

Waterlines

WESTERN REGIONAL AQUACULTURE CENTER

2020
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 2019–2020.

IN THIS ISSUE

- 2 WRAC Spotlights
- 4 Highlights of WRAC Research and Outreach Projects
- 10 In the Press & At the Podium



United States Department of Agriculture
National Institute of Food and Agriculture



Photo: Courtesy of Kenneth Cain





FROM THE DIRECTOR

It is a pleasure to highlight the accomplishments of WRAC projects during FY20 in this issue of *Waterlines* (pages 4–9). The strength of the western region's aquaculture community is also reflected in the large proportion of pre-proposals for FY21 funding that were submitted by early-career researchers who had not applied to WRAC previously—a big welcome to those new to WRAC!

One attribute of WRAC that is underscored by the current need to conduct our business virtually is the sense of community and shared goals at our IAC/TC and Board meetings. Rest assured that we are working with the committee chairs to come up with formats for virtual meetings to retain that collegiality.

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 2020 WRAC Directory (depts.washington.edu/wracuw/about/organization.html).

Board of Directors

- **Board Chair Updates**

Walt Dickhoff elected for July 1, 2020–June 30, 2022.

Ron Hardy, previous Chair, served two consecutive terms.

Walt is affiliate faculty at the University of Washington and a Division Director at NOAA. Congratulations Walt!

Ron, who recently retired from the University of Idaho (June 2020), will remain on the WRAC Board. Many thanks Ron and congratulations on your retirement!

- **WAAESD Representative changes**

Dan Edge retired from Oregon State University and the Western Association of Agricultural Experiment Station Directors (WAAESD). He served as the WAAESD representative on the Board for several years. Thanks Dan and best wishes for your retirement!

John Talbott is the new WAAESD representative (May 2020). He is Associate Director, Agricultural Experiment Station, Oregon State University, and Director, Sun Grant Western Regional Center. Welcome John!

Industry Advisory Council (IAC)

Renewing through 2023

Sue Cudd (Whiskey Creek Shellfish Hatchery, OR), **Sean Nepper** (Riverence, WA), and **Leo Ray** (Fish Breeders of Idaho, ID) were approved by the Board to continue their terms. Thank you all!

Transitions

Neal Barker decided not to request another term in order to pursue new business ventures. Thanks Neal for your long-term service to the IAC.

New appointment to the IAC through 2023

The Board approved **David Beugli**. He was selected from among seven nominees, who represented a diverse range of industry in

the region. David brings experience as an Executive Director of the Willapa-Grays Harbor Oyster Growers Association, Long Beach, WA. Please welcome David to WRAC.

Technical Committee/Research Subcommittee

Renewing through 2023

Ken Cain (Distinguished Professor, Aquaculture Research Institute, University of Idaho, ID), **Matt Powell** (Associate Professor, Aquaculture Research Institute, University of Idaho, ID), Thank you both!

Moving on from the Research Subcommittee

After many years of service to WRAC, and following his retirement from Agriculture Research Station, **Rick Barrows** stepped down from the Research Subcommittee. We look forward to his continued involvement in WRAC projects.

New appointment to Research Subcommittee

With three nominations provided, the Board appointed **Vikas Kumar** (Assistant Professor–Research, Department of Animal, Veterinary and Food Sciences, University of Idaho). Welcome Vikas.

Technical Committee/Extension Subcommittee

Renewing through 2023

Big thanks go to **Rossana Sallenave** (Extension Aquatic Ecology Specialist, Department of Animal Sciences & Natural Resources, New Mexico State University) for her ongoing commitment to WRAC. Not only an Extension Subcommittee member, Rossana continues as a Board member (representing New Mexico), contributes as Editor of the Publications Committee, and is a member of the Strategic Planning Committee.

Transitions

Gary Fornshell retired in June 2020 from his position as Aquaculture Specialist at the University of Idaho Extension in Twin Falls. Gary will be missed by all at WRAC, as well as many aquaculture organizations and associations, for his commitment and dedication during his many years of service. Congratulations Gary!

