

Waterlines

WESTERN REGIONAL AQUACULTURE CENTER

2018
ANNUAL REPORT

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

We are pleased to present this issue of *Waterlines*, our 2018 newsletter and report of accomplishments to USDA/NIFA.

IN THIS ISSUE

- 2 WRAC Spotlights
- 4 Highlights of research and outreach projects funded by WRAC from Sept. 1, 2017 through Aug. 31, 2018
- 10 In the Press & At the Podium

Photo: Joth Davis



United States Department of Agriculture
National Institute of Food and Agriculture



WRAC Spotlights

September 2017–August 2018

WRAC NEARS THE END OF THE PROPOSAL SELECTION CYCLE



Fall 2017—Setting the stage, research priorities

At the joint meeting of the industry and technical committees (IAC/TC), members determined priority areas for research identified by the industry and based on feedback from stakeholders. The IAC/TC developed 10 new “problem statements” that formed the basis of the Request for Research and Outreach Proposals for funding year 2019 (RFP FY19). These problem statements were sent to the Executive Committee for review and recommendations to the WRAC Board of Directors, who approved them at their November meeting.



Winter-Spring 2018—Distribution of RFP FY19

The Request for Research and Outreach Proposals for FY2019 was distributed in January, and by the April deadline, a total of 14 submissions were received. Each project pre-proposal addressed one or more of the 10 problem statements.



Spring 2018—Invitations to submit Full Proposals

After the submission period for pre-proposals closed, the Executive Committee worked in teams to review them and make recommendations to the Board. The Board then selected eight projects to receive invitations to submit full proposals in May, which were due in July 2018.



Fall 2018—Review of Full Proposals & Project Selection

The IAC/TC will review the full proposals and hear presentations from the eight project investigators in October. Their recommendations will be key to the selection of projects by the Board in November.



Wade Cavender



Jon Boren



Ashley Stokes

UPDATES TO THE WRAC 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. Changes to the roster are reflected in the July 2018 WRAC Directory (depts.washington.edu/wracuw/about/organization.html) and are also listed below and on page 3.

Board of Directors

- A heartfelt thanks to Eric Wagner for his tenure on the WRAC Board representing Utah. Eric’s research expertise and editorial eye were assets to the Board.
- Please welcome the new Utah representative, Wade Cavender, who is Assistant Aquatic Section Chief for the Utah Division of Wildlife and Fish Experiment Station. We look forward to having you on board.
- In July, the Western Extension Directors Association (WEDA) elected a new representative to WRAC.
 - We truly appreciate the work of out-going WEDA representative, Jon Boren from New Mexico State University. We will miss Jon’s guidance on policy and extension.
 - The new WEDA representative, Ashley Stokes, is currently the Assistant Vice President for Engagement and Deputy Director of Extension at Colorado State University. Please welcome Ashley.

Photos, l to r: Courtesy of Utah Division of Wildlife, Courtesy of National Marine Fishery Service, Courtesy of Colorado State University

WRAC Spotlights *continued*

Industry Advisory Council (IAC)

- Approved by the Board to continue their terms through June 30, 2021: Ken Beer, The Fishery, Inc. (CA); Jim Gibbons, Seattle Shellfish (WA); Jeff Hetrick, Alutiiq Pride Shellfish Hatchery (AK); and Dallas Weaver, Scientific Hatcheries (CA). Thank you all!

Technical Committee/Research Subcommittee

- Bob McGorrin (OSU) and Jim Nagler (UI) are both willing to serve another term through 2021 and were unanimously approved by the Board. Thank you both!
- Departures from the Research Subcommittee
 - Congratulations to Jim Bowker on his retirement at the end of 2017 from USFWS and the Aquatic Animal Drug Partnership Program in Bozeman, MT. Best wishes Jim on your new endeavors.
 - Gil Sylvia, Coastal Oregon Marine Experiment Station, is unable to continue to serve on the Research Subcommittee. We are grateful for the time and expertise you have given to WRAC.
- With his new extension appointment, Jackson Gross transitions from the Research to the Extension Subcommittee.
- New Research Subcommittee appointments, approved by the Board in May 2018:
 - Brian Small, Director, Hagerman Fish Culture Experiment Station (ID)

- Michael Graham, Director of Research and Development, Moss Landing Marine Laboratory Center for Aquaculture (CA)
- One opening on the Research Subcommittee remains as the Board works to balance geographic representation and expertise in freshwater and marine finfish, shellfish, macroalgae, and other research specialties.

