ABSTRACT

HOVIS, MEREDITH ELAINE. An Evaluation of Hofmann Open-Water Laboratory (HOWL): A Pilot Project for Participatory Research in Eastern North Carolina. (Under the direction of Dr. Frederick Cubbage).

Citizen science, also known as participatory research, combines the efforts among professional researchers and community volunteers to collect data. For this project, we have established a collaborative project in eastern North Carolina, near the 79,000-acre Hofmann Forest, comprising of 55,000 acres of planted forests and 24,00 acres of deep pocosin natural forests. The White Oak River, New River, and Trent River all flow out of the Hofmann, giving it a keystone ecological role for the nearby coast.

The Hofmann Open-Water Laboratory (HOWL) science team has established a participatory research project to analyze how the Hofmann Forest acts as a significant ecosystem service, as well as assess the water quality of the three rivers. HOWL wishes to understand the Hofmann's place in the coastal ecosystem and how its quality affects the surrounding human and ecological community. The HOWL team has set-up sites to monitor chemical, physical, and biological properties outside of the Hofmann. The hopes of HOWL is to monitor water quality on the forest. The project integrates the scientific efforts of local researchers representing community groups from NC Cooperative Extension Service, White Oak-New River Keeper Alliance, Izaak Walton League of America (IWLA), homeschools, Boy Scouts and Cub Scouts, and Onslow County 4-H groups. The scientific and participatory effort is designed to offer an innovative and collaborative approach to engage citizens and community groups to extend data within the North Carolina coastal region; help citizens better understand the world in which they live; and create a partnership between professional researchers and organizations with local volunteers. The citizen science approaches involving locals, professional scientists, field collection technology, and fieldwork will allow citizen scientists to understand, measure, and

monitor their local community, as well as, improve natural resource management, protection, and decision-making for North Carolina's coast.

The purpose of this thesis research was to evaluate the HOWL project to determine the perceptions of the HOWL participants and analyze if the project has met its goals of individual development and community engagement. Two major conclusions were drawn from the research. First, community engagement and collaboration increased in rural Eastern NC while participating in water monitoring and natural resource management. Second, citizen scientists achieved their personal goals and objectives by participating in the HOWL project. Further, the results will be used to sustain the collaborative efforts of the HOWL citizen science project for the future.

An Evaluation of Hofmann Open-Water Laboratory (HOWL): A Pilot Participatory Research Project in Eastern North Carolina

by
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DEDICATION

To my mother,

my father,

and to all of those who have supported me along the way.

BIOGRAPHY

Meredith Hovis was born in Statesville, North Carolina, and raised 30 miles down the road in Salisbury, NC. She graduated, as student-body President, from Salisbury High School in 2012. During high school, she earned her Girl Scout Gold Award after thirteen years in the program. She was accepted at Meredith College, an all-women's liberal arts college in Raleigh, North Carolina. During her undergraduate career, she studied abroad at La Universidad Nacional in Heredia, Costa Rica. Soon after, she was one chosen of four students, nationally, by the Organization of Tropical Students (OTS) for a research workshop in La Selva, Costa Rica. Because of this experience, she decided she wanted to continue her passion within natural resources and research. Hovis graduated with a B.A. in Environmental Sustainability, and a B.A. in Spanish at Meredith College in 2016. She will never be let down that "Meredith went to Meredith." She was accepted at North Carolina State University in the Department of Forestry and Environmental Resources to pursue a M.S. in Natural Resources; in hopes of making the world a little bit better than how she found it.

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Additionally, I would like to recognize the support and guidance from my committee members Dr. Kathleen McGinley, Dr. Madhusan Katti, and Dr. Marcelo Ardon-Sayao along the way of completing my thesis. Each of them challenged me to become a better researcher and encouraged me through the difficulties of graduate school.

I also wish to thank my advisor, Dr. Fred Cubbage, for allowing me the opportunity to continue my education towards a master's degree, and soon to be doctorate degree. He introduced to me the concept of citizen science and participatory research approaches. I'm grateful for his continuous patience with me, and always taking the time with me no matter how near his own deadlines were. I admire his hard work, dedication, enthusiasm, and commitment to natural resources and as a professor. He has inspired and empowered me to act upon what is right.

Lastly, I would like to thank my mother and father – Marcus and Vanessa Hovis – for supporting me emotionally, mentally, and financially during my academic adventures, and challenges. I am blessed with unbelievably encouraging and helpful parents, who continue to motivate me daily. I can never fully express how thankful I am for everything they've done for me.

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1.1 What is Citizen Science?

Citizen science combines research efforts among professional scientists and community volunteers. Citizen science approaches have recently emerged within the past decade. A search for "citizen science" in Web of Science identified only 19 scientific articles published between 1950 to 1990 (Lepczyk et al., 2009). However, from 1990 to 2013 there were over 400 papers on the subject. Now, in 2018, if searched "citizen science" in Web of Science, over 2000 articles are available. Even a search for similar phrasing such as "participatory research" from 1990 to 2013 retrieved approximately 300 articles; however, in 2018, Web of Science discovered more than 700 publications.

Although the terminology of "citizen science" evolved only recently, participatory and stakeholder involvement approaches are quite old. For example, early practices arose from naturalist hobbyists like John Muir (Dickinson et al., 2012). But today, Dickinson et al. (2012) describe any individual who engages in scientific processes as a "citizen scientist." Individuals who lack experience or a background in a science discipline or practices are citizen scientists. As citizen scientists dedicate their lives to a natural or environmental hobby, they feed observations and data from a wide range of geographic areas and share with the world. Thus, as citizen science approaches increase, researchers are using and designing different types of participatory research projects to meet their goals. Most are developed to meet a scientific outcome (Cooper et al., 2007), but some are created to reach goals of increasing community networking, building community engagement, participant's perceptions of stewardship, and environmental education.

1.2 HOWL Citizen Science Background

1.2.1 The Formation of HOWL

The Hofmann Forest, founded in 1936, is North Carolina State University's 79,000-acre education and research forest (North Carolina State University, 2017). The Hofmann Forest landscape, comprised of wetlands, agriculture, and forests, is the country's largest university

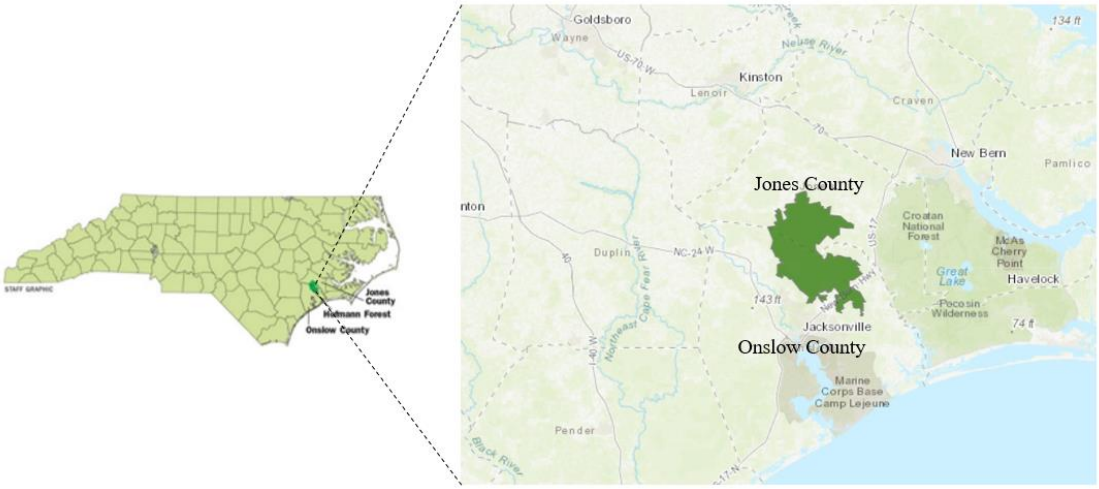

Figure 1: Placement of Hofmann Forest in Jones and Onslow Counties.

forest. It also contains a large variety of flora and fauna, including vulnerable and keystone species such as the Leatherback sea turtle (*Dermochelys coriacea*) and the Venus fly-trap (*Dionaea muscipula*) (U.S. Fish & Wildlife Service, 2018). Hofmann is situated in eastern North Carolina, falling within both Onslow and Jones Counties (Figure 1).

In January 2013, the NCSU Endowment Fund and Natural Resources Foundation initiated a proposed sale of the Hofmann Forest (Cubbage, Roise, & Sutherland, 2016). The Hofmann Forest sale proposal alarmed numerous individuals not only in Raleigh, NC, but, also, across North Carolina's coastal plain, especially within Jones, Onslow, and Carteret Counties. A coalition consisting of local community members, coastal conservation groups, school groups, and other interested individuals did not dissolve in 2015 when the decision to retain the forest

was announced.

The citizen's collaborative efforts and actions to save the Hofmann Forest prompted additional, and continued, involvement at the Hofmann to solidify its value and importance within the coastal community. The triggering event of the proposed sale stirred the group to stay connected. The project was initiated by a faculty member at NC State University and, then further supported by the local community members and groups. Hofmann Open-Water Laboratory (HOWL) was developed by a team of researchers and then recruited additional community members to join in the collaborative efforts. HOWL is a citizen science project,

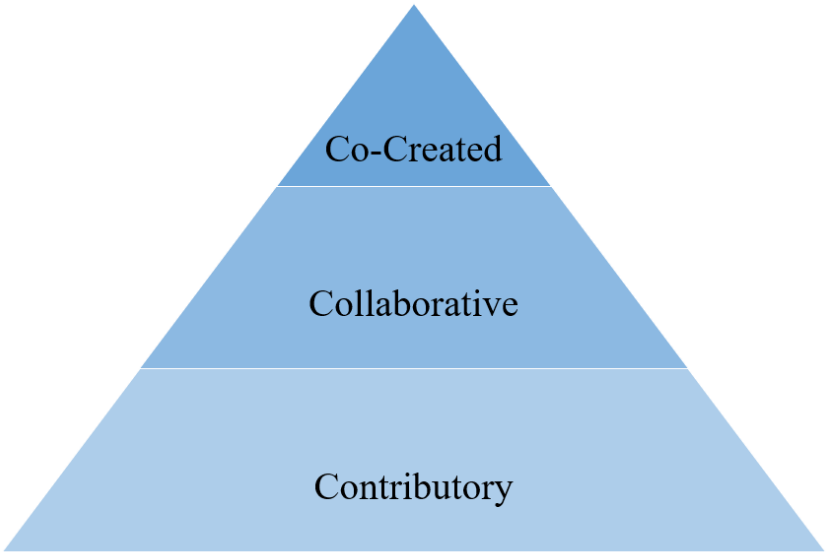

Figure 2: The pyramid diagram demostrates the various types of citizen science projects pet Shirk et al. (2012). Co-created projects are the rare pinnacle amongst the other types of citizen science projects. Many citizen scientists and projects fall in the bottom tier, contributory projects, where volunteerts collect observations and experiences to feed into the research system. Collaborative projects lie between the two, giving more responsbility to participants of contributory projects. However, projects that are co-created call upon citizen scientists with a lot of skills and expertise to achieve the duties of data analysis, visualization, and sharing.

allowing the citizen cooperation to develop research questions of Hofmann's importance in NC's inner-coastal plain, collect data, and test hypotheses on water quality and quantity, as well as wildlife. Because the idea of Hofmann Open-Water Laboratory (HOWL) was first thought of by NC State's professional researcher, HOWL is considered a "collaborative" project.

Shirk et al. (2012) describes a collaborative citizen science project as a project that is established by scientists and call on local community members to contribute to data collection, analyzation processes, and sharing the findings (Shirk et al., 2012). Not only do members collect water monitoring samples and wildlife images via camera traps for the project, but also help in the processes of statically analyzing data, asking questions, and developing a new database for benthic macro-invertebrates for North Carolina's brackish waters.

In contrast to collaborative citizen science projects, Shirk et al. (2012) explains a co-created project as a project designed jointly by scientists and local members. This was not the case for HOWL. There is equal ownership of data, authority, and idea-generation. Contributory projects give even less responsibility to the local community members than the other two types of projects. Contributory projects are designed by scientists and specifically reach out to citizen scientists to collect data. The information is interpreted and shared by the project designers, but do not allow any other responsibilities to the volunteers (Figure 2: The pyramid diagram demostrates the).

1.2.2 HOWL Collaborators

The HOWL team consists of a community of partners, including professors, research associates, and students at North Carolina State University, local conservation organizations, and interest groups at the North Carolina coast—IWLA, White Oak-New River Keeper, and NC Cooperative Extension Service. Additionally, Scout groups and leaders; homeschool students and instructors; 4-H clubs and directors; youth groups; K-12 school groups and teachers are targeted to participate in the HOWL project. All participants involved in the groups above are considered a part of the HOWL team (Figure 3). All participants engage in the project by learning about watershed quality analysis methodologies, the Hofmann Forest and its history,

teamwork skills, scientific fieldwork, and the importance of a healthy watershed in a community and the environment. HOWL participants also contribute significant scientific findings via the collection of data on water quality and quantity. Participants engage in data collection by following project protocols, allowing them to learn and collect information about physical, chemical, and biological water quality indicators.

Water quality modeling efforts are led by the Department of Forestry and Environmental Resources at NC State University, as well as Cooperative Extension through NC State University. The IWLA and Cooperative Extension assists leading, training, and organizing citizen groups such as Girl Scouts, Boy Scouts, homeschoolers, and 4-H in the region to become involved in monitoring water quality. Lastly, the White Oak-New River Keeper Alliance provides local knowledge of the water quality and ecological habitat of the sampling site

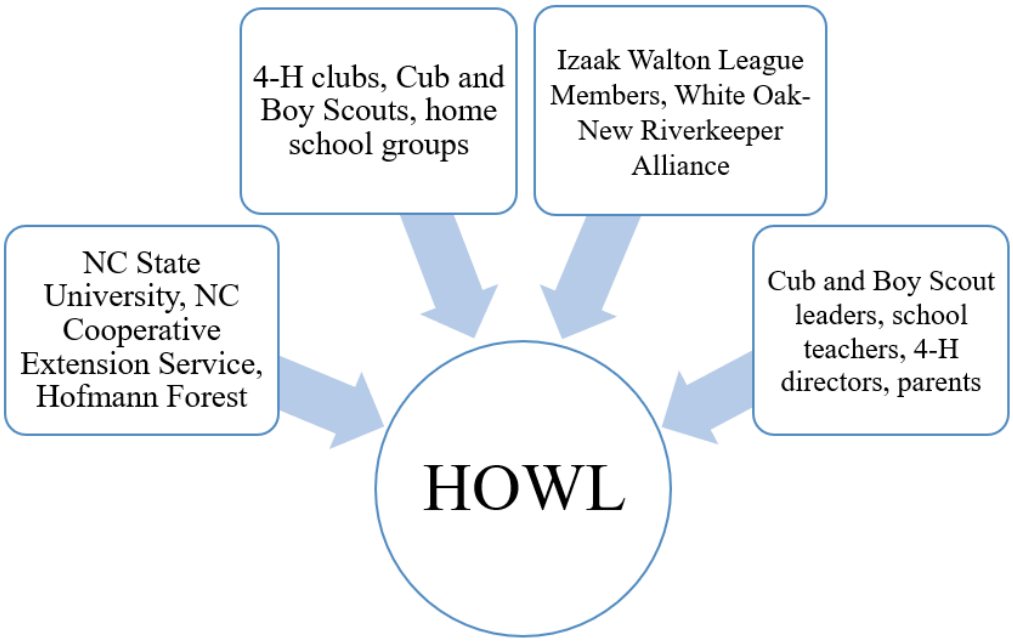

Figure 3: All members, trainers, and organization come to the HOWL table with various, unique, and significant backgrounds and skills.

locations. The collaboration of diverse ideas, backgrounds, and skills from each individual organization and member make this project valuable as a participatory research project (Figure

3). A citizen science team must consist of individuals who can contribute alternate perspectives and who possess a variety of areas of expertise (Bennett et al., 2010). Such a team will promote collaboration that will help solve a project's mission and goals.

1.2.3 HOWL Goals

As one of the project creators, I have categorized HOWL's mission to achieve the following four goals: (1) to learn, (2) to teach, (3) to make a difference, and (4) to foster partnership and collaboration within the community. To be clear, these four goals have been created for the HOWL project, not for the purposes of this thesis.

The first goal of HOWL was to collect data to increase understanding of North Carolina's rapidly changing coast due to the threats of sea-level rise, flooding, deforestation, agricultural expansion, and new substantial developments. The HOWL project seeks to gain knowledge of water quality, and quantity, of the White Oak, New, and Trent Rivers in and around the Hofmann Forest in Eastern NC to understand the forest's significance in the inner coastal plain. Citizen scientists will assess water quality using parameters developed by the Izaak Walton League of America (IWLA). Currently, the protocols, specifically the biological properties of sampling benthic macro-invertebrates, are established for freshwater sources, whereas Eastern NC's waters are brackish waters, a mixture of salt and freshwater. Thus, the HOWL team develops, documents, and analyzes benthic macro-invertebrate samples to aid in the formation of brackish water quality protocols.

