Oct. 14th-15th
Virtual Conference
33nd Annual Conference
Lake Diversity
From Ponds to Reservoirs
WASHINGTON STATE LAKE PROTECTION ASSOCIATION

Plenary Session – Racial and Social Justice in Freshwater Systems

- **Melissa Haeffner,** Portland State University
- **Angela Strecker,** Western Washington University

It is essential for anyone working in freshwater systems to acknowledge the human communities that impact and are impacted by those systems. The history of spatial segregation in the US has had real consequences for how water is distributed, diverted, stored, and managed for across urban and rural landscapes. This has resulted in uneven access to clean, reliable water and differential access to water-related decision-making. In this talk, I will introduce a theoretical framework based on current research in environmental justice that considers distributive, procedural, and recognition justice. Looking at case studies in the Pacific Northwest, I will demonstrate how water managers and researchers can use this framework to ask questions that will illuminate opportunities to support antiracist and decolonized approaches in their work.

Session 1 - Restoration

A Tale of Two Contrasting Lakes and HAB Control Plans

- **Rob Zisette,** *Herrera Environmental Consultants*

Algae management plans were prepared concurrently for two small lakes in western Washington that are both closed each year due to exceedingly high concentrations of anatoxin-a produced by Dolichospermum. Lone Lake is polymictic with drainage from rural residential and small farms served by septic systems. Anderson Lake stratifies and its watershed is entirely within a forested state park. Phosphorus budgets for both lakes show high internal phosphorus loading is primarily causing the algae blooms. Using grants provided by the state, in-lake management techniques were evaluated and recommended to reduce the HABs. Lone Lake stakeholders chose no action due to funding limitations and potential recovery by recent grass carp removal efforts and the return of native aquatic plants. Anderson Lake stakeholders chose no action because paleolimnological analysis of sediment pigments indicate cyanobacteria are naturally present and management of natural conditions does not align with park policy.

A Tale of Two Lakes - Part I: Understanding lake nutrient dynamics using a cost-effective approach (Using the data you have coupled with good detective work)

- **Shannon Brattebo,** *Tetra Tech*
- Coauthors: Harry Gibbons, *Tetra Tech*, Marisa Burghdoff, Jennifer Oden, Katie Ruthenberg, *Snohomish County Surface Water Management*

This is the first half of a two-part talk exploring the development of algae control plans at two small residential lakes suffering from toxic algae blooms. The focus will be on the analysis performed to understand the nutrient dynamics including external and internal loading. Historic data was used coupled with detailed in-lake water quality monitoring and sediment core sampling. This approach was used in lieu of a full, costly hydrologic and nutrient budget. The talk will discuss the unique nutrient inputs of each lake (e.g. 100s of trumpeter swans) and overcoming uncertainty in data. Ultimately, the analysis allowed for the development of achievable water quality objectives for each lake and the ability to evaluate the effectiveness and costs of potential restoration alternatives. These two plans provide examples of cost-effective lake analysis that can guide lake restoration planning especially in smaller systems where study costs may exceed implementation costs.

A Tale of Two Lakes Part II: Selecting lake restoration alternatives through community collaboration

- **Marisa Burghdoff,** *Snohomish County Surface Water Management*
- Coauthors: Jennifer Oden, Katie Ruthenberg*, Snohomish County Surface Water Management,* Shannon Brattebo, Harry Gibbons*, Tetra Tech*

This is the second half of a two-part talk exploring the development of algae control plans at Sunday Lake and Lake Loma. Both are small residential lakes in Snohomish County that suffer from excessive algal growth. The focus of this talk will be on the identification of lake restoration alternatives and the community outreach conducted to select preferred options. The talk will explore the most effective & least costly options to reduce internal and external phosphorus loading including surface alum treatments and alum injection with aeration. Solutions to prevent future residential phosphorus also include creation of a septic savings program and continued implementation of the County's LakeWise outreach program. Finally, the presentation will explore the effectiveness of two outreach approaches that were used obtain public feedback to collaboratively finalize the restoration plans - one in person and the other virtually due to COVID restrictions.