From Problem Statement to Full Proposal Selection

- OCT 2019 IAC/TC and WRAC Board finalize Problem Statements and Request for Pre-Proposals.
- JAN 2020 Request for Pre-Proposals is released.
- APR 2020 14 Pre-Proposals received. Executive Committee (EC) reviews, ranks, and sends recommendations to the Board.
- MAY 2020 Board reviews EC recommendations; invites 8 projects to proceed to Full Proposals.
- SUM 2020 External Review of Full Proposals, with 4–5 external reviewers for each project.
- SEP 2020 PIs of Full Proposals receive anonymous external reviews and are offered the opportunity to respond in writing to the IAC/TC (a new WRAC policy).
- OCT 2020 PIs of the 8 Full Proposals present their projects at the IAC/TC meeting. IAC/TC selects final Full Proposals and sends recommendations to the Board.
- NOV 2020 Funding selections made at Board meeting.
- FALL 2021 Selected projects start, based on availability of funds from NIFA.

WRAC MEETINGS

In the summer of 2020, the Board and IAC and TC Chairs concluded that virtual meetings were in order due the health and safety for all during the ongoing pandemic.

IAC/TC Meetings

October 13–14 and Oct. 20, 2020 via Zoom

Board Meeting

November 17 and 30, 2020 via Zoom

WRAC Project Highlights

September 1, 2019–August 31, 2020

Contact the
WRAC Administrative Office
for complete annual reports.

1 Adapting Aquaculture to Changing Water Chemistry in the Pacific Northwest Termination Report

PRINCIPAL INVESTIGATORS: George G. Waldbusser and Brian Haley, *Oregon State University*; Alan Barton, *Whiskey Creek Shellfish Hatchery*; Benoit Eudeline, *Taylor Shellfish, Inc.*; Chris Langdon, *Oregon State University*

Outreach Representative: Brad Warren, *National Fisheries Conservation Center*

Industry Advisor: Sue Cudd, *Whiskey Creek Shellfish Hatchery*

Project Monitor: Ron Hardy, *Emeritus, University of Idaho*

ISSUE: Water quality issues continue to affect the ability of major commercial oyster hatcheries in Oregon and Washington despite the significant improvements in production associated with buffering seawater to mitigate ocean acidification impacts. Industry personnel estimate that, on average, production is still 20% or so below historic values. The decreases in production appear to manifest in later-stage larvae and generally occur in the late summer. One of the current limitations on expansion of oyster aquaculture has been seed supply; thus, increasing production will help the market expand and meet demand.

RESPONSE: The project team focused on identifying water-quality issues associated with production decreases

through various monitoring and measurement approaches. We installed additional monitoring equipment in one hatchery to add to the high-frequency data collection underway, and carried out two field campaigns of targeted measurements (nutrients, metals, inorganic carbon, oxygen, oxygen demand, and sulfide) of water as it moves through the hatchery setting and within static culture tanks over time. Our results are being used to develop a best management practices (BMP) guide for water quality and ocean acidification for oyster hatcheries and growers.

RESULTS: The results from measurements of water quality outside and inside the hatcheries, discussions with hatchery operators, and synthesis of existing and new knowledge has narrowed the potential scope to a few key issues (that vary between the hatcheries). First, tidal effects in some estuaries and bays increase the probability of hatchery failures. Second, metabolic effects in tanks are significant, with large increases in nitrogen and possible interactions with metals and buffering slurry suggest care must be taken in managing these other possible effects. Third, it is reasonable to assume that the interaction of these external (and somewhat predictable events) cooccurring with internal tank effects can amplify production challenges.

IMPACTS: Within the first years of the project, study hatcheries had already included oxygen concentrators to help alleviate possible oxygen consumption issues. Identification of low-tide issues at one hatchery or other deep-water issues at the other hatchery provide cost-effective manageable mitigation strategies. The production of a BMP guide for hatchery and grower water-quality management will help transfer knowledge from this funded work and industry partners to other industry stakeholders, as more growers appear to be setting up their own smaller hatcheries.



