EVALUATING SCIENCE COMMUNICATION EFFORTS AND CITIZEN SCIENTISTS' KNOWLEDGE OF, ATTITUDE TOWARD, AND BEHAVIORAL INTENTIONS RELATED TO THE NORTH AMERICAN RIVER OTTER

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ABSTRACT

EVALUATING SCIENCE COMMUNICATION EFFORTS AND CITIZEN SCIENTISTS' KNOWLEDGE OF, ATTITUDE TOWARD, AND BEHAVIORAL INTENTIONS RELATED TO THE NORTH AMERICAN RIVER OTTER

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Citizen Science (CS) and scientific visual, spatial, and graphic art projects have the potential to engage community members, provide opportunities for advances in scientific literacy, increase interest in science and local environmental knowledge, and elevate pro-environmental attitudes. CS depends upon public participation, and motivation for participation is varied, including participants' desire to learn something new or contribute to science or scientific knowledge. An effective CS project will be rooted in an understanding of individuals' motivations for participation, striving to meet those motivations, and effectively evaluating not only the scientific outputs of the project but also whether participants' motivations are being satisfied through participation. Using survey research, this study sought to understand how a CS project and communication of scientific topics through art and interactive methods affected participants' knowledge of North American river otters (*Lontra canadensis*) and their habitats, likelihood of future participation in CS, and attitudes towards the environment. Participants held baseline high pro-environmental attitudes and participation in this study did not further elevate pro-environmental attitudes. Participants' knowledge of river otters and their habitats increased slightly with supplemental science communication efforts. Participants who received supplemental science communication were slightly more likely to state an interest in future participation in citizen science, suggesting additional engagement from project leaders could increase future participation. These findings complement the growing field of citizen science and model methods for how citizen science projects can prioritize project outcomes, evaluate outcomes for participants, and consider further efforts for community engagement.

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INTRODUCTION

Citizen Science or Community Science (CS) refers to community members' participation in scientific investigation. It is the practice of engaging the public in a scientific project in which the project produces reliable data that can be utilized by the public, scientific community, or policy makers. CS has the potential to engage community members, advance scientific literacy, and increase interest in science and local environmental knowledge (Miller-Rushing et al. 2012). Additionally, CS extends the reach of scientists gathering field data through community observers' ability to cover large geographical areas over long periods of time. It can provide data for natural resource managers to consider when making management decisions and may contribute to peer reviewed publications (McKinley et al. 2017, Bird et al. 2014).

The Cal Poly Humboldt River Otter Demography Study is an ongoing citizen science project which documents the distribution and demographics of North American river otters (*Lontra canadensis*) on the coasts, wetlands and watersheds in Humboldt, Del Norte and adjacent counties in Northern California. In this thesis, I consider the impact of presenting information through an interactive multimedia platform and a webinar on CS participants' knowledge of and attitudes towards North American river otters, and behavioral intentions towards further participation in citizen science. I begin with a brief review of the literature on citizen science and its scientific and social value; science communication that incorporates art; and environmental knowledge and attitudes. An extensive discussion of the survey, interactive mapping and storyboard development methods applied in this thesis follows. This section includes reference to the study design that had to be adapted repeatedly due to limitations caused by the Covid-19 pandemic. Research results are presented and discussed next and are summarized in key findings in the conclusion.

While the term “citizen science” was created to give a title to those without formal scientific background who elect to participate in the scientific process, in more recent times the term has been identified as a potential barrier to participation in the act of citizen science. The word “citizen” may imply a person who resides in a place legally or may exclude those without citizenship status in a particular country. Popular alternatives to the term citizen science include civic science, neighborhood science, and most popular, community science. Community science in and of itself is its own research paradigm, separate from citizen science (Cooper et al. 2021). This body of research does not attempt to justify which term is most appropriate or will lead to more inclusive scientific opportunities for community members. I acknowledge the inherent flaws present in the term citizen science as well as its ability to unify citizen science efforts nationally and internationally as well as its general name recognition. For these reasons, I have elected to use the term citizen science (CS) for this research.

LITERATURE REVIEW

Citizen Science

CS efforts can cover regional, national, to global scales over long periods of time allowing CS to support large-scale conservation efforts (Loss et al. 2015). Some of the most notable current examples of CS include the Breeding Bird Survey in the UK (https://www.bto.org/our-science/projects/bbs), the Christmas Bird Count (http://gis.audubon.org/cbclive/), iNaturalist (https://www.inaturalist.org/) and eBird (https://ebird.org/) in the USA. Created by the Cornell Lab of Ornithology and the National Audubon Society, eBird supports a worldwide community of bird watchers through the creation of a globally accessible database that operates in real-time in which observers can submit their bird observations (Sullivan et al. 2009). With over a million observations annually, eBird is just one example of how CS can engage community members in wide-scale data collection and support numerous fields of science.

The impacts of CS reach beyond its ability to contribute to science, as research shows that it can support the development of social capital, environmental democracy, and inclusivity (sharing of information), and provides the public with opportunities to connect with the environment and build scientific literacy (Conrad et al. 2011). Bliss et al. (2001) indicate that CS can build social capital through activities that engage volunteers, develop leadership capacity, solve problems, and identify community and resource values. In this way CS provides opportunities for building social networks and contributing to healthy communities. Through CS, a possibility exists to engage a greater number of people in science and strengthen environmental literacy.

Scientific research conducted in wildlife biology has long engaged community members from outside the world of academia. Community member participation in formal observation for wildlife biology dates back at least to the late 19th century when bird migration data began to be collected on “Migration Observation Cards" by birding enthusiasts in North America. While it’s hard to accurately measure the exact number of CS projects that focus on urban wildlife ecology, SciStarter, a globally acclaimed, online citizen science hub hosts more than 3,000 citizen science projects of which 314 are focused on animals (SciStarter 2022). Even this number is likely a conservative estimate of the number of existing citizen science projects. Public participation in science is growing, in part because technological developments have reduced barriers to participation like access to expensive equipment, and expanded the variety of tasks that can be completed (Frigerio et al. 2018). For example, eBird, project creators were able to develop a web-based platform that supports access to data in real time, a centralized and standardized repository of observations, as well as opportunities to engage with expert curators on the platform and explore the data through visualization tools (Sullivan et al., 2009). This open access and sharing of CS data between the general public and science experts can strengthen the relevance and utility of CS data for all participating parties, ensuring collection efforts and results from CS projects can not only be shared in scientific literature but by project participants and the public at large as well. CS projects that are effective in their outreach and science communication have the potential to reach new audiences and in turn connect them with wildlife. Belaire et al. (2015) suggest that CS programs have been shown to enhance dwellers' awareness of wildlife in their outdoor spaces. Furthermore, new web-based and smartphone applications may make CS a more accessible and engaging way for people to connect with wildlife in their own green spaces than traditional wildlife field guides (Belaire et al. 2015).

Investments in communicating CS data and understanding project participants' motivations for being involved are needed to increase engagement of existing participants and reach new audiences (Ganzevoort et al. 2017, McKinley et al. 2017). Communication and dissemination are essential to the success of citizen science projects. Through CS, a possibility exists to engage a greater number of people in science and strengthen environmental literacy. Communication in CS could include recruiting, motivating, and retaining participants through recognizing and acknowledging their inputs, informing them of projects' aims and scientific processes; and exchanging information about project results and outcomes (Rüfenacht et al. 2021).

Motivations for participation in community science projects are varied and range from interest in the project's topic, desire to learn something new, or contributing to science or scientific knowledge or environmental conservation (Vries et al., 2019). Participants also cite the importance of having their contributions and project findings clearly communicated as a motivation for participation (Vries et al., 2019). To satisfy these motivations and create sustained community participation, it follows that it is important to communicate the results of such participation effectively to citizen science participants, members of the scientific community and the general public.

CS projects can typically be grouped into three types of public participation - contributory, collaborative, and co-created. Contributory projects are designed by scientists, and data collection is conducted by community members (Miller-Rushing et al. 2012). Contributory projects comprise most CS projects, given the minimal commitment required by participants (Bonney 1996, Kransy and Bonney 2005, Bonney 2007, as cited in Bonney et al. 2009). Collaborative projects are similar to contributory projects in structure; however, community members may also help with aspects of project design and data analysis. Co-created projects are designed by scientists and community members jointly and community members are typically involved in most or all steps of the process. CS participant engagement and commitment may increase with collaborative projects and even more so with co-created projects where CS participants are often the main driver of the research (Bonney et al. 2009).

While there are different degrees of engagement in CS, participants are interested in collected data and other scientific outputs that emerge from the CS project. In a review of 32 peer-reviewed papers, Vries et al. (2019) found that CS participants value being able to access their collected data, communicate with researchers about project findings, and be acknowledged in related publications. Clearly communicating scientific outputs to participants acknowledges CS participants as collaborators with scientists and natural resources professionals, increasing inclusivity and transparency while demonstrating the reciprocal relationship that exists between citizen scientists and researchers (Vries et al., 2019).

Science Communication Utilizing Art and Interactive Multimedia Methods

Visual, spatial, and graphic arts have the potential to engage and connect people to science. Research related to K-12 projects that integrate art into math, technology, engineering, and science projects (STEAM) show that such projects can generate broader access and inclusion and enhanced learning of scientific concepts (Bequette 2012). There are compelling reports of collaborations at the K–12 and professional levels that have demonstrated benefits not just to audiences but also to the scientists and artists who participate in STEAM projects (Osbourne 2008, Felton 2003, Stiller-Reeve & Naznin, 2018). However, little literature exists that explores the integration of art and (citizen) science in order to engage community members in projects. One climate research project conducted in Bangladesh by Stiller-Reeve and Naznin (2018) demonstrated how merging art and citizen science increased collaboration and improved a sense of community. Gurnon et al. (2013) conducted a review of several attempts to integrate art and science in undergraduate education and argued that combining art and science had transformative effects on teaching scientific literacy and engaging community members in CS in new ways. Creating works of art, visualizations and other data representations tied to citizen science research projects may provide opportunities to engage current citizen scientists, provide an entry point for those new to CS, and promote best management outreach/data sharing practices for CS projects (McKinley et al. 2017).

Environmental Knowledge

Knowledge is the result of a person’s lifelong learning process including the accumulation and organization of information (Geiger et al. 2019). For my research I utilize the term environmental knowledge to refer to research participants’ knowledge of the North American river otter and their associated habitats.' Advocates of CS suggest CS participants may, among other things, increase their environmental knowledge and scientific literacy through participation in citizen science (Phillips et al. 2018). While many CS projects cite deepening participants’ knowledge, awareness, or understanding of a particular scientific concept, phenomena, or theory as central to the project, minimal literature exists which demonstrates or evaluates the ability of CS projects to reach these learning outcomes (Phillips et al., 2018). CS project leaders are not the only ones who seek to achieve these learning outcomes through CS. CS participants also identify their interest in the project’s topic, desire to learn something new or contribute to science or scientific knowledge as motivations for participating (Vries et al., 2019). As the field of citizen science continues to grow it will be important for project leads to not only identify and evaluate their effectiveness in achieving scientific outcomes and objectives, but also in meeting learning outcomes for participants to ensure their goals and interests are being met. Addressing participants' interests will contribute to sustained community member participation in CS and continued contributions to science as well as the CS project’s ability to enhance environmental literacy.

Environmental Attitudes and Behavior

The perceived benefits of CS and informal science education are numerous, ranging from participant gains in: knowledge about science and the scientific process; interest in science and nature; environmental attitudes, behaviors, and stewardship; self-efficacy for environmental action; opportunities for scientific inquiry and skill development and data interpretation (Phillips et al., 2018). Environmental attitudes (EA) in particular, are psychological tendencies expressed by evaluating the natural environment with some degree of favor or disfavor (Milfont, 2007). Research suggests that attitude formation comes from an individual’s most intimate past and present experiences, which form a part of their self-identity. Changes in EA may be a driving force in advancing towards a more sustainable world, when formed and accumulated through social constructivist processes (Eilam and Trop, 2012). Social constructivist process refers to the process in which people develop shared attitudes through language and interactions with others (Akpan et al., 2020). Research suggests direct experiences in nature, such as participation in CS, might impact the development of an individual’s environmental attitude (Rosa & Collado, 2019). However, the capacity within the CS field to measure how effective CS projects are in having a positive influence on participants’ environmental attitudes is limited given a lack of valid assessment tools (Bonney et al., 2016).

In a literature review conducted by Eilam and Trop (2012), the authors suggest that environmental education type programs have often viewed participants’ attainment of environmental behaviors as the end goal for programming, with environmental attitudes serving as a stepping stone along the way. Eilam and Trop (2012) in contrast suggest that while environmental behaviors are an important goal for relevant programs, it is the attainment of pro-environmental attitudes that represents a deeper change in participants. Environmental attitudes represent a more rock-bottom foundation for how individuals perceive the environment with some degree of favor or disfavor. Therefore, programs designed specifically to impact an individuals' environmental attitude may drive greater pro-environmental change over time (Eilam and Trop 2012).

