The Role of Images in Freshwater Conservation in South Africa: An Analysis of Images and Perceptions of Freshwater Fish

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Abstract

Freshwater biodiversity is highly threatened, but under-represented in media, and less well known than marine and terrestrial counterparts. The current lack of public awareness of freshwater species and ecosystems may limit freshwater conservation as a popular cause. The manner in which species are portrayed in the popular media can influence awareness and support for conservation. In this digital age, images in particular may play a major role in public support for conservation. In this study, I examined images sourced from the web of ten native South African freshwater fish species and images of a general search for 'freshwater fish South Africa' to investigate the kinds of images people are exposed to. Results show that only 28% of species-specific images showed the fish in a water habitat, with the remaining images showing the fish out of water, often with the presence of humans. I then conducted an online survey of people's perceptions of freshwater fish images. Respondents were shown images of native South African fish in water and out of water. From this survey, 73% of respondents stated they would choose images of fish in water in their natural habitat to communicate the importance of conserving freshwater ecosystems and freshwater fish. Over 95% of respondents, agreed that images play an important role in rallying support for nature conservation in general. When shown images of fish in water, 57% of respondents stated the in-water images evoked a desire to know more about freshwater environments and 49% stated a desire to know more about freshwater fish. The survey also investigated respondent willingness to donate money and time to freshwater conservation and explored whether showing either 'in-water' or 'out of water' images beforehand influenced this response. The results suggested that the type of images presented beforehand had little to no effect on willingness to donate, but other factors such as gender, natural sciences background, and history of visiting freshwater environments influenced respondent willingness to donate time and money. Overall this study suggests that future considerations should be given to how freshwater fish species are portrayed in science communication and environmental education through imagery.

1. Introduction

1.1 Biodiversity loss

Since the industrial revolution, human activities have progressively destroyed and degraded important ecosystems. There are various environmental problems that threaten environmental sustainability, among the most serious are global warming, air pollution, water shortages, habitat degradation, and a loss of biodiversity (Steg & Vlek 2009). Biodiversity is fundamental to human life, but the Earth's biodiversity is being destroyed by humans at a rate unprecedented in history (Almond et al. 2020). Not only does biodiversity provide food, fiber, water, energy, medicines, and other genetic materials; it also regulates climate, water quality, pollution, and pollination services (Almond et al. 2020). The many essential activities to human subsistence has led to a trend of continued and growing biodiversity loss (Díaz et al. 2006). Global economic growth in the last half century has changed the world and has come at a huge cost to nature and the stability of the Earth's systems that sustain human life (Almond et al. 2020). In 2020, the Living Planet Index (LPI) showed an average reduction in 68% species' populations between 1970 and 2016 (Almond et al. 2020). With the current rate of global biodiversity loss, it will be imperative to gain more awareness in communities, and people's involvement in conservation will be vital to the survival of ecosystems.

Although biodiversity loss is a global issue, biodiversity abundance is declining at different rates in different places in the world, and in different ecosystem types. The Living Planet Indices report showed that within the African continent there has been a 65% decline in biodiversity since 1970 (Almond et al. 2020). Africa's biodiversity loss is being driven mainly by climate change, land use change, land degradation and deforestation (Almond et al. 2020). For example, in West Africa, the globally significant rainforests are under threat, with an estimated 10 million hectares being lost in the 20th century (Norris et al. 2010). The future of the region's biodiversity is closely linked with the lives of local people as these forests provide ecosystem services to more than 200 million people in the region (Norris et al. 2010). Southern Africa is one of the most biodiverse regions in the world, and with the diversity of its ecosystems, the impact of land transformation is southern Africa is projected to have a disproportionately high impact on global biodiversity (Biggs et al. 2008).

1.2 State of freshwater biodiversity

Freshwater ecosystems are no exception to the biodiversity loss being seen on a global scale. These pressured ecosystems support an extremely high proportion of the world's biodiversity (Abell et al. 2008), occupying just 0.8% of the Earth's surface but being home to an estimated 100,000 species, or about 6% of all described species (Dudgeon et al. 2006), and half of the world's fish (Hughes et al. 2021). Since 1970, global freshwater species numbers have declined by 84% (Almond et al. 2020). Globally, almost one in three freshwater species are at a high risk of extinction, with most of the population declines in freshwater being seen in amphibians, reptiles, and fish (Almond et al. 2020). The state of biodiversity of inland waters (rivers, lakes, floodplains, wetlands, reservoirs, inland saline systems) are in a worse condition than any other system (MEA 2005). Globally, almost 90% of wetlands have been lost since 1700, with recent global mapping showing that humans have altered millions of kilometers of river systems (Almond et al. 2020). We are seeing wetlands vanish three times faster than forests (Tickner et al. 2020), while freshwater vertebrate species have fallen at a rate that is more than twice that of land or ocean vertebrates (Grooten & Almond 2018). In recent decades, more than an estimated 20% of the world's 10,000 described freshwater fish species have become threatened, endangered or extinct (Revenga et al. 2000). It is estimated that up to 3,000 species of freshwater fish, about 30% of the 10,000 known species, will become extinct by 2033 (Cambray 2003).

Freshwater biodiversity has been strongly affected by human impacts on water quality, habitat modification and invasive species (Grooten & Almond 2018). Some of these impacts include excavation of riverbeds, excess water abstraction for agriculture and introduction of non-native species whether deliberate or accidental (Dudgeon et al. 2006; Tickner et al. 2020). Certain ecosystem types such as inland wetlands and lakes, amongst others, take up less than 5% of South Africa's territory, but are responsible for a much larger number of benefits such as water purification, recreation and harvesting of food directly from nature (Skowno et al. 2019). Freshwater fish species restricted to these wetlands, and to rivers, are declining at a rate faster than terrestrial species, mainly due to habitat loss, pollution, and poor management of invasive species and water systems such as dams (Skowno et al. 2019).

South Africa is an ecologically-diverse country with seven major terrestrial biomes (Turpie 2003) and home to 1% of the world's freshwater fish species (Skowno et al. 2019). The Fynbos Biome in particular has exceptional species richness and numbers of endemic species. The Cape Floristic Region (Myers 1990) constitutes one of the world's 35 hotspots (Skowno et al. 2019), which corresponds to the Cape Fold Ecoregion. The Cape Fold Ecoregion (CFE) is also one of the 200 global aquatic ecoregions. The Cape Floristic Region (CFR) is located largely in the Western Cape province (Turpie 2003), and is home to two-thirds of South Africa's endemic species (Skowno et al. 2019). The endemism of the CFR is comparable to that found on islands, which is highly unusual for mainland areas (Linder 2003). Although freshwater species numbers are lower in the CFR than other regions, the proportion of endemic freshwater species is higher than that of plants (Wishart & Day 2002). The Western Cape Province, specifically, is home to the highest concentration of endemic fishes in all of South Africa and has the highest number of threatened and endemic fish species (Impson et al. 2017). The Cape Fold Ecoregion is home to 21 naturally occurring fish species, 20 of which are endemic to the region. Of the 20 endemic species, 16 are listed as either Vulnerable, Endangered, or Critically Endangered according to the ICUN Red-list criteria (Ellender et al. 2017).

In South Africa, inland wetland, river, and estuarine ecosystems experience high levels of threats, with rivers and wetlands having the highest proportion of ecosystem types that are considered Critically Endangered of 42% and 61% respectively (Skowno et al. 2019). Estuaries have the highest proportion of threatened ecosystem types with 86%, and rivers with 64% (Skowno et al. 2019). These proportions paint the harsh reality that inland aquatic ecosystems are suffering throughout the country. In contrast, a large proportion of the country's marine and terrestrial ecosystems are listed as Least Concern (Skowno et al. 2019). Freshwater fish have the highest proportion of species that are not protected with 19%, 94% of which are endemic to South Africa and 100% of these species being threatened with extinction (Skowno et al. 2019). This is in comparison to birds and reptiles having more than 85% of their taxa well protected. This contrast shows a disproportionate level of pressure placed on freshwater ecosystems in comparison to other ecosystems, as well as unequal protection.

While biodiversity loss, due to human impact, and environmental factors are the main reasons freshwater ecosystems are in peril, the existence of a major information gap cannot be ignored. A comprehensive global analysis of freshwater biodiversity, comparable to the recent analyses for terrestrial systems, does not exist (Myers et al. 2000). Much of the existing data on freshwater biodiversity are biased in terms of geography, taxonomy, and habitat types, with most populations and habitats in some regions not being monitored at all (Myers et al. 2000). To ensure the survival and sustainability of freshwater ecosystems and species, an appreciation of the value of freshwater biodiversity is imperative. The 'value' of freshwater is the importance, usefulness or worth, including monetarily, that freshwater holds, as viewed by humans. Scientists must be willing to place a value on the many "free" ecosystem services freshwater systems provide in order to gain buy-in from politicians and policymakers, as well as the general public, or they risk these services being valued at zero (Dudgeon et al. 2006). The value of inland water systems will surely increase as ecosystems become more stressed causing scarcer goods and services (Dudgeon et al. 2006). Although many believe in the intrinsic value of nature, a value on a monetary or benefit scale is often needed to gain the support needed for conservation, especially in highly threatened and often unseen freshwater habitats.