Photo: Courtesy of George Waldbusser



2 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*; Shawn Young, *Kootenai Tribe of Idaho*; Rick Barrows, *Emeritus, USDA/ARS*; Luke Oliver, *University of Idaho*; Moureen Matuha, *University of Idaho*

Outreach Representative: Gary Fornshell, *University of Idaho (retired June 2020)*

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

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

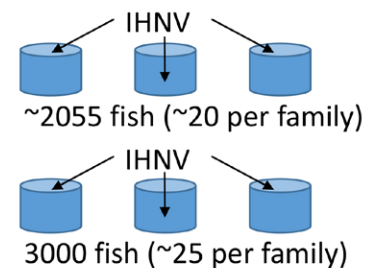
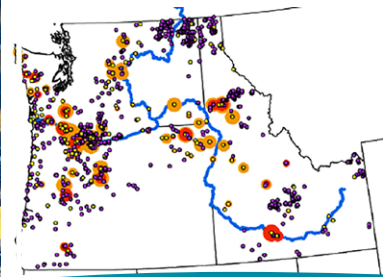
ISSUE: The integration of burbot (freshwater cod) production into existing trout farms presents a novel, low-risk strategy to develop this species for commercial aquaculture. By expanding production, this project addresses the USDA-NIFA challenge areas of food security, water, childhood obesity, and 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: We hypothesize that growth and performance at all life stages can be optimized to make culture of burbot efficient and economically attractive. Our objectives are to: optimize spawning, early rearing, and grow out; conduct commercial pilot scale trials and gather data relevant to production; determine water-quality limits; determine if triploid induction is possible and if it may be feasible to produce sterile burbot; conduct a basic economic analysis of production costs; and disseminate results broadly to the aquaculture industry.

RESULTS: Results thus far are encouraging and clearly show the biological feasibility of commercial burbot culture. This past year, results from diet trials demonstrating that burbot grow well on trout-like diets were published. Additionally, we have gained a better understanding of water-quality (dissolved oxygen and ammonia) requirements, demonstrated that triploids (and tetraploids) can be produced, showed that we can shift spawning times by photothermal manipulation, and demonstrated that the period of live feeding during larval weaning can be shortened by two-to-three weeks. Furthermore, we previously determined that egg incubation temperatures above 4°C result in high deformity and low survival rates, and temperatures of 6°C during early incubation are lethal to embryos.

A consumer survey and sensory taste panel evaluation demonstrated that burbot is a high quality fish and was preferred over two other common aquaculture products (trout and tilapia), suggesting that this species will have high consumer acceptance in the marketplace.

IMPACTS: This research and our outreach efforts strongly suggest that commercial burbot aquaculture is feasible and is of interest to existing producers and entrepreneurs. We have shown that culture bottlenecks can be overcome, such as out-of-season spawning, larval weaning to dry diets, and grow-out on lower cost feeds. Although work continues to better define production economics and confirm that triploid induction produces sterile fish, this project has demonstrated that burbot could be a new and viable commercial aquaculture species for the United States.



3 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 San Diego Aquaculture Extension*

Industry Advisor: Stephen Reichley, *Clear Spring 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 aquaculture.

RESPONSE: Hendrix Genetics created progeny representing 100 families from the “November Even Year” line. A total of 2,055 fish were distributed among three challenge tanks and challenged for 21 days with IHNV. In May 2019, Hendrix personnel created 120 “May Odd Year” line families. These progeny fish were transferred to the Western Fisheries Research Center in August 2019, and we conducted pilot virus challenge experiments to

determine the optimal dose for the main challenge, which was conducted in September 2019.

RESULTS: Whole genome DNA was extracted from the fin tissues obtained from IHNV-exposed progeny and their parents for genotyping with the high density 57,000 SNP chip at the USDA National Center for Cool and Cold Water Aquaculture in Leetown, WV and the Center for Aquaculture Technologies, San Diego, CA. A total of 4,200 fish, including 1,900 progeny from each line, were genotyped. Analysis has begun on the November line because this line will begin spawning towards the end of October. The genotype data was used to successfully assign all the November line progeny to their respective families. The genotype data files have been transferred to Hendrix Genetics for calculation of genome-enabled breeding values to enable incorporation of genomic selection for resistance to IHNV in the selective breeding scheme for this genetic line.

