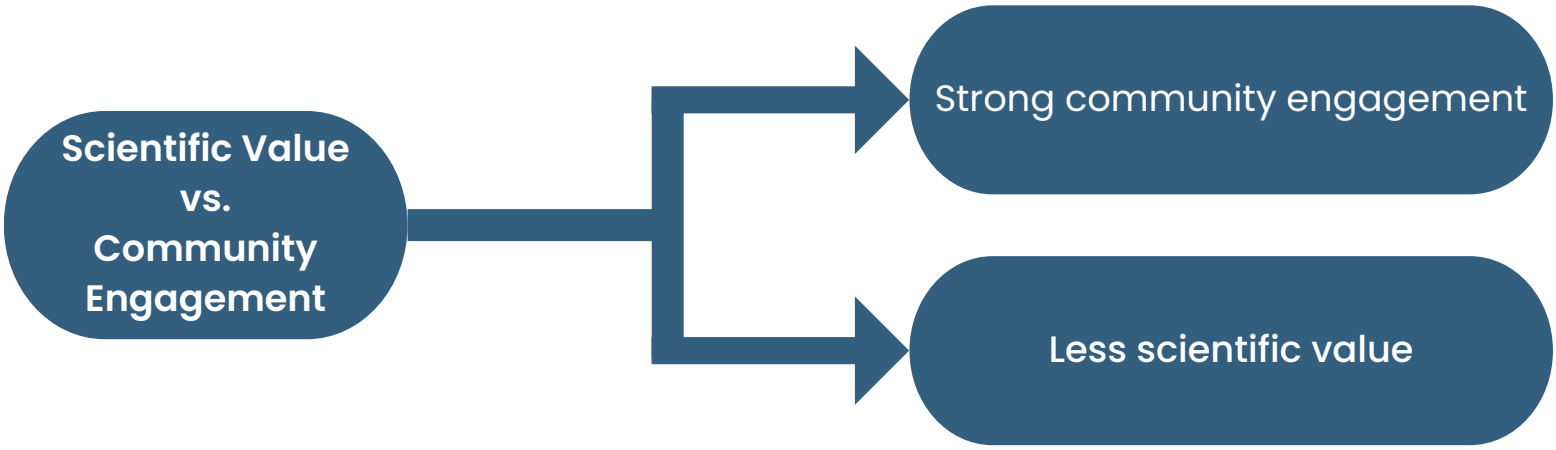


Figure 20: *Scientific value and community engagement evaluation*

The next principle focused on standardizing the collection area. We found that the locations where the survey is conducted are standardized around Port Phillip Bay. However, there is a lack of consistency regarding the shell collection areas within these locations.