Session 2 - Water Quality

Examining the Spatial Dynamics of Algal Blooms in Lake Whatcom, WA, using Satellite Remote Sensing

- **Emily Deardorff**, *Institute for Watershed Studies, Western Washington University*
- Coauthors: Angela Strecker, *Institute for Watershed Studies, Western Washington University*, David Wallin, *Huxley College of the Environment, Western Washington University*

Lake Whatcom is a mid-sized lake in northwest Washington State that is responsible for providing drinking water to about 85,000 residents and is also popular for recreation. Development within the watershed poses an increased risk for human impact on the water quality. While monthly water quality testing has provided insight as to the seasonality of nutrients and productivity, these data are lacking in spatial detail. We used Landsat 8 surface reflectance imagery to analyze algal biomass patterns in the lake from 2013 to 2019. The satellite band brightness was extracted in Google Earth Engine and analyzed alongside water quality data. Chlorophyll indices were used to create algae hotspot maps for Lake Whatcom, which provide insight as to how well the long-term sampling locations reflect actual algal dynamics in the lake. Strengthening the collective understanding of where algal blooms occur will allow for more focused studies of seasonal blooms as well as improved watershed management.

Spring Fever Revisited. Relationships among Lake Sammamish thermal stratification, anoxia, and phosphorus.

- **Curtis DeGasperi**, *King County Water and Land Resources Division*

Lake Sammamish is a relatively large, deep, lake in King County, Washington. Dissolved oxygen (DO) levels in the hypolimnion during thermal stratification decline steadily and the hypolimnion is largely anoxic (DO <2 mg/L) by late summer. As bottom water DO levels decline, phosphorus levels increase as a result of decomposition of surface water algae production settling to the bottom and the release of phosphorus from anoxic sediments. A graduate student thesis covering data collected between 1993 and 2012 is revisited using data collected from 1993 through 2019 to evaluate relationships among the onset timing of thermal stratification, onset timing and duration of anoxia, and the maximum level of late summer hypolimnetic phosphorus. The implications of these relationships in the context of regional and global warming trends will be discussed.

Synergistic Impact of Urbanization and Climate Change on the Water Quality and Ecosystem Services provided by Lake Sammamish (WA)

- **Laura Costadone**, *Portland State University*
- Coauthor: Mark Sytsma, *Portland State University*

The overall focus of this study was to assess how urban development and climate change can impact water quality and ecosystem services of Lake Sammamish in the next 50 years. Three land use scenarios that illustrate different urban development patterns were evaluated. Results revealed that urbanization and climate change will likely increase external P input to the lake ranging from 3 to 30%, depending on the different patterns of urban development depicted by the scenarios. Higher P input will likely cause the trophic state of the lake to shift from mesotrophic to eutrophic condition. This forecasted higher level of productivity could cause a reduction of 3 to 4 m in water transparency with detrimental consequences on the aesthetic and recreational suitability of Lake Sammamish. Under these scenarios, strict implementation of nutrient management practices will be necessary to offset the negative impact of urbanization and climate change on water quality and ecosystem services.

Session 3 – Algae

Direct DNA sequencing of CyanoHAB lake samples reveals genome sequences and population structures of extant Pacific NW blooms

- **Theo W. Dreher**, *Department of Microbiology, Oregon State University*
- Coauthor: Ryan S. Mueller*, Department of Microbiology, Oregon State University*