IMPACTS: The anticipated benefits of the research are the application of the genomic tools developed in this project for the genetic improvement of aquaculture broodstock lines that, in turn, support a significant portion of the rainbow trout grow-out industry. These tools can be integrated into broader approaches for disease management in aquaculture in the species. The wider benefits will be the characterization of candidate genomic regions underlying the evolution of host resistance to a key viral disease. These data will contribute to IHNV epidemiological models for cultured and natural populations in western North America.



4 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 & 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—parasitic polychaetes in the genus *Polydora*—are responsible for substantial losses to commercial oyster industries worldwide. These polychaetes burrow into the shells of bivalves and cause unsightly blisters that release detritus, mud, and fecal material, fouling oyster meats. Until this project, there had been no reports in the scientific literature of any *Polydora* species in Pacific oysters from Alaska, Washington, or Oregon. Our data now confirm that several species of blister-forming spionid polychaetes are widespread and abundant throughout the west coast states (AK, CA, OR, WA). Pacific oysters are the most important cultured shellfish in the Pacific Northwest and 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 three sampling missions to quantify the prevalence of shell-boring polychaetes at 33 oyster farms throughout California, Oregon, Washington, and Alaska. We have also collected nearly half of the data needed to identify the environmental factors that predict high infestation rates. Finally, one experiment, designed to identify the most effective intervention that growers can use to reduce transmission and mitigate the negative impacts of infection on product value, showed that there are effective treatments for killing shell-boring polychaetes without negative impacts on oysters.

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 currently uninfested areas. All results of our sampling, data collection, and experiments 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.



5 Emerging and Re-emerging Flavobacterial Pathogens in Aquaculture

Annual Progress Report

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

Outreach Representative: Gary Fornshell, *University of Idaho (retired June 2020)*

Industry Advisor: Tom Van Tassel, *Evaqua Farms*

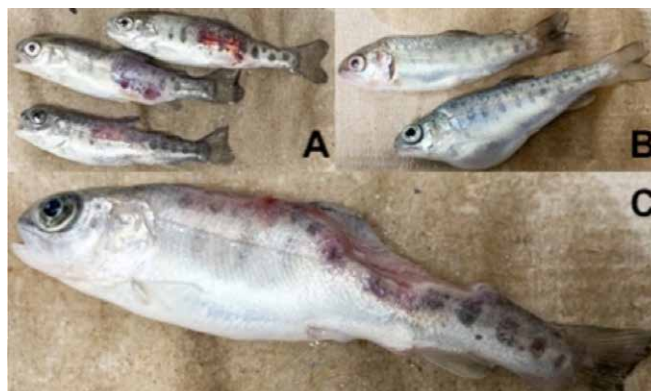
Project Monitor: Stephen Reichley, *Clear Springs, Inc.*

ISSUE: The incidence of clinical disease linked to emerging (and re-emerging) pathogens in the *Flavobacteriaceae* family appears to be increasing and there is a need to better define distribution in the western region of the United States. In addition, it will be important to identify effective disease control or prevention tools for these pathogens. 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.) isolated from aquaculture facilities in the western states. Furthermore, strains will be screened against 18 antibiotics to determine potential treatment options, while 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: This project has just been initiated, but results to date clearly show that many new and novel bacteria in this *Flavobacteriaceae* family are causing clinical disease in fish at aquaculture facilities in the western region. Strains are being screened and many are susceptible to a range of antibiotics that may be important as potential treatments. We were able to publish work (as part of another project) that showed that our BCWD vaccine did provide cross-protection against some of these bacterial strains that were isolated from fish in the Great Lakes region, suggesting that similar benefits may be identified for western region isolates.

IMPACTS: This project is in its beginning stages, and results have not had impact in the industry as yet; however, we anticipate that in the next year, we will have a clear picture of the distribution and potential treatment options for many of these novel bacterial pathogens. Such information will be important and impactful for salmonid aquaculture in the West.