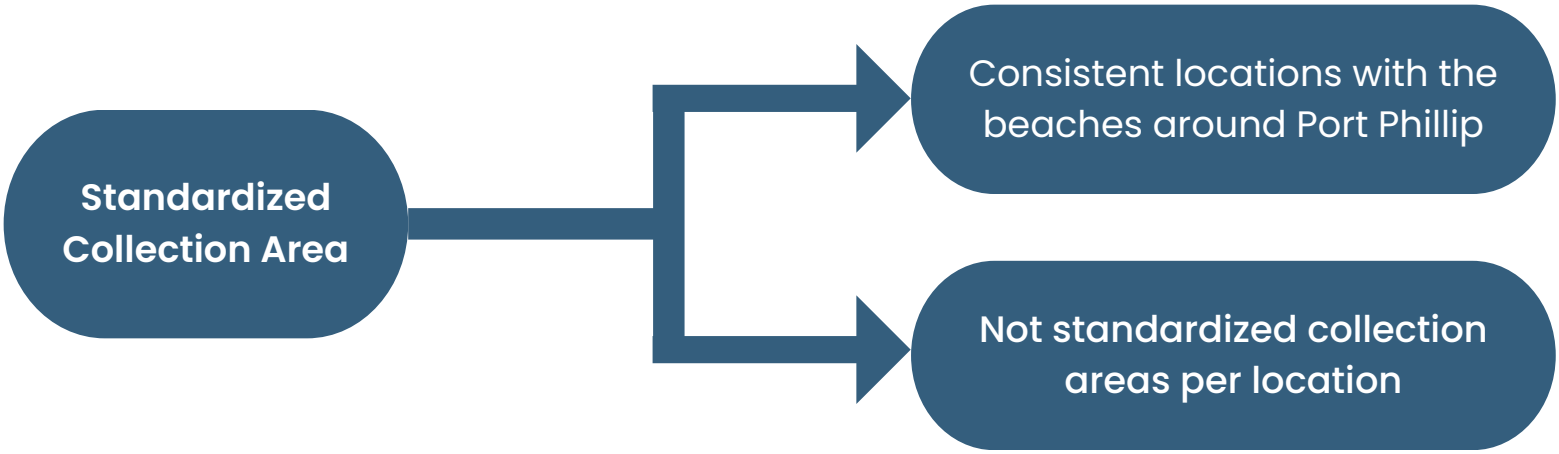


Figure 21: *Standardized area evaluation*

Our final principle focused on a consistent methodology and identification of resources. We found that when completing the survey, we had to confirm shell identification with Mr. Blake before recording the information. This was a great way to use expert identification in the reliability of data. However, without a field expert such as Mr. Blake, it would be difficult to ensure the data represented an accurate identification of species on the beach.

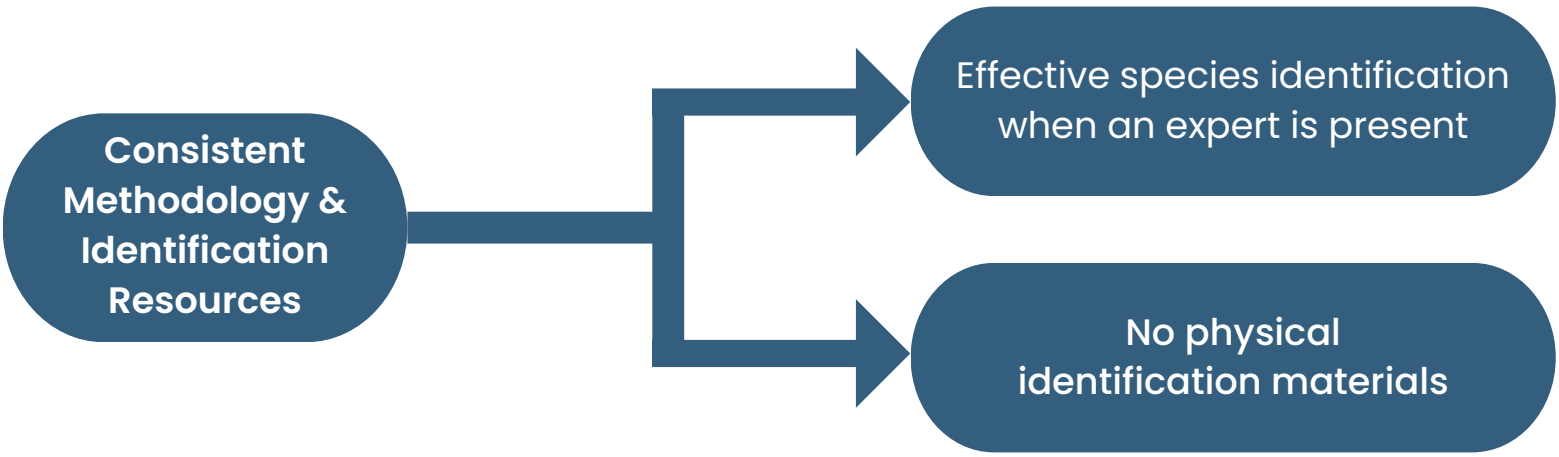


Figure 22: *Consistent methodology & identification resource evaluation*

In conclusion, the evaluation of these principles helped guide the development of our new survey methodology, and helped to establish the additional deliverables and our recommendations.

UPDATED SHORELINE SHELL SURVEY DESIGN

This section outlines our findings in terms of the recommendations and deliverables created to update the current shoreline shell survey. Some of the key aspects of these updates included species identification, survey location, and clarity of methods.

