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Aquatic Invasive Species Prevention Internship

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COLLEGE OF THE ENVIRONMENT

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AIS Inspector

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City Of Bellingham

Internship Report

Aquatic Invasive Species Prevention Internship

During the summer of 2022, I was hired as an aquatic invasive species inspector for the City of Bellingham.

The Aquatic Invasive Species (AIS) program at the City of Bellingham is a very unique program. Founded in 2012, the goal of this voluntary initiative was to ensure that the natural resources of Lake Whatcom, Lake Samish and other important bodies of water in the Bellingham area are preserved and protected. In 2011 the Asian Clam (*Corbicula fluminea*) was detected for the first time in Lake Whatcom, sparking concern for some about future invasions. Aquatic Invasive species are non-native pathogens, animals, and plants whose habitat is primarily the aquatic environment. Effects of the invaders can be ranging. In extreme cases pathogens can be introduced to bodies of water frequented by swimmers. When these pathogens come into contact with victims, rashes and irritation can occur. Lake Whatcom plays a very important role in the resources available to residents as the lake is the direct source of most of the drinking water consumed in the community (~ 100000 individuals).

Both Lake Samish and Whatcom host a handful of residents that have their own personal water collection and purification systems stemming directly from the lake. This practice of constructing and maintaining private water acquisition and purification systems is more common on Lake Samish than Lake Whatcom for several reasons. Some residents aren't capable tapping into city water sources because of the great distance their residence is from the closest main and others prefer to invest in construction of their own water acquisition systems rather than make monthly payments to the City of Bellingham. The Lake Whatcom watershed is home to more than 18000 residents who use the watershed in many different ways. Although Lake Whatcom provides drinking water to over 100000 people, not all are within the boundary of the watershed. Those who are within the watershed are typically in view of the lake and may have properties on the waterfront or near a tributary.

Recreation on Lake Whatcom and Lake Samish is very popular. In recent years there has been an emerging trend of increased numbers of people using personal watercraft. On pristine days the surface of both bodies of water is ideal for waterskiing, wake-surfing, wakeboarding, and tubing. Recently, Western Washington University has taken advantage of this unique natural resource and integrated a wakeboarding club amongst its many other extracurricular activities available for students. Lake Whatcom also boasts some of the best sport fishing in the Pacific Northwest and was featured on the Northwest Fishing Report hosted by Q13 FOX in the summer of 2022. The fishery that is most commonly targeted in Lake Whatcom is the landlocked Kokanee fishery. A large variety of fish can be caught aside from Kokanee in Lake Whatcom and Lake Samish including large and smallmouth bass, cutthroat trout (which typically aren't legal to keep when caught), yellow perch, pumpkin seed, brown bullhead catfish, and northern pikeminnow.

Lakes Whatcom and Samish host many varieties of wildlife that depend upon the resources provided by the lakes. Until European exploration and subsequent expansion established a significant footprint on the

landscape only roughly 200 years ago, this area had been an unimpeded home for thousands of species of plants and animals since time for millennia. Indigenous peoples recognize this place as their home since time immoral and prior to contact had used ancestral knowledge to subsist while maintaining a balanced and respectful relationship with nature. Today, the relationship held by the public with nature is far from as cohesive and sustainable. The interface between the highest level of lake water and the surrounding woodlands or wetlands serves as one of the most important habitats for wildlife. Raptors, migratory birds, bats, insects, small mammals, and reptiles are present in these areas and are historically provided with food, suitable habitat for spawning, and protection.

Above: A Western Tanager (*Piranga ludoviciana*) I was lucky enough to have photographed at the Lake Samish Boat Launch. On slower days, I was able to spend some time birdwatching and observing the daily habits of the lakefront's original residents. I observed amazing community interactions among many species.

The tributaries surrounding and feeding into lakes Whatcom and Samish are the lifeblood of the organisms rely on the lakes for habitat. Landlocked kokanee in particular rely on the gravels and sediment-rich stream beds for spawning between the months of August and November. For months following the successful fertilization of the kokanee's eggs in the sediments, the development of the kokanee embryos takes place. From beneath the gravels and sediments salmon fry emerge months later in March-April and journey to the larger and deeper waterbodies of Lake Whatcom or Samish.

Lake Whatcom and Lake Samish are also home to a variety of crustaceans. The species of crayfish that inhabit both lakes are the red signal crayfish (*Pacifastacus leniusculus*), and the non-native rusty crayfish (*Orconectes rusticus*). Some trap crayfish (the non-native species exclusively) in the lakes today. This opportunity for another fishery has been taken advantage of multiple times in the recent past. Commercial crayfishing was somewhat successful in Lake Whatcom in the late 1990s and 2000s, and today Lake Whatcom still boasts fantastic opportunities to trap crayfish in moderation.

The beginning of the program:

Aquatic Invasive Species (AIS) are animals, plants, and pathogens that are especially apt to thrive in new foreign environments and are primarily found in aquatic environments. Plants that are AIS, usually propagate around a body of water after introduction and come to rest and thrive in areas deep within the lake, just below the water's surface (slightly submerged), or on the surface of the water. Aquatic invasive plant species are notoriously proliferous and tricky to mitigate as some plants can spread via plant fragments (fragmentation). Unlike most aquatic invasive animal species, plants that spread via fragmentation can easily be transported by water currents, humans, and even on the hair of dogs that have entered infested waters. The effects of the presence of these invasive aquatic species is a broad spectrum detrimental damages that harm not only humans but the native plant and animal species that inhabit the lake.