Despite the ubiquity of freshwater cyanobacterial blooms and the desire to investigate the precise factors that make them so prevalent, we are at present limited by our knowledge of the genome sequences and population structures of extant blooms. This limits our ability to fully utilize advanced metagenomic and other tools, such as in studies aimed at identifying the drivers of bloom expansion and decline or understanding the relationships among extant freshwater HABs. To address this knowledge gap, we have applied a hybrid sequencing approach using PacBio long-read and Illumina short-read sequencing to analyze standing bloom samples from the Pacific NW, without cultivation. Our studies have emphasized Anabaena/Dolichospermum, Aphanizomenon flos-aquae and Gloeotrichia blooms, with several goals: 1) identifying the producers and genetic determinants of toxins and taste-and-odor compounds, 2) determining relationships between morphotype and genotype, 3) determining the genetic variation in bloom-forming species within single bloom events, between succeeding years in a single lake, and at regional scales, 4) refining the taxonomy of the Anabaena/Dolichospermum/ Aphanizomenon flos-aquae (ADA) consortium, and 5) identifying co-occurring bacteria that might constitute commensals, synergists or predators in the phycosphere. Among our results, we have

determined the complete genome sequence of the Anabaena/Dolichospermum producer of cylindrospermopsin that was the cause of a drinking water crisis in Salem, OR, in June 2018. The same strain was present during 2016 and 2017, with toxin biosynthetic genes appearing to be present on a ~200 kbp extrachromosomal element. In both years, the most abundant co-occurring bacterium was a strain of Opitutus (phylum Verrucomicrobia). Our analyses have emphasized that extant ADA CyanoHABs are members of a distinct genome-level clade as first identified by Driscoll et al. (2018) that is a logical group to which the now-commonly used genus name Dolichospermum could be applied.

The influence of floating logs on lake ecosystems: a comparison of Coldwater Lake and Spirit Lake, Mt. St. Helens

- **Angelica Lucchetto**, *University of Washington Bothell*
- Coauthors: Kena Fox-Dobbs, *University of Puget Sound*, Avery Shinneman, *University of Washington Bothell*, James Gawel, *University of Washington Tacoma*

Coldwater and Spirit Lakes both formed following the 1980 eruption of Mount St. Helens. Ongoing work at Spirit Lake has focused on ecosystem sampling from areas with and without dense floating logmats within the lake. Comparisons with Coldwater, which has no floating logmat, provide an additional opportunity to assess their influence on the lake ecosystem. Results suggest higher benthic algal diversity in Spirit Lake. There is also a notable absence of cyanobacteria in samples from Coldwater Lake, whereas they made up a significant proportion of Spirit Lake periphyton throughout the summer, peaking in August. Biogeochemical analyses and analysis of diatom assemblages in lake sediments provide insight into the amount and source of productivity over time. Both lakes have areas with high organic content in surface sediments, but Spirit Lake sediments record the novel input of log mat derived organic material, and higher contribution of benthic versus planktonic diatoms.

Nutrient Removal from an Urban Lake Using an Algal Turf Scrubber

- **Sarah Norberg***, City of Tacoma*
- Coauthors: Kenneth Burkart, James Gawel

A small-scale algae turf scrubber (ATS) was deployed in Wapato Lake, located in Tacoma, Washington, to evaluate the effectiveness of using managed algae production to permanently remove excess nutrients entering the lake from urban sources. We constructed a floating ATS (1 m x 1.5 m) comprised of a solar powered 2000 gph pump with adjustable flowrate positioned to continuously pump water over a 1 m2 screen at a slope of 2Â°. The ATS was anchored facing south to ensure full sun exposure. Water was pumped over the screen at a rate of ~1,300 gph. The ATS operated 21-days prior to sample collection to allow for seeding of the screen with native periphyton species. Regular algae harvest took place at approximately 14-day intervals. Harvested biomass was transferred to UWT where it was dried and weighed prior to nutrient analyses. Lake water was sampled to determine dissolved N and P concentrations. The results of this pilot study will be discussed.