Only a handful of studies have sought to measure changes in attitudes towards science through participation in CS and even fewer have attempted to measure changes in attitudes towards the environment (Brossard et al. 2005, Crall et al. 2013). Crall et al. (2013) argue that to increase our understanding of how CS and informal science education are affecting participants' attitudes towards the environment, further evaluation of CS projects must be conducted utilizing standardized measures in order to compare results across multiple projects and audiences. One tool that might be applied to assessing implications of participation in CS on attitudes toward the environment is the Revised New Ecological Paradigm scale (NEP), an updated scale from the original New Environmental Paradigm published in 1978 by Riley Dunlap and colleagues at Washington State University (Anderson 2012). The revised and original scale have been extensively used for classifying the views that people have about the natural environment (styled as "ecological worldview" by Dunlap et al., 2000). The NEP includes 15 statements that relate to limits to growth, the position of humans in the environment, the fragility of nature, and the imminence of eco-crisis. The validity of the construction of the NEP and its ability to accurately represent attitudes towards the environment have been repeatedly tested (Dunlap and Van Liere, 1978; Dunlap, 2008).

While measuring environmental attitudes was one of the main focuses of this research, it is understood that the delivery of environmental content and education is multifaceted and often supports the attainment of environmental attitudes as well as environmental behaviors. For this reason, it seems worthwhile to evaluate both. Environmental behaviors can be understood as any active responsiveness to current environmental issues, believed to be pro-environmental by the person performing the response (Eilam and Trop 2012). Research conducted by Hines et al. (1987) identified 'intention to act' as a determinant of pro-environmental behavior. Environmental behavioral intentions are important to measure as they may indicate how likely someone is to engage in actions that could have a positive impact on the environment (Chawla, 2006). As measuring actual behavior was outside of the scope of this research, I followed other research which supports the of behavioral intentions to predict behavior (Wilson et al., 1975).

The River Otter Demography Study

My thesis focused on environmental knowledge creation in CS through enhanced communications for the Cal Poly Humboldt (formally Humboldt State University) River Otter Demography Study, an ongoing contributory citizen science project documenting the distribution and demographic of river otters (*Lontra canadensis*) on the coasts, wetlands and watersheds in Humboldt, Del Norte and adjacent counties in California, USA. This contributory citizen science project was initiated in 1999 (Black, 2009). Community members were encouraged to participate in the study through invitations distributed to wildlife and fisheries students and professionals in the region, signs placed adjacent to public water body access points (replaced as needed), and annual email reminders to past participants. Observers were asked to self-identify as only one of the following observer types: citizen scientist/other, nature or outdoor enthusiasts, or having a science background. Data were submitted via email, mail, fax, phone, in person and/or via a website where project information could be obtained and submitted (Black, 2009).

A component of the River Otter Demography project, the North Coast Otters Public Art Initiative, was a 2020/21 environmental education initiative and festival that sought to engage Northern California communities in otter conservation through an educational art festival. Project leaders commissioned 108 unique pieces of Otter Art (painted sculptures) which were displayed at various locations in Northern California during the summer of 2021. A component of the North Coast Otter Art Initiative, and of this thesis research, included the creation of a project website, art-focused webinar on social media, and interactive web map, described in detail below. The website, webinar, and interactive map served as a mechanism to synthesize spatial, temporal, and reproductive river otter data collected by citizen scientists, provided basic river otter information in Northern California, and highlighted key outcomes from the summer art initiative.

Including the North American River Otter there are thirteen species of otters worldwide. With the exception of the North American River Otter, all twelve of the other otter species are listed in the IUCN Red List of Threatened Animals as either "Vulnerable", "Near threatened" or "Endangered" due to loss of habitat, food availability, pollution, illegal trade, and impacts from climate change (Duplaix and Salvage, 2018). Fortunately, the North American River Otter is currently listed as "Of Least Concern", and it is important to provide opportunities for community members to connect and build relationships with this species and help to sustain their habitats into the future (Duplaix and Salvage, 2018). The North Coast Otters Public Arts Initiative is one way to connect people to the North American River Otter locally. Bridging the gap to connect local communities with global efforts to support otter conservation, the initiative launched the educational art festival of World Otter Day in May 2020.

Hypotheses and Research Questions

This study aimed to assess the impact of presenting information about North American river otters and their habitats through an interactive multimedia platform and a webinar on CS participants' knowledge of and attitudes towards North American river otters, and behavioral intentions towards further participation in citizen science.

I hypothesized that:

H1: Participants' who received and assimilated interactive science communication content will rate the project's ability to communicate project findings and results higher than participants who did not.

H2: Presenting citizen science project information and knowledge about the North American River Otter and their habitats through interactive science communication will increase participant's knowledge of the North American River Otter and their habitats.

H3: Presenting citizen science project information and knowledge about the North American River Otter and their habitats through interactive science communication will elevate participants' positive environmental attitudes towards the North American River Otter and their habitats.

H4: Presenting citizen science project information and knowledge about the North American River Otter and their habitats through interactive science communication will increase participant's behavioral intentions for future participation in citizen science.

METHODS

I conducted an evaluation of the North Coast River Otter Demography study (CS study) and developed an art-focused webinar and website for the North Coast Otters Art Initiative with several goals in mind. First, I evaluated participants' preferences for science delivery and communication. Next, I sought to assess the effects of the CS study and science communication initiative on participants' knowledge of river otters and their habitats, their attitudes towards the environment, and behaviors related to participation in the project.

In order to achieve the above goals, I modeled my research on other research that attempts to assess the impacts of CS project(s) on participants (Brossard et al. 2005, Crall et al. 2013). A pre- and post- study design was selected as the most appropriate method for evaluation given its ability to measure change over time, compare across groups rather simply, collect quantitative data that can be analyzed using statistical methods, and be administered online (Friedman, 2008).

Research conducted was approved by the Cal Poly Humboldt Institutional Review Board (IRB) approval number: IRB 19-173 on 5/11/2020 and renewed on 4/30/2021.

Sampling, Recruitment and Pre and Post-Test Survey Data Collection

To recruit participants for the pre- and post-survey I utilized the database of wild river otter observations to retrieve email contact information from CS participants (J.M Black, unpublished data). All CS observers voluntarily submit their email and contact info with each observation. Between 2015-2019 there was a population of 764 CS observers (n=764).

Prior to the supplemental science communication efforts, I sent a pre-test invitation to take part in a questionnaire survey to all previous CS project participants who had contributed to the CS study within the past five years (2015-2019). In May 2020 I sent out the initial survey email to 764 individuals. Of these, 40 emails bounced back, and 42 emails were duplicates bringing the population size down to 682. Of 682 pre-test invitations, there were a total of 227 respondents yielding a response rate of 33.3%.

Of the pre-test respondents, 179 participants included email addresses in their pre-survey. Based on those email addresses, I used a random number generator to split the participants into two equal-sized groups, an Experimental Group (n=90) and Control Group (n=89). The website and webinar (described in detail below) were shared with one subset sample of CS participants who participated in the pre-test survey (Experimental Group); the other subset (Control Group) did not receive any supplemental information, though they did receive a short Year in Review letter which briefly shared findings from 2020 and some words of thanks from CS project creator, see Appendix A for the full Year in Review Letter. Between February 18th – March 11th, 2021, the Experimental Group was formally invited to review the website via email on three different occasions. In addition to the website, the Experimental Group was invited to participate in the Otterly Wild webinar session where I, alongside Professor Black, provided information on how to use the website, shared project findings, and conducted a Q&A session (see Appendix B for Webinar Invitation). Immediately after the webinar and invitations to review the website, I conducted a post-survey with both Experimental and Control groups of the CS participant population. The post-survey invitation email was delivered to all 90 Experimental Group participants. Four email invitations to the Control Group bounced back reducing the total number of participants from the Control Group to 84. Of the 90 participants in the Experimental Group, 46 submitted a post-survey response for a response rate of 51.11%. Of the 84 participants in the Control Group, 48 completed the post-survey, for a response rate of 53.33%., see Figure 1 for a flowchart of the survey group configuration. For a complete list of outreach conducted by type, delivery methods, and dates refer to Table 1.

Table 1. A complete list of outreach conducted as part of this thesis research and the larger North Coast Otter Public Arts Initiative organized by type, delivery methods, and dates. Outreach was conducted between May 2020 – September 2021.

Outreach Name	**Outreach Type**	**Delivery Method**	**Date(s)**
Pre-survey with CS Participants	Survey	Virtual	May 19th, 2020: Initial survey request sent June 8th, 2020: Follow-up survey request sent June 15th, 2020: Survey closed
North Coast Otters Public Arts Initiative Festival	Supplemental Science Communication	Virtual & In-person	May 27th, 2020: Festival began virtually on World Otter Day 2020 June 22nd, 2021: Festival moved to in-person September 15th, 2021: Festival concluded
North Coast Otters Website Launch	Supplemental Science Communication	Virtual	February 18th, 2021: Initial invitation sent

Outreach Name	**Outreach Type**	**Delivery Method**	**Date(s)**
			February 25th, 2021: Reminder invitation sent March 31st, 2021: Reminder invitation sent
Otterly Wild Webinar	Supplemental Science Communication	Virtual	February 18th, 2021: Initial webinar invitation sent February 25th, 2021: Reminder invitation sent March 4th, 2021: Webinar hosted
Year In Review Letter	Control Group Follow-up	Virtual	February 18th, 2021: Year-in-review letter sent
Post-survey with CS Participants	Survey	Virtual	March 11th, 2021: Initial survey request sent March 18th, 2021: Follow-up request sent March 31st, 2021: Survey closed

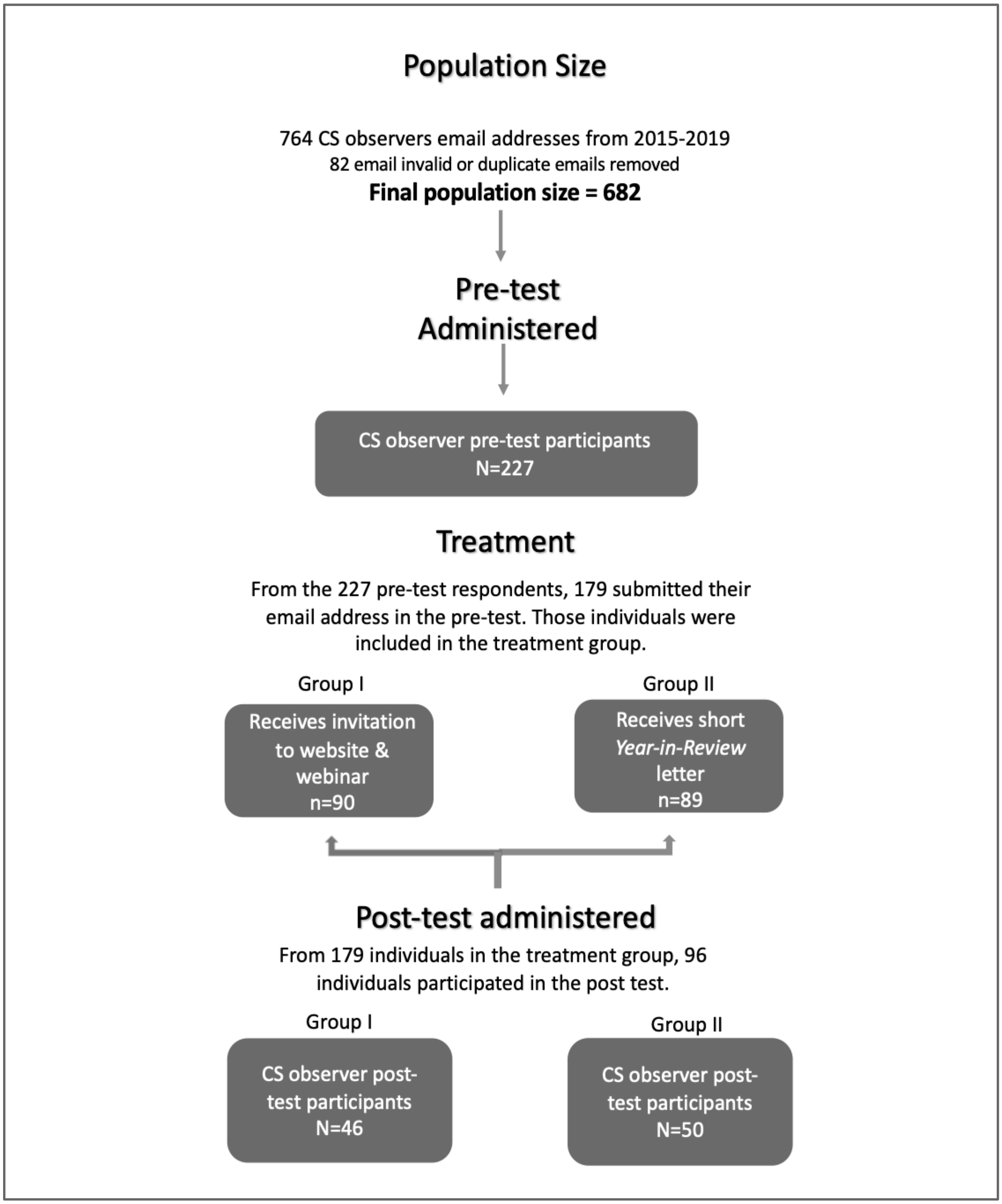

Figure 1. Flowchart of survey treatment groups beginning with the initial population of CS observers who submitted an observation to the CS project between 2015-2019. The flowchart outlines how the treatment groups were assigned, post-tests were administered, and number of participants in each group. Survey research took place between May 2020 – March 2021.