1.3 Public engagement in conservation

Today's global environmental problems are caused by human activity, and there is a disconnect between humans and the environment (Stern 2000). The social values in society structure its traditions, institutions and laws (Jepson & Canney 2003). Support from the public is an increasingly relevant issue in current nature and wildlife management (Verbrugge et al. 2013), as well as in conservation (Monroe et al. 2009). Today, conservation managers understand that public support for their conservation activities and initiatives is vital to the success or failure of their projects (Bremner & Park 2007). For instance, the methods of control and eradication of invasive species will affect the levels of public support, especially for the animal and plant species that communities find appealing (Manchester & Bullock 2000). Researchers and conservationists are continuing to realize the issue of managing species, particularly invasive species, is as much a social issue, encompassing political and human factors, as it is a scientific one (Bremner & Park

2007). Some conservationists and scientists believe that some species attributes can influence people's views on conservation actions and which species these actions should target, thus affecting the legitimacy of management strategies (Fischer et al. 2011). Support of the public might in fact make conservation action more successful (Rodríguez et al. 2004).

Understanding and awareness will be key in bridging the gap between people and nature, in order to ensure long-term persistence of natural spaces and biodiversity (Piccolo 2016). Conservationists and wildlife professionals agree that people's views toward wildlife have changed drastically over the second half of the 20th century with a gradual shift away from the more traditional values that focus on the use and management for human benefit (Manfredo et al. 2003). In today's world, some of the ethical arguments for conservation have been focused on the need to protect ecosystems for their economic value, natural capital and role in human life support (Cooke et al. 2021). A strong determinant of public attitude towards conservation actions is also the extent to which an individual believes in the intrinsic value of a species (Hill et al. 2007) or ecosystem. For instance, studies in North America have shown urban perceptions of wildlife can be measured by high valuation of nature and more empathy for animals (Manfredo et al. 2003; Hill et al. 2007). A win-win solution would be to look for conservation solutions that can have economic and ecological rewards (Cooke et al. 2021).

Public engagement is a key component in the foundation of effective conservation (Fischer et al. 2011), and public attitudes towards environmental initiatives can be a major policy driver that can ultimately influence the outcomes for biodiversity (Martín-López et al. 2009). Species that are known and advocated for by people and scientists are usually more likely to obtain the needed funding for conservation, while species with less support are often not included as critical species in conservation strategies (Martín-López et al. 2009). There is a need that science provide the best available data to inform the public of the challenges in biodiversity conservation (Martín-López et al. 2009). In order to improve the success of conservation action and policy, it is key to have a good understanding of the public's views and their underlying values regarding nature (Teel & Manfredo 2010).

The human-nature relationship and the importance that is placed on nature is a key consideration when engaging the public in conservation efforts. The human-nature relationship, or 'relationship', is the way in which nature and humans are connected, and the services nature and humans provide to each other. Over the last several decades, research has been done on the human-nature relationship and has evolved into a research field encompassing four classifications of the relationship between humans and nature (De Groot et al. 2011): mastery over nature; stewardship of nature; partnership with nature and; participant in nature. In mastery over nature, humans are above nature and are allowed to exploit nature as they see fit in order to benefit society. In the stewardship of nature relationship, humans are still over nature but have a responsibility to take care of nature. In partnership with nature, an equal relationship between nature and humans exist within a dynamic process of interactions and mutual development. The participant in nature relationship is where humans are a part of nature and have a sense of belonging. In some studies, these human-nature relationship classifications were predictors for preferred river management styles (De Groot et al. 2011). Ultimately, these relationships and their dynamics can lead to helping or hindering conservation success.

1.4 Public engagement in freshwater conservation

Rivers, lakes and wetlands provide vital resources to all humans on the planet (MEA 2005) but the responsibility of conserving freshwater ecosystems has historically been left up to recreational users of freshwater systems (Monroe et al. 2009). With freshwater benefiting much of the human race worldwide, the question becomes: how does the education of valuing and investing in freshwater conservation reach more of the general public? Anglers, hunters, and people from boating communities have been the most active champions for freshwater conservation, with a focus on protection and restoration of freshwater systems (Monroe et al. 2009). In a study by Dunlap and Heffernan (1975), there were three hypotheses regarding the relationship between participation in outdoor recreation activities and people's concern for the environment: (1) a positive association exists between involvement in outdoor recreation activities and environmental concern; (2) the association between appreciation activities such as wildlife viewing and environmental concern is stronger than between hunting and environmental concern; and (3) a

stronger association exists between outdoor recreation and concern for protecting certain aspects of the environment in order to pursue activities than between outdoor activities and environmental issues such as water and air pollution (Dunlap & Heffernan 1975; McMullin et al. 2007). Dunlap and Heffernan's study, along with other studies have found little to no support for the hypothesis that a positive association exists between involvement in outdoor activities and environmental concern. More recent studies have argued for the relationship between outdoor recreation and pro-environmental behavior (McMullin et al. 2007). Although a relationship exists between angling and boating participation and nature activism and support, there was less of a relationship with participation as there was with other factors that influence the public's support for freshwater conservation (McMullin et al. 2007).

In South Africa, freshwater fish are the most threatened species group (Skowno et al. 2019), but a lack of awareness may limit freshwater conservation, thus impacting the success of conservation interventions aimed to protect these critically imperiled environments. This lack of awareness of freshwater habitats is not restricted to one region, as the lack of awareness is spread throughout the globe. Although freshwater ecosystems represent one of Earth's richest pools of biological diversity (Monroe et al. 2009), covering less than 1% of the Earth's surface (Tickner et al. 2020), a vast majority of freshwater species remain "out of sight, and out of mind" (Rolston 1991).

Although the preferences of the general public are not always easy to predict, there are taxa that tend to be more effective for the communication of a conservation message (Rodríguez et al. 2004). Many conservation efforts for freshwater ecosystems are restricted by the fact that most of the species in diverse communities are rare, and thus knowledge about their history tends to be lacking (Sheldon 1988). This makes analysis of true global biodiversity of freshwater habitats virtually impossible, thus impacting the success of freshwater conservation efforts.

The current lack of public awareness of freshwater species and ecosystems may limit freshwater conservation as a popular cause (Monroe et al. 2009). Freshwater ecosystems are being destroyed twice as fast as marine and terrestrial ecosystems (Tickner et al. 2020), so awareness and commitment to conserving freshwater biodiversity is vital in order to preserve these

ecosystems long-term. The terms “vanishing”, “in peril”, “declining”, “crisis”, and “extinctions” are appearing in titles of papers on freshwater fish more frequently (Cambray & Bianco 1998), but are we seeing the justified response in conservation efforts? The failure to engage the public in freshwater conservation and management issues will hinder the efforts to slow the loss of freshwater habitats and aquatic biodiversity (Cooke et al. 2013). The success or failure of environmental management practices and goals is partially attributed to the support from the general public (Walker-Springett et al. 2016). Gaining support from the general public can be challenging as the scale of problems in freshwater ecosystems are often quite large, thus the need to engage large proportions of the public may be necessary at times (Walker-Springett et al. 2016).

There are barriers unique to freshwater systems that make it challenging to improve public engagement in freshwater conservation. With the complexity of these systems, there is a lack of understanding in how human actions negatively affect freshwater ecosystems, especially indirect actions such as land-use changes in water catchment areas (Cooke et al. 2013). There is also the challenge that the role of freshwater fish and aquatic systems have not been properly quantified in a way that demonstrates their contribution to human well-being (Welcomme 2011). Many people do not think of fish other than a source of food, as pets, or recreational prizes, but fish contribute to human life in other less recognized ways such as to manufacturing and industry, technology and healthcare (Olden et al. 2020). Increased urbanization and how communities function are impacting people’s sense of belonging and connectedness to nature, which impacts stewardship for freshwater conservation (Cooke et al. 2013). Although there are barriers to knowledge and understanding of the role freshwater ecosystems play ecologically, and their importance to human well-being, there are opportunities to improve the way freshwater ecosystems and species are portrayed to the public.

Looking forward towards the future, having a deeper understanding of the public’s perception of freshwater ecosystems and the species that inhabit these systems will be vital in the sustainability and protection of these valuable ecosystems. A better understanding of the human-environment relationship and what influences people’s interactions with, and attitudes towards, freshwater habitats will be key in developing effective conservation actions and policies (Walker-Springett et al. 2016). An increased understanding of these relationship dynamics will facilitate

stronger relationships and information sharing between scientists and conservation leaders, and if partnered with more transparency and engagement with the general public, it will likely improve the likelihood of freshwater species and habitat survival.

1.5 Media in conservation

With rapid recent advances in technology and social media over the last decade, conservationists and conservation organizations have changed the way they share information in order to adapt to this new media age (Büscher 2016). In this technologically advanced era, social media platforms (e.g., Facebook, Instagram, Twitter, WeChat, Flickr, Google+, etc.) garner more than two billion users worldwide, which equates to approximately 29% of the world population and 67% of the world's internet users (Wu et al. 2018). As the influence of media, especially social and popular media, continues to increase, it will be of upmost importance for conservationists to be mindful how species and nature are being portrayed. Given the critical state of the Earth's biodiversity, actions that promote society engagement in conservation activities that would lead to change in attitudes towards the natural environment are necessary (Ehrlich & Kennedy 2005). Increasing public awareness plays an important role in eliciting environmental stewardship from the general public concerning conservation issues (Jefferson et al. 2015). Currently, both printed and electronic media have been the major sources of information on nature for the general public; as these image-based media aim to evoke emotions and impact attitudes towards wildlife conservation (Wu et al. 2018).

