

Waterlines

WESTERN REGIONAL AQUACULTURE CENTER

2021
ANNUAL REPORT

Alaska • Arizona • California • Colorado • Idaho • Montana • Nevada • New Mexico • Oregon • Utah • Washington • Wyoming

This issue of *Waterlines* contains our newsletter and report to USDA-NIFA of our accomplishments for 2020–2021.

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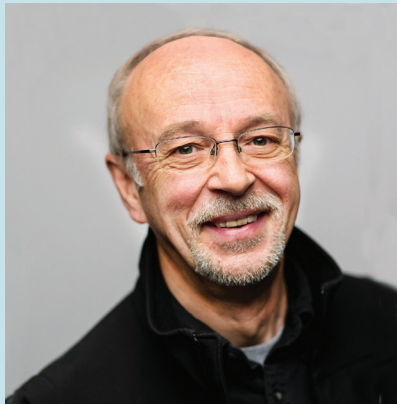
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From the Director



“I am looking forward (with some sense of pride) to providing the review panel with examples of the many ways in which our research and outreach projects have supported commercial aquaculture in our region since the inception of the program in 1987.”

Dear WRAC community, stakeholders, and state and federal partners,

Our annual *Waterlines* report on accomplishments and news about our community is always one that makes manifest the sheer pool of research and extension talent we have in the western region, the strong long-term collaborations that have developed, and the collegiality between industry, research, and extension that the WRAC process has helped to facilitate. Industry-driven and industry-responsive are terms that I often use to describe our program. The USDA/NIFA-funded external review of the RAC program commenced just after the reporting period covered in this edition: I am looking forward (with some sense of pride) to providing the review panel with examples of the many ways in which our research and outreach projects have supported commercial aquaculture in our region since the inception of the program in 1987.

The time period covered by this edition of *Waterlines* is one in which many of our Work Groups faced severe challenges due to restrictions imposed by responses to the pandemic. Thus, the considerable progress that Work Groups were able to achieve is all the more impressive. At the time of writing this message, we are hoping to move out of the virtual WRAC meeting world in 2022—I look forward to meeting with you in person.

With best wishes,
Graham Young

Updates to the Roster

WRAC welcomes new and continuing members of the Board, IAC, and Research and Extension Subcommittees and thanks all who have served this past year. The Board strives to consider a mix of geographic representation and diverse areas of expertise when considering new appointments to WRAC committees. Changes to the roster are provided here and in the July 2021 WRAC Directory (depts.washington.edu/wracuw/about/organization.html).

BOARD OF DIRECTORS

Gary Freitag retires from University of Alaska, Fairbanks, June 2021. Thankfully, he is continuing on as an active WRAC Board member as Emeritus Professor representing Alaska. Congratulations Gary on your retirement. We look forward to seeing you on the Board.

INDUSTRY ADVISORY COUNCIL

Ken Beer (The Fishery, Inc., CA), **Jim Gibbons** (Seattle Shellfish, WA), **Jeff Hetrick** (Alutiiq Pride Shellfish Hatchery, AK), and **Dallas Weaver** (Scientific Hatcheries, CA) were approved by the Board to continue their terms through 2024. Thank you all for your representing the voices of shellfish, finfish, and scientific technology industry sectors.

TECHNICAL COMMITTEE/ RESEARCH SUBCOMMITTEE

Renewing through 2024

Robert McGorin (Professor, Food Science & Technology, Oregon State University, OR); **Brian Small** (Director, Aquaculture Research Institute, University of Idaho, ID). Thank you both for bringing your research specialties to WRAC.

Transitions

We were sorry to see **James Nagler** step down from the Research Subcommittee after his many years of service to WRAC. James continues his work as Professor, Chair, and Director of the Center for Research on Invasive Species at

the University of Idaho. Also, **Michael Graham** elected not to renew, but continues his mariculture work as Professor, business owner, and researcher at Moss Landing Marine Laboratories, CA. Best regards to you both. We look forward to your future involvement with WRAC projects.

New appointments to the Research Committee

With three highly recommended nominations provided and as many committee openings to fill, the Board appointed all three nominees. Please welcome them to WRAC.

Jordan Hollarsmith (Lead Research Biologist, Ted Steven's Marine Research Institute, NOAA/Alaska Fishery Science Center, Juneau, AK). Jordan's specialty areas are in mari-culture and macroalgae.