The second goal of the project is to teach. As Cooperative Extension, IWLA, and NC State University have been the three key collaborators and project managers of HOWL, we wish to educate individuals in the area. We hold "training the trainer" sessions so citizen scientists can, too, be the ones teaching others and potential HOWL participants about water monitoring and

natural resource management in their area.

The third goal of the HOWL project is that participants learn the importance of water stewardship and conservation. Volunteers learn about the relevance of water quality to the health of ecological communities, and that how people treat watersheds determines the health of ecosystems downstream. Conserving forest habitats is essential to help humans sustainably manage the local's resources, and, through the HOWL project, volunteers learn to appreciate ecosystem services, and the importance of natural resource management. Citizen scientists gain hands-on experience and fieldwork of water systems within their local surroundings. HOWL citizen scientists not only learn how to take water samples, but learn scientific methods, protocols, and analysis processes. They learn how to collect water quality, and wildlife, samples accurately, and how the importance of following scientific parameters is critical for research and decision-making.

The fourth goal focuses on the enhancement of a robust collaboration among stakeholders, organizations, and partners. The project's partners consist of the IWLA, NC Cooperative Extension Service, Boy Scouts, 4-H clubs, White Oak-New Riverkeeper Alliance, homeschool groups, and other interested individuals in the community. The establishment of volunteer collaboration among these various disciplines and interests bring the project innovative ideas, solutions, and outlooks.

1.2.4 HOWL Outcomes to be Evaluated

The goals previously discussed were established so that they may achieve scientific, individual, and socio-ecological outcomes, drawn from a framework constructed by Shirk et al. (2012). The three outcomes -- scientific, individual, and socio-ecological -- cannot be met without the utilization of local interests and participatory approaches.

As discussed by Shirk et al. (2012), there are various outcomes associated with specific approaches in "public participation in scientific research" (PPSR), another way to phrase citizen science. To influence natural resource conservation and management, PPSR projects commonly strive for outcomes within three categories:

- Outcomes for research (e.g., scientific findings);
- Outcomes for individual members (e.g., obtaining new knowledge);
- Outcomes for socio-ecological purposes (e.g., building community networks and relationships) (Shirk et al., 2012).

However, not all PPSR projects address all three of the outcome types. Depending on the project, the outcome types are based on the activities, or inputs, performed (Figure 4). The PPSR outcome types examined by Shirk et al. (2012) were used for the establishment of HOWL's

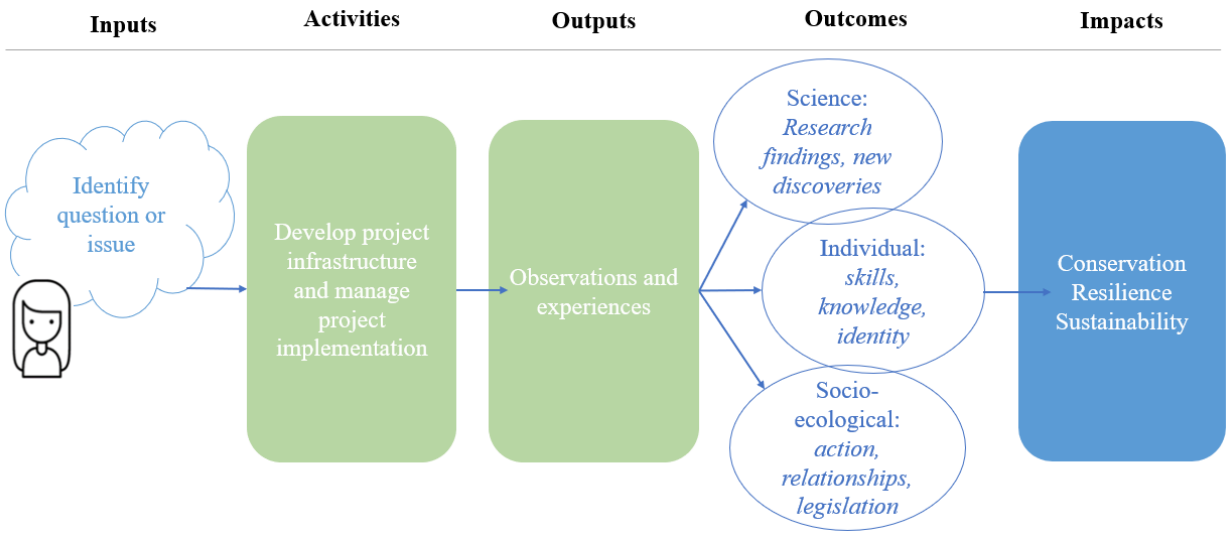

Figure 4: PPSR project's outcomes and impacts result based on the inputs, activities, and output performed by citizen scientists (Adapted from Shirk et al., 2012).

projected outcomes. PPSR projects must balance the inputs from scientific interests, as well as public interests. Table 1 addresses the necessary planning components of PPSR for the HOWL project, as well as the outcomes that I have predicted to hear from the interviewees. In this thesis,

discussed in Chapter 2, I will analyze only the socio-ecological and participant outcomes of the HOWL project based on the interviews from HOWL participants. As the water quality data is continuously collected by citizen scientists, we hope that we can evaluate the scientific goals of HOWL.

Table 1: Predicted outcomes and impacts for the future of HOWL based on Shirk et al. (2012) PPSR framework

	Strategies →		Targeted HOWL Results	
Inputs	**Activities**	**Outputs**	**Outcomes**	**Impacts**
Time to collect data	Training trainers	Citizen scientist observations	Increased knowledge of water quality monitoring	Appreciation of environment
Citizen scientist interests	Measuring parameters	Citizen scientist experiences	Increased understanding of scientific procedures	Appreciation for Hofmann Forest and White Oak, New, Trent Rivers
Equipment and testing materials	Reporting and analyzing data		Increased public awareness	Closer relationships with community groups
Permission to use site locations	Networking with community members and organizations		Changed behaviors towards environmental stewardship	Sustainable actions for Eastern NC
Develop scientific questions	Recruiting citizen scientists		Gained collaboration with community organizations	

1.2.4 HOWL Project Framework

When designing the format of the HOWL project, I followed the Citizen Science Program Model developed by the Cornell Lab of Ornithology (CLO). CLO manages many citizen science projects, attracting participants from across the nation. The lab designs their projects to answer scientific questions while informing the public of ecological systems (Bonney et al., 2009). The model used for the HOWL design was constructed by members of the lab to fulfill goals of recruitment, research, conservation, and education. The CLO model for developing a citizen science project completes the following nine steps: (1) choosing a scientific question(s), (2)

forming a leadership team, (3) developing, testing, and using protocols and data forms, (4) recruiting participants, (5) training participants, (6) accepting, editing, and displaying data, (7) analyzing the data, (8) sharing and dispersing the results, and (9) evaluating the outcomes.

Step 1: Choosing a scientific question

The HOWL project will analyze the water quality of the New, Trent, and White Oak Rivers. All of which flow out of the Hofmann Forest. We are also interested to evaluate Hofmann's location in Eastern NC and determine how it may affect the surrounding human and ecological community.

Monitoring of water quality, and quantity, is urgent in eastern NC. There are some existing chemical and physical metrics that are monitored between state, federal, county, and citizen science groups for water quality in the target watersheds (Figure 5). However, these locations do not monitor the same metrics at the same time or place. Therefore, participatory approaches will focus on utilizing citizen scientist efforts to best leverage existing sites for consistent measurements, as well as including additional sites around the forest. Additionally, this approach will serve to identify new areas to improve spatial representativeness for monitoring, and to ensure data quality.

Forests provide ecosystem services, including water quality filtering that removes excess nutrients and toxic pollutants from the environment (Lautenbach et al., 2012). Forests also prevent erosion. Water quality in eastern North Carolina are at risk of harmful substances due to deforestation, sea-level rise, substantial development, agricultural expansion, and concentrated animal feeding lots (Edwards & Driscoll, 2008; Huffman & Westerman, 1995; Government Accountability Office, 2008; Nicole, 2013; U.S. Geological Survey, 2018) (Figure 5). We hypothesize that Hofmann Forest reduces levels of nitrogen, phosphorous, heavy metals, and

pesticides. All these substances can be partly or temporarily removed from soil or rivers (Lautenbach et al., 2012; Semlitsch & Bodie, 2003).

Additionally, there is value in the forest's water regulating service for human purposes, including: decreased water quality treatment costs, increased aesthetic values for tourism pleasures in eastern NC, and increased fishing harvest for commercial, recreational, and tourism

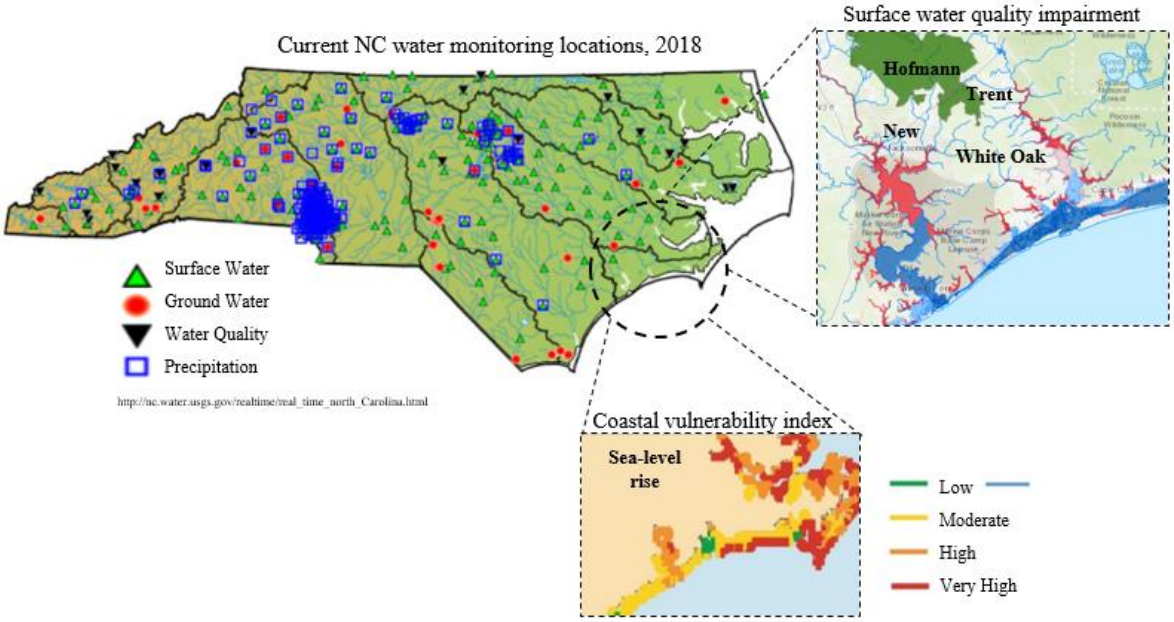

Figure 5: North Carolina map representing water monitoring locations in White Oak River Basin, as well as threats of water quality impairment and sea-level rise issues (USGS, 2018).

audiences (Brauman et al., 2007; Lautenbach et al., 2012; Loomis, 2000). Without the Hofmann Forest

providing as a crucial ecosystem service, the rest of eastern NC further downstream would lose significant social, environmental, health, and economic benefits. These benefits of the Hofmann Forest provide the basis for several targeted hypotheses important to the HOWL project:

H1: Water quality on more developed land use is worse than on forested land use

H2: Planted forest water quality is equal to natural forest

H3: Citizens can collect scientifically valid data

H4: Citizen science efforts are sustainable for natural resource management and conservation

The initial stage of this integrated citizen science project was set in the North Carolina

Figure 6: Major River Basins of North Carolina (North Carolina Office of Environmental Education, 2016).

Coastal Plain described by the region delimited by Jacksonville on the west, Kinston on the North, New Bern on the east, and the Atlantic Ocean on the south. The area largely contains the watersheds of the White Oak, New, and Trent Rivers which flow from the Hofmann Forest in Jones and Onslow County to the Atlantic Ocean. This region is called the White Oak River Basin (Figure 6).

Five sites scattered on the White Oak, New, and Trent rivers, and their tributaries, have been selected to perform water quality, and quantity measurements. The sites are situated in Onslow, and Carteret, Jones Counties. The sites were chosen due to their proximity to the Hofmann Forest, and the topography of the watershed, allowing runoff to drain towards in the direction to the east coast. Also, they were selected due to their safety, accessibility, and proximity to HOWL participants.

Step 2: Forming a leadership team

Bonney et al. (2009) express the importance of developing a leadership team comprising of multiple disciplines to form a successful citizen science project. The HOWL leadership team is composed of representatives from the conservation and youth groups. The leadership team is individuals who carry a managing role in the project. They also lead team members in data collection and assist in training the trainers. The representatives have completed the training using the water monitoring protocols established by the Izaak Walton League of America.

The majority of the HOWL leadership team are Scout leaders, 4-H directors, adult IWLA members, White Oak-New River Keeper members, and homeschool teachers. The leaders collaborate, acting as representatives from their prospective organization. The project design organizes the trainers as the "leader" of the monitoring site. Each site leader will lead and instruct water monitoring protocols with their groups. Also, they are responsible for collecting all data sheets at the end of the collection day and reporting back to the rest of the representatives.

Step 3: Developing, testing, and using protocols and data forms

For accurate water monitoring results and data collection, it is necessary to train and educate HOWL citizen scientists on standard monitoring protocols. Protocols are a formal design for citizen scientists to follow to collect data (Bonney et al., 2009). They are simple and clear to understand for users who may not be familiar with the field. The protocols used for the HOWL project were adopted by the Izaak Walton League of America (IWLA) Creek Freak's program. The Creek Freaks program has created data sheets for citizen scientists to record biological, chemical, and physical measurements. The HOWL groups will complete the forms at each site visit. The data forms follow the project protocols and used in data analyzation (Bonney et al., 2009). Copies of the data forms are shown in Appendix B.

Additionally, three videos are posted on the HOWL website (hofmanncitizenscience.com) for members, and other interested individuals to refresh or learn testing chemical, physical, and biological properties. The videos are available for all members to refresh their knowledge of sampling water quality, and quantity, parameters so that they may be ready in the field. The videos demonstrate how to perform the sampling and the equipment needed for each parameter. Following procedures and understanding the processes are crucial for data quality assurance.

Step 4: Recruiting participants

The HOWL project reaches out to all ages and individuals, especially to less-involved and minority groups in the rural counties. HOWL, also, reaches to inner-city schools, local youth organizations, and conservation groups in Jones, Onslow, and Carteret Counties by aligning our goals with the community's interests. For people who live near the Hofmann Forest, the knowledge of the quality of the watershed's impact on the nearby communities can prompt many to become involved to help understand the quality of the water in their area.

The most vital persuasive strategy employed for recruitment is relating the project to volunteers on a personal level (Petty, 1981). Those who feel personally responsible for and associated with HOWL or the Hofmann Forest are those who will be most likely to participate. Therefore, two specific strategies were used to personally connect participants to the HOWL project: (1) stressing the need for clean water for individuals in and around the eastern North Carolina, as well as (2) promoting the ability for volunteers to learn and gain opportunities they would not have achieved otherwise (such as building and maintaining community and individual relationships).

There are common interests among public volunteers in other environmentally-related citizen science projects that may help us determine the motivations for participants in HOWL for the future. For example, these common interests include contributing to scientific knowledge, making scientific discoveries, collection and dissemination of information, affecting resource stewardship, protecting livelihoods, or satisfying personal identities and learning goals (Shirk et al., 2012). Many of these participants will be minors, so their intentions may be more linked with the organization or institution (e.g., Boy Scouts) through which they are involved in HOWL. For example, a teacher from Beaufort Elementary School may be motivated by her interests in environment and science, but students will be more interested in how participating in HOWL will affect their curriculum and grade for their class (Domroese & Johnson, 2017). Furthermore, a teacher or scout leader may be motivated to participate in exposing their students to science and environmental stewardship and may not desire a direct learning experience for themselves (Domroese & Johnson, 2017). Nonetheless, this project aims to devote its resources to ensure participants feel that their interests are important to the HOWL science team and the project as a whole.

Motivation is a significant behavioral component and is imperative to impacting positive performance patterns (Denhardt, 2016). While the HOWL team plans to emphasize the socio-ecological goals of community building and conservation stewardship to volunteers, motives related to factors such as loyalty, duty, citizenship, and values of social equity may exist. Like goal-setting approaches, public service and community networking motivation may arise from an individual’s commitment to governmental policies or function. This theory, developed by Perry and Wise (1990), states that public service or stewardship practices are supported by people’s feelings, emotions, and beliefs.

