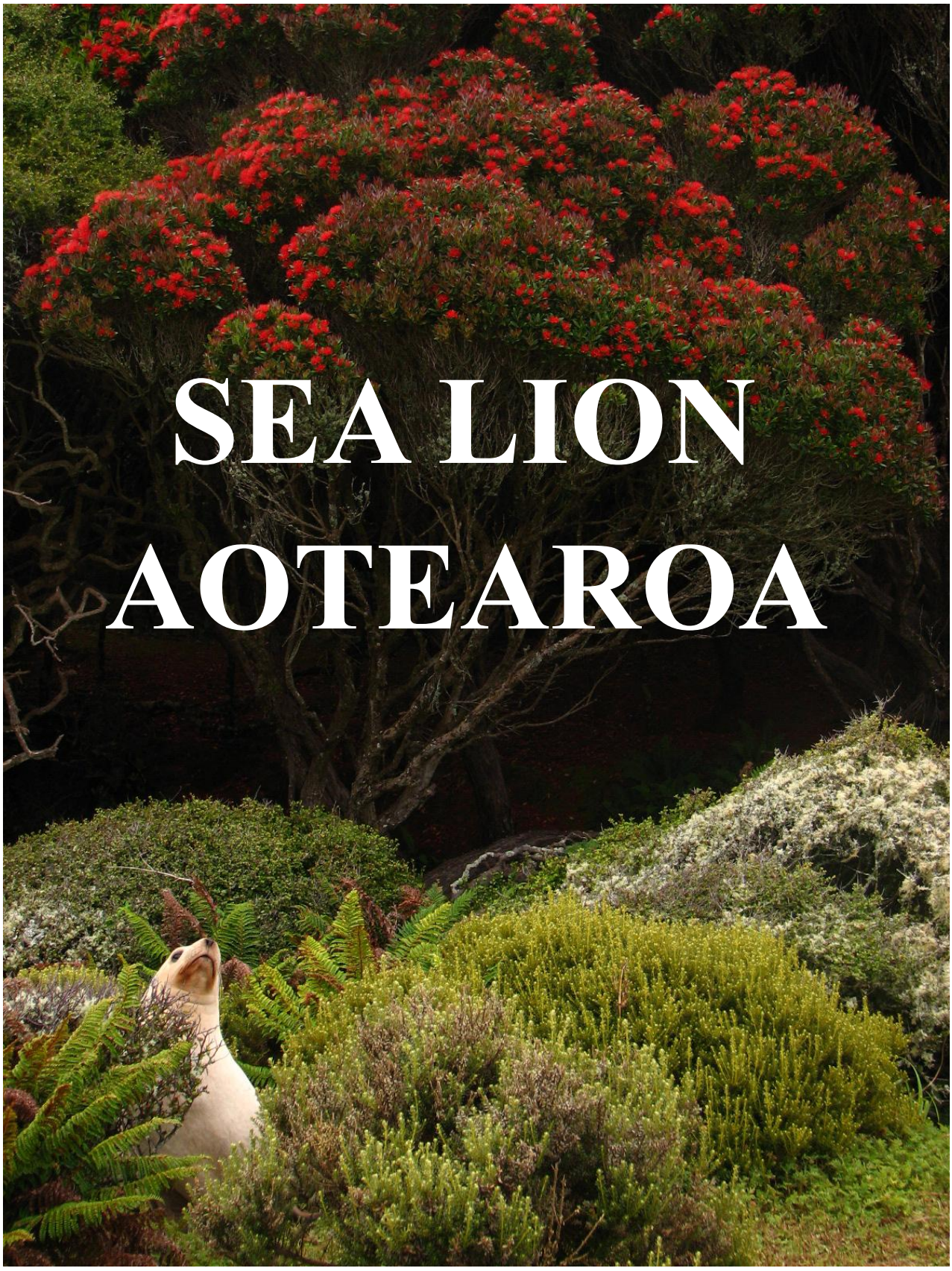

Julia Farnum Carlie Flanagan Kaitlin Kelley Lily Spero

Sea Lion Aotearoa

An Interactive Qualifying Project Submitted to the faculty
Of the WORCESTER POLYTECHNIC INSTITUTE
In partial fulfillment of the requirements
of the Degree of Bachelor of Science

By
Julia Farnum
Carlie Flanagan
Kaitlin Kelley
Lily Spero

Wellington, New Zealand Project Center
Wellington, New Zealand

Date:
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Report Submitted to:

Dr. Laura Boren, Science Advisor Mountains to Sea Team
New Zealand Department of Conservation
Jooles Clements, Head of Brand Experience & Business Development
Auckland Zoo
Professor Shana Lessing and Professor Yunus Telliel
Worcester Polytechnic Institute

Abstract

The New Zealand Sea Lion (pakake) population has declined significantly over the past two decades, having led the **New Zealand Department of Conservation** (DOC) to take action in conserving them. The purpose of this project was to prototype an online **citizen science platform** that enables DOC to monitor the effectiveness of sea lion protection shelters, and to educate the public. We successfully created a citizen science platform, **Sea Lion Aotearoa**, on Zooniverse that meets DOC's requirements. With the interest and assistance of the public, DOC will be able to monitor pakake populations more accurately and how effective the shelters are at protecting them from harsh conditions.

Executive Summary

Background

The New Zealand Sea Lion (pakake) population has been dwindling for decades and is currently considered by the New Zealand Department of Conservation (DOC) to be 'nationally vulnerable.' Significant threats facing the pakake include harsh weather, disease, getting stuck in trawling nets, and other human impacts that affect their habitat and wellbeing. These factors contribute to extremely high pup mortality rates. At the largest breeding area on the Auckland Islands, there has been a 50% decline in the number of pups born between 1998 and 2009. Between 2019 and 2020, Campbell Island, home to the southernmost breeding population of pakake, had a notoriously high pup mortality rate, reaching 81% (New Zealand Department of Conservation, 2021).

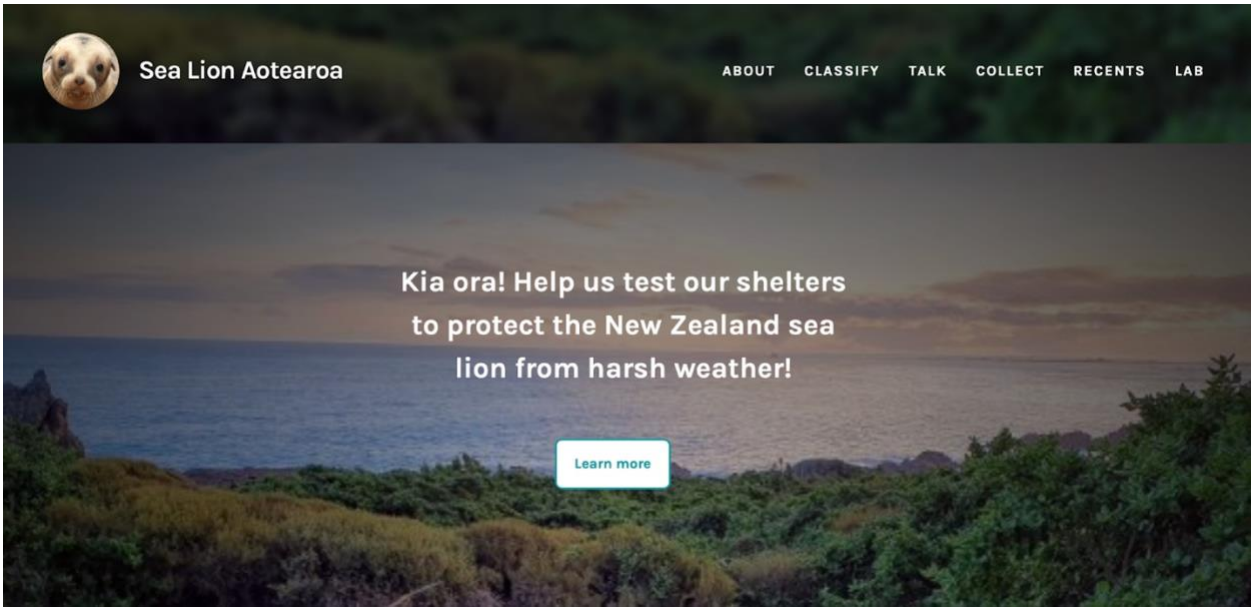
In 2020, DOC and the Auckland Zoo partnered to engineer and prototype pakake shelters that could protect vulnerable young pups. The shelters were tested on Mātakitaki-a-Kupe (Cape Palliser), which is located on the North Island. Because pakake breeding sites are located mainly in the subantarctic islands, fur seal (kekeno) pups were used to test the shelters since kekeno populations breed farther north in places such as Mātakitaki-a-Kupe. The shelters were also equipped with cameras to monitor the animals in them. In order to determine if pups are using the shelters, DOC has compiled images from the shelters that now need to go through a series of classifications. Because of the sheer number of images that they compiled; DOC decided to use citizen science to help with the classifications.

Methodology

The purpose of our project was to prototype an online citizen science platform, using image analysis, that enables DOC to educate the public and raise funds for conservation efforts. In order to meet this goal, we identified three objectives: explore outreach and science communication techniques for educating the public so that we use informative, engaging, and clear messaging, understand best practices in citizen science platform designs to determine how they work and how we could structure our platform, and finally, assess feedback from platform development to improve user experience. Our strategies to meet these objectives included interviews, feedback surveys, and various methods of data collection, such as case studies, general research, and participant observation.

Results

The team created a citizen science platform, Sea Lion Aotearoa, on the site Zooniverse. On this site, users are asked a series of questions regarding the image. These questions asked the user to count the amount of kekeno in each photo as well as whether the picture is a motion photo (M) or time lapse photo (T). Depending on the answers that the participant gave, additional questions, including if the animal is an adult or pup, their activity level, and whether they are in the shelter or not, were asked. The research content and design of the website were products of the information we gathered during our research.



