THE BRINK OF EXTINCTION: SAVING THE MĀUI DOLPHIN USING SURFER SCIENCE

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Abstract

This project aided the World Wide Fund for Nature - New Zealand and the Department of Conservation in improving the Spatially Explicit Fisheries Risk Assessment habitat model of the endangered Māui dolphin. We developed and tested a survey to estimate surfer effort along the West Coast of the North Island. Survey analysis indicated that this method can be used to measure surfer effort and improve spatial modeling techniques. We successfully distributed awareness materials to promote the importance of reporting Māui dolphin sightings. Our findings show that this methodology can be applied to other cases of endangered species habitat mapping.
Executive Summary

Background

The Māui dolphin (*Cephalorhynchus hectori Māui*), also called Māui’s dolphin, is a subspecies of Hector’s dolphin that is endemic to the West Coast of New Zealand’s North Island. The Māui dolphin is physically identical to the Hector’s dolphin, pictured below. The Māui dolphin is critically endangered, with estimates suggesting that only around 60 dolphins remain (Baker et al. 2016). There are several threats that affect the Māui dolphin’s chance of survival. The most prominent threat stems from dangerous fishing practices that result in the bycatch of Māui dolphins. Currently, the species can only withstand one human-induced death every 10 to 23 years to stand a chance at population rebound. However, recent estimates suggest that an average of 5.27 Māui dolphin deaths occur each year as a result of fishing practices (Curry et al. 2012).

To combat the trend in declining dolphin numbers, the New Zealand Department of Conservation (DOC) and the World Wide Fund for Nature-New Zealand (WWF) have been driving efforts for Māui habitat protection. The New Zealand Government has devised the Spatially Explicit Fisheries Risk Assessment (SEFRA) to gain an understanding of the interplay between fisheries and the Māui dolphin population. SEFRA is a modeling system that maps the distribution of the Māui dolphin and compares that range to areas where dangerous fishing practices take place. This estimates the risk that the fishing industry poses to the dolphins (Lonergan, Phillips, Thomson & Zhou, 2017). SEFRA utilizes verified sightings from New Zealand citizens and scientists to map this distribution. A large portion of these reports come from surfers who are active in the same area as the dolphins.
While SEFRA currently has data on the number of dolphins spotted across the coast, it is unable to estimate the density of the dolphins based on surfer sightings because there is no measure of effort from the surfing population. Effort varies spatially, which can lead to disparities between the actual number of dolphins and the number of dolphins that are reported. A value is needed to estimate the probability that the presence of a Māui dolphin will be reported, and that also accounts for factors that vary by location. This value is termed surfer effort, but the variables that constitute it are not well-defined. By defining and collecting data regarding surfer effort, SEFRA scientists will be able to map the spatial density of the Māui dolphin along its range (Jim Roberts and Ben Sharp, personal communication, January 11, 2019).

**Goals, Objectives, and Methods**

This project aimed to develop a method for estimating the spatial distribution in surfer effort along the West Coast of the North Island of New Zealand. It also aimed to promote the importance of reporting Māui dolphin sightings to the surfing population in this region.

To achieve these goals, we designed the following objectives:

**Objective 1:** Identify key surfing beaches and virtual communities that have the potential to provide the necessary data on surfing populations.

The team consulted with SEFRA scientists Ben Sharp and Jim Roberts to identify locations to survey. We targeted surfing beaches as well as virtual communities. To narrow down the possible range of social media pages and internet forums, the team chose pages that had the criteria of being surfing or conservationist related and had members that are from the North Island of New Zealand.

**Objective 2:** Identify the factors that prevent the use of surfer sightings in SEFRA. Define the values that constitute surfer effort.

The team conducted interviews with key individuals including Ben Sharp, Jim Roberts, Laura Boren, and Amanda Leathers. In all interviews, we addressed questions regarding how SEFRA works, what prevents surfer sightings from being used in the system, and how to address the data needs of SEFRA through survey questions. Following the interviews, we developed a more solidified concept of surfer effort and the data needed to define it.

**Objective 3:** Gather data regarding spatial distribution, density, and reporting habits of surfers along the West Coast of New Zealand’s North Island using a participatory survey.

The team created a survey using an online survey and data analysis application. The survey was designed to satisfy three criteria: it should gather relevant data regarding surfer effort, be time efficient, and be user-friendly. We evaluated the effectiveness of the survey based on several measures such as quantity and frequency of responses, average completion time, and the average score received from a survey satisfaction question.
Objective 4: Promote awareness of the Māui dolphin and the importance of becoming a surfer scientist by reporting sightings of the subspecies.

To promote awareness, we created awareness campaign materials. A sticker and a matching flyer were designed with consideration from the WWF and DOC. These materials included suggested ways to report sightings. The stickers were given to survey participants and distributed to surf shop. The flyers were posted at surfing beaches and locations such as surf shops, cafes, and hostels.

Findings, Conclusions, and Recommendations

Finding 1: Surfing-related Facebook and Reddit pages, as well as the physical locations of Raglan, Piha, and New Plymouth were selected as communities to be surveyed.

Based on our conversations with Ben Sharp and Jim Roberts, the team identified Raglan, Piha, and New Plymouth as important surveying locations. These locations contain large surfing communities and fall within the Māui dolphin habitat. Due to time constraints we were only able to do in-person surveying in Raglan. Additionally, we identified Facebook and Reddit as platforms to post our survey to. The survey was posted to Facebook pages including SURFING Stock Exchange, Surfing New Zealand Discussion Group, NZ Surfers Group, and Raglan Surf School. In addition, Peggy Oki, a contact in Raglan, posted the survey on Let’s Face It Visual Petitions Facebook Page, which advocates for Māui dolphin conservation. Peggy Oki also contacted Christine Rose, a member of the Muriwai community, who posted the survey to the Muriwai community page, the Dolphin Defenders NZ page, and the Cetacean Spotting page. The team posted the survey to the New Zealand subreddit on the Reddit internet forum as well.
In Raglan, we surveyed three main beaches: Manu Bay, Ngarunui Beach, and Whale Bay. While all these beaches neighbor each other, they each have different conditions and therefore draw different demographics. We found that breaks with popular waves as well as an area to sit and rest provided the best opportunity for surveying the Raglan Surfing community. This combination of made people more willing to talk with us and participate in the survey.

**Finding 2: Surfer effort is a complex statistic composed of values including density of surfers, how likely the surfers are to report a sighting, and the number of days surfers are available to make a sighting.**

According to interviews with Ben Sharp and Jim Roberts, surfer sightings cannot be used in the SEFRA system because there is too much statistical variability between locations sightings are reported from. Key variables differ between spatially explicit areas, including the density of surfers, the number of days surfers inhabit the beach, and how likely the surfers are to report a sighting. All these factors can create a discrepancy between the number of dolphins reported and the actual density of dolphins. This must be mathematically factored in to convert the number of sightings into density in each reporting area.

**Finding 3: The survey gathered data regarding spatial distribution, density, and reporting habits of surfers needed for SEFRA.**

Following our interview with Ben Sharp and Jim Roberts, we edited our original survey to include questions aimed at finding out the surfing frequency and most popular surfing locations, as well as the likeliness of reporting a Māui dolphin sighting from a surfer.

Upon distributing the survey to selected Facebook groups, we obtained 34 responses. The greatest peak in responses occurred within a day of posting the survey. The post to the New Zealand subreddit resulted in 12 responses within the first three days. The subreddit post also received somewhat negative comments from users sharing the opinion that it was too late to save the Māui dolphin, and that the subspecies “was already extinct”.

In-person surveying in Raglan resulted in 36 responses. From the survey, we collected data such as number of days surfed, number of surfers seen on average per day, most popular surfing phone applications and websites, and the likelihood of reporting a sighting. Using respondent feedback, we constructed a finalized survey to best collect surfer effort data.
Finding 4: We created and distributed stickers and flyers that promote awareness of the Māui dolphin as well as the importance of reporting dolphin sightings.

The finalized sticker and poster design had the same theme and were visually appealing. They were well received by surfers and locals and posted around Raglan. On multiple occasions, survey participants asked if they could have more than one. Many said they liked the color scheme and were visually attracted to them before reading the content.

Conclusion
Through feedback consideration, survey improvements and data analysis based on our initial discussion with Ben Sharp and Jim Roberts, we concluded that the survey was effective in gathering data components of surfer effort. By providing the SEFRA scientists with these data, we helped them estimate effort and incorporate surfer sightings of the Māui dolphin into the SEFRA modeling system. The addition of these data to SEFRA maps will allow scientists to make recommendations to the government regarding fishing restrictions.

By testing various distribution pathways, we found that the most effective way to gather data from New Zealand’s North Island surfing community was through in-person surveying because of increased participant engagement. In-person distribution gave participants more incentive to take, complete, and provide feedback on the survey in a way that the online surveys fell short. Due to the increased engagement from this surveying method, our effort to increase participation and awareness of reporting sightings was also promoted.
Based on the positive reactions that respondents had when they received a sticker or a flyer, we determined that the awareness materials were successful. Surfers enjoyed the design and were enthusiastic about using them to get involved in reporting sightings and spreading awareness for the Māui dolphin on their own.

Before this project, there was minimal information regarding effort values for citizen science-based mapping. Our developed concept of surfer effort can be used as a model of how to synthesize a spatial effort value and therefore can provide legitimate value to projects which map comparative spatial variation phenomena or events using citizen science.

**Recommendations**

Based on these findings, we recommended that the WWF and/or DOC:

1. Continue to increase the number of surveyed beaches and communities by expanding surveying efforts
2. Form partnerships with local organizations hosting surfing competitions in order to distribute the survey and awareness materials
3. Increase online conservation and data collection efforts
4. Repeat the survey in the winter months to obtain seasonal surfer effort estimations
5. Continue to distribute our awareness materials, including at Raglan’s Māui dolphin Day.
6. Re-print the designed stickers to be waterproof so they can be placed on surfboards, cars, and boats.
7. Analyze the effectiveness of awareness materials by measuring the number of reported sightings in Raglan after the flyers and stickers were distributed and comparing it to the number of reported sightings before.
8. Use the emails compiled from the survey to create a Māui dolphin supporter group
9. Encourage the reporting of all rounded-fin dolphin sightings on the North Island, regardless of whether the reporter believes the dolphin is a Hector’s or Māui.
10. Distribute both an online and mobile phone version of the survey to increase the user-friendliness of the questions

*Surfers at Manu Bay (Reiniger, 2019).*
Authorship
The report was written and edited by all members of the team. The following is a list of the specific team members that took the lead role in the first draft of each respective section.

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Having spent the last five months developing an understanding of the Māui dolphin and New Zealand conservation efforts, we’d like to extend our sincerest hopes and wishes for future Māui dolphin conservation success and population rebound.
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1. Introduction

Marine biodiversity plays a critical role in global ecosystem health, including resilience to extinction. The ocean accounts for approximately 70% of the Earth’s surface area and is home to over 2 million classified species, thus the maintenance of marine biodiversity plays a huge role in life on Earth (Mora, Tittensor, Adl, Simpson & Worm, 2011; Williams, 2014). Species variety in marine ecosystems promotes the ocean’s ability to withstand changes in climate and habitat disturbances. Declines in biodiversity affect more than just the environment. There are 2.6 billion people who rely on ocean fisheries for both food and income (U.S. Agency for International Development, 2017). Decreases in biodiversity result in ecosystems that are less efficient in production of essential goods, such as food and fuel. Beyond impacts on human livelihood, the affected ecosystems have reduced participation in global cycling of key nutrients, water, oxygen, and energy. These factors are vital to the support of the world’s species.