To gain interest and recruit project membership, the leadership team held a HOWL Science Kick-Off event on October 5, 2017. The event was held at the White Oak Campground sampling site and advertised to the campground residents and visitors, and other members of the community. The team posted flyers in community centers, schools, and other local meeting points in Onslow, Jones, and Carteret Counties. The flyer contains the HOWL team contact information and general event information to engage prospective participants (Appendix C). The event gave a preview of water quality and benthic macro-invertebrate sampling to engage attendees to become HOWL citizen scientists and continue to participate in the project. There was also an extensive write-up of the event in the Carteret County News-Times, which helped promote citizen scientist participation and recruitment.

Another recruitment mechanism is the HOWL website. The website (hofmanncitizenscience.com) acts as an engagement strategy for HOWL citizen scientists and potential participants. The site will motivate and encourage citizen scientists by recognizing their achievements, and participation. The will provide updates and images from fieldwork days or outreach events. It offers potential members to sign-up to become involved, as well as learn the first steps of participating in HOWL. When creating the web design, it is important to recognize the diverse audience whom may come across the page. Many individuals may approach the page with little to no scientific background, or experience with water monitoring sampling. The designers have adapted the website's language and content with simple and clear wording for those who may not be familiar with the scientific or natural resource field. Volunteer recruitment and retention centers around usability, accessibility, and attractiveness of the website. The utilization of user feedback will enhance and revise the site, as well as meet the needs of the project and its citizen scientists (image shown of website show in Figure 7).

Figure 7: Website for HOWL citizen scientists and potential participants (hofmanncitizenscience.com).

In addition to the website, a HOWL Twitter handle, @HOWLScience, has been established to connect, and advertise, to potential citizen scientists. Social media networks integrate HOWL citizen science findings with other participatory research projects collecting similar information across the nation and globe. The social media outlet solicits innovative ideas, increases participant participation, and enhances problem-solving and critical thinking (Chun & Reyes, 2012; Khan, 2013; & Khan et al., 2014). The HOWL Twitter page promotes interactions between groups and users through sharing information, opinions, and interests (Khan et al., 2014).

Step 5: Training participants

Training procedures are adapted from the IWLA Creek Freaks program. The HOWL project adopts the “training the trainer” approach. Once a member is trained, they then train their group to adequately monitor and collect data. The training process helps reach the goals of getting participants to understand, learn about, and follow the scientific method. Not only do the protocols mandate step-by-step processes that require precise measurements, but participants are

also be required to enter the same data in multiple locations. The training protocols explain the purpose of various data entries, and the importance of precise measurement. Bonney et al. (2009) discuss providing citizen scientists with training allows for confidence gain in their data-collection skills.

The monitoring protocol videos (as previously discussed) were created for trainers, and newly-trained members to review and practice the water sampling procedures. Participants should refer to the videos before entering the site to familiarize themselves with the steps and materials.

Step 6: Accepting, editing, and displaying data

HOWL data collected via paper data forms will be accepted, edited, and analyzed by citizen scientists. In addition to acting as a recruitment strategy, the HOWL website is a tool to store and display water monitoring data, as well as camera trap deployment images to the public. Displaying the data and images allow the public to see that their collected data is being used (Bonney et al., 2009). The web presentation of data and dynamic maps with the ability for citizen scientists to view their observations in near real time will help build capacity within the network, contributing to overall sustainability and enhancing participant retention.

Step 7: Analyzing the data

The water quality data are in the process of being analyzed. The project designers will take similar strategies to data analyzation as the CLO model. However, the HOWL project recognizes that there may be potential biases based on personal motives of participants. Specifically, conservation NGOs and outdoors groups may report incorrect results if they believe this will assist in a political agenda in which they support.

After substantial data have been collected, the data will be analyzed to determine their contribution to the research questions. Because of the lack of knowledge of data analytics across citizen scientists, the project will also require a data analyst. Having an analyst will allow HOWL to represent data to support scientific inquiries statistically. Day-to-day quality assessment will be the responsibility of the leadership team. The project hopes to find a qualified data manager who will act as a steward of the data while they are being collected, processed, and analyzed. Should personnel changes occur, all data management and sharing responsibilities will be transferred to members of the leadership team who will be given access to all documents and electronic files. IWLA and NC State University will have primary responsibility for how the data will persist over time if the original collaborators are no longer active with the project.

Community researchers, collaborators, and citizens will be able to view existing- and user-generated data. Additionally, data can be uploaded by citizen scientists through smartphones or tablets via the iNaturalist application (website: www.inaturalist.org/projects/hofmann-citizen-science). iNaturalist is a citizen science service designed to offer an innovative and participatory approach to engage citizens in enhancing data, incorporating the use of other data collected in the area, helping citizens better understand the world in which they live, and extending the reach of community and other organizational networks. The data will be reviewed primarily by the data manager before posted for the public. Any errors or data concerns will be eliminated from the data set and not provided in the enterprise system.

Data gathered by the HOWL members will be stored and compared with current and archived water quality data provided by NC Extension Service in Onslow County, NC State University Hofmann Forest, and NC Department of Environmental Quality. The nutrients and

water properties monitored vary between the organizations. However, some of the chemical and physical properties overlap (Appendix A). HOWL is the only partnering organization that monitors biological properties, using benthic macro-invertebrate indicators. For quality data assurance, as well as for scientific discoveries, it is necessary to compare HOWL citizen science results and patterns with the data presented by the project's partners. Both accuracy and precision of the datasets, as well as any other statistical analyses that could assist us with quality analysis.

Step 8: Sharing and dispersing the results

The HOWL team is in the processes of sharing and dispersing the collected data.

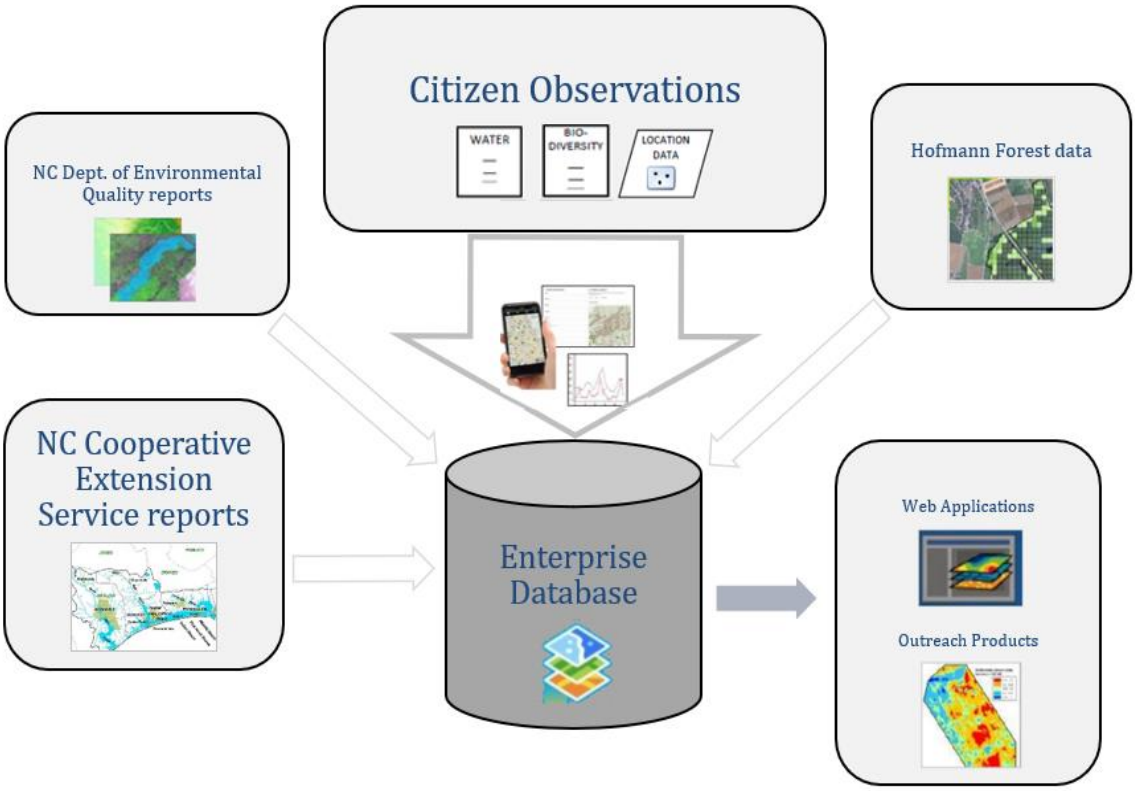

Figure 8: Model displaying data efforts integrated with NC Cooperative Extension Service in Onslow County, HOWL citizen scientist observations, existing Hofmann Forest data provided by the forest manager, and NC Department of Environmental Quality. The long-term goal is these inputs will be collected and maintained in such an enterprise spatial database housed in the Center for Geospatial Analytics at NC State University. When the HOWL project begins to obtain large quantities of data, it will be necessary to switch to a larger, and more collaborative, network.

However, the data that has already been recorded by citizen scientists is available to the public via iNaturalist and the HOWL website. The public online database will be updated and compared to the results generated by NC Cooperative Extension Service, NC Department of Environmental Quality, and Hofmann Forest manager (Figure 8). Having a combined database provides a data sharing mechanism for researchers, citizen scientists, and non-governmental organizations to offer a new, and innovative, interdisciplinary opportunity for research and engagement. The data to be produced will be of interest to scientists who wish to understand the water quality of watersheds within eastern North Carolina, as well as to the youth citizen scientists who collected the data. In addition to the research community and citizen scientists, these data will be used by natural resource managers, practitioners and policymakers.

Step 9: Evaluating the Outcomes

Chapter 1 explores the process of how HOWL formulated its project based on CLO steps 1 through 8. Chapter 2 and 3 are the primary sections of this thesis study. Chapter 2 analyzes the results of the perceptions and perspectives from HOWL participants to assist evaluating the outcomes. Chapter 3 examines the CLO model step 9 and evaluates the socio-ecological and participant outcomes, discussed by Shirk et al.'s PPSR model. According to Jollymore (2017), much of the literature in the citizen science field focuses on the data and scientific discovery successes. However, many scholars have not investigated the perspectives and perceptions of the participants.

Thus, the objectives of this thesis on the Hofmann Open-Water Laboratory were:

- To assess how well HOWL achieved our outcome of community engagement and collaboration.

- To assess the degree if HOWL participants constructed sustainable community relationships and networks.
- To assess how well HOWL participants achieved their personal outcomes while participating in the HOWL project.

Step 1	Choosing scientific question(s)
Step 2	Forming a leadership team
Step 3	Developing, testing, and using protocols and data forms
Step 4	Recruiting participants
Step 5	Training participants
Step 6	Accepting, editing, and displaying data
Step 7	Analyzing the data
Step 8	Sharing and dispersing the results
Step 9	Evaluating the outcomes

- To determine if HOWL participants believe if the HOWL project will be sustainable for the future.

CHAPTER TWO: ASSESSING HOWL SUCCESS

2.1 Introduction

The purpose of this study was to evaluate the Hofmann Open-Water Laboratory (HOWL) citizen science project and its participant's goals. This study evaluates if citizen scientists have achieved their personal outcomes through the project and if HOWL has achieved their goal of community collaboration and networking. The results will be used to help implement the citizen science project, so it may be maintained in the future by the volunteers, as well as continue to nurture collaborative efforts.

This chapter explores the final step in Cornell Lab of Ornithology (CLO) model. Step 9 in a citizen science project design is to "measure the outcomes and impacts" of the project (Bonney et al., 2009). In this final step, the project outcomes and outputs should be measured to assess if the project met its science, individual, and socio-ecological goals (Shirk et al., 2012). I measured two of the three citizen science outcomes discussed by Shirk et al. (2012): individual and socio-ecological. I evaluated whether the HOWL project's citizen scientists achieved their personal goals while participating in the project (i.e., individual objectives), as well as the increase in community engagement and collaboration between the various organizations (i.e., socio-ecological objectives).

Expected individual objectives from the responses included an increase in understanding of scientific subjects and/or field research (Ballard & Belsky, 2010; Shirk et al., 2012; Trumbull et al., 2000), a deepened relationship with other community members and organizations (Bell et al., 2008; Kountoupes & Oberhauser, 2008; Overdevest et al., 2004; Shirk et al., 2012), and/or an

enhanced sense of place and/or stewardship (Evans et al., 2005; Shirk et al., 2012; Wilderman et al., 2004a; Wondolleck & Yaffee, 2000). As for socio-ecological outcomes, I expected responses such as an increase in community engagement and/or collaboration (Ballard et al., 2008; Shirk et al., 2012; Tudor & Dvornich, 2001; Wondolleck & Yaffee, 2000), increased access to natural resources management, data, and educational outreach programs (Overdevest & Mayer 2008; Shirk et al., 2012), and/or an increase in likelihood of future collaboration between participants on other projects, especially engaging in public policy and decision-making (Overdevest et al., 2004; Shirk et al., 2012; Wilderman et al., 2004a). While I measured these two objectives, I gained further information on how the project could be improved or re-designed for its future continuation.

As discussed in Chapter 1, the objectives of the study on the Hofmann Open-Water Laboratory were:

- To assess how well HOWL achieved their outcome of community engagement and collaboration.
- To assess the degree if HOWL participants constructed sustainable community relationships and networks.
- To assess how well HOWL participants achieved their personal outcomes while participating in the HOWL project.
- To determine if HOWL participants believe if the HOWL project will be sustainable for the future.

2.2 Qualitative Research Approach

I chose a qualitative research approach to achieve the study's objectives and gather information from the HOWL participants. Qualitative research as defined by Denzin and Lincoln

(2005) is “a complex, interconnected family of terms, concepts, and assumptions.” Qualitative research models are often used to describe the perceptions and beliefs of a group of individuals such as students in a chemistry classroom (Phelps, 1994) or this case, citizen scientists in the HOWL project. Unlike quantitative approaches, a qualitative framework may not experimentally examine or measure terms of quantity, amount, or frequency (Denzin & Lincoln, 2005). However, instead, it focuses on questions about how social experiences are created and give meaning to projects. A qualitative structure may contain a mixture of a few empirical tools. However, in this study, I focused on the words and perceptions of the interviewees.

Qualitative researchers use methods to examine issues in-depth and in detail (Anderson, 2010). Such methods include, but not limited to: interviews, document-review, focus groups, and observations (Anderson, 2010). I assessed the HOWL participant perceptions through semi-structured interviews. Interviews as a tool for data collection can reveal complex experiences and ideas that are more compelling than quantitative data. For the HOWL project, I chose this method because interviews allow for thorough and comprehensive human experience information of a certain case, which may not represent the broader population. Interviews can also be re-structured and easily revised as new information is gathered. In addition, an interview structured is not restricted to a set number or specific questions (Anderson, 2010).

However, there are limitations of such qualitative approaches that are necessary to understand. Qualitative research may sometimes be manipulated by researcher’s personal biases (Anderson, 2010). The interviewee’s words and opinions can be interpreted and understood by the interviewer differently than anticipated. Also, the presence of the interviewer impacts the responses given by the interviewee (Anderson, 2010).

I took necessary steps to limit bias and data validity and credibility. To provide comprehensive data from the participants, thorough note-taking and audio recordings were utilized. After each interview, I used the audio recordings to transcribe the responses of the participant. In cases of uncertainty, the investigator summarized and reciprocated the participant's statements to clarify their meaning. However, the limitation of accurate responses due to the presence of the interviewer is often unavoidable in qualitative approaches (Anderson, 2010).

2.3 Methodology

The data collected were through semi-structured interviews with HOWL participants. Interviews are a beneficial method to gauge the reality of experiences of people who took part in them (Peräkylä, 2005). Through this approach, project participants were asked open-ended questions. If interviewees answered with a "yes" or "no" or similar responses given little information, I encouraged the participants to expand on their answers. An interview questionnaire was designed to gather participant's perceptions of the project.

The interview script was constructed before the interview process (Appendix D) and submitted to North Carolina State University IRB (Appendix E). The questionnaire was developed to discover the impacts of the project on the citizen scientists, how they believed the project could be sustained, and their opinions on working in a collaborative setting. The questions covered topics of project sustainability, collaboration with other partners and HOWL members, and individual goals and perceptions. Table 2 was developed for use during the interview process. The questions were grouped according to the research objectives for the study.