Aquatic invasive plants can damage native populations of plants in a few ways. Native plant populations are put at risk when aquatic invasive plants devastate habitats directly or indirectly. Aquatic invasive plants can directly impact native plants by making their habitat unfavorable. As the native plants in Lake Whatcom and lake Samish inhabit the upper trophic levels of the water column in shallow waters,

they are at risk of being shaded out by floating invasive plants above them, thereby reducing the amount of photosynthesis that can take place. Invasive plants that float on the surface of the water can produce shade that is especially threatening to native plants that inhabit the bottom of the lake in shallow waters. Invasive aquatic plants also pose a large threat to infrastructure crucial to the residents of Bellingham.

Large quantities of invasive plants can block intakes that feed into municipal water treatment plants as well as agricultural and commercial water supply and distribution. Presence of large mats of vegetation in areas with swimmers and recreational visitors can be harmful to their health, producing rashes and increasing the risk of developing infections in open wounds. Pathogen presence in Lakes Whatcom and Samish threatens the health of those who enter the water, but also adds difficulty to the process of municipal water treatment. Fecal coliform is a pathogen that threatens Lake Whatcom especially with recent threats coming from waste from high population of Canada Goose, and waste associated with resident's pets.

The Zebra/Quagga Mussel Threat:

The most substantial threat to Lake Whatcom in terms of ecological, native flora & fauna, and human health is the spread of Zebra and Quagga mussels. In my college coursework, I learned much about these disturbances. Originating from the black sea region these small non-native mussels are masters of proliferation for several biological reasons. Zebra and Quagga mussels were first detected in the Great Lakes of the US in the late 1980s. In Europe, these mussels had been introduced and already proliferated to uncontrollable levels by the mid-1700s. It is thought that the most likely vector for introduction to the Great Lakes of the US is through the uptake and release of ballast water from large ocean-going container and tanker vessel.

Above: A picture of me holding a living specimen of Western-Ridged Mussel (*Gonidea angulate*), a native freshwater mussel I observed at the Summer camp survey site on Lake Samish.

In the Black Sea region, once cargo had been unloaded, water is pumped from the surrounding body of water into the holds of large shipping vessels to account for the lack of cargo thereby correcting the depth at which the vessel rides in the water. Intake of ballast increases the likelihood of high maneuverability in rough seas and decreases the risk of capsize. Once safely across the Atlantic, these vessel traverse a series of locks ultimately delivering them to the Great Lakes. In preparation for loading more cargo for the next trip across the Atlantic, the ships release their ballast into the Great Lakes. What was once contained within the black sea, the zebra and quagga mussels are then released into the Great lakes, given a free ride to a new foreign habitat rich with vulnerable and unoccupied niches. Lake St. Clair was the first to declare their presence in June 1988, and within a matter of three years zebra and quagga mussels had propagated to all 5 basins of the Great Lakes.

Comparable to the size of an American quarter, zebra and quagga mussels can display a broad variety of colors and patterns from black to near yellow. A unique feature of these non-native mussels that isn't present on native populations is byssal threads. These fibrous filaments protrude from the hinge of the mussel shell and attach to any available surface in order to provide stability. The presence byssal threads allows for zebra and quagga mussels to attach to surfaces that would otherwise be free of native mussels. Blockages of intake manifolds, exhaust vents, can result when populations crowd each other via

Above: Me holding a specimen of a Fragrant Waterlily (*Nymphaea odorata*). This species is in fact a threat to native habitats in Washington state and is already present in both Lake Whatcom and Samish. Despite this, for unknown reasons fragrant waterlily's spread in our areas lakes is relatively confined and doesn't spread rapidly.

attachment with byssal threads. Important fittings, moving parts of ships, and rock surfaces become completely inundated with attached mussels. These mussels are filter feeders and use intake and outtake syphons to pump water across their gill epithelia. The gill epithelia are coated with a mucus membrane that acts as a trap for any organic material for consumption. Large colonies of Zebra and quagga mussels once established, are nearly impossible to completely eradicate, so enterprises in the Great Lakes regions frequently demand divers with special training to manually scrape and crush all mussels on the target area. This is not a long-term solution however, as mussels inevitably will re-colonize on the new mussel-free surface.

Ever since the introduction into the Great Lakes, Zebra and Quagga mussels have slowly but surely propagated from waterway to waterway. Rapid spread occurs in rivers and connected waterways by transport in current. The lifecycle of zebra and quagga mussels is composed of two major stages, the planktonic, and the benthic stage. The very first stage of life for these invasive freshwater mussels is known as the veliger stage. In the veliger stage, the embryos of the larvae are microscopic and free-floating within the water column. After four to eight weeks, the veligers undergo metamorphosis in which time the hinge of their shell forms, allowing differentiation of either side of their shell. By this time the rough size of the veligers is around 150-200 μm, still not visible with the naked eye. During metamorphosis, the developing mussels settle to the bottom of the water column, attaching to anything available (i.e., rocks, sand, skin of aquatic species, shells of native species). These juvenile mussels are known as settlers, and they eventually settle to the deeper benthic zones of the water column.

The benthic stage of the mussel life cycle is characterized by development of shell patterns, extension of byssal threads, and sizes roughly 250 μm-10 mm across. Once the juveniles have matured, they become sessile adult mussels. Using byssal threads, the mussels form dense clusters with many individuals attaching and piling atop one another. Eventually, the mussels that are deepest in the pile are suffocated by the mussels above them. Typically, the time to complete one full lifecycle is roughly 4-5 years. Only after the mussels are matured are they visible to the naked eye which poses many challenges for those trying to mitigate the risk of spread.