Supplemental Science Communication Efforts

The supplemental science communication efforts were a component of the North Coast Otter Public Art Initiative summer art festival described above. Utilizing multiple web design applications and plugins I developed a website with a dynamic map that displays river otter citizen science observations from 2015-2020 as well as narrative text, images, and multimedia content from project leads and participants. In order to develop a dynamic map that synthesizes the river otter observations, I acquired citizen science river otter GPS location data (latitude/longitude data) from 2015-2020 (J.M Black, unpublished data). I evaluated the dataset using a quality assurance and control process (QAQC). The QAQC process identified the date of creation, data type, spatial references, and any major problems. The GPS location data did not show any major problems, however the coordinate data varied in format ranging from UTM, Degrees, Decimals, Seconds (DMS), Degrees and Decimals Minutes (DDM), and Decimals Degrees (DD).

For the purpose of my research, I converted all coordinates into a DD format. I removed any observations that did not contain coordinates or valid coordinates. In addition to the citizen science river otter GPS location data, I synthesized stories of people, places, and otters within the project area. These stories were integrated onto the dynamic website map accompanied with relevant photos. Using ArcGIS Pro version 2.5.1, I created a map that synthesized citizen science river otter observations from project participants from 2015-2020 in Del Norte, Humboldt, Mendocino, and Trinity Counties, see Figure 2 for a screenshot of the map.

I then conducted outreach in the form of email and zoom meetings with project participants and project leads in order to synthesize 12 short narrative texts and images related to people, places and otters. These narratives include quotes from citizen scientists and local artists who participated in the North Coast Otters Public Art Initiative.

I developed a website called North Coast Otters using WordPress version 5.5.1 which contains a dynamic map that displays river otter observations from the Cal Poly Humboldt Citizen Science River Otter Study as well as narrative text and images. I used Canva version 3.0, a graphic design platform, to create several visual graphics that are included on the website.

In order to insert the ArcGIS Pro map into WordPress, I converted shapefiles into GEOJSON files. Within the GEOJSON files I manually input text and image location as HTML code to be displayed (see Appendix C for complete code). Next, I utilized a map plugin called CanvasMap version B3.10 to aggregate the data and produce a map that was inserted into my WordPress website via an iframe.

The website went live in Spring 2021 first to Experimental Group survey participants, described above. Upon completion of the post-survey, the website was made available to the public. It is free and accessible on any smart device: http://hsu.reclaim.hosting/NorthCoastOtters/.

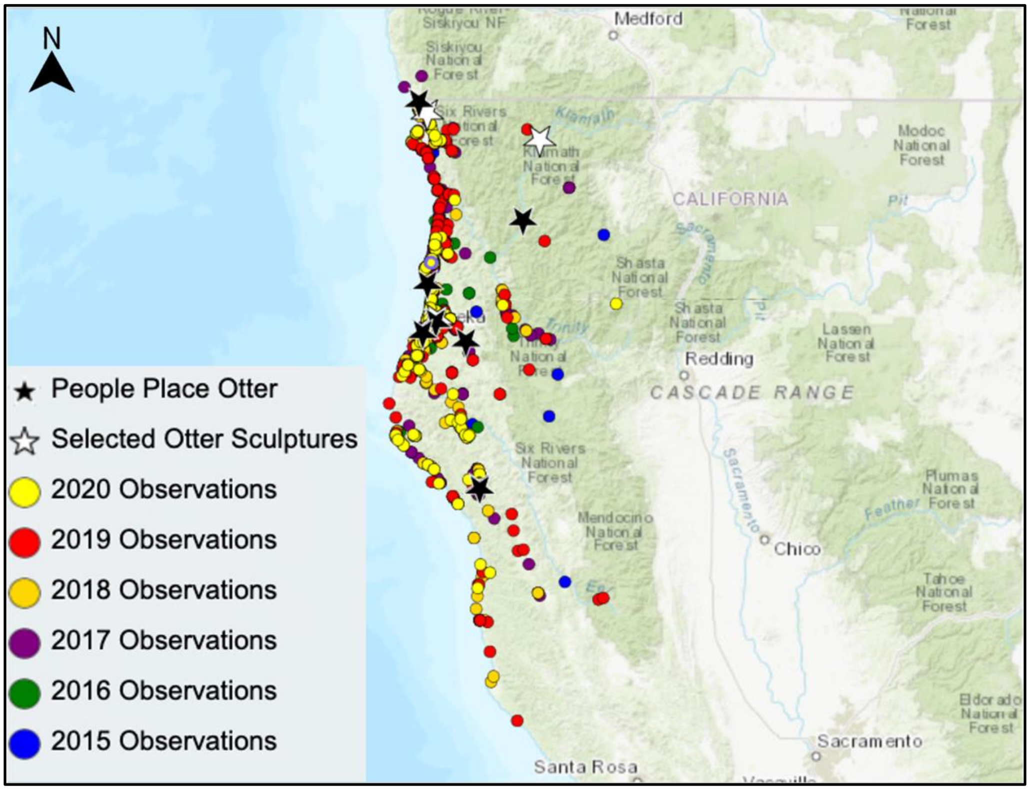

Figure 2. Screenshot of the North Coast Otters Website displaying the interactive map of river otter observations by year and results from the study. The North Coast Otters Website was developed to support supplemental science communication efforts delivered to the Experimental Group as part of this research as well as the larger North Coast Otters Public Arts Initiative. The North Coast Otters Website went live in Spring 2021.

In addition to the interactive website, project lead Professor Black and I also hosted a one-hour Otterly Wild Webinar available to Experimental Group participants on March 4th, 2021. During the webinar, 11 Experimental Group participants were present to learn how to use the website, hear about project findings, and were given the opportunity to ask questions of the project leaders. A copy of the presentation was made available upon request for any Experimental Group participants who requested it.

Survey Variables Measured

The survey was divided into four main sections including demographic information, knowledge of river otters and their habitats, and environmental attitudes and behaviors. The post-test had an additional section focused on science communication and delivery preferences.

Demographic Information

The survey solicited demographic information including age, gender, education, and race. The complete questionnaire is presented in Appendix D.

Science Communication and Delivery Preferences

To assess science communication and delivery preferences CS participants were asked how they would rate the project's ability to communicate project information and results, from far above average to far below average. Additional questions asked how they would prefer to receive project information and results. From the Experimental Group participants who viewed the website (n=17), I also solicited the average amount of time spent engaging with the website.

Knowledge of River Otters and Their Habitats

Knowledge of river otters and their habitats was assessed with 14 questions developed specifically for the project participants. Survey questions were pilot tested by subject experts and evaluators to ensure accuracy and clarity. Questions varied in format from true or false, multiple choice, photo identification, fill in the blank, scale, choose the correct image, and yes or no. Total scores fell on a fourteen-point scale, -14 (no knowledge) to 14 (high knowledge).

Environmental Attitudes

To capture participants' environmental attitudes, I utilized the Revised New Ecological Paradigm (NEP) scale (Anderson, 2012). I sought to elicit project effects on participants' attitudes towards the environment in a way that could be compared to data from other projects. Given participants' voluntary participation in CS and environment related projects, this population may already have stronger positive attitudes towards the environment than the general public. This possibility paired with a measurement instrument that was designed to sample the US population may end up being too general to capture attitudinal changes of participants. To account for this, I added seven additional questions, designed to examine changes in attitudes specific to the project and region. Environmental attitudes are defined as the psychological tendencies expressed by an individual evaluating the natural environment with some degree of favor or disfavor (Hawcroft and Milfont, 2010).

New Ecological Paradigm (NEP) Questions

The NEP includes 15 statements that relate to limits to growth, the position of humans in the environment, the fragility of nature, and the imminence of eco-crisis. Respondents are asked to record their agreement with these items on 5-point Likert-like scales. The validity of the construction of the NEP and its ability to accurately represent attitudes towards the environment have been repeatedly tested (Dunlap and Van Liere 1978, Dunlap 2008). Apart from the 15-question revised scale, a shortened, original, and children's version of the scale exists. It is relatively common for researchers to select certain items from the scale to form their own versions or alter the wording to fit their research needs (Hawcroft & Milfont, 2010). I used a 12-question sub-set of the NEP to assess the following aspects of an ecological worldview including:

- Anti-anthropocentrism: Beliefs that human beings have the right to modify and control the natural environment.
- Fragility of nature's balance - Beliefs that human activities impact the balance of nature.
- Rejection of exemptionalism - Beliefs that humans are not exempt from the constraints of nature.
- Possibility of an eco-crisis - Beliefs that humans are causing detrimental harm to the physical environment (Amburgey et al. 2012).

Respondents were asked the extent to which they agreed or disagreed with each of the following statements about the relationship between humans and the environment for the NEP environmental attitudes questions using a five-point Likert scale where 1 indicates "strongly disagree" and 5 indicates "strongly agree." These items, split into the various aspects of an ecological world view which include:

Anti-anthropocentrism

- Humans have the right to modify the natural environment to suit their needs (1)
- Plants and animals have as much right as humans to exist (5)
- Humans were meant to rule over the rest of nature (9)

The vulnerability of natural balancing

- When humans interfere with nature it often produces disastrous consequences (2)
- The balance of nature is strong enough to cope with the impacts of modern industrial nations (6)
- The balance of nature is very delicate and easily upset (10)

Rejection of exemptionalism

- Human ingenuity will ensure that we do not make the Earth unlivable (3)
- Despite our special abilities humans are still subject to the laws and nature (7)
- Humans will eventually learn enough about how nature works to be able to adapt to it (11)

Possibility of an eco-crisis

- Humans are seriously abusing the environment (4)
- The so-called “eco crisis” facing humankind has been greatly exaggerated (8)
- If things continue on their present course, we will soon experience a major ecological catastrophe (12)

Northern California Specific Questions

I also created seven region specific questions designed to examine changes in attitudes specific to the project and region. Respondents were asked the extent to which they agreed or disagreed with each of the following statements about Northern California's environment, again using five-point Likert scale where 1 indicates "strongly disagree" and 5 indicates "strongly agree":

- There are sufficient environmental laws and regulations in place to protect the environment in northern California.
- My well-being is connected to the well-being of northern California's environment.
- I am concerned for future generations of northern Californians and the condition of the environment that they will have to live in.
- Watershed health is an important concern in northern California.
- If everyone implemented environmentally friendly behaviors such as driving less, eating locally produced food, and using reusable bags, that would be enough to have a healthy environment in northern California.
- We should manage the environment in northern California by implementing laws and regulations to ensure wildlife benefit.
- Environmental degradation is more of a risk in other parts of the state than it is in northern California.

Behavioral Intentions

One question from the survey sought to gauge participants' behavioral intention for further participation in CS. The question asked respondents: if they were to observe a wild river otter tomorrow, how likely would they be to report the sighting to the Cal Poly Humboldt Citizen Science River Otter Records Project? Respondents had the option to select very likely, somewhat likely, not likely, I would not report an observation, or don’t know.

Statistical Analysis

Using a pre-post experimental design (Friedman 2008), I initially sampled environmental knowledge, attitudes, and behavioral intentions of the project’s CS participants who contributed at least one river otter record between 2015-2019. As noted above, pre-survey respondents were randomly assigned into two groups. One group (the Experimental Group) received supplemental science communication content (website and webinar) while one group did not (Control Group). Post-surveys were administered to both Experimental Group and Control Group to evaluate participants’ preferences for science communication and delivery as well as compare shifts in knowledge gained, attitudinal change, and behavioral intentions between pre- and post-test scores as well as between the two groups.