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

Annual Progress Report

PRINCIPAL INVESTIGATORS: Matt Hawkyard, *Oregon State University*; 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 on 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 drawbacks 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. In addition to the new platform being developed, 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: We have found that a whole-cell *Aeromonas salmonicida* vaccine can be incorporated into complex particles at a high rate (~25% of the particle volume) and have the potential to deliver a high payload of vaccine to target animals. We have also found that free amino acids or similar feeding stimulants must be included and retained by the complex particles in order to maximize feed uptake by target animals. ELISAs are being developed to measure the immune response of sablefish and trout to experimental vaccines and will be applied to immunization trials that are currently underway.

IMPACTS: This research is in the very early stages and will not have an immediate impact on industry or other stakeholders. However, we anticipate that the methods and technologies will be transferred to industry and ultimately improve the economy and application of vaccinations in the finfish industry.

In The Press & At The Podium

JOURNAL PUBLICATIONS & MANUSCRIPTS

- Ashton NK, Jensen NR, Ross TJ, Young SP, Hardy RS, Cain KD. 2019. Temperature and maternal age effects on burbot reproduction. *North American Journal of Fisheries Management*. doi.org/10.1002/nafm.10354.
- Bruce TJ, Gulen S, Oliver LP, Ma J, Cain KD. 2020. Evaluation of commercial and experimental grower diets for use in intensive burbot (*Lota lota maculosa*) culture. *Aquaculture* 528:735490.
- Bruce TJ, Ma J, Knupp C, Loch TP, Faisal M, Cain KD. 2020. Cross-protection of a live-attenuated *Flavobacterium* psychrophilum immersion vaccine against novel *Flavobacterium* spp. and *Chryseobacterium* spp. strains. *Journal of Fish Diseases* 2020;00:1–14. <https://doi.org/10.1111/jfd.13201>
- Martinelli JC, Lopes HM, Hauser L, Jimenez-Hidalgo I, King TL, Padilla-Gamiño JL, Rawson P, Spencer LH, Williams J, Wood CL. 2020. Confirmation of the shell-boring oyster parasite *Polydora websteri* (Polychaeta: Spionidae) in Washington State, USA. *Scientific Reports* 10: 2961.
- Oliver LP, Ma J, Bruce TJ, Evavold JT, Korbel DB, Cain KD. 2020. Triploid induction in cultured burbot (*Lota lota*) using thermal and hydrostatic shock. *Aquaculture* 515 (2020): 734582.

MASTER'S THESIS

- Fairchild, W. (2020) High-resolution carbonate dynamics of Netarts Bay, OR. 2014–2019. Oregon State University MS Thesis, B. Hales advisor, 106 pages.

PRESENTATIONS & POSTERS

- Binkley A, Clees T, Cole B, Fogarasi S, Hundley A, Kerrick S, McDevitt R, Meyer M, Nestlerode R, Swedfeger M, Thibedeau I, Torres A, Weigang M, Vaage B, Myrick C. Shelter or not to shelter: the effects of cover varieties on juvenile burbot growth rates. Celebrate Undergraduate Research and Creativity Conference, Fort Collins, CO. 2020.
- Bruce TJ, Cain KD. Investigation of gut microbiota, physiological stress response, and immune parameters in cultured burbot (*Lota lota maculosa*). Poster. Aquaculture America 2020. Honolulu, HI. Feb. 9–12, 2020.