Tiny Bubble Solving Big Problems - Nanobubbles as a Chemical-Free Method for Algae Control

- **Christian Ference,** *Moleaer Inc, Carson, CA*

Nanobubbles (<200 nm in diameter) exhibit unique properties: negative surface charge, long-term stability, and neutral buoyancy. These properties enable a high oxygen transfer efficiency, distributing oxygen equally throughout a water column and across a waterbody. By returning oxygen levels in a waterbody to healthy levels, a lake's internal nutrient loading is minimized and a primary contributor to harmful algae blooms issues is eliminated. Nanobubble generation technology was installed on a 10-acre, 100 acre-ft lake in Central California that routinely experienced algae blooms. The lake is up to 20 ft

in depth leading to thermal stratification and low oxygen levels below 5 ft. Three nanobubble generators injected a total of 450 GPM of a nanobubble solution created using a 90% oxygen gas. Oxygen concentrations and other water quality parameters were measured using real-time remote sensors at two points in the lake.

Session 4 – Lake Ecology

Population Structure and Habitat Availability Determine Resource Use by Rainbow Trout in High Elevation Lakes

- **Beka Stiling,** *University of Washington*
- Coauthors: Julian Olden, Gordon Holtgrieve

Fish acquire carbon from pelagic, littoral-benthic, and terrestrial habitats in varying proportions. Habitat availability, allochthonous inputs, and population density are known to influence this variability, however the extent that these factors interact are not well understood. We leverage the similar food webs of stocked mountain lakes to address how population size and habitat availability determine reliance on basal resources by rainbow trout. In 16 lakes we measured bathymetry, CPUE, and fish muscle and primary producer C and N stable isotope ratios. Stable isotope mixing models quantified proportional reliance on resources for each fish. Compositional regression analysis identified how interactions between habitat availability and population size influence reliance on basal resources. At low abundance resource utilization is similar regardless of relative habitat availability; at high abundance rainbow trout increase reliance on terrestrial or pelagic resources.

Primary Succession and Community Assembly in Ponds Created by the Mount St. Helen's Eruption

- **Angela Strecker**, *Western Washington University*
- Coauthors: Meredith Holgerson, Charlie Crisafulli, James Gawel

The eruption of Mount St. Helens was a massive landscape-scale disturbance. One of the little known consequences of the eruption was the creation of >100 new ponds. These ponds are one of the few examples of primary succession of aquatic ecosystems, and as such, present a novel opportunity to study community assembly and the factors that influence it. Twenty-four ponds were sampled in 2015 and 2017 for macroinvertebrates, zooplankton, and physicochemical variables. Colonization and contemporary distribution dynamics appear to be related to a complex mixture of terrestrial succession, pond hydroperiod, spatial patterns of pond distribution, and variations in physical and chemical conditions. Zooplankton and macroinvertebrate communities were more similar than expected despite the presence of strong environmental gradients. Our study may fill a significant gap in our understanding of the dynamics of primary succession in freshwater ecosystems using a unique natural experiment.

Life History of a Caddisfly in Coeur d'Alene Lake

- **Elizabeth Hoots**, *University of Idaho*
- Coauthors: Ben Scofield*, Coeur d'Alene Tribe Lake Management Department*, Frank Wilhelm, *University of Idaho*

The current trends in global climate have the potential to affect the rates of processes across all ecosystems. Water bodies are among the most affected ecosystems, warming at rates greater than the surrounding terrestrial landscapes. This will fundamentally alter underlying basic temperature-mediated processes and interactions among organisms. In northern Idaho, Coeur dâ€™Alene Lake is not exempt from these global trends. This study investigates how expected changes in water temperature will affect

the physiology of the lentic case-building caddisfly, Nectopsyche albida. We collected 5th instar larvae from the southern Chatcolet Lake region to quantify the duration of their pupal life stage at different temperatures. Comparing the changing timing of the N. albida life cycle with the growth of native and introduced macrophytes, provides insights into the potential dynamics of the larger Chatcolet Lake ecosystem in response to a changing global climate.