Technical Committee/Extension Subcommittee

- Kevin Fitzsimmons (AZ), Quentin Fong (AK), and Gary Fornshell (ID) were approved by the Board to continue another term. Thank you all.
- Congratulations to Jackson Gross on his new position as Extension Specialist at the University of California, Davis, which includes an appointment to the WRAC Extension Subcommittee by UC leadership. Approved by the WRAC Board, he joins the Extension Subcommittee this fall.

UPCOMING WRAC MEETINGS

IAC/TC Meeting

October 8–10, 2018, Doubletree Hotel, Spokane, WA

Board Meeting

November 13, 2018, San Diego, CA



Jim Bowker



Gil Sylvia



Brian Small



Michael Graham



Jackson Gross



WRAC Project Highlights

September 1, 2017–August 31, 2018

Full annual reports available at:
[depts.washington.edu/wracuw/
research/current_research.html](https://depts.washington.edu/wracuw/research/current_research.html)

1 Triploids, Tetraploids, and Successful Metamorphosis in Purple Hinge Rock Scallop (*Crassadoma gigantean*) Termination Report

PRINCIPAL INVESTIGATORS: Jonathan P. Davis, *Puget Sound Restoration Foundation*; Brent Vadopalas, *School of Aquatic and Fishery Sciences, University of Washington*; Benoit Eudeline, *Taylor Shellfish Co.*
Outreach Coordinators: Paul G. Olin, *UC Sea Grant Extension Program, UC San Diego/Scripps Institution of Oceanography*; Carolyn Culver, *UC Sea Grant Extension Program, Scripps Inst. of Oceanography, UC San Diego and Marine Science Institute, UC Santa Barbara*
Industry Advisor: Sue Cudd, *Whiskey Creek Shellfish Hatchery*
Suggested Project Monitor: Gary Freitag, *U of Alaska Fairbanks*

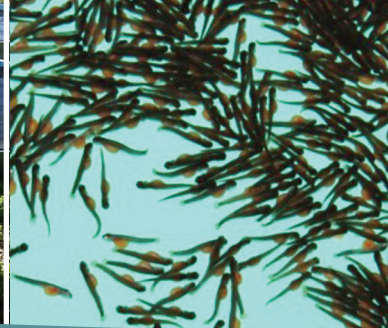
ISSUE: Commercial shellfish growers in the WRAC region expressed interest in pursuing culture techniques for the purple hinge rock scallop, a high-value seafood product. The critical information needed when developing a new species for aquaculture includes: performance (growth and survival characteristics), optimal husbandry techniques, and the size and age at which sexual maturation occurs.

RESPONSE: WRAC funded a project to pursue grow-out trials in different environments in Washington State to shed light on when farmed stocks mature and to further develop ways to produce sterile

rock scallops to help safeguard wild stocks from interbreeding with farmed stocks.

RESULTS: Purple hinge rock scallops exhibited significant growth differences at different sites, indicating that production of a marketable rock scallop can occur in as little as three years, though the vast majority are male at this age, and the extent of gonadal development is minimal. Because of ongoing difficulties with conditioning rock scallops to reach sexual maturity in the hatchery, further work on producing sterile stocks via ploidy manipulation has been hindered.

IMPACTS: As a result of the study, significantly more is known about the performance characteristics of rock scallops grown under commercial conditions. Information on growth rate, survivorship, and especially cementation behavior for seven locations is available to shellfish companies, which are now in a better position to make informed decisions about whether to initiate further commercial development of this species. State and tribal wild resource management agencies have critical information on gametogenesis and sex ratios of rock scallops maintained in the field, which may help inform the potential for interbreeding of farmed and wild stocks.