Landing page for Sea Lion Aotearoa
https://www.zooniverse.org/projects/carlieerin/sea-lion-aotearoa

Recommendations

The team has identified several recommendations regarding our platform as well as recommendations for future organizations looking to develop a citizen science platform as a means of data analysis. In regard to the platform itself, the main updates the platform will require in the future are to update key information, upload new photos, export data, and change workflows. It is important for any organization thinking to use a platform to conduct citizen science to perform their own research on which platform suits their needs. Zooniverse was the platform which best fit our criteria, however different projects may be better suited for other citizen science platforms, or even the creation of a new one. In addition to conducting original

research about citizen science platforms, the team also recommends that future organizations think about their attainable outreach at the time. Citizen science only works when the people are involved and therefore there needs to be sufficient outreach for citizens to be interested in the project.

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Chapter 1 Introduction

The New Zealand sea lion (pakake) is one of the rarest sea lion species in the world. The pakake population has been dwindling for decades and is currently considered by the New Zealand Department of Conservation (DOC) to be 'nationally vulnerable.' Significant threats facing the New Zealand sea lion include disease, harsh weather, getting stuck in trawling nets, and other human impacts that affect their habitat and wellbeing. These factors contribute to extremely high pup mortality rates. At the largest breeding area on the Auckland Islands, there has been a 50% decline in the number of pups born between 1998 and 2009. Between 2019 and 2020 at Campbell Island, home to the southernmost breeding population of New Zealand sea lions, has a notoriously high pup mortality rate, reaching 81% (New Zealand Department of Conservation, 2021).

In 2020, DOC and the Auckland Zoo partnered to engineer and prototype pakake shelters that could protect vulnerable young pups. The design included cameras to record and observe pakake behavior and outcomes in these shelters. However, the majority of the pakake population is found on Auckland Island and Campbell Island. DOC stated that "while they breed on the Otago Peninsula [...], the pups would be too big and too spread out in winter" (New Zealand Department of Conservation, 2021). Consequently, DOC decided to test their shelters with "New Zealand fur seals (kekeno) whose pups would be the right size, at the right time for a storm" (New Zealand Department of Conservation, 2021). Though the shelters were tested on fur seals, DOC intends to use these shelters for pakake in the future. Prior to implementing shelters in pakake habitats, the agency needs help with camera records to determine the effectiveness of the shelters. DOC currently has over 20,000 fur seal images to analyze and would like to utilize citizen science as a way to involve the community in assisting with interpreting the collected images and videos.

The purpose of our project was to prototype an online citizen science platform, using image analysis, that enabled DOC to educate the public and raise funds for conservation efforts. To meet this goal, we identified three objectives. Our first objective was to explore outreach and science communication techniques for educating the public so that we use informative, engaging, and clear messaging. Next, our team aimed to understand best practices in citizen science platform designs to determine how they work and how we could structure our platform. Finally,

we assessed feedback from platform development to improve user experience. We applied all gathered information and concepts to design and created a functioning citizen science platform for use of the New Zealand DOC.

Chapter 2 Literature Review

In this chapter, we present critical threats to the pakake as well as information on several different partners and protectors of the pakake. We also present research on the general climate and harsh conditions in which the pakake live on Campbell Island, and explore the complex attitudes, both positive and negative, towards pakake in New Zealand.

2.1 Population Decline of Pakake and Conservation Opportunities

In 2015 the pakake of New Zealand's international conservation status was raised from "vulnerable" to "endangered" (World Wildlife Foundation, n.d.). Due to the impacts of colonization and hunting, the mainland populations of pakake became extinct shortly after human arrival. Currently, over 99% of the pakake breeding population is located on the Subantarctic Islands, primarily Auckland and Campbell Islands. As shown in Figure 1, prior to 2003 nearly the entire pakake population belonged to the Auckland Islands colony. After 2003, a small population began breeding on the mainland, which was the first occurrence of mainland breeding in 150 years. Despite this new colony, the pakake population has been in overall decline since 1998, as demonstrated in the figure below (Chilvers and Meyer, 2017; Collins et al., 2014).

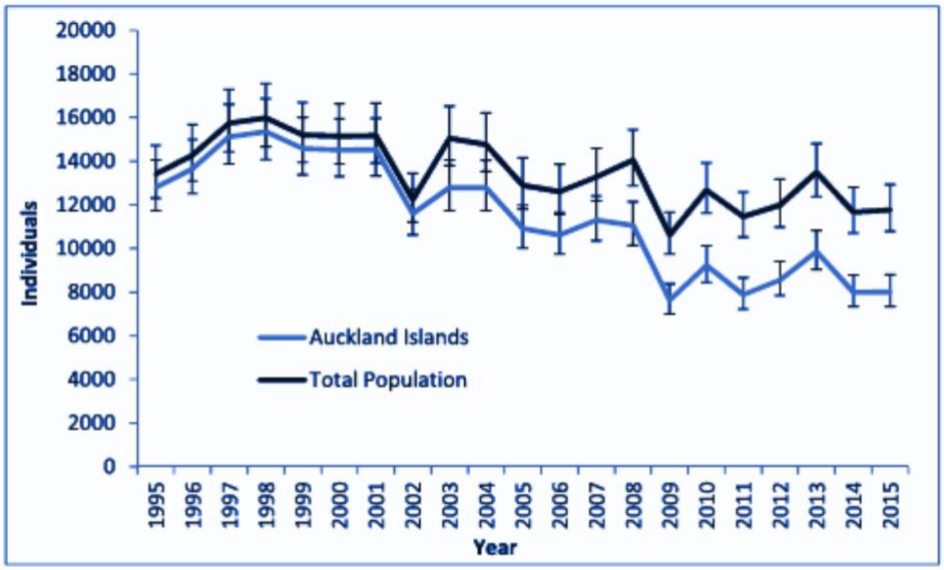

Figure 1: Representation of pakake total and Auckland Islands population trends between 1995 and 2015 (Chilvers & Meyer, 2017).

While the threats facing the pakake include both natural hazards and human-animal conflict, the most significant outcome is vulnerable pup mortality. In the Auckland Islands colony, "a series of bacterial outbreaks [...] led to the mass mortality of pups" from 1998 to 2003, peaking in 1998 with 53% pup mortality. In total, the rate of pup production declined 31% between 1997 and 2006. DOC has identified pup mortality at Campbell Island as notoriously high, reaching a peak in 2019-2020 at 81% (Jefferson et al., 2015; Chilvers et al., 2007; New Zealand Department of Conservation, 2021). Campbell Island is part of the New Zealand Subantarctic and is the southernmost breeding point of the pakake (see Figure 2, right). As illustrated, the site is located between New Zealand and the Antarctic continent, making local conditions on the island windy and cold. DOC suspects that the pup mortality is related to exposure to this harsh weather, "as more pups were found dead after periods of high rainfall and low windchill" (New Zealand Department of Conservation, 2021).

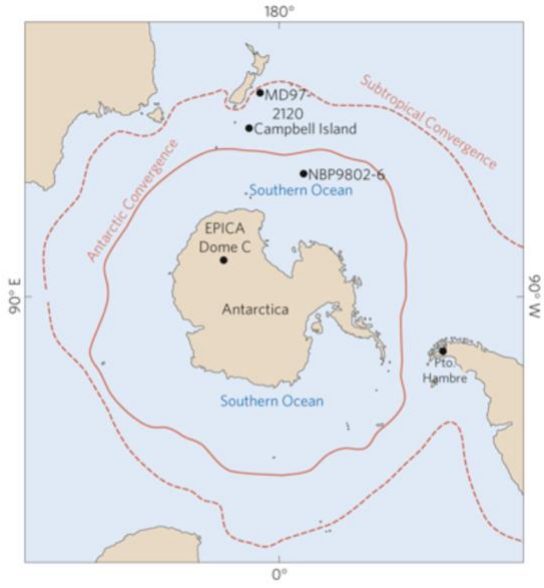

Figure 2: Map showing the location of Campbell Island (Turney, n.d.)

In order to save the pakake from further population decline and escape the threat of extinction, human conservation and intervention efforts are necessary. In 2017, DOC published a Threat Management Plan with four work streams to boost recovery: engagement, direct mitigation, targeted research, and evaluation. Full explanations of each of these components can be seen in Figure 3, below, with the ultimate goal being the recovery of the pakake population (New Zealand Department of Conservation, n.d.). In order to recover the species, according to DOC, it is necessary to recognize and reduce key threats to the species, encourage public engagement, and monitor the progress of species population. Figure 3 also demonstrates conservation efforts taken by DOC in 2017 to 2018. We will later expand upon DOC's current conservation effort of designing shelters to host pups in the winter season.

Figure 3: Full explanation of pakake threat management plan workstreams (New Zealand Department of Conservation, n.d.)

2.2 Partners and Protectors of Pakake

Pakake populations are slowly making their way back to the mainland, causing more human-pakake interactions. DOC has prioritized educating the public on how to coexist with the pakake. While New Zealander public perceptions are generally positive towards pakake, there have been incidents of deliberate killings of the species (Graham-McLay, 2021). Previous reports have noted conflicts with beachgoers and dogs, as well as with the fisheries in the area.

DOC is a key stakeholder and partner in developing awareness and interest for marine mammal conservation in New Zealand. The agency was established in 1987 under the Conservation Act to forefront conservation of New Zealand's natural and historic heritage (New Zealand Department of Conservation, 2020). Their mission is to preserve terrestrial wildlife and marine species. Dr. Laura Boren is a Science Advisor at DOC, who has led conservation projects for numerous species such as the Southern right whale, the Māui dolphin, fur seals, and many other critical species. Dr. Boren is currently carrying out DOC's Threat Management Plan for the New Zealand Sea Lion, which extends over a five- year period to try to eliminate the decline of

the species' population (New Zealand Department of Conservation, n.d.). This plan uncovered the main threats that the pakake population faces and was the first step for the idea of building shelters on the Subantarctic Auckland and Campbell Islands to protect the pakake from harsh storm events (Wairarapa Times-Age, 2021).