Slow, but steady infection:

In 2007, the very first occurrences of Zebra and quagga mussels was recorded west of the 100th meridian. Colonies were detected in Lake Mead, Lake Havasu, Lake Mohave, the Colorado river, and waterways in California. The discovery of these invasive mussels in Lake Havasu in particular are especially significant. Because Lake Havasu is nearly 1,000 miles from what was the nearest infected body of water (in 2007), the most likely vector for transport to new uninfected bodies of water, was by overland transportation on or in the hulls and on the trailers of recreational vessels. Zebra and Quagga mussels, when introduced to a new body of water cause a multitude of effects that can compound on one another. Often times one of the most characteristic features of an infected body of water is the presence of a stench, accompanied by foul tasting drinking water. Because of the efficiency of their filter feeding

lifestyle, they are able to intake massive amounts of organic debris for nutrition, depleting availability for other consumers. This also decreases the population of microorganisms and maintain the nutrient flux. Disturbances in this nutrient flux is often the culprit for “stinky” water.

Although mussel species native to the pacific northwest are classified as filter feeders too, the sheer density and quantity of non-native zebra and quagga mussels in combination with their efficient filter feeding strategy almost always allows them to outcompete native mussels. Mass filter feeding brought on by large numbers of mussels also directly effects the nutrient cycle of bodies of water. Non-native mussels once established, act as a sink for nutrients that would otherwise be consumed by native populations of organisms in the ecosystem. This deficit can be detrimental to the native populations that exists within the population especially considering the extent of interconnectedness amongst all those involved in the nutrient/food web.

Eradicating the mussels from waterbodies isn’t feasible for several reasons. The handful of efforts that have been successful in eradication of Zebra and Quagga mussels involved poison/chemical control but were confined to man-made reservoirs and small lakes with no natural living ecosystem besides the non-native mussels. In my college courses I have spent considerable time learning techniques to monitor the spread of invasive species, and measure the effects imposed by those species (which were mostly plants). For instance, I conducted research on Japanese Knotweed (*Polygonum cuspidatum*) and its incursion into local riparian environments. Similar to the incursion of Z/Q mussels, this fast-growing bamboo-like plant is often only noticed after establishment. Fortunately for the COB, EDNA tests are conducted frequently to test if DNA of Z/Q mussels is present in Lake Whatcom and Samish in any capacity. This is an extremely valuable early warning system that could one day detect Z/Q presence in our lakes and help quicken the response to the infestation. This made me realize that there is little research into the early warning signs of incursion for other invasive species (like *Polygonum cuspidatum*), and some opportunities for future research.

Alternatively, a less invasive approach to eradication of zebra mussels in Arizona found success in taking advantage of the sun’s energy. Zebra and Quagga mussels can tolerate ambient temperatures between 1° C and 30° C. A reproductive difference exists between both Zebra and Quagga mussels require ambient temperatures to be above 12° to reproduce successfully while the Quagga mussels are capable of reproduction in waters with ambient temperatures as low as 9°C. When temperatures exceed 112°, Zebra and Quagga mussels die very rapidly.

In their natural environment, these freshwater mussels are sometimes at the mercy of the elements. When the scarcity of water becomes a concern to a colony, individual mussels can shut their shells, and remain out of the water for up to 40 days. This adaptation allows the mussels to overcome the uncertainly of finding suitable habitat. In the instance where the suns energy was used to eradicate the invasive mussels, large plastic sheets of transparent vinyl were spread over the entire beach/ water interface. The relatively shallow depth of this body of water allowed for nearly all infected areas to be treated despite distance from the shore. Solar energy transmitted through the plastic sheeting becomes trapped within the membrane. Eventually, the temperature within the membrane reaches an extreme in which no mussel is able to survive (around 100°C). After a period of a week or so, the likelihood of a living mussel under the sheets is astronomically small.

It should be noted that the mussels within this body of water had not fully established themselves. Because the mussels weren’t given time to establish and layer upon one another, the overall success of the eradication increased dramatically. The speed at which a response to an infestation is delivered also significantly alters the likelihood that the body of water will recover. When non-native mussels are given

time to establish, they're given time to reproduce which allows microscopic veligers to develop in the water column. Smaller, more difficult-to-detect life stages exist in communities that are well established.

History, and Mitigation of Spread :

In their natural environment, AIS populations are typically kept in check by a system of relationships that make up the nutritive cycle. Predators keep populations at sustainable levels, geographical barriers limit the distance species can travel, and seasonal events like flooding or freezing can directly reduce population. It is only when AIS are introduced to a new foreign habitat that their normal attributes condemn them to an episode of destruction.

Much like the suspected means of transmission for Zebra and Quagga mussels into the great lakes in the 1980s, recreational vessels provide a means of transportation to a possible new body of water. Due to the fact that Z/Q mussels spend a portion of their life in the microscopic "veliger" stage it should be assumed that water from an infested body of water is positive for the presence of Z/Q mussel veligers. Because the larvae aren't visible with the naked eye, this poses one of the most threatening means of transmission. Most recreational watercraft involve some sort of system that moves water from outside, to the inside of the vessel for either mechanical cooling, or ballast.