Impacts of Hydrodynamic Processes on Pelagic Fish Habitat in Clear Lake, CA

- **Drew Stang**, University of California, Davis and Herrera Environmental Consultants
- Coauthors: Alexander Forrest, Geoffrey Schladow, Andrew Rypel, Alicia Cortes

A multi-basin, hypereutrophic, polymictic lake, Clear Lake, CA, experiences extreme hypoxic events during periods of stratification which continue to impact the system in a myriad of ways. This study used oceanographic instruments and novel processing techniques to quantify the dominant hydrodynamic processes controlling stratification, hypoxia and the influence that these conditions have on pelagic fishes. Physical conditions were controlled by diurnal winds that forced spatially variable circulation patterns. Winds caused upwelling events as well as surface seiches and high frequency internal waves which were both visually captured through use of an echosounder. Pelagic fishes experienced vertical habitat compression, avoiding hypolimnetic hypoxia (DO < 4 mg/L) and warmer epilimnetic temperatures, thus forcing fishes to reside near the metalimnion. Fishes maintain this avoidance behavior even as physical conditions fluctuated at hourly time scales.

Panel Discussion – Supporting Public Access to Washington Lakes

- **Avery Shinneman**, *University of Washington Bothell*
- **James Gawel**, *University of Washington Tacoma*

Lakes in Washington State are faced with meeting an array of demands, sometimes with conflicting pressures. have complex property rights; both small and large lakes often have both public and private ownership and access, and the needs of these two groups may be at odds. WALPA has a long history of working with lakeside homeowners associations on lake improvement projects. During this panel we will hear from various stakeholders in public lake access and discuss how WALPA may be able to better support increased lake access and lake stewardship at public access points throughout the State.

Student Poster Session

Impacts of Wildfire Reburn Events on Water Storage and Transport in the Washington Cascades

- **Katherine Swensen**, *Washington State University Vancouver*
- Coauthor: Kevan Moffett

Washington State's hydrologic resources may become progressively degraded as wildfire activity increases, snowpack levels decline, and spring snowmelt accelerates under a warming climate. While wildfire impacts on water resources typically diminish with time, the hydrologic recovery trajectory is unknown in reburned ecosystems. In this study, we test the hypothesis that more reburns leads to delayed hydrologic recovery (i.e. earlier snowmelt) through a comparison of water balances in forested, southern Washington Cascades hillslopes that have been unburned (>200yr) or burned by one (2008 or 2015), two (2004/2008 or 2008/2015), or three (2004/2008/2015) short-interval wildfires. Preliminary results are aligned with our hypothesis, with earliest snowmelt occurring in the triple burn site. Our findings have implications for watershed management as delayed hydrologic recovery may be tied to an extended period of degraded water quality for Washington State's lakes, streams, and rivers.

Broadscale distribution, abundance, and habitat association of the Asian clam Corbicula fluminea in the lower Columbia River, USA

- **Salvador Robb-Chavez**, *Washington State University Vancouver*
- Coauthors: Stephen Bollens; Gretchen Rollwagen-Bollens; Timothy Counihan

The Asian clam, Corbicula fluminea, is an invasive freshwater bivalve that has established populations throughout the globe, including the Pacific Northwest, USA and which is thought to have deleterious effects on natural and human systems. During 2017-2020 we collected C. fluminea from 15 mid-channel and 29 shore-based sampling locations throughout the lower Columbia River to elucidate the association of C. fluminea with habitat characteristics including dissolved O2, pH, temperature, salinity, specific conductivity, depth, geographic location, chlorophyll a concentration, bank slope, and sediment composition (granulometry, TOC). Regression models are used to determine potential relationships between C. fluminea populations and habitat characteristics. Our results provide a better understanding of the basic ecology of this global invader as well as provide natural resource managers with information on where, when and why this bivalve invades temperate river ecosystems.