5.1: Species Identification Tools

To address the lack of identification resources, we developed a species identification guide. In previous surveys, an expert was necessary to identify the different types of mollusc species correctly. Our newly developed species guide contains pictures and descriptions of various molluscs likely to be found during the shoreline shell survey. This includes 27 species of mostly gastropods and bivalves. The team determined the most common species to add to the guide based upon previous survey results. The guide enables citizen scientists to identify mollusc species correctly without expert supervision, leading to more reliable data. This also serves as a resource that can excite citizens about molluscs, aiding to our goal of increasing community engagement.

Figure 23: *Examples of fresh kills from new survey methods*

Figure 24: *Sample page from new Species Identification Guide*

Fresh kills are one of the metrics measured in the shoreline shell survey. A fresh kill is a bivalve that was recently killed, and has its hinge still intact. To aid volunteers in identifying a fresh kill, the team added descriptions and figures to the survey methods.

5.2: Standardized Area and Time

To standardize study areas, the team created a shoreline survey location guide. With the EcoCentre's current survey locations, the team outlined boundaries at each beach to guide the participants' study. When different volunteers complete the survey at a specific beach, they will be studying the same area. The guide briefly describes the survey areas and then presents three images to further clarify the study area for the volunteer. The survey location guide is an essential change to the shoreline shell survey. Standardized survey areas will allow the EcoCentre to monitor species population trends within these areas over time.

Along with this change, the team also standardized a time cap of twenty minutes for all surveys. Standardizing the survey effort among all participants ensures consistency and comparability of survey results, enhancing the scientific value of the shoreline survey by enabling the EcoCentre to collect and compare useful data.