The Auckland Zoo, another partner in pakake conservation efforts, has also played a key role in the conservation of many native New Zealand species. The Zoo staff dedicate an average of 6,000 hours to the breeding and release of endangered animals every year. An average of 8,000 hours a year has been contributed to researching and surveying populations of endangered species and protecting vulnerable wildlife. The Auckland Zoo Vet Hospital is known globally for its astounding conservation research and medical care. In addition to the Zoo's residential animals, they also provide care to sick and injured species all over New Zealand. (Auckland Zoo, n.d.) Therefore, it is no surprise that they are working with DOC to aid in the conservation effort of native pakake.

The Auckland Zoo is an important stakeholder involved in the project. The Zoo has been conducting pakake research since 2011, starting with the funding of GPS tags for continuous monitoring of the species. In 2013, the Zoo teamed with DOC to gather official pup counts from tagging (Reid, n.d.). Today, the Zoo continues to work with DOC on pakake tagging and is actively involved in the trial of pakake shelters as protection from the elements. They are responsible for the initial shelter design and further developed it with help from DOC and sea lion biologists (Wairarapa Times-Age, 2021). DOC and the Auckland Zoo are key contributors of pakake conservation who played an important role in the success of our project.

2.3 Shelter Structure and Campbell Island Climate

In recent years, pakake conservation data shows that the pup mortality rate has been increasing. In a project that started in 2017 and is scheduled to go until 2022, DOC has been working at four different breeding locations including Auckland Island, the Southland coast, Stewart Island, and the Subantarctic Islands (which includes popular breeding sites such as Campbell Island). The 5-year program will provide an opportunity to learn much more about the pakake habitats and how they might be used (New Zealand Department of Conservation, n.d.).

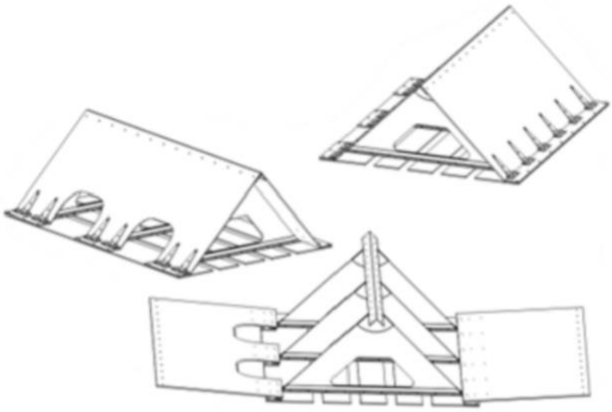

Figure 4: Representation of the A-frame design (New Zealand Department of Conservation, 2021).

DOC hosted an engineering challenge to design a shelter to be built to both monitor and protect pakake. The Auckland Zoo provided the favored structure using an A-frame design as shown in Figure 4.

The structure is designed to have one opening which goes all the way through the length of the tent, along with two openings in one of the diagonal side flaps leading into the shelter, thus leaving the other side flap completely intact in order to protect against harsh environmental conditions. Conservationists also created a pipe-based structure design (see Figure 5) which was tested as a comparison against the A-frame structure. The pipe design uses large conduit pipes connected to form a single length with intermittently spaced cut outs to allow for entrance and exit.

While both designs provided protection against harsh climates, the A-frame design was proven to be more successful with the fur seals as it was used more frequently by them than the pipe design. Therefore, DOC determined that the A-frame design will be implemented for pakake use on Campbell Island (New Zealand Department of Conservation, 2021).

Figure 5: Pipe model (New Zealand Department of Conservation, 2021).

Images already received from an A-frame shelter trial come from Matakitaki a Kupe, Cape Palliser on the southern end of New Zealand's northern island. This test site was chosen to evaluate whether or not marine mammals could avoid the harsh conditions of Campbell Island in these structures, and whether or not they hosted sufficient pups to use the shelter in order to generate data to analyze. The testing team plan to run the test through varying conditions such as

upcoming storms to ensure that the shelter is able to remain intact during harsh conditions which more so mirror the climate of Campbell Island (New Zealand Department of Conservation, 2021).

The structural integrity of the shelters is critical as Campbell Island and other breeding sites are home to hundreds of pakake. At these breeding sites, it rains around 300 days a year at moderate intensity. Since Campbell Island lies within the Subantarctic Islands, it is consistently hit with strong westerly winds as well as powerful cyclones and other storms, which typically come from the south. The majority of the winds experienced on Campbell Island are in the range of 20-40mph, making a harsh and windy environment for the animals living on the island (De Lisle, 1965). Furthermore, general conditions on the island are relatively bleak and cloudy due to the combination of extreme temperature differences between the latitudinal lines as well as the general rotation of the earth thus forming cyclonic vortexes. Additionally, the terrain of Campbell Island is composed of rocky beaches, large cliffs, and bays with sandy beaches, as the region has emerged from the remains of a shield volcano. There is also a drastic difference in the marine habitat of the island, as the water depth immediately surrounding the island is around 100m deep which increases to 200m deep closer to the border of the territorial sea. The climate and environment of Campbell Island has been a challenging site for both scientists and sea lions (De Lisle, 1965).

2.4 The Complex Attitudes Towards Pakake in New Zealand

While scientists and conservationists are gaining traction, public support for pakake conservation is not without controversy. A practice that has contributed to pakake mortality is bycatch. Bycatch refers to "the unwanted fish and other marine creatures caught during commercial fishing for a different species" (Oxford Lexico, n.d.). Three primary trawl fisheries are located near the Auckland Islands breeding grounds. It is estimated that six pakake die annually in trawl nets when pakake swim into the nets looking for prey and end up getting caught (Ministry for Primary Industries, n.d.). The squid trawl fishery has created sea lion exclusion devices (SLEDs) (see Figure 6), that only allow smaller species to be captured in the net while larger animals like pakake can escape through a hatch (Ministry for Primary Industries, n.d.). There is debate as to whether or not these devices are actually helpful because they are only effective to an extent. The species have been known to get injured and drown when being

transported through the escape hatch (New Zealand Department of Conservation n.d.). In midwater trawl nets, 88% of pakake that are caught by a SLED are able to escape. In bottom trawl nets, only 57% of pakake that are caught by a SLED are able to escape. To combat this issue, The Ministry for Primary Industries put a limit on the number of bycatches pakake mortalities a year, and if reached, the fishery will be closed (Ministry for Primary Industries, n.d.). Closing of fisheries could generate negative attitudes among workers at these fisheries if they believe the sea lions put them out of work. Working with the public to address these concerns and to paint a better picture of the threats facing pakake may change the public perceptions of these animals.

A similar trend has shown that the deliberate killings of fur seals has become a problem for the conservation community. On 5 November 2021, 11 fur seals were found dead at Ōhau Point Fur Seal Sanctuary. These deaths were thought to be intentional rather than death from natural causes due to the amount of blood (Radio New Zealand, 2021). The killings of fur seals come at a time when fur seal populations are starting to rise again. These killings are a result of the attitude that the public holds toward fur seals. Many fishers think that the fur seal population is growing too rapidly and that killing fur seals "would be an inevitable necessity" (Lalas, 2001). Many people also hold the misconception that humans and fur seals are in competition for fish stocks. In reality, the probable cause of decreased fish stocks is an increase in fisheries (Lalas, 2001). Misconceptions and dangers facing fur seals and sea mammals in general continue to be traced to a lack of knowledge about the species.

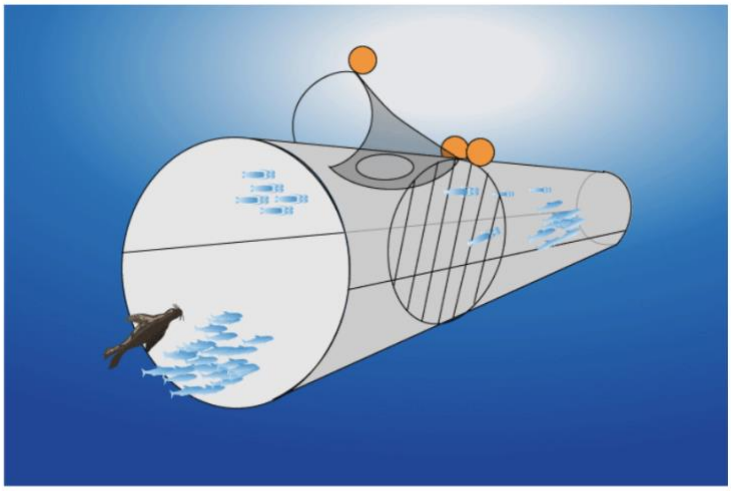

Figure 6: Sea lion exclusion device (SLED) (Ministry for Primary Industries, n.d.)

2.5 Challenges and Opportunities for Citizen Science

A citizen scientist is defined as "a volunteer who collects and/or processes data as part of a scientific enquiry" (Silvertown, 2009). A citizen science platform, then, is any platform that allows participants to act as citizen scientists. An early and successful citizen science platform in the United States is the National Audubon Society's Christmas Bird Count, which has run every year since 1900. The Christmas Bird Count is a major source of scientific data on trends of bird species in North America, and as of 2009 nearly 350 scientific papers and reports using these data have been published. Additionally, as of 2017 about 1110 peer-reviewed publications, technical reports, and PhD included data collected by citizen scientists across eight major platforms. Citizen science platforms have since collected meaningful and important data, contributing to scientific studies across various fields (Silvertown, 2009; Mitchell et al., 2017). Citizen science presents an opportunity for science to better engage the public, which may not otherwise be possible due to reasons such as scale or location. Recent technological tools, such as those that leverage the internet and mobile computing, have allowed citizen science platforms to reach broader audiences of volunteers and have made collecting data more accessible to a global population (McKinley et al., 2017).

With the accessibility of online platforms, however, come some challenges. The first is that citizen scientists must be motivated to conduct research. Since there is often no monetary incentive, and the volunteers are not scientists by career, it is necessary to find a way to motivate the participants using a citizen science platform. Additionally, as with all scientific experiments, data must be validated and collected in a standardized manner, with as little assumptions as possible, to prevent poor quality data and misleading information (Silvertown, 2009; Eisen & Eisen, 2021). Another issue that arises with any digital media is the need to be efficient and visually appealing, in other words it needs a good user interface. Without a good user interface, the platform will not attract enough users to the site, resulting in poor data.