WRAC-funded projects

Sept. 1, 2019–Aug. 31, 2020

- Bruce TJ, Gulen S, Oliver LP, Ma J, Cain KD. Evaluation of commercial and formulated diets for juvenile and sub-adult burbot (*Lota lota maculosa*) culture. Idaho Chapter of the American Fisheries Society Annual Meeting. Coeur d'Alene, ID. Mar. 11–13, 2020.
- Bruce TJ, Ma J, Knupp C, Loch TP, Cain KD. Cross-protection of a live attenuated coldwater disease immersion vaccine against novel *Flavobacterium* spp. and *Chryseobacterium* spp. Aquaculture America. Honolulu, HI. Feb. 9–12, 2020.
- Bruce TJ, Ma J, Knupp C, Loch TP, Cain KD. Live-attenuated bacterial coldwater disease (BCWD) vaccine provides cross-protection against novel *Flavobacteriaceae*. Northwest Fish Culture Concepts. Victoria, BC, Canada. Dec. 3–5, 2019.
- Bruce TJ, Oliver LP, Small BC, Hardy RW, Brown ML, Craig SR, Cain KD. Growth and immune responses on cultured burbot (*Lota lota maculosa*) fed varied inclusions of soy protein sources. Aquaculture America 2020. Honolulu, HI. Feb. 9–12, 2020.
- Cain KD. Current and future management tools for coldwater disease (CWD). US Trout Farmers Annual Meeting/Conference, (Invited talk). Seattle, WA. Sept. 4–6, 2019.
- Cain KD. Idaho freshwater cod: developing burbot aquaculture from a conservation focus to a potential high value commercial product! Aquaculture America. (Invited talk) Honolulu, HI. Feb. 9–12, 2020.
- Cain KD. Idaho's Freshwater Cod: Burbot in the Kootenai (Past, Present and Future). Malcolm M. Renfrew Inter-disciplinary Colloquium, University of Idaho. (Invited talk) Dec. 10, 2019.
- Fleener HR, Hawkyard M. Evaluation of complex particle feeding by sablefish *Anoplopoma fimbria* and steelhead trout *Oncorhynchus mykiss*. Aquaculture America 2020. Honolulu, HI. Feb. 9–12, 2020.
- Fleener HR, Hawkyard M. Evaluation of complex particle feeding by sablefish *Anoplopoma fimbria* and steelhead trout *Oncorhynchus mykiss*. Poster. Oregon Chapter of the American Fisheries Society. Mar. 3–6, 2020.

Lee C, Vaage B, Myrick CA. Discovering the fingerprints of a burbot. Poster. Colorado-Wyoming Chapter of the American Fisheries Society, Laramie, WY. Feb. 25–27, 2020.

Lopes H, Martinelli JC, Padilla-Gamiño JL, Hauser L, Jimenez-Hidalgo I, Williams JD, King TL, Wood CL. Morphological and molecular identification of shell-boring mudworm *Polydora websteri* (Polychaeta: Spionidae) from Puget Sound, Washington. Pacific Coast Shellfish Growers Association 72nd Meeting, Blaine, WA. Sept. 20, 2018.

Lopes H, Martinelli JC, Padilla-Gamiño JL, Hauser L, Jimenez-Hidalgo I, Williams JD, King TL, Wood CL. Poster. Morphological and molecular identification of shell-boring mudworm *Polydora websteri* (Polychaeta: Spionidae) from Puget Sound, Washington. Washington Sea Grant Shellfish Growers Conference, Union, WA. Mar. 5, 2018.

Lopes H, Martinelli JC, Wood CL. Presence and prevalence of shell-boring mudworm *Polydora* spp. (Polychaeta: Spionidae) in Washington State. Washington Sea Grant Shellfish Growers Conference, Union, WA. Mar. 5, 2018.

Martinelli JC, Lopes H, Padilla-Gamiño JL, Hauser L, Jimenez-Hidalgo I, Williams JD, King TL, Wood CL. 2019. Morphological and molecular identification of shell-boring mudworm *Polydora websteri* (Polychaeta: Spionidae) from Puget Sound, Washington. World Aquaculture Society Meeting, New Orleans, LA. Mar. 17–19, 2019.

Matuha M, Oliver LP, Evavold J, Gulen S, Oliver LP, Ma J, Bruce TJ, Cain, KD. Evaluation of early larval weaning of live feed for burbot (*Lota lota maculosa*). Idaho Chapter of the American Fisheries Society Annual Meeting. Coeur d'Alene, ID. Mar. 11–13, 2020.

Oliver LP, Ma J, Bruce TJ, Evavold J, Cain KD. Triploid induction in cultured burbot (*Lota lota maculosa*) using thermal and hydrostatic shock. Idaho Chapter of the American Fisheries Society Annual Meeting. Coeur d'Alene, ID. Mar. 11–13, 2020.

Oliver LP, Gulen S, Bruce TJ, Ma J, Cain KD. Determination of optimum diet for commercial juvenile burbot (*Lota lota maculosa*) culture. Aquaculture America. Honolulu, HI. Feb. 9–12, 2020.