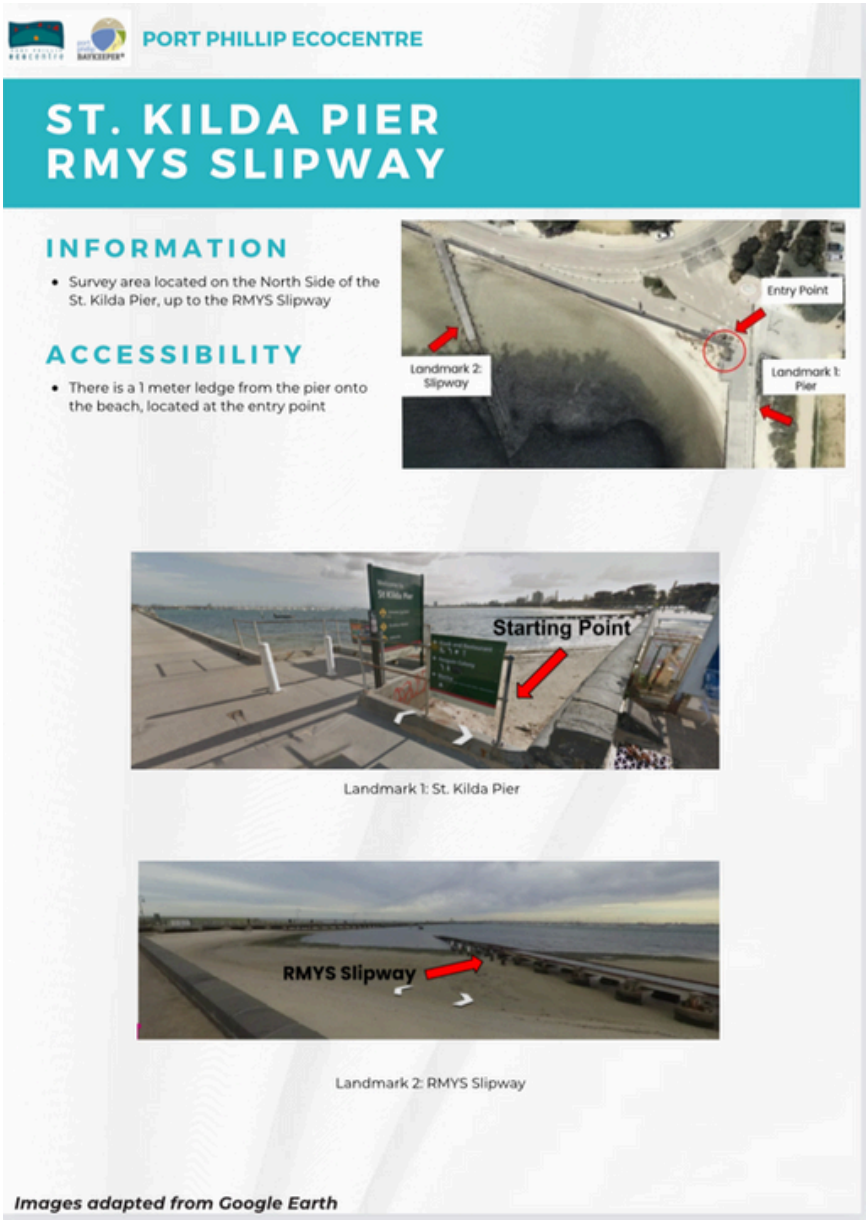


Figure 25: *Page from newly developed Survey Location Guide*

While the focus of these adjustments is based on scientific value, we also took community engagement into account. We grappled with implementing widely known and scientifically valid methods, such as a transect. However, these methods can be complex and difficult for casual citizen scientists to execute correctly. Through discussions with Mr. Blake, Dr. Trocini, and Mr. King, the team concluded it was best to not sacrifice community engagement in this area. Complex survey methods could take away from the volunteer having a positive experience, which is one of the main goals of the EcoCentre. Along with this community engagement aspect, scientific validity is still emphasized as the EcoCentre can now monitor mollusc population trends over time within the standardized survey areas and time. The team believes these methods strike the balance between community engagement and scientific validity.

5.3: Clear and Precise Methods

Making survey methods more thorough and precise allows the volunteer to complete the survey more effectively. This leads to reliable data collection. The team made small but important updates to make the shoreline survey more precise. Figures were added to display the survey area and a visual representation of the high tide line. The added figures will help volunteers understand and visualize what the survey area looks like. Lastly, we added an instruction to measure the smallest small shell size along with the largest shell. This will add to the scope of data collection and research, by providing a range of shell sizes for each species.

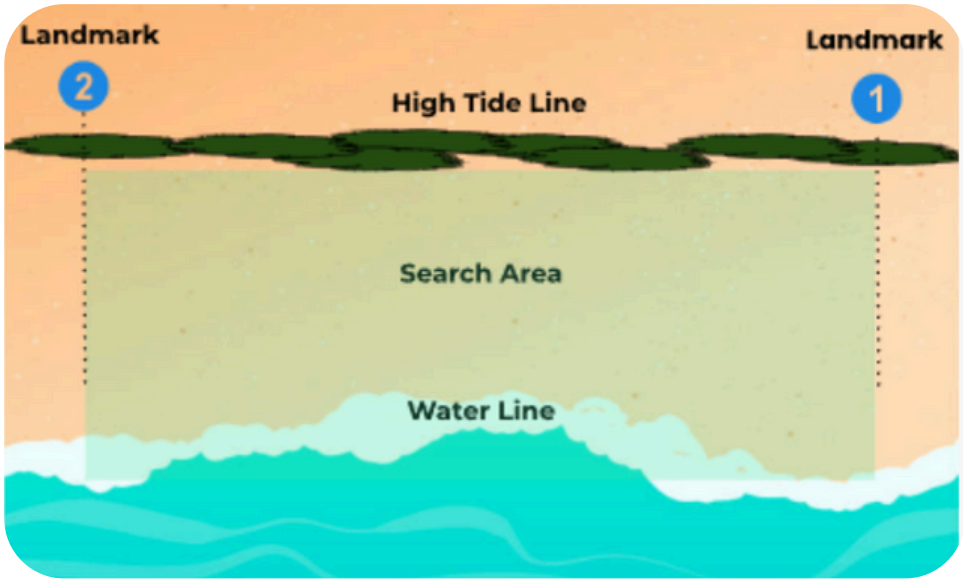


Figure 26: *Diagram of the standardized search area located in updated survey methods*