2 If You Feed Them, Will They Grow? A Dietary Approach to Improving the Growth of Juvenile Cutthroat Trout

Termination Report

PRINCIPAL INVESTIGATORS: Christopher A. Myrick, *Fish, Wildlife, and Conservation Biology, Colorado State University*; Biswamitra Patro and Madison Powell, *Aquaculture Research Institute, University of Idaho*; Wendy Sealey, *USFWS, Bozeman Fish Technology Center*

Outreach Representative: Gary Fornshell, *University of Idaho Extension*

Industry Advisors: Jeremy Liley, *Liley Fisheries*, David Brock, *Rangen, Inc.*, Jackie Zimmerman, *Skretting USA*

Project Monitor: Rick Barrows, *USDA, Hagerman, ID*

ISSUE: While there are commercially available feeds for rearing trout, none is formulated specifically for cutthroat trout. The goal of this project is to build upon the WRAC-funded work of Myrick et. al. 2010 to identify suitable feeds for the production of market-sized cutthroat trout.

RESPONSE: In order to improve the efficiency of cutthroat trout production, we studied the effects of diet type (including physical form and experimental vs. existing commercial diets) and diet formulation (including lysine, digestible protein, digestible energy, and vitamin/mineral levels) on the performance of juvenile cutthroat trout under laboratory and production conditions.

RESULTS: Cutthroat trout (CTT) perform equally well on floating and sinking pelleted diets, but do not perform well on flake diets. Growth rates are highest and feed conversion ratios are lowest when CTT are fed diets with high protein and lipid contents; currently available diets that meet these requirements include premium trout and steelhead feeds. CTT best when fed at lysine levels of 2.4% or higher. Results indicate that CTT perform better when fed more nutrient dense diets than rainbow trout even though their feed intake and growth rates were lower than rainbow trout of comparative size. Optimal DP:DE (digestible protein:digestible energy) ratios for growth of fish generally range between 81 and 117. The highest SGR (specific growth rate) of 1.04% per day was obtained for the diet containing 41.7% DP and 4370 kcal/kg DE. Specific growth rates exhibited by fish fed test diets were $\geq 0.91\%$ d⁻¹, and higher than the commercial diet (0.84 % d⁻¹).

IMPACT: The poor performance of flake feed diets clearly demonstrated that flake feeds are not ideal for cutthroat trout. Information on the suitability of existing feed types for use in cutthroat trout culture and on lysine and DP to DE levels, along with optimal vitamin and mineral premix supplementation, should help aquaculture producers and the feed industry select appropriate feeds for cutthroat trout culture.



3 Determining Causes, Costs, and Benefits of Triploidization to Improve Sturgeon Caviar Production

Annual Progress Report

PRINCIPAL INVESTIGATORS: Andrea Schreier, Joel Van Eenennaam, Anne Todgham, and Fred Conte, *UC Davis*, Molly Webb, *Bozeman Fish Technology Center*, Shawn Young, *Kootenai Tribe of Idaho*

Outreach Representative: Ray RaLonde, *Alaska Sea Grant*

Industry Advisors: Peter Struffenegger, *Stellar Biotech*; Linda Lemmon, *Blind Canyon Aqua Ranch*

Project Monitor: Kevin Fitzsimmons, *University of Arizona*

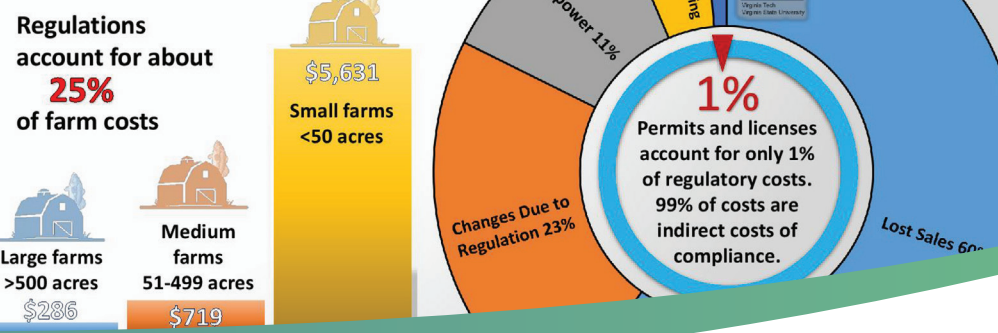
ISSUE: Spontaneous triploidy, or unintentional induction of genetic triploidy, has been detected in white sturgeon production facilities across the West. There are some possible benefits of triploidization, including larger eggs and a female-biased sex ratio, but possible negative impacts include the production of reproductively impaired 10N progeny in crosses between spontaneous triploid (12N) and normal (8N) broodstock. Thus far, no studies have evaluated the relative costs and benefits of triploidization on the caviar industry.