Table 2: The questionnaire used during the interview process

Measurable Outcomes	Question Number and Interview Question
Socio-ecological Outcomes	Q1: Did you (or your organization) work together with other community groups or networks before the HOWL project?
	Q2: Do you think all community partners will continue to work together on this project?
	Q3: Do you think the HOWL project can continue without collaboration from all partners?
	Q4: How do you work with the other community groups and organizations?
	Q5: Do you think other partners are apt to join the efforts? If so, who?
	Q6: Do you think you (or your organization) will work with one (or more) of the other partners on projects other than HOWL in the future?
Participant Outcomes	Q7: What worked well in the citizen science training?
	Q8: What can be improved on in the citizen science training?
	Q9: How well have you achieved your personal objectives related to the citizen science project?
	Q10: If you achieved a personal objective from the project, what helped you achieve it? If you have not, what could have been done (by the project) to achieve your objective?
Project Sustainability	Q11: What components worked well and should be maintained to sustain the HOWL project for the future?
	Q12: What components should be improved on when trying to sustain the HOWL project for the future?
	Q13: Do you feel confident that the project will continue another year? How about five years?

Attempts were made to contact 17 HOWL participants. HOWL participants were invited to participate in the interviews via email (Appendix F). The participants contacted were individuals who participated showed commitment to the project and completed more than one monitoring activity. 12 individuals (*N*=12) who were contacted responded (70% participation rate). The other 5 individuals out of the initial 17 HOWL participants never responded to my

initial email. These individuals have not attended a monitoring event since I sent the email asking to participate in the interview. None of the 5 remaining individuals completed a HOWL training session.

Interviews were conducted over the phone and in-person. 3 of the interviewees had participated in monitoring activities only once, while 9 had participated 2 or more times. The ages ranged between 26 and 65 years old; 2 males and 10 females. All interviewees permitted to audio record their interview session. I took extensive notes during each session. Each interview took between 30-60 minutes. All organizations involved in the HOWL project were represented in the interview process.

2.6 Analysis

Because the data acquired were relatively small, I analyzed all data by grouping all repeating themes, underlying patterns, or concepts that emerged (Glaser & Strauss, 1967; LeCompte, 2010). Then, I grouped the themes into categories and compared them to one another. Spradley's semantic relationship theory was used to define the categories clearly (Figure 9). For example, I substituted "social media" as a kind of "recruitment," as well as "planning" is a part

1. X is a kind of Y	7. X is a place for doing Y
2. X is a place in Y	8. X is used for Y
3. X is a part of Y	9. X is a way to do Y
4. X is a result of Y	10. X is a stage or step in Y
5. X is a cause of Y	11. X is a characteristic of Y
6. X is a reason for Y	12. X is a place for doing Y

Figure 9: Spradley's semantic relationship theory (LeCompte, 2010).

of "collaboration." Identifying patterns and themes help reveal a clear description of the project, as well as solve key problems that occurred and create explanations for events that happened (LeCompte, 2010). The groups were then sorted to fit into the overarching categories: individual

outcomes, socio-ecological outcomes, and project longevity, which are discussed in the following section.

2.7 Results

2.7.1 Perceptions Regarding Socio-ecological Outcomes

Collaboration. Nearly half of participants (*n*=5) indicated they had never worked with any of the other organizations or members before the HOWL project. 58% of participants (*n*=7) stated they had worked with at least one of the organizations, but the collaboration was minimal. The participants that stated that there was "minimal involvement with the other groups" acknowledged that the collaborative efforts were only with the Izaak Walton League (IWLA). One member of the IWLA, CS5, stated, "we had worked together but not very well, nor effectively." The members that stated "no" expressed that this was the first project that they had worked with the other groups.

When asked if participants believed all partners would continue to work on HOWL together, nearly two-thirds (*n*=7) answered "yes," while the remaining (*n*=5) responded "maybe." Participants that stated phrases like "yes, but…" or "yes, if…" were considered as a "maybe." For example, CS8 responded, "yes, if there is funding available… and if interest continues to grow." The interviewees that responded with an affirmative "yes" were counted as "yes." For instance, CS6 said, "yes, we plan to expand and do more this year." No members believed that the partners would not continue to work together.

All participants (*n*=12) indicated they believed the HOWL project would not continue if any of the partners were to drop out of the collaboration. For instance, CS3 said, "collaboration is vital for it to really grow into a successful program". A couple of participants (*n*=2) revealed that it was crucial for the IWLA to continue to be involved in the project. CS10 answered,

"IWLA plays a big part and role… they are the main pusher in the program." However, CS6 expressed the importance of the University's involvement in the project, stating, "My credentials don't mean much, but it looks good to have NC State University involved." CS7 responded similarly to CS6, saying:

> If we are trying to get children involved, it is good to show the kids in this area about college. In eastern North Carolina, it's very rare for people to have a bachelor's degree. It's not often that a graduate or college student come talk about the river – other than the use for recreation – but about the health of it. This program is a STEM [Science, Technology, Engineering, and Mathematics] activity for them and if we are going to pursue and address college and career for children, it is important to have higher education involved.

90% of the respondents (*n*=11) indicated they plan to work with one (or more) of the other partners in the future other than on the HOWL project. For instance, CS2, said, "I plan to go and talk to the Scouts and other school groups to discuss other environmental subjects outside of water quality." The remanding (*n*=1) expressed they only plan to work on the HOWL project, responding, "No, not on other projects, but more work on the HOWL project."

Participant's Roles in Collaborating. I was interested in the participant's expertise and various roles that they brought to the collaboration. The interviewer asked how they worked with the other organizations. Three categories emerged from this question: (1) education (e.g., leading 4-H groups in educational activities), (2) networking (e.g., communicating and recruiting with other citizen scientists), and (3) statistical or technical work (e.g., water quality analysis).

Nearly half of the participants (*n*=5) indicated they work with the other organizations for educational purposes. These participants expressed they were a leader of youth or school group in which they lead environmental education activities. For example, CS2 said, "I set up workshops for 4-H groups… I also work with school and Scout groups… I set up different educational stations at the Farmer's Market, Growing Minds program, and Earth Day event." CS10, also, stated, "I am a Cub Scout leader and homeschool mom… every time the kids find a

creek we try to go see what critters we can find." Also, all participants (*n*=5) in this "education" category had completed the "trainer's training," thus, able to lead and educate other citizen scientists in the water monitoring procedures.

One-third of the participants (*n*=4) indicated they communicated with or recruited other participants. I categorized this as "networking" skills. For example, CS8 described themselves as "a communicator to the public to make sure there is involvement." Similarly, CS3 said, "I communicate and work to bring the expertise, people, and enthusiasm to the project." Additionally, CS5 specifically categorized themselves as a "networker," stating:

> I'm a networker… I work with people who have a common interest. We are always going to have the Hofmann Forest close to us. The forest and what we can do to save the White Oak River is what bring us together. It's headwaters in the Hofmann are some of the most pristine waters. The river and its health are the common denominators that bring us together.

A couple of participants (*n*=2) noted the expertise they shared with the HOWL group. I categorized this as a "technical or statistical" skill. For example, CS4 reported, "I work on the statistical analysis side of the water quality data that has been collected."

Every participant that answered this question (*n*=10) stated they directly worked with at least one other organization in the HOWL project.

Potential Collaborators and Future Efforts. Respondents identified different local and community groups and organizations as partners apt to join in the HOWL project. Seven categories emerged from the responses: (1) teachers (excluding homeschool teachers), (2) community colleges and universities, (3) day and summer camps (including after-school programs), (4) Camp Lejeune Marine Base, (5) non-profit organizations, (6) municipalities, (7) additional homeschool and Scout groups.

One-third of the participants (*n*=4) acknowledged teachers as an excellent audience to reach. For instance, CS3 noted, "we need to reach out to high school teachers… I know some of

the agriculture and science fields are interested. Additionally, CS6 suggested to engage teachers, saying:

> We need to throw it out there to the schools in this area. Teachers don't want you to drop-off a flyer. They are always looking for free STEM activities or presenters.
> In this area, the majority of the day spent for teachers is math and reading, but social studies and science is extra…. Also, it's hard to get parents to commit and bring the students to anything educational, so these types of activities are left up to the teachers.

A few participants (*n*=3) noted that the project should recruit community college and research university professors and students. CS2 noted, in particular, Coastal Carolina Community College and said, "those students may want to get involved… I know they need a certain number of volunteer hours." CS6 agreed and stated:

> I would like to see some involvement from the local community colleges who might be interested. When you think about this area, there are not many large universities. In Onslow and Carteret Counties there are community colleges and lot of good things are happening at these little 2-year schools. Maybe we can get some of the students involved who are thinking about transferring to 4-year schools, too.

Some interviewees (*n*=2) perceived day and summer camps or other after-school programs as a good avenue for children to become involved. For instance, CS9 said, "we haven't tried publicizing to after-school programs in the area… I think there could be more day camps involved, also." CS1 answered similarly to CS9, saying, "I think a good audience is anyone who has a summer camp for children – maybe county day camps, recreation camps, and camps for Boy Scouts and Girl Scouts.

A couple of respondents (*n*=2) expressed the need to reach out to the marine base, Camp Lejeune, in Jacksonville, NC. CS7 said:

> We should be talking to the base down here. The scientists on the bases are interested in the same tests that we are taking. I think they would be happy to be involved… Especially get the schools on the base and have kids check the rivers. We can get the professionals from the field to show the kids. Also, they have a lot of resources and power – they are the economic driver in eastern North Carolina.

Several citizen scientists (*n*=3) suggested that the project should engage nonprofit organizations in the area. In particular, CS8 suggested, "North Carolina Coastal Federation because they are interested in the same things we are… educating and gaining knowledge of water quality." CS10 proposed to mobilize the "Boy's & Girl's Clubs in the area."

One participant (*n*=1) suggested to reach out to nearby towns that the White Oak River flows through, CS5 saying, "We need to reach out to the town of Swansboro, the town of Peletier, and their planning boards… We need to get some municipalities in here and educate the officials."

Some respondents (*n*=3) proposed to engage additional Scout and homeschool groups. For instance, CS10 identified other Boy Scout and Cub Scout groups, saying, "I think we should go to the councils and their district meetings… even their day camps. I think we would get a lot more participation. We haven't done that route at all yet."

2.7.2 Perceptions Regarding Participant Outcomes

In response to questions about the achieving a new skill or goal by participating in the HOWL project, three-fourths of respondents (*n*=9) explained they first joined the project with some initial objective or goal in mind (Table 2). The remaining that responded to this question (*n*=2) said they did not have a goal, initially, they wanted to work toward. CS7 stated, "I didn't really have a goal or an objective… I really didn't know what to expect or what was going to happen."

Nearly all participants (*n*=10) communicated an outcome they achieved after participating in HOWL. The remaining (*n*=1) did not feel like they had achieved a personal objective. CS1 expressed, "it was vague what my role was… I feel like I didn't fit in. I would have liked if someone told me what roles were available and where I could fill-in."

Five recurring, or significant, achieved-outcomes that participants identified emerged. Participants: (1) collaborated, (2) learned something new about science, (3) educated someone else using their expertise, (4) acted as an environmental steward, and (5) contributed to the community (Table 2).

Collaborated. Almost half of the interviewees (*n*=5) collaborated with new community groups and individuals. CS3 said, "I was guided by other people… everyone does what they do best and bring their expertise and experiences to the trainings and field days." Likewise, CS4, said, "what helped me be a part of the project was talking to the people who have participated and collected data before me… you know? Communicating with other people who have been involved and learning from them."

Learned about Science. Some of the participants (*n*=4) perceived learning scientific procedures, data collection, and fieldwork as their achieved outcomes from HOWL. For example, CS2, said, "I improved my familiarity and how to identify macro-invertebrates. I have never done that before this project." CS4 had never been involved with any sort of data collecting before, saying, "before the kick-off I have never been involved with any kind of fieldwork before… I wanted to see how water quality data is collecting… This one-day kick-off wasn't enough. It made me want to participate more and know more."

Educated Others. A few citizen scientists (*n*=2) also recognized they gained teaching and instructing skills. Participants learned the procedures that they could then educate their prospective groups, such as CS8 who "wanted HOWL to be an educational program to my organization… I want to get the board members to become trainers… I think we can then get kids out to learn about monitoring."

Acted as an Environmental Steward. One participant (*n*=1), CS5, revealed two personal goals, first, "IWLA involved in citizen science was achieved… and has brought back the name of the IWLA to the area and what we do as a conservation group." CS5 continues, "my second goal is a life-long goal… to fix the White Oak River… or allow it to fix itself… well, facilitate in helping it fix itself."

Contributed to the Community. A couple respondents (*n*=2) perceived the HOWL project as a way to recruit participation and involvement of rural communities and minority groups. CS6 believed HOWL provides the opportunity of scientific and community engagement, saying:

> For me, it was a sense of community and raising awareness about the waters and streams for families to be involved. It was so nice to see people in a rural development involved. This area, especially the town of Maysville, is one of the poorest cities in the county. Kids don't get the opportunity to learn about science and do this. So, it was nice to see kids who probably hear about it in school get involved. During the kick-off event, I thought, 'wow! This is a great, free activity for them to see science happening in their own backyard.' It was so great to see kids getting to see what technology, like the monitoring kits and microscope cameras, can do other than like texting and for them to be outside in the water and get muddy in a safe environment. These kids don't know about the White Oak or New Rivers or exactly what's out there, and a free event like this to engage them and their family is a great opportunity.

Additionally, CS12 discussed the increase of the community's value of the Hofmann Forest because of HOWL, stating, "I think we have kept Hofmann in the hearts of locals pretty well."

Table 2: Interview participant information and their outcomes achieved

Citizen Scientist	Organization represented	Completed "training the trainer"?	Had an initial personal objective?	Achieved a new skill or goal?	Outcome achieved
CS1	NC Cooperative Extension	No	No	No	N/A
CS2	NC Cooperative Extension	Yes	Yes	Yes	Learned macro-invertebrates identification
CS3	IWLA	Yes	Yes	Yes	Collaborated with other organizations
CS4	NC State University	No	Yes	Yes	Learned scientific procedures
CS5	Boy Scouts	Yes	Yes	Yes	Collaborated with other organizations Helped the White Oak River
CS6	IWLA	No	Yes	Yes	Gained "sense of community" via collaboration Raised awareness to community
CS7	IWLA	No	No	Yes	Had fun
CS8	White Oak New Riverkeeper	Yes	Yes	Yes	Educated children and adults
CS9	NC State University	Yes	No	Yes	Collaborated other organizations Learned scientific procedures
CS10	Homeschool; Cub Scouts	Yes	Yes	Yes	Educated children Learned scientific procedures
CS11	Cub Scouts	Yes	N/A	N/A	N/A
CS12	NC State University	Yes	Yes	Yes	Collaborated with other organizations Raised awareness to community

2.7.3 Perceptions Regarding the Trainer's Trainings

Over half of the participants (*n*=7) completed the citizen science training session to become a trainer.

Table 3 defines what the trainers believed to work well in the training sessions and what

What worked well in the trainings:	**What should be improved on in the trainings:**
Hands-on and organized (*n*=7)	Recruit to diverse audiences (*n*=3)
Multiple trainers to lead various stations (*n*=4)	Dates not communicated well nor planned regularly (*n*=4)
Clear instructions and comprehensive protocols (*n*=4)	Backup plan for adverse weather (*n*=2)

components still needed improvement. All participants gave positive feedback about the trainings. Three aspects participants perceived to work well emerged: (1) hands-on and organized, (2) multiple trainers to lead, and (3) clear instructions and comprehensive protocols.

Hands-On and Organized. Participants who had completed a training session (*n*=7) appreciated that it was hands-on and organized. CS1 thought the training was "well organized… so when we into the field everything was planned and ready to go." CS3 agreed, saying, "The hands-on part is good. The trainers demonstrate the part and let the trainees do the work after." Likewise, CS10 responded, "everything was prepared… I'm a sensory person and it was good to have hands-on and watch the trainer… I'm glad that I didn't have to sit inside a room all day to learn everything." CS9, also, stated "that you made sure everyone was prepared to go out into the field and when it came time to clean up the equipment, everyone had a role. It went very smoothly."

Multiple Trainers. Some participants (*n*=4) indicated having more than one trainer to lead the session was helpful. "It was good to have key trainers be involved rather than one person

taking charge," recalled CS1. Likewise, CS8 said they liked "there was more than one leader there to make sure everyone got the information and attention they needed… especially having trainers that know what's going on."

Clear Instructions and Comprehensive Protocols. A few trainers (*n*=4) expressed instructions and protocols were easily and clearly explain, especially for individuals who do not have a background with scientific protocols and field research. CS5 had a difficult time thinking of something that needed improvement, stating: "Gosh, I think it all worked pretty well… Especially the water quality methods that the national IWLA has in place… they are straight forward and easy to understand." CS9 liked that "directions were clear… trainers explained the procedures of what we were going to next and each step."