Water infested with veligers once pumped into the ballast tank of a wakeboard boat for instance, can support a small community of growing mussels for weeks within hidden compartments of the vessel. Standing water can also accumulate at the lowest point of the hull above the keel, as water inevitably enters most boats through fittings near the propeller. Most vessels that encounter infested bodies of water are accompanied by a trailer allowing for transport across state, county lines to visit other bodies of water. Vessels that remain in infested bodies of water commonly have their propellers fouled, as well as coolant intakes blocked by adult mussels. This obviously poses a threat to any non-infested body of water, as only a few adult individuals or veligers need to enter a body of water to begin establishing a dense colony.

Above: Wild Western Ginger (Asarum caudatum). Also Known as British Colombia Wild Ginger this small cluster of shiny waxy leaves is extremely hidden at Lake Samish Park. This plant is particularly uncommon in the area, and it's scent never failed to spark awe into visitors who'd never seen wild ginger

Education as a first line of defense:

The challenges associated with eradication are often too costly or will do more damage than that's posed by the mussels themselves. Because of the clear lack of methods to control the spread of mussels once established, prevention of the spread of these invasive species is the most valuable means of defense against this threat. The main goal of the AIS program is to act as a guide for the prevention, monitoring of AIS and the education and outreach of the general public. Aside from the physical inspections of vessels, the education of the public on the threat of AIS and the associated effects does by far the most in terms of protecting against new foreign invasions.

I was heavily influenced at a young age by people who had become strong ambassadors between the natural environment and the public. While visiting National Parks, I

found myself captivated by the stories the Park Rangers knew about plants hidden in the mountains, or the daily habits of big raptors. these people would teach, listen to questions, and show things that would be missed otherwise. To some people a small amount of extra knowledge can completely change their experience. This happened to me when I learned about the striations in rocks ground-down by glaciers. Standing atop the striations in stone and imagining the mile thick ice sheet rising in front of me allowed me to experience the space in a completely new way.

Above: Ghost Pipe (Monotropa uniflora L.) is a perennial plant that can only be found in a narrow window of time at the Lake Samish Park. I expected this plant in particular to fall victim to foot-traffic trampling but was proven wrong. Teaching others about how this plant lacks energy producing chlorophyll and instead saps nutrients from surrounding tree roots, seemed to cast a cage of protection around the little pale colony. It's my hope these strangers went out of their way to preserve it so they could show it to their friends.

Public outreach was one of the major parts of this internship that I feel like I improved upon the most as most of the job was spent at the boat launches of Lake Whatcom and Lake Samish. I have had much experience with public outreach through volunteer experience. These past experiences included positions at museums and interpretive sites that I was very familiar with. Like these past experiences, I was expecting to spend a significant amount of time interacting with the public. In talking with the hundreds of boaters that I encountered at the boat launch I found that above all else, their variability of understanding of the environment was extremely broad. Some boaters I interacted with knew of the threats my team and I were trying to mitigate, while others weren't aware in any capacity.

When I encountered a boater that wasn't familiar with the reasons why our team was at the boat launch, I found it created an ideal opportunity to que someone in. I began with introducing myself and leveling myself. I found that this key point in the interaction was very important. It can be overwhelming to be approached by an official with high visibility clothing, and often times I encountered boat owners that were hesitant to interact with me outright from fear of penalties for some unseen reason. From firsthand experience I have encountered people who controlled natural resources that were very harsh in communication. Past experiences where boaters had 'negative' interactions with officials like game wardens, DNR, and natural officers can make the public fearful and hesitant to interact with officials in the future no matter their duty. I found that in the processes of leveling and introducing myself to boaters I was given the first critical opportunity to make the boater feel comfortable, heard, and respected.

Because the aquatic invasive species program is nearly exclusive to Whatcom County, not many new boaters or visiting boaters are aware of the requirements all vessels must meet before launching and can sometimes be caught off guard by the process. In my introduction to the visitors unfamiliar with the program I found it was sometimes effective to firstly explain what exactly we were looking for, instead explaining what we were there to protect. Letting the boater know that I am there to make sure there aren't any plants or mussels on the boat that could enter the lake encouraged them to see me as someone who wouldn't impose a fine or penalty on them. Some visitors wanted to expedite the process so they

could get on the water as soon as possible which unfortunately sometimes limited the amount of time I could use to introduce them to the program. Thankfully most new visitors to the inspection station were very eager to learn what they could about the program. From the perspective of a visitor, it would be easy to assume that the only obligation to my job was to be present, but my investment was also very personal.

I have a very deep respect for nature and am very inquisitive, so when my personal investment was challenged I found it easy to prove the contrary. Expressing my individual investment in the lakes and my job as an inspector was very important as it helped me interact with the boater in a more conversational way.

In the future I want to use the skills that I've learned in earning my degree to encourage the public to become aware of the environment around them. Awareness of the environment can be expressed in many ways like gratitude and reverence but can also constitute the way someone goes through their day. Kayakers, skiers, hikers, and cyclists or anybody else who spends their time "in the moment" in nature are often acutely aware of the state of their surrounding environment. I consider myself to be one of these people, spend a significant amount of time in nature in my free time, and have formed a strong bond to the environment as a result. This made it especially easy to communicate with individuals who also shared the same love of the environment. In my own experiences, I have encountered changes in the environment that were concerning to me. Growing up in the acres of woods behind my house I watched for years as Scotch Broom (*Cytisus scoparius*), Japanese Knotweed (*Polygonum cuspidatum*), and Himalayan Blackberries (*Rubus armeniacus*) slowly, but steadily propagated further into the forest. To this day I have tirelessly attacked these species that threaten to change my favorite bit of forest into a botanical wreck. Although I can mitigate these threats, there are many changes which I haven't been able to prevent.