Jung Kwon (Assistant Professor, Department of Food Science & Technology, Seafood Research & Education Center, Oregon State University, Astoria, OR). Jung's specialties include seafood quality, processing, and consumer education.

Mackenzie Gavery (Environmental Physiology Program, NW Fishery Sciences Center, Seattle, WA and Affiliate Faculty, University of Washington). Mackenzie's specialties include genomics and shellfish aquaculture.

TECHNICAL COMMITTEE/ EXTENSION SUBCOMMITTEE

While we must rely on Extension Subcommittee members being appointed by their institutions, we are working to grow this small, but mighty committee. We are so grateful for the many roles our current members are willing to serve.

Renewing through 2024

A big thanks goes to both **Kevin Fitzsimmons** (Director, International Initiatives; Professor, Department of Environmental Science; Team Leader, Myanmar Sustainable Aquaculture Program, University of Arizona, AZ) and **Jackson Gross** (Cooperative Extension Aquaculture Specialist, University of California, Davis). Kevin

brings a long-term commitment to WRAC Extension, as a Board representative for AZ and as an active member of many committees. We are pleased that Jackson continues another term on the Extension Subcommittee (he is currently the Chair), as a project monitor, and as a Board representative for CA. Jackson started on the Research Subcommittee for WA and has transitioned well into his current extension appointment in CA.

Congratulations to **Angee Doerr** (Assistant Professor of Practice Extension Service, Lincoln County; Oregon Sea Grant Extension Marine Fisheries Specialist, OR) as she transitions from a temporary extension appointment (filling in for Tim Miller-Morgan) to full WRAC Extension Subcommittee member. Angee has already jumped into several roles on WRAC committees and projects.

Transitions

Thanks go to **Tim Miller-Morgan** (DVM, University of Oregon) for volunteering to the Extension Subcommittee and then your recommendation and support of Angee's appointment!

After many years representing Utah Extension, **Dr. Chris Luecke** moves on from the committee. Chris continues as Dean of Quinney College of Natural Resources at Utah State University. Best wishes to you Chris. ■

UPCOMING WRAC MEETINGS

Monday
October 11, 2021
Biennial IAC meeting

Tuesday
October 12-13, 2021
IAC/TC meeting

Monday
November 15, 2021
Board of Directors meeting



COMPLETING ONE PROJECT CYCLE & STARTING ANOTHER

At the biannual Board of Directors meeting, the Board extended thanks to the IAC/TC and Executive Committee (EC) for their thorough review of and reporting on submitted proposals. Due to the hard work of the committees, the Board was able to move forward confidently with their decision to fund three of the eight proposals. Congratulations to all of the investigators.

FY 2021 PROJECTS SELECTED

(listed by lead PI, project title, time period, and funding request)

1. Wendy Sealey (USDA/ARS, Bozeman, MT), Mixing up an optimal diet for white sturgeon grow-out, 4 years. Total request \$423,921
2. Jonathan van Senten (Virginia Tech University), Characterization of aquaculture in the western US, 2 years. Total request \$237,218
3. Xiang (Chrystal) Yang (University of California, Davis), Optimization of pre- and post-harvest factors to extend the shelf life and improve the quality of whole fish and fillets of salmonids and white sturgeon, 3 years. Total request \$359,835

PROPOSAL CYCLE FOR FY 2023

- Over the summer of 2021, the IAC/TC contacted their colleagues and stakeholders for input on the problems and issues facing western region aquaculture
- A survey collected their responses through August 2021
- The IAC will present the submissions at the upcoming fall 2021 IAC/TC meeting



WRAC Project Highlights

September 1, 2020–August 31, 2021

Contact the
WRAC Administrative Office
for complete annual reports.