Citizen Science Descriptive Statistics and Demographics

Prior to administering the surveys and engaging in supplemental science communication efforts, I used descriptive statistics to summarize the CS river otter observations submitted for the project between 2015-2019. Records included observation date, time, location, and number of otter adults and pups (Black 2009). Observers also documented otter behavior, habitat features, tracks, slides, scat, dens, prey items, and social interactions. To assess observation accuracy, observers were asked to self-identify as one of the following angler/hunter, citizen scientist, nature or outdoor enthusiasts, or having a science background. Data were submitted via email, mail, fax, phone, in person, or the project website (Black 2009).

To better understand the network of CS observers, I analyzed the following variables from 1,975 records: number of observations made per year, annual number of volunteers who participated in CS, and CS self-identification (naturalist, outdoor enthusiasts, etc.).

Once the pre-survey was delivered, I prepared descriptive statistics for the following survey variables: age, gender, education, and race to further understand the make-up of CS observers.

Science Communication and Delivery Preferences - Project's Ability to Communicate Information and Results

Experimental Group and Control Group respondents were asked on a scale of 1-5, where 1 indicates far above average and 5 indicates far below average, to rate the project's ability to communicate project information and results. Given a lack of variability in responses, and to reduce the amount of cells with a count of less than five and ensure chi-squared analysis assumptions were met, I collapsed these categories into two, “Above Average” and “Not Above Average” in order to conduct a 2x2 chi-squared analysis on the variables to understand whether a participant’s rating of the project’s ability to communicate project information and results was associated with their survey group. Participants who reported “Above Average” or “Far Above Average” were collapsed into the “Above Average” category. All other responses: “Average”, “Below Average”, and “Far Below Average” were collapsed into the “Not Above Average” category.

Environmental Knowledge

Fourteen questions were asked to determine participant knowledge of river otters and their habitats. Responses were scored from -1 to 1, where -1 means ”incorrect,” 0 means “don’t know,” and 1 means “correct.” Therefore, the maximum score a participant could earn on the knowledge items was 14. For each group, I created a combined knowledge measure (the sum of correct answers out of the 14 questions) to compare across groups. An independent samples *t*-test was conducted to understand whether there was a significant difference between Experimental Group and Control Group scores. For all the questions, I recoded the responses into dichotomous values, “correct” or “incorrect.” I conducted chi-square analysis to understand whether a participant’s environmental knowledge scores were associated with their survey group. For each question, chi-square test assumptions were evaluated and in the event an assumption was violated, I reported the Fisher’s Exact statistic.

Environmental Attitudes

Environmental attitude responses were separated into two categories: responses to the Revised New Ecological Paradigm (NEP) questions and the Northern California questions.

New Ecological Paradigm (NEP)

For the NEP questions, higher scores indicate a greater concern (or higher environmental attitude) for each aspect of the natural environment. While the four individual dimensions of the NEP (Anti-anthropocentrism, Fragility of nature's balance, Rejection of Exemptionalism, and Possibility of an eco-crisis) can be taken as stand-alone measures, numerous studies have created a single measure of environmental attitude (Hansen 2012; Good 2007) so long as the measures are correlated. I conducted a Cronbach Alpha reliability test of the entire scale and the individual dimensions for Pre-test, Experimental Group, and Control Group respondents. The following cutoff values are generally followed for interpreting the Cronbach's alpha reliability coefficient: _> .9 – Excellent, _> .8 – Good, _> .7 – Acceptable, _ > .6 – Questionable, _> .5 – Poor (George & Mallery 2003, as cited in Gliem & Gliem, 2003). I conducted reliability analysis on each of the four dimensions for each of the survey groups. Using independent sample t-tests I evaluated if there were significant differences between pre-test and

Experimental Group environmental attitudes, pre-test and Control Group environmental attitudes, and between Experimental Group and Control Group environmental attitudes.

Northern California Specific Questions

I reverse recoded negative environmental attitude questions so that higher assessments would be associated with a more positive attitude and maintain a consistent trajectory of response. I then conducted a series of independent sample t-tests to evaluate if there were significant differences between the pre-test and Experimental Group environmental attitudes, pre-test and Control Group attitudes, and between Experimental Group and Control Group environmental attitudes.

Behavioral Intentions - Likelihood of Submitting a Future River Otter Observation

Pre-test, Experimental Group, and Control Group respondents were asked on a scale of 1-4, where 1 indicates “Very Likely” and 4 indicates “I would not report”, to rate how likely they would be to submit a river otter observation to the citizen science project if they were to observe a river otter(s) tomorrow. Given a lack of variability in responses, and to reduce the number of cells with a count of less than five and ensure chi-squared analysis assumptions were met, I collapsed these categories into two groups, “Very likely” and “Not Very Likely,” and conducted a chi-squared analysis on the variables to understand whether a participant’s likelihood of submitting a river otter observation to the citizen science study was associated with their survey group. Participants who reported “Very Likely” remained in the “Very Likely” category. All other responses were collapsed into a “Not Very Likely” category.

RESULTS

Citizen Science Descriptive Statistics and Demographics

Analysis of the CS river otter observation data between 2015-2019, demonstrated that during the five-year period of observations submitted by community scientists, 2018 had the largest number of river otter observations at 504, which comprises approximately twenty-five percent of all observations. The years of 2017 and 2019 came close to the number of observations reported in 2018 with 437 and 492 observations recorded. The average number of observations made annually was approximately 395 (see Table 2).

Table 2. Number of field observations in Humboldt, Del Norte, and adjacent counties in northern California contributed by Citizen Science volunteers to Cal Poly Humboldt River Otter Demography study between 2015-2019.

Number of Observations	**N**	**%**
2015	186	9.4
2016	354	17.9
2017	437	22.1
2018	504	25.5
2019	492	24.9
Total	1,973	100.0
Average Number of Observations Annually	394.6 (SD=117.3)	-

The number of observers between 2016 and 2019 increased with 220 citizen scientists in 2016 and 258 citizen scientists in 2019. There were more observers who participated in 2019 than 2018, however, the number of observations was greater in 2018. Analysis of the river otter observation data showed that over the five-year period, the number of observers between 2015 and 2019 increased, with 132 community scientists contributing in 2015 and 258 community scientists in 2019. The average number of observers for the five-year period was 220 annually, Table 3.

Table 3. Number of Citizen Science volunteer observers in Humboldt, Del Norte, and adjacent counties in northern California that participated in Cal Poly Humboldt River Otter Demography study between 2015-2019.

Number of Observers	**N**
2015	132
2016	220
2017	246
2018	247
2019	258
Average Number of Observers per Year	220.6 (SD=46.0)

As can be seen in Table 4, twenty percent of observers self-identified as having a science background (wildlife, biology, forestry, etc.), while nineteen percent of observers identified as nature enthusiasts (bird watcher, tracker, etc).

Table 4. Observer self-identification type of citizen scientists in Humboldt, Del Norte, and adjacent counties in northern California that participated in Cal Poly Humboldt River Otter Demography study between 2015-2019.

Observer Self Identification Type	**N**	**%**
No Response	802	40.6
Science Background (wildlife, biology, forestry, etc.)	400	20.3
Nature Enthusiast (bird watcher, tracker, etc)	367	18.8
Outdoor Recreation Enthusiast (surfing, hiking, etc.)	183	9.3
Citizen Volunteer	107	5.4
Citizen Volunteer (new to otters)	73	3.7
Angler, Forester, Hunter, etc.	43	2.2
Total	1,975	100.0

Project participation by age varied throughout the five-year period suggesting a wide range of community interest across different age groups. Participants ranged from 20-85 years old, with an average age of 50.1 years old. Approximately 51% of participants are 50 years old or older (see Figure 3).

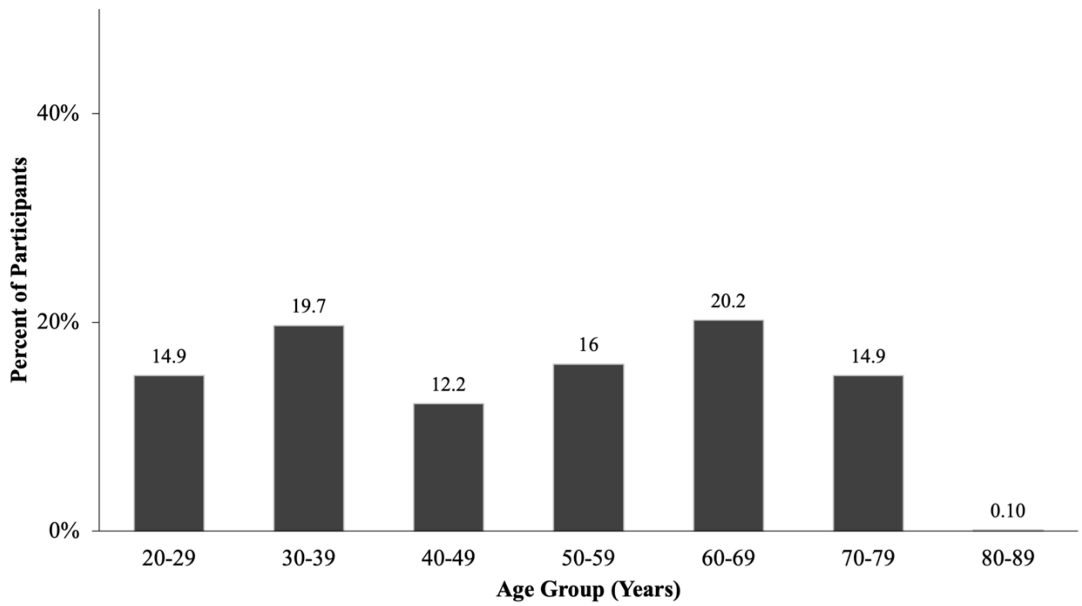

Figure 3. Percentage of age groups of citizen science participants in the Cal Poly Humboldt River Otter Demography study between 2015-2019 collected via survey in Spring 2020.

Nearly 73% of participants identified as White/Caucasian. The second largest self-identifying group was Latinx at approximately 5%, followed by 3% of participants who self-identified as Native American. Results from the survey demonstrated that women participated at a slightly higher percentage than men, 53% and 45%, respectively. Approximately 2% of participants identified as non-binary, genderqueer or transgender. As can be seen in Figure 4, 80% of participants had a college degree or higher.

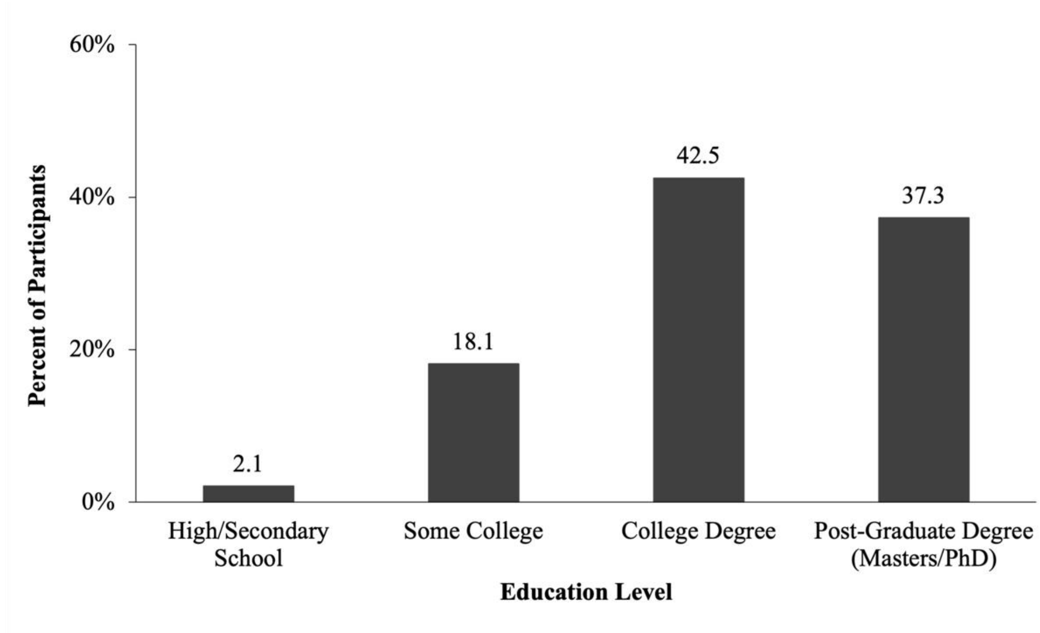

Figure 4. Percentage of participation by citizen scientists' level of education in the Cal Poly Humboldt River Otter Demography study between 2015-2019 collected via survey in Spring 2020.

Science Communication and Delivery Preferences

Out of the Experimental Group participants, 46 participants completed the post-survey. Of the 46 participants, 17 reviewed the website and 11 attended the webinar. Of the 17 participants who viewed the website, the most common amount of time spent on the website was about 10-20 minutes.

Delivery Preferences

When given the option to select multiple delivery preferences between email, in-person events, scientific reports, social media, and a website, a majority of participants selected email as their preferred method for communication. The next highest preferred method of communication was a website (Figure 5).