2.6 Summary

From a review of the literature, we identified three key takeaways that we needed to keep in mind throughout the duration of the project. One point that was established was the importance of the balance between the views of the sponsors and the views of the public. While DOC is interested in the conservation of pakake, other stakeholders have opposing views. In

order to attract users to our site, the platform had to be interesting to look at but also educational. Lastly, the harsh outlook for pakake was a pressing matter that needed to be addressed in a delicate manner. We needed to be cautious of the impact our project would have on the species to ensure that the platform was to the benefit of the pakake, as they had more at stake than the humans involved.

Chapter 3 Methodology

The purpose of our project was to prototype an online citizen science platform, using image analysis, that enabled DOC to educate the public and raise funds for conservation efforts. In order to meet this goal, we identified three objectives, which are as follows:

- Explore outreach and science communication techniques for educating the public so that we use informative, engaging, and clear messaging.
- Understand best practices in citizen science platform designs to determine how they work and how we could structure our platform.
- Assess feedback from platform development to improve our platform and improve user experience.

In this chapter we will present the methods that our team used in order to meet the previously stated objectives.

3.1 Exploring Outreach and Engagement Strategies

In order to determine how to best inform and educate the public on issues concerning pakake mortality, the team needed to understand which outreach strategies would be most influential on the public. The approach for our strategy was to utilize methods which convey information in a clear yet engaging manner. We leveraged campaigns that have worked well for DOC in the past in order to tap into successful outreach that has proven to work in New Zealand.

Our research focused on types of strategies that are most engaging including infographics, videos, comics, and text. The way we presented educational information was important because we wanted our participants to be attentive and interested in learning more about the species. Through these strategies, we painted the species in a positive light and got the public more involved in the conservation effort.

3.2 Understanding Best Practices in Citizen Science Platform Design

Our next objective was to understand best practices in citizen science platform designs. Gaining an understanding of citizen science platforms helped us determine how they work. To achieve this objective, our team identified three means of data collection: case studies, research, and participant observation. These three strategies for data collection enabled our team to gain

deeper insight into what makes a citizen science platform successful, as well as the possible ways that we could model our own platform.

In order to better understand citizen science platforms, we evaluated case studies pertaining to citizen science websites and interactive platforms. Research included case studies about platforms that were successful, how conservation platforms work best, and identifying high quality platforms that feature wildlife conservation.

In addition to in-depth case studies, we also needed to gain a better understanding of how to build and maintain a citizen science platform. To do this, we researched best practices for collecting data to ensure reliability and quality. We examined who citizen scientists are by researching volunteer demographics and motivations, as an important aspect of platform maintenance is knowing our user base and keeping our users interested.

Our last method for this objective was to use participant observation on current citizen science platforms. To aid our observations, we created a checklist of items that we deemed important for a citizen science platform. We then went through the checklist as we observed various citizen science platforms. Our checklist can be seen in Appendix C. From this method, we compiled a comprehensive list of what would be important to include in our own platform.

To understand user perspectives, we investigated a sample of the platform ourselves to determine quality, and capability of hosting our stakeholders' site requirements, primarily the abilities to post photos and videos, display educational information, and to fundraise. From this, we were able to compare platforms to determine which best suits our needs and noted qualities that made them user- friendly. Once the platform was developed, the next step was to find a sample of our user base to prepare for user-testing.

3.3 Assessing Feedback from Platform Development

Our final objective was to assess feedback from platform development to improve our platform and improve user experience. To gather accurate and relevant feedback, our first method was to create a survey for platform users to inform our design processes. The user feedback form can be found in Appendix B. Through the different iterations of the citizen science platform, there was an allocated time for potential users and volunteers to interact with the platform and provide feedback on their experience with it. We sent out a survey to facilitate this process and used the feedback to aid in our design decisions to ensure a positive user

experience. We also met with our DOC and Auckland Zoo sponsors during the platform development process to gather and implement changes based on their concerns and input.

Chapter 4 Results and Discussion

Through our research on both outreach and public engagement strategies, as well as reviewing and analyzing previously existing citizen science platforms, we were able to create a platform which best suits the needs of DOC. In addition, we integrated DOC's requirements of image classification, education, and fundraising into our citizen science platform with our findings to create an engaging experience for users. In order to better understand user perspectives, we tested our site with participants after initial development of the platform. Based on feedback from the initial testing, the platform went through several rounds of revisions to meet both functional and aesthetic standards.

4.1 Exploring Outreach and Engagement Strategies

There has been significant research conducted about the motivations of volunteers. In 2007, volunteer citizen scientists were asked to rate seven potential motivators on a scale of strongly unimportant (1) to strongly important (7). The motivations included: help the environment, career, user, learning, values and esteem, social, and project organization. Of these, the top motivation reported was a desire to help the environment. Second was values and esteem, specifically volunteers' desire to express their values through their work and to feel needed. The rank order was followed by the user, meaning those who want to improve an area they visit and enrich their future recreational experiences. Finally, additional high-ranking motivations included learning: those who want to learn about specific animals, and the environment. In fact, the New York City Great Pollinator Project, a citizen science study where volunteers gather accurate data from bee observations, surveyed participants in 2009, and found that volunteers' top motivation for participating in the project was "to learn about bees (27%)," followed by a desire to contribute to science and conservation (Domroese & Johnson, 2017). Thus, in developing a citizen science platform, it is important to focus on education of the public and make the significance of volunteer contributions explicit to keep citizen scientists motivated (Bruyere and Rappe, 2007).

From our research to determine the best outreach and engagement strategies for promoting our platform, we found that a well thought out user interface plays an important role in website engagement. Psychological studies have shown that people absorb and retain information better when it is presented alongside images (Veasey, 2019). Visual communication

is processed very differently than verbal or textual information. Our minds decode text in a linear format which takes time to process, whereas images are absorbed into the brain almost instantly. Compared to text, images also have more of an effect on our emotions (Parkinson, n.d). We utilized this image-based strategy to maximize the emotional response of users which will, in turn, foster interest and engagement (see Figure 7). We also found that approximately 65% of the population are visual learners (Abante et al., 2014). We therefore included a documentary from the Auckland Zoo explaining the project to show the overarching idea of this conservation effort, and get people interested enough to participate.

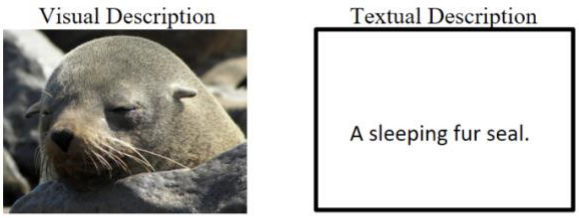

Figure 7: A visual description versus a textual description

We also investigated different ways to promote the platform and found that social media is an effective way to spread awareness. In this technological age where about 84% of the world's population owns a smartphone, social media is very easily accessible (Turner, 2018). There are about 2 billion social media users worldwide using sites such as Facebook, Instagram, Twitter, reddit, etc (Wu et al., n.d.). Social media connects a vast network of people together from all parts of the world. The outreach capabilities of online postings are vast. Social media will allow us to reach as many people as we can with this platform. A link to the platform has been posted on Instagram as well as multiple Facebook groups focused on conservation in New Zealand.

In our interview with Hiromi Beran, we were also given ideas about how to get more people to interact with our platform. One of the suggestions she made was to have students in schools use our platform. Students can range from school aged children all the way through university students. Another idea that she suggested was to display our platform in public places, such as zoos. Because of the simple nature of the classification on our platform, having people in public interact with our platform wouldn't be difficult. From our research, we have found many options for promoting our platform, all of which are effective in getting people to participate in our citizen science platform.

4.2 Understanding Best Practices in Citizen Science Platform Design

To understand best practices in citizen science, we conducted participant observation of three major online citizen science platforms in order to assess and compare them as case studies.

Case 1: Video analysis with Chimp & See

Chimp & See (www.chimpandsee.org) is a successful citizen science platform on which participants are asked to differentiate chimpanzees. The goal of this project was to assess "a) the number of individual chimpanzees detected in camera trap video clips, (b) the frequency with which individual IDs could be assigned, and (c) the agreement level for individual ID assignments made by citizen scientists and experts" (McCarthy et al., 2020). Data was collected by using motion activated cameras to capture chimpanzees in their natural habitats. Analysis of the videos was done by prompting citizen scientist and experts to watch 15-second videos and identify the age and sex of the chimpanzee. If the participants were able to identify both criteria, they are prompted to give the chimpanzee a unique ID. Chimp & See requires each video to be analyzed by three different participants, allowing for a reduced error rate and, therefore, more accurate results. An analysis of this experiment found that citizen scientists and experts agreed 87% of the time (McCarthy et al., 2020). By using a citizen science format, the organization has been able to analyze a multitude of videos with accuracy.

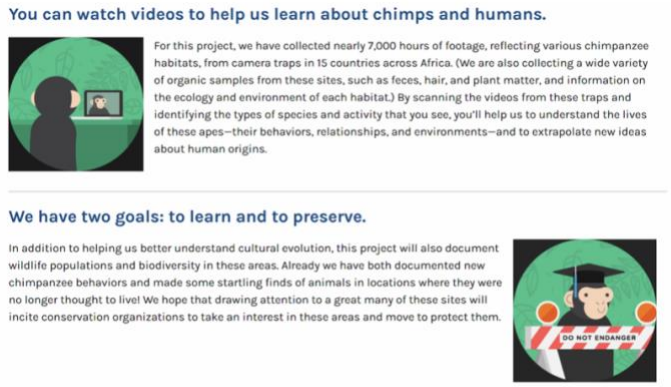

Figure 8: A portion of the Chimp & See About page, which clearly states the project and goals

Chimp & See is hosted on the platform Zooniverse, where organizations are able to promote their conservation efforts using citizen science. The site is very well organized, with clearly stated goals, instructions, and project background; this makes the site easy to navigate and aesthetically pleasing.