1 Developing “Freshwater Cod” or Burbot (*Lota lota*) into a Viable Commercial Aquaculture Species in the United States

Annual Progress Report

PRINCIPAL INVESTIGATORS: Kenneth Cain, *University of Idaho*; Christopher Myrick, *Colorado State University*; Ben Vaage, *Colorado State University*; Luke Oliver, *University of Idaho*; Moureen Matuha, *University of Idaho*

Outreach Representative: Kenneth Cain, *University of Idaho*; Christopher Myrick, *Colorado State University*

Industry Advisors: Linda Lemmon, *Blind Canyon Aqua Ranch*

Project Monitor: Mark Drawbridge, *Hubbs-Seaworld Research Institute*

ISSUE: The integration of burbot (freshwater cod) production into existing trout farms presents a novel, low-risk strategy to develop this species for commercial aquaculture. By expanding production, this project addresses the USDA-NIFA challenge areas of food security, water, childhood obesity, and food safety. The goal and challenge is to provide US fish growers with applied knowledge of burbot farming, thereby encouraging diversification of crops and enabling competition in potentially lucrative food and other niche markets.

RESPONSE: This project has focused on: 1) optimizing spawning, early larval rearing, grow-out, and other aspects of burbot aquaculture; 2) conducting pilot-scale trials at commercial facilities and supporting potential burbot farms by providing fish when possible; 3) determining water-quality limits of production; 4) determining if triploid induction is possible as a means to produce sterile burbot;

5) conducting a basic economic analysis of production costs; and 6) disseminating results broadly to the aquaculture industry.

RESULTS: Results clearly show the biological feasibility of commercial burbot culture. We have published results describing out-of-season spawning, replacement of fish meal with soy meal in diets, temperature impacts on eggs and embryos, immune response, disease susceptibility, ammonia tolerance, and triploid induction. We will be finalizing our larval weaning results, showing an ability to use various commercial products to minimize the period of live feeding with rotifers and/or *Artemia*. An enterprise budget to evaluate the economic feasibility of rearing burbot is nearly complete and will provide a valuable tool for potential burbot farmers to estimate cost of production and requirements for profitability. To date, outreach has targeted media and trade journals, and we have presented our results at conferences. This has generated substantial interest in burbot aquaculture, and multiple companies have contacted us to assist with fish supply and business planning.

IMPACTS: This project has raised the visibility of burbot aquaculture and demonstrated that burbot are a new and viable commercial aquaculture species for North America. Many potential bottlenecks have been addressed and overcome, and the stage is now set for existing farmers, entrepreneurs, and start-up companies to apply the results of this research to successfully culture this species for the foodfish market.



2 Identification of Genetic Markers for Disease Resistance to Infectious Hematopoietic Necrosis Virus (IHNV) in Commercial Populations of Rainbow Trout through Genome-wide Association Analysis

Annual Progress Report

PRINCIPAL INVESTIGATORS: Kerry Naish, *University of Washington*; Maureen Purcell, *Western Fisheries Research Center, US Geological Survey*; Kyle Martin, *Hendrix Genetics/Troutlodge Inc.*; Yniv Palti, *National Center for Cool and Coldwater Aquaculture*

Outreach Representative: Luke Gardner, *California Sea Grant Extension*; Jackson Gross, *University of California, Davis Aquaculture Extension*

Industry Advisor: Stephen Reichley, *Mississippi State, (formerly at Clear Springs Foods, Inc.)*

Project Monitor: Kathleen O'Malley, *Oregon State University*

ISSUE: Disease is the single largest cause of production-related mortality in the rainbow trout (*Oncorhynchus mykiss*) industry, accounting for 90% of the total losses (25.4 million fish) in 2015 (NASS 2016). Efficacious control methods are not available for all diseases, or if available, may add significantly to production costs. Thus, there is a need and an opportunity to develop additional approaches to mitigate disease losses in trout aquaculture.

RESPONSE: The collection of genomic information across individual fish used for broodstock can significantly improve the efficiency of selective breeding for many desirable traits, including disease resistance. Researchers are utilizing a high density single nucleotide polymorphism

(SNP) array and whole genome sequencing to identify markers linked to resistance to the important salmonid pathogen, infectious hematopoietic necrosis virus (IHNV). These markers can then be used to assess the potential for genomic selection for the improvement of aquaculture populations.

RESULTS: IHNV disease challenges were conducted on over 4000 fish that represented two lines cultured by the Hendrix Genetics nuclear breeding program (the “May” and “November” Troutlodge lines). Genome-wide surveys revealed several genetic regions (quantitative trait loci, QTL) linked to disease resistance, with moderate effect on the phenotype. Several QTL explained a significant amount of genetic variation in disease resistance—these regions will be characterized further by DNA sequencing.