RESPONSE: We are doing several experiments designed to determine how/why spontaneous triploids are produced in white sturgeon culture and to compare metabolic performance, stress response, and immune function among 8N, 10N, and 12N fish. We are studying the relationship between ploidy and female reproductive development and have compared different methods of ploidy

detection so we could provide producers with recommendations about how best to identify 10N and 12N fish.

RESULTS: We confirmed that mechanical shock from vigorous treatment during siltation is a major cause of spontaneous triploidy. Preliminary data suggest that egg aging and mechanical shock during siltation can increase the number of 12N progeny. Although 8N, 10N, and 12N white sturgeon exhibit similar responses to warming and acute stress, individuals with abnormal ploidy are different metabolically from 8N sturgeon. Although 10N females seem to have delayed reproductive development and fatty ovaries, they can reach sexual maturity, and some 8N females exhibit a similar phenotype. This suggests that factors other than ploidy contribute to late sexual maturation.

IMPACTS: Our Year 3 results indicate that minimizing *in vivo* oocyte aging and handling eggs very gently during siltation should reduce spontaneous triploidy, although some females may produce 12N progeny regardless of treatment. Metabolic differences in 10N and 12N white sturgeon may affect their performance in culture. We recommend further investigation of the factors causing delayed maturity in white sturgeon females and suggest that producers reconsider keeping late-maturing females, regardless of ploidy, because they tend to have fatty ovaries with low caviar yield.



4 The Economic Impact of Regulations on Shellfish and Trout Aquaculture Growth in the Western United States

Annual Progress Report

PRINCIPAL INVESTIGATORS: Carole R. Engle, *University of Arkansas*; Fred Conte, *UC Davis*; David Landkamer, *Oregon State University*; Bobbi Hudson, *Pacific Shellfish Institute*

Outreach Coordinator: Gary Fornshell, *University of Idaho*

Industry Advisor: Bill Dewey, *Taylor Shellfish Farms*

Project Monitor: Gunnar Knapp, *University of Alaska*

ISSUE: Regulations affecting U.S. aquaculture often overlap, trigger other permitting requirements, and frequently result in a lengthy and convoluted chain of approvals. There is growing concern that this regulatory framework has contributed to declines in several sectors of U.S. aquaculture and prevented growth of others. Only one study has been done to quantify the regulatory cost burden and economic impact of the total set of regulations; that study focused on baitfish and sportfish farms. Results showed that the regulatory cost burden constituted 25% of the total costs of U.S. baitfish/sportfish farms and that the effects were disproportionately greater on smaller farms. However, no attempts have been made to assess the effects on shellfish and trout aquaculture growth in the western United States.

RESPONSE: In-person surveys were designed to systematically measure the regulatory cost burden on shellfish farms in the western region and on trout farms nationally (additional funding from

USDA-APHIS and the U.S. Trout Farmers Association was used to cover survey costs in states outside the western region). This project developed detailed information on the complete set of regulatory filings as well as the costs incurred to obtain the necessary permits and to comply with all monitoring, compliance, and reporting requirements.

RESULTS: The total regulatory cost burden was estimated to be \$188.5 million for West Coast shellfish farms and \$28.3 million for U.S. salmonid farms. Environmental management regulations were the most costly for both types of farms. Fish health testing costs were especially significant for salmonid producers selling into recreational markets. For shellfish, the greatest costs were associated with delays in obtaining permits—costs associated with manpower expended; sunk costs invested in anticipation of permit approvals; fees for consultants, attorneys, and expert witnesses; and expenditures on surveys and other analyses requested by permitting authorities. Results of both surveys support previous findings that regulatory costs pose a disproportionately greater burden on smaller scale producers.

IMPACT: Study data provide insight into the overall cost burden and the types of reporting, monitoring, and compliance requirements that have created the greatest adverse effects on West Coast shellfish and U.S. salmonid farms. To date, there have been five news stories and 19 invited presentations on this project.