Case 2: Bird data on Ornitho

Ornitho (https://www.ornitho.de) is another citizen science platform focusing on bird watching. This platform was launched in 2011 and is still used today in several countries

including Germany, Switzerland, and France. This is a platform where participants are able to submit their observations as well as learn more about the species they identified. A case study was performed using the platform Orintho in order to compare citizen science platform users to nonusers. This study was carried out by circulating surveys with questions pertaining to demographics, whether or not they used a citizen science platform, their level of commitment, and other questions. Surveys were distributed through announcements on bird watching related websites, through chapters of bird watching clubs, Facebook groups, and birdwatching journals. All of the surveys were voluntary, and participants were able to quit at any time (Randler, 2021).

Data collected from the surveys were analyzed and it was found that in general, citizen science platform users were younger, were more committed to bird watching, and were more competent regarding bird knowledge. The results stated that citizen science users were "able to identify 4 times more bird species by song and appearance compared to non-users" (Randler, 2021). This study was a success in showing the benefits of using a citizen science platform for both scientific data collection and user education.

Ornitho is a standalone citizen science platform. The website on the surface is not pleasing to the eye, nor particularly easy to navigate for a first-time user. Additionally, the graphs that were used were a bit confusing. Nevertheless, there is a significant amount of information once oriented with the layout of the website.

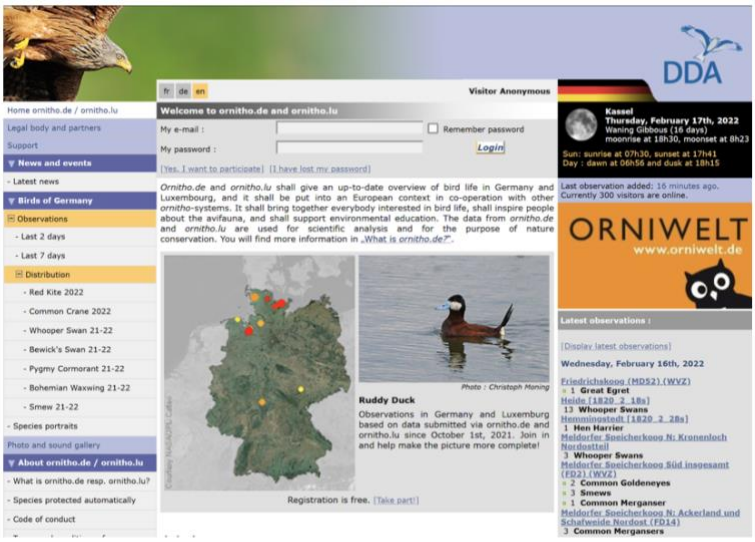

Figure 9: Ornitho's home site, which has a lot of information but no clear starting location

Case 3: Sediment and Seashores Project

Marine Metre Squared, or MM2, (https://www.mm2.net.nz) is a platform focused on capturing observations on New Zealand shores. The Sediment and Seashores project, which ran from 2015-2017, allowed schools and local groups to work alongside marine scientists to

establish monitoring sites, photograph and survey marine life and rocks. An assessment of Sediment and Seashores examined how citizen science can affect learning, skill development and environmental attitudes, specifically if citizen science could incite civic responsibility for the environment. The case study concluded that a key motive for students involved was "learning about the marine environment (73%)" (Carson et. al., 2021). The study found that students had gained valuable education, including content-specific knowledge, science skills, and awareness of environmental issues. Students also gained a greater understanding of how they can participate in civic conservation action (Carson el. Al., 2021). For the project's duration, scientists collected similar data, and there was no significant difference between the student's data and the scientist's data (Sediment and Seashores Project: MM2, n.d.). Sediment and Seashores was successful in showing the educational benefits to various demographics, including primary schoolers, secondary schoolers, and teachers, as well as the value of citizen science in data collection.

4.3 Conclusions for Best Practices

We analyzed scientific journals and articles on the best practices relevant to data collection to ensure our platform collects quality data. An important aspect is to collect a significantly large amount of data, so that outliers can be neglected (Kosmala et. al., 2016). It is also important that all collected data has an enforced type and standardized format (Kosmala et. al., 2016). For example, instead of having the user type in the number of fur seals in an image, the user is given a multiple-choice question with preselected numbers. In citizen science, it is recommended to only use existing platforms, as they are already tested, and are likely to have fewer issues (de Sherbinin et. al. 2021). It was also crucial that we create a positive user experience with our user base, as motivated users will submit quality data. It was thus important that we understand the age demographics we wanted to appeal to. A Pew Research Center survey found that in 2020, 10% of adults and 14% of adults millennial & younger had participated in citizen science in the past year (Pew Research Center, n.d.). When assessing data quality in citizen science study, it was found that participants younger than 45 performed better (Crall et. al., 2011).

Another best practice of citizen science was ensuring a positive user experience. The three most important aspects to ensure a positive experience were user friendliness, ease of use and accessibility (Rambonnet, 2019). Specifically, to make a citizen science platform accessible, any assigned tasks should be as simple and straightforward as possible (Kosmala et. al., 2016). From our research we concluded that keeping users interested is strongly related to maintaining a user-friendly platform. It is vital that users are motivated to use the platform. Users click onto a platform due to interest, and often want to gain topological knowledge, so a platform should be both interesting and educational (Keyles, 2018).

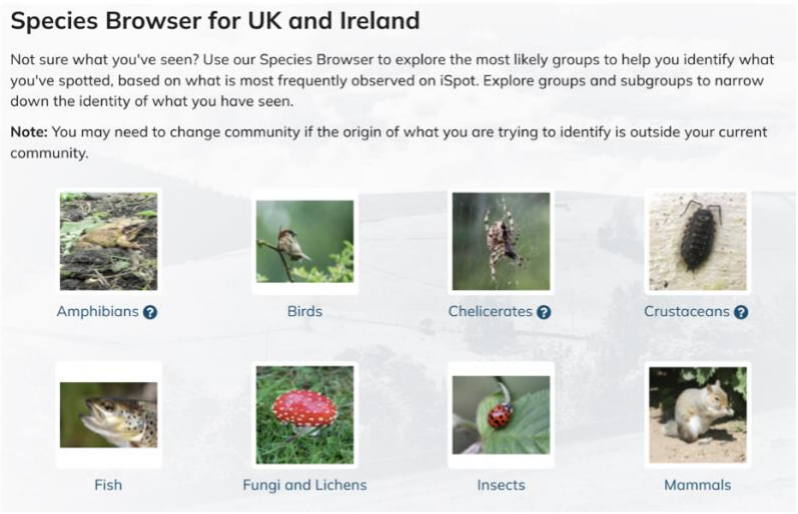

Figure 10: iSpotNature's Species Browser

In order to understand the best practices in platform design, we analyzed numerous citizen science platforms to examine how user friendly they were, and which aspects of their design aesthetically pleasing. While we are including significant observations here, our full participant observation can be found in Appendix D. The platform "Wrens - little birds big voices" hosted on iSpotNature had a species browser, which was a creative way to educate users on the animals they were seeing and ensure users are educated enough to make quality classifications. "Cambridge Urban Tree Monitoring," on CitSci.org, allowed users to input a lot of data on a dropdown menu, such as selecting a tree from a list of types. This felt much simpler than attempting to classify a tree by typing in a tree type, and the simplicity also reduced error. However, there were blank fields which were not type formatted, and the user could input letters into number columns. We studied the "Penguin Watch" platform on Zooniverse, which was easy

to use and straightforward, but the About section lacked images and had large chunks of words that could have been broken up.

4.4 Assessing Feedback from Platform Development

To gain a better understanding of peoples' understanding of the platform we created, we encouraged participants to complete a user feedback form after using our citizen science platform (see Appendix B). We have collected 29 responses. The general consensus is positive and constructive. The questions in the user feedback form can be broken down into three categories: user demographics, platform ease of use, and knowledge gained from the platform.

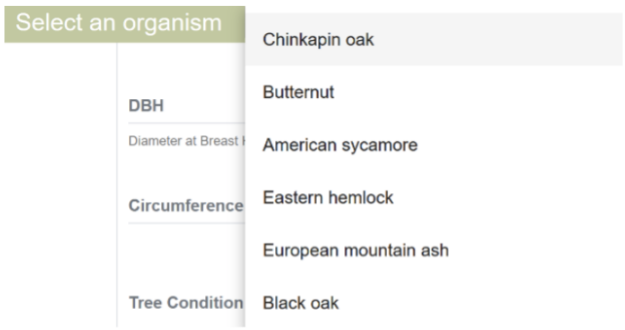

Figure 11: The "Select an organism" dropdown on Cambridge Urban Tree Monitoring

We found that most of the users were younger. Out of the users that filled out the feedback survey 46.4% of the participants were 21 years old. In total, 96.4% of the participants were between the ages 18 - 22. Additionally, 55.2% of participants heard about the platform from word of mouth, while 44.8 heard about it through email or otherwise. Because of barriers, like requiring people to sign a consent form for the survey, we were not able to reach as many people as we would have liked.

Many participants found our platform easy to use. Specifically, 62.1% of users found the platform "very easy" to use while 37.9% of users found it "moderately easy" (see Figure 12). The comments that were given in the form enabled us to see our project in a new way. Because we were the ones to develop the platform, we were somewhat unaware of the difficulties that users might have.