IMPACTS: The immediate benefit of the research has been the application of the tools to the genetic improvement of the aquaculture broodstock lines, which in turn support a significant portion of the rainbow trout grow-out industry. The broader benefits are that these tools can be integrated into effective approaches for disease management in rainbow trout aquaculture and for informing IHNV epidemiological models for cultured and natural populations in western North America.



3 Detection and Control of Mud Blister Worm (*Polydora* spp.) Infestation on Commercial Oyster Farms throughout the Pacific Northwest

Annual Progress Report

PRINCIPAL INVESTIGATORS: Chelsea Wood, *University of Washington*; Jacqueline Padillo-Gamiño, *University of Washington*; Lorenz Hauser, *University of Washington*; Steve Rumrill, *Oregon Department of Fish and Wildlife*; Teri King, *Washington Sea Grant*

Outreach Representative: Teri King, *Washington Sea Grant*

Industry Advisor: Tom Bloomfield, *Seattle Shellfish, LLC*

Project Monitor: Jackson Gross, *University of California, Davis*

ISSUE: Infestations of mud worms are responsible for substantial losses to commercial oyster industries worldwide. These polychaetes can cause unsightly blisters that release detritus, mud, and fecal material, fouling oyster meats. Until our project, there had been no reports in the scientific literature of any shell-boring polychaete species in Pacific oysters from Alaska, Washington, or Oregon. Our data now confirm that several species of blister-forming polychaetes are widespread and abundant throughout the Pacific Northwest, where oysters are the most important cultured shellfish. Mud worm infections represent a serious threat to the sustainability of this industry.

RESPONSE: To defend against this threat to the region's oyster industry, we must know which growing areas are currently affected, what environmental factors predispose an area to becoming infected, and what treatments are most effective for reducing worm burdens on farms. Our project will assess the scale of the threat represented by *Polydora* spp. infections on oyster farms throughout the US Pacific

Northwest and outline the management approaches that will allow oyster growers to surmount this significant obstacle to long-term oyster production sustainability.

RESULTS: We have completed sampling to quantify the prevalence of shell-boring polychaetes at 33 oyster farms throughout the US Pacific Northwest and have preliminary results regarding the current distribution of *Polydora* spp. We have collected almost all of the primary empirical data needed to identify the environmental factors that predict high infestation rates. In addition, we have completed experiments designed to identify the most effective intervention that growers can use to reduce transmission and mitigate the negative impacts of infection on product value, and we have a clear result that has already been reported directly to growers and will soon be reported in the form of a peer-reviewed paper and best practices manual.

IMPACTS: Our sampling has yielded a preliminary map of where infestations are common and where they are rare across the study region, providing growers with the knowledge needed to avoid bringing infested oysters into uninfested areas. We have identified the most effective interventions that growers can use to reduce transmission and mitigate the negative impacts of infection on product value—three treatments that are suitable for killing shell-boring polychaetes without negative impacts on oysters (drying at room temperature, freshwater dip + drying, drying in a refrigerator). All results are being shared with our industry advisory group, the Healthy Oysters Steering Committee, to allow growers to immediately begin using this newly acquired knowledge to benefit their businesses.



4 Emerging and Re-emerging Flavobacterial Pathogens in Aquaculture

Annual Progress Report

PRINCIPAL INVESTIGATORS: Kenneth Cain, *University of Idaho*; Esteban Soto, *University of California, Davis*; Timothy Bruce, *University of Idaho*; Jie Ma, *University of Idaho*; Brent Vuglar, *University of Idaho*; Taylor Heckman, *University of California, Davis*

Outreach Representative: Robert Durborow, *Kentucky State University*

Industry Advisor: Tom Van Tassel, *Evaqua Farms*

Project Monitor: Stephen Reichley, *Mississippi State University (formerly at Clear Springs Foods, Inc.)*

ISSUE: The incidence of clinical disease linked to emerging (and re-emerging) pathogens in the *Flavobacteriaceae* family has increased, and there is a need to better define distribution in the western region of the United States. In addition, effective disease control or prevention tools for these pathogens are needed. This contributes to the USDA-NIFA's major challenge area, food security.