Marine species, more specifically marine mammals, are key members of marine ecosystems due to their role in the passing of energy through ecosystem levels, also known as energy flux (Katona & Whitehead, 1988). Marine mammals are indicators of ecosystem health and productivity. This is because they are higher up in the marine food chain, and thus suffer more obvious effects when overall ecosystem health is suffering (Katona & Whitehead, 1988). Whales, dolphins, and porpoises—collectively known as cetaceans—are vulnerable to endangerment and population decline due to this significant role. Threats such as reduction of prey species and unintentional capture from fishing practices, also known as bycatch, have taken tolls on cetacean quantities worldwide and forced species to extinction (Read, 2008). One affected species is the Yangtze River Dolphin, which is considered the first documented cetacean extinction (Turvet et al, 2007). Facing a similar fate is the Vaquita, a porpoise native to the Gulf of California that is facing critical endangerment with under 30 individuals left in its population (Porpoise Conservation Society, 2016). Without intervention, the Vaquita and other marine mammals will be lost.

To combat species loss and the associated decreases in biodiversity, many organizations pursue conservation efforts. For example, in 1964 the International Union for Conservation of Nature (IUCN) developed a list of endangered species to spearhead conservation efforts. This “Red List” serves as a global reference for all species’ current population states and what efforts are being enacted to protect them. Marine Protected Areas (MPAs) are the leading marine conservation programs in many countries (Gubbay, 1995). MPAs are government regulated areas of water that aim to protect marine life within them, which is important for cetaceans that get tangled in fishing gear or collide with vessels (Gubbay, 1995). As of 2018, MPAs combine to cover approximately 7.44% of the global marine environment, a 10-fold increase since 2000 (Protected Planet, n.d.). Although efforts like MPAs exist around the world, biodiversity is concentrated around island nations. Thus, it is important to spearhead protection measures in these areas (U.S. Agency for International Development, 2017).

One region experiencing marine mammal species decline is New Zealand. Because New Zealand is an island nation, it has evolved copious endemic species. Its biodiverse environment houses nearly 4,000 species considered to be endangered (Endangered Species Foundation, n.d.). Among these is the Māui dolphin, a subspecies of the more numerous Hector’s dolphin. This dolphin is in the top 10 most endangered species in New Zealand, with around 60 individuals remaining (Baker et al., 2016). According to the IUCN, the Māui dolphin is critically endangered and protected under the New Zealand Marine Mammals Protection Act (Currey, Boren, Sharp & Peterson, 2012). Additionally, the New Zealand government began assessing the current threats to the Māui dolphins. This includes the Spatially Explicit Fisheries Risk Assessment (SEFRA) system, which measures the risk fishing boats pose to Māui dolphins. Data for this effort are collected from public and scientific sightings. Each sighting must be verified by a
specialist for it to be used in the system. SEFRA allows scientists to develop a spatial model that can accurately describe the scope of the dolphins’ habitat and therefore can influence fishing restrictions. While the government has recently expanded the prohibited fishing areas (Department of Conservation, 2013), disputes between fishermen and conservationists over the range of the Māui dolphins has left their habitat underrepresented (Gardner & van Beynen, 2015). Reported sightings often come from surfers, but the reports cannot be fully incorporated into the official SEFRA model because it is difficult to measure the spatial distribution and “effort” of this demographic (Amanda Leathers, personal communication, November 19, 2018). These sightings have the potential to expand the model’s representation of the Māui dolphins’ range and enable the SEFRA system to impact other conservation efforts around the world.

This project aimed to develop a method for estimating the spatial variation in surfer effort along the West Coast of the North Island of New Zealand. Surveys were used to collect data pertaining to the surfing community that interacts directly with the currently projected Māui dolphin range. Surveys required face-to-face interactions with surfers to determine where they surf, when they surf, and their awareness and interest in using reporting methods to record sightings of the Māui dolphins. The surveys were administered at locations on the North Island’s West Coast, identified through analysis of surfing population statistics and interviews with knowledgeable surfing community members. Factors that prevent the use of surfer sightings in SEFRA were identified through interviews with Jim Roberts, a scientist from National Institute of Water and Atmospheric Research (NIWA), and Ben Sharp from the Ministry of Primary Industries (MPI). We considered these factors to develop a methodology to determine surfer effort. Additionally, this project promoted awareness of the Māui dolphin and the importance of reporting sightings through the distribution of awareness materials at surveyed locations.
2. Background

The goal of this section is to identify and describe the concerns regarding the conservation of the Māui dolphin in New Zealand, which exemplify the broader problem of global marine mammal endangerment. To best understand this issue and how to approach it using “surfer science,” previous examples of citizen science programs are examined. Additionally, awareness and conservation efforts surrounding endangered marine mammal species are reviewed to develop an understanding of methodology that has been effective or insufficient, and how these approaches can be refined to fit the Māui dolphin specifically.

2.1 Impacts of Biodiversity Loss and Marine Biodiversity

Since the late 19th Century, global conservation efforts have focused on species vulnerability and loss. More recently in the 1990s, biologists sparked campaigns to protect endangered species and pushed movements for action (Cardinale et al, 2012). These campaigns aimed at conserving species numbers and focused on the roles these species play in the sustainability of the Earth’s ecosystems (Marshall, 2015). For example, outcries over the unintentional bycatch of marine species like dolphins led to resolutions such as the International Dolphin Conservation Act of 1992 (Studds, 1992). This act was an amendment to the United States Marine Mammal Protection Act of 1972, the first legislation aimed at managing the health and stability of the marine ecosystem (Marine Mammal Commission, 2015). Despite these efforts, the world entered the twenty-first century with a steady decline in marine mammal species that continues today.

The decline of marine mammal populations affects global biodiversity and ecosystem “services”. These “services” are benefits humans receive from the environment that would otherwise be unavailable to us and are supplied by marine based ecosystems (United States Environmental Protection Agency, 2016). The study of marine systems contributes to understanding environmental and ecosystem processing, even extending to land-based communities (Stachowicz, Bruno & Duffy, 2007). Marine systems help to uphold the delicate balance of producers, predators, and prey that contributes to species richness and nutrient cycling (Stachowicz et al, 2007). Recent estimates predict that over two million of the nearly nine million global species are marine-based (Mora, Tittensor, Adl, Simpson & Worm, 2011), and of those, 130 species are mammalian (Berta, Sumich & Kovacs, 2015). Marine mammals are especially important in ocean environments due to their influence on the structure and function of both sea and coastal communities (Bowen, 1997). Unfortunately, the rate at which marine mammal species are lost has become more drastic in the last century due to the increase in coastal communities and the adoption of commercial fishing practices (McCauley et al., 2015). Of all marine mammals, cetaceans face a particularly alarming set of hazards including collisions with shipping vessels, noise pollution, and entanglement in fishing gear (World Wildlife Fund, n.d.).

The hazards posed to cetaceans are apparent in the case of the Yangtze River Dolphin, or baiji. This species is considered extinct because there are no recent reports of sightings recently despite surveys carried out by vessels and acoustic technology throughout its entire habitat range (Turvet et al, 2007). The loss of the baiji represents the first world-wide extinction of a large vertebral species in more than half a century (Turvey et al, 2007). Another cetacean species facing a similar fate is the Vaquita porpoise of the Gulf of California, which is one of the most endangered cetacean species in the world (Jaramillo-Legorreta et al., 2007). The main threat to the Vaquita is bycatch from commercial fishing techniques (Jaramillo-Legorreta et al., 2007).

Organizations like the Whale and Dolphin Conservation work to improve the status of cetacean species by raising funds and working with governments to enforce stronger fishing regulations (Whale and Dolphin Conservation, n.d.). Divisions of the United States Government, like the National
Oceanographic and Atmospheric Administration (NOAA) took measures to establish marine wildlife sanctuaries to protect endangered marine species (NOAA Fisheries, 2018). Although these measures have addressed the issues involving marine mammal endangerment, cetacean species like the Vaquita continue to decline. Marine preservation scientists are not able to obtain enough quantifiable data to produce species projection maps that can be used to inform public policy; a larger pool of data is needed to fill this gap. This call for more data can be answered through the implementation of citizen science programs.

### 2.2 Citizen Science

A key method often employed in ecological studies for big-data collection is citizen science. Citizen science requires non-professional members of the public to act as data-collecting scientists for a given cause. The crowdsourced data is centrally compiled and provides a rich picture of the trends being studied (NESTA, 2018). This technique is well-suited for ecological issues because of its ability to recruit a large sample-collecting population which can out-produce data collected by a smaller population of funded scientists in the field (NESTA, 2018). For example, citizen science was used to monitor species of bumblebees in the United Kingdom to track their distribution in the midst of various species’ population declines (Lye, Osborne, Park & Goulson, 2012). Efforts to map species distribution expanded into the United States for its bumblebee populations, many of which also face decline. In the United Kingdom, mass data collection resulted in enough evidence to support the first official recognition of the endangered status of the *Bombus affinis* bumblebee in March of 2017 (Greshko, 2017). These studies show that citizen scientists increase the number of observations and allow collection of data from less accessible areas, such as private property. The use of citizen science strengthens data collection, and examples like the bumblebee highlight the inherent ability of citizen science to combat biodiversity loss on a large scale.

Although many successful campaigns have utilized citizen science, it has faced opposition from individuals and groups who claim that its use widens the gap between institutionalized power and the public by taking advantage of free labor (Mirowski, 2017). However, proponents of the technique recognize that volunteers who participate do so for their own satisfaction and collect meaningful data which is often rewarded with authorship in publications (Stilgoe, 2016). The excitement and interest that citizen participation stimulates is one of the positive outcomes of citizen science initiatives, as it promotes community awareness and change. These outcomes are beneficial to conservation efforts around the globe, as they lead to a greater feeling of personal responsibility in environmental protection.

An additional argument against citizen science stems from the belief that data gathered by non-professionals is inferior to professional data. However, studies of the method of citizen science found that this is not the case. For example, researchers discovered that volunteer scientists were able to identify and map the distribution of invasive plant species, estimating statistics with similar fidelity as trained plant taxonomists (Crall et al., 2011). Additionally, results from several citizen science based-projects have been published in top-tier research journals such as *Nature* (Horowitz et al., 2016; Khatib et al., 2011). This argues that data collected from these programs undergoes the same stringent peer review and quality control as data from professionals. The data collected from citizen science programs has even resulted in “higher quality models” than single highly trained professionals (Horowitz et al., 2016; Khatib et al., 2011). Given these considerations, the importance of citizen science and its potential in global marine biodiversity issues cannot be overlooked.
2.3 New Zealand Specific Species Problem

New Zealand is an isolated island nation, home to unique wildlife and endemic species. This exclusive environment makes the nation vulnerable to species loss, as endemic island species have evolved apart from mainland selective pressures (Island Conservation, 2015). As a result of millions of years of isolated evolution, endemic species are more sensitive to unfamiliar disturbances in their specialized environment (Island Conservation, 2015). This trend is visible in New Zealand, where of the 80,000 species that call New Zealand home (Stats NZ, 2008), 4,000 are listed as endangered (Endangered Species Foundation, n.d.). The Department of Conservation of New Zealand (DOC) is involved in the protection of these endemic species and considers the island to be a biodiversity hotspot with many species in need of conservation (Townsend et al., 2008). Beyond the ecosystem effects, biodiversity and species richness are imperative components for the success of New Zealand’s industries, including fishing, tourism, and agriculture (Ministry for the Environment, 2018). In addition, according to the New Zealand Conservation Authority, conservation of endemic species is vital to preserving the culture of the indigenous Māori people. The Māori people cherish nature and all it has to offer. They consider all animals inhabiting the island to be sacred (New Zealand Conservation Authority, 1997). New Zealand specifically values its marine species and their role in the balance of the sea; however, 28% of the endemic marine species are listed as endangered as of 2013 (Baker et al, 2016). Marine species, especially cetaceans, are particularly threatened by the fishing industry.