Effects of boat wakes on the nearshore of the Spokane River in North Idaho

- **Krystal Saunoa**, *University of Idaho*
- Coauthors: Dr. Frank Wilhelm, *University of Idaho,* Julie Vanmiddlesworth, *North Idaho College*

Cultural eutrophication is the occurrence of excess nutrients in water bodies that stimulates plant growth resulting from anthropogenic activities. Among these activities, watersports that generate wakes in the nearshore likely contribute to this phenomenon via the release of nutrients (particularly phosphorus) associated with the resuspension of sediment as disturbances are created. We examined changes in turbidity in relation to disturbance regime and frequency (both natural and anthropogenic) in the Spokane River at the mouth of Coeur D'Alene Lake, Idaho. Boating activity directly increased turbidity and was larger in magnitude compared to naturally occurring waves.

Seasonal spatial distribution of zooplankton in Willow Creek Reservoir in relation to hypolimnetic anoxia

- **Hana Haakenstad**, *University of Idaho*
- Coauthor: Dr. Frank Wilhelm, *University of Idaho*

Zooplankton, specifically Daphnia, are the "cows" of aquatic ecosystems; they are important grazers of primary production and form a vital link to higher trophic levels in aquatic food webs. Typically, large zooplankton migrate down to low light depths in the hypolimnion during the day. However, if the hypolimnion becomes anoxic, this dark refuge is unavailable and they are forced into the epilimnion. To evade predation, large zooplankton may migrate to nearshore areas, thus allowing algal blooms to proliferate. We analyzed horizontal distribution of zooplankton along two transects, from the pelagic to the near shore, in response to hypolimnetic anoxia to test the null hypothesis that the distribution of Daphnia (vertical and horizontal) is not related to the change in dissolved oxygen in the hypolimnion in Willow Creek Reservoir. Our data showed significant density differences between the pelagic versus the nearshore sites.

Session 5 – Health Risks

Human health risk from consumption of aquatic species in arsenic-contaminated shallow urban lakes

- **Marco Barajas and Erin Hull**, *University of Washington Tacoma*
- Coauthors: Kenneth Burkart, Samantha Fung, Brian Jackson, Rebecca Neumann, Julian Olden and James Gawel

Arsenic (As) can be mobilized from lake sediments during stratification and hypolimnetic anoxia in the summer. Dissolved As can then be taken up by phytoplankton and enter the food web. The trophic transfer of As is enhanced during summer mixing events typical in shallow lakes, when As mobilized in near-bottom waters is mixed into overlying oxygenated waters where biota reside. Our previous work measured sediment As concentrations of over 200 Âµg/g in Puget Sound lakes affected by the former ASARCO smelter, and significant bioaccumulation of As in plankton in shallow lakes. In this study, we quantify As concentrations and associated health risks in human-consumed tissues of sunfish, crayfish, and snails from lakes representing a gradient of As contamination and differing mixing regimes. We find an increased cancer risk for high-consuming populations harvesting aquatic organisms in As-contaminated shallow lakes and make recommendations for better protecting human health in the future.

Seasonal patterns of mixing and arsenic concentrations in a small, arsenic contaminated lake

- **Samantha Fung**, *University of Washington*
- Coauthors: Erin A. Hull, Ken Burkart, Marco Barajas, Alex Horner-Devine, James Gawel, Rebecca Neumann

Many lakes in the South-Central Puget Sound region contain legacy arsenic in their sediments. We analyzed seasonal patterns of lake mixing and arsenic concentrations using a 17-month dataset from Lake Killarney, Federal Way, WA. During times of arsenic mobilization from the sediments, we observed two mixing types. In early summer, multi-week periods of stratification caused arsenic buildup at the sediment water interface and episodic mixing transferred arsenic into the lake epilimnion, leading to high concentrations of bulk water arsenic. During late summer, convection-driven diel overturning led to a homogenized water column with lower arsenic levels. Diffusive porewater peeper data revealed that arsenic mobilization from the sediment and diffusion into bottom waters both exhibited a temperature threshold behavior. Our analysis connects meteorological forcing, mixing and the distribution of arsenic in lake water, improving identification of lakes vulnerable to sediment contamination.

Building a Bayesian network from expert knowledge to evaluate microcystin production in King County lakes under various external load reduction scenarios.