RESPONSE: The goal of this project is to identify and further characterize, at the genetic, antigenic, and virulence level, *F. columnare* strains along with other pathogenic *Flavobacteriaceae* members (i.e., *Chryseobacterium* and *Flavobacterium* spp.). This project will also provide baseline information on clinical outbreaks from aquaculture facilities in the western states. Disease control strategies following screening with 18 antibiotics will assist in determining potential treatment options for producers. Additional pathogenic *F. columnare* and novel-flavobacterial strains will be selected to determine if a live attenuated Bacterial Coldwater Disease (BCWD) vaccine can provide cross-protection and prevent disease.

RESULTS: Results from the molecular identification and genetic diversity analyses demonstrate the range of diversity of *Flavobacterium* and *Chryseobacterium* isolates collected from clinical disease outbreaks at aquaculture facilities in the western region. Antibiotic sensitivity testing is nearly complete, and many strains show susceptibility to a range of antibiotics that may prove important for disease control treatments. Antigenic diversity has thus far revealed a number of antigens that are recognized by serum antibodies from fish vaccinated with a live attenuated BCWD vaccine. Virulence testing is underway along with challenge model development for *F. columnare* and other flavobacterial strains.

IMPACTS: The primary impact at this point is a greater realization from the industry that this group of pathogens represents an emerging concern for production. We anticipate that antimicrobial susceptibility and vaccine cross-protection results will provide potential treatment or prevention options for salmonid aquaculture producers.





5 Development of Oral Vaccine Delivery Methods for Prevention of Disease in Finfish Culture

Annual Progress Report

PRINCIPAL INVESTIGATORS: Matt Hawkyard, *Oregon State University/University of Maine*; Kenneth Cain, *University of Idaho*; Mary Arkoosh, *NOAA*; Joseph Dietrich, *NOAA*; Evan Jones, *University of Idaho*; Cameron Schuster, *Oregon State University/Cooperative Institute for Marine Resources Studies*

Outreach Coordinator: Angie Doerr, *Oregon State University/Oregon Sea Grant*

Industry Advisor: Jim Parsons, *Cooke Aquaculture Pacific*

Project Monitor: Wendy Sealey, *US Fish and Wildlife Service*

ISSUE: The development of marine and freshwater finfish aquaculture in the western United States is dependent upon a stable and robust supply of juveniles. However, significant disease-associated mortality occurs during commercial culture, requiring disease control and prevention. Current vaccination methods for bacterial pathogens generally rely on injecting juvenile fish, which has several drawback, including: 1) injections can only be performed with larger fish (>20 g); 2) injections are labor intensive, which may not be economical for large-scale, commercial production; and 3) injection methods require a high degree of handling, which may lead to increased stress response in the fish.

RESPONSE: The goal of this project is to develop and evaluate novel complex particles as a platform for oral vaccination of marine and freshwater finfish. Specifically, we aim to immunize sablefish and trout for resistance

against *Aeromonas salmonicida*. The development of oral vaccination methods would have several major benefits by: 1) allowing smaller fish to be vaccinated than would be typically permitted using injection methods; 2) reducing the labor (and cost) associated with administering injection-based vaccines; and 3) providing a tool for vaccination boosters, which could work in conjunction with more traditional vaccines. This project will also result in the development of an ELISA (enzyme-linked immunosorbent assay) for measuring the immune response to experimental vaccines in sablefish and trout.

RESULTS: This project has resulted in two new ELISAs that will allow researchers to measure the immune response of sablefish and trout to experimental vaccines. These assays are being used in research trials to investigate novel oral vaccination methods. Early results with trout show higher levels of antibody production (as measured via ELISA) in fish fed the experimental oral vaccine compared to those in fish from non-vaccinated control groups. However, current oral vaccination formulations and protocols have not yet reached the levels of antibodies observed in treatments in which fish received vaccination by injection. Similar trials are underway with sablefish. Current efforts are aimed at improving feeding protocols and particle formulations to boost the efficacy of the oral vaccination strategy.

IMPACTS: We anticipate that upon completion of this project, the methods and technologies we have developed will be transferred to industry and other stakeholders and ultimately improve the economy and application of vaccinations in the finfish industry.