Table 3: Training component successes and suggested improvements

What worked well in the trainings:	**What should be improved on in the trainings:**
Hands-on and organized (*n*=7)	Recruit to diverse audiences (*n*=3)
Multiple trainers to lead various stations (*n*=4)	Dates not communicated well nor planned regularly (*n*=4)
Clear instructions and comprehensive protocols (*n*=4)	Backup plan for adverse weather (*n*=2)

When asked what training aspects needed improvement, the majority of the trainer participants (*n*=6) gave suggestions. Three different categories trainers recognized needed improvement were: (1) to recruit to diverse audiences, (2) dates should be communicated better and often, and (3) to have a "backup plan" for adverse weather or location conditions (e.g., high water-level rise; creating an unsafe environment for participants).

Recruitment Needs. Some participants (*n*=3) expressed that the trainings should also be "advertised to the public," expressed CS9, not just to HOWL citizen scientists. CS1 suggested

"to keep diversifying the people we are trying to reach… we should reach a broader audience." Agreeing, CS8 said to "advertise the trainers better when we establish the date."

Communication Needs. Several trainers revealed the training sessions were not held regularly or were nor communicated well to HOWL citizen scientists who wanted to become a trainer. For example, CS8 expressed their frustration with the lack of communication, stating, "keep trainers updated when the trainings are being held, so everyone is on the same page and in-the-loop… Maybe we need to establish a monthly or every-other-month trainer meeting to see who is still active and so everyone is in-the-loop." (See additional results in *Section 2.7.4).*

"Backup Plan" Needs. Based on experience, a few participants (*n*=2) noted that there was a need to prepare for a "backup plan" if there was adverse weather, or if conditions of the site were not suitable for participants to take samples. For instance, CS2 indicated, "having a good location is crucial… a place that is not too deep or too swift. A lot of the time we are regulated by weather and having a good location. We need to consider locations people can get to easily, and safely." CS9 also suggested having an alternative to unfavorable site conditions, stating, "maybe in those circumstance we can bring water samples back to the shelter, so we can look at the samples and search for macro-invertebrates, but not at the site."

2.7.4 Perceptions Regarding Project Longevity

When asked what project components worked well and should be maintained to sustain the HOWL project, seven responses evolved: (1) hands-on and interactive, (2) HOWL kick-off, (3) collaboration, (4) trainings, (5) recruitment, (6) camera traps, and (7) website (Table 4).

Hands-on and Interactive. Nearly half of interviewees (*n*=5) perceived HOWL to be hands-on and interactive, which they considered as an aspect that should be maintained. For instance, CS10 stated, "I loved the fact that my Scout kids could go and explore and dig through

the mud." Additionally, CS11 agreed that "the hands-on was the most enjoyable" and likes "digging in the mud, using the microscope, and having kids or participants operating the equipment themselves." CS3 also liked "the hands-on, demonstrating part and letting the kids do the work."

HOWL Kick-Off. Many participants (*n*=4) thought one of the best components was the HOWL kick-off. CS3 stated, "we had a great kick-off and had more people than we had even hoped for… I was very satisfied with everything." Additionally, CS9 could not believe "how well the community perceived the kick-off" and stated, "we should have more kick-offs throughout the year." Likewise, CS12 said, "the kick-off day was great" and "worked about as well as we could have hoped for."

Collaboration. Several participants (*n*=3) indicated the collaboration between partners was something that needed to be maintained when moving the project forward. CS3 felt strongly, explaining, "as long as each representative from each organization is at each event, it will stay alive… [speaking on behalf of the IWLA] This is our mission. This is our job. Collaborating is key." CS9 stated, "I really like the collaboration with the university, homeschool, Scouts, and other community groups. I think whoever organized that was a good idea. It this is a great group to work with, and I think that it can be expanded on and continue to grow."

Trainings. As previously discussed in *Section 2.7.3*, trainers (*n*=6) recognized positive components of the trainings. A few participants (*n*=2) indicated the trainings as a strong aspect of the project, which should be continued. CS9 believed "having the trainings were good," as well as CS12 who stated the trainings as "a great component."

STEM Opportunity. A handful of participants (*n*=4) felt the project itself and the opportunities it gave to the public were unique to the region. For example, CS5 indicated "there

are not a lot of STEM projects like this in the community for children to be involved in." Likewise, CS6 conveyed that teachers in the area are always looking for presenters for "STEM activities" like this one. Additionally, CS5 mentioned, "kids growing up want to be scientists and want to be involved outside and look at bugs." HOWL gives them this opportunity.

Camera Traps. A couple of participants (*n*=2) acknowledge the camera traps, located around the Hofmann Forest, was another great component of HOWL. When asked what should be maintained for the future, CS12 acknowledged, "the camera traps around the Hofmann boundaries." Similarly, CS5 believed the "camera traps worked well and should be kept and maintained at Hofmann," they continued stating, "volunteers are interested in running the traps at Hofmann."

Website. One participant (*n*=1), CS12, believed the HOWL website was "a great element" to recruit and engage participants.

Another seven components arose when participants recognized the project's overall improvements: (1) resources and funding, (2) meeting regularly, (3) additional trainings, (4) recruitment, (5) data-reporting, (6) inclusion and valuing participant involvement, and (7) a webmaster or key coordinator (Table 4).

Table 4: HOWL project components successes and suggested improvements

What should be maintained in the future to sustain HOWL:	**What should be improved upon when continuing HOWL:**
Hands-on & interactive component (*n*=5)	Resources (for equipment & coordinator position) (*n*=4)
The HOWL kick-off (*n*=4)	Meeting regularly (*n*=6)
Collaboration (*n*=3)	Additional trainings (*n*=3)
Trainings (*n*=2)	Recruitment (*n*=3)
STEM opportunity (*n*=4)	Data-reporting (*n*=2)
Camera traps (*n*=2)	Inclusion & valuing participant involvement (*n*=3)
Website (*n*=1)	Key coordinator and/or webmaster (*n*=5)

Resources and Funding Needs. Nearly half of respondents (*n*=5) advised to apply for grants or obtain funding and financial resources. One participant (*n*=1), CS3, noted it "would be nice to have funding to purchase additional equipment to keep on hand." CS4 explained, "we should apply for grants to have funding… it would be good to have someone that could be paid?" CS12 agreed, discussing, "some big or small external grants would be helpful for more success."

Meeting and Communication Needs. Half of the participants (*n*=6) advocated for regularly scheduled meetings with all HOWL participants, as well as more communication efforts. CS2 indicated, "we need to try to make things happen more regularly than just meeting a few times per year." CS9 agreed, saying, "We've set-up meetings and trainings, but to make this sustainable, we need to do it on a regular basis." CS8, also, suggested meeting more regularly for everyone to stay up-to-date, stating, "we should have a meeting where the members meet quarterly to keep people involved, aside from the monitoring days… establishing actual dates will help keep it surviving."

Trainings Needs. As previously discussed, participants acknowledged that the trainings were not communicated well nor planned often. A handful of participants (*n*=3), trainers and non-trainers, conveyed there needed to be additional trainings. CS7 stated, "I wanted to become a trainer. I was told we had to have some special and formal training. It seems like a big secret." CS6 responded similarly, saying, "I was told people who have already been trained were going to come in and train us… like a 'training-the-trainer type of thing'… It was never clear when that was going to happen." CS12 also suggested there should be "more trained experts."

Recruitment Needs. Even though a couple of participants (*n*=2) believed the recruitment strategies worked well, some participants (*n*=3) believed there was room for improvement. For

instance, “we should reach out more via social media, especially Facebook… you can create an event and invite everyone to it. The students you are recruiting will notice that more than in the newspapers or on flyers,” said CS4. Likewise, CS9 stated:

> One of the biggest issues is getting the word out and getting people involved. To get the word out and hold interest, we should publicize in the newspapers, radio, have flyers to put out in the community, maybe even put flyers out at the local YMCA, 4-H day camps, homeschool association… We need to think of more groups like that we can reach out to.

CS3 explained the vitality of recruitment also, saying, “recruitment is 100% important. If you don’t recruit, you don’t have participants.” CS5 agreed, stating, “keep reaching out to the community and let them know that we are continuingly doing this.”

Data-reporting Needs. A few individuals (*n*=2) recommended strengthening data reporting to the iNaturalist site and the HOWL citizen scientists. CS5 said, “we need to improve on data reporting… in particular, for the water quality data.” Additionally, CS5 acknowledged:

> The protocols are not specifically for brackish waters, and we need to figure out what we do about reporting our standards. Reporting the data should be improved on in the trainings and for the entire project. What do we do with all the data? We still need to figure that part out.

Inclusion and Valuing Participant Involvement Needs. A few respondents (*n*=3) indicated the project needed to be more inclusive and further value participant’s involvement. From the same participant who felt like their “role was vague… and did not fit in”, CS1 expressed to improve on, “making them feel like they are making a difference… or make people feel like there is an incentive or helping towards some sort of goal, not just meaninglessly participating.” Another participant, CS9, stated, “maybe have an incentive for participant’s efforts to participate… it would be nice to give them a certificate for being involved.” CS3 also answered similarly, explaining, “letting them know they are doing something powerful and meaningful.”

Key Coordinator Needs. Nearly half of the participants (*n*=5) recognized the project needed a webmaster or a "key leader or someone that can be in charge and can oversee the project," said CS9. CS5 suggested, "maybe a new IWLA member or a new student that came take over the project and continue it on." CS12 who said, "I thought the website worked well," also believed "we need a webmaster" who can keep-up the website and the working-database. CS2 recommended to "hire a person full-time for HOWL," they continued, "this would create a local adoption as a more permanent level rather than just an interest level." Also, CS4 indicated:

> Find a volunteer or a student who wants to continue the project…. Reach out to students and get someone to work part-time. One person can take on the job. Maybe someone that can be paid? Like a coordinator?

Lastly, almost all the participants (*n*=11) reported they believed the project would continue for one more year. CS2 said, "yes, because we already have monitoring dates scheduled." Similarly, CS7 responded, "yes, we are already putting things in place for the next year."

However, when asked if they believed the project would continue for 5+ years, only a few participants (*n*=3) responded with an affirmative "yes." For instance, CS5 said, "Absolutely! I think it's going to explode. The river is only getting worse, and it will begin to become foul upstream. We need this kind of program."

Three-fourths of participants (*n*=9) responded with a "maybe" or an uncertain response such as "yes, but…" or "yes, only if…." However, the majority (*n*=6) of these "maybe" respondents, indicated that key players or a main coordinator are crucial to continuing the project for 5+ years. For example, CS9 indicated the project would continue but only if there were key players to make it happen, saying, "If we have a leader and someone that can be in-charge and oversee the project, I think it can continue for 5 years, if not longer." Likewise, CS1 expressed

the need for key individuals or representatives for continuation, responding, “I do, but the only catch with that one is if there are organizations or a few individuals pushing it forward. If partners do not feel supported, it’s not something they want to be a part of and continue on.”

However, the respondents (*n*=2) that did not acknowledge the need for collaboration or critical players to mobilize the project expressed their “maybe” with even more uncertainty. For example, CS10, stated, “I’m 50/50 on that one. I’m not so sure.” CS8 acknowledged a challenge that may hinder the development of the project, revealing, “I have a little less confidence… because of the IWLA’s leadership change. It’s unclear what his/her motives may be.”

CHAPTER THREE: THE FUTURE OF HOWL

3.1 Discussion

The purpose of my study was to explore the Hofmann Open-Water Laboratory (HOWL) participant's perceptions of their own objectives and goals, the collaboration between various community groups, and the project's longevity. I evaluated the HOWL project's outcomes based on Bonney et al.'s (2009) step 9 of the Cornell Lab of Ornithology (CLO) model. The final step, step 9, to designing and implementing a citizen science project, is to measure its impacts. Within this step, scientific and/or educational objectives can be reviewed (Bonney et al., 2009). I evaluated the participant and socio-ecological outcomes using the perceptions of the HOWL participants. In addition, I explored the participant's opinions of the project's future, as well as their recommendations to sustain the project.

Using the "public participation in scientific research" (PPSR) model developed by Shirk et al. (2012), I reviewed the project's socio-ecological and participant outcomes. The PPSR model explores the outcomes that emerge from participatory action research (Shirk et al., 2012). As previously discussed in Chapter 1, PPSR projects, such as HOWL, strive to achieve outcomes that reside in three of the following groups:

- Outcomes for research (e.g., scientific findings);
- Outcomes for individual members (e.g., obtaining new knowledge);
- Outcomes for socio-ecological purposes (e.g., building community networks and relationships) (Shirk et al., 2012).

Although HOWL could be evaluated for all three of Shirk et al. (2012) outcomes, the purposes of this study were to evaluate both outcomes for individual members and socio-ecological purposes. Outcomes are measurable components (e.g., skills and knowledge) that results from a project (Shirk et al., 2012). In addition to measuring individual outcomes and socio-ecological outcomes, I used the perceptions discussed by the participants to use for project implementation and sustainability (Figure 10).

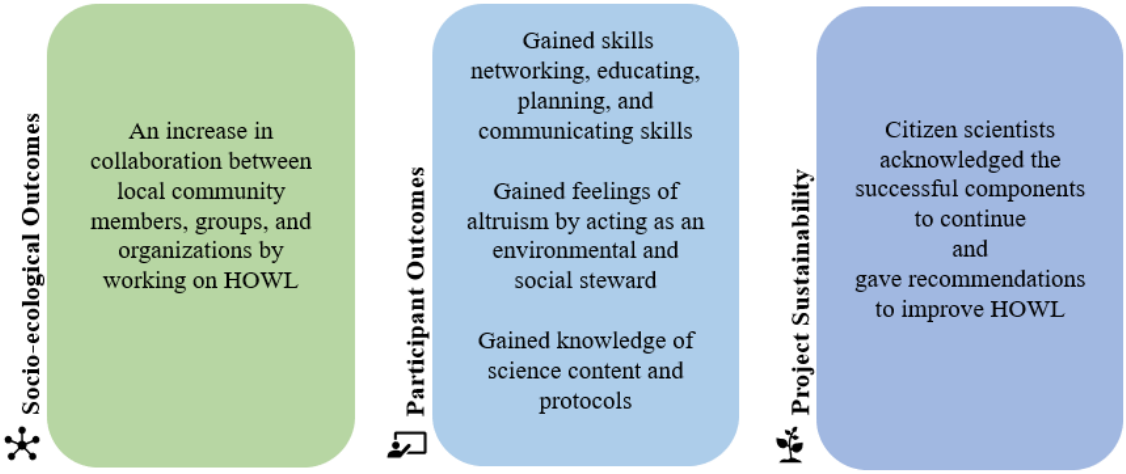

Figure 10: HOWL socio-ecological outcomes, participant outcomes, and project sustainability perceptions.

3.1.1 Perceptions Regarding Socio-ecological Outcomes

An example of a socio-ecological outcome that may result from a citizen science project is a developed and/or deepened relationship between communities and organizations (Tudor and Dvornich, 2001; Ballard et al., 2008; & Shirk et al., 2012). As discussed in Chapter 1, the organizations involved in the HOWL project include NC Cooperative Extension Service, NC State University, White Oak-New River Keeper Alliance, Izaak Walton League of America (IWLA), homeschools, Boy Scouts and Cub Scouts, and Onslow County 4-H groups. I was interested to discover what the community groups were doing before the HOWL project and if the HOWL project was the reason they all began to collaborate. Many interview participants

indicated collaborating with community groups and partners for the first time when participating in HOWL.

Almost half of the participants indicated they never worked with any of the other organizations participating in the HOWL project, while a little over half of the participants recalled they had worked with at least one of the other organizations before HOWL, but the collaboration was very minimal. A few participants recognized the importance IWLA plays in the collaboration. IWLA worked with almost all the organizations at least once. A representative from IWLA agreed they had worked with the other organizations before HOWL but believed the collaborative efforts were not efficient nor effective. Further, all participants strongly believed the collaboration would continue, especially if funding or a principal coordinator mobilized the project.

This evidence is consistent with Wondolleck and Yaffee (2000) that people come together when there is a shared interest or mission. They also come together when there is a shared connection or attachment to a specific place or location (Wondolleck & Yaffee, 2000). In addition, individuals join to collaborate when they share a mutual goal or vision, and they work towards it (Wondolleck & Yaffee, 2000). For HOWL community groups and organizations, they all share the common interest of environmental education and stewardship. The HOWL citizen scientists were brought together by their mutual relationship and attachment to their unique inner coastal community; complemented with the Hofmann Forest and White Oak, New, and Trent Rivers.

Wondolleck and Yaffee (2000), also, discuss not only do partners come together when there is a common goal or interest but when there is a shared fear or problem. Consistent with this evidence, HOWL community members were mobilized after the NCSU Endowment Fund

and Natural Resources Foundation initiated a proposed sale of the Hofmann Forest in January 2013 (Cubbage, Roise, & Sutherland, 2016). The Hofmann Forest sale proposal worried many individuals in the coastal area, especially in Jones, Onslow, and Carteret Counties. HOWL citizen scientists felt the urge to act and become involved somehow in the community and with the forest. Thus, the HOWL project evolved. HOWL participants became active to monitor the White Oak, New, and Trent river, which all flow out of the Hofmann Forest. Participants, also, fear threats to the rivers from the increase of deforestation, construction, substantial development, agriculture, and nearby concentrated animal feeding operations.