2.4 Culture of the New Zealand Fishing Industry

The New Zealand fishing industry has been an integral part of the island nation’s economy since modern fishing methods were adopted. Even before the modern industry, fishing was a large source of food for the Māori people before the Europeans arrived to inhabit the islands (Walrond, 2006). The industry was small until the 1920’s when technologies such as refrigeration and new fishing techniques were introduced. Gradually, the industry grew until the 1970’s when the government began putting regulations on certain fish in order to protect them from over-fishing. At this time, most vessels focused on fishing close to shore because of accessibility to Blue Cod, Snapper, and Groper (Walrond, 2006). Bigger ships avoided these regulations by looking for fish in deeper waters, outside of New Zealand’s territory. They discovered different varieties of fish, including the Orange Roughy and Hoki, which led to a large expansion of companies. Another incentive for this expansion was the collapse of the cod industry in the Northern Hemisphere. The goal of these companies was to capitalize on the industry’s failure by selling their catches in the Northern Hemisphere.

Today, the fishing industry is the biggest contributor to New Zealand’s economy (Williams, Stokes & Dixon, 2017). The annual economic output is approximately 4.2 billion NZ dollars (Williams et al., 2017). Not only does this industry make a large profit, it also employs greater than 17,000 people through fisheries and seafood processing companies (Williams et al., 2017). The size and importance of this industry makes promoting conservation efforts and sustainability difficult. Its economic importance gives the industry a strong influence on government policy, despite the government’s interest in protecting marine species, such as the Māui dolphin. This controversial issue has led to conflict amongst lawmakers.

2.5 The Critically Endangered Māui Dolphin

The Māui dolphin (Cephalorhynchus hectori Māui), also known as Māui’s dolphin, is a subspecies of the physically identical Hector’s dolphin and is endemic to the West Coast of New Zealand’s North Island. The Māui dolphin is a small coastal dolphin with a distinctive rounded dorsal fin. It is classified as “critically endangered” on the Red List of Threatened Species by the International Union for Conservation of Nature (IUCN) and is ranked as “nationally critical” under the New Zealand Threat
Classification System (Baker et al. 2016). Critically endangered species are taxa that face an extremely high risk of extinction in the wild (Biodiversity A-Z, n.d.). If the decline of the Yangtze River dolphin from 40 individuals in 1998 to extinction in 2006 (Akamatsu et al. 2007) is any indication, then the Māui dolphin is in dire need of conservation efforts.

Figure 1. Hector’s Dolphin (Balaji, 2019)

DOC’s 2016 population estimate suggests that only around 60 Māui dolphins remain, a decline from both the 2004 estimate of 111 Māui dolphins and 1985 estimate of 140 dolphins (Baker et al. 2016, Slooten et al. 2006). The low number of Māui dolphins remaining makes it the rarest dolphin in the world.

Due to their short 20-year lifespan, infrequent breeding, and relatively late sexual maturity (breeding happens ages 7 to 9) the Māui dolphin has a low reproductive rate. This makes them susceptible to population decline arising from human impacts (Currey et al. 2012). Even without human-caused mortality, the subspecies would only have a 1.8% population growth, or about 1 individual per year. This puts an upper limit on how many dolphins can die and still ensure population survival. This limit, known as the Potential Biological Removals (PBR), indicates that the Māui dolphin species can only withstand one human-induced death every 10 to 23 years for their population to have any reasonable chance of recovery (Curry et al. 2012).

There are several threats that affect the Māui dolphins’ chance of survival. These include direct threats like fishing and indirect effects like pollution. Of all the threats faced by these dolphins today, an estimated 95.5% of all human-associated mortalities are fishing-related (Currey et al. 2012). The Māui dolphin has an estimated 5.27 mortalities per year due to fishing, which means it is the only threat that exceeds the PBR (Currey et al. 2012). If new efforts are not made to save the dolphin and the high death rate continues, there will be a 7.6% decline in the Māui dolphin population every year. Fishing is a serious threat to the Māui dolphin, and efforts to protect its habitat are necessary.

2.6 Dangerous Fishing Methods

Fishing methods used in New Zealand include set-net and trawling, both of which have been linked to the accidental capture of dolphins (Lennert-Cody et al., 2012). Set-net fishing involves a long net anchored to the sea floor with weights (Ministry for Primary Industries, 2019). Trawling, which drags a net across the ocean floor, is a major cause of dolphin bycatch as well (Thompson, Abraham & Berkenbusch, 2013). These methods do not allow fishermen to control what they catch.

Out of 4299 trawl tows observed by fisheries over 16 years, there were 119 dolphin catches (Thompson et al., 2013). The locations of where these methods are used is important in assessing
dolphin safety. A change in the location of these fishing vessels to less dolphin-populated waters could reduce the amount of Māui dolphin bycatches; however, some fishermen argue there is no need to move, as they believe that Māui dolphins do not swim deeper than 20 meters, which is too shallow for fishing nets to be set (Gardner & Von Beynen, 2015). Some fishermen believe that the regulations are making their work more difficult for minimal conservation benefit (Gardener & Von Beynen, 2015). Thus, proof of legitimate risk to the dolphins is needed to argue a need for improved and enforced fishing restrictions. The current conflict between the fishing industry and conservationists has led to attempts at a variety of data-driven conservational approaches to solve the problem.

2.7 Conservation Efforts and Current Reporting Methods

Current efforts in preserving the remaining Māui dolphin population were initiated by several national and local organizations, including the government of New Zealand. A prime example of these efforts is the Marine Mammal Sanctuary, which was created in 1978 to mark the habitat of marine mammals. To protect marine wildlife, fishing restrictions were created by the Fisheries Act 1996 and passed by the New Zealand Ministry of Primary Industries (MPI).

Despite several expansions to the restricted areas, these fishing restrictions only cover a fraction of the West Coast Marine Mammal Sanctuary (WCNIMMS), which is a main area of concern due to its protection of the Māui dolphin habitat (see Appendix D and E) (Currey et al. 2012). The main goal of the WCNIMMS is to protect Māui and Hector’s dolphins by restricting not only fishing, but also seabed mining and acoustic seismic survey work. However, the regulations lack strong enforcement and leave the sanctuary under protected (Amanda Leathers, personal communication, January 16, 2019).

More recently, DOC collaborated with the MPI to carry out abundance estimates and risk assessments to properly inform the review of the Hector’s and Māui dolphin Threat Management Plan (Ministry of Primary Industries & Department of Conservation, 2012). They hope to better understand the effect of fishing and other human-related activities on the Hector’s and Māui dolphin and to minimize or remove these threats. In addition to estimating the remaining population, DOC and MPI used aerial surveys and DNA profiles as part of the abundance estimates to map the location, group size, and genetic diversity of Māui dolphins.

To aid the MPI, the World Wide Fund for Nature (WWF) and DOC set up several avenues for the public to report sightings of the Māui dolphin. This includes DOC and the WWF phone lines, the WWF mobile app (Figure 2), and the WWF and DOC web forms. DOC compiles these public sightings in a database along with survey and research sightings to try to paint a better picture of where the Māui dolphins exist along the coast.
In addition to reporting efforts, several organizations have developed awareness campaigns in order to inform the public of the importance of reporting sightings of this critically endangered species.

2.8 Raising Awareness

Prominent barriers to effective conservation efforts of endangered species include the lack of knowledge regarding the state of the environment and how personal impacts on the environment have consequences (Potenza, 2018). In fact, many people do not realize that even “green” actions, like rinsing containers before recycling and purchasing environmentally friendly products, can harm the environment. For example, rinsing, although needed for the recycling process, wastes water, a key resource needed for life. “Eco-friendly” bioplastics often have effects including carcinogenicity, ecotoxicity, and ozone depletion, like synthetic plastics (Tabone, Cregg, Beckman & Landis, 2010). There are also more common and noticeable examples of human-caused ecosystem destruction from uninformed actions. For example, in 1950, the Brown Tree Snake was introduced to Guam, an isolated island north-west of New Zealand (IUCN Global Invasive Species Database, 2018.; United States Department of Agriculture, 2011). This snake quickly dismantled the ecosystem of Guam, causing the...
extinctions of over half of the native bird and lizard populations (IUCN Global Invasive Species Database, 2018; United States Department of Agriculture, 2011). The loss of this species had massive and lasting consequences on the biodiversity of the area. This example is one argument that is used to push for awareness efforts. Many countries, including the United States, Canada, and New Zealand, have increased efforts to reduce species introductions by informing the public of the associated dangers, as well as regionally regulating the transport of foods and animals when traveling (Ministry for Primary Industries, 2018; U.S. Customs and Border Patrol, 2016; Canadian Food Inspection Agency, 2015). Following this increase in public awareness, the rate of introduced species has decreased (Seebans et al., 2017). These examples reiterate the importance of promoting an aware public for maintaining biodiversity.

In New Zealand, the state of environmental awareness is relatively high, with numerous regionally and locally sponsored conservation practices (Department of Conservation, n.d.). In recent years, many awareness campaigns have been utilized, such as the WWF’s Māui Dolphin Challenge. This challenge catered to a variety of audiences by having people pledge to do tasks related to the number 55, an estimate of the number of dolphins remaining (World Wildlife Fund, 2017). While wide-range campaigns have the potential to reach a variety of individuals, more targeted awareness campaigns can raise awareness in one group. For example, in 2015, a Worcester Polytechnic Institute (WPI) student Interactive Qualifying Project group in New Zealand created a children’s book which explained the plight of the Māui dolphins and how the public has the potential to help save the dolphins (Caccioppoli, Gotts, Hunker & Gaetano, 2015). By making an informative book that is easily understood by children, the authors promoted awareness, education, and excitement of conservation in the youth. Another group of WPI students also worked in collaboration with DOC to create a slogan, bumper sticker and posters, as seen in Figures 3, 4, and 5 below (Lehman, Foster, Barboza & Lowe, 2014). This technique proved to have an impact on the public’s knowledge of the endangerment of the Māui dolphin.