Living in the Eastside of Washington I found myself growing up as corporations like Microsoft, Amazon, Costco and T-Mobile established headquarters within 10 miles of my home. These growing companies hired workers from out of state and beyond, without much regard to where their employees would call home. As a result, the hasty development of old growth and second growth forest, wetlands, and peat bogs into expansive 3-story single-family houses began. Today, most of the forests I once found myself infatuated with are erased and replaced with parking lots and cookie cutter homes. Seeing changes like this made me somewhat feel responsible for the mitigation of the lasting effects of anthropogenic change.

Looking back, I can identify many times where I was overwhelmed with the level of infection of native lands with invasive species. As someone who loved the environment, I wanted fix it, and prevent these changes ever happening again. I would identify the threat and become extremely knowledgeable on it before conceiving an attack plan to best control the change. Above all else, I remember wanting other around me to be concerned and aware of the problem.

As an aquatic invasive species inspector, I was overjoyed to answer people's questions. I felt eager to use the opportunity to teach about the environment and wanted to get people involved. Several instances in particular highlight this and helped me realize how effective teaching is as a tool for preventing unwanted changes in the environment.

On the first occasion after I had received around 2 months of experience as an inspector, I was approached by a visitor while stationed at Sudden Valley Park. After small introductions and learning how their day was, I was excited to see them produce a small jar from their handbag, sealed with a metal lid and some tape. As this retired resident lives on the lakefront, they spend a significant portion of their

day on their dock. They had chosen to walk from their house down to the inspection station to ask some question regarding what they had found on their dock.

Inside the jar was a snail (thankfully a non-threatening Chinese Mystery Snail). I soon learned that she had encountered the snail by chance while returning to her house from her dock. She was concerned that it may have been an invasive or a harmful species in the lake that could turn the water foul-smelling. She and her husband had been residents for over 40 years and had seen many changes come to the Lake Whatcom Basin. This experience showed me how critical it is to encourage others to be vigilant in nature and monitor changes. If this small snail had in fact been an undocumented species that posed a risk to the lake, its inevitable spread would be more easily controlled owing to the lakefront resident's early warning. Comparable to having sensors for environmental health distributed across the region, having a network of individuals that are in tune with their surroundings, and are acutely aware of even the smallest changes can be critical in ensuring that threats to the environment are addressed and resolved. I realized the value of this citizen-level involvement and encouraged this vigilance in the future. Early in the boating season when the weather is less than ideal, the number of visitors to the inspection stations can be very low, and it was very satisfying to know that there were others in the general public that had been inspired by the AIS program to keep a watchful eye on the condition of the environment.

The general public often times only need the idea in their head for it to take root and develop into a habit. As I spent the majority of the day at the parks around the boat launch parks I was able to see the daily habits of people of all lifestyles. The variety of activities that the lake and its shores allow are vast and are constantly growing. Some individuals test experimental watercraft on the lake and one-of-a-kind floatplanes frequently visit. While I enjoyed seeing odd vehicles fly and sail (and sometimes fail), one of the things I looked most forward to in my day was the "regulars" that walk each morning or evening each and every day. I found that these small relationships were very easy for me to build and were beneficial in many ways. Friendships were an obvious joy and I often times found myself talking to individuals whom I would have never expected to befriend like fluvial morphologists, archaeologists, diplomats, Boeing engineers, prospectors, and authors. These ranging interests from visitors made each and every interaction interesting in its own way.

Wild Strawberries (*Fragaria vesca*) are my favorite treasure to find in the forest. An uncommon sight and frustratingly small, I was delighted to be shown two independent patches by locals while at Lake Samish. I found utilizing these small fruits as teaching tools (and appealing to their taste buds) was overall one of the best ways to get visitors interested in the environment.

Inspecting the many boats that come to visit the lakes is a very rigorous job and during the hottest summer weeks, the days can get quite hectic. On both busy days and slow days, I especially loved the times when I was on my break and could sit by the shore while I had lunch. After eating, I nearly always found time to spend wandering on the beach before I had to return to the inspection station. When the boating season began in early April, the beach at the Samish Boat launch was very contaminated with waste, plastic, styrofoam, glass, and even biohazards like hypodermic needles. On my breaks I would often collect and offsite the trash. Only an hour of work in total was needed throughout the week to keep

the beach free of plastic debris and garbage. While it was satisfying to see hundreds of feet of fishing line, and an equal amount of colored pieces of styrofoam and plastic consolidated in one bag, the improved state of the beach was incomparably rewarding. Like any highly-trafficked spot, the extremely busy nature of the Samish Boat launch means that waste and trash accumulates at a quick and steady pace.

A week into my endeavor to maintain the beach, a visitor approached the inspection stand and commented about how "wonderfully clean" the shore was. As I expected, they had seen me remove some trash, but I noticed that they too had collected some waste and wished to put it in our trash can. Although a small action, this was very satisfying to because I saw someone become inspired by an action I did. This experience showed me the possibilities that come with putting small ideas into the minds of others. I felt that this was extremely powerful because if someone who walked every morning or evening was attentive to the condition of the beach, the amount of trash that would enter the lake would be greatly reduced. I see many applications for this in the future for my career. Encouraging others to be more aware of their environment in order to keep a sharp eye on its health is one of the main goals for my career. Today when I visit Lake Samish, I usually find the beach in spectacular condition compared to how it was before the 2022 boating season, and I like to think that I played a role in inspiring others to be more caring in their environment.