In our modern, technologically advancing world, people are becoming increasingly distant from the natural world and are increasingly reliant on media for information. Ross et al (2008) showed that the prevalent use of chimpanzees in movies, television, and advertisements was linked to the public being less likely to view chimpanzees as endangered compared to other ape species. These results show how a species portrayal in media linked to public attitudes, which may then influence support for conservation efforts (Ross et al. 2011). This study demonstrated how the inappropriate portrayal of apes in advertisements was undermining scientific and conservation goals (Ross et al. 2008). This study also surveyed the public on different kinds of images that

included chimpanzees with the aim to see if people had different responses to the different images. The images included chimpanzees in a zoo setting, a chimpanzee with a blank background, a human-centric setting with a person and a chimpanzee, and a chimpanzee in a natural jungle setting (Ross et al. 2011). The collection of images also included photographs, cartoons, and pencil drawings of chimpanzees. The results showed that respondents viewing the human-centric images with a chimpanzee standing next to a human, were 35.5% less likely to categorize chimpanzees as endangered/declining compared to respondents viewing images of chimpanzees standing alone (Ross et al. 2011). In this case, the presence of humans in photographs impacted respondent's views of the reality of the status of chimpanzees, thus potentially influencing the perceived need for conservation support.

Photography and imagery have helped shape societal views and policies on issues related to the natural environment (Ward 2008). Wu et al. (2018) collected data from WeChat (the largest social media platform in China) on the Indo-humpback dolphin (*Sousa chinensis*), listed as a Grade 1 Protected animal in China. They found that greater numbers of pictures of dolphins increased readership counts (Wu et al. 2018). Pictures may be more popular amongst younger adults (Pittman & Reich 2016), where high-quality images that are centered on conservation are shown to increase popularity on social media (Papworth et al. 2015). In today's world, the use of the Internet is a highly effective way to disseminate information to large audiences. By increasing readership, information can reach more people, thus creating greater public awareness on critical issues such as conservation.

The lack of public knowledge and understanding in conservation issues is mainly attributed to the lack of communication by scientists and policy makers (Papworth et al. 2015). Often times the conservation community itself fails to reach and engage the general public (Wright et al. 2015). Technology is an effective tool to increase meaningful communication with words and images. Conservation marketing applies social-marketing strategies to conservation issues, and is gaining more recognition as an impactful approach to increasing public awareness of biodiversity loss and participation in conservation activities (Wright et al. 2015). Often, when attempting to bring awareness to conservation issues, conservationists use species as the focus of their conservation marketing to better engage their target audience (Verissimo et al. 2011). One example of successful

social marketing, focused on a species, was the documentary *Blackfish*, which documented issues related to captive Orcas (*Orcinus orca*). The documentary was trending on social media before it was aired on television, and at that point, had already generated a lot of discussion and focus on the issue (Wright et al. 2015). In this documentary, the use of video and photographic imagery was used to not only tell a compelling story, but also evoke emotion and public awareness of the issue. The use of technology, especially imagery in media, is growing in popularity to bring awareness to many issues around the world. Conservation is no exception and can greatly benefit from more thoughtful use of images and media.

1.6 Media in freshwater conservation

There appears to be a lack of knowledge and focus on freshwater biodiversity in society and conservation literature compared to marine and terrestrial biodiversity (Monroe et al. 2009). Aquatic life is generally less visible to the human eye than terrestrial life, so visually connecting freshwater ecosystems and species to human stewards through images, such as photographs and video, is important for freshwater conservation. Although freshwater ecosystems and species are less visible than other habitats and species, freshwater ecosystems are vital to human survival. To understand why freshwater conservation has a limited following by the public, it's portrayal in media and perception by the public needs to be considered (Monroe et al. 2009).

Most popular images of freshwater fish are of sport fishes and other species after they have been "landed" and removed from their natural habitat (Monroe et al. 2009). This removal from their natural habitat may prevent people from having a more empathic perspective of the species' life and habitat (Monroe et al. 2009). In a 2014 study by Maceda-Veiga et al., aquarium owners were surveyed on their preference of pictures of a wild-caught and captive-reared fish species common in the aquarium trade, the guppy (*Poecilia reticulata*). Of the randomly selected aquarium owners, 100% responded that they preferred the pictures of the more colorful captive-reared guppy to the more drab looking wild type (Maceda-Veiga et al. 2014). These findings may demonstrate that the visual attraction to fish may sometimes be valued more than the fish in its

natural state or habitat, which potentially reduces empathy and appreciation for these species in the wild.

Flagship species are often used to highlight conservation issues that not only bring awareness to that specific species, but also to the ecosystem they inhabit as a whole. Unlike terrestrial and marine flagship species, freshwater species are underrepresented in the public eye (Monroe et al. 2009). The high proportion of "fish-out-of-water" freshwater fish images online that rarely depict the ecosystem as a whole contributes to the lack of awareness and engagement in freshwater conservation (Monroe et al. 2009). Underwater images of fish and other species in their natural habitat may be able to more naturally convey the intrinsic and ecological value of freshwater species and ecosystems (Monroe et al. 2009). These more ecologically and visually empathetic images may resonate more with the general public, and are more likely to rally support for freshwater conservation (Jepson & Canney 2003).

This study was designed to examine the images people are exposed to of freshwater fish in South Africa, and if these images have an effect on their willingness to donate time or money to freshwater conservation efforts. This study first examined images sourced from the web of native South African freshwater fish. Then, an online survey was conducted to investigate people's perception of freshwater fish images and their use to convey the importance of conserving freshwater ecosystems, and whether the type of images (showing fish in-water or out of water) influenced their willingness to donate their time or money to freshwater conservation.

2. Aims and Hypotheses

The main research question of this study is: do the kinds of images of freshwater fish that people are exposed to influence their perceptions of, and support for, conservation of freshwater fish and ecosystems? To answer this question, I assessed (1) the kinds of images of South African fish that people are exposed to in the public media (such as Google); (2) emotions towards images of freshwater fish in their natural habitat and images showing the fish out of water; (3) people's preference of image types to be used to rally support for freshwater conservation; and (4) their willingness to support freshwater conservation efforts after exposure to images of freshwater fish in water or out of water.

Based on my research aims and literature review, I tested how a set of response variables (image type preference, willingness to donate time to volunteer, and willingness to donate monetarily) are influenced by the following explanatory variables: the type of images respondents were passively exposed to during the survey, frequency of visits to freshwater environments, formal education in the natural sciences, and gender.

Understanding the influence of images on people's desire to support freshwater conservation is critical in making decisions on how to communicate information and what type of images should be used to elicit more impactful responses from the public. I hypothesized (1) that people are exposed to more 'out-of-water' images online, (2) people would prefer viewing images of freshwater fish in water, in their natural habitat, when the images were used to rally support for freshwater conservation; and (3) that images people were exposed to would influence their willingness to participate, both monetarily and in volunteering their time, in freshwater conservation efforts. I predicted that respondents who were exposed to images of fish in their natural habitat would be more willing, and have a greater desire, to conserve freshwater fish species and their freshwater environment.

3. Methods

3.1 Google Image analysis

Images of native South African fish species were selected for Google image analysis to investigate the kinds of images people are exposed to online. Species that are popular angling fish were identified as well as ones not targeted by anglers but that are more well known for their endemism. Both angling and non-angling species were selected to see if the general public is exposed to more South African freshwater fish species based on human influence and their value for recreational purposes compared to non-angling species that may be more or less well-known. Information on the types of images was collected using photographs from the Internet from September-November 2020. This was done by using a software developed to analyze Google Images, called "MORPHIC". For each search query, this application (http://morphs.io) scrapes and caches images found using Google Images (Leighton et al. 2016).

The search was done by entering search queries into MORPHIC, then I visually examined the 400 resulting images per search query. Two different surveys were created, one for the species search and one for a general search term. For the species survey we recorded for each image, whether the image included a fish, if the fish was in water or out of water, if a human was present in the image, and if it was the correct species. The general search survey contained fields on whether the fish was a freshwater species or marine species, if the fish was in water, if it was in or around a natural habitat type, and if there was a human present in the image. Images that did not include any fish, was a document that included several images, or had a URL that was expired or no longer working was removed from the sample and marked "not usable".

The image searches were done on ten native South African freshwater fish species and one general search query for 'freshwater fish South Africa'. Not only were species selected based on their angling status, but also a variety of sizes and different conservation statuses. The focus was on species present in the Cape Fold Ecoregion, since that was where most respondents were based. The search queries were conducted on the species: *Cheilobarbus serra* (Sawfin), *Enteromius anoplus* (Chubbyhead barb), *Galaxias zebratus* (Cape galaxias), *Labeo capensis* (Orange River

mudfish), *Labeo seeberi* (Clanwilliam sandfish), *Labeo umbratus* (Moggel), *Labeobarbus kimberleyensis* (Vaal-Orange largemouth yellowfish), *Labeobarbus seeberi* (Clanwilliam yellowfish), *Pseudobarbus burgi* (Berg River redfin), and *Sandelia capensis* (Cape kurper).