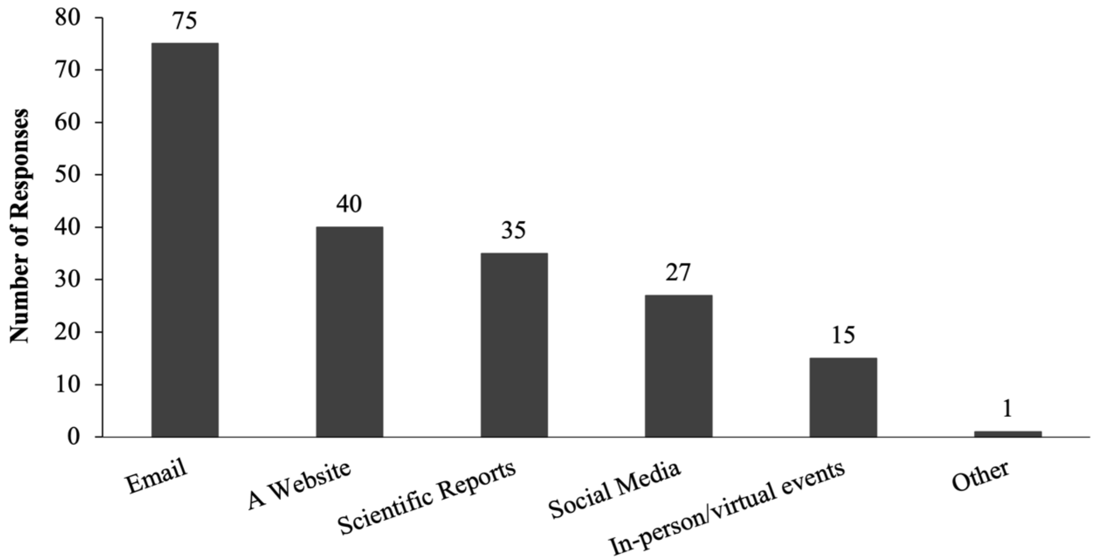

Figure 5. Participants' preferences for communication methods collected via survey in Spring 2020 with Cal Poly Humboldt River Otter Demography study participants from 2015-2019.

Project's Ability to Communicate Information and Results

H1: Participants' who received interactive science communication efforts will rate the project's ability to communicate project findings and results higher than participants who did not.

The analysis suggests that the participants' rating of the project's ability to communicate project information and results does not vary by survey group. According to the data, regardless of group number, there was no statistically significant difference between participants' rating of the project's ability to communicate project information between Experimental Group and Control Group participants $\chi^2(1, 80) = 1.501$, $p=0.221$, $\Phi=0.137$, Table 4. Overall, a majority of Experimental Group and Control Group respondents rated the project's ability to communicate project findings as above average

(Table 5). Seventy-two percent of Experimental Group respondents, who received supplemental science communication efforts, indicated the project's ability to communicate project information and results as "above average," which is 13 percent higher than their Control Group counterparts at 59%.

Table 5. Communication rating chi-squared results for Experimental Group (N=39) and Control Group (N=47) collected via survey in Spring 2021. Experimental Group received supplemental science communication and Control Group did not receive additional supplemental science communication in Spring 2021. Communication rating results refers to how respondents rated the project's ability to communicate project findings.

		Above Average	Not Above Average	Total	% Who Reported Above Average
Experimental Group	Count	26	10	36	72.2%
	Expected Count	23.4	12.6	36	-
Control Group	Count	26	18	44	59.1%
	Expected Count	28.6	15.4	44	-
Total	Count	52	28	80	-
	Expected Count	52	28	80	-

Environmental Knowledge

Pre-test participants' responses to the knowledge portion of the survey suggest they knew relatively little about river otters and their associated habitats (*M*=6.69, *SD*=2.64). Pre-test participants were most successful at correctly identifying a river otter from a sea otter with a success rate of nearly 90%. Seventy-five percent were able to correctly identify which habitat types are not river otter habitats demonstrated in Table 6. However, the responses suggested that overall, there was room to strengthen participants' knowledge of river otters and their habitats with an average score from all participants closer to 50%. Ninety-nine percent of pre-test participants failed to identify the correct response regarding how difficult life is for a river otter in northern California habitats. Only 44% knew the correct term for a river otter's shared bathroom and communication site. Fifteen percent of participants correctly identified the number of river otter species that exist globally.

Table 6. Pre-test environmental knowledge results including survey questions with correct answer bolded and percentage of pre-test respondents who provided the correct answer to the environmental knowledge questions (N=228). Pre-test survey responses were collected via survey in Spring 2020. The table also includes a knowledge index score which is the average sum of correct answers out of the 14.

Questions	**Number who Provided Correct Answer**	**% Who Provided the Correct Answer**
Image Selection: Choose the Image of a river otter: 1. Image of a sea otter 2. **Image of a river otter**	162	89.0
Yes/No Question: Are Fish prey/food for river otters? 1. **Yes**	171	87.2

Questions	Number who Provided Correct Answer	% Who Provided the Correct Answer
2. No 3. Don't know		
Yes/No Question: Are Crayfish prey/food for river otters? 1. **Yes** 2. No 3. Don't know	155	79.1
Multiple Choice: River otter habitats include all of the following except (Choose one): 1. Rivers 2. Bays 3. **Open Ocean** 4. Marshes 5. Estuaries 6. Inland Wetlands 7. Don't know	146	74.5
Yes/No Question: Are Frogs prey/food for river otters? 1. **Yes** 2. No 3. Don't know	131	67.2
True or False: River otters are a top predator in freshwater habitats. 1. **True** 2. False 3. Don't know	128	65.0
Yes/No Question: Are Aquatic Insects prey/food for river otters? 1. Yes 2. **No** 3. Don't know	93	47.7
Multiple Choice: Which of the following otter species live in at least one of the following Counties: Del Norte, Humboldt, Mendocino, Siskiyou, and/or Trinity.	91	46.2

Questions	Number who Provided Correct Answer	% Who Provided the Correct Answer
1. **North American River Otters (*Lontra canadensis*)** 2. Sea Otters (*Enhydra lutris*) 3. Both River Otters and Sea Otters 4. None of the above 5. Don't know		
0. Fill in the blank: River otters use a __________ as a shared bathroom and communication site through a sense of smell. **Answer: latrine**	43	44.3
Multiple Choice: River Otters are considered to be: 1. Herbivores (plants only) 2. Omnivores (Meat and plants) 3. **Carnivores (Meat and fish)** 4. Piscivores (Fish only) 5. Scavengers (Dead things only) 6. Don't know	83	42.1
Yes/No Question: Are Ducks prey/food for river otters? 1. **Yes** 2. No 3. Don't know	70	36.1
Yes/No Question: Are Sea Urchin prey/food for river otters? 0. Yes 0. **No** 0. Don't know	57	30.2
True or False: There are 13 types of otters in the world, 12 of which are listed as endangered or near-threatened. 1. **True** 2. False 3. Don't know	29	14.7

Questions	Number who Provided Correct Answer	% Who Provided the Correct Answer
Scale bar: On a scale of 1-5, how easy (1) or difficult (5) is the life of a river otter living in north coast habitats: 1. 1 - very easy 2. 2 - easy 3. 3 - neutral 4. 4 - difficult 5. **5 - very difficult**	2	1.1

H2: Presenting citizen science project information and knowledge about the North American River Otter and their habitats through interactive science communication will increase participant's knowledge of the North American River Otter and their habitats.

<u>Pre-test and Experimental Group</u>

Contrary to expectations, presenting citizen science project information and knowledge about the North American River Otter and their habitats through interactive science communication did not increase participant's knowledge of the North American River Otter and their habitats. The results suggest there was no significant difference [t(226)=1.41, p=0.080] in the mean number of questions answered correctly between the Experimental Group respondents (*M*=7.36, *SD*=2.38) and pre-test participants (*M*=6.69, *SD*=2.64). However, chi-squared analysis on a question-by-question basis demonstrated that Experimental Group participants' results varied from the Pre-test environmental knowledge results (see Table 7). Experimental Group participants were significantly more likely to know a river otter's range ($\chi 2(1,234) = 7.22$, p=0.007 (one-tailed), Φ=0.176), identify latrines ($\chi 2(1, 114) = 5.979$, p=0.014 (one-tailed), Φ=0.137), and accurately rate how difficult the life of a river otter is ($\chi 2(1, 215) = 40.99$, p=0.001 (one-tailed), Φ=0.437). Based on the odds, the likelihood of Experimental Group participants correctly identifying latrines and a river otter's range was 4.1 and 2.7 times higher than Pre-test participants, respectively. Effect sizes for these relationships were moderate and weak respectively. Similarly, based on the odds, the likelihood of Experimental Group participants accurately rating the difficulty of the life of a river otter was 39 times higher than Pre-test participants and the effect size of this relationship was moderate to large.

Pre-test and Control Group

Control Group participants on average answered almost seven questions correctly (*M*=6.96, *SD*=2.64) which is very similar to pre-test scores (*M*=6.69, *SD*=2.647). Overall, the results suggest that Control Group participants' scores did not significantly differ from pre-test results [t(237)=-.079, p=.937], which was expected given Control Group participants did not receive supplemental science communication through the webinar or website. Surprisingly, chi-squared analysis on a question-by-question basis demonstrated that there were several instances in which Control Group participants' results varied from the Pre-test environmental knowledge results. Control Group participants were significantly more likely to accurately rate how difficult the life of a river otter is ($\chi 2(1, 215) = 40.99$, p=.001, Φ=0.437 (two-tailed) and identify crayfish as part of a river otter's diet ($\chi 2(1, 114) = 5.979$, p=.014, Φ=0.137 (two-tailed). Based on the odds, the likelihood of Control Group participants accurately rating the difficulty of the life of a river otter was 66 times higher than Pre-test participants, the effect size of this relationship was large. Similarly, based on the odds, the odds of Control Group participants correctly identifying crayfish as part of a river otter's diet was 3.9 times higher than Pre-test participants respectively. The effect size for this relationship was weak.

Experimental and Control Group

The results suggest there was no significant difference in Experimental Group scores (*M*=7.36, *SD*=2.38) and Control Group scores (*M*=6.69, *SD*=2.64) for any of the questions asked or as it relates to the knowledge index for the two groups overall [t(81)=1.4, p=.083]. Similarly, on a question-by-question basis, chi-squared analysis suggests Experimental Group participants' results did not vary from the Control group participants' environmental knowledge results, Table 7.

Table 7. Pre-Test (N=228), Experimental Group (N=36) and Pre-test participants (N=228) survey results from the environmental knowledge section of the survey including the survey questions, percentage of respondents who provided the correct answer and number who answered correctly. Survey responses were collected between Spring 2020 – Spring 2021.

Questions (answers removed)	**Pre-test % Correct**	**Pre-test # Who Answered Correctly**	**Experi-mental Group % Correct**	**Experi-mental Group # Who Answered Correctly**	**Control Group % Correct**	**Control Group # Who Answered Correctly**
Image Selection: Choose the Image of a river otter:	89.0	162	90.9	30	88.1	37
Yes/No Question: Are Fish prey/food for river otters?	87.2	171	97.3	36	93.5	43
Yes/No Question: Are Crayfish prey/food for river otters?	79.1	155	83.8	31	93.6*	44

Questions (answers removed)	Pre-test % Correct	Pre-test # Who Answered Correctly	Experi-mental Group % Correct	Experi-mental Group # Who Answered Correctly	Control Group % Correct	Control Group # Who Answered Correctly
Multiple Choice: River otter habitats include all of the following except:	74.5	146	78.4*	29	73.9	34
Yes/No Question: Are Frogs prey/food for river otters?	67.2	131	69.4	25	69.6	32
True or False: River otters are a top predator in freshwater habitats.	65.0	128	81.1	30	74.5	35
Yes/No Question: Are Aquatic Insects prey/food for river otters?	47.7	93	11.1***	4	4.3***	2
Multiple Choice: Which of the following otter species live in at least one of the following Counties: Del Norte, Humboldt, Mendocino, Siskiyou, and/or Trinity.	46.2	91	70.3	26	57.4	27
Fill in the blank: River otters use a __________ as a shared bathroom and communication site through a sense of smell.	44.3	43	76.5*	13	61.5	16

Questions (answers removed)	Pre-test % Correct	Pre-test # Who Answered Correctly	Experi-mental Group % Correct	Experi-mental Group # Who Answered Correctly	Control Group % Correct	Control Group # Who Answered Correctly
Multiple Choice: River Otters are considered to be:	42.1	83	54.1	20	46.8	22
Yes/No Question: Are Ducks prey/food for river otters?	36.1	57	51.4	18	37.0	17
Yes/No Question: Are Sea Urchin prey/food for river otters?	30.2	29	40.0	14	32.6	14
Scale bar: On a scale of 1-5, how easy (1) or difficult (5) is the life of a river otter living in north coast habitats:	1.1	2	28.1***	9	40.0***	18

*$p < 0.05$, **$p < .01$, ***$p < .001$

Environmental Attitudes

NEP Questions

Analysis of the four individual NEP constructs (anti-anthropocentrism, vulnerability of natural balancing, rejection of exemptionalism, and possibility of eco-crisis) when taken as a whole for each group showed acceptable reliability for the various groups (see Table 8). The individual dimensions demonstrated varying degrees of reliability from relatively high to low (Table 9). Given the variability in reliability between the different dimensions, I elected to combine the four dimensions into one scale measure of participants' environmental attitude, with a higher mean suggesting a more positive attitude toward the environment.