Vaage B, Myrick CA. Ammonia overload: measuring the acute and chronic limits of burbot. Colorado–Wyoming Chapter of the American Fisheries Society, Laramie, WY. Feb. 25–27, 2020.

Vaage B, Myrick CA. Ammonia overload: measuring the acute and chronic limits of burbot. Colorado Aquaculture Association Annual Meeting, Natrop, CO. Jan. 31–Feb. 1, 2020.

IN THE MEDIA & ON THE WEB

A Swimming Recovery, 2020. Featured story for *Here We Have Idaho Magazine* and posted on University of Idaho website. www.uidaho.edu/news/here-we-have-idaho-magazine/burbot-aquaculture

Burbot Bounce Back. Featured story on the University of Idaho's College of Natural Resources website. 2019. www.uidaho.edu/cnr/about/feature-stories/burbot-biology

Burbot conservation effort spawns commercial aspirations. Global Aquaculture Advocate. Feb. 2020. www.aquaculturealliance.org/advocate/burbot-conservation-effort-spawns-commercial-aspirations/

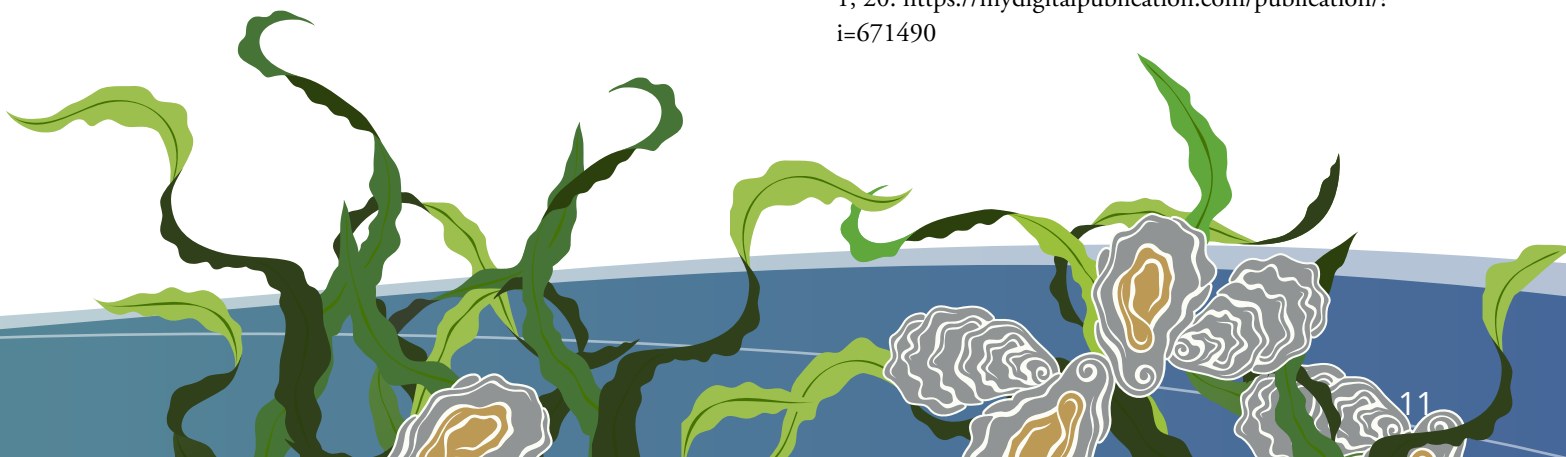
Idaho burbot researchers look to shift from conservation to commercial aquaculture. Seafood Source. Dec. 2019. www.seafoodsource.com/news/aquaculture/idaho-burbot-researchers-look-to-shift-from-conservation-to-commercial-aquaculture

Researching Burbot: Restoration of the Burbot Fishery in Idaho. YouTube. 2020. www.youtube.com/watch?v=-KvOjYUgAQc

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

The freshwater cod with a Lota potential for farming. The Fish Site. 2020. thefishsite.com/articles/the-freshwater-cod-with-a-lota-potential-for-farming

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>



Waterlines

Western Regional Aquaculture Center
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