3.2 Questionnaire methods

3.2.1 Survey design

A survey with predominantly closed-ended questions (see Appendix 1) was used to survey people's perceptions of the role of images in freshwater conservation and people's willingness to contribute to freshwater conservation. The survey was designed in Survey Monkey and disseminated electronically. After pilot testing of the survey was completed by peers, the survey was manually emailed out to respondents via personal and professional networks and to staff and students at The University of Cape Town between December 2020 and early January 2021. The professional networks included angling, academic and conservation networks. In order to reach as many respondents as possible, personal and professional networks were asked to forward the survey and supporting background information on to anyone they know in South Africa. The target population of respondents included people residing in South Africa, and University of Cape Town students and staff. The sampling of survey recipients was purposive and non-random, so no generalizations can be drawn about South Africans in general. A total of 688 respondents completed the survey. It was also circulated on Twitter and Facebook.

3.2.2 Image selection

A selection of images of native South African fish species were selected to assess respondent's perceptions toward freshwater fish and freshwater ecosystems. One collection of images included freshwater fish shown in water in their natural habitat within a freshwater ecosystem (Figure 1b). The second collection had fish shown out of water (Figure 1a), some with human presence, but all with the emphasis on the individual fish. Consideration was given to the kinds of images selected for the out of water collection as to not have overly human-centric

photographs or ones that were trophy-like images. I chose not to include heavily human-centric images to avoid 'human presence' bias in perceived differences between the two image collections that could potentially affect respondent's answers to the survey. The species used for the image collections ranged in size, conservation status, popularity, and included both angling species, and less-known endemic species that are not targeted by anglers.

a) Image Collection A

b) Image Collection B

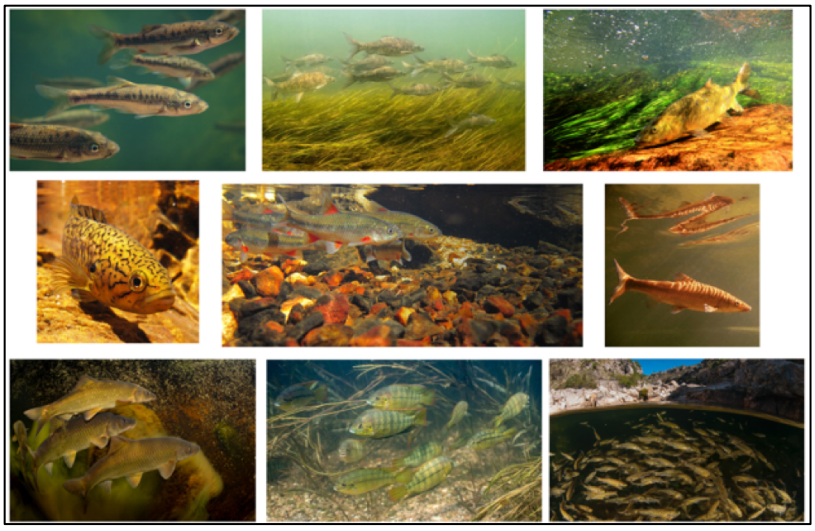

Figure 1. Image collections of native South African freshwater fish out of water (image collection A) and in water (image collection B) that were passively shown to survey respondents during survey completion.

3.2.3 Survey question selection

The questions selected for the survey were organized into three groups: (1) respondent profiling, including interactions with freshwater environments, fishing experience, and standard profiling variables; (2) respondent's willingness to donate time and money (in South African rand "ZAR") to freshwater conservation activities; and (3) questions to assess respondent perceptions of different images of South African freshwater fish in water and out of water. Some of the profiling questions were selected to investigate respondent's prior experience with freshwater ecosystems and their experience with fishing for freshwater fish to provide insight into potential connections between respondents and their perception and utilization of freshwater. After respondents completed the profiling questions, they were passively shown a random image collection of South African freshwater fish before answering questions about their willingness to participate in conservation activities and their opinions of images. The passively shown image collections were used to assess whether the images that respondents were exposed to had a subsequent effect on their willingness to participate in conserving freshwater ecosystems and their preference for images used in conservation communication. The image questions assessed respondent's emotions to fish and freshwater ecosystems, and their preference of image collections used to communicate the importance of conserving freshwater ecosystems and freshwater fish.

Respondent profile

Standard socio-demographic questions were asked, including gender, age, and diet (i.e. meat eater, vegetarian, pescatarian, vegan). Information on whether respondent's had natural sciences formal education (i.e. whether respondents had some form of formal education in Biology, Geology, Physics, Chemistry, Astronomy, Earth Science, etc.) was also collected. Respondents were also asked about their interactions with freshwater ecosystems: if they had visited freshwater ecosystems in the past, how often did they or do they visit freshwater, for what reasons they visit freshwater, and if they consider themselves a freshwater fisherman, in order to investigate their personal experience with freshwater fish and freshwater environments.

Willingness to donate questions

Two scenario-based questions were selected to investigate respondent's willingness to donate time and money to freshwater conservation activities. The first question was a scenario selected to investigate willingness to donate time volunteering with a conservation group to assist in cleaning up a nearby river to save a threatened species of freshwater fish. For this question, respondents were given options of no time, a morning, a day, a weekend, or several weekends. The second question was a scenario selected to investigate how much money (in South African Rand "ZAR") respondents would be willing to donate to a local freshwater conservation effort working to save freshwater fish. Respondents had answer options of R0, R10, R100, R500, R1000, R5000, and "Other" where respondents could enter the amount they would be willing to donate.

Perception of images questions

Four questions were selected to investigate respondent emotions associated with two image collections of freshwater fish (collection A - freshwater fish shown outside of water; collection B - freshwater fish shown under water in their natural freshwater environment). Two questions investigated the respondent's emotions associated with each collection. Respondents could select multiple options: happy for fish, sad for fish, feel good about freshwater environments, concerned about freshwater environments, desire to know more about the fish, desire to know more about freshwater environments, and no emotion. Respondents were also able to enter additional emotions in a free text field labeled "Other". The third question asked respondents to identify which image collection they would prefer to use to communicate the importance of freshwater fish and ecosystem conservation. The last question asked respondents if they felt images play an important role in rallying support for nature conservation.

3.3 Data analysis

Analyses were performed in R (R Core Team 2019). I used Generalized Linear Models (GLMs) to investigate three questions: (1) Did the type of images respondents were passively shown (either fish in water or fish out of water) in the survey have an effect on the types of images they would choose to communicate the importance of conserving freshwater ecosystems and freshwater fish; (2) did the willingness of respondents to donate monetarily towards a local freshwater conservation effort vary depending on the images of freshwater fish they were passively shown during the survey; and (3) did the willingness of respondents to donate their time toward a freshwater conservation effort vary depending on the images of freshwater fish they were passively shown during the survey. When exploring these questions, we also controlled for co-variables variables such as age, diet, freshwater experience, education and gender. For gender, "Non-binary" and "Other" were removed from the statistical analysis due to low frequencies of 1.31% (n=9) and 0.29% (n=2), respectively.

I ran three models to explore the best predictors of the following response variables:

I) Respondent's image collection choice to best represent freshwater conservation (in-water or out-of-water photos).

II) Willingness to donate monetarily towards freshwater conservation. For this variable, we recoded the respondent's choice of rand (ZAR) amounts (R0, R10, R50, R100, R500, R1000, R5000, or a specified amount) into two different binary categories: firstly, no money (0) or some money >0 ZAR (1); and secondly, less than R100 (including R0) (0) and R100 or greater (1).

III) Willingness to donate time towards freshwater conservation. For this variable, we recoded the respondent's choice of time amounts into two different binary categories: no time (0); or some time (1) (including a morning, a day, a weekend, or several weekends), and secondly, no or a little time (no time or up to 1 day during the year 2021) (0) or considerable time (1 weekend or more during the year 2021) (1).

For each of the five models, I included an initial set of predictors: that were i) the image collection type they were randomly and passively shown during the survey (i.e. image collection A: nine

photographs of native South African freshwater fish out of water; image collection B nine photographs of native South African freshwater fish in water in their natural habit), ii) age of respondent, iii) gender, iv) diet, v) Natural Sciences education , and vi) whether or not they had ever visited freshwater environments of any kind.

Model selection was then carried out using backwards stepwise regression to create a minimum adequate model (MAM) (Redpath et al. 2017). At each step, I removed the variable with the highest p-value, until only variables with a p-value of <0.1 remained. The 'Image Test' variable was retained in all models as a permanent fixed effect.

4. Results

4.1 Google Image Analysis

Of the 4,000 species-specific images (400 images per 10 species) obtained from our web search, 398 were determined to be of the correct species. Of the 398 images showing the correct species, 115 (28.9%) showed fish in a water habitat of some kind, whereas 283 (71.1%) showed fish out of water. The other 3,602 images either showed the incorrect species, had no fish present in the image or was an expired image or document.

Images showing the five species of fish not targeted by anglers (*Pseudobarbus burgi* (Berg river redfin); *Galaxias zebratus* (Cape galaxias); *Sandelia capensis* (Cape kurper); (*Enteromius anoplus* (Chubbyhead barb); and *Labeo seeberi* (Clanwilliam sandfish)), accounted for 37.4% (149) of the correct species images (Table 1). Of these 149 images, 52.3% (78 images) showed the correct species of fish in water. Images showing the five fish species targeted by anglers (*Labeobarbus seeberi* (Clanwilliam yellowfish*)*; *Labeo umbratus* (Moggel); *Labeo capensis* (Orange River mudfish); *Cheilobarbus serra* (Sawfin); and *Labeobarbus kimberleyensis* (Vaal-Orange largemouth yellowfish)), accounted for 62.6% (249) of the correct species images (Table 1). Of these 249 images, only 10.8% (27) showed the species in the water.