Table 8. Reliability scores for combined constructs within the NEP (anti-anthropocentrism, vulnerability of natural balancing, rejection of exemptionalism, and possibility of eco-crisis) for each survey group. Survey responses were collected via survey between Spring 2020 – Spring 2021.

Group	**N**	**Mean**	**Cronbach's α**
Pre-test	189	3.88	.667
Experimental Group	34	3.84	.696
Control Group	46	3.88	.550

Table 9. Reliability scores for the four different constructs (anti-anthropocentrism, vulnerability of natural balancing, rejection of exemptionalism, and possibility of eco-crisis) for each survey group. Survey responses were collected via survey between Spring 2020 – Spring 2021.

NEP Dimension	**Pre-test**	**Experimental Group**	**Control Group**
Anti-Anthropocentrism	.289	.190	.177
Vulnerability of Natural Balancing	.584	.407	.319
Rejection of Exemptionalism	.315	.402	.379
Possibility of an Eco-crisis	.618	.683	.394

H3: Presenting citizen science project information and knowledge about the North American River Otter and their habitats through interactive science communication will elevate participants' positive environmental attitudes towards the North American River Otter and their habitats.

Pre-test and Experimental Group

In general, receiving supplemental science communication through the website and webinar did not elevate Experimental Group participants' positive attitudes toward the North American River Otter and their habitats. Experimental Group attitude scores did not differ from the pre-test environmental attitude scores (Table 10). Both groups demonstrated relatively high pro-environmental attitude average scores. The mean attitudinal index score for Experimental Group and pre-test participants were nearly the same (*M*=3.84, *SD*=0.37 and (*M*=3.88, *SD*=.42), respectively, and the observed difference was not statistically significant [t(238)=-559, p=0.29].

Pre-test and Control Group

As expected, the mean attitudinal index scores for Control Group and pre-test participants were the same (*M*=3.88, *SD*=.362) and (*M*=3.88, *SD*=.421), respectively, and the observed difference was not significantly different [t(248)=-.001, p=.999)]. Both groups demonstrated a relatively high pro-environmental attitude average score which suggests a more positive attitude toward the environment.

Experimental Group and Control Group

Contrary to expectation, the mean attitudinal index scores for Experimental Group and Control Group participants were approximately the same (*M*=3.84, *SD*=.374) and (*M*=3.88, *SD*=.362) respectively and were not statistically significant [t(81)=-.513, p=.609)].

Table 10. Mean environmental attitude results and standard deviation for Pre-test participants (N=203), Experimental Group (N=37), and Control Group (N=47) on the NEP section. On a scale of 1-5, higher scores indicate a greater concern (or a more positive environmental attitude) for each aspect of the natural environment. Survey responses were collected via survey between Spring 2020 – Spring 2021.

	Pre-test Mean	Pre-test Std. Dev	Experi-mental Group Mean	Experi-mental Group Std. Dev	Control Group Mean	Control Group Std. Dev
Attitude Index (average of the items combined)	3.88	.421	3.88	3.74	3.88	.362

Northern California Questions

Pre-test respondents strongly agreed that their well-being is connected to the well-being of northern California's environment and are concerned for future generations of northern Californians and the condition of the environment that they will have to live in.

In general, environmental attitudes of pre-test participants specific to Northern California demonstrated a positive attitudinal response to the seven questions, suggesting a more positive attitude toward the environment (*M*=4.01, *SD*=0.42; Table 11).

Table 11. Mean environmental attitude results and standard deviation for Pre-test participants (N=200). On a scale of 1-5, higher scores indicate a greater concern (or a more positive environmental attitude) for each aspect of the natural environment. Survey responses were collected via survey between Spring 2020 – Spring 2021.

Question	Mean	Std. Dev.
Watershed health is an important concern in northern California.	4.70	.592
My well-being is connected to the well-being of northern California's environment.	4.51	.666
I am concerned for future generations of northern Californians and the condition of the environment that they will have to live in.	4.48	.673
We should manage the environment in northern California by implementing laws and regulations to ensure wildlife benefit.	4.24	.692
If everyone implemented environmentally friendly behaviors such as driving less, eating locally produced food, and using reusable bags, that would be enough to have a healthy environment in northern California.	3.52	1.07
There are sufficient environmental laws and regulations in place to protect the environment in northern California.	3.52	.933
Environmental degradation is more of a risk in other parts of the state than it is in northern California.	3.10	1.05
Attitude Index (average of the items combined)	3.74	0.54

Pre-Test and Experimental Group

Contrary to expectations, on average, the experimental group’s environmental attitude scores did not outperform pre-test participant scores. Both groups demonstrated relatively high environmental attitude average scores, with no attitudinal average scores lower than M=3.10 (pre-test group). Surprisingly, even though the experimental group was exposed to the educational website and webinar, their environmental attitude toward implementing laws and regulations in northern California to ensure wildlife and the environment benefit, was significantly less than pre-test participants [t(231)=-1.68, p=0.047)]. The mean attitudinal index score for Experimental Group and pre-test participants varied slightly (*M*=3.98, *SD*=.395) and (*M*=4.01, *SD*=.425), respectively, and was the observed difference was not statistically significant [t(234)=-.40, p=.34)].

Pre-test and Control Group

As expected, there were no statistically significant differences in the average environmental attitudes held by the control group and pre-test participants (Table 12). The mean attitudinal index score for Control Group and pre-test participants were essentially the same (*M*=4.00, *SD*=0.42) and (*M*=4.01, *SD*=0.43, t(245)=-.045, p=0.48).

Experimental Group and Control Group

Despite supplemental science communication efforts being administered to the experimental group, there were no statistically significant differences in the average environmental attitudes between the groups (Table 12). The mean attitudinal index score for Experimental Group and Control Group participants were essentially the same (*M*=3.98, *SD*=0.39) and (*M*=4.00, *SD*=0.42, t(81)=-.30, p=0.38).

Table 12. Environmental attitudes mean scores and standard deviation by question for Pre-test participants (N=200), Experimental Group (N=36), and Control Group (N=47). On a scale of 1-5, higher scores indicate a greater concern (or a more positive environmental attitude) for each aspect of the natural environment. Survey responses were collected via survey between Spring 2020 – Spring 2021.

	Pre-test Mean	Pre-test Std. Dev.	Experi-mental Group Mean	Experi-mental Group Std. Dev.	Control Group Mean	Control Group Std. Dev.
Watershed health is an important concern in northern California.	4.70	.592	4.75	.439	4.77	.428
My well-being is connected to the well-being of northern California's environment.	4.51	.666	4.65	.504	4.55	.583
I am concerned for future generations of northern Californians and the condition of the environment that they will have to live in.	4.48	.673	4.49	.612	4.43	.688
We should manage the environment in northern California by implementing laws and regulations to ensure wildlife benefit.	4.24	.692	4.03	.696	4.15	.859

	Pre-test Mean	Pre-test Std. Dev.	Experi-mental Group Mean	Experi-mental Group Std. Dev.	Control Group Mean	Control Group Std. Dev.
If everyone implemented environmentally friendly behaviors such as driving less, eating locally produced food, and using reusable bags, that would be enough to have a healthy environment in northern California.	3.52	1.07	3.42	1.025	3.60	1.070
There are sufficient environmental laws and regulations in place to protect the environment in northern California.	3.52	.933	3.36	.798	3.45	.974
Environmental degradation is more of a risk in other parts of the state than it is in northern California.	3.10	1.05	3.31	.98	3.13	1.05
Attitude Index (average of the items combined)	4.01	.425	3.98	.395	4.00	.419

Behavioral Intentions

Likelihood of Submitting a Future River Otter Observation

H4: Presenting citizen science project information and knowledge about the North American River Otter and their habitats through interactive science communication will increase participant's behavioral intentions for future participation in citizen science.

Overall, a majority of the pre-test respondents reported that they would be “very likely” to submit a wild river otter sighting to the community science river otter project if they saw one tomorrow. Nearly 79% of Experimental Group respondents, compared to 74% of Control Group respondents, who received supplemental science communication efforts, indicated that they would be “very likely” to report a wild river otter sighting, up five percent from pre-test respondents. Descriptive statistics for the variables in the Chi-squares analyses are presented in Table 19. The analysis suggests that the likelihood of a participant submitting a wild river otter sighting to the study does not vary by survey group. According to the data, regardless of science communication efforts, there was no statistically significant association between the likelihood of future participation between the groups $\chi^2(2, 290)=0.66$, $p=0.72$, $V=0.05$ (two-tailed). The effect size of this relationship was weak, chi-squared analyses are shown by group (Table 13).

Table 13. Chi-squared analysis for likelihood of future project participation and % who reported very likely for Pre-test (N=205), Experimental Group (N=38), and Control Group (N=47) participants collected via survey in Spring 2020 and 2021. Participants were asked on a scale of 1-4 how likely they would be to report a wild river otter observation if they observed one tomorrow, responses were recoded into two categories, “Very Likely” and “Not Very Likely”.

		Very Likely	Not Very Likely	Total	% Reported Very Likely
Pre-test	Count	149	56	205	72.6%
	Expected Count	151.3	53.7	205	-
Experimental Group	Count	30	8	38	78.9%
	Expected Count	28	10	38	-
Control Group	Count	35	12	47	74.4%
	Expected Count	34.7	12.3	47	-
Total	Count	214	76	290	-
	Expected Count	214	76	290	-

DISCUSSION

Citizen Science Descriptive Statistics and Demographics

The number of river otter observations has steadily increased between 2015 and 2019 from 185 to 492. This increase in observations is also associated with an increase in the number of citizen science participants. In fact, between 2015 and 2016 the number of participants nearly doubled from 132 to 220 and has slowly increased with each subsequent year. This could be a result of several factors. Firstly, in areas frequented by wild river otters and people, project leads have posted signs that encourage people to submit any wild river otter sightings to the project. Second, people will often recreate with their phones, using them to take photos, play music, or track a workout. Having a phone at the ready could enable community members to report a wild river otter observation more easily via text in the moment without needing to go elsewhere to access the internet or make a phone call.

When given an option to self-identify their observer type, close to half of the participants identified as either having a science background or being a nature enthusiast. Whereas fewer than 10% considered themselves to be citizen volunteers/scientists. Understanding participants' self-identified observer type can increase the project's ability to create relevant and meaningful engagement. As a majority of participants self-identify as nature enthusiasts or scientists, it is important for this project to create/maintain opportunities that utilize and leverage these identities to ensure greater retention of its current participants allowing them to utilize existing skills and knowledge and feel more motivated to participate. For example, if a majority of participants identified as volunteers, it would be imperative for project leads to conduct outreach on volunteer opportunity boards or with organizations who are committed to volunteerism highlighting the volunteer aspects of citizen science. However, because most of the participants identified as nature enthusiasts or scientists the more impactful places to conduct outreach may be where people frequent nature, near businesses where people buy outdoor related gear, or at learning institutions. Tailoring project outreach and opportunities may result in the participant satisfying multiple intrinsic and extrinsic desires, interests, and motivations, e.g, participants get to engage in both nature related activities and support citizen science (West & Pateman 2016).

While participant age in this project is wide ranging, the average age is 55, which suggests more can be done by project leaders to increase relevancy to younger community members. Additionally, nearly seventy-three percent of participants identify as White/Caucasian with the next largest self-identifying group being Latinx at approximately five percent. This suggests that more can be done by project leaders to increase relevancy to historically excluded community members.

While project participants' self-identified race reflects the dominant racial makeup of Humboldt County’s residents (83% of Humboldt County’s residents identify as White (U.S. Census Bureau (*2020*), the project should consider how to engage with other groups. The next largest self-identified group is Latinx at approximately twelve percent. Additionally, at Humboldt State University in 2020, approximately 34% of the student population was Latinx (Cal Poly Humboldt, n.d.). An opportunity exists for project leaders to deepen their engagement with Latinx Cal Poly Humboldt students and community members. Project leads may consider engaging Latinx Cal Poly Humboldt students or students in the Spanish department who identify as Latinx to produce bilingual (Spanish/English) project content that could not only increase the project's accessibility and relevancy, but also provide helpful professional development opportunities for Latinx Cal Poly Humboldt students. While this research evaluated the effectiveness of supplemental science communication of project results and information through a website and webinar, project leads may consider utilizing other social platforms such as TikTok or Instagram to increase relevancy and perhaps reach a larger audience.