5 Adapting Aquaculture to Changing Water Chemistry in the Pacific Northwest

Annual Progress Report

PRINCIPAL INVESTIGATORS: George G. Waldbusser, Brian Haley, and Burke Hales, *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: Kenneth Cain, *University of Idaho*

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

RESPONSE: We are focusing on identifying water-quality issues associated with production decreases through various monitoring and measurement approaches. We have installed additional monitoring equipment in one hatchery to add to the high-frequency data collection and have carried out two field campaigns of targeted

measurements of nutrients, metals, inorganic carbon, oxygen, oxygen demand, and sulfide in water as it moves through the hatchery setting and within static culture tanks over time. Our results are also being used to develop a best management practices guide for water quality and ocean acidification for oyster hatcheries and growers.

RESULTS: Results are pointing towards a few related causes: Oxygen demand (and associated redox potential) appears to be impacting specific cohorts when we record spikes in BOD (biological oxygen demand) in the monitoring data—these spikes show some alignment with tidal and light phasing; Metabolism within tanks appears to be exacerbating water-quality issues, with possible indirect effects on metals toxicity through speciation; Metal concentrations appear to be sporadically elevated in some culture tanks—this may be due to varying levels in the agricultural soda lime used to buffer pH changes in tanks.

IMPACTS: To keep the U.S. strong in the global aquaculture market (and provide opportunities for the sector to grow), providing tools and approaches for oyster hatcheries to adapt to changing water chemistry will “future-proof” this base of the industry. Hatcheries are increasing water-quality monitoring and treatment equipment, and by identifying the key mechanisms for failures will ensure the most efficient use of resources and provide opportunities for targeted treatment.



6

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*, Rick Barrows, *USDA/ARS Bozeman Montana*, Shawn Young, *Kootenai Tribe of Idaho*, Christopher Myrick, *Colorado State University*
Outreach Representative: Gary Fornshell, *University of Idaho*
Industry Advisors: Linda Lemmon, *Blind Canyon Aqua Ranch*
Project Monitor: Mark Drawbridge, *Hubbs Seaworld Research Inst.*

ISSUE: The integration of burbot (freshwater cod) production into existing trout farms (or other aquaculture operations) presents a novel, low-risk strategy to develop this underutilized species for freshwater commercial aquaculture. The overarching goal and challenge will be to use results from this project 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: 1) optimize spawning, early rearing, and grow out of burbot; 2) conduct commercial pilot-scale trials and gather data relevant to production conditions; 3) determine water quality limits of production; 4) determine if triploid induction is possible and if it may be feasible to produce

sterile burbot; 5) conduct a basic economic analysis of production costs; and 6) disseminate results broadly to the aquaculture industry.

RESULTS: Results from preliminary triploid induction trials showing 100% triploidy are promising and demonstrate the potential to produce burbot that may be sterile. Furthermore, it was found 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. Burbot from this program have been distributed to commercial producers in Southern Idaho, processed, and sold at local restaurants, where customer survey results indicate high consumer acceptance in the marketplace.

IMPACTS: On a broad scale, it is clear that burbot would be well received as a new aquaculture species, and results continue to suggest that this is a feasible commercial species. In the future, the ability to induce triploidy may have impacts on regional distribution by reducing any risk of escaped “sterile” fish reproducing in favorable environments. Results on temperature impacts for broodstock spawning and early embryo development provide critical data important for understanding the biological requirements of this species, and in turn, will guide system design for maximum production efficiency.

In The Press & At The Podium

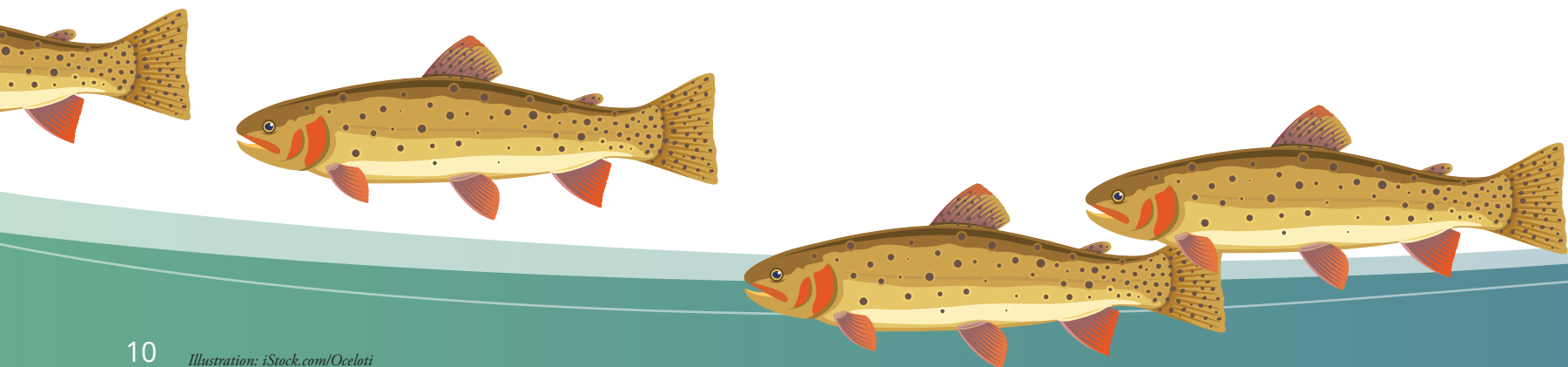
WRAC-funded projects
Sept. 1, 2017–Aug. 31, 2018