Figure 3. DOC Educational Resources “Rounded fin? Send it in!” Bumper Sticker. (Lehman, Foster, Barboza & Lowe, 2014)
Figure 4. DOC Educational Resources “Rounded fin? Send it in!” Poster. (Lehman, Foster, Barboza & Lowe, 2014)

Figure 5. DOC Educational Resources “Māui’s Dolphin Story” Poster (Lehman, Foster, Barboza & Lowe, 2014).
In the past, the WWF and DOC have spearheaded efforts and awareness campaigns directed at specific demographics. This included leading a beachcomber event where young members of the surfing community learned about the Māui dolphins, threats to them, as well as how to identify them (Argent & Sheeran, 2012). This is an example of New Zealand’s active push for awareness a specific community, still many New Zealand citizens have not been targeted by such campaigns. By expanding these awareness campaigns, we can help create a community who is more aware of the Māui dolphins’ plight and who understands their role in the conservation of the species.

2.9 SEFRA and Surfer Science

In addition to becoming more aware of the current state of the Māui dolphin, citizens can further help to promote the protection of the cetacean by directly helping scientists. One area in need of citizen help is SEFRA, a modeling system which maps the distribution of the Māui dolphin and compares that to where dangerous fishing practices take place. This mapping is done in order to estimate the spatial distribution of risk that the fishing industry poses to the dolphins (Lonergan, Phillips, Thomson & Zhou, 2017). The model aims to use the spatial overlap maps to provide a basis for public policy generation.

Currently, data for SEFRA are collected through both government-funded scientists and citizen-reported sightings, with the latter contributing most of the data. However, the model cannot currently make use of these citizen reports because there is no way to assess the distribution and effort of the populations of individuals available to report the sightings (Amanda Leathers, personal communication, Nov, 19, 2018). Counts of sightings in spatially different areas cannot be meaningfully compared as dolphin density data and therefore risk cannot be assessed.

Capitalizing on the potential data offered through citizen sightings can be done by targeting groups that are inherently in the same areas as the dolphins. Citizen science has the potential to provide an excellent opportunity to strengthen the existing SEFRA model for Māui dolphins in New Zealand. The addition of more data-collecting people over larger areas of the coast would increase the number of verified sightings of the dolphins over more days, times and seasons, therefore increasing the model’s accuracy and predictive power. Incorporating these data from citizen science would improve the model’s ability to accurately depict the range of the Māui dolphin and increase the legitimacy of the model in negotiating conservation action. Utilizing citizens who are normally active in the same area as the dolphins is important; this key data set can be collected by New Zealand’s active surfer population (see Figure 6).
The popularity of surfing in New Zealand is undeniable and growing. Worldwide there are between 17 and 35 million surfers (SurferToday.com, 2018). New Zealand is estimated to have 145,000 surfers, which is approximately 4% of the total New Zealand population (Ben Kennings, personal communication, November 11, 2018). A 2016 survey by Surfing New Zealand mapped the distribution of surfers in New Zealand, finding that 50% of the surfing population are located on the West Coast of the North Island, as seen in Appendix F (Ben Kennings, personal communication, November 11, 2018). This puts them within the range of the Māui dolphin. The potential of surfers acting as citizen scientists can be observed in previous work, such as gathering information on ocean temperature; using SmartFin, a surfboard fin product, surfers in the past have measured the temperature and wave characteristics. The information was used to study ocean trends and health (Surfrider Foundation, 2017). This example shows the potential that surfing populations have in gathering information about the ocean which could be applied to benefit the Māui dolphin.

The popularity of surfing in New Zealand has allowed SEFRA to begin to use surfers to better measure the distribution and density of the Māui dolphin population. This concept is known as surfer science; surfers report sightings of Māui dolphins via the routes described in Section 2.7. Once a sighting is verified by Deanna Clement, a marine ecologist, the data point can be counted as a sighting. In order to obtain the distribution of dolphins, an additional value must be considered that estimates the probability that a dolphin will be reported. This value needs to account for factors that vary spatially. These factors lead to disparities between the actual number of dolphins and the number of dolphins that are reported. This value is termed surfer effort, but currently the variables which constitute it are poorly defined. By defining and utilizing surfer effort, SEFRA scientists will be able to map the spatial density of the Māui dolphin along its range (Jim Roberts and Ben Sharp, personal communication, January 11, 2019). The power of surfer science, and even more broadly citizen science, has the potential
to have a lasting global impact on the protection and preservation of marine mammals, starting with citizens in New Zealand.
3. Methodology

Our project aimed to achieve two main goals. The first goal was to develop a method that could be used to estimate spatial variation in surfer effort. This method was created to help improve the New Zealand Government’s SEFRA system by allowing meaningful incorporation of surfer sightings into the database. This was done by gathering location-specific data about the density of surfers, the probability of those surfers reporting a sighting of a Māui dolphin and what method of reporting individuals are most likely to use. The second goal was to raise awareness for both the conservation of the Māui dolphin and the importance of acting as a surfer scientist to report sightings of the species.

To achieve these goals, the team focused on the following four objectives:

1. Identify key surfing beaches and virtual communities that have the potential to provide the necessary data on surfing populations.
2. Identify the factors that prevent the use of surfer sightings in SEFRA. Define the values that constitute surfer effort.
3. Gather data regarding spatial distribution, density, and reporting habits of surfers along the West Coast of New Zealand’s North Island using a participatory survey.
4. Promote awareness of the Māui dolphin as well as the importance of becoming a surfer scientist and reporting sightings of the species.

3.1 Objective 1: Identify Surfing Communities

Identify key surfing beaches and virtual communities that have the potential to provide the necessary data on surfing populations.

3.1.1 Beach Selection

To determine where to travel to measure surfer effort and raise awareness about Māui dolphins on New Zealand’s North Island, we identified key surfing beaches and surfing communities. The team used a combination of online information and expert opinions to narrow down the pool of potential locations. The three criteria used to find these key surfing communities were:

1. Popular surfing beaches on the West Coast of the North Island
2. Locations that have a high number of confirmed Māui dolphin sightings
3. Locations that represent the border of the projected Māui Dolphin habitat

We contacted important members of the SEFRA development team to obtain location recommendations. Jim Roberts and Ben Sharp were interviewed about the locations they believed were most pertinent to survey. Based on this interview, the location we decided to survey was Raglan (see Section 4.1).

In Raglan, we interviewed Phil McCabe. He is an avid surfer and co-founder of Solscape, a hostel dedicated to peace, health, and surfing. We chose to interview Phil McCabe because we believed that he could provide us with beneficial insight into the behaviors and attitudes of the surfing community in Raglan, as well as direct us to which surf breaks would give us the best output for our survey. Based on this conversation, we chose to Manu Bay, Whale Bay, and Ngarunui Beach.

3.1.2 Virtual Community Selection

To determine where to post the survey to measure surfer effort and to raise awareness about Māui dolphins on New Zealand’s North Island, we identified key surfing-related virtual communities. We
used a combination of online information and expert opinions to narrow down the pool of potential communities. The criteria used to find these virtual communities included:

1. Surfing related pages
2. Pages that are active
3. Pages that agree to post the survey

Also, Māui dolphin activists were contacted to post the survey to their personal social media accounts and protection groups.

3.2 Objective 2: Defining Components of Surfer Effort

Identify the factors that prevent the use of surfer sightings in SEFRA. Define the values that constitute surfer effort.

3.2.1 Interviews with Key SEFRA Scientists and Conservation Parties

We chose to use interviews to gather information because they provide an opportunity for collaborative discussion. Because a true value of surfer effort was not established prior this project, these interviews served to provide a basis for what should constitute this value and how the value would be applied to SEFRA.

A joint-interview was conducted with Ben Sharp and Jim Roberts, who are the scientists responsible for the development of the SEFRA modeling system. Through interviews, we aimed to understand the SEFRA system as well as surfer effort and the values that should comprise it.

We also interviewed Amanda Leathers of the WWF and Laura Boren of DOC. These interviews provided additional information regarding the goals of surveying the surfing community and what data is important to obtain for the SEFRA system.

We addressed the following questions and points of interest in all interviews:

- Describe the SEFRA model from your point of view.
- What inhibits the incorporation of surfer sightings into SEFRA?
- Describe what would make a measure of surfer effort
  - What quantitative statistics should make up this overarching value?
  - What information is needed about surfers to make their sightings statistically significant?
- How were boat sightings integrated into SEFRA? Do you think that similar trends will result from surfer sightings?
- What types of questions would you consider vital to an effective surfer survey?

The team discussed and reviewed the survey we developed during the interview with Ben Sharp and Jim Roberts to receive feedback and input about the types of questions that were important to ask participants. The interviewees informed us that asking specific questions about how frequently people surf and where they are most likely to surf during the summer months would gather important data for surfer density, which is a component of surfer effort. Additionally, the scientists suggested that we should include questions about the reporting habits of the surfers. These questions aimed to find out the how often surfers report sightings of the Māui dolphin, the likeliness that they would report a sighting, and what available techniques they use to report a sighting. This information also constitutes surfer effort because it supplies information about the reliability of surfer sightings.
To promote discussion of key points, we solicited responses between interviewees. In the interview with Ben Sharp and Jim Roberts, we brought up important points of our previous interview with Amanda Leathers. Conversations from both interviews were then shared with Laura Boren in her individual interview. Multiple group members transcribed the discussions during each of the interviews. Having more than one account of the conversation allowed for easier retrieval and analysis of information, as well as a higher quantity of information gathered. At the end of the interviews, we developed a more solidified concept of surfer effort and the type of information needed for the surfer sightings to be incorporated in the SEFRA model.

3.3 Objective 3: Gather Preliminary Surfer Distribution Data

Gather data regarding spatial distribution, density, and reporting habits of surfers along the West Coast of New Zealand’s North Island using a participatory survey. Determine the efficacy of using participatory surveys for gathering this type of data.

3.3.1 Surveys

The team developed a survey with the following intended characteristics:

1. Gathers relevant data to help determine surfer effort
2. Time efficient
3. User friendly

With these characteristics in mind, the survey was presented to SEFRA scientists, DOC, and the WWF to receive feedback before distribution.

The team conducted surveys with beach-goers and the surfing community. Beach-goers include individuals who visit the identified beaches from Objective 1, who are not surfers. We defined the surfing community as not only the individuals physically riding the waves in Māui dolphin habitat, but also surf-shop employees and surf club members in the surrounding areas. By expanding the definition of surfer to include these additional groups, the chances of surveying individuals who have seen, or know someone who have seen, a Māui dolphin increased. Both beach-goers and surfers had a high probability of interacting with a Māui dolphin due to the overlap of their activities and behavior in and around the coastal waters where the Māui dolphins reside.

Before distributing the survey, we informed the targeted respondents of the purpose of the information being gathered. The purpose was to collect data regarding differences in the spatial distribution, density, and reporting habits of surfers on the West Coast of the North Island in order to improve SEFRA modeling and efforts to save the Māui dolphin. The survey, as seen in Appendix B, was administered directly to surfers and beach-goers at popular surf breaks in Raglan, as well as in surf shops and on webpages of surf clubs.