As for age, 54% of Humboldt County residents are within the ages of 10-49, however the average age of project participants is 55 with only 10% of residents falling within the age range of 50-59 (*Census Profile* 2019). Part of this discrepancy could also be attributed to the fact that there is no information related to the number of participants under the age of 20. An area of growth for this citizen science effort could be centered around building relationships with local middle and high schools to set up partnerships or longer-term observation opportunities for younger students to participate in place-based citizen science while learning more about local biodiversity e.g., Arcata Marsh, Sequoia Zoo. Increasing the number of younger participants could create a bigger base of long-term citizen scientists. Project leaders may consider utilizing the North Coast Otters website to share project information with teachers and students. Given the adaptable nature of the website, an opportunity could exist to have students submit observations to the website and populate their observations into the interactive map under their school's name to track their observations over time and space.

Science Communication and Delivery Preferences

The project is currently engaging with citizen scientist participants utilizing their preferred method of communication which is email. As a result of this research, the project is also engaging the participants in their second preferred form of communication which is a website. As the average age of participants is 55, these current communication preferences may be reflected in these results. While social media ranks fourth on the list of preferred communication preferences, should there be an influx in the number of younger participants it would be worthwhile to revisit communication preferences to ensure all participants are receiving project information and results through the most meaningful modes of communication. And vice versa, should project leads decide to increase their presence on social media platforms they could attract a younger cohort of participants.

Pre-test survey results from all participants suggest a significant portion of the citizen scientists rated the project's ability to communicate information and results as above average. While it was not statistically significant, Experimental Group received supplemental science communication and had a higher percentage of respondents who indicated the project's ability to communicate project information and results as "above average" than Control Group, whose members did not receive supplemental science communication. This might suggest that the supplemental science communication efforts conducted as part of this research may have influenced participants' perception of the project's effectiveness at communicating information and results. I believe an opportunity to further evaluate participant perception of the project's effectiveness at communicating information and results exists. As my research did not require Experimental Group pre-test participants to engage in the supplemental content before taking the post-test, I would recommend future research be designed in a manner that ensures a larger cohort of CS participants would review the supplemental content before taking the post-test in order to elicit greater response rates.

As for the generation of the North Coast Otters website itself, I found that building a website and dynamic map was an effective mechanism for synthesizing citizen science observations and project information. Wordpress was a relatively user-friendly web platform to build a website. There were instances where I couldn't get the website to display images and narratives with desired flexibility. When this occurred, I found using other web design platforms such as Canva to be very helpful to create graphics and insert them into the website.

CanvasMap made for an effective plugin app to create a dynamic map. The process of using CanvasMap required significant coordination with Jim Graham, Associate Professor of Geospatial Science at Cal Poly Humboldt and plugin creator. The opportunity to work collaboratively with Dr. Graham allowed for ample learning opportunities writing HTML code and ensuring successful transformation of data from ArcGIS Pro shapefiles to JSON files and finally HTML code. In debrief conversations with Dr. Graham we identified the need to improve the editing and draft development process within CanvasMap to maximize collaborative editing efficiency. Dr. Graham mentioned he is in the process of creating an option which will allow for online content editing and hopefully increased efficiency. I believe this new online editing option will reduce time invested on subsequent projects by Dr. Graham while providing the application to others. I would utilize both Wordpress and CanvasMap again if I were to conduct other similar efforts that required synthesizing CS project information and results.

Environmental Knowledge

Overall, participants' baseline environmental knowledge related to the North American River Otter and their associated habitats was relatively low as measured by the survey. Pre-test results demonstrated that participants on average only answered 50% of the environmental knowledge questions correctly. This suggests an opportunity to support participants' in deepening their knowledge of the North American River Otter and their habitats through effective science communication that leverages their preferences for communication. In fact, Experimental Group participants, who received the supplemental science communication efforts as part of this research, increased their environmental knowledge scores to a greater degree than Control Group respondents on average. With additional science communication efforts and time, the average environmental knowledge of participants may increase. While there are numerous reasons as to why an individual may decide to participate in citizen science, two main motivations include the desire to learn something new or contribute to science/scientific knowledge and the importance of having their contributions clearly communicated as a motivation for participation (Vries et al., 2019). To satisfy these motivations and create sustained community participation it is essential for project leads to continue to communicate the results of community member participation and knowledge of river otters and their habitats effectively. Research conducted by Asah et al. (2014) suggested that CS participants are almost 20 times more motivated to participate if a CS opportunity provides personal enhancement such as learning or career opportunities versus environmental motivations. This highlights the importance of creating opportunities for participants to learn.

Environmental Attitudes

Minimal changes in environmental attitudes were demonstrated across participant groups and between the two different sets of survey questions. Overall, there were relatively high pro-environmental attitudes reflected in both the NEP and Northern California specific questions. The average Northern California specific environmental attitudes for all treatment groups were more positive than the broader NEP environmental attitude questions. This could indicate participants hold stronger pro-environmental attitudes when it comes to regional issues. As for the Northern California environmental attitude questions, there was only one question which elicited a statistically significant difference. The question asked the degree to which one agrees or disagrees with the following statement: We should manage the environment in northern California by implementing laws and regulations to ensure wildlife benefit. In fact, the pre-test group score was statistically significantly higher than Experimental Group's score (*M*=4.03, *SD*=.696) and (*M*=4.24, *SD*=.692) respectively, though this decrease in attitude between pre-test and post-test results was overall low (.21) and general sentiments remain high. As attitudes reflect a deep foundation for how an individual perceives the world (Eilam and Trop 2012); it may be that this effort was not sustained or in-depth enough to change participant's attitudes. It is possible that the NEP scale was too general an instrument to capture subtle changes in environmental attitudes. As the NEP is meant to be applied to the general US population, it may be less useful when measuring a small comparatively homogeneous sample like these CS participants. Similarly, as these individuals already demonstrate relatively high pro-environmental attitudes, the margin for growth may be narrower for them, then for individuals who have a slightly lower pro-environmental attitude to start or have not participated in CS previously. While the validity of the construction of the NEP and its ability to accurately represent attitudes towards the environment have been repeatedly tested (Dunlap and Van Liere, 1978; Dunlap, 2008), research conducted by Amburgery et al. (2012) indicates the instrument may be too general to tap into more specific beliefs comprising worldviews and may lack specificity to account for attitudes and beliefs pertaining to current environmental issues. This may also suggest that messaging from the project that's designed to strengthen environmental attitudes may need to recognize the strong pro-environmental attitudes that already exist when developing future content for the existing audience. That said, without knowing more about environmental attitudes within the general population of northern California, project leads may consider exercising caution when delivering content intended for existing participants more broadly. Messaging that appears too pro-environmental could dissuade new participants who may have varied attitudes towards the environment.

Behavioral Intentions

In general, participants across all treatment groups would be “very likely” to submit a wild river otter sighting to the citizen science project if they observed one tomorrow, suggesting that participants’ behavioral intentions to participate in the future are high. Given that pre-test participants demonstrated a relatively high likelihood for future CS participation to begin with, the margin for growth may be narrower for them then for an individual who would have a lower likelihood to participate to start. While not statistically significant, Experimental Group participants, who received the supplemental science communication efforts, increased their likelihood of submitting an observation by five percent. This could suggest that supplemental science communication and efforts made by project leads to engage participants could lead to continued sustained project participation over time. Observations of wild river otters can be few and far between for participants, depending on their activity levels, time spent in nature, responsibility, etc. For that reason, I believe it is important for project leads to continue to engage participants in supplemental science communication activities to ensure they remain connected to and reminded of the project. From a time management perspective, maintaining already engaged individuals may prove easier than trying to elicit participation from new community members.

COVID-19 Adaptations and Considerations

Due to unforeseen challenges to public health prompted by COVID-19, significant modifications to my research design had to be made. Initially, I had planned to engage three groups in the pre/post survey, a community group, an art festival group, and the Citizen Science River Otter participants. However, I could not conduct in-person surveys with the community group and essential in-person events like the North Coast Otters Public Art Initiative summer festival were postponed during the data collection phase of my research. One of the main modifications was a change in the study population to focus solely on the Cal Poly Humboldt Citizen Science River Otter participants. This shift came after I had already conducted my initial pre-survey data collection with the CS participants. Given my pre/post survey design, I was not able to change questions on the survey at that point even though these questions were designed to not only survey CS participants but also general community members, and North Coast Otters Public Art Initiative festival participants. If I had known I was just going to focus on the citizen scientists from the start, I would have opted to ask more questions related to their motivation for participating in citizen science to try and better understand how the project could have addressed those motivations and hopefully would have achieved more insight on retaining participants. As for response rates within the treatment groups, I had not designed the research in a way that would have required Experimental Group pre-test participants to engage in the supplemental science communication content before taking the post-test. This resulted in lower than anticipated numbers for pre- and post-comparison across treatment groups, despite numerous reminders and invitations to review the content. Had I known the study group was going to be CS participants only, I would have designed the study it in a way that would have ensured a larger cohort of CS participants would have reviewed the supplemental science communication content before taking the post-test in order to elicit greater response rates across treatment groups and increase the statistical power of my analyses to detect statistically significant differences.

Future Research

This research examined the environmental knowledge, attitudes, preferences, and behavioral intentions of one specific subset of the community, citizen scientists who have participated in the Cal Poly Humboldt Citizen Science River Otter Study. While this research implemented an experimental design that assigned CS participants randomly into an experimental or control group, it could be worthwhile to assess participants' environmental knowledge, attitudes, preferences, and behavioral intentions based on CS project participation. It would be worthwhile to see if there's an association between an individuals' environmental knowledge, attitudes, preferences, and behavioral intentions and their project participation.

Additionally, should further research be conducted, I believe it would be worthwhile to collect data on other subsets of the community to develop a greater baseline understanding of regional environmental knowledge, attitudes, communication preferences, and behavioral intentions.

Due to Covid-19, this research did not incorporate participants in the North Coast Otters Public Arts Initiative, a component of the larger Cal Poly Humboldt Citizen Science River Otter study. Should future research continue related to this subject, it would be worthwhile to evaluate the North Coast Otters Public Arts Initiative participants' knowledge of the North American river otters, and attitudes towards and behavioral intentions related to citizen science as a result of their participation in the art festival. Data collected from the Public Art Initiative participants could be compared to the baseline data collected from the CS participants. Additionally, project leads could review the CS and Public Arts Initiative participation data to see if participation in the Public Art Initiative led to participation in the CS project or vice versa. An additional opportunity exists to collect environmental knowledge, attitudes, and behavioral intention data from general community members who have not engaged in the art or CS efforts. Comparison across these different subsets of community members might create an opportunity for project leads to better understand their current audience in relation to the larger community while at the same time providing insight on how to reach new audiences and increase project participation.

As the field of citizen science continues to grow, it is more important than ever for CS projects to better understand individuals' motivations for participation, strive to meet those motivations, and effectively measure project outcomes with respect to participants. However, as each CS project varies in goals and outcomes, minimal research and few methods exist for how to effectively monitor outcomes for each project. This research provided a model for how citizen science projects can evaluate outcomes for participants such as environmental knowledge and attitudes, while considering further efforts for community engagement.

As this research took place during Covid-19, a time where individuals and communities were more socially distant and perhaps operating in a more virtual settings than before, it would be worthwhile to understand how the project's ability to communicate project findings and delivery preferences may change once in-person events increase in frequency e.g., changes in preference from virtual to in-person events. Similarly, it would be worthwhile to do additional quantitative analysis of the CS data during Covid-19 to see if there have been significant changes in the number of observers or number of observations submitted annually to the projects. An increase in the number of observers or observations could suggest more community members were getting outside or looking for activities that were safe during Covid-19. It would be helpful to know whether those numbers hold steady or change as Covid-19 mandates are lifted and in-person and indoor activity options resume.

CONCLUSION AND RECOMMENDATIONS

Through this research, I attempted to understand ways in which communicating science through interactive and interpretive methods influences CS participants' knowledge of North American river otters and their habitats, attitudes towards the environment, and behavioral intentions related to participation in CS. In this study 228 citizen scientists completed an initial pre-test survey. After the pre-test survey, participants were assigned to a treatment and control group. Half of the participants received supplemental science communication efforts in the form of a website and webinar. The other half did not receive supplemental science communication efforts. After the experimental treatment, I administered follow-up surveys to all the participants to evaluate shifts in knowledge of, attitudes towards, and behavioral intentions.