Figure 27: *Figure of high tide line from updated survey methods*

RECOMMENDATIONS FOR ENHANCED COMMUNITY ENGAGEMENT IN THE MOLLUSC PROGRAM

From the on-site workshop, interviews, and case studies, we developed a set of principles that guided our recommendations for increasing community engagement through media. Those principles are “Media Inspires People to Engage,” “Accessible Findings Incentivize Citizen Science Involvement,” and “Program Follow-Up Fosters Interpersonal Relations.”

Figure 28: *Three principles developed for community engagement*

6.1: Media Inspires People to Engage

Through the workshop, there was a consensus on the importance of providing media such as a project story or providing a source of inspiration for a program. This engages and motivates participants, energizing them to take part in the program. One participant commented, “I wish there was an aspect to excite people before going to the survey.” This could be facilitated through an inspirational project story on digital or physical media.

Next, our interview with Mr. Mills provided valuable insight into how his citizen science program works to engage a large number of volunteers. The importance of a set schedule of recurring events, such as a monthly or semi-annual program, keeps volunteers engaged with citizen science while also providing more data. His team also uses an email alias and social media to promote upcoming programs, conducted over a set period of time.

Lastly, we found the EcoCentre has their website connected with landing pages for other programs, containing great information about the project story and resources. However, the mollusc citizen science program does not have a landing page or well-defined location on the website. Providing a resource would allow volunteers to be engaged with the program before, during, and after participation. We found the use of media encourages communities to become dedicated to a cause and motivates citizen scientists to actively participate in support of environmental initiatives (*The Positive Side of Social Media*, n.d.). At a future glance, our team hopes that excited volunteers will increase participation in the mollusc citizen science program.