In Raglan, we distributed the survey near the parking lots of Manu Bay, Whale Bay, and Ngarunui Beach as people entered and exited. This area increased participants’ willingness to take the survey and increased the quantity of participants we interacted with. We made the survey available to participants by temporarily providing a team member’s phone to them for surveying purposes. Having virtual surveys avoided the potential issue of getting surveys blown away by strong winds or becoming wet from the sea water. In addition to the distribution of the survey directly on the selected beaches, we posted the survey to internet forums including Facebook groups and websites pertaining to the surfing community, as identified in Objective 1. This increased responses and broadened the range of participants who took the survey.
We created the survey using Qualtrics and analyzed it through Qualtrics’ web platform. The questions and responses to the survey were nominal; they provided information about which response was most frequently recorded (The University of Reading Statistical Services Centre, 2001). The Qualtrics application saved all survey responses and analyzed them with its built-in software. This included bar graphs breaking down response frequencies of the different questions.

We evaluated the effectiveness of the survey in two ways. First, the usability of the survey was analyzed. This was done by observing how long each response took and how easy the respondents found the survey based on their response to a post survey question. The usability of the survey contributes to the likelihood that others will complete the survey in the future. The second evaluation of the survey was to analyze the results using Qualtrics, as mentioned above, and evaluate the effectiveness of the survey in collecting appropriate data based on our initial interviews with SEFRA scientists.

3.4 Objective 4: Promoting Awareness

Promote awareness of the Māui dolphin as well as the importance of becoming a surfer scientist and reporting sightings of the species.

3.4.1 Awareness Campaign

The purpose of this objective was to spread awareness about the current situation of the Māui dolphin to New Zealanders who live near their habitat. This campaign also had an emphasis on the importance of becoming a surfer scientist, and the impact of reporting sightings of the Māui dolphin. In order to spread awareness, we designed stickers and flyers and distributed them throughout the process of surveying the selected beaches. Flyers and stickers were posted at the entrances and exits of beaches, on message boards, and in shops around town. These shops included Raglan Surf Company, The Raglan Roast, Raglan Backpackers, and SuperValue Supermarket.

Figure 7. Example of a posted “Report a Māui dolphin” Sticker
The team designed several drafts of flyers and stickers using Adobe Illustrator. We then solicited suggestions and approval from DOC and the WWF before printing of the materials began. The team designed the flyer so that it could both be printed for placement around surf breaks as well as digitally added to surfing newsletters and Facebook groups. In order to design stickers that were visually appealing to the surfer population, we referenced surf stickers from other organizations and companies to find common themes and components.

The sticker design included a QR code that, when scanned, brings the user to the WWF reporting website. DOC printed the materials prior to the team’s travel to the selected beaches. We gave out the stickers at every location the survey was administered. Stickers were also given to surf clubs and surf shops in the area so that they could be given out after our research is finished. Local citizens who received the materials placed the stickers on items like surfboards, water bottles, street signs, and car bumpers.

The team made the flyers to encourage surfers to become surfer scientists and report sightings. These flyers included the same QR code as the stickers which brings users to the WWF reporting website. The flyer was designed in partner with DOC and the WWF. We posted the flyers around the selected beaches. In addition, surf clubs posted copies to local surf club message boards.
4. Findings

The surveyed surfing communities yielded the data needed to help integrate surfer sightings into the SEFRA modeling system. The awareness materials were an effective way to spread awareness of not only the Māui dolphin, but also of the importance of participating in citizen science through becoming a “surfer scientist” and reporting dolphin sightings.

4.1 Selected Surfing Communities

Surfing-related Facebook and Reddit pages, as well as the physical locations of Raglan, Piha, and New Plymouth were selected as communities to be surveyed. Beaches with bigger waves and places for surfers to sit and rest near the water encouraged surfers’ willingness to participate in our survey, making them the best locations for surveying New Zealand surfers.

Regarding selected virtual communities, we identified Facebook and Reddit as the best avenues to find and select groups that fit the criteria mentioned previously in Objective 1. The Facebook pages that were chosen for survey posting included the SURFING Stock Exchange, Surfing New Zealand Discussion Group, NZ Surfers Group, Raglan Surf School, and the Raglan Community Notice Board. To expand online posts of the survey, Peggy Oki of Raglan was contacted and asked to post the survey on her Facebook page. She posted the survey on the Let’s Face It Visual Petitions Facebook Page which advocates for Māui dolphin conservation. Additionally, Peggy Oki contacted Christine Rose, a member of the Muriwai community, and she posted the survey to the Muriwai community page, the Dolphin Defenders NZ page, and the Cetacean Spotting page.

During the interview with Ben Sharp and Jim Roberts, we concluded that Raglan, Piha and New Plymouth were the most important areas to survey. We also consulted Amanda Leathers for approval of the selection of these locations to confirm that they were of interest to the WWF as well. Due to time constraints preventing travel to all these communities, we selected Raglan as our sole in-person surveying destination.

Figure 8. Raglan Center (Reiniger, 2019).
Within Raglan, we surveyed three main surf breaks: Manu Bay, Ngarunui Beach, and Whale Bay. While all these surf breaks neighbor each other, each has different conditions which make the surf more suited to a particular experience level.

Ngarunui Beach, located 5 kilometers west of the center of Raglan, is more geared towards tourists and the inexperienced or beginner surfer; we met people from Germany, central United States and France. We found that a large proportion of individuals at this beach were taking surfing lessons, with two main companies offering lessons: Raglan Surf School and Green Wave Raglan Surf School. In addition, Ngarunui also hosts the headquarters for the Raglan Surf Lifesaving Club. Ngarunui has a large sandy beach, offering many places to sit.

Manu Bay is located 8 kilometers west of the center of Raglan and is a more popular beach for experienced surfers in the area. It draws in many surfers from around the world because it is said to have one of the longest breaks in the world, resulting in a population of advanced tourist surfers. Manu Bay also has a grassy area and guardrail along the water that offers spots for people to sit and watch near the water.
Whale Bay is located just beyond Manu Bay and has challenging waves recommended only for experienced surfers. This area attracts a lot of experienced surfers, however there is no beach or location to sit; the walk from the parking lot to the water is uneven rocky terrain.

4.2 Defining Components of Surfer Effort
Surfer effort is a complex statistic composed of values including density of surfers, how likely the surfers are to report a sighting, and the number of days surfers were available to make a sighting.

SEFRA estimates the number of expected deaths to Māui dolphins as a result of the fishing industry by overlaying the predicted density of dolphins in spatially defined areas with known fishing efforts. According to interviews with Ben Sharp and Jim Roberts, surfer sightings cannot be used because there is too much statistical variability between sightings. In fact, key variables differ between spatially explicit areas, including the density of surfers, the number of days surfers inhabit the beach and how likely the surfers are to report a sighting. These factors lead to disparities between the actual number of dolphins and the number of dolphins that are reported. Currently, the model uses sighting counts to try to estimate density, but in doing so, it assumes effort does not vary spatially. In order to convert count data into comparable density data, an effort value must be included in order to normalize the data. For example, if one beach area had a reported 30 detections in a span of 10 days, a basic measure of effort, while another beach had 60 reported detections over 120 days, it could be assumed that the density of dolphins is higher at the first beach, even though the number of detections was lower. When dealing with citizen reported sightings, however, more variables, such as those described, also vary and must be included.

The team discussed and reviewed the survey during the interview with Ben Sharp and Jim Roberts to receive feedback and input about the types of questions that were important to ask participants. The interviewees informed us that asking specific questions about how frequently people surf and where they are most likely to surf during the summer months would gather important data for surfer density, which is a component of surfer effort. Additionally, the scientists suggested that we should include questions about the reporting habits of the surfers. These questions aimed to find out how often surfers report sightings of the Māui dolphin, the likeliness that they would report a sighting, and what available techniques they use to report a sighting. This information also constitutes surfer effort because it supplies information about the reliability of surfer sightings.

4.3 Data Collection
The survey gathered appropriate data regarding spatial distribution, density, and reporting habits of surfers needed for SEFRA

We distributed the survey to nine Facebook groups, yielding 34 responses. In general, the greatest peak in responses occurred within a day of the posting. Posting on the New Zealand subreddit resulted in 11 responses within the first three days. Surveys distributed in person in Raglan yielded 36 responses, with the most responses coming from Manu Bay on Saturday morning. The average time it took a respondent to finish a question was 4 minutes and 12 seconds. The percent of respondents who completed the entire survey was 84%. A question asking about respondent satisfaction on the ease of the survey resulted in an average rating of 4.4 /5 with 5 being extremely pleased (Figure 11).
Additionally, the data indicated that on average, over 50% of survey participants classified themselves as surfers (Figure 12). The average number of days surfers surfed at their most frequently visited beach from November to April was 26-50 days (Figure 13). We also found that most survey participants had never seen a Māui dolphin (Figure 14) but were extremely likely to report a sighting if they ever did see one (Figure 15).
Figure 12. Participant Identity Classification.

Figure 13. Average Days Surfed by Participants from November 2017 to April 2018.
Figure 14. Frequency of Participants Sighting a Māui Dolphin.

Participant Likelihood to Report a Māui Dolphin Sighting

Figure 15. Participant Likelihood to Report a Māui Dolphin Sighting.
The online post of the survey to the New Zealand subreddit received relatively negative comments. For example, some Reddit users expressed that they felt the subspecies were already extinct and that it was too late to attempt to save them. The commenting users also felt that the government had waited too long to act in trying to conserve the Māui dolphin.

We also gathered intangible data with in-person surveys. By considering signs like respondent confusion or irritability and relating these responses to the question being answered, we were able to refine our survey and change questions. Common difficulties and questions brought up by respondents included:

1. What do I do if I’m a surfer and a NZ Resident/tourist?
2. How do I use the map?
3. I’m not from here, how do I answer some of these questions?

Based on these identified issues, we revised our survey to better suit the audience being targeted.

Through both online and in-person surveys, we collected data regarding components of surfer effort. The survey revealed that many of these components do vary spatially. For example, questions regarding surfer density showed that most surfers were most likely to surf in Raglan, specifically at Manu Bay. However, there were surfers who responded that they most frequently surfed at Piha or Muriwai. The survey also revealed that the most popular surfing apps are Magic Seaweed, Surf2Surf and SwellMap (see Appendix G).

Based on conversations with Ben Sharp and Jim Roberts, we confirmed that the information collected fit the needed data for developing surfer effort values for the areas surveyed.

4.4 Awareness Materials
We created and distributed sticker and flyer designs that promote awareness of the Māui dolphin as well as the importance of becoming a surfer scientist and reporting dolphin sightings.

Feedback from DOC and the WWF on the initial draft of the sticker design (Figure 16) were considered in the making of the final design (Figure 17). It includes a QR code that sends users to the DOC reporting website. It also includes the reporting phone number. A cartoon Māui dolphin is also on the sticker to show the key features of the Māui dolphin. The same color scheme was used in the flyer as well. Bluestar Group printed 1500 copies of the sticker and DOC printed 1500 flyers. The team distributed stickers to individuals in Raglan who participated in our survey. We also posted flyers in bathrooms and on telephone poles at Manu Bay, Whale Bay, and Ngarunui Beach. In Raglan Center, we distributed stickers and flyers to shops and destinations including Raglan Surf Company (Figure 18), Raglan Backpackers, the Police Station, Indi Restaurant, and Raglan Roast (Figure 19). Each location received between 50 and 150 stickers and flyers. Stickers were also posted on signs around Raglan, and flyers were hung up in the supermarket and put on community notice boards (see Appendix I).
Figure 16. Initial Sticker Design.

Figure 17. Final Sticker Design.
Figure 18. Raglan Surf Company.