However, with the shared fears and threats aside, HOWL participants have a shared mission to maintain the Hofmann Forest, as well as, manage and help facilitate the White Oak, New, and Trent Rivers. This shared vision, referred to as a "superordinate goal," is the

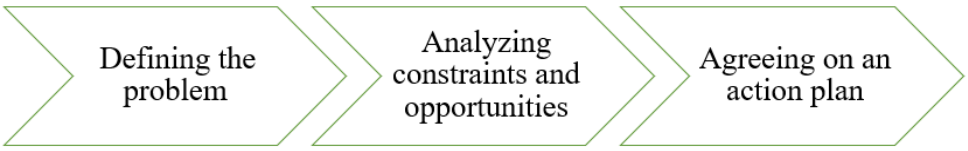

Figure 11: Process to engage participants (Ramirez, 1999).

overarching vision individuals work towards and the goal that resides above the current problem or issue (Wondolleck & Yaffee, 2000). A superordinate goal helps to imagine a solution to the shared problem and creates an accomplishment that aids in collaboration (Wondolleck & Yaffee, 2000).

Further, interview participants recognized additional partners who are apt to join the collaborative efforts. For instance, interview participants acknowledged local conservation groups and non-profits, municipalities, colleges and universities, teachers and schools, and Camp Lejeune Marine Base to recruit to join HOWL. Consistent with Wondolleck and Yaffee (2000), HOWL citizen scientists believe the potential collaborators have a shared interest in the project,

such as environmental education, water quality health, and natural resource stewardship. In addition, according to Ramirez (1999), there are three phases to engage stakeholders in collaboration: defining the problem, analyzing constraints and opportunities, and agreeing on an action plan to move forward (Figure 11).

As previously mentioned, community partners have a shared fear or threat that mobilizes them to become involved. Additionally, as several interviewees mentioned, HOWL needs both financial and technical resources. Reaching out to community groups who have power in terms of funding, as well as diverse knowledge or skills they can provide to the collaboration is crucial for the project (i.e., analyzing their constraints and opportunities). Lastly, when recruiting to additional community groups, HOWL citizen scientists must agree on a common vision they work towards (i.e., agree on an action plan). Currently, as described in Chapter 1, HOWL's goals are to learn, teach, make a difference, and foster partnership and collaboration within the community.

3.1.2 Perceptions Regarding Participant Outcomes

Typical participant outcomes that arise from a citizen science project include establishing a new set of skills (Bell et al., 2008; Ballard and Belsky, 2010; & Shirk et al., 2012), learning scientific procedures and topics (Trumbull et al., 2000; Ballard and Belsky, 2010; & Shirk et al., 2012), creating a connection to a place, community, or people (Wilderman et al., 2004a; Evans et al., 2005; Shirk et al., 2012; & Wondolleck & Yaffee, 2000), and increasing appreciation of the environment (Bell et al., 2008; Shirk et al., 2012). Interview participants' responses were favorable to the outcomes discussed by Shirk et al. (2012). Four achieved outcomes emerged as participants discussed their experiences with the HOWL project. HOWL citizen scientists have:

(1) learned a new set of skills, (2) gained knowledge of scientific and research procedures, (3) developed attachment the community or a place, and (4) acted as an environmental steward.

First, some of the HOWL participants noted they gained the new skill of educating others. After participating in the project, completing the training sessions, and leading Scout, homeschool, and 4-H groups, participants learned how to instruct others. Members also indicated they learned skills of networking, event planning, and communicating while involved in the project. Second, participants learned about scientific processes and research protocols. Many individuals recognized they had never participated in fieldwork or research prior to participating in HOWL. Additionally, one participant noted they learned a lot about benthic macro-invertebrates and their importance of testing when monitoring water quality. Third, HOWL citizen scientists felt they were helping the community, especially in a rural part of North Carolina, where minority groups do not typically receive adequate environmental education or science opportunities. According to Pandya (2012), individuals in rural areas are not typically involved in citizen science projects because of barriers such as lack of transportation, access to the environment, or scientific education. Because some of the monitoring events were located in these rural communities, many of the local citizens joined in the efforts. HOWL participants felt altruistic and happy about reaching out and educating local children and their families. Fourth, not only did citizen scientists feel as if they made a difference in a social asset but also in an ecological one. Several interview participants believed they contributed to environmental stewardship by managing the White Oak, New, and Trent Rivers, and educating members who live nearby to protect its waters.

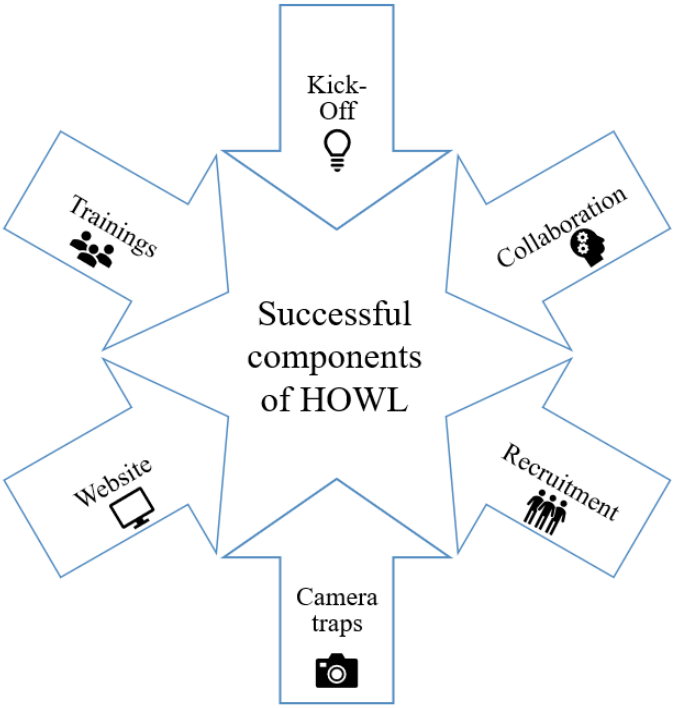

Figure 12: Six successful components of HOWL which should be maintained for project continuation.

3.1.3 Perceptions Regarding Project Longevity

In addition to project creation and structure design, CLO can be utilized for project implementation and evaluation to ensure longevity (Bonney et al., 2009). Interview participants shared their perspectives of what components worked well in the HOWL project and should be continued in the future. According to Kaufman et al. (2014), evaluating participatory research projects serve to gain insight for two purposes: continuing good practices or improving upon specific aspects. Evaluation is a reflective process to generate knowledge for design, implementation, and recalibration (Kaufman et al., 2014).

HOWL participants indicated they liked the project's hands-on, organized, and interactive characteristics. Additionally, many of the participants liked how multiple trainers were at each event to lead the various sections, which allowed the trainers to spread themselves

widely for assistance and guidance among the many participants involved. Interviewees also acknowledge they liked the protocols established by the IWLA. They believed they were clear and easy-to-understand, especially for individuals without a science background.

Also, HOWL participants recognized six other strong aspects of the project: (1) the kick-off community outreach and recruitment event, (2) collaborative efforts between local organizations and partners, (3) recruitment strategies, (4) camera trap deployments, (5) HOWL website as a recruitment and engagement tool, and (6) the training sessions (Figure 12).

In the following section, recommendations and ideas for implementation are discussed based on HOWL participant's opinions.

3.2 Recommendations for HOWL

Interview participants contributed feedback and suggestions to improve HOWL project's

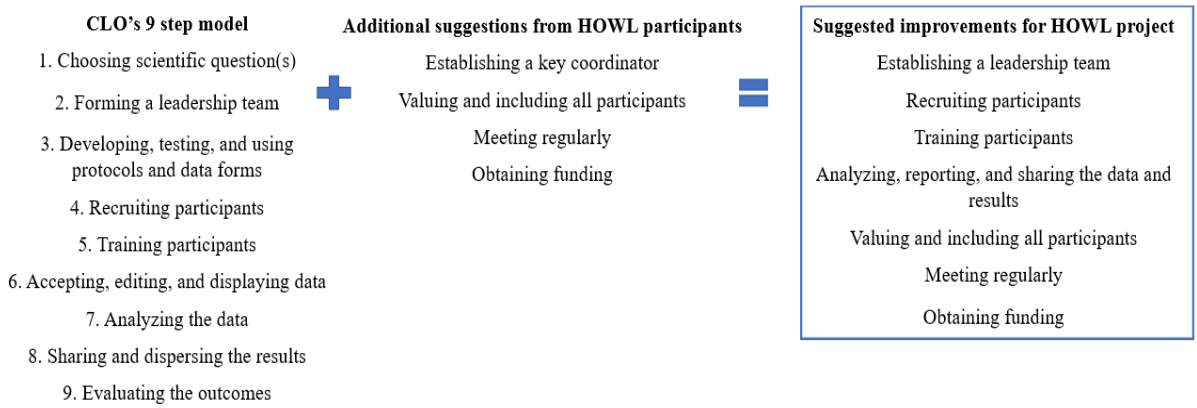

Figure 13: CLO model recommendations and the suggestions by HOWL participants taken into consideration to formulate my final recommendations for HOWL.

components. Some of the participant's recommendations fell within the steps described in CLO. I also took into consideration additional improvements that participants had expressed in the interviews. These categories did not fall within one of the 9 steps discussed in the CLO model. I, then, combined the recommended improvements into a total of seven categories: (1) establishing a leadership team, (2) recruiting participants, (3) training participants, and (4) analyzing,

reporting, and sharing the data and results, (5) valuing and including all participants, (6) meeting regularly and communicating often, and (7) obtaining funding (Figure 13).

3.2.1 Establishing a leadership team

A few participants conveyed a need for key representatives from each organization to lead the project, similar to the approach discussed in step 2 of the CLO model, forming a leadership team. Some interview participants believed there needed to be one overall coordinator to supervise the project and manage the organization's representatives. This information overlaps with the evidence provided by Bonney et al. (2009). A successful citizen science project consists of a team consisting of members with various backgrounds (Bonney et al., 2009). Additionally, Wondolleck and Yaffee (2000) support the need for "an advisory committee" or leadership team. They suggest forming an advisory committee, consisting of different interests and backgrounds, to discuss, evaluate, and make recommendations about desired decisions.

As indicated by many of the HOWL participants, it is essential to have a coordinator who can organize, recruit, and plan sampling days; however as discussed by scholars, additional key leaders are needed for the project to flourish. For example, an educator should be available to provide information about water monitoring protocols and procedures; a data statistician or analyst should acquire, analyze, and visualize the data that the citizen scientists collect; a webmaster may be needed to actively recruit and update the project's social media and websites; and an evaluator is necessary to ensure the project has measurable outcomes and to assess the project for sustainability (Bonney et al., 2009). Thus, HOWL should try to acquire additional citizen scientists to fulfill these roles or fill the positions with current citizen scientists who contain these technical and leadership skills.

3.2.2 Recruiting participants

Several interview participants suggested the project needed to recruit to a more extensive range of people and more diverse audiences, especially when recruiting leaders and trainers. A couple of interviewees recommended using different methods of recruiting then what had been currently used, such as additional social media networks. One interviewee suggested creating Facebook events, especially since the project wants to gear the attention of more youth members.

According to West and Pateman (2016), when recruiting collaborators, it is important to understand what motivates them to participate. If citizen scientists feel like their motivations are met, they will continue to be involved (Peachey et al., 2014; West & Pateman, 2016). West and Pateman (2016) suggest recruiting and advertising to "diverse groups, through diverse means," as well as ensuring a "diverse range of people are represented" in advertising approaches (p 3). Thus, as indicated by the interviewees, HOWL should utilize the power of the internet and social media as recruitment strategies.

Further, Bonney et al. (2009) discuss the advantage of recruiting to teachers. Citizen science can help teachers develop and adapt the project's curriculum to their classroom (Bonney et al., 2009). Also, teachers have the flexibility to work the subjects into their lessons (Bonney et al., 2009), as well as reach many diverse children. This evidence is consistent with the suggestions created by the interview participants.

3.2.3 Training participants

The majority of the participants enjoyed the trainings sessions, which were informative, organized, and interactive. However, the advice that many participants suggested in the interview was the need for regularly organized and publicly announced sessions throughout the year. A few participants conveyed they wanted to become a trainer, but they were confused about who was in-charge of the trainings and how to schedule a session. Consistent with Bonney et al.

(2009) the training sessions for trainers are held at a partner's site, Hadnot Creek in Swansboro, NC. The issue is session dates are not consistent nor advertised well. Creating more scheduled training sessions will, also, help prevent potential biases or errors in the data (Bonney et al., 2009). The more practice and training participants are exposed to; the fewer data errors will occur.

3.2.4 Analyzing, reporting, and sharing the data and results

A handful of interviewees acknowledged the need to analyze the water quality data, as well as report and share the information with the coastal community, as well as the national IWLA chapter. The data are currently displayed through iNaturalist (website: www.inaturalist.org/projects/hofmann-citizen-science); however, the results should be further analyzed, enhanced, and visualized. As previously discussed, a data analysis leader is needed to review and interpret the results (Bonney et al., 2009). Further, the results should be published to display the results to the public and demonstrate how citizen science contributes to the science fields (Bonney et al., 2009).

According to Wang (2015), citizen science data should document descriptive metadata for participants to recall the results of the data collected, and how to interpret and use the

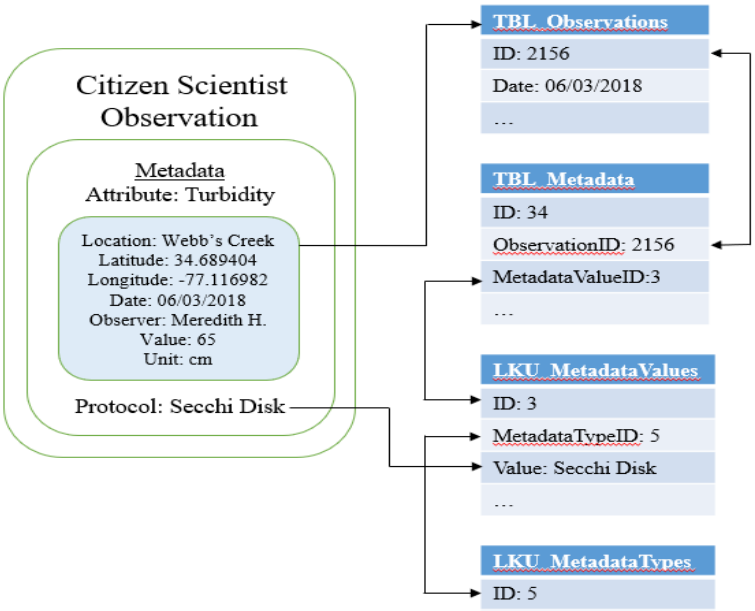

Figure 14: A metadata organizing scheme of the "back-end" side of CitSci.org after participants enter their observations (Adapted from Wang, 2015).

information. Wang (2015) suggests CitSci.org as a mechanism to document citizen science data. CitSci.org is a free platform (www.citsci.org) "to support the entire data lifecycle" (Wang, 2015, p 2). CitSci.org allows for participants to enter sampling techniques (e.g., how temperature was measured), location (e.g., latitude and longitude), time and date, and the parameter values (Wang, 2015). On the "back-end" side of the platform, a coordinator or webmaster can tailor the attributes and fields to fit the project's scheme (Figure 144). Additional features include visual mapping, summary statistics, and easily downloaded datasheets (Wang, 2015). Also, the site enables project coordinators or leadership team members to document many components of the project other than the data results, such as training and protocol materials and information.

A visualization and sharing network, such as CitSci.org, is necessary for researchers, citizen scientists, and other interested individuals to access the data. HOWL currently uses iNaturalist as a data sharing and storage unit; however, CitSci.org can be an exhaustive tool to store, analyze, and share data, as well as manage a citizen science project as a whole. HOWL should adopt a program that can facilitate metadata and produce documentation. In doing so, potential issues regarding trust, bias, or errors that can be related to citizen science data collection and analysis can be limited. With an increase in data transparency and openness, as well as technical components that are simple-to-use, citizen science data can be greater received and incorporated by the broader scientific community (Wang, 2015).

3.2.5 Valuing and including all participants

A few interview participants voiced their experiences with the lack of inclusion or self-value while participating in the project. A couple of participants expressed they would have liked a specific role in the project where they could have prospered. One participant never returned after participating once in a monitoring day, because they did not feel like they fit in with the

group. As previously discussed, there were a few participants who wanted to become a trainer but felt like “it was a secret” and did not feel welcomed. However, fortunately, these participants continued to be involved in the project. Also, some participants indicated they wanted to feel like their work was contributing to something greater or making a difference. According to Bell et al. (2008), HOWL leaders and trainers should communicate to participants that their work and data is “useful” and “vital” (p 3451). By showing that citizen scientist’s data, work, and time are valued, ensures participant self-value, which in turn creates a long-lasting and greater participation (Bell et al., 2008). Accordingly, HOWL definitely should try to be as inclusive, open, and encouraging as possible.