The results of the general image search of "freshwater fish south Africa" provided 189 images of freshwater fish. Of the 189 images of freshwater fish, 94 (49.7%) images were of fish in water. Images showing freshwater fish out of water accounted for 50.3% (95 images) of the total 189 images.

Table 1. Results of Google Image search of each of the ten native South African freshwater fish species that were queried in MORPHIC. Data on each species includes: whether the species is frequently targeted by anglers for recreational fishing; number of images that were of the correct species (of the 400 images analyzed for each species search query), percentage of images of the correct species shown in water (of the total count of correct species images), average correct species count, average percentage of images showing the correct species in water, and total number of images for species both targeted an not targeted by anglers.

Species Name (scientific and common)	**Correct Species Count**	**Correct Species in Water** (%)
Not targeted by anglers		
Pseudobarbus burgi (Berg River redfin)	17	64.7%
Galaxias zebratus (Cape galaxias)	21	52.4%
Sandelia capensis (Cape kurper)	57	61.4%
Enteromius anoplus (Chubbyhead barb)	27	25.9%
Labeo seebri (Clanwilliam sandfish)	27	51.8%
Average	29.8	53.7%
Total images of species not targeted by anglers	149	
Targeted by anglers		
Labeobarbus seeberi (Clanwilliam yellowfish)	41	19.5%
Labeo umbratus (Moggel)	41	4.9%
Labeo capensis (Orange River mudfish)	48	4.2%
Cheilobarbus serra (Sawfin)	26	57.7%
Labeobarbus kimberleyensis (Vaal-Orange largemouth yellowfish)	93	10.7%
Average	49.8	19.4%
Total images of species targeted by anglers	249	

4.2 Survey respondent profile

A total of 688 people from mainly South Africa (n=650), with some respondents outside South Africa (n=38), took part in the survey. Since not all surveys were complete, response rates and sample sizes vary slightly between analyses. Analysis of the demographic variables showed an age range of 18-83. The gender distribution was 57.56% Female, 40.84% Male, 1.31% Non-binary and 0.29% identified as Other. Table 2 shows the demographic characteristics, or respondent profiles, included in the survey of the respondents.

Table 2. Demographic characteristics of the 688 respondents.

Category	Options	Respondents (n=688)
Age (years)	Mean	36.02
	Range	18-83
Gender (%)	Female	57.56%
	Male	40.84%
	Non-binary	1.31%
	Other	0.29%
Province (%)	Eastern Cape	4.80%
	Free State	1.89%
	Gauteng	20.35%
	KwaZulu-Natal	6.25%
	Limpopo	3.63%
	Mpumalanga	3.20%
	Northern Cape	0.44%
	North West	1.45%
	Western Cape	52.47%
	Other (outside South Africa)	5.52%
Natural sciences formal Education (%)	Yes	72.82%
	No	27.18%
Visited freshwater (%)	Yes	95.46%
	No	4.54%

4.3 Top predictors of choice of image collection type

Overall, 73.5% respondents said that they would choose pictures of freshwater fish in water to communicate the importance of conserving freshwater ecosystems and freshwater fish. (Figure 1), and 96.2% of respondents thought that images played an important role in rallying support for nature conservation in general.

More positive (e.g happy) and less negative (e.g. sad) emotions towards the fish were associated with the 'in water' image collection compared to the 'out of water' collection (Table 3). More positive and less negative (e.g. concerned) emotions towards freshwater environments were associated with the 'in water' image collection compared to the 'out of water' collection (Table 3). The 'in water' image collection was also associated with a higher desire to know more about freshwater environments, compared to the 'out of water' collection.

Table 3. Survey respondent emotion selection associated with in water and out of water images.

Emotion	Out of water images (collection A)	In water images (collection B)
Happy for fish	5.01% (33)	55.42 % (363)
Sad for fish	42.49% (280)	3.51% (23)
Feel good about freshwater environments	19.12% (126)	58.32% (382)
Concerned about freshwater environments	43.70% (288)	27.18% (178)
Desire to know more about the fish	38.54% (254)	49.62% (325)
Desire to know more about freshwater environments	35.36% (233)	57.25% (375)

The final MAM exploring image choice (collection of images, either in-water or out of water, chosen by respondents to best represent freshwater conservation) included the types of images that were passively shown (image test) and the gender (which was marginally non-significant) (Table 4). Overall nearly three quarters of respondents chose the 'fish in water' image collection as being better for freshwater conservation. However, an even greater proportion of respondents chose this collection (77%) that were passively shown images of fish out of water, compared to those that were passively shown images of fish in water (70%) (Figure 2a). The non-significant gender relationship suggested that there was a tendency for more female respondents (76%) to select the in-water images than male respondents (70%) (Figure 2b).

Table 4. Results of final generalized linear model (GLM) selection examining predictors of image choice to be used to best represent freshwater conservation. The 'image test' explanatory variable was retained for this model as a permanent fixed effect. Explanatory variables with a p-value lower than 0.1 were retained in the model. Variables were considered statistically significant if they had a p-value less than 0.05.

Response variable	**Predictor variables**	**Estimate**	**±SE**	**$\chi 2$**	**p-value**
Image Choice	Intercept	0.955	0.148	6.438	1.21e-10
	Image Test	0.417	0.183	2.282	0.022
	Gender	-0.317	0.182	-1.734	0.082

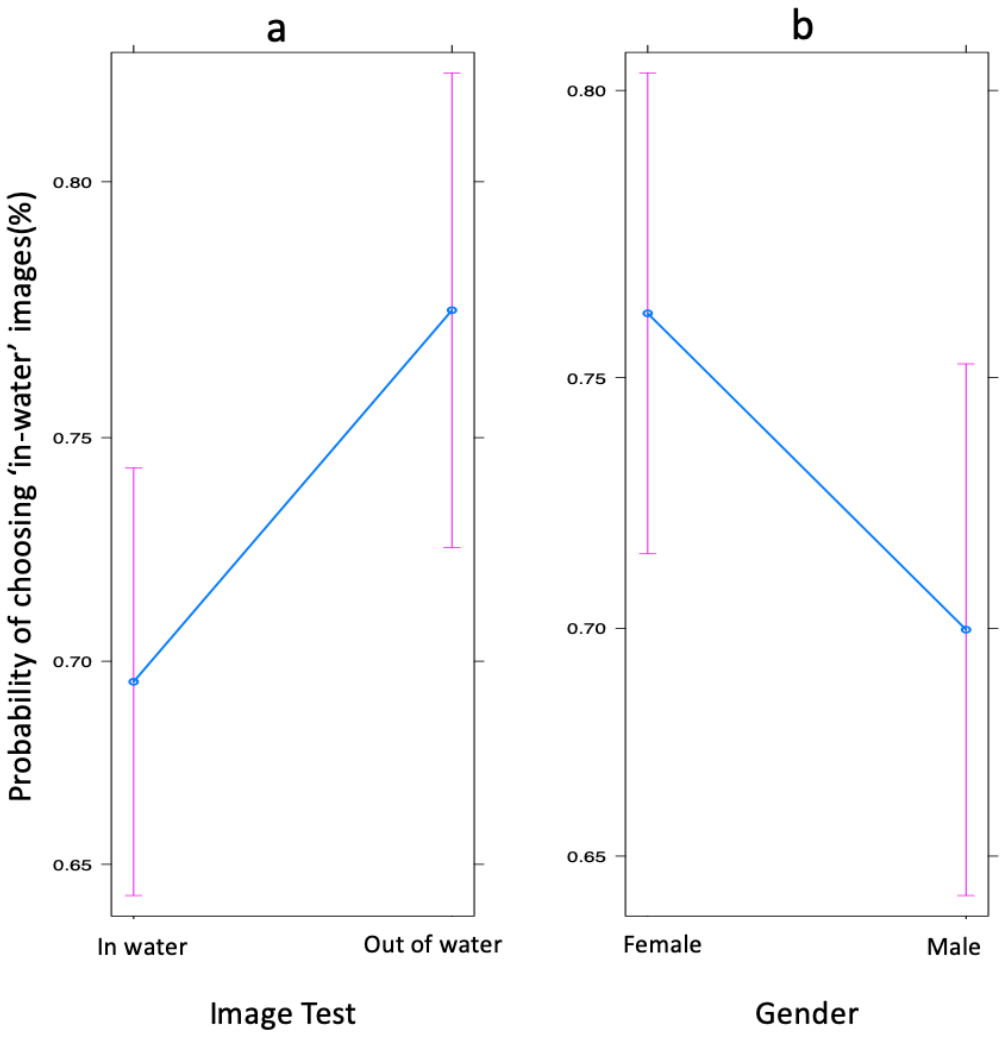

Figure 2. Effect plots of the final predictors retained in the generalized linear model (GLM) examining the probability of choosing 'in water' image collection as being better for freshwater conservation. The error bars represent 95% confidence intervals. The Image test result was statistically significant (P=0.02).

4.4 Top predictors of willingness to donate monetarily towards freshwater conservation

The final MAM exploring willingness to donate some amount of money (ZAR) towards freshwater conservation included only gender, which was marginally non-significant, and the types of image test that were passively shown (image test) (our permanent fixed effect) but was not statistically significant (Table 5). The non-significant gender relationship suggested that there was

a tendency for more female respondents (81%) to donate some amount of money (ZAR) than male respondents (75%) (Figure 3b).