Figure 19. Raglan Roast Café.
The stickers were well received by survey respondents. The designs were eye-catching enough for respondents to put them on their items, like water bottles and surf boards. Some survey participants asked us directly if they could have a sticker without being asked to take the survey.

The initial flyer design (Figure 20) was also commented on by the WWF and DOC in order to complete a final flyer design (Figure 21). The final design centers around the sticker design with the phrases “Help save the Māui dolphin” and “Become a Surfer Scientist”. The color scheme matches the sticker to create a consistent campaign theme. The bottom of the flyer has reporting techniques, such as the WWF reporting form via QR code, the WWF reporting form URL, and the WWF reporting hotline. The bottom also features the WWF and DOC logos. Like the stickers, the flyers were also well received by the Raglan community. Many recipients said they liked the colors and were visually attracted to the flyers before reading the content. Surf shops were welcoming and allowed us to put them up around their store.

![Flyer Design](image-url)
HELP SAVE THE MĀUI DOLPHIN

REPORT A MĀUI
0800 4 MĀUIS

BECOME A SURFER SCIENTIST

Use this QR code, call this number or visit us online to report a sighting.
Call 0800 4 MĀUIS
Or go to wwf.org.nz/sighting

Figure 21. Final Flyer Design.
5. Discussion

5.1 Discussion of Selected Surfing Communities

We selected Facebook for online surveying because it allows search-queries for groups of a desired theme, the ability to join these groups upon request, and the ability to send inquiry messages to page owners to obtain permission before posting. These qualities allowed us to share materials and information. In addition to posting the survey to the identified pages, we also were able to engage with the individuals and organizations in charge of running the various pages. Through Facebook Messenger and email, we were able to inform organizations like Surf Life Raglan and Raglan Surf School, about the importance of our project and why they should care about posting the survey. Facebook served as a means of communicating with a community we were not directly a part of.

Reddit has a slightly different user population than Facebook, which is why the team selected it as another avenue to post our survey. Like Facebook, Reddit hosts themed groups, called subreddits. Individuals can post text or website links on these subreddits which can be viewed, commented on, and shared by members. Posting the survey in the selected groups received positive feedback, indicated by comments and responses received directly after the survey link was released. This suggests that there is a general interest from surfers in the conservation of the Māui dolphin.

For in-person surveying we selected Raglan and Piha because they are locations that have numerous Māui dolphin sightings and a high quantity of surfers. By identifying these popular surfing areas on the North Island, we targeted a greater number of surfers, specifically in Raglan, for data collection. These locations overlap with the projected Māui dolphin habitat. Conversely, New Plymouth represents a location that has a smaller surfing population than Raglan and Piha and sits at the outer border of the projected Māui dolphin habitat. We selected New Plymouth to determine whether the lack of sighting data in the area is due to a low density of dolphins or due to low effort in the region. Surveying in both types of locations would allow the software to more accurately describe dolphin density across spatially explicit areas. As mentioned before, however, we were only able to do in-person surveying in Raglan.

In order to determine specific locations in Raglan in which to conduct in-person surveys, we consulted Phil McCabe. He informed us that Ngarunui beach was a location with more beginner surfers. He suggested instead that we visit Manu Bay and Whale bay, where more experienced surfers go. Experienced surfers surf more often and surf farther out in the ocean, making them more likely to see a Māui dolphin. Additionally, Phil McCabe informed us that there was a local surf contest held by the Point Boardriders Club at Manu Bay on Saturday, February 16th, which was the day after we arrived in Raglan. This information presented us with an opportunity to survey large numbers of local surfers and distribute stickers and flyers to the local surf community.

Working off Phil McCabe’s suggestions, we surveyed Manu Bay. While surveying there, we discovered that other aspects of the surf break besides popularity are important. We found that surfers spent most of their time in the water and only spend a few minutes by their car to get changed before leaving. This makes the window of time for surveying them very short. Because Manu Bay had places for surfers to sit and rest in between surf sessions, it provided an opportunity to target surfers while they were not busy surfing. Whale Bay, which had a very rocky coastline, was more difficult to survey because there was less space for surfers to congregate.
Ngarunui Beach, which attracts beach-goers, tourists, and inexperienced surfers, was not ideal for collecting data. Because of this mixed demographic, it was difficult to survey surfers who contribute to surfer effort. However, the presence of surfing schools and the lifesaving clubs there provided a limited but present avenue for surveying and distributing materials to instructors, so these types of beaches should not be discounted.

5.2 Discussion of Defining Components of Surfer Effort

Discussing the concept of surfer effort with Ben Sharp and Jim Roberts allowed the team to form a better understanding of SEFRA and its needs. The developed definition of the values that constitute surfer effort can be utilized with sighting data in the SEFRA modeling system to create spatial density maps of the Māui dolphin range. The making of these maps could be influential in forming public policy. If DOC and the WWF can supply the New Zealand Government with accurate maps of the Māui dolphin habitat, they will be more likely to form policies, like fishing restrictions, to protect the dolphin habitat area. Furthermore, this definition of surfer effort can be used as a model of how to synthesize a spatial effort value for other similar projects. Defining the “effort” of a particular group can help to give legitimate value to projects which map comparative spatial variation phenomena or events using citizen science.

5.3 Discussion of Data Collection

In order to test the effectiveness of the survey, the team posted it to various Facebook pages. These initial postings of the survey revealed that certain questions did not produce the desired responses and needed to be altered. Making these alterations supported our goal to develop an efficient method of collecting surfer effort data. One alteration made was to change a question asking about the frequency of surfing of survey participants over a six-month period, which originally had a series of ranges up to and including “21+ days”. Within the first seven responses to this question, five of the responses were “21+ days”, indicating that respondents surfed much more frequently than we initially expected. To solve this, we expanded the range of options to include higher numbers of days. This resulted in a more accurate representation of the surfing habits of surveyed individuals, because it elongated the distribution of surfing frequency over a wider range. The realization that surfers along the West Coast populated the beaches so frequently further supported our belief that the surfing community has the potential to make a difference in the conservation of the Māui dolphin.

Another change made to the survey was to require responses to certain questions. In the initial testing of the online survey, ten respondents submitted the survey without answering all of the questions. To solve this, we made the most important questions required questions, meaning the respondent could not move on until the question was answered. The remaining questions were not required but gently reminded the respondent that they forgot to respond if a question was skipped. Encouraging the completion of survey questions reiterated to the participants the importance of the information being gathered. By requiring and reminding the survey respondent to answer all the questions, it holds them accountable for the data they can potentially provide, which did not appear affect response rate. This sense of responsibility helps the surfing community join the effort to save the Māui dolphin.

In addition to the feedback from online surveys, surveying in Raglan provided us with a variety of feedback from in-person survey participants. Some of the participants had difficulty answering certain questions on the mobile phone survey. For example, the question that included a map to allow the survey participant to drop a pin on their most frequently surfed location was difficult to complete on a mobile phone screen. We also gathered, from the reactions of survey participants, that it was difficult to estimate how many days they surfed last year over a six-month period. Instead, they suggested to our
team that we ask how many times a week, on average, people surf during the summer months. Asking
the question in this way would be easier on respondents, but it would be less accurate when expanding
it over a 6-month period. Additionally, participants found that on the mobile phones it was difficult to
slide the scale for answering the question regarding their feelings about the ease of the survey. This
could be solved with a simple question rating the survey on a scale of one to five, instead of requiring
the sliding of a scale. This could have been fixed with a larger device, like a tablet.

Participants completing the in-person survey also recommended that we survey the local
recreational fishing community in Raglan. Many people we talked to who had seen Māui dolphins had
done so while fishing along the coast. This suggests that recreational fishing community could provide
valuable data for gauging the density of Māui dolphins in the Raglan area.

While conducting in-person surveys, we noticed that the participants seemed motivated to
report sightings once we explained the importance of the data they could potentially provide. Most
participants knew that there was an issue with the Māui dolphins but did not know that they could
actually make a difference in the dolphins’ conservation. Our knowledge and passion regarding the
dolphins’ endangerment helped participants realize just how dire the situation is and how necessary it is
to collect the survey data.

Based on the findings from the online and in-person surveys, we found that in-person surveys
were more effective. With online surveys, it was difficult to target surfers specifically; 57% of the online
responses were not from surfers. Although we did collect useful data from online surveys, the majority
of surfer responses we obtained were from the in-person surveys. This was because we could pick and
choose who to survey and who not to survey, as some people were clearly not surfers. We also found
that participation was much higher with in-person surveys because we were there to explain the scope
of the project, what type of data we were after, and why the data was needed. With the exception of
surfers who were on their way into the water and did not have time to answer questions, everyone we
asked agreed to take the survey.

Because the data collected met the goals of the project, the spatial density maps of the Māui
dolphin habitat can be improved over time as the surveying process is continued and expanded to
include more participants and locations. The more data the modeling system obtains, the more accurate
the density comparisons between separate areas will be, and the more relevant the produced maps will
be in the guidance of public policy. In addition, our survey serves as a proof of concept that surveys can
be used to gather data constituting effort in similar studies.

5.4 Discussion of Awareness Materials

The stickers were a great success. The final design was very popular, not only among surfers, but
with everyone we encountered. Some people asked if they could have more than one. The surf shops
we visited, including Raglan Surf Co., were more than happy to give these stickers out to customers who
visited their shop. They even asked how they could get more if they ran out. We did not expect the
stickers to be as popular as they were. We knew that a lot of young people like to decorate their
belongings with stickers, but the sense of making a difference by applying the sticker must have had an
added effect to their motivation. However, we believe that the design is more important than the
content because surfers were drawn to the design before they read the content. Also, they would not
put a poorly designed sticker on their personal items even if it was for a good cause.

When we pointed out the QR code on the stickers and flyers, respondents did not ask any
questions about it. They seemed to know how to scan one and some mentioned that they had done it
before. This was one of our original concerns, but our doubts were refuted.
The posters were a success as well. The design stood out to the surfers at the beach because of the bright colors. We saw multiple surfers and beach-goers approach the posted flyers and read them. We hope that knowledge of the information on them will be spread to those who do not see them. This resource was a great addition to the stickers because they provided more information than the stickers. Because they had the same theme, surfers were able to associate the stickers with the poster immediately.

Distributing stickers to local shops in Raglan allowed us to engage with a wider range of individuals beyond surfers. People who visited the shops and restaurants that received the stickers were interested and excited to take stickers. In fact, while surveying at Manu Bay, we spoke with an individual who already had one of our stickers because he had seen it at Raglan Surf Company while he was shopping there. This suggested that distributing the stickers to local businesses was an effective way to spread awareness for reporting the Māui dolphin.

We also found that even though we were unable to survey kids under the age of 18, they were still eager to take stickers and post them on their surfboards, water bottles, and their parents’ car windows. This solidified our belief that we designed awareness materials that effectively engaged the community and made the community interested in conservation of the Māui dolphin.
6. Recommendations and Conclusion

6.1 Limitations

Although we were successful in reaching the goals, we set out to accomplish, several limitations were encountered throughout the stages of this project.