- **Timothy Clark**, *King County Water and Land Resources Division*

Expert knowledge was elicited by King County to construct a causal model of biotic and abiotic factors influencing King County swimming beaches (freshwater and marine), including fecal contamination and algal toxin risk. This causal model is part of a larger project that provides tools to inform County decision-making in selecting cost-effective water quality investments, reducing pollutant load, and improving ecological and human-health outcomes. The causal model used is a Bayesian network that relies on conditional probabilities based on the state of various environmental parameters.

Session 6 – Invasives Management

Understanding angler-driven vectors of invasive species transmission using social media and mobile technology

- **Julian D. Olden,** *School of Aquatic and Fishery Sciences, University of Washington*
- Rachel M. Fricke, *School of Aquatic and Fishery Sciences, University of Washington*; Spencer A. Wood*, eScience Institute, University of Washington*, and Dustin R. Martin, *ReelSonar, Inc., Seattle, Washington*

Prevention of aquatic invasive species is a fundamental management challenge in limnology. With hundreds of millions of people participating in fishing trips each year, understanding angler movements that transmit invasive species among lakes can provide critical insight into the most effective locations and scales at which to apply preventative measures. Recent evidence suggests that social media and mobile technologies provide new opportunities to understand angler movement behaviors beyond what is possible with infrequently and sparsely conducted in-person boat surveys and mail questionnaires. Here we capitalize on data provided by geotagged social media posts and ReelSonar's iBobber, a sonar-enabled bobber with over 5 M recorded fishing locations, globally. By quantifying geographic patterns of fishing activities and assessing how these patterns change seasonally, we explore angler behavior across 20,000+ lakes in the continental United States in terms of fishing frequency and distance traveled, and characterize the attributes of fished lake ecosystems. We found that anglers undertook 70,000+ trips to over a two-year period. Anglers were more likely to visit larger, deeper and more urbanized waterbodies, and these waterbodies were over five times more likely to be a reservoir compared to a lake. Inter-waterbody travel road distances averaged 93 km (SD = 277 km; range < 1 - 300 km), and nearly half of these movements occurred over a timespan of two days or less; a timeframe that we show falls well within the desiccation tolerance window of many prevalent plant and animal invasive species. Our study offers novel insight into spatiotemporal patterns of angler behavior well beyond the geographical and temporal extent of conventional ground-collected approaches and carries important implications for predicting and preventing future transmission of aquatic invasive species via recreational fishing.

Whatcom Boat Inspections: Preventing the spread of aquatic invasive species in Whatcom County, Washington

- **Teagan Ward,** *City of Bellingham*

The Lake Whatcom Management Program began implementing the Whatcom Boat Inspection Program in 2012 to prevent the introduction of zebra and quagga mussels and other aquatic invasive species to Whatcom County waters. To date, the program has conducted over 75,000 watercraft inspections at Lake Whatcom and Lake Samish. The program has not only helped to prevent the spread of additional aquatic invasive species to these local lakes, it has also helped to increase community awareness regarding the threats that aquatic invasive species pose to Washington waters and how to prevent their spread. This presentation will provide an overview of the Whatcom Boat Inspection Program highlighting outreach efforts, inspection results, and lessons learned from 2012 through 2020.

Ludwigia peploides (floating primrose-willow) control in an off-channel constructed wetland near Seattle.

- **Ben Peterson**, *King County Noxious Weed Program*

Ludwigia peploides (floating primrose-willow), a Class A noxious weed, has been known to occur at a site in King County adjacent to Taylor Creek, close to the Cedar River. First found in 2004, control work has continued through 2020. Through the construction of a three-acre off-channel deep water wetland and beaver activity the area of the infestation expanded to cover over 5,000 square feet. Control work eventually transitioned from the use of foliar sprayed aquatic herbicide to careful searching and hand pulling of plants. This year we have found (and pulled) just four plants on two different survey trips and there is hope the infestation will soon be eradicated.