Upon review of the results, several conclusions can be drawn. First, in terms of science communication preferences, across the groups, the preferred method of communication is email followed by a website. In an effort to retain participants, the citizen science study should consider continuing to engage participants through these means.

Second, in terms of demographics, the average age of project participants was 55 years old, with participants ranging from 20-85 years old. Approximately three quarters of the participants primarily identified as White/Caucasian. Generally, participation did not differ by gender. When it comes to education, 80% of participants have a college degree or higher. Project leaders might work to expand participation from less represented groups.

Third, participants' initial knowledge of the North American River Otter and their habitats was relatively low, indicating an opportunity for project leaders to expand education opportunities for participants to learn about the North American River Otter and its habitats. In fact, participants who received supplemental science communication improved their environmental knowledge scores to a greater degree. This suggests the citizen science study may consider additional efforts to increase project results, information, and findings in order to increase participants' environmental knowledge.

Fourth, participants in this study hold relatively high pro-environmental attitudes. This could be part of the reason why they have self-selected to participate in this voluntary citizen science effort. In terms of improving environmental attitudes, I found no significant differences between the experimental and control groups. Efforts conducted as part of this research may not reach the necessary depth or longevity needed to influence environmental attitudes.

Fifth, the likelihood of future participation from participants was high. Nearly 75% of participants indicated that they would be “very likely” to submit a wild river otter observation if they were to observe one tomorrow. The likelihood of submitting wild river otter observation increases slightly among Experimental Group participants who received supplemental science communication efforts. While this increase was only substantively significant, this could indicate that additional engagement from project leaders could increase future participation.

I recommend that future research compile data on other subsets of the community to determine a greater baseline understanding of regional environmental knowledge, attitudes, communication preferences, and behavioral intentions. A deeper understanding of the community at large could support the growth and longevity of this Cal Poly Humboldt Citizen Science River Otter Study.

Reaching beyond the Cal Poly Humboldt Citizen Science River Otter Study, CS has the potential to contribute to science in meaningful ways while at the same time supporting community members' access and inclusivity to the field of science. CS projects can connect participants with their natural environments, supporting their knowledge of and relationships with these environments. Deepening an individual's relationship with, attitude towards, and knowledge of the natural world may lead to a global community that is more informed and passionate about the environment, increasing our collective capacity for environmental conservation and problem solving. While CS cannot solve all the environmental issues that face our global communities, it offers a pathway for all community members to become engaged in science and the environment regardless of education, age, or other socio-economic status.

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Appendix A. Year in Review letter for Control Group participants. The Year in Review is a letter from Project creator Jeff Black that briefly summarizes 2020 findings from the Cal Poly Humboldt Citizen Science River Otter Project. Sent to Control Group on February 18th, 2021.

Dear Otter Spotter!

Thank you for your continued support of the HSU Citizen Science River Otter Project in 2020! It was a turbulent year, and we're pleased to announce that it was also a year of river otter sightings here on the North Coast. In fact, there were 605 river otter observations submitted to the project!

Jeff Black, Project founder, offers these word from his year in review:

"I found a new routine in light of the covid-19 pandemic. In recent months I have taken to biking down to the Arcata Marsh almost daily to observe the river otters who frequent the 'constructed' series of wetlands. I watched pups grow up, gained insight on how many males move through the area and saw firsthand how an otter's diet shifts depending on the season. With each encounter I'm reminded that the river otters themselves are the best teachers celebrating clean water and healthy habitats!"

Sincerely,

Jeff Black
HSU Wildlife Department

Submit your 2021 wild river otter sightings here:

otters@humboldt.edu (707) 826-3439 Online submission form

Appendix B. HTML code utilized to display input text and image location on the ArcGIS Pro/CanvasMap inset map that appears on the North Coast Otters Website. This text was manually inputted within the GEOJSON file and completed for the 12 different short narrative text and images related to people, places, and otters.

{ "type": "Feature", "properties": { "Latitude": 41.92629195, "Longitude": -124.1481707, "Galabids": 97, "Surname": "Slayton", "Otter_Name": "Luna", "Host_Site": "Del Norte County Library Smith River Branch", "Address": "241 First Street, Smith River, CA 9556", "HTML": " <h2> Luna by Jessica Slaton </h2><img src='otter_jessica_slaton.jpg' width='500' height='333'> <p> This sculpture is hosted at the Del Norte Library Smith River Branch and sponsored by Pine Grove Elementary and the Del Norte Library Smith River Branch.

 www.instagram.com/slayton.jas
 Tribal affiliation: Yurok. </p>"}, "geometry": { "type": "Point", "coordinates": [-13820111.145240403711796, 5149944.722235943190753] } }]}

Appendix C. North Coast Otters - Public Arts Initiative: A Survey of Public Environmental Attitudes and Knowledge consists of five sections: informed consent, project participation, attitudes toward the environment, knowledge of river otters and their habitats, and basic demographic information. Survey was delivered online to Cal Poly Humboldt Citizen Scientist project participants between Spring 2020-Spring 2021.

NORTH COAST OTTERS PUBLIC ARTS INITIATIVE

Welcome!

INFORMED CONSENT

This survey focuses on understanding local participation in citizen science, knowledge of river otters and their habitats, and attitudes towards the environment.

Participant Role

If you volunteer to participate, you will be asked to answer and submit this survey. Your participation in this study will last approximately ten minutes.

Voluntary Participation

I want to be sure you know that your participation is voluntary and you have the right to change your mind and withdraw at any time.

Risks and Benefits

I anticipate no risk to you participating in this project. You will not receive any direct benefits for your participation, but I hope that you will find it rewarding to share your knowledge. Data collected cannot be withdrawn once submitted. There is no monetary or other incentive as part of this research study.

Protecting Anonymity

It is anticipated that study results will be shared with the public through presentations and/or publications. Any information that is obtained in connection with this study and that can be identified with you will remain confidential. In order to ensure your confidentiality, questionnaires will be collected and stored in a password protected file, identifying information will not be shared. The de-identified data will be maintained in a safe location and may be used for future research studies or distributed to another investigator for future research studies without additional informed consent from you.

Concerns

If you have any questions about this research at any time, please call or email me at kdj117@humboldt.edu or (805) 975-5889. You may also contact my supervisor, Yvonne Everett at everett@humboldt.edu or (707) 826-4188. If you have any concerns with this study or questions about your rights as a participant, contact the Institutional Review Board for the Protection of Human Subjects at irb@humboldt.edu or (707) 826-5165.

Please print this informed consent form now and retain it for your future reference.

* If you agree to voluntarily participate in this research as described, please check the box below to begin the online survey. Thank you for your participation in this research and know that you may withdraw your consent at any time.

- I consent
- I do not consent

Citizen Science and Visual Arts Project Participation

I would like to know about your participation in the HSU Citizen Science River Otter Records Project and the North Coast Otters - Public Arts Initiative. Please answer the following four (4) questions. Please respond regardless of whether you've previously participated in the projects.

In the past year, approximately how many individual wild river otter(s) have you seen?

- I have not seen a wild otter
- 1-4 wild otters
- 5-9 wild otters
- 10 or more wild otters

In the past year, approximately how many observations of wild river otter(s) did you report to the HSU Citizen Science River Otter Records Project? Please select the number of observations you have submitted to the project, not the individual numbers of otters observed.

- I did not report any observations
- 1-5 observations
- 6-10 observations
- 11-14 observations
- 15 or more observations

Have you participated in the North Coast Otters - Public Arts Initiative Virtual Festival?

- Yes
- No
- I have not heard of the North Coast Otters - Public Arts Initiative Festival
- Don't know

If you were to observe a wild river otter tomorrow, how likely would you be to report the sighting to the HSU Citizen Science River Otter Records Project?

- Very likely
- Somewhat likely
- Not likely
- I would not report an observation
- Don't know

Attitudes toward the Environment

Please indicate the extent to which you agree or disagree with each of the following statements about the relationship between humans and the environment.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Humans have the right to modify the natural environment to suit their needs.					
When humans interfere with nature it often produces disastrous consequences.					
Human ingenuity will ensure that we do not make the Earth unlivable.					
Humans are seriously abusing the environment.					
Plants and animals have as much right as humans to exist.					
The balance of nature is strong enough to cope with the impacts of modern industrial nations.					
Despite our special abilities, humans are still subject to the laws of nature.					
The so-called "ecological crisis" facing humankind has been greatly exaggerated.					
Humans were meant to rule over the rest of nature.					
The balance of nature is very delicate and easily upset.					
Humans will eventually learn enough about how nature works to be able to adapt to it.					
If things continue on their present course, we will soon experience a major ecological catastrophe.					

The following seven (7) statements refer to northern California. For the purpose of this survey, northern California collectively refers to the following counties: Del Norte, Humboldt, Mendocino, Siskiyou, and Trinity.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
There are sufficient environmental laws and regulations in place to protect the environment in northern California.					
My well-being is connected to the well-being of northern California's environment.					
I am concerned for future generations of northern Californians and the condition of the environment that they will have to live in.					
Watershed health is an important concern in northern California.					
If everyone implemented environmentally friendly behaviors such as driving less, eating locally produced food, and using reusable bags, that would be enough to have a healthy environment in northern California.					
We should manage the environment in northern California by implementing laws and regulations to ensure wildlife benefit.					
Environmental degradation is more of a risk in other parts of the state than it is in northern California.					

NORTH COAST OTTERS PUBLIC ARTS INITIATIVE

Knowledge of River Otters and their Habitats

This section is about river otters and their habitats. Please answer the following questions to the best of your ability without using other resources. If you don't know the answer to a question leave it blank or mark "Don't Know".

Which of the following otter species live in at least one of the following counties: Del Norte, Humboldt, Mendocino, Siskiyou, and/or Trinity.

- North American River Otters (Lontra canadensis)
- Sea Otters (Enhydra lutris)
- Both River Otters and Sea Otters
- None of the above
- Don't know

River otters are a top predator in fresh water habitats.

- True
- False
- Don't know

There are 13 types of otters in the world; 12 of which are listed as endangered or near-threatened.

- True
- False
- Don't know

On a scale of 1-5, how easy (1) or difficult (5) is the life of a river otter living in north coast habitats:

1 - Very Easy	Neutral	5 - Very Difficult

River otter habitats include all of the following <u>except</u> (Check one):

- Rivers
- Bays
- Open ocean
- Marshes
- Estuaries
- Inland wetlands
- Don't know

River otters are considered to be:

- Herbivores (plants only)
- Omnivores (Meat and plants)
- Carnivores (Meat and fish)
- Piscivores (Fish only)
- Scavengers (Dead things only)
- Don't know

Choose the image of a river otter:

River otters use a _______________ as a shared bathroom and communication site through sense of smell.

For each item listed, indicate whether the following is or is not prey/food for river otters:

	Yes	No	Don't Know
Crayfish			
Fish			
Sea Urchin			
Ducks			
Frogs			
Aquatic Insects			

NORTH COAST OTTERS PUBLIC ARTS INITIATIVE

Basic Demographic Information

I would like to know a little more about you so that I can be sure I have reached a broad group of people. Please answer these few questions about yourself.

Please provide your email address:

I ensure it will not be used or shared outside this survey.

What is the name of the town you currently live in?

Did you live in at least one of the following counties at any point in the last five (5) years: Del Norte, Humboldt, Mendocino, Siskiyou, and/or Trinity?

In what year were you born?

I identify my gender as:

- Female
- Male
- Genderqueer
- Non-Binary
- (please specify)

What is your race or ethnicity? (Check all that apply)

- Black or African American (for example: African American, Nigerian, Jamaican, Ethipian, Haitian, Somali)
- American Indian, Native American, or Alaskan Native
- Asian (for example: Chinese, Vietnamese, Filipino, Korean, Asian Indian, Japanese)
- Hispanic, Latino, or Spanish (for example: Mexican or Mexican American, Salvadoran, Puerto Rican, Dominican, Cuban, Colombian)
- Middle Eastern or North African (for example: Lebanese, Syrian, Iranian, Moroccan, Egyptian, Israeli)
- Native Hawaiian or Other Pacific Islander
- White, Caucasian, European American
- Decline to answer
- Not listed (please specify):

What is the highest level of education you have completed? (Check one)

- ◯ Preschool/Kindergarten
- ◯ Elementary/Primary School
- ◯ Middle/Junior High School
- ◯ High/Secondary School
- ◯ Some College (less than four years)
- ◯ College Degree (Bachelor)
- ◯ Post-Graduate Degree (Master/PhD)

Do you have a fond memory of a time when you observed a wild river otter? If so, please share your experience:

Is there anything else you would like to share that was not covered in the survey?

Appendix D. Otterly Wild Webinar invitation sent electronically to Experimental Group. The invitation informed participants of the date, time, location, and general structure of the webinar. The Otterly Wild Webinar was conducted on March 4, 2021 with 11 Experimental Group Participants.