3.2.6 Meeting Regularly and Communicating Often

Many interview participants indicated it was crucial for HOWL to schedule meetings throughout the year. One interviewee recommended meeting quarterly to allow participants to update on the project’s goals and mission, as well as plan for recruitment, collaborating, training, and funding needs on a yearly basis. Further, most participants said it was necessary to communicate often. Otherwise, participants feel left-out or “out-of-the-loop.”

According to Wondolleck and Yaffee (2000), communication should occur early, on-going, and at all times. Communicating often establishes relationships and builds trust among partners, which, in turn, increases volunteer involvement and retention. Involving all members in communication and decision-making processes is more likely to results in more meaningful, useful, and enduring decision-making and processes (Wondolleck & Yaffee, 2000).

3.2.7 Funding

Almost all participants noted the need for project funding. All citizen scientists and trainers are volunteers, and all database storage networks are used via free websites such as

iNaturalist. Some funding has been acquired for monitoring equipment and the HOWL website. Interview participants suggest applying for grants to fund a part-time coordinator, or as the CLO model recommends a leadership team consisting of a data statistician, educator, coordinator, and webmaster. Bonney et al. (2009) believe a successful citizen science project requires the staff members to direct and manage project development, support and recruit participants, and analyze and curate data. Further, Bonney et al. (2009) convey that citizen science projects are "cost-effective over the long term," as they produce high quantities and quality of data (p 983). Thus, HOWL should seek additional funding through grants or potential collaborators to sustain the project for the future.

3.3.1 Opportunities for Future Collaboration at Hofmann Forest

In July 2016, the NCSU Endowment Fund and Natural Resources Foundation sold a 50-year contract for the rights to harvest the timber and to manage the Hofmann Forest to Resource Management Service LLC (RMS), a private timber investment management organization (TIMO) (Hartman, 2016). RMS is required to operate the forest to meet sustainable forest management certification requirements (Hartman, 2016) under the Sustainable Forestry Initiative (SFI). According to the SFI's Forest Management Standards and Rules, forest managers are obligated "to broaden the practice of *sustainable* forestry through public outreach, education, and involvement." In addition, SFI's Forest Management Standards and Rules provide "educational opportunities promoting *sustainable* forestry" examples for forest managers, "such as (a) field tours, seminars, and workshops, (b) educational trips, (c) self-guided forest management trails, (d) publication of articles, educational pamphlets or newsletters, and (e) support for state, (Sustainable Forestry Initiative, 2015, p 9)."

Hofmann Forest would be a huge and iconic draw for the local community, which could also further connect HOWL with the University, and forge links with RMS. Currently, all of HOWL's monitoring sites are located outside and surrounding Hofmann Forest. It would be an emblematic opportunity to have participatory research and educational involvement on the forest for both parties, HOWL and RMS. Citizen scientists could monitor the unique headwaters of the White Oak, and Trent rivers, which begin in Hofmann, as well as manage camera traps to monitor local, and vulnerable wildlife. This citizen science data and observations could be used in RMS' annual reporting standards and to demonstrate cooperation with "state, provincial, and local forestry organizations and soil and water conservation districts (Sustainable Forestry Initiative, 2015, p 9)." Additionally, RMS could have "open houses", field visits, or barbecues on the forest occasionally, as well as forest and environmental education tours for the local community.

This opportunity would also benefit the organization's social mission, which they state on their website to be, "we make the lands we manage available as outdoor classrooms for students at all levels and for landowner education programs… forests can benefit society and the public because of their unique natural characteristics (Resource Management Services LLC, 2015)."

3.4.1 Future Evaluation Research

Recommendations to sustain HOWL for the future, suggested by HOWL citizen scientists and scholars in the discipline, have been outlined in this paper. For future evaluation and research on the HOWL project and its participants, it is recommended to utilize additional qualitative methods, such as a survey questionnaire and focus groups. This triangulation approach allows for new perceptions and information to be gathered.

Further, it is recommended to provide a pre-survey or questionnaire before HOWL citizen scientists participate in the project. Such pre-questionnaire can gather information on the participant's initial objectives or goals (i.e., individual outcomes) which they wish to achieve when working on the HOWL team, as well as what motivates them to participate (West & Pateman, 2016). A simple pre-survey or "quiz" could also gain insight into how much a participant knows about scientific processes and content before participating in HOWL. Then, a follow-up should be given to evaluate participant's knowledge of scientific procedures and subjects after a year (or less) participating in the project (Bonney et al., 2009). Collecting this information early-on can help HOWL coordinators and/or trainers assist citizen scientists in meeting their individual goals and tracking their progress. The hope is that being involved in goal-setting processes can increase volunteer retention, as well as help in environmental learning.

In addition to evaluating how well participants have met their goals, specific community engagement and achievements (i.e., socio-ecological outcomes) can be evaluated. In the short-term, future HOWL research should review the number of participants and collaborators involved over the project's lifespan (Bonney et al., 2009). In the long-term, future HOWL research should review the number of cases where citizen science data was used in local decision-making or policy formation or implementation.

Lastly, not measured in this thesis research, are the water quality, and quantity, data (i.e., scientific outcomes). Future HOWL research should focus on the discoveries founded by citizen scientists and assess the scientific questions initially formed (step 1 of the CLO model). As discussed in Chapter 1, the hypotheses relevant to the HOWL project are the following:

H1: Water quality on more developed land use is worse than on forested land use

H2: Planted forest water quality is equal to natural forest

H3: Citizens can collect scientifically valid data

H4: Citizen science efforts are sustainable

As HOWL participants continue to collect water quality and wildlife data, we hope to analyze the findings and test the project's hypotheses.

3.5.1 Research Bias and Limitations

It was important for me, as both one of the creators of HOWL and the project's evaluator, to understand the bias that I potentially brought to the research results and analysis. As previously stated in Chapter Two of this thesis, face-to-face interviews can cause the interview participants to hold back their honest opinions and perceptions. Since 2016, I have worked closely and developed a sincere relationship with the citizen scientists involved in HOWL. While holding the position of both a creator and evaluator, my presence could have impacted the responses given by the interviewees (Anderson, 2010). I believe the interviews were a significant way to gather the experiences and stories from the participants; however, I acknowledge that such qualitative approaches could also be manipulated by my personal biases, or even the ways I wanted to interpret or understand the participant's perceptions. To address this limitation of personal bias or errors in participant's responses, I wish the project can be evaluated in the future by an external interviewer, followed by anonymous surveys.

3.6.1 Conclusions

The purpose of this study was to follow the Cornell Lab of Ornithology (CLO) model to design and implement Hofmann Open-Water Laboratory (HOWL) in eastern North Carolina and to evaluate the project's outcomes. Two major conclusions were drawn: (1) participant's individual goals are achieved when involved in citizen science. In addition to these implications, the study gathered further knowledge of the good practices to be continued and the aspects of the

project that should be improved upon for the future. These suggestions will be considered to help HOWL continue to grow in participants and expand in the coastal region of the state. Further, it is strongly recommended that research further examine the perceptions of citizen science participants and how such participatory research initiatives can be a mechanism for community engagement and collaboration.

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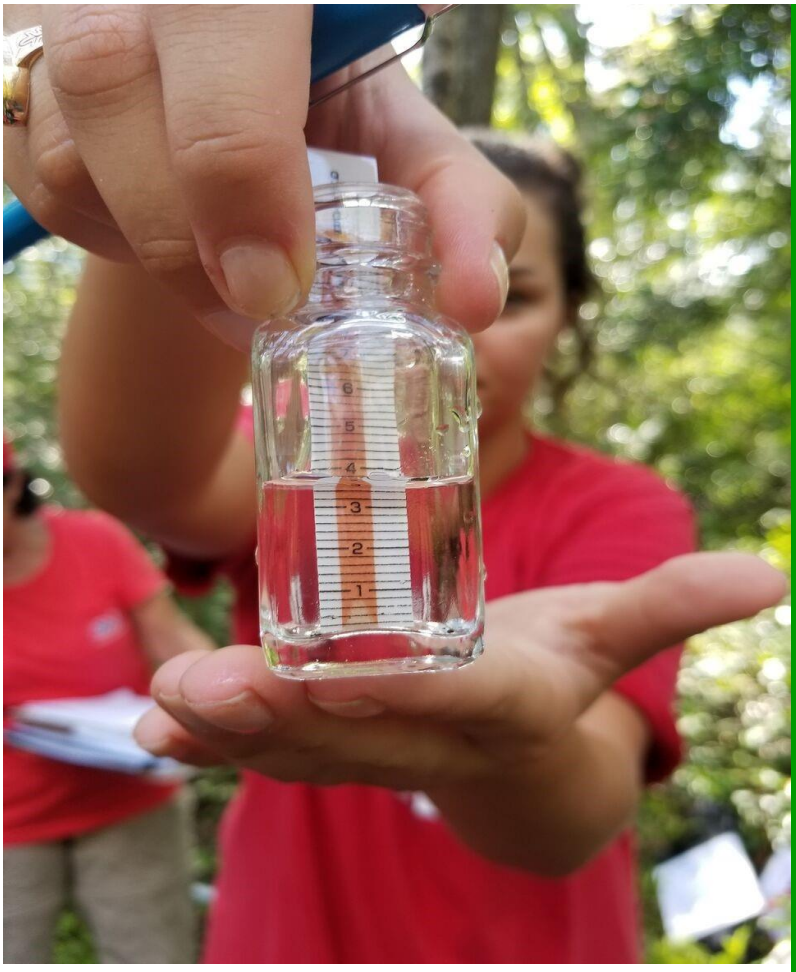
APPENDICES

APPENDIX A

Water monitoring parameters by organization

Water Quality Test/ Organization	**IWLA Creek Freaks Program**	**HOWL**	**Onslow County**	**Hofmann Forest**
Water Transparency	X	X		
Water Temperature	X	X	X	
Salinity		X	X	
Nitrate		X	X	
Nitrite		X	X	
Fresh water macro-invertebrates	X			
Salt/brackish water macro- invertebrates		X		
pH	X	X		
Dissolved Oxygen	X	X	X	
Phosphate	X	X		X
Orthophosphate		X	X	
Chloride	X	X		
Ammonium				
Conductivity			X	
Enterococcus bacteria			X	
Silver				X
Aluminum				X
Arsenic				X
Calcium				X
Cadmium				X
Chrome				X
Copper				X
Iron				X
Mercury				X
Potassium				X
Manganese				X
Sodium				X
Nickle				X
Lead				X
Total organic compound				X
Triose Phosphate				X
Zinc				X

APPENDIX B
HOWL kick-off flyer



HOWL SCIENCE Kick-Off

NC State University and Izaak Walton League wants you to become a part of the HOWL Science Team! Come learn about the water quality in your area. Bring your *water shoes or boots* to search for macro-invertebrates hidden in the streambeds, craft-skills, and friends! *All ages welcomed.*

Check us out at: hofmanncitizenscience.com

@HOWLScience

Hofmann Open-Water Laboratory (HOWL)

Explore local streams!

Crafts!

Free Food!

Discuss and identify river critters!

Where: White Oak River Campground

7660 New Bern Hwy.

Maysville, NC 28555

When: Oct. 8 @ 1:30 PM

RSVP

@ 704-235-8398

OR @ mehovis@ncsu.edu

APPENDIX C
Data reporting sheets

THE IZAAK WALTON LEAGUE OF AMERICA Creek Freaks | *Stream Quality Survey*

Please refer to the Izaak Walton League's volunteer stream monitoring protocol and identification guides to learn how to complete this form. Please use the League's *Field Guide to Aquatic Macroinvertebrates* to complete portions of this stream quality survey form. For assistance, please call (800) BUG-IWLA or send an e-mail to sos@iwla.org.

Date _____

Time _____

Name _____

Stream: _____ Station/Site Name: _____ County/City: _____

Location: _____ **GPS coordinates: _____**

Weather Conditions (last 72 hours): _____

Rocky Bottom Sampling

Before sampling, record riffle composition on the back of this form. Take 3 samples in the same riffle area, fill out this form, and keep the highest scoring sample for your records. To help track the number of samples you have collected, check one of the boxes below:

Sample 1 Sample 2 Sample 3 Is this your highest score sample?

Muddy Bottom Sampling

Record the total number scoops taken from each habitat type and provide details to best describe the specific habitat on the lines below.

Steep bank/vegetated margin: _____

Woody debris with organic matter: _____

Rock/gravel/sand substrate: _____

Silty bottom with organic matter: _____

Macroinvertebrate Count

Consult the stream monitoring instructions on how to conduct the macroinvertebrate count. Use letter codes (A = 1-9, B = 10-99, C = 100 or more) to record the numbers of organisms. Add up the number of organism types (or number of letters) found under each category (sensitive, less sensitive, etc.) and multiply by the indicated index value. Although A, B, and C ratings do not contribute to the water quality rating, the letters track the population size in each category to see how the macroinvertebrate community changes over time.

SENSITIVE	**LESS SENSITIVE**	**TOLERANT**
_____ Caddisflies (except net spinners) _____ Mayflies _____ Stoneflies _____ Watersnipe flies _____ Riffle beetles _____ Water pennies _____ Gilled snails	_____ Dobsonflies _____ Fishflies _____ Common net spinning Caddisflies _____ Crane flies _____ Damselflies _____ Dragonflies _____ Alderflies _____ Crayfish _____ Scuds _____ Aquatic Sowbugs _____ Clams _____ Mussels	_____ Aquatic worms _____ Black flies _____ Midge flies _____ Leeches _____ Lunged snails
___# of letters multiplied by 3 =____	____ # of letters multiplied by 2 =_____	____ # of letters multiplied by 1 =_____
Now add the three totals from each column for your stream's index value. Total index value = _____		

Compare the final index value to the following ranges of numbers to determine the water quality of the stream sample site.

THE IZAAK WALTON LEAGUE OF AMERICA

Creek Freaks

Tally Form

Under each type of macroinvertebrate on the tally sheet, write the number found in your net. Use the boxes with your group number. If none are found of that type, leave it blank.

SENSITIVE

Caddisfly larva (except common net spinning caddisfly)

1 | 2 | 3

Riffle Beetle (adult and larva)

1 | 2 | 3

Mayfly nymph

1 | 2 | 3

Water Penny larva

1 | 2 | 3

Stonefly nymph

1 | 2 | 3

Gilled Snail

1 | 2 | 3

Water Snipe Fly larva

1 | 2 | 3

SOMEWHAT SENSITIVE

Dobsonfly larva

1 | 2 | 3

Fishfly larva

1 | 2 | 3

Common Net Spinning Caddisfly larva

1 | 2 | 3

Crane Fly larva

1 | 2 | 3

Scud

1 | 2 | 3

Clam

1 | 2 | 3

Damselfly nymph

1 | 2 | 3

Dragonfly nymph

1 | 2 | 3

Alderfly larva

1 | 2 | 3

Crayfish

1 | 2 | 3

Aquatic Sowbug

1 | 2 | 3

Mussel

1 | 2 | 3

TOLERANT

Aquatic Worm

1 | 2 | 3

Black Fly larva

1 | 2 | 3

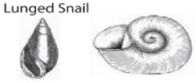
Midge Fly larva

1 | 2 | 3

Leech

1 | 2 | 3

Lunged Snail



1 | 2 | 3

GROUP 1

Add the totals from your group for the stream's index value.

Sensitive: _____ # of boxes filled in X 3 = _____

Somewhat Sensitive: _____ # of boxes filled in X 2 = _____ +

Tolerant: _____ # of boxes filled in X 1 = _____ +

Total index value Group 1 = _____

GROUP 2

Add the totals from your group for the stream's index value.

Sensitive: _____ # of boxes filled in X 3 = _____

Somewhat Sensitive: _____ # of boxes filled in X 2 = _____ +

Tolerant: _____ # of boxes filled in X 1 = _____ +

Total index value Group 2 = _____

GROUP 3

Add the totals from your group for the stream's index value.