JOURNAL PUBLICATIONS & MANUSCRIPTS

- Allan CP, Waldbusser GG, Hales B. (in prep) 2018. Empirical prediction of estuarine carbonate weather. To be submitted to *Limnology and Oceanography: Methods*.
- Geisler CE, Kentch KK, Renquist BJ. 2017. Non-mammalian vertebrates: Distinct models to assess the role of ion gradients in energy expenditure. Accepted. <https://www.frontiersin.org/articles/10.3389/fendo.2017.00224/full>.
- Leal MJ, Clark BE, Van Eenennaam JP, Schreier AD, Todgham AE. 2018. The effects of warm temperature acclimation on basal stress, immunity, and metabolism in white sturgeon (*Acipenser transmontanus*) of different ploidies. *Comparative Biochemistry and Physiology A: Molecular and Integrative Physiology* 224:23–34.
- Owens CE, Sealey WM, Conley ZB, Fornshell G, Myrick CA. 2017. Evaluating dietary impacts of commercial-type diets on the growth of Snake River cutthroat trout (*Oncorhynchus clarkii behnkei*). *Aquaculture* 480: 77–82. <https://doi.org/10.1016/j.aquaculture.2017.08.011>.
- Stuart K, Johnson RB, Armbruster L, Drawbridge M. 2017. Arachidonic acid in the diet of adult California yellowtail *Seriola dorsalis* and its effect on egg quality. *North American Journal of Aquaculture*. First published December 11, 2017. <https://onlinelibrary.wiley.com/doi/abs/10.1002/naaq.10003>.

PRESENTATIONS/POSTERS

- Allan CP, Waldbusser GG, Hales B. Omega Oracle: Forecasting estuarine carbonate weather. Salish Sea Ecosystem Conference, Seattle, WA, April 4–6, 2018.
- Engle CR, van Senten J. On the road to measuring the regulatory burden on U.S. trout farms. U.S. Trout Farmers Association Annual Meeting, Twin Falls, ID, September 22, 2017.
- Engle CR, van Senten J. The regulatory cost burden on U.S. aquaculture farms. Aqua 2018, World Aquaculture Society, Montpellier, France, August 25–27, 2018.
- Engle CR, van Senten J. Why are U.S. aquaculture producers so concerned about regulations? Inter-Agency Working Group on Aquaculture, Washington, DC, April 9, 2018.
- Fiske A, Van Eenennaam JP, Todgham AE, Holem-Bell C, Young S, Schreier AD. A comparison of methods for determining ploidy of cultured white sturgeon. 8th International Symposium on Sturgeon, Vienna, Austria, September 10–16, 2017. Oral presentation.
- Leal MJ, Van Eenennaam JP, Schreier AD, Todgham AE. Physiological differences in white sturgeon of different ploidies in response to chronic and acute stressors. International Congress on the Biology of Fish, Calgary, Canada, July 15–19, 2018. Oral presentation.
- Powell M, Patro B. Recent advances in cutthroat trout nutrition. U.S. Trout Farmers Association Annual Meeting, and Idaho Aquaculture Association, Twin Falls, ID, September 22, 2017.