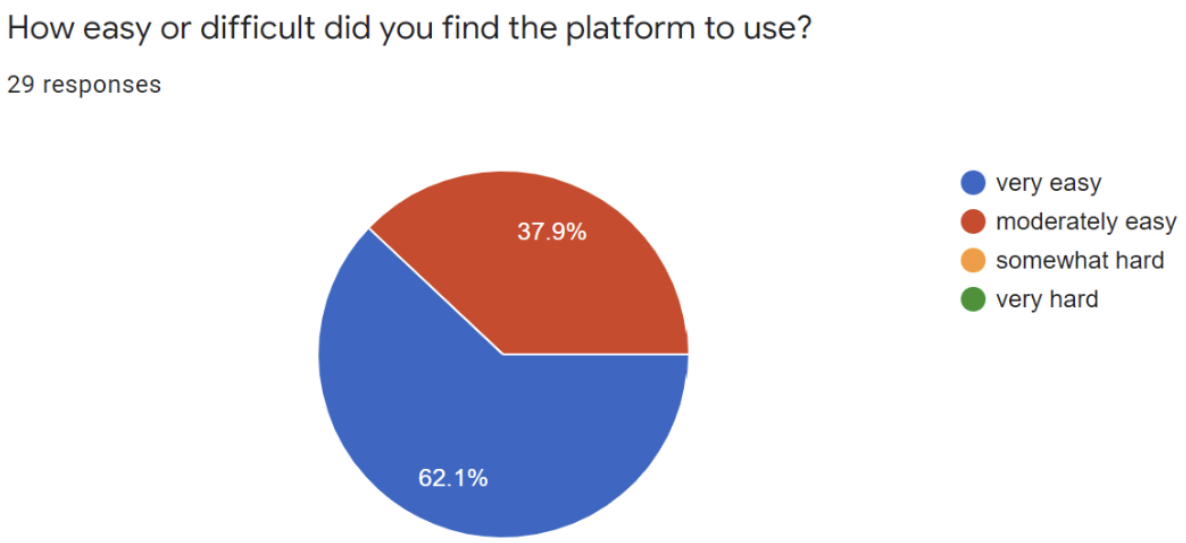

Figure 12. Pie chart representing data from the team's feedback form

While the interactive part of our platform was successful, the education part was not. One of our objectives for our project was to educate the public about the New Zealand sea lions and fur seals. In order to do this, we included 'Research' and 'Education' sections within our platform. From the user feedback survey, we found that 32.1% did not look at the pages on our site, other than the classify page. While photo classifications are our main objective, the education part is still important. We added a banner on the home page that encourages users to navigate to the other pages of the site to learn more about the conservation effort.

Another takeaway from the survey is that a good portion of the users answered incorrectly when prompted to state the project goal. As previously mentioned, many users did not navigate to the other pages, specifically the 'Research' and 'Education' page, which as a result may affect their understanding of the goal. We decided that it would be beneficial to have a clear and concise goal statement at the home page of the site to eliminate confusion. After reviewing all of the survey responses we made some final changes to the platform before presenting the final product to our sponsors.

4.4 Discussion of Results

Our results demonstrated a variety of important findings for us to consider when moving forward with the project. From our interviews with members of DOC we gained insightful

information such as the importance of reaching out to different locations and organizations to spread awareness of our platform. This allows for a variety of people, not all from the same organization, to use our platform and provide helpful feedback. When interviewing Hiromi Beran, we found out that she was the sole intern working on this project. This was something we were surprised to find out considering that we assumed there were multiple people working on it along-side her. Since she was the only one working on the platform, it shows that citizen science platforms, once developed, require minimal work for it to be sustainable.

The user interface of the platform is important as people of different ages, organizations, and general backgrounds will be using the platform. Based on this factor, one of the key takeaways from our research is that people are more likely to retain information via images than bodies of text. Taking into account that people learn better this way, we included two videos from the Auckland Zoo explaining the project. This was done in order to show the pakake conservation efforts, as well as to convey a lot of information in a way which is easier to understand than text. These changes will get people interested enough to participate without weighing them down with text. The data we found from this research strengthens and adds to what we found out from the literature review, where we speculated that images and videos likely should be a large part of our work, to create a platform with strong user experience.

From our research on citizen science strategies, the team found the key takeaways to be focused on creating a user-friendly platform on which to conduct the citizen science work. The main user base will likely be Generation X and younger. With such a large user base, we will need to make sure that the tutorials on the platform are clear and allow for people within that age range to be able to follow the instructions. When looking at the different pre-existing citizen science platforms, we were surprised at the differences between them all. We were also surprised at the difficulty of user experience we encountered on many of them. We had thought initially that there would have been a few platforms which included all of our needs, however Zooniverse was the only one which allowed for us to develop the platform and include all of the required aspects of the project. Another takeaway of the citizen science research we conducted is the importance of considering how data is collected given that many people will be analyzing the same images. With such a large quantity of data, it is important to have a method to sort through the analyzed data to facilitate the data collection on the organization's end.

The user feedback surveys were a helpful tool to gauge how people were interacting with the platform that we created. Though the information was helpful, the data may have been skewed a certain way because we chose who to send the platform and survey out to. Because of this, most of the initial testing was completed by college students in their early twenties. Overall, people have been able to use the platform with little to no problems. This may have been due to the fact that not many people in Generation X or the younger side of Generation Z were able to test it. If the team had obtained more responses from people in those age ranges, the results would likely be different and allow for the team to have a more accurate understanding of the accessibility of the platform.

Chapter 5 Recommendations

After the completion of our citizen science project, our team has identified four main areas for recommendations:

- Maintenance for the citizen science platform
- Using Zooniverse
- Advice for students and advisors at Worcester Polytechnic Institute
- Advice for organizations wanting to use citizen science

From these recommendations, we hope to positively influence future citizen science platforms.

5.1 Maintenance of Sea Lion Aotearoa

In order to maintain the site, we have identified four recommendations: to update key information, upload new photos, export data, and change workflows. The information in the research section of our site may need to be updated periodically to reflect progress that has been made since the information is only representative of what has been done up to March 2022. Additionally, as more photos are taken of the shelters, those photos will need to be uploaded onto the site. In addition to uploads, the data collected from citizen scientists' classifications will also need to be exported. While exporting the data isn't a hard task, it does take a while. Photo uploads and data exporting are relatively straightforward, so it should be easy for one person to do. Lastly, the workflows on the site will need to be switched over. Currently on the site, there are two workflows, the Sea Lion Workflow, and the Fur Seal Workflow. The site is currently on the Fur Seal Workflow; this means that the photos shown to participants are fur seal photos. As the cameras in the shelters start to capture photos of sea lions, those pictures will need to be uploaded to the sea lion workflow. The workflows must then be manually changed in the site editing section of Zooniverse. With these recommendations, we hope that the site is able to stay relevant after we hand it over to DOC.

5.2 Online Citizen Science and Zooniverse

For institutions and researchers wishing to use an online citizen science platform, we strongly recommend institutions conduct their own research. The Zooniverse website best fits our need to collect data on a series of images, but every citizen science project is unique, with its

own specific needs. Our team decided to use Zooniverse after conducting participant observation on seven major platforms. We suggest that researchers conduct similar observations before beginning work.

Furthermore, we suggest anyone developing an online platform to seek as much feedback as possible. Developers must consult any sponsors or project leaders to ensure the product is up to their standards and includes all needed features. Developers should also seek user feedback, as it will give the best sense of the platform's quality. User feedback allows users to raise issues a developer may not have noticed or thought of, as well as providing users a submission area to make suggestions on improvements.

For researchers and developers who do decide to use Zooniverse, we have identified two recommendations when building a project: keep images and videos uniform and simplify the data export

Our first recommendation is to keep all images and videos of relatively uniform size. In our interview with Hiromi, we discovered that some projects take extremely high-quality images and videos that Zooniverse can't host, because the images are too large. If this is the case, we recommend using a program to automatically resize all media to below Zooniverse's maximum image size. We also suggest keeping media a consistent size to improve user quality. In our participant observation of the Beluga Bits platform, we noticed that the image sizes are inconsistent and can at times be small and difficult to see. For this, we also recommend resizing images to increase their visibility.

For reading the data that Zooniverse provides, we recommend modifying Zooniverse's exported data, which is difficult to read and contains unnecessary information. Instead, we suggest using the "Processing Zooniverse Data Exports" script, made by a Zooniverse employee[1]. This program has clear instructions on how to modify the code for each individual project's needs. This makes the data easier to read and reduces work for researchers.

[1] You can find the link to my modified "Processing Zooniverse Data Exports" notebook at this link:
https://colab.research.google.com/drive/1b0_3Hf3qt_hkYIJuV8xkTFylIF4r0FAi?usp=sharing
You can find the link to the original notebook here:
https://colab.research.google.com/github/zooniverse/Data-digging/blob/master/notebooks_ProcessExports/zoo_processexport_lifevison.ipynb

metadata	annotations
{"source":"	[{"task":"T0","task_label":"How many fur seals are there?","value":"2"},{"task":"T5","task_label":"Are the fur seals sleeping or alert? If t
{"source":"	[{"task":"T0","task_label":"How many fur seals are there?","value":"0"}]
{"source":"	[{"task":"T0","task_label":"How many fur seals are there?","value":"1"},{"task":"T5","task_label":"Are the fur seals sleeping or alert? If t
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{"source":"	[{"task":"T0","task_label":"How many fur seals are there?","value":"1"},{"task":"T5","task_label":"Are the fur seals sleeping or alert? If t

File Name	Animal	Animal Count	Date	Time	Motion or '	Sleep or Active
2021-07-18 23-16-26 frontlow.jpg	Fur Seal	2	7/18/2021	23-16-26	M	Alert
2021-07-21 07-39-57 frontlow.jpg	Fur Seal	0	7/21/2021	07-39-57	N/A	N/A
2021-07-17 04-55-03 frontlow.jpg	Fur Seal	1	7/17/2021	04-55-03	M	Alert
2021-07-21 04-11-45 frontlow.jpg	Fur Seal	1	7/21/2021	4/11/1945	M	Unsure
2021-07-18 21-06-47 frontlow.jpg	Fur Seal	1	7/18/2021	21-06-47	M	Alert
2021-07-18 22-52-30 frontlow.jpg	Fur Seal	3	7/18/2021	22-52-30	M	Some sleeping, some alert
2021-07-16 19-43-00 frontlow.jpg	Fur Seal	1	7/16/2021	19-43-00	M	Alert
2021-07-14 20-49-25 frontlow.jpg	Fur Seal	0	7/14/2021	20-49-25	N/A	N/A
2021-07-17 00-35-05 frontlow.jpg	Fur Seal	1	7/17/2021	00-35-05	M	Sleeping
2021-07-16 07-34-32 frontlow.jpg	Fur Seal	0	7/16/2021	07-34-32	N/A	N/A
2021-07-17 04-55-09 frontlow.jpg	Fur Seal	1	7/17/2021	04-55-09	M	Alert
2021-07-15 00-33-45 frontlow.jpg	Fur Seal	0	7/15/2021	00-33-45	N/A	N/A
2021-07-21 00-17-12 frontlow.jpg	Fur Seal	0	7/21/2021	00-17-12	N/A	N/A
2021-07-14 22-54-20 frontlow.jpg	Fur Seal	0	7/14/2021	22-54-20	N/A	N/A
2021-07-14 22-50-54 frontlow.jpg	Fur Seal	0	7/14/2021	22-50-54	N/A	N/A
2021-07-16 19-43-02 frontlow.jpg	Fur Seal	1	7/16/2021	19-43-02	M	Sleeping
2021-07-18 21-06-36 frontlow.jpg	Fur Seal	1	7/18/2021	21-06-36	M	Alert

Figure 13: Zooniverse classification data before and after the "Processing Zooniverse Data Exports" script

5.3 Advice for Future Student Projects at Worcester Polytechnic Institute

For future students working on citizen science projects, we recommend using a platform that hosts citizen science platforms rather than creating a website and building from scratch. Most host platforms are set up with fields to enter information about your project with the user interface already created so that no coding is required. If the project was built from scratch on our own site there might not be as much engagement. Using a known host platform also allows for more easy discovery of the project. Zooniverse has a projects tab that allows anyone to browse projects by different categories of interest. Using a host platform will also require less maintenance. For our project we are passing on the platform to our sponsoring organizations. Thus, it is important that future maintenance of the site is very little. If we had created a website from scratch to host the project, our sponsoring organizations would have to change the code in order to update information on the site. Depending on the organization, that might not be feasible, and result in poor upkeep of the site. A host platform like Zooniverse, allows for easy updating of the project information.