Sensitive: _____ # of boxes filled in X 3 = _____

Somewhat Senstive: _____ # of boxes filled in X 2 = _____ +

Tolerant: _____ # of boxes filled in X 1 = _____ +

Total index value Group 3 = _____

THE IZAAK WALTON LEAGUE OF AMERICA
Creek Freaks | *Chemical Monitoring Data Form*

Date: _____ Time: _____ Number of participants: _____

Program Leader _____ Site Name: _____

GPS Coordinates: _____

WEATHER CONDITIONS

Check all that apply:

Today:
❑ **Sunny** ❑ **Overcast** ❑ **Intermittent Rain** ❑ **Steady Rain** ❑ **Heavy Rain** ❑ **Snow**

Yesterday:
❑ **Sunny** ❑ **Overcast** ❑ **Intermittent Rain** ❑ **Steady Rain** ❑ **Heavy Rain** ❑ **Snow**

Day Before Yesterday:
❑ **Sunny** ❑ **Overcast** ❑ **Intermittent Rain** ❑ **Steady Rain** ❑ **Heavy Rain** ❑ **Snow**

Nitrate-N _____ (mg/l)

Phosphate _____ (mg/l)

Chloride _____ mg/l (Convert Quantab Units to mg/L using the chart provided on the bottle)

Transparency (record whole numbers only – no tenths) _____ centimeters

Other Stream Assessment Observations and Notes:

_____

_____

_____

Water Quality Summation for Chemical Tests				
	EXCELLENT	GOOD	FAIR	POOR
Dissolved Oxygen (% Saturation)	80-120	70-80 120-140	50-70 >140	<50
pH (units)	7.0-7.5	6.5-7.0 7.5-8.5	5.5-6.5 8.5-9.0	<5.5 >9.0
Chloride (Cl) ' (mg/L)	0-20	20-50	50-250	>250
Reactive Phosphate ($P0_4X^3$ (mg/L)	0-0.2	0.2-0.5	0.5-2.0	>2.0
Nitrate (NO_3)' (mg/L)	0-3	3-5	5-10	>10
Transparency (cm)	> 65.0	65.0-35.0	35.0-15.5	< 15.5

Source: Izaak Walton League's Project Watershed CNY/SOS, 1999; Milchell and Stapp, 1997; http://watermonitoring.uwex.edu/pdf/level1/datasheets/ data-DOTempTrans2010.pdf

STUDENT-COLLECTED DATA

Dissolved Oxygen

_____mg/L

_____ % saturation

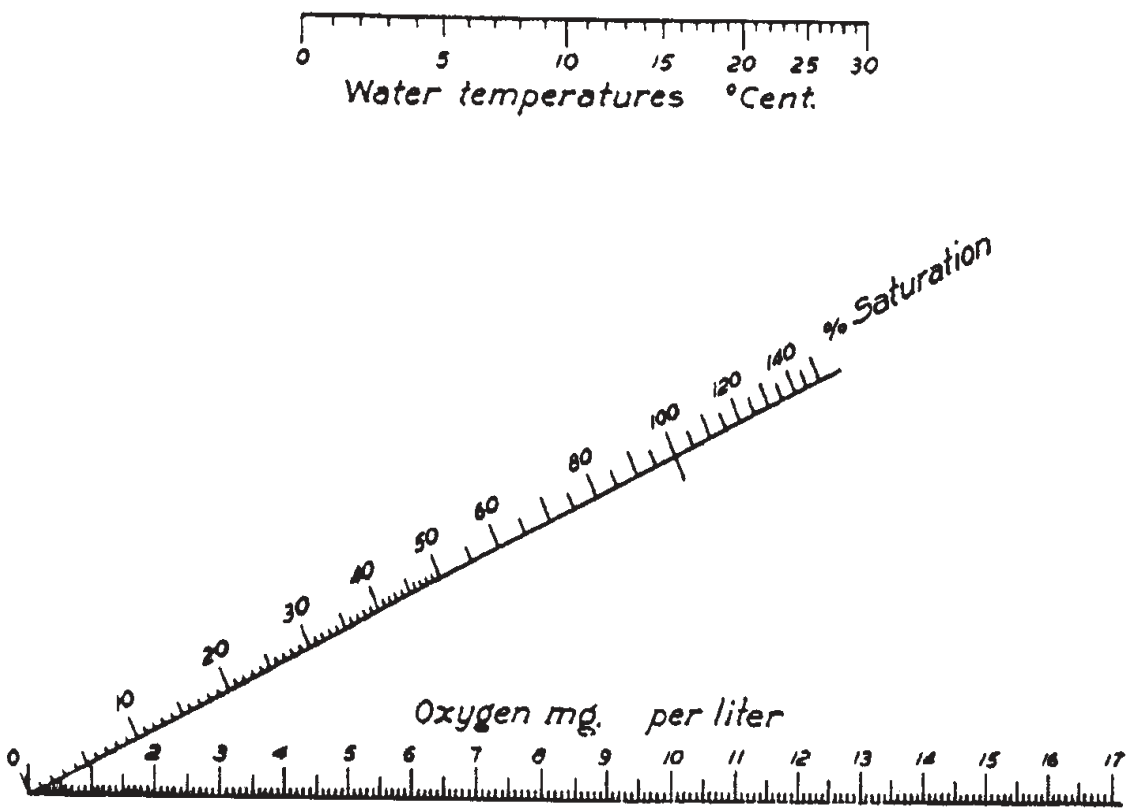
Water Temperature

_____ °C

pH

_____ pH units

FINDING THE PERCENT SATURATION OF DISSOLVED OXYGEN



To read this chart, use a straight edge. Place the straight edge on the mg/L of oxygen you have determined for your site, then place the other end of the straight edge on the water temperature you have measured. The point where the straight line passes through the line labeled "% Saturation" is your percent saturation.

Diagram reprinted with permission from M.K. Mitchell and W. B. Stapp, *Field Manual for Water Quality Monitoring*

THE IZAAK WALTON LEAGUE OF AMERICA

Creek Freaks | *Physical Monitoring Data Form*

Name of Stream: _____ **River or Lake Basin:** _____

County: _____ **School/Group Name:** _____

Field Personnel Involved:

_____

Survey Date: _____ **Start Time:** _____ End Time: _____

Location (description):

_____

GPS Coordinates: _____ **Weather Conditions (last 3 days):** _____

VISUAL OBSERVATIONS				
Water Appearance ❑ Clear ❑ Brownish ❑ Blackish ❑ Foamy ❑ Oily ❑ Milky ❑ Muddy ❑ Scummy ❑ Other: _____	**Stream Bottom Appearance** ❑ Grey ❑ Orange/red ❑ Yellow ❑ Black ❑ Brown ❑ Other: _____	**Odor** ❑ None ❑ Musky ❑ Rotten eggs ❑ Oil ❑ Sewage ❑ Other: _____	**Algae Color and Texture** ❑ Light green ❑ Dark green ❑ Brown ❑ Matted ❑ Hairy	**Algae Amount** ❑ Scarce ❑ Scattered ❑ Moderate ❑ Dense

Stream Bed Stability *(Bed sinks beneath your feet in)* ❑ No spots ❑ A few spots ❑ Many spots	**Riparian Zone Width** *(looking upstream from transect)* 0-10' 11-50' 51-100' 100+' Left Bank ____ ____ ____ ____ Right Bank ____ ____ ____ ____	**Stream Channel Shade** *(estimate)* ❑ >80% (excellent) ❑ 50%-80% (high) ❑ 20%-49% (moderate) ❑ <20% (almost none)
	Stream Bank Composition High Medium Low Trees ❑ ❑ ❑ Shrubs ❑ ❑ ❑ Grass ❑ ❑ ❑ Bare soil ❑ ❑ ❑ Rocks ❑ ❑ ❑ Other: _____ ❑ ❑ ❑	**Stream Bank Erosion** *(estimate)* ❑ >80% (severe) ❑ 50%-80% (high) ❑ 20%-49% (moderate) ❑ <20% (slight)

STREAM FLOW ESTIMATE

Estimated flow rate: ❑ high ❑ moderate ❑ low ❑ negligible

STREAM FLOW MEASUREMENT

Measured flow rate: Flow = Area x Velocity = Cubic Feet Per Second

AREA

Measure Stream Depth at Five Equidistant Intervals Across the Stream: ***Depth*** *will be measured in inches and needs to be converted into feet. Convert by dividing number of inches measured by 12. For example, 6 inches/12 inches = .5 feet.*

1 _____ inches /12 = _____ feet

2 _____ inches /12 = _____ feet

3 _____ inches /12 = _____ feet

4 _____ inches /12 = _____ feet

5 _____ inches /12 = _____ feet

Calculate Average Stream Depth: *Calculate average stream depth by adding the results, in feet, of 1through 5 above and dividing by 5.*

Average Stream Depth: _____ feet

Measure Stream Width: *Measure stream width at a point that visually appears to be the average width of the stream. Measure width rounded to the nearest foot.*

Stream Width: _____ feet

Calculate Area of Stream Transect: *Average Stream Depth x Stream Width = Area.*

Area of Stream Transect: _____ square feet

Velocity: *Measure and mark a distance along the stream (normally from 20 to 30 feet, depending on the stream) where you will start and end your float trials.*

Length of Stream Run: _____ feet

Float Time Trials: *Time how long it takes for a wiffle ball to travel the length of the stream run.*

1 _____ seconds 4 _____seconds

2 _____seconds 5 _____seconds

3 _____seconds

Average Float Time: *Calculate average float time by adding results for trials 1 through 5 and dividing by 5.*

Average Float Time: _____ seconds

Calculate Average Velocity: *Velocity is a measurement of feet traveled per second. Divide length of stream run by average float time.*

Average Velocity: _____ feet/second

Flow Rate: *Calculate the flow rate by multiplying Area of Stream Transect by Average Velocity.*

Flow or discharge = Area x Average Velocity = _____ cubic feet/second

APPENDIX D

Interview script (submitted to NC State IRB)

Introduction:
Materials required: Audio-recorder, note-book, pen
Estimated duration*: 5 minutes*

Greetings:
Thank you for volunteering to participate in the interview today. I truly appreciate you taking the time to help me better understand the various aspects of success of the HOWL citizen science project. Today, Meredith Hovis will facilitate the interview and will take some notes. I will next review consent information, let us know if you have any questions.

Consent:
If you agree to participate, you will be asked to answer questions about your participation and perceptions of volunteering with the HOWL citizen science project. This study may help sustain the HOWL collaborative and research efforts for the future. This interview should take about 45 to 60 minutes. There should be no significant business or personal risks from this study. You are free to skip any questions that makes you uncomfortable or that you do not know the answer to. The information in this study will be kept strictly confidential. Your participation in this study is voluntary; you may decline to participate. If permitted, we will audio-record the interview. If you decide to participate, you may withdraw from the study at any time. If you understand the information I have just stated, and agree to participating in this study please state "I agree".

Study Overview:
The objectives of this study on the Hofmann Open-Water Laboratory are:

- To assess how well HOWL achieved their outcome of community engagement and collaboration.
- To assess the degree if HOWL participants constructed sustainable community relationships and networks.
- To assess how well HOWL participants achieved their personal outcomes while participating in the HOWL project.
- To determine if HOWL participants believe if the HOWL project will be sustainable for the future.

I plan to probe and follow-up with questions, asking individuals to expand on their answers.
Estimated time: 45 mins.

Objective	*Question Number and Interview Question*
Socio-ecological Outcomes	Q1: Did you (or your organization) work together with other community groups or networks before the HOWL project?
	Q2: Do you think all community partners will continue to work together on this project?

	Q3: Do you think the HOWL project can continue without collaboration from all partners?
	Q4: How do you work with the other community groups and organizations?
	Q5: Do you think other partners are apt to join the efforts? If so, who?
	Q6: Do you think you (or your organization) will work with one (or more) of the other partners on projects other than HOWL in the future?
Individual Outcomes	Q7: What worked well in the citizen science training?
	Q8: What can be improved on in the citizen science training?
	Q9: How well have you achieved your personal objectives related to the citizen science project?
	Q10: If you achieved a personal objective from the project, what helped you achieve it? If you have not, what could have been done (by the project) to achieve your objective?
Project Sustainability	Q11: What components worked well and should be maintained to sustain the HOWL project for the future?
	Q11: What components should be improved on when trying to sustain the HOWL project for the future?
	Q12: Do you feel confident that the project will continue another year? How about five years?

Conclusion:

I really appreciate your time and help with my thesis. I received very good insights today that will help promote the success of the HOWL project in eastern North Carolina. Thank you for sharing your ideas. Have a great rest of your day!

APPENDIX E
Informed consent (submitted to NC State IRB)

North Carolina State University
INFORMED CONSENT FORM for RESEARCH

Title of Study: Evaluation of Hofmann Open-Water Laboratory (HOWL): A Pilot Participatory Action Research Project in Eastern North Carolina
Principal Investigator: Meredith Hovis Faculty Advisor: Dr. Fred Cubbage

What are some general things you should know about research studies?
You are being asked to take part in a research study. Your participation in this study is voluntary. You have the right to be a part of this study, to choose not to participate or to stop participating at any time without penalty. The purpose of research studies is to gain a better understanding of your experiences in the Hofmann Open-Water Laboratory (HOWL) project, skills you have gained, and your overall thoughts of the longevity of the project.

You are not guaranteed any personal benefits from being in a study. Research studies also may pose risks to those that participate. In this consent form you will find specific details about the research in which you are being asked to participate. If you do not understand something in this form, it is your right to ask the researcher for clarification or more information. If you would like, a copy of this consent form will be provided to you. If at any time you have questions about your participation, do not hesitate to contact the researcher named above.

What is the purpose of this study?
The purpose of the study is to evaluate the HOWL citizen science project progress and participant progress, so it may sustain in future years to continue collecting data about the rapidly changing coast. This research evaluates if citizen scientists have achieved their personal outcomes through the project, and if HOWL has achieved their goal of community collaboration and networking. The results will be used to implement the project so that it may be maintained in the future by the volunteers.

What will happen if you take part in the study?
If you agree to participate in this study, you will be asked a series of questions regarding your participation in the HOWL citizen science project, and your beliefs regarding the sustainability of the project. If applicable, interviews will take place at the White Oak Chapter Izaak Walton League of America clubhouse in Swansboro, NC. If participants are not able to meet, phone interviews will take place. The interview should last about one hour. An audio recording will be taken of each interview for the purposes of the researcher's notes. After the interview, I will analyze the results on how well the project has done on meeting its overall goals. Your answers to this interview will aid in the revision of the HOWL project and help sustain it for the future.

Risks and Benefits
There are minimal risks associated with participation in this research. There are no direct benefits to your participation in the research. The indirect benefit includes gaining knowledge of the HOWL citizen science project.

Confidentiality
The information in the study records will be kept confidential to the full extent allowed by law. Data will be stored securely in a secured database on a locked computer only accessed by the researcher, Meredith Hovis. No reference will be made in oral or written reports which could link you to the study. I will voice record the interview for the purpose of note-taking, but I will erase all audio recordings and transcripts after the purposes of the study. I will not need the data for future research matters. The computer where the data will be stored is locked and secured by the investigator. All research obtained is confidential.

Compensation
There is no payment or compensation.

What if you are student?
Participation in this study is not a course requirement and your participation or lack thereof, will not affect your class standing or grades at your respective institution.

What if you are a NCSU employee, government, or non-government employee?
Participation in this study is not a requirement of your employment, and your participation or lack thereof, will not affect your job.

What if you have questions about this study?
If you have questions at any time about the study itself or the procedures implemented in this study, you may contact the researcher, Meredith Hovis, 213 Taylor Street #D Raleigh, NC 27607, mehovis@ncsu.edu, 704.235.8398.

What if you have questions about your rights as a research participant?
If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during this project, you may contact the NCSU IRB Office via email at irb-coordinator@ncsu.edu or via phone at 1.919.515.8754

Consent to Participate
"I have read and understand the above information. I have received a copy of this form. I agree to participate in this study with the understanding that I may choose not to participate or to stop participating at any time without penalty or loss of benefits to which I am otherwise entitled."

Subject's signature _____ Date _____

Investigator's signature_____ Date _____

APPENDIX F

Interview recruitment email (submitted to NC State IRB)

Dear XYZ,

I am writing to invite you to participate in a research study exploring the HOWL citizen science project. You were contacted to participate in this research study based on your previous participation with the project. Specifically, I'm interested to hear your perspective to determine the successful collaborative components within the project. This research will provide an analysis of the efforts between the various partnerships over the course of time.

As part of this study, I am also contacting other HOWL citizen scientists in phone interviews or applicable, face-to-face interviews. If you do not have the time to participate, I would welcome a suggestion of someone else who, in your organization, has participated in the project in some shape or form. The participation of your **[organization, community group, etc.]** is very important to my thesis and to help sustain the HOWL project for the future.

Your participation in this interview is entirely voluntary and all of your responses will be kept confidential. No personally identifiable information will be associated with your responses in any reports of this interview information. With your permission, I would like to record the conversation to improve the ability to accurately represent your opinions.

I have attached the informed consent information for your consideration. The interview would take no more than 1 hour of your time and can take place over the phone at a date and time convenient to you.

Please let me know if you are interested in participating in this study so that we can set up a time for your phone interview.

Should you have any further questions or comments, please feel free to contact me at mehovis@ncsu.edu or (704) 235-8398.

I appreciate your time and willingness to participate in this interview.

Best regards,
Meredith Hovis