One thing that I didn't expect to learn during this experience was all of the valuable information and insight I obtained from these friendships. For instance, one of my friendships at the Samish Bay launch was sparked by amateur ornithology. After many passing conversations with fellow birdwatching enthusiasts, I was able to learn about the hidden hotspots for migratory birds like the Bohemian Waxwing *(Bombycilla cedrorum)* which migrate in the late summer and fall, and while an uncommon sight at the boat launches it could be viewed at a small wetland almost without fail, down the beach near the Samish boat launch. This small snippet of "insider" information is just one instance of many where learning from others in the community helped me learn about my own surroundings and in this case, some very elusive birds.

The community of birds in our area while diverse, is composed many species that are either masters of camouflage and stillness or prefer habitats unreachable to us thus limiting out interactions. Western Tanager (*Piranga ludoviciana*) is a brightly colored bird that caught my attention for the first time while at the Lake Samish Launch. While I spotted migratory this bird by mere coincidence, I learned later from a passing visitor that I had been hearing their call for weeks already and didn't even know it.

Field Surveys of Lake Samish:

In conducting field surveys, I learned a few crucial lessons, and enjoyed putting my skills to the test. In conjunction with a few other inspectors, I was tasked with performing presence/absence tests for foreign and already established invasive species on Lake Samish. Boating in my free time on Lake Whatcom made me very familiar with the general surface conditions of the water (i.e. plant fragments, terrestrial

Above: AIS Crew 1. conduct quadrat surveys for the target species Asian Clam (*Corbicula fluminea*) at Bloedel Donovan Park. This photo shows the relative distance between the quadrats in order to include the largest possible (most inclusive) survey area.

debris, chemical contaminants) but as I had not spent as much time on the Lake Samish, I was eager to learn the differences and similarities between the two.

The presence/absence test we conducted different ways depending on the target depth of the bottom of the lake. In shallow depths where we found it possible to safely enter the water, we performed quadrat surveys to both test for presence/absence, and the population density of the target invasive species the Asian Clam. In deeper water, a dredging rake was cast as far as possible away from the caster and then retrieved in hopes of snagging plant fragments and debris from the bottom of the lake. Using a dredging rake is an economic and efficient way to obtain a biological snapshot of the plant community below the water. This is also an effective tool for reaching areas that are unreachable by foot even when their shallow enough to wade in. At each site, a preliminary search of the ground was made to observe plant fragments and terrestrial plants. I was very pleased to learn that I was very proficient in my identification of the aquatic plant species, which allowed me to effectively survey areas in a short amount of time. I feel that having this familiarity with the types of plants I was encountering gave me an advantage in observing the plant community cohesively because I was able to notice subtle ques like the abundance or absence of a certain texture or color in large clumps of watergrass and debris. I have always been a habitual notetaker and this proved very useful in this situation.

The very first site that I visited to conduct a field survey was at a private dock at a the Lutherwood Camp and Retreat Center on Lake Samish. Because we weren't able to enter the water due to its depth, we conducted dredge rake sampling to compromise. The data I took on this first sample was good, but there could have been improvement in depth of information I was writing. My notes were detailed, but were missing a few things I didn't have a chance to write down because I was spending time elaborating on my notes. This situation taught me the importance of time management, and showed me how important it is to effectively communicate in my scientific writing. There were no invasive species at this first location, and we observed mostly native aquatic plant species. The Samish beach park was the second target location, and thankfully the depth of the water allowed for quadrat surveys to be conducted. Before even coming to this site the other inspectors and I had been told this beach in particular hosted a huge Asian clam population. Owing to the sandy/muddy bottoms that are mostly gravel and cobble free, Asian clams flourish in this these conditions and easily became established once introduced. While quadrat surveys usually involve a geometric square sector, our team chose to use hoops that would float on the surface of the water. To ensure accurate area specific counts, the hoop's positions were held in place by wooden dowels that were driven into the shallow lakebed. Excavation of the sediment within the quadrat area was done using a variety of tools to ensure all sizes and shapes of biological materials were included in our samples. The tools we used consisted of shovels, small hand shovels, buckets, sieves, and magnifying glasses. In each quadrat the sediment was excavated to a depth of 1 foot, which was then sifted, and washed to expose any debris or organisms left behind. On all of the occasions, Asian clams were found at depths of 1 inch to no more than a foot below the surface of the shallow lake bottom. It was after a few quadrat surveys that I "got into a roll" and had developed my own method of effective note taking. After

Above: AIS Crew 1. performing a size-analysis of Asian Clam (*Corbicula fluminea*). These clams were collected from Bloedel Donovan Park, Hertz trail, and Sudden Valley private marine launch.

Above: The first steam runabout (photo taken around 1890) to launch on Lake Whatcom, "Geneva" was wood-fired and carried passengers and small loads of cargo all across the lake until it was destroyed in a catastrophic fire and sunk less than a quarter mile from the Bloedel Donovan Park.