The final MAM exploring willingness to donate an amount of R100 (ZAR) or greater towards freshwater conservation concluded that there were no variables significantly associated with the probability of donating R100 or greater, with the type of image that was passively shown (image test) being non-significant.

Table 5. Results of final generalized linear model (GLM) selection examining predictors of willingness to donate money with the response variable grouped into two groups of (1) willingness to donate no money and (2) willingness to donate some amount of money. The image test explanatory variable was retained as a permanent fixed effect. Variables were considered statistically significant if they had a p-value less than 0.05.

Response variable	**Predictor variables**	**Estimate**	**±SE**	**$\chi 2$**	**p-value**
Willingness to donate money	Intercept	1.471	0.163	0.021	<2e-16
	Image test	-0.042	0.191	-0.223	0.823
	Gender	-0.342	0.191	-1.784	0.075

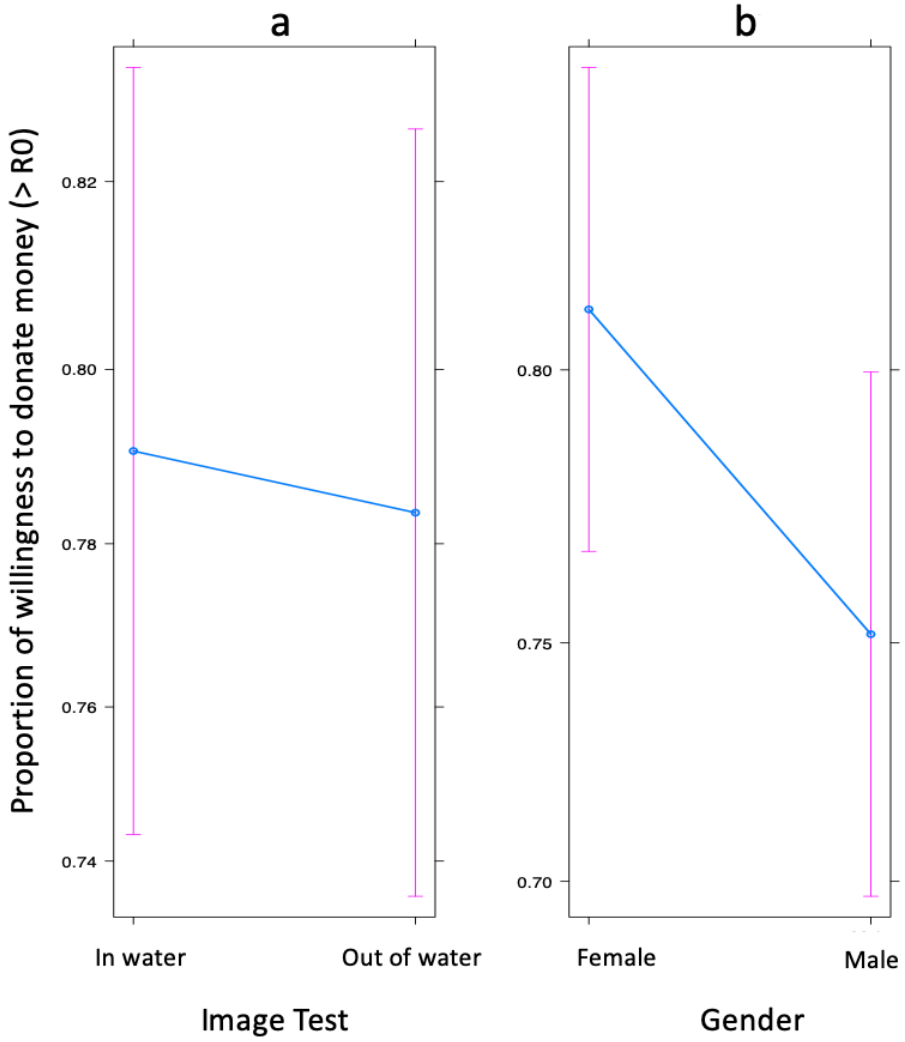

Figure 3. Effect plots of the final predictors retained in the generalized linear model (GLM) examining the probability of willingness to donate some amount of money greater than R0 (ZAR) towards freshwater conservation. The error bars represent 95% confidence intervals. The Image test result was non-significant (P=0.82).

4.5 Top predictors of willingness to donate time towards freshwater conservation efforts

The final MAM exploring willingness to donate some amount of time towards freshwater conservation included gender, visiting freshwater environments, and natural sciences education with our permanent fixed effect of image test being non-significant (Table 6). Male respondents

were more willing to donate some amount of time than female respondents (Figure 5b). Respondents who had not visited freshwater environments in the past had a greater tendency of willingness to donate some amount of time (> no time) (Figure 5c). We also found that respondents who did not have formal education in the natural sciences had a greater willingness to donate some amount of time (> no time) (Figure 5d).

Table 6. Results of final generalized linear model (GLM) selection examining predictors of willingness to donate time with the response variable grouped into two groups of (1) willingness to donate no time and (2) willingness to donate some amount of time. The image test explanatory variable was retained for hypothesis testing. Variables were considered statistically significant if they had a p-value less than 0.05.

Response variable	**Predictor variables**	**Estimate**	**±SE**	**$\chi 2$**	**p-value**
Willingness to donate time	Image test	0.238	0.254	0.937	0.348
	Gender	0.664	0.258	2.575	0.010
	Visited freshwater	-1.613	0.417	-3.870	0.0001
	Natural sciences	-0.531	0.266	-1.996	0.046

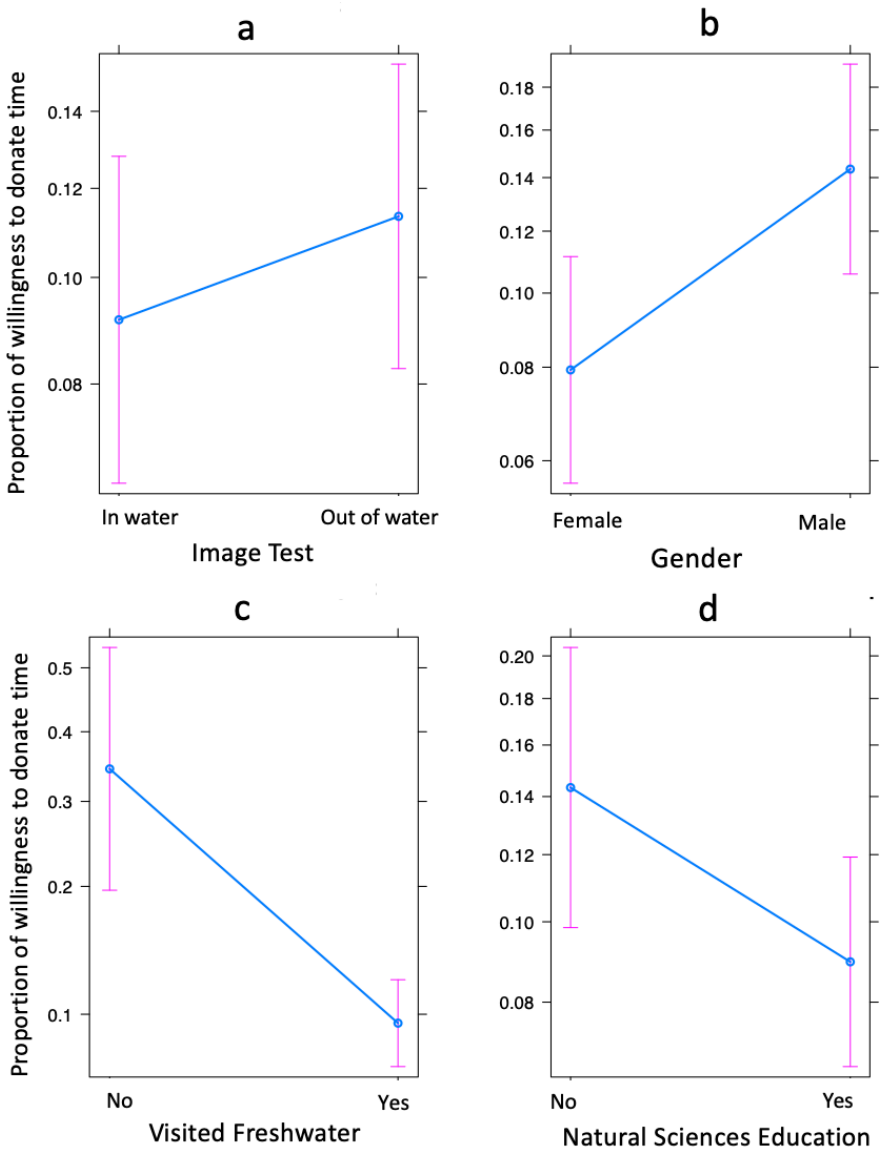

Figure 5. Effect plots of the final predictors retained in the generalized linear model (GLM) examining the probability of willingness to donate some time (> no time) towards freshwater conservation. The error bars represent 95% confidence intervals. The Image test result was non-significant (P=0.34).

The final MAM exploring willingness to donate considerable amount of time (one weekend or more) towards freshwater conservation included gender, visiting freshwater environments, and natural sciences education (Table 7). Female respondents were more willing to donate greater amounts of time than male respondents (Figure 6b). Respondents who had visited freshwater environments in the past had a greater willingness to donate greater amounts of time (one weekend

or more) (Figure 6c). We also found that respondents who did have formal education in the natural sciences had a greater willingness to donate greater amounts of time (one weekend or more) towards freshwater conservation efforts (Figure 6d).