Due to time restrictions, we were only able to conduct in-person surveys and distribute awareness materials in Raglan. To maximize the effectiveness of this survey, all surfing communities on the West Coast of the North Island should be surveyed. Different surfing communities vary in regard to their reporting habits, effort, and the density of Māui dolphins in the area. For these reasons, the survey should be replicated in other communities so that the SEFRA model more accurately reflects the spatial differences in surfer effort along the West Coast and can therefore predict density with greater fidelity. New Plymouth was intended to be selected as it is on the southern edge of the predicted Māui dolphin habitat and lacks sufficient information regarding sightings (see Appendix H). Surveying here would provide insight to the question: are there actually low Māui dolphin numbers in this area, or just low effort?

One limitation of the conducted interview with Ben Sharp and Jim Roberts and the individual interview with Amanda Leathers was that the discussions were held separately. Amanda Leathers and Laura Boren were not available to join in the group interview we conducted and were interviewed separately. Thus, their answers to our questions were entirely their own thoughts and not influenced by other parties. These individual interviews provided differing answers than those of the group interview, because they were not the result of the sharing of beliefs between parties. A group conversation would have provided an opportunity for dialogue and might have yielded different types of answers.

An additional limitation faced was that many interview participants were taking part in efforts to conserve the Māui dolphin. This created a one-sided perspective of the issue, because only a pro-conservation approach to the issue was provided. This could be balanced by interviewing other members of the community, like representatives from the fishing demographic. These representatives could provide information regarding the effects of conservation efforts on their business and recreational habits, and how they feel about the concern surrounding the Māui dolphin. This would allow for a more complete understanding of the issue and all of its stakeholders.

Survey questions also had the potential to lead to biased results. Specifically, the question asking if participants were “aware of the Māui dolphins’ current endangerment” could have yielded biased responses, because people may have felt obligated to say yes to avoid admitting they were uninformed or unaware of the situation.

One limitation that we faced while surveying in Raglan was that there were more tourist surfers than we anticipated. Targeting surfers that contributed to Raglan’s surfer effort was a goal of our survey, so this made surveying the community challenging. Most tourists agreed to take the survey, but they quickly had questions about it. Some of the questions did not apply to them because they had not been in the area for the entire summer or they were traveling around and not staying in one place. This led to some misleading data. One question we asked ourselves is: Should we analyze the tourist surfer responses differently?

Another difficulty the team faced while conducting in-person surveys was picking the right time to approach a potential participant. We quickly learned that asking before they were getting ready to go into the water was not a good strategy because they were focused on that. Once they were out of the water, we had to wait for them to dry off and change before we could approach. This worked most of
the time, but sometimes they would jump in their car and leave before we could ask them. Luckily, especially at Manu Bay, surfers would come out of the water to rest and eat before they would get back in. This gave us a lot of time to approach them and we had the most success with these surfers.

Other limitations we faced as a team included delayed production of our designed awareness materials and subsequent delay of travel. Because the stickers were printed by a company outsourced by DOC, we had no control over how quickly they were produced. This delayed our ability to form concrete travel plans, as we could not schedule flights and housing arrangements until we knew when the awareness materials would be delivered to be taken on our trip.

6.2 Recommendations to the Sponsor

In this section, we discuss our recommendations to the WWF and DOC on how to continue and expand the surveying along surfing beaches of the West Coast of the North Island. Additionally, we include recommendations on how to further distribute the developed awareness materials and gauge their impact.

We recommend the WWF and DOC increase the number of beaches and communities that are surveyed in-person. By targeting more beach communities on the North Island’s West Coast, including locations such as Piha and New Plymouth, more information regarding the variation in surfer effort can be collected. These data would help to make the SEFRA system more accurate by describing the differences in values of surfer density and distribution at more points along the projected Māui dolphin habitat. The use of targeted campaigns could create a sense of responsibility at more locations and help increase the participation of the surfing public in the efforts to save the dolphin. We do recommend traveling to these locations because the in-person survey responses very effect in motivating respondents to help in the conservation efforts.

Additionally, the survey could be distributed along the East Coast. This could provide information about the span of the dolphin range and if the dolphins travel beyond current projections. According to Amanda Leathers of the WWF, there have been dolphin sightings on the East Coast of the North Island. However, it is currently unknown if the sighted dolphins are Māui or Hector dolphins, or another type of dolphin. Expanding the survey to include this region could potentially eliminate doubt by providing information about density and distribution of surfers, which in turn could help to map the range of the sighted dolphins.

We recommend that the WWF and DOC investigate forming partnerships with organizations hosting surfing events around the North Island. These organizations include Oceanbridge, Surfing New Zealand, and Corona. Surfing competitions pull in large crowds of both avid surfers and spectators, but we found that because the surfers are on the water and focused on the competition, they are less available to be surveyed. In order to obtain information from this demographic, we propose that DOC and WWF work with the organizers to include our survey in the registration process which occurs online in advance of these events. While the survey would still be voluntary, we found that the surfing demographic is generally willing to help in conservation work and willing to answer given they have time. Including the survey in registration would increase the number of potential survey takers and would not require in-person surveyors to go beach to beach, which would potentially save time and money. In addition, the population targeted in this way represents the heart of the surfing population, which could potentially create further avenues for spreading of the campaign by word of mouth.

We recommend that the WWF and DOC continue online survey efforts. This expansion could include posting the survey directly to DOC and the WWF webpages as well as other Facebook pages
relating to selected beach communities such as Piha and New Plymouth. This could potentially be done through paid Facebook ads, specifically released to local communities of interest.

We recommend that the WWF and DOC repeat the survey in the winter months. Because the duration of this project was conducted in the summer, the survey only asked about the habits of surfers during the summer months of November to April. Repeating this survey in the winter could describe seasonal changes in surfer effort and help make the sightings used in SEFRA more accurate throughout the year. This could also potentially reveal changes in Māui dolphin distribution depending on the season based on the responses of surfers from May to October.

We recommend that the WWF and DOC distribute our awareness materials at Raglan’s Māui Dolphin Day. This event will draw crowds that are enthusiastic about and interested in Māui dolphin conservation. This could be impactful because the participants will be encouraged to become surfer scientists and report sightings of the Māui dolphin. By distributing the designed stickers and flyers at this event, the importance of citizen science would be stressed to the audience and would increase the number of individuals who could potentially report a sighting using the QR code provided on the awareness materials.

We recommend that the WWF and DOC print waterproof stickers in the future. Although surfers liked the stickers and put them in a variety of places, we received suggestions to make the stickers waterproof so that they could be put on surfboards or car bumpers. These recommendations suggest that members of the surfing community considered placing them on their surfboards. Providing suitable materials to do this in the future would expand the usage of the stickers.

We recommend that the WWF and DOC measure the impact of the awareness materials. This could be done by comparing the amount of reported sights in Raglan from before and after the distribution of the awareness materials. A significant increase in reported sights would indicate that the awareness materials were effective. It could also be used as an argument for continuing the campaign in other locations.

We recommend that the WWF and DOC use the emails collected in the survey to create a Māui dolphin supporter mailing list. People with the highest interest or strong opinions on Māui dolphin conservation are the most likely to have voluntarily provided their email address on the survey. This resulted in a list that is rich with individuals who are willing to support the WWF and DOC in future Māui dolphin conservation work. Updates and or requests can be made through this list which can ultimately help improve campaigns or spread the word about a Māui-related event.

We recommend that the WWF and DOC encourage reporting of both Hector’s and Māui dolphins. While surveying, a participant mentioned to us that though they had seen dolphins with rounded fins, they never reported them because they assumed the cetaceans were Hector’s dolphins since Māui were so rare. Thus, we suggest that the reporting of all rounded fins be encouraged, because there is no physical difference between Māui and Hector’s dolphins. This could potentially lead to more sightings if there are more individuals who don’t report due to this assumption.

We recommend that two versions of the survey be distributed: an online version and a mobile phone version. Having two separate versions of the survey would avoid the challenge of some survey features on a mobile phone. For example, having an interactive map to pin surf locations is an effective feature for an online survey taken on a computer, however it does not work as smoothly on a small mobile phone screen. Thus, having one version of the survey that has the map, and another version of
the survey for mobile phones that obtains the same map data through a different question, would be the most effective way of distributing the survey to different technology users.

6.3 Summary of Results

After posting online surveys via Facebook and Reddit, conducting in-person surveys in Raglan, and distributing awareness materials to the Raglan community, we believe we have produced an effective methodology to both gauge surfer effort and promote the importance of reporting Māui dolphin sightings. Beach communities were selected based on the criteria in Objective 1 and recommendations from the interview with Ben Sharp and Jim Roberts. Piha and Raglan were selected as destinations to administer the surveys in person, however only Raglan was surveyed due to time restrictions. The survey was posted to a variety of Facebook groups as well. Based on interviews with SEFRA scientists, surfer effort is defined as a complex statistic composed of values including density of surfers, how likely the surfers are to report a sighting and the number of days surfers were available to make a sighting. Follow-up conversations with Ben Sharp and Jim Roberts provided confirmation that the survey gathered appropriate data for the synthesis of surfer effort data in Raglan, which was the location where we distributed in-person surveys. Flyer and stickers with a consistent message and theme were designed and distributed with support from DOC and the WWF. The designs were well liked by the surfing community based on the quantity of materials taken by survey participants and Raglan community members.

6.4 Future Research

One area of research that could be explored would be adapting the survey for recreational fishing boats. The survey would be very similar to the one used for surfers. Wording changes would be made to tailor the survey to the audience of fishers, but overall the data collected would serve the same purpose. These data could provide the effort value needed for fishing-boat related sightings to be integrated into the SEFRA system.

Adaptations of the survey produced in this project could be used to help other endangered species. By utilizing surfers, recreational fishing boats, or another identified demographic to measure effort, the habitat range of an endangered species could be mapped. Similar to the maps of the Māui dolphin, these maps could be used to inform public policy formation to benefit the endangered species.

Using surfers or recreational fishing boats might not be a useful demographic to target in every circumstance for species mapping. For this reason, a survey for land observers may be another option to be developed. Once the survey is altered to compensate for varying communities, it can be replicated similarly to the way it was done for the Māui dolphin.

The developed survey could also be altered to include a more specific range of surfing frequency. By breaking down the survey into specific months and asking surfers to answer the subsequent questions based on each specific month, the survey would obtain a more accurate representation of surfer density, distribution, and effort as well as how those factors vary month to month. This would result in a more exact value for surfer effort. In return, this more accurate representation could produce SEFRA models that depict a more authentic Māui dolphin habitat range.

6.5 Reflection

Upon coming to New Zealand, we did not anticipate becoming part of the whānau popoto, the Māui dolphin family. Through our involvement with the WWF and DOC, we learned valuable lessons in
the importance of not only species conservation, but also the cultural and social values of preserving endemic species. The passion and enthusiasm for this project brought forth by Laura Boren and Amanda Leathers gave us a sense of purpose and importance in this foreign land.

When we first learned about the Māui dolphin, the outlook for the cetacean seemed grim. The population is in decline, government regulations protecting the subspecies are lacking, and the public seems to view it as a lost cause. However, our visit to Raglan changed our minds. Talking to residents there, it became clear that they will not see the Māui dolphin silently disappear from this Earth. They intend to do everything in their power to make a positive change. This was truly inspiring to us, showing us that when people come together, anything is possible. Communities like Raglan are the reason that endangered animals stand a chance at survival.