In The Press & At The Podium

JOURNAL PUBLICATIONS & MANUSCRIPTS

- Ashton NK, Ross TJ, Hardy RS, Stephenson SM, Evans V, Jensen NR, Young SP, Cain KD. 2021. Effects of temperature fluctuation on burbot embryos: Implications of hydropower and climate change. Transactions of The American Fisheries Society <https://doi.org/10.1002/tafs.10311>.
- Bruce TJ, Oliver LP, Ma J, Small BC, Hardy RD, Brown ML, Craig SR, Cain KD. 2021. An initial evaluation of fish-meal replacement with soy protein sources on the growth and immune response of burbot (*Lota lota maculosa*). Aquaculture 545:737157.
- Bruce TJ, Ma J, Oliver LP, Jones EM, LaFrentz BR, Cain KD. 2020. Isolation and experimental challenge of cultured burbot (*Lota lota maculosa*) with *Flavobacterium columnare* and *Aeromonas* sp. isolates. J Fish Dis. 2020;00:1–13. <https://doi.org/10.1111/jfd.13169>
- Considine M, Martinelli JC, Wood CL, King T, Rumrill S. In preparation. Detection of mud blister worm infestations on Oregon oyster farms. Target journal: Aquaculture Research.
- Martinelli JC, King TL, Wood CL. In preparation. Traces of mud-worm *Polydora* spp. (Annelida: Spionidae) infection in oyster seed from Washington State, USA. Target journal: Aquaculture.
- Martinelli JC, Lopes HM, Jimenez-Hidalgo I, Hauser L, King TL, Rawson P, Williams JD, Padilla-Gamiño JL, Wood CL. In preparation. Distribution and prevalence of shell-boring polychaetes *Polydora* spp. (Annelida: Spionidae) in Washington State, USA. Target journal: Biological Invasions.
- Martinelli JC, Spencer LH, Alma L, Padilla-Gamiño JL, Wood CL. In preparation. Evaluating treatments for shell-boring polychaetes *Polydora* spp. (Annelida: Spionidae) infestations in Pacific oysters (*Crassostrea gigas*) from the US Pacific Northwest. Target journal: Aquaculture.

WRAC-funded projects

Sept. 1, 2020–Aug. 31, 2021

- Oliver LP, Evavold JT, Cain KD. 2021. Out-of-season spawning of burbot (*Lota lota*) through temperature and photoperiod manipulation. Aquaculture 543 (2021) 736917 DOI: 10.1016/j.aquaculture.2021.736917.
- Spencer LH, Martinelli JC, King TL, Crim R, Blake B, Lopes HM, Wood CL. 2021. The risks of shell-boring polychaetes to shellfish aquaculture in Washington, USA: A mini-review to inform mitigation actions. Aquaculture Research 52: 438–455.
- Vaage B, Myrick CM. 2021. The effects of acute and chronic exposure of ammonia on juvenile burbot (*Lota lota*) growth and survival. Aquaculture 542:736891.
- Vaage B, Myrick CM. In review. Growth, metabolism, and dissolved oxygen tolerance of juvenile burbot. Aquaculture.

DISSERTATIONS & THESES

- Ashton NK. (2021) Temperature effects on early life stages of the North American burbot: Implications for restoring the lower Kootenai River population. University of Idaho PhD Dissertation.
- Considine ME. (2021) Oral Presentation: Shell boring polychaetes and the Oregon oyster aquaculture industry: spatial distribution, regulatory actions, and stakeholder engagement. Marine Resource Management Thesis Defense, Oregon State University.
- Vaage B. (2021) Measuring the effects of ammonia and dissolved oxygen on juvenile burbot (*Lota lota*) growth and survival. Colorado State University MS Thesis.

PRESENTATIONS & POSTERS

Bruce TJ, Bledsoe JW, Cain KD. Growth performance and gut microbiota in cultured burbot (*Lota lota maculosa*) fed dietary plant-based proteins. Conference of Research Workers in Animal Diseases. Virtual Meeting. Dec. 4–8, 2020.

Bruce TJ, Bledsoe JW, Cain KD. Investigation of growth performance and gut microbiota in cultured burbot (*Lota lota maculosa*) fed plant-based diets. Aquaculture America 2021. San Antonio, TX. Aug. 11–14, 2021.

Bruce T J, Oliver LP, Ma J, Jones EM, Vuglar BM, Cain KD. Assessment of burbot (*Lota lota maculosa*) immune responses following infection with *Aeromonas* spp. Aquaculture America 2021. San Antonio, TX. Aug. 11–14, 2021.