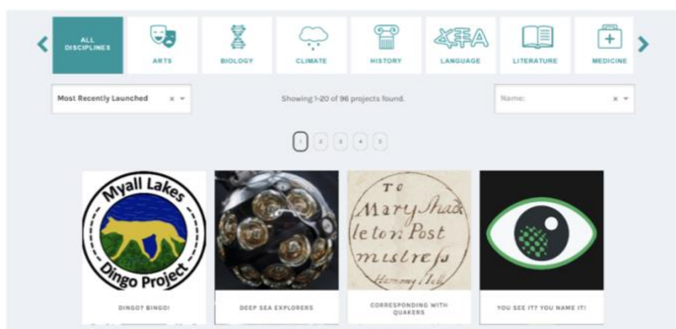

Figure 14: Screenshot of Zooniverse's 'Explore Projects' page

We advise future IQP teams that will be working on developing a platform or website to start building the platform from the first week to leave plenty of time for user testing. Getting the

feedback in advance allows for another round of final edits to polish out the platform before handing it off to your sponsoring organizations.

5.4 Advice for Organizations Wanting to Use Citizen Science

Based on the work the team conducted in both researching and building the citizen science platform, we have gathered some recommendations for future organizations wanting to use citizen science for data analysis. Citizen science can be an effective method for data analysis, however the organization behind the data needs to think about some aspects of their access to citizen science before jumping into developing a platform for it. One of the main aspects of citizen science which organizations should have an idea of is their outreach capabilities, specifically how many people can the organization realistically reach in order to aid with citizen science. In the case of DOC, there is a pre-existing media influence which allows them to share any new platforms with the public through that. In addition to media, DOC also has access to local schools and other public organizations to allow for demonstrations and discussions about citizen science. Future organizations interested in citizen science need to consider the fact that the wider available outreach the organization has access to, the more people will be involved with citizen science. While this manifests in the form of media and local outreach strategies for DOC, outreach can come around in many ways. If the organization has a stronger influence in the community, the organization could promote their citizen science through local discussions and displays. If they are more of a media-based organization, it would be beneficial to use the media to their advantage and spread awareness via social media and other news sources.

As a whole, citizen science is ideal for low budget, outsourcing work, as it largely thrives on volunteers. Depending on the type of citizen science the organization plans on using, the work can be done at home or requires going out into the environment to record data. Therefore, there are minimal costs for the organization to allow citizen science to be accessible to the public, making it highly appealing to many organizations. While citizen science is good for getting a widespread amount of data, the data is not always entirely accurate since it is coming from volunteers, and it is possible that certain aspects of performing the analysis get overlooked. This can be countered by the organization developing their citizen science in a way where multiple people analyze the same image, in the case of an image analysis project. Another recommendation could be for organizations which ask for volunteers to monitor a certain

location for changes or to count a certain species in the area. The organization could allow for higher accuracy by making the time periods on a regular basis and short enough where the volunteers would hold their attention the whole time.

Chapter 6 Conclusion

The goal of our project was to create a citizen science platform where citizen scientists are able to classify photos that were provided by DOC. We were able to successfully fulfill this goal by creating an interactive platform, on Zooniverse, for citizen scientists to use. Due to the simple nature of the classifications that are required for each picture, we expect that citizen scientists will be willing to make classifications on one, if not many, photos. With the help of volunteers, our project will fulfill DOC's photo classification needs as well as educate the public on New Zealand pakake. Educating the public is an integral part of conserving the pakake since the general public may not know a lot about pakake. This project is an advancement in the conservation of the New Zealand pakake. With the help of DOC and other conservation organizations, pakake populations will rise and no longer be endangered.

References

Auckland Zoo. (n.d.). *About us*. Auckland Zoo. https://www.aucklandzoo.co.nz/about-the-zoo

Auckland Zoo (n.d.). Wild work: Our conservation work. Retrieved November 17, 2021, https://www.aucklandzoo.co.nz/wildwork

Bruyere, B., & Rappe, S. (2007). Identifying the motivations of environmental volunteers. *Journal of Environmental Planning and Management*, *50*(4), 503–516. https://doi.org/10.1080/09640560701402034

Carson, S., Rock, J., & Smith, J. (2021). Sediments and Seashores—A Case Study of Local Citizen Science Contributing to Student Learning and Environmental Citizenship. Frontiers in Education, 6. https://www.frontiersin.org/article/10.3389/feduc.2021.674883

Chilvers, B. L., Wilkinson, I. S., & Childerhouse, S. (2007). New Zealand sea lion, Phocarctos hookeri, pup production—1995 to 2006. *New Zealand Journal of Marine and Freshwater Research*, *41*(2),205–213. https://doi.org/10.1080/00288330709509909

Chilvers, B. L., & Meyer, S. (2017). Conservation needs for the endangered New Zealand sea lion, Phocarctos hookeri. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *27*(4), 846–855. https://doi.org/10.1002/aqc.2742

Collins, C. J., Chilvers, B. L., Taylor, M., & Robertson, B. C. (2016). Historical population size of the threatened New Zealand sea lion Phocarctos hookeri. *Journal of Mammalogy*, *97*(2), 436–443. https://www.jstor.org/stable/26373062

Collins, C. J., Rawlence, N. J., Prost, S., Anderson, C. N. K., Knapp, M., Scofield, R. P., Robertson, B. C., Smith, I., Matisoo-Smith, E. A., Chilvers, B. L., & Waters, J. M. (2014). Extinction and recolonization of coastal megafauna following human arrival in New Zealand. *Proceedings of the Royal Society B: Biological Sciences*, *281*(1786), 20140097. https://doi.org/10.1098/rspb.2014.0097

Crall, Alycia W., Newman,Gregory J., Stohlgren, Thomas J., Holfelder, Kirstin A., Graham, Jim, Waller , Donald M. (2011). Assessing citizen science data quality: an invasive species case study. Conservation Letters: A Journal for The Society for Conservation Biology, 4. https://doi.org/10.1111/j.1755-263X.2011.00196.x

De Lisle, J. F. (1965). The climate of the Auckland Islands, Campbell Island and Macquarie Island. *Proceedings (New Zealand Ecological Society)*, *12*, 37–44. http://www.jstor.org/stable/24061169

De Sherbinin, A., Bowser, A., Chuang, T.-R., Cooper, C., Danielsen, F., Edmunds, R., Elias, P., Faustman, E., Hultquist, C., Mondardini, R., Popescu, I., Shonowo, A., & Sivakumar, K. (2021). The Critical Importance of Citizen Science Data. Frontiers in Climate, 3. https://www.frontiersin.org/article/10.3389/fclim.2021.650760

Domroese, M. C., & Johnson, E. A. (2017). Why watch bees? Motivations of citizen science volunteers in the Great Pollinator Project. *Biological Conservation*, *208*, 40–47. https://doi.org/10.1016/j.biocon.2016.08.020

Eisen, L., & Eisen, R. J. (2021). Benefits and Drawbacks of Citizen Science to Complement Traditional Data Gathering Approaches for Medically Important Hard Ticks (Acari: Ixodidae) in the United States. *Journal of Medical Entomology, 58*(1), 1–9. https://doi.org/10.1093/jme/tjaa165

Free Image on Pixabay—Sea Lion, New Zealand, Kaikoura. (n.d.). Retrieved December 7, 2021, from https://pixabay.com/photos/sea-lion-new-zealand-kaikoura-happy-1923946/

Godman, L. (n.d.). *New Zealand's subantarctic islands map, codes of survival.* Retrieved November 17, 2021, from https://www.lloydgodman.net/codes/Introduction/into2.html

Graham-McLay, C. (2021, November 9). New Zealand's sea lions are back, and crashing golf courses and soccer matches. *The New York Times*. https://www.nytimes.com/2021/11/09/science/new-zealand-sea-lions.html

Keyles, S. (2018). Citizen Science, Important Tool for Researchers. Science Connected Magazine. https://magazine.scienceconnected.org/2018/09/citizen-science-important-tool/

Kosmala, M., Wiggins, A., Swanson, A., & Simmons, B. (2016). Assessing data quality in citizen science. Frontiers in Ecology and the Environment, 14(10), 551–560. https://doi.org/10.1002/fee.1436

Jefferson, T. A., Webber, M. A., & Pitman, R. L. (2015). 6. In T. A. Jefferson, M. A. Webber, & R. L. Pitman (Eds.), *Marine Mammals of the World (Second Edition)* (pp. 358–522). Academic Press. https://doi.org/10.1016/B978-0-12-409542-7.50005-6

Lalas C., Bradshaw C. (2001). Folklore and chimerical numbers: Review of a millennium of interaction between fur seals and humans in the New Zealand region. *New Zealand Journal of Marine and Freshwater Research*. 35:3, 477-497, https://doi.org/10.1080/00288330.2001.9517017