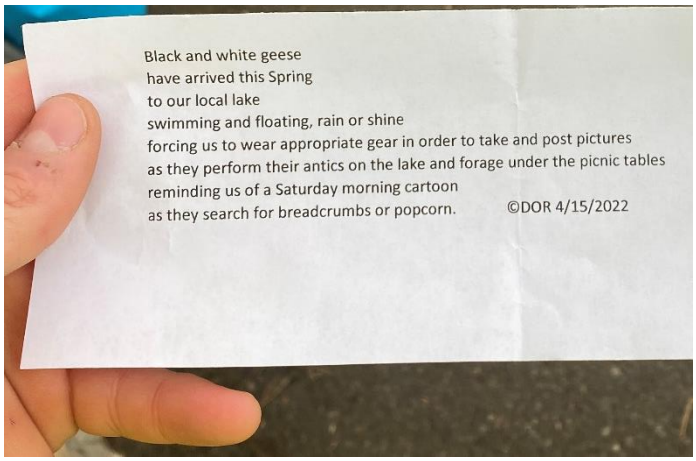
each individual quadrat survey, I would compare my notes to the notes of my superior, Teagan Ward to make sure the information I was taking down was relevant and useful. I found that in especially "hectic" situations where there are many people performing surveys, waves are crashing on you, and your quadrat is undulating with the waves out of control its enormously helpful to have a clear procedure for note taking and data collection. This experience gave me valuable insight into not only the importance of good notetaking, but how to design and perform field surveys.

In the years earning my degree, the importance of unbiased study has become engrained into my work style. Because access to our target sites lies on the interface between the forest and the lake, the difficulty of working around private property commonly arises. This study was designed to provide insight into the biotic health of the lake and stay true to the rules of good sampling techniques by providing unbiased results. With private property off-limits, our chosen survey sites had to represent the lake's many different aquatic environments including those which we felt were underrepresented.

My background knowledge of the environment and that which I gained in my college classes also helped me produce extremely accurate notes. Because I am very passionate about geology, botany, and soil sciences, and other disciplines I've become familiar with the many names and classifications of sediments, soil, stratigraphy, and flora/fauna ID. This helped tremendously in creating detailed reports on each site because I was able to provide so much conditional data. Temperature (air and water), water level relative to the highest water line, water, barometric pressure, sediment size, current strength, sunlight exposure, organic matter concentration, point sources of pollution, water-smell, clarity, turbidity, present algal, as well as plant and invertebrate species, were the kinds of observations that I succeeded in successfully collecting at each site. While these data points may be of little use by themselves, they each represent a condition that when all viewed cohesively, can help clearly describe a trend or pattern in the environment. For instance, we observed that the Asian clams have a clear preference for habitats 1-4 ft. deep receiving high light, with minimal aquatic plant presence and small sediment class (fine sediments over gravel or cobbles). This pattern was very clearly evident in the notes as the sites hosting the highest number of clams fit these conditional parameters. Our target species the Asian clam was very abundant at some of our sites and the large number of individuals allowed us to sort them by maturity. This information was important as it informs the AIS crew on the relative spread (zone of establishment) of the invasive species, how fast, where, and when they are reproducing.

One duty I had as an aquatic invasive species inspector was to complete a Lake Report. The purpose of a lake report is to give the reader an informative view a particular body of water by explaining the history of the lake, cultural uses and history, geologic origin, current importance as a resource, current condition and risks posed to its conservation. It was my duty in particular to create a lake report for Lake Pontchartrain in Louisiana and its surrounding water basin. In creating my lake report I found that my

past experience from researching in college made it very easy for me to obtain information vital to my lake report while ensuring I was only using reputable sources and accurate information. Creating the lake report also showed me the importance of historical and geological context. I was shocked by the amount of information available on what I believed was a small unassuming lake. For instance, a 1940s lead-based paint factory that utilized a low-order stream in the Lake Pontchartrain Basin is invisible today minus some eroding foundation. Though demolished decades ago, contaminants from the old factory continuously leech into the main-stream channel undetected. Uncovering this kind of crucial historical and situational context data showed me the value of good and thorough research. Though not required of me this inspired me to delve into the past use of Lake Whatcom and Samish as a natural resource which itself allowed me to see our lakes in a completely new light. My college coursework helped tremendously in researching as those experiences honed my skills in researching, building reports and reporting citations and concisely stating evidence from credible sources. The expected layout of my report on lake Pontchartrain did not take me by surprise and was very similar to the final report I created in my water quality class at WWU.



Above: On a very rainy day while I was manning the Bloedel Donovan park inspection site, a couple who always visited the inspection stand on their daily walks gave me and the other inspectors this poem about the lake to thank us for sticking it out in the

From the perspective of a visitor, the rules and regulations of the water, and the transport of AIS may have seemed overly complex and intimidating. I found that this was a lot less of a concern once I had become familiar with Bellingham Municipal Code 12.12.280, and Whatcom County Code 2.27A. These two ordinances are good examples of the regulations that were crucial to performing my duties by the book and more importantly providing accurate information to the general public. Aside from becoming acquainted with laws and regulations like the clean water act, the 303 (d) list, etc. in my coursework, working as an AIS inspector first showed me the importance of knowing the "ins & outs" of laws and regulations when it comes to working with the general public and protecting natural resources.