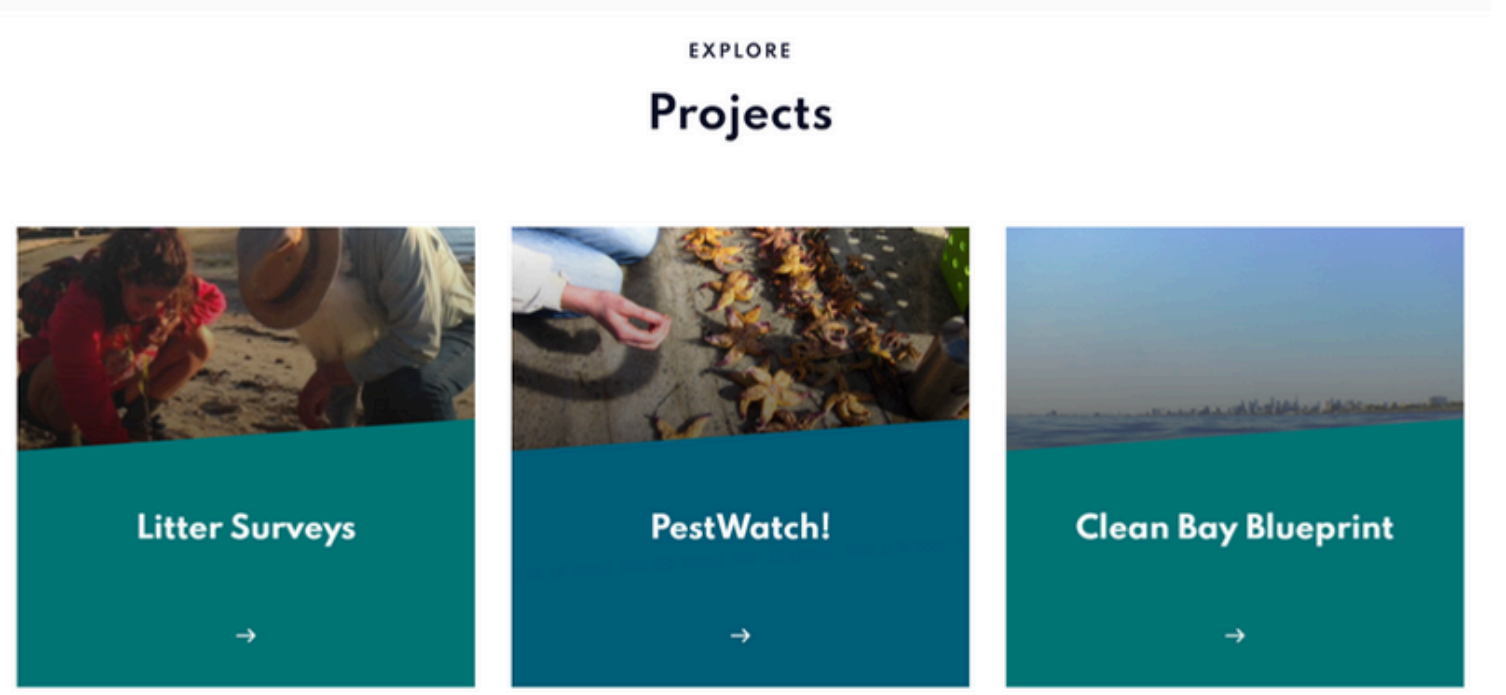


Figure 29: *Current landing page for EcoCentre programs*

6.2: Accessible Findings Incentivize Citizen Science Involvement

One of the biggest incentives for participant involvement was transparency and accessibility of data. We found that participants would be more involved if they saw the end result of their work, through findings such as databases or summary graphs.

Currently, the mollusc citizen science program data is only accessible to EcoCentre staff. The data is currently stored in a Microsoft Excel spreadsheet, with the Baykeeper responsible for data entry and management. Part of what motivates citizen scientists to participate in events, such as the shoreline shell survey, is understanding their impact on environmental studies. There could be an opportunity for this data to become more accessible for continued engagement and involvement, as we'll elaborate on the deliverables for this objective.

6.3: Program Follow-Up Fosters Interpersonal Relations

From the workshop, we found that participants value follow-up information after participating in a program. One participant suggested providing, “certificates or any recognition volunteers can cherish or repost on social media.” By following up through examples like a “Thank you” email, or certificate of completion, those actions foster a relationship between the participants and the program facilitator. Those interpersonal relations could also incentivize participants to collaborate in the future.

The mollusc citizen science program does not currently have follow-up opportunities with participants, or a form of returns to engage participants in future opportunities. Providing a pathway to follow-up could foster these interpersonal relations between volunteers as well. With no local or state funding being directed towards the program, volunteer retention is important for the continuation of the mollusc citizen science program.

6.4: Program Recommendations

Following the development of these principles, our team recommended a website outline, intended to increase community engagement. Currently, the EcoCentre has multiple landing pages for each of their programs, but not the citizen science mollusc program. The website would begin with a project narrative aimed at captivating participants and fostering engagement with the program. Figure 30 illustrates a proposed project story for the website.