While surveying in Raglan, the team noticed something unexpected about the surfing community there. We realized that it was not a closed group comprised of only local surfers who resided in Raglan or the surrounding towns but included surfers from all over the globe. These surfers come and go into the community of Raglan, some staying for months on end, others just stopping by for a few weeks. This created a welcoming community that centered around surfing and a laid-back lifestyle. While taking surfing lessons on Ngarunui Beach, we felt connected to this community. Our instructors were approachable and kind; they were excited to learn about our project and participate in our survey. The other amateur surfers were eager to hear about where we were from and what we were doing in New Zealand. The camaraderie experienced both within our group and with other members in the lesson was heartening and is an outlook we hope to continue.

On leaving New Zealand, our team will take the people we've met and stories we've heard back with us. New Zealand has proved to be filled with unique people and places. From the offices of the WWF and DOC in Wellington, to the rocky coasts of Raglan, we found inspiring stories and passionate individuals everywhere we visited. The people of New Zealand, the kiwis, seem to really care about the world around them. They care for themselves, for each other, and for the wildlife that they share their home with. It is this mentality of care, and of action, that we found so impactful. Kiwis don’t just talk about conservation, they practice conservation. When looking at the way of life in the United States we are returning to, we hope to bring these actions to life for our homeland. We as individuals must take responsibility for our world and the influences, we have on it if we are to ever live up to the standard of conservation New Zealand has set forth. Conserving species is not the job of one country, but of all countries. So, our team poses the question: what will you do to help conserve our delicate environment?
Bibliography


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Appendices
Appendix A: Deliverable Survey

We are conducting research on the public's awareness and reporting habits of the Māui dolphin. Please fill the survey out in regard to the beach you frequent most often. If you'd like to answer for more than one beach, feel free to fill it out again! The entire survey should only take about 4-5 minutes, and your responses are completely anonymous. You must be at least 18 years of age to take this survey. Your response to the survey is voluntary.

We really appreciate your input!

Q1 Pick which category best applies to you.
   o Local, resident of New Zealand
   o Tourist, first-time visitor of New Zealand
   o Tourist, repeat visitor of New Zealand
   o Other

Q2 Are you a surfer?
   o Yes
   o No

Q3 Are you aware of the Māui dolphins' current endangerment?
   o Yes
   o No
   o Somewhat

Q4 Do you know what characteristics distinguish a Māui/Hector’s dolphin from other dolphin species? If yes, what are the unique characteristics?

________________________________________________________________

Q5 During the New Zealand summer months (November-April), what beach on the West Coast of the North Island are you most likely to be at?

________________________________________________________________

Q6 During the New Zealand summer months (November-April), how many days a week are you surfing on average at the location you specified?
   o 0 days/week
   o 1 day/week
   o 2 days/week
   o 3 days/week
   o 4 days/week
   o 5 days/week
Q7 What is the average number of surfers you saw per day at your specified location during the summer months (November-April)?
- 0 surfers
- 1-9 surfers
- 10-19 surfers
- 20-29 surfers
- 30-39 surfers
- 40-49 surfers
- 50-59 surfers
- 60+ surfers

Q8 At your specified location, how many days did you see a Māui dolphin in the last year?
- 0 days
- 1 day
- 2 days
- 3 days
- 4 days
- 5 days
- 6 days
- 7 days
- 8 days
- 9 days
- 10+ days

Q9 How often have you reported these Māui dolphin sightings?
- Always
- Most of the time
- About half the time
- Sometimes
- Never

Q10 If you were to see a Māui dolphin now, how likely would you be to report the sighting?
- Extremely likely
- Moderately likely
- Neither likely nor unlikely
- Moderately unlikely
- Extremely unlikely

Q11 Do you know how to report a sighting of a Māui dolphin? How?
Q12 Have you ever spotted a dead Māui dolphin?
   ○ Yes
   ○ No

Q13 What would you do if you did find a dead Māui dolphin?
   ________________________________________________________________

Q14 Have you been asked about your surfing habits or Māui dolphins by another organization? If so, by who?
   ________________________________________________________________

Q15 If you would like to be added to a Māui dolphin supporter alias to continue to follow the Māui dolphin's conservation progress, enter your email below. This is not required, and you may unsubscribe at any time.
   ________________________________________________________________

Q16 How would you rate this survey?
   ○ 0
   ○ 1
   ○ 2
   ○ 3
   ○ 4
   ○ 5
   ○ 6
   ○ 7
   ○ 8
   ○ 9
   ○ 10
Appendix B: Distributed Survey

We're conducting research on the public's awareness and reporting habits of the Māui dolphin. Please fill the survey out in regards to the beach you frequent most often. If you'd like to answer for more than one beach, feel free to fill it out again! The entire survey should only take about 4-5 minutes, and your responses are completely anonymous. You must be at least 18 years of age to take this survey. Your response to the survey is voluntary.

If you have any questions about the survey, please email us: gr-dolphins-nz@wpi.edu.

We really appreciate your input!

Q1 What category would you place yourself under?
- Resident of NZ beach goer
- Tourist
- Surfer
- Other

Display This Question:
If What category would you place yourself under? = Surfer

Q2 Do you use any surfing apps to track the breaks you use?
- Yes
- No

Display This Question:
If Do you use any surfing apps to track the breaks you use? = Yes

Q3 If yes, which ones?

Q4 Are you aware of the Māui dolphin's current endangerment?
- Yes
- No
- Somewhat

Q5 Do you know what characteristics distinguish a Māui/Hector’s dolphin from other dolphin species? What are they?

Q6 Last year, during the summer months (November-April), what beach on the west coast of the North Island were you most likely to be at?

Q7 Please move the red pin on the map to the geographical location of the beach answered in the previous question. Please be as specific as possible.
If What category would you place yourself under? = Surfer

Q8 Last year, during the summer months (November-April), how many days did you surf, in total, at this beach during the full 6-month period?
- 0 days
- 1-5 days
- 6-15 days
- 16-25 days
- 26-50 days
- 51-75 days
- 76-100 days
- 101+ days

Q9 Last year, what was the average number of surfers you saw per day at this beach during the summer months (November-April)?
- 0 surfers
- 1-5 surfers
- 6-10 surfers
- 11-20 surfers
- 21+ surfers

Q10 At this beach, on how many days did you see a Māui dolphin in the full six month period (November-April)?
- 0 days
- 1-5 days
- 6-10 days
- 11-20 days
Display This Question:
If At this beach, on how many days did you see a Māui dolphin in the full six month period (November... = 1-5 days
Or At this beach, on how many days did you see a Māui dolphin in the full six month period (November... = 6-10 days
Or At this beach, on how many days did you see a Māui dolphin in the full six month period (November... = 11-20 days
Or At this beach, on how many days did you see a Māui dolphin in the full six month period (November... = 21+ days

Q11 On how many of these occasions did you report the sighting?
  o None of the times
  o 25% of the time
  o 50% of the time
  o 75% of the time
  o 100% of the time

Q12 If you were to see a Māui dolphin now, how likely would you be to report the sighting?
  o Extremely likely
  o Moderately likely
  o Neither likely nor unlikely
  o Moderately unlikely
  o Extremely unlikely

Q13 Do you know how to report a sighting of a Māui dolphin? How?
________________________________________________________________

Q14 Do you know anyone who has reported a sighting of a Māui dolphin? If yes, who?
________________________________________________________________

Q15 Have you ever spotted a dead Māui dolphin?
  o Yes
  o No

Q16 What would you do if you did find a dead Māui dolphin?
________________________________________________________________
Q17 Have you been asked about your surfing habits or Māui dolphins by another organization? If so, by who?
________________________________________________________________

Q18 If you would like to be added to a Māui dolphin supporter alias to continue to follow the Māui dolphin's conservation progress, enter your email below. This is not required and you may unsubscribe at any time.
________________________________________________________________

Q19

Please rate your feelings about the ease of use of this survey by sliding the pointer.
Appendix C: Initial Survey Draft

Q1 What category would you place yourself under?
   o Resident of NZ beach goer
   o Tourist
   o Surfer
   o Other

Display This Question:
If What category would you place yourself under? = Surfer

Q2 Do you use any surfing apps to track the breaks you use?
   o Yes
   o No

Display This Question:
If Do you use any surfing apps to track the breaks you use? = Yes

Q3 If yes, which ones?
   ___________________________________________________________________________________

Q4 Are you aware of the Māui dolphin and its endangerment?
   o Yes
   o No
   o Somewhat

Q5 Do you know what characteristics distinguish a Māui/Hector’s dolphin from other dolphin species?
   What are they?
   ___________________________________________________________________________________

Display This Question:
If What category would you place yourself under? = Surfer

Q6 In the summer months (November-April), how many days do you surf on the west coast North island?
   o 0 days
   o 1-5 days
   o 6-15 days
   o 16-25 days
   o 25+ days

Display This Question:
Q7 What locations are you most likely to surf at in the summer months?

Q8 How many surfers do you see on average per day in the summer?
- 0 surfers
- 1-5 surfers
- 6-10 surfers
- 11-20 surfers
- 20+ surfers

Q9 How many days do you see a Māui dolphin in the summer months?
- 0 days
- 1-5 days
- 6-10 days
- 11+ days

Q10 Do you know how to report a sighting of a Māui dolphin? How?

Q11 Have you ever reported a sighting?
- Yes
- No

Display This Question:
If Have you ever reported a sighting? = Yes

Q12 If yes, how many times have you reported a sighting? How did you report it?

Display This Question:
If Have you ever reported a sighting? = No

Q13 If no, how likely are you to report a sighting?
- Extremely likely
- Moderately likely
- Neither likely nor unlikely
Q14 Do you know any other surfers that have seen and reported a sighting of a Māui dolphin? If yes, who?
________________________________________________________________

Q15 Have you ever spotted a dead Māui dolphin?
○ Yes
○ No

Q16 What would you do if you did find a dead Māui dolphin?
________________________________________________________________

Q17 Have you been asked about your surfing habits or Māui dolphins by another organization? If so, by who?
________________________________________________________________

Q18 Thank you! How did you feel about this survey?
○ Informed
○ Confused
○ Indifferent
Appendix D: New Zealand North Island Māui Dolphin Protection Map

Map of protection measures for the Māui dolphin on the West Coast North Island (MPI, 2013)
Māui dolphin distribution created mostly from the sightings and effort data from nine aerial and biopsy surveys conducted between 2000 and 2012 (Currey et al. 2012)
Appendix F: Surfing New Zealand Surfer Distribution

2016 Surfing New Zealand National Surfing Survey: Surfer Residence Data
Appendix G: Surfing Apps and Websites Used by Survey Participants

![Surfing Apps and Websites Chart]

- Surfzon: 8 participants
- Windy: 4 participants
- Surf Forecast: 3 participants
- Magic-Seaweed: 3 participants
- Surfstats: 7 participants
- Swellmap: 3 participants
- Windguru: 4 participants
- Windfinder: 1 participant
- Marine Weather: 1 participant
- Surf: 1 participant
- Surfweather: 2 participants
Appendix H: Validated Non-Motorized Māui Dolphin Sightings SEFRA Map

Non-motorized Māui Dolphin Sightings SEFRA Map (Jim Roberts, personal communication, December 5th 2018)
Appendix I: Posted Awareness Materials

Sticker Posting on Back of Raglan Traffic Sign

Flyer Posting on Raglan Notice Board