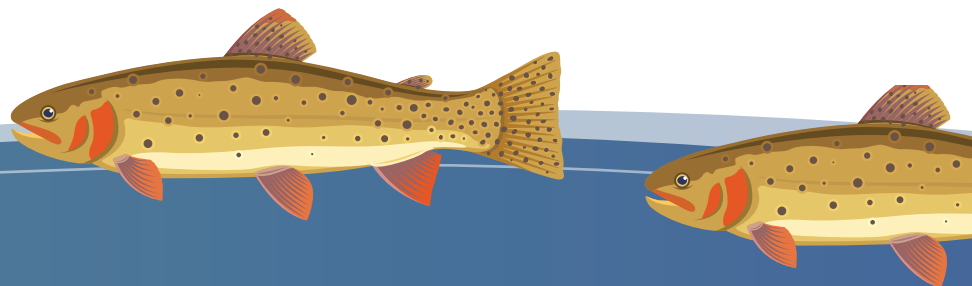


In The Press & At The Podium *continued*

- Sallene R. Western Regional Aquaculture Center Extension: Outputs, impacts, & future outlook. Poster presentation representing the Western Regional Aquaculture Center, National Aquaculture Extension Conference, Boise, ID, June 6–8, 2017.
- Schreier A, Van Eenennaam J, Todgham A. Determining the causes of spontaneous autopolyploidy in cultured white sturgeon. 8th International Symposium on Sturgeon, Vienna, Austria, September 10–16, 2017. Oral presentation.
- Todgham A, Leal MJ, Van Eenennaam J, Schreier AD. Impacts of polyploidy on the physiological performance of white sturgeon. 8th International Symposium on Sturgeon, Vienna, Austria, September 2017.
- Van Eenennaam J, Todgham A, Conte F, Schreier A. Reducing spontaneous autopolyploidy in white sturgeon. 8th International Symposium on Sturgeon, Vienna, Austria, September 10–16, 2017. Oral presentation.
- van Senten J, Engle CR. The farm level effects of regulations on U.S. trout producers. 2018 Annual Meeting, Idaho Aquaculture Association, Twin Falls, ID, June 2, 2018.
- van Senten J, Engle CR. The effects of the regulatory environment on U.S. aquaculture producers. USDA Economic Research Service Seminar, Washington, DC April 9, 2018.
- van Senten J, Engle CR. The effects of the regulatory environment on U.S. aquaculture producers. 2018 Interstate Seafood Seminar, Rehoboth Beach, DE, March 27–29, 2018.
- van Senten J, Engle CR. The cost of regulatory compliance on West Coast shellfish farms. National Shellfish Association Annual Meeting, Seattle, WA, March 1–22, 2018.
- van Senten J, Engle CR. The farm-level effects of regulations on US trout producers. Aquaculture America 2018, Annual Meeting of the U.S. Aquaculture Society and the National Aquaculture Association, Policies and Permitting Session, San Antonio, TX. February 23, 2018.
- van Senten J, Engle CR. The costs of regulatory compliance on West Coast shellfish farms: effects and impacts on producers. Aquaculture America 2018, Annual Meeting of the U.S. Aquaculture Society and the National Aquaculture Association, Policies and Permitting Session, San Antonio, TX, February 22, 2018.
- van Senten J, Engle CR. The effects of regulations on U.S. trout producers: costs and impacts. Aquaculture America 2018, Annual Meeting of the U.S. Aquaculture Society and the National Aquaculture Association, U.S. Trout Farmers Association Annual Meeting, San Antonio, TX, February 20, 2018.
- van Senten J, Engle CR. How much does government cost the shellfish industry? 44th Annual East Coast Commercial Fisherman's & Aquaculture Trade Exposition, Ocean City, MD, January 12–14, 2018.
- van Senten J, Engle CR. Regulations from a producer prospective. Virginia Aquaculture Conference, Newport News, VA, November 18, 2017.
- van Senten J, Engle CR. Cost of regulations in U.S. aquaculture. Maryland Shellfish Growers Meeting, MD, October 12, 2017.
- Warren B, Feely R. Accelerating ocean change in the PNW: New research, and new policy tools to protect healthy waters. Pacific Coast Shellfish Growers Association Meeting, Blaine, WA, September 18–20, 2018.

IN THE MEDIA/ON THE WEB

- Cooper, Leigh. Burbot Bounce Back: researchers tweak fish's biology for aquaculture industry. University of Idaho, College of Natural Resources. [Features WRAC funded research and PI K. Cain]. Found at <https://www.uidaho.edu/cnr/about/feature-stories/burbot-biology>.



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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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