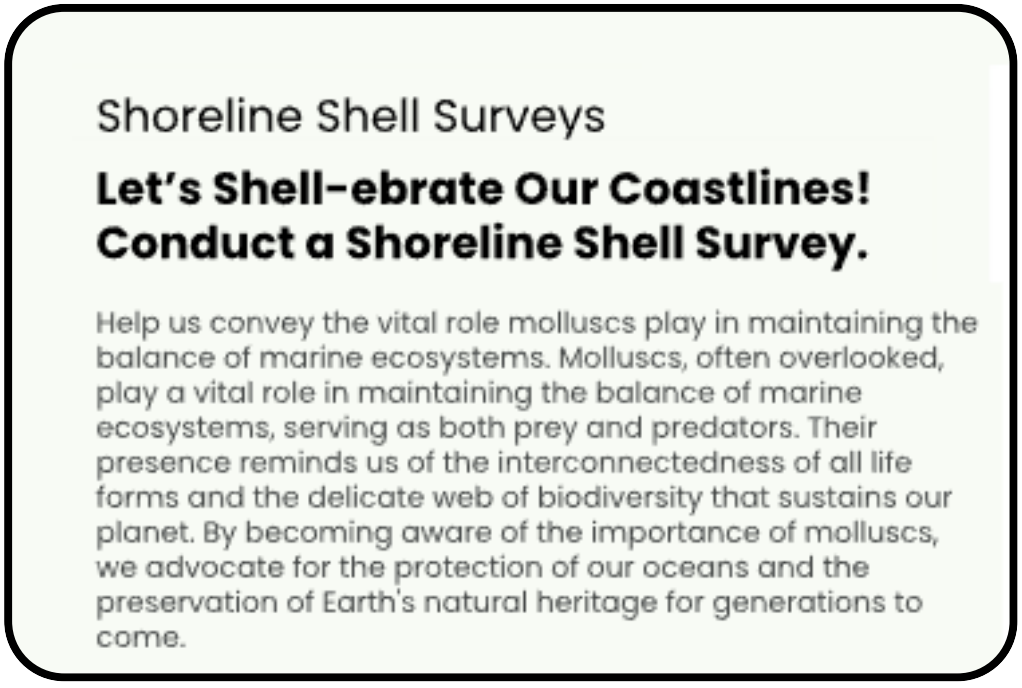


Figure 30: *Proposed project story for the mollusc citizen science program*

There will also be a section which would allow users to view an online database. Within the database, users will have viewing access to monitor the EcoCentre's mollusc spreadsheet and mollusc data from previous years. There will also be resources such as the Molluscs Matter report, the survey location guide, and the survey methods. This allows participants to easily access information regarding the EcoCentre's mollusc program. Figures 31 and 32 showcase the proposed online database and the resource links, respectively.

	B	C	D	E	F	G	H	I	J	K	L	
		Participant Name										
		Survey date		11/3/2011			2/18/2014			5/1/2014		
Ref page	Common name	Scientific name	Max Length	Datasheet #	Abundance	Length	Datasheet #	Abundance	Length	Datasheet #	Abundance	Length
76	Blue Mussel	*Mytilus galloprovincialis*	80	4	10	70	1	10	75	15	10	76
86		*Fulvia tenuicostata*	50	6	8	45				22	10	25
74	Sydney Cockle	*Anadara trapezia*	80	5	5	70				23	8	55
		Turbo undulatus	60	1	2	60	4	8	50	3	5	45
36	Sand Snail	*Polinices sordidus*	50	2	2	40	6	5	35	1	8	35
80	Common Mud Oyster	*Ostrea angasi*	100	7	2	70				14	10	88
96	Smoky Venus	*Eumarcia fumigata*	42	11	1	42						
50	Cominella	*Cominella lineolata*	37							10	5	34
94		*Soletellina biradiata*	60							21	10	46
20		*Austrocochlea odontis*	20							5	8	12
36	Conical Sand Snail	*Polinices conicus*	35	2	2	32				2	5	35
		Cellan solida	40									
98	Ridged Venus	*Katelysia rhytiphora*	45	10	5	45						
80		*Notospisula trigonella*	24							28	10	24
02		*Pholas australasiae*	85	3	2	85	2	2	70			
		Katelysia scalarina	35							24	5	

Figure 31: *Section of the online database draft*

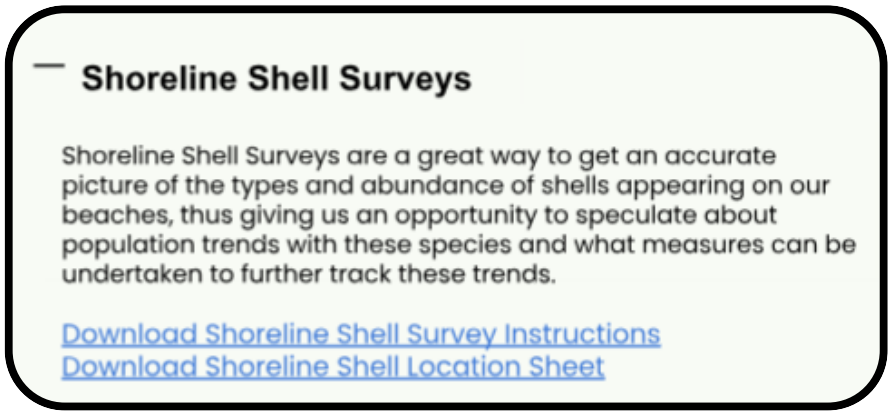


Figure 32: *Resources section, specifically the shoreline shell survey links*

With easily accessible information, participants will be more engaged. These additional recommendations will all contribute toward enhancing the EcoCentre's citizen science program for mollusc monitoring.