Table 7. Results of final generalized linear model (GLM) selection examining predictors of willingness to donate time with the response variable grouped into two groups of (1) willingness to donate no time or up to one day and (2) willingness to donate one weekend or several weekends. The image test explanatory variable was retained for hypothesis testing. Variables were considered statistically significant if they had a p-value less than 0.05.

Response variable	**Predictor variables**	**Estimate**	**±SE**	**$\chi 2$**	**p-value**
Willingness to donate time	Image test	-0.005	0.169	-0.028	0.977
	Gender	-0.361	0.171	-2.110	0.035
	Visited freshwater	0.772	0.378	2.041	0.041
	Natural sciences	0.508	0.186	2.729	0.006

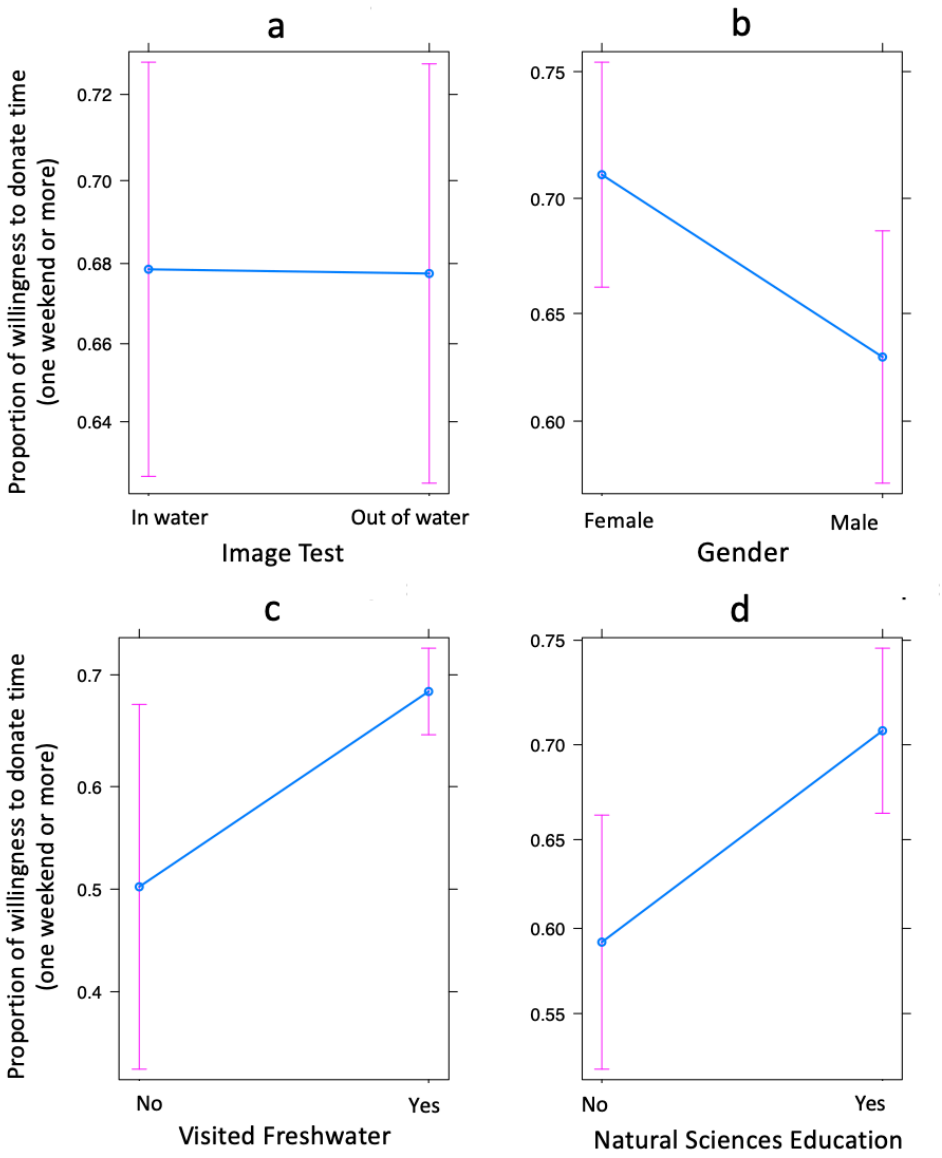

Figure 6. Effect plots of the final predictors retained in the generalized linear model (GLM) examining the probability of willingness to donate considerable time (one weekend or more) towards freshwater conservation. The error bars represent 95% confidence intervals. The image test result was non-significant (P=0.97).

5. Discussion

Freshwater biodiversity lacks representation compared to marine and terrestrial ecosystems (Monroe et al. 2009). This under-representation and lack of public awareness may negatively impact freshwater conservation and progress in saving South Africa's most threatened species group, freshwater fish. The disconnect between freshwater systems and humans themselves can be addressed and potentially resolved with the use of effective and appropriate imagery and consideration in how freshwater species and ecosystems are portrayed. In our current age of technology, the use of images can play a major role in gaining support for conservation by evoking emotional responses from people that ultimately lead to action and change. The information on freshwater ecosystems that is available to people has an impact on people's perception of the value and importance in these highly diverse systems and in conserving them. Currently, the general public has significantly more access to images of freshwater fish out of water than images showing the fish in water in their natural habitat, which is linked to human disconnect from nature. Although media and imagery are being used effectively in many ways, and in conservation, freshwater ecosystems are often being neglected or misrepresented.

In this study I first analyzed images of freshwater fish on Google to investigate the types of images people have access to when seeking more information on specific species or general freshwater fish in South Africa. My study found that more images showed fish out of water than in water in their natural habitat. Second, when I surveyed respondents throughout South Africa, 73.5% of respondents preferred images showing freshwater fish in their freshwater habitat over images showing freshwater fish out of water. Images of fish in their freshwater ecosystem evoked more emotions from respondents than those of fish out of water. Third, this study found that passively viewing images of fish in water or out of water had no effect on respondent's willingness to donate money or time towards freshwater conservation. Other factors such as gender, education in natural sciences, and past experience of visiting freshwater had a more significant effect on respondent willingness to donate money or time to freshwater conservation efforts. My study addresses the need for more mindful and deliberate efforts in how species and ecosystems, especially largely unknown ones like freshwater, are portrayed in media for conservation.

5.1 Google Image Analysis

The portrayal of species or nature can impact the way they are viewed by the public, and in turn the support for their conservation. The findings that there were more images available online for angling species versus non-angling species is not overly surprising. My study's results that the majority of species were portrayed by 'out-of-water' images is consistent with my hypothesis that people are often times exposed to more images of freshwater fish 'out-of-water'. Images showing species outside of their natural habitat can impact their perceived importance and value to nature. Human influence and human-centric images with nature are potential influences on both the available images of freshwater fish in media and how images and species are perceived by the public. A similar study found that respondents viewing pictures of chimpanzees standing next to humans were 35.5% less likely to believe chimpanzees were endangered or declining compared to respondents viewing images of chimpanzees standing alone (Ross et al. 2011). This study result demonstrates how the type of images can reinforce a disconnect between people and their perception of nature and that images that are human-centric can detract from the focus on a species and the reality of its conservation status. This disconnect between humans and nature directly impacts people's perception of the importance and need for conservation efforts.

The kind of image used in portraying the different fish species had an effect on the emotions respondents associated with in-water and out of water images. Overall, respondents associated more positive emotions with pictures of fish in their natural habitats over images showing the fish out of water and sometimes in the presence of humans. A greater desire to know more about freshwater fish and freshwater environments evoked by viewing images of fish in their natural habitat has positive implications for increased awareness and involvement in freshwater conservation actions. Emotions often play a major role in the decisions we make and the actions we take. When emotions are added to an experience or learning, it makes it more memorable (Jacobson et al. 2007). Environmental organizations often use art to attract new audiences or supporters and to facilitate dialog on important issues (Jacobson et al. 2007). In my study, 73.5% of respondents felt images of fish in their natural habitats and in water would best communicate the importance of conserving freshwater ecosystems and freshwater fish over images showing fish out of water. When asked, 96.2% of respondents stated they thought images plan an important role

in rallying support for nature conservation. A study in 2000 found that 85% of survey respondents thought that an art show they attended had successfully depicted forest issues in Oregon, and 77% agreed that viewing the art had increased their understanding of the complexity of forest issues (Withrow-Robinson et al. 2002). Images can be an emotion evoking tool that connects people with conservation issues and gains more buy-in from the general public.

5.2 Predictors of willingness to donate money towards freshwater conservation efforts

In my study, there were no significant predictors of donating money towards freshwater conservation. When analyzing the donation of no money versus some amount of money, respondents who viewed out of water images were slightly more likely to donate and those who had visited freshwater environments in the past were more likely to donate some amount of money. This finding contrasts with my hypothesis that images would influence respondent's willingness to donate money. The survey results showed 95% respondents had visited some type of freshwater environment in the past, which could suggest some sample selection bias. The survey also asked respondents to select which types of freshwater environments they had visited and the frequency in which they visit freshwater environments in an attempt to investigate the effect of visiting freshwater environments. Although my findings showed a marginally non-significant relationship between gender and willingness to donate some amount of money, female respondents were more likely to donate money. A previous study found that marine resource users gave significantly more when donating money compared to time, which is contrast with most existing literature (Nelson et al. 2018). My study results showed that more respondents were willing to donate no money (18.5%) than those who were not willing to donate their time (11.3%).