Performing Inspections:

The general inspection of a watercraft to ensure that it's free of plant debris, standing water, and/or mud relies heavily on the cooperation of the boat owner (visitor). Assuming that the boater is already permitted we first retrieve the boater's information on the AIS database using ipads. Once the boater's history with the AIS program is found on in the database, the date and site location are recorded to reflect the current inspection. Because inspections constitute a thorough search possible hideaways for AIS, its often required to get inside the boat. When possible, the plug of the boat is pulled which allows the expulsion of any water sitting stagnate in the lowest points of the boat. The engine compartment as well as any areas that store items such as buoys, ropes, anchors, and lifejackets are also inspected. In the summer of 2022 a total of 14,305 inspections took place, and the decontamination of 24 high risks vessels took place. On one occasion the owner of a sailboat who has participated in the program for years asked to have his vessel inspected after returning from Lake Havasu in Arizona. During the inspection, one of

my fellow inspectors discovered that on the rope attaching the anchor to the hull of the boat had intact zebra mussels on it. The 2 intact zebra mussels less than 2 cm in length had interweaved their byssal threads into the fibers of the anchor rope, firmly attached. The fact that these mussels stowed away attached to this rope hidden in the moist anchor compartment was a stark reminder of how important it is for each and every vessel to be inspected to the same degree of precision each time. Being the very first decontamination of the 2022 season, this first interception of mussels served as proof of the excellent capabilities of all of us as inspectors, and more broadly the program as a whole.

A decontamination procedure is made up of several important steps. First, evidence is collected much like a crime scene. Photographs, notes, and samples can provide clues that can be useful in the future (i.e. new hiding places, individual species of concern). Loose materials like sand, dust, debris (plant and animal) are then removed by hand. If standing water is present and its accessible, its absorbed with towels. Because mussels, including microscopic veligers cannot tolerate temperatures greater than around 100°F, hand washing then heated machine drying destroys any living AIS still on the towels. The Landa 3000 is essentially a massive tea kettle with a reservoir of around 300 gallons of water attached to an industrial pressure washer. Contaminated vessels are completely washed outside and in via the high-pressure washer, and scalding water is cycled through the cooling, bilge, plumbing, and ballast systems. Using hot water instead of other decontamination practices like use of poison, ensure that no impact is made on the environment we're trying to conserve.

The owner of the contaminated vessel is the only reason why the mussels were discovered I the first place. If he hadn't contacted the program to let us know that he'd sailed in an infested body of water, the risk of transmission to our local waters would have been dangerously high. As this boater frequently took his boat to Lake Havasu in Arizona during the winter months, the inspection and decontamination of his boat was imperative in making sure mussels from Lake Havasu didn't hitchhike north. This great relationship between the boater and the inspectors facilitates somewhat of a "tradition" for the boat owner. No fines were imposed on the boat owner of course, and only two to three hours are needed for a thorough inspection and decontamination.

Conclusion:

In reflecting on my time working as an AIS inspector I'm reminded of several takeaways I wished to improve upon before beginning my internship. I wanted to learn about the management of aquatic invasive species contamination, and skills to help research and monitor AIS. This experience was very unique in that it allowed me to gain experience that would be hard to get elsewhere (i.e., performing physical decontaminations, and performing field surveys).

I also wished to come out of this internship with better experience in working with the general public. In the future I want to teach and use my knowledge and skills to improve the relationship between the public and nature, and the many days I spent speaking to hundreds of individuals at the boat launch really improved my skills in public speaking, and general communication with the public. As a city employee I felt the duty to do my job to the highest degree of precision, and was reflected in the quality of my reports, and comments from the general public. As I want to be a US Park Ranger in the future, I was very eager to use this learning opportunity to get a taste of what environmental protection and enforcement was like. I found that this job can be made to be very personal and I feel I took advantage of that. Forming relationships with "regulars", teaching my passions to others, inspiring kids, and seeing the effects of positive change like cleaner beaches are just a few of the kinds if interactions and experiences I feel made this so.

My college education has given me a deep understanding of the dynamic lake ecosystem and this prepared me for the analytical aspects of this position. My experience in chemistry, organic chemistry, biology, and water quality labs helped me immensely as I was able to excel when tasked with analytical tasks like field monitoring and biological (quadrat testing). Working independently has always been one of my strengths, and I learned I am very confident as a leader when it came working aside other inspectors, and training new employees. The many scientific papers I've written in my past college courses have allowed me to refine my scientific writing style, with maximum accuracy and detail which allowed me to make equally accurate and detailed inspection notes and survey observations. The passion I have for nature allowed me to look forward to each and every day I spent inspecting vessels as I knew deep down I was truly the first line of defense against threats to the ecosystem I love so much. Not long after I began inspecting vessels, I began to feel particular excitement in coming to work each day simply because I was eager to speak to others, teach and inspire.

I am very eager to continue the this kind of work where I am able to spend each day directly influencing others to love and respect the environment as much as I do. Looking back when I first began training I was nervous that I wouldn't meet the teams expectations when it came to scientific know-how, but I ended up more prepared than most. Focusing on the knowledge I brought to the table initially, I was blindsided when I began to discovered how much I could learn on top of what I know. From observing wild birds, to learning history of the lake from long-time residents, to pulling aquatic plants from nooks and crannies of boat trailers, my experiences in the summer of 2022 are simply invaluable to me and my future in environmental conservation.

Work Cited:

"Center for Pacific Northwest Studies." CPNWS - Biery (Galen) Papers and Photographs, https://west.wwu.edu/cpnws/photo_display.asp?PageNo=69&CollectionID=41.

Lake Samish Comprehensive Stormwater Plan - Whatcom County. https://www.whatcomcounty.us/DocumentCenter/View/2768/Lake-Samish-Comprehensive-Stormwater-Plan?bidId=.