Session 7 – Waves and Source Tracking

Literature review of sediment and nutrient resuspension in response to surface hydrodynamic disturbance: current state and directions for future research.

- **Basile Cousin***, UFR Temps et Territoires, Université Lumière Lyon 2, Lyon, France*
- Coauthors**:** Heather Crawford, Krystal Saunoa, Frank Wilhelm

With the increasing popularity of recreational activities such as boating in affluent countries, nearshore areas may be experiencing increased disturbance from wakes which may be resuspending sediments and releasing associated nutrients. We undertook a meta-analysis that included more than 180 peer-reviewed articles to identify the main ideas emerging from research over the last decades; from the physical dynamics of disturbance itself, through the factors governing sediment resuspension and nutrient release, to possible consequences on aquatic ecosystems. We identified several key 'missing pieces' which included a dearth of studies that simultaneously measured shear stress, water velocity, sediment resuspension and nutrient release to adequately address potential consequences in nearshore areas in response to the increase in recreational boating. This weakness must be rectified to provide meaningful decisions such as "no wakes zone".

Using ground-based LiDAR 3D scanning to measure shoreline accretion and erosion in response to waves and wakes

- **Heather Crawford**, *University of Idaho*
- Coauthors**:** Jan Eitel, Basile Cousin, Frank Wilhelm

The land-water interface is highly dynamic and water motion is a key factor that shapes the ecotone because it moves material. Eroded material is added to the waterbody and during the transition, nutrients associated with the resuspended material are susceptible to release which can contribute to nearshore productivity (eutrophication). We are interested in quantifying the amount of material and nutrients resuspended in response to waves (natural disturbances e.g., wind) and wakes (human-caused). Here we detail the use of a Leica C10 ground-based terrestrial laser scanner (LiDAR) to measure changes in the shoreline of Big Payette Lake, Idaho, USA in response to waves and wakes at sub-centimeter accuracy. We envision that quantifying the contribution of wakes to dynamics in the nearshore environment will provide an important tool for policymakers to make science-based decisions such as setting 'no wake zones' to protect shorelines and the overall lake environment.

Isotope Tracers in Nutrient Source Tracking (NST) of Nitrate, a Different Perspective of Surfaceand Groundwater Remediation

- **Sean P. Ahearn**, *Beta Analytic, Inc*.

Excess nitrogen as nitrate is an increasing problem worldwide. Anthropogenic activity continues to stress nutrient balance in shallow groundwater systems, estuaries, lakes and wetlands causing both short and long term environmental consequences. Stormwater events mix and move massive amounts of water and nutrients into and out of urban and rural watersheds, this causes stormwater runoff to carry a mixture of several sources of nutrients making point source and nonpoint sources of contamination difficult to differentiate. Here we present and review some of the leading techniques in isotope tracers and their applications to Nutrient Source Tracking (NST) with a focus on nitrate and boron fingerprinting. By incorporating isotopic data into hydrological studies, isotope tracers can be used to suggest the type of nitrate contamination and its origin.

Monitoring Phosphorus and Fecal Bacteria Loading Rates to Lake Whatcom in Drainage from Areas Served by Septic Systems and Sanitary Sewers

- **Rob Zisette**, *Herrera Environmental Consultants*

Millions are being spent on stormwater treatment to restore Lake Whatcom, which serves over 100,000 people and is impacted by cultural eutrophication, while little is done about sewage inputs. Genetic analysis of two human fecal biomarkers, one approved by EPA and another recently developed by University of Wisconsin scientists, was used to estimate human waste loadings in drainages from three different types of basins: undeveloped, septic systems, and sanitary sewers. High human biomarker loadings were observed in three of five septic basins, but not in any of the five sewer basins or two undeveloped basins. However, no significant differences were observed between the three types of basins for total phosphorus or fecal coliform loadings. The study results show that human fecal biomarkers are useful for detecting septic system inputs, but those inputs do not necessarily relate to phosphorus or fecal coliform inputs due to differences in transport and retention of pollutants in soils.