McCarthy MS., Stephens C., Dieguez P., et al. (2020). Chimpanzee identification and social network construction through an online citizen science platform. *Ecology and Evolution.* 2021;11:1598-1608. https://doi.org/10.1002/ece3.7128

McKinley, D. C., Miller-Rushing, A. J., Ballard, H. L., Bonney, R., Brown, H., Cook-Patton, S. C., Evans, D. M., French, R. A., Parrish, J. K., Phillips, T. B., Ryan, S. F., Shanley, L. A., Shirk, J. L., Stepenuck, K. F., Weltzin, J. F., Wiggins, A., Boyle, O. D., Briggs, R. D., Chapin, S. F., … Soukup, M. A. (2017). Citizen science can improve conservation science, natural resource management, and environmental protection. *Biological Conservation*, *208*, 15–28. https://doi.org/10.1016/j.biocon.2016.05.015

Ministry for Primary Industries. (n.d.). *Fisheries and the New Zealand sea lion.* Retrieved November 17, 2021, from https://www.mpi.govt.nz/fishing-aquaculture/sustainable-fisheries/protecting-marine-life/recovering-sea-lion-rapoka-populations/fisheries-and-the-new-zealand-sea-lion/

Mitchell, N., Triska, M., Liberatore, A., Ashcroft, L., Weatherill, R., & Longnecker, N. (2017). Benefits and challenges of incorporating citizen science into university education. *PLOS ONE,* 12(11), e0186285. https://doi.org/10.1371/journal.pone.0186285

New Zealand Department of Conservation. (2021). *Stormy success for sea lions.* Conservation blog. https://blog.doc.govt.nz/2021/08/06/stormy-success-for-sea-lions/

New Zealand Department of Conservation. (2020). Conservation act 1987. https://www.doc.govt.nz/about-us/our-role/legislation/conservation-act/

New Zealand Department of Conservation (n.d.). *Fieldwork to recover the NZ sea lion population.* https://www.doc.govt.nz/nature/native-animals/marine-mammals/seals/new-zealand-sea-lion/research-and-fieldwork/

New Zealand Department of Conservation. (n.d.). *Sea lion monitoring on the Auckland Islands.* https://www.doc.govt.nz/our-work/sea-lion-monitoring-on-the-auckland-islands/

New Zealand Department of Conservation. (n.d.). *Our purpose and outcomes.* New Zealand Department

of Conservation. https://www.doc.govt.nz/about-us/

New Zealand Department of Conservation (n.d.). Campbell Island/Moutere Ihupuku marine reserve. https://www.doc.govt.nz/parks-and-recreation/places-to-

go/southland/places/subantarctic-islands/campbell-island/campbell-island-moutere-ihupuku-marine-reserve/

New Zealand Department of Conservation (n.d.). *Threat management plan for New Zealand sea lion*. Retrieved November 17, 2021, from https://www.doc.govt.nz/nature/native-animals/marine-mammals/seals/new-zealand-sea-lion/new-zealand-sea-lion-rapoka-threat-management-plan/

New Zealand Department of Conservation(n.d.). *Threats to New Zealand sea lion*. Retrieved November 17, 2021, from https://www.doc.govt.nz/nature/native-animals/marine-mammals/seals/new-zealand-sea-lion/threats/

Oxford Lexico. (n.d.). "by-catch". In *Oxford English US Dictionary*. Retrieved November 17th, 2021, from https://www.lexico.com/en/definition/by-catch

Parkinson, M. (n.d.). The Power of Visual Communication. 7. Retrieved February 16, 2022, from https://innovativeresearchmethods.org/wp-content/uploads/2020/10/The-Power-of-Visual-Communication_Parkinson.pdf

Radio New Zealand. (2021). DOC investigating death of 11 fur seals in Kaikōura. *Radio New Zealand.* https://www.rnz.co.nz/news/national/455046/doc-investigating-death-of-11-fur-seals-in-kaikoura

Rambonnet, L., Vink, S. C., Land-Zandstra, A. M., & Bosker, T. (2019). Making citizen science count: Best practices and challenges of citizen science projects on plastics in aquatic environments. Marine Pollution Bulletin, 145, 271–277. https://doi.org/10.1016/j.marpolbul.2019.05.056

Randler C. (2021). Users of a citizen science platform for bird data collection differ from other birdwatchers in knowledge and degree of specialization. *Global Ecology and Conservation.* 27. https://doi.org/10.1016/j.gecco.2021.e01580

Reid, R. (n.d.). *Back from the brink: New Zealand sea lions given fighting chance.* Auckland Zoo. Retrieved November 16, 2021, https://www.aucklandzoo.co.nz/news/back-from-the-brink-new-zealand-sea-lions-given-fighting-chance

Silvertown, J. (2009). A new dawn for citizen science. *Trends in Ecology & Evolution*, *24*(9), 467–471. https://doi.org/10.1016/j.tree.2009.03.017

Turner, A. (2018, July 10). How Many People Have Smartphones Worldwide (Feb 2022). https://www.bankmycell.com/blog/how-many-phones-are-in-the-world

Turney, C. (n.d.). *Figure 1: Map showing the location of Campbell Island and the key Southern Ocean sites discussed in the text.* ResearchGate. Retrieved December 2, 2021, from https://www.researchgate.net/figure/Map-showing-the-location-of-Campbell-Island-and-the-key-Southern-Ocean-sites-discussed-in_fig2_45530590

Wairarapa Times-Age. (2021, July 22). *Getting the seal of approval.* https://times-age.co.nz/getting-the-seal-of-approval/

Ward, K. (2014). *Researching the city*. SAGE Publications, Ltd, https://www.doi.org/10.4135/9781526401885

World Wildlife Foundation. (n.d.). New Zealand sea lions. World Wildlife Foundation New Zealand. Retrieved November 15, 2021, https://www.wwf.org.nz/what_we_do/species/sealions2/

Wu, Y., Xie, L., Huang, S., Li, P., Yuan, Z., Liu, W., (n.d.). Using social media to strengthen public awareness of wildlife conservation | Elsevier Enhanced Reader. (Feb 2022). From https://doi.org/10.1016/j.ocecoaman.2017.12.010

Veasey, Adriana. (2019, May 8). Web Design: Effective UX Strategies for Educational Websites.Blog.Icons8.Com.https://blog.icons8.com/articles/ux-design-educational-websites/

Wang, Z., Wang, S., Farinella, M., Murray-Rust, D., Henry Riche, N., & Bach, B. (2019, February 26). Comparing Effectiveness and Engagement of Data Comics and Infographics. https://doi.org/10.1145/3290605.3300483

Citizen science more common among younger, highly educated Americans | Pew Research Center. (n.d.). Retrieved January 31, 2022, from https://www.pewresearch.org/fact-tank/2020/06/25/younger-more-educated-u-s-adults-are-more-likely-to-take-part-in-citizen-science-research/

How to Make a Website More Engaging in 15 Easy Steps. (n.d.). WebFX. Retrieved January 31, 2022, from https://www.webfx.com/web-design/learn/how-to-make-website-more-engaging/

Sediment and Seashores Project: MM2. (n.d.). Retrieved February 10, 2022, from https://www.mm2.net.nz/get-involved/sediment-and-seashores-project

Appendices

Appendix A: Interview Questions for DOC members

1. Do we have your consent to record audio and video for this interview?
    a. This project is recording interviews as part of an educational project. By appearing on camera/audio, you are consenting to the use of your image/voice for the purpose of our project which will be published on the WPI website.
2. What is your job title?
    a. What is your day to day job at DOC?
    b. What experience do you have, if any, with DOC's public engagement or marketing?
3. To your knowledge, what are DOC's current strategies for public engagement?
    a. In your opinion, have these methods been successful?
    b. If so, why would you say they've been successful?
    c. If they have been unsuccessful, what has impacted this?
    d. Do you have any suggestions for public engagement?
4. Are you familiar with citizen science platforms?
    a. Have you ever worked on one?
    b. If so, could you explain what went well? What would you change?
5. Ideally, what would the new citizen science platform include?
    a. What is the most important feature you'd like to see?
6. Do you have any additional questions or comments?

Appendix B: User Feedback Survey Questions

1. In which browser(s) have you tried the project?
    a. Chrome
    b. Safari
    c. Firefox
    d. Internet Explorer
    e. Edge
    f. Other: (specify: _____)

2. How did you hear about this platform?
    a. Social Media (specify: _____)
    b. Website (specify: _____)
    c. Email
    d. News article
    e. Word of mouth
    f. Other (specify: _____)
3. What is your age?

    _____
4. How easy or difficult did you find the platform to use?
    a. very easy
    b. moderately easy
    c. somewhat hard
    d. very hard
    e. Other (specify: _____)
5. If you had any difficulty please explain below.

    _____
6. Did the tutorial adequately explain how to use the interface to complete the required tasks?
    a. Yes
    b. No
    c. I didn't read the tutorial
    d. Other (specify: _____)
7. What do you think the project's goals are, based on what you've read?

    _____
8. What additional information or capability would you find helpful or interesting?

    _____
9. Did you find the additional information on the other pages useful? (E.g. the 'Research' page or 'Education' page)
    a. Yes
    b. No

c. I didn't read the other pages

d. Other (specify: _____)

10. Would you recommend this platform to others?

a. Yes

b. No

11. Any additional comments or feedback?

Appendix C: Participant Observation Checklist

Platform Name: _____

Host Site (if applicable): _____

- This platform allows me to look at images
    - I can input data I collected from these images
- This platform allows me to look at videos
    - I can input data I collected from these videos
- This platform hosts educational media
    - Text
    - Image/infographic
    - Video
    - Other (specify: _____)
- This platform allows fundraising
- On a scale of 1-7, using this platform is:

Very difficult and confusing	Difficult	Slightly difficult	Neutral	Slightly easy	Easy	Very easy, no confusion
1	2	3	4	5	6	7

    - Explain:

_____

- Additional comments/feedback (Include notable additional features here):

_____

- Overall score out of 10: _____