Often times, many factors influence a person's willingness to donate monetarily to conservation. Socioeconomic factors often play a major role in making decisions concerning money. Given the current COVID-19 pandemic and many people being negatively impacted financially, more people may be less likely to donate money to any cause, not just conservation efforts. Current pandemic regulations may also create more of an opportunity for people to donate

their time if they are not working, working from home, or attending university remotely. Employment status and income are also additional factors to take into consideration when investigating people's reasons for not donating money.

5.3 Predictors of willingness to donate time towards freshwater conservation efforts

In my study, gender, natural sciences education, and history of visiting freshwater environments were determined to be significant predictors in respondent's willingness to donate their time towards conservation efforts aimed to save threatened freshwater fish species. These findings contrast with my hypothesis that image type would influence people's willingness to donate their time towards conservation efforts. The amount of time was shown to impact the results and people's willingness to donate their time. When grouped into categories of donating no amount of time versus donating some amount of time, respondents who did not have a history of visiting freshwater environments and those who did not have natural sciences formal education were actually more likely to donate some amount of time. Gender was also a factor where male respondents were predicted to be more likely to donate some amount of time. When the time variable was grouped into different groups of donating no time up to one day versus one weekend or several weekends, the results were different. With the new category of time, respondents who had a history of visiting freshwater environments or who had a natural sciences education of some kind were predicted to have a higher probability of donating a weekend or more of their time towards freshwater conservation. When given options of donating no time or some amount of time, respondents who had passively viewed out of water images were more likely to donate time. This result could be linked to emotional responses to images where 43.7% of respondents stated they were concerned about freshwater environments when viewing the image collection of out of water images. This emotional response could impact people's willingness to donate their time to freshwater conservation. There was a change in the gender variable as well with females being more likely to donate a weekend or more of their time. My study shows that while gender, history of visiting freshwater and natural sciences education were significant in predicting respondent willingness to donate time, it was the actual amount of time that also influenced the predictions of willingness to donate time.

Several factors can play a role in people's willingness to donate their time towards conservation action and efforts. In past studies, educational levels have been linked to people's concern and increased likelihood of participation in environmental protection activities (Buttel & Flinn 1974). In previous research on donating time, females were more likely to donate their time (Hill et al. 1979). In my study, female respondents were predicted to be more likely to donate greater amounts of time. Overall, 67.6% of respondents said they would be willing to donate a weekend or several weekends to freshwater conservation whereas 21.1% responded that they would donate a morning or a day, and 11.3% stated they would not be willing to donate any time.

A survey question and factor that was not included in my study was income or current employment status. This could potentially be a predictor in people's willingness to donate time or money towards freshwater conservation efforts. Due to the current COVID-19 pandemic and a portion of the target survey audience being university students, current employment and income could greatly impact one's decision and/or ability to donate their time or money. Another question consideration would be to ask why people answered that they would not donate time or money. Analyzing these responses would also provide significant insight into understanding potential environmental behavior and decision-making drivers. Because volunteer interpretations of the environment is framed by their values and attitudes towards nature (Halpenny & Caissie 2003), including survey questions to analyze respondent values and perceptions of nature in general and freshwater would be beneficial to provide more understanding of willingness to donate time or money. Finally, an additional limitation of this study is related to the freshwater fish images selected to be included in the survey. All respondents were passively shown a collection of images of freshwater fish either in water or out of water before answering questions about their willingness to donate time and money towards freshwater conservation. By having a random sample of respondents not be shown any images, this would have allowed for stronger statistical analysis and a control group.

5.4 Future considerations

For future analyses, I would recommend looking at age as a potential predictor for willingness to donate time and money. Because age was determined to not be significant in my first model of determining predictors for image collection choice, I excluded it from the second and third statistical models for predicting willingness to donate time and donate money. Future survey consideration would be to have less categories for willingness to support conservation monetarily or with time. Research shows that a 'hypothetical bias' exists when surveying consumers about their willingness to pay for a good or service where what they state they would pay (hypothetical willingness to pay) may be different from what they are actually willing to pay (real willingness to pay) or end up paying (Schmidt and Bijmolt 2020), but this bias was not accounted for in this study. Another consideration for further investigation would be how people's previous experience with freshwater environments may impact their willingness to donate time or money to freshwater conservation. Future image analysis could be done to incorporate images from social media platforms such as Facebook and Instagram as well as conservation literature. The number of species used for image analysis could also be expanded to include a larger sample of species that covers a wider spectrum of species categories. Another important future analysis would be to further investigate the relationship between specific emotional responses to freshwater images and people's willingness to donate their time towards freshwater conservation. For instance, would people who associated more positive or negative emotions with the photographs of fish in water or out of water be more or less likely to donate their time or money towards helping freshwater species and ecosystems? In one study, the research found that volunteers conceptualized their nature in four ways: nature in crisis, nature as it should be, nature as outside or something different, and nature as nurturing (Halpenny & Caissie 2003). Other considerations to make would be 'out-of-water' image type and if the passive image exposure during the survey was the best way to gauge effectiveness of garnering conservation support. In my study, the 'out-of-water' images were not overly human centric, but including more trophy-like images could potentially garner different responses from people. More deliberate exposure of images during the survey where respondents are asked about their willingness to donate their time or money towards freshwater conservation based on their perceptions of specific images could provide opportunity for more in depth investigation into the influence of image type. Trophy-like and more human-

centric images are common in the media but were not included in this study. If emotions evoked by images could be tied to these conceptualizations of nature, it potentially would provide better understanding to willingness to volunteer time in conservation activities.

6. Conclusions and recommendations

In conclusion, my study found that (1) people are exposed to significantly more images of freshwater fish out-of-water on Google than images of the fish in water; (2) people preferred images of freshwater fish in water for rallying support for freshwater conservation; (3) images showing fish in water evoked a greater desire to know more about freshwater ecosystems and the fish species that inhabit them; (4) images did not play a significant role in people's willingness to participate in conservation activities while other factors such as gender, natural sciences education, and history of visiting freshwater environments did and; (5) people believe that images play an important role in rallying support for nature conservation.

My study results demonstrate that more people in this study sample preferred images of fish in their natural habitats when communicating the importance of conserving the species and their habitat, so careful consideration should be given to image selection as part of environmental education and science communication. These findings should be considered when selecting material used for raising freshwater awareness, rallying freshwater conservation support and communicating freshwater science to the general public. Images showing fish in their natural environment evoked greater desire to know more about the freshwater fish and freshwater ecosystems and were considered a more effective means in advocating for freshwater conservation than images showing fish out of water. Therefore, environmental organizations should be strategic in their image selection when promoting conservation in published literature and educational materials.

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8. Appendix

Appendix 1: The survey

1. Age
2. Gender
3. Province
4. Town/City
5. Do you have any formal education in the natural sciences (Biology, Geology, Physics, Chemistry, Astronomy, Earth Science, etc.)?
    a. Yes b. No
6. Which best describes your diet
    a. Meat eater
    b. Vegetarian – *does not eat mean, chicken, or fish/seafood*
    c. Pescatarian – *does not eat meat or chicken but DOES eat fish/seafood*
    d. Vegan - *does not eat any animal products (meat, seafood, eggs, dairy, etc.)*
    e. Other
7. Have your visited freshwater environments in the past?
    a. Yes b. No
8. What type of freshwater environments have your visited?
    a. River b. Lake c. Dam d. Wetland
    e. Estuary f. Urban aquatic ecosystem
9. How regularly do you visit freshwater environments?
    a. Rarely (1-2 times per year) b. Sometimes (3-5 times per year)
    c. Monthly d. Weekly e. Daily
10. What was your reason(s) for visiting freshwater systems? (select all that apply)
    a. Fishing for food b. Fishing for recreation c. Camping
    d. Drinking/collecting water e. Washing/sanitation f. Swimming
    g. Boating h. Walking i. Nature and wildlife
    j. Conservation
11. Are you a freshwater fisherman?
    a. Yes b. No

12. In the year 2021, how much time would you be willing to spend joining a local conservation group to help clean up a nearby river to save a threatened species of freshwater fish?

a. Several weekends b. A weekend c. A day d. A morning

e. No time

13. How much money would you be willing to donate to support a local freshwater conservation effort working to save freshwater fish?

a. Several weekends b. A weekend c. A day d. A morning

e. No time

14. Which emotions, if any, do you associate with picture collection A (fish out of water) (select all that apply?

a. Happy for the fish b. Sad for the fish c. Feel good about freshwater environments d. Concerned about freshwater environments

e. Desire to know more about the fish f. Desire to know more about freshwater environments g. No emotion h. Other (please specify)

15. Which emotions, if any, do you associate with picture collection B (fish in water) (select all that apply?

a. Happy for the fish b. Sad for the fish c. Feel good about freshwater environments d. Concerned about freshwater environments

e. Desire to know more about the fish f. Desire to know more about freshwater environments g. No emotion h. Other (please specify)

16. Which collection of pictures would you choose to communicate the importance of conserving freshwater ecosystems and freshwater fish?

a. Collection A b. Collection B

17. Do you think images play an important role in rallying support for nature conservation?

A. Yes b. No

Appendix 2: Respondent responses (optional) of reasons for choosing images of freshwater fish in water (image collection B) to communicate the importance of conserving freshwater ecosystems and freshwater fish

Appendix 2: Respondent responses stating why images play an important role in rallying support for nature conservation