CONCLUSION

From all of our findings, the final project deliverables focus on providing the EcoCentre with materials to enhance and promote their citizen science mollusc program. Through updated survey methodology, supplementary resources, and a proposed website design, the EcoCentre can further engage community members while providing important scientific value towards mollusc population trends.

Our team met the goal of assisting the EcoCentre with their mollusc citizen science program. By developing these recommendations, the EcoCentre can utilize this material to improve the impact of citizen science programs around Port Phillip Bay. We hope that these recommendations increase community engagement with their program, while also increasing the reliability of data with their shoreline shell surveys.

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APPENDIX A: PROJECT TIMELINE

Methods	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Draft State of Knowledge Report							
Develop Recommendations for Adjustments to Rubric and Surveying Protocols							
Prepare and Facilitate Hands-on Workshop with PPEC Staff							
Conduct Interviews with PPEC Staff							
Create Media Content For PPEC Outreach							

APPENDIX B: INTERVIEW OUTLINE

Interview Plan

1. Mr. Neil Blake, Baykeeper, Port Phillip EcoCentre
    a. Focus on his current perspective on the surveys and how he believes they can be improved
    b. Abundance and length of shellfish are two key pieces of information
2. Dr. Sabrina Trocini, Environmental Project Manager (Citizen Science), Port Phillip EcoCentre
    a. After the workshop during Week 4
    b. Focus on citizen science, what flaws/successes they notice while conducting their citizen science projects
3. Mr. Tyler King, Impact Team Leader, Port Phillip EcoCentre
    a. After the workshop during Week 4
    b. Focus on citizen science, and what flaws/successes they notice while conducting their citizen science projects
4. Dr. Gary Poore, Principal Marine Biology Curator, Museums Victoria
    a. Crustacean expert, use for the knowledge report to further back up our team's claims
5. Mr. Kade Mills, Victorian National Parks Association Reefwatch Coordinator
    a. Citizen science expert, also ask about current citizen science projects and their effectiveness within his programs

Logistics

Interviews will occur from Week 3 into Week 4, with analysis and extra time in Week 5. The interviews will either be facilitated in person at the Port Phillip EcoCentre or on Zoom, depending on the preferred method of the interviewee and consent will be obtained beforehand. The specific goals of the interviews vary by each individual, but the overarching theme is to obtain knowledge to improve our deliverables. For example, the knowledge report and survey recommendations are two key deliverables that will be enhanced. Each team member will alternate between interview roles in a discussion format with leading questions.

Kade Mills (2/8 at 12pm)
Victorian National Parks Association Reefwatch Coordinator

1. What does your current role as Reefwatch Coordinator entail?
2. With your experience, in what ways was a citizen science rubric helpful for your projects?
3. How do you ensure the quality and reliability of data collected through citizen science projects?
4. How do you engage and retain participants in citizen science projects over the long term?
5. What are some similarities or differences within certain CS rubrics you've viewed?
6. What's your familiarity with the Port Phillip mollusc species?

Gary Poore (2/9 at 10am)
Previous Principal Marine Biology Curator at Museums Victoria

1. What was your role at the Victoria Museum and what information did you provide them with?
2. In regard to population trends, what have you witnessed over the years with molluscs (both past and present)?
3. With your experience, what do you think are the most current threats in Port Phillip Bay?
4. Do you have any experience in aquaculture and the contributions that may have to the bay?
5. Do you have any opinions on the shoreline shell survey/methods that are in place?
6. What are some methods that you're familiar with for monitoring population trends with crustaceans?