Cain KD. Solutions through science: research as a critical component to enhancing fish culture and fisheries. Virtual Idaho Chapter of the American Fisheries Society (ICAFS) Annual Meeting. (Plenary talk) Mar. 1–5, 2021.

Considine ME. Shell boring polychaetes and the Pacific Northwest oyster aquaculture industry: spatial distribution, regulatory actions, and stakeholder engagement. Hatfield Marine Science Center Seminar. Sept. 2, 2021.

Considine ME. Shell boring polychaetes in Pacific oysters: an emerging Pacific Northwest concern. People and Nature Seminar Series, Oregon State University. Sept. 2, 2021.

Considine ME. Poster: Mud blister worms in Pacific Oysters. Pacific Estuarine Research Society. (online) Apr. 22–24, 2021.

Considine ME. Mud blister worms in Pacific Oysters: Identification, distribution, and mitigation strategies. (lightning talk) State of the Coast, Oregon. 2020.

Considine ME. Mud blister worms and Pacific Oysters. Oregon Sea Grant Careers in Science Webinar Series. Nov. 5–6, 2020.

Martinelli JC. Invasive, shell-boring polychaete pests on oyster farms: What we've learned from California to Alaska. The Kenneth K. Chew Endowed Professorship in Aquaculture Series: Recent advances in shellfish aquaculture. (online) 2021.

Martinelli JC. Polydora Mud Worm Workshop: What we have learned from Alaska to California. 27th Conference for Shellfish Growers, Washington Sea Grant, online. 2021.

Martinelli JC. Polydora Mud Worm Workshop: Effective treatments to control infestations. 27th Conference for Shellfish Growers, Washington Sea Grant, online. 2021.

Martinelli JC, Considine ME, King TL, Hauser L, Padilla-Gamiño JL, Rumrill S, Wood CL. *Polydora websteri* in Pacific oysters from the US west coast: distribution, identification, and mitigation strategies. Pacific Coast Shellfish Growers Association, 74th meeting (online) Oct. 6–8, 2020.

Matuha M, Oliver LP, Evavold J, Cain KD. Early weaning of burbot (*Lota lota maculosa*) larvae onto artificial artemia (EZ Artemia) and Gemma micro diet. Idaho Chapter of the American Fisheries Society (ICAFS) Annual Meeting. Virtual. Mar. 2021.

Matuha M, Oliver LP, and Cain KD. 2021. Optimizing early weaning of burbot (*Lota lota maculosa*) larvae. Aquaculture America. San Antonio, TX. Aug. 11–14, 2021.

Oliver L, Bruce T, Ma J, Cain K. Development of an anti-IgM monoclonal antibody for burbot (*Lota lota*). Conference of Research Workers in Animal Disease. Virtual. Dec. 5–8, 2020.

Oliver L, Evavold J, Cain KD. Out of season spawning of burbot *Lota lota* through temperature and photoperiod manipulation. Idaho Chapter of the American Fisheries Society. Virtual. Mar. 1–5, 2021.

Oliver L, Evavold J, Cain KD. Out-of-season spawning of burbot *Lota lota* through temperature and photoperiod manipulation. Aquaculture America. San Antonio, TX, August 11–14, 2021.

IN THE MEDIA & ON THE WEB

US researchers build case for burbot aquaculture. 2020. Aquaculture North America. Sept/Oct. Vol 11 (5), pgs, 1, 20. <https://mydigitalpublication.com/publication/?i=671490>

Scientists discover broader benefits of coldwater disease vaccine. 2020. Aquaculture North America. Sept/Oct. Vol 11 (5), pg. 26. <https://mydigitalpublication.com/publication/?i=671490> or <https://www.aquaculture-northamerica.com/scientists-discover-broader-benefits-of-coldwater-disease-vaccine/>

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Waterlines is a publication intended to inform the general public and various aquaculture groups about WRAC activities and regional news. These include highlights of USDA/NIFA-funded research and extension projects as well as articles regarding aquaculture appropriate to the western region. Readers are encouraged to submit material for inclusion in *Waterlines*. Publication of material in *Waterlines* does not imply endorsement by WRAC.

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