Waterlines

WESTERN REGIONAL AQUACULTURE CENTER

2013–2014

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

We are pleased to present this issue of *Waterlines*, our 2013–2014 newsletter and report of accomplishments to USDA/NIFA.

IN THIS ISSUE

USDA

United States Department of Agriculture
National Institute of Food and Agriculture

U.S. AQUACULTURE CENSUS

In September 2014, the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS) released the 2013 Census of Aquaculture, the third national aquaculture census conducted by NASS. The previous census was conducted in 2005.

The census provides detailed information about production volume and methods, surface water acres and sources, sales, point-of-first-sale outlets, and aquaculture distributed for restoration, conservation, enhancement, and recreational purposes.

To access the 2013 Census of Aquaculture and other agriculture census data, visit *www.agcensus.usda.gov* or the Quick Stats database at *http://quickstats.nass.usda.gov.*

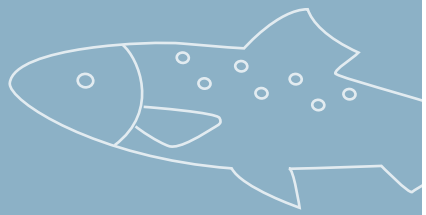
HIGHLIGHTS

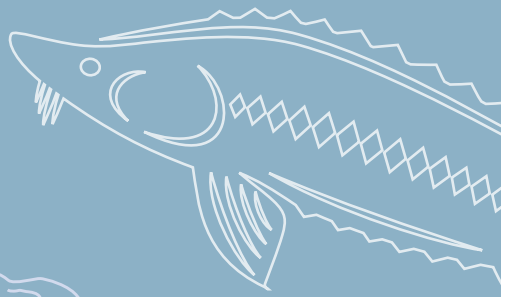
$1.37 BILLION
Total sales of aquaculture products in the United States, an increase of 26% from 2005

$732 MILLION
Sales of food fish—
an increase of 9% from 2005

$329 MILLION
Sales of mollusks—
an increase of 62% from 2005

$85 MILLION
Crustacean sales—
up 59% from 2005





WORLD AQUACULTURE

Also in 2013, the Food and Agriculture Organization of the United Nations (FAO) updated the Global Aquaculture Production statistics database.

Highlights

- Notably, world aquaculture production continued to grow in 2013, with an estimated value of $157 billion annually. (*http://www.fao.org/3/a-i4899e.pdf*)
- Globally, inland finfish (an important sector for WRAC) has been the most important driver for total increase in annual output. This subsector contributed 64.9% to the 2003–2013 increase in farmed food fish production.

The database, covering 1950–2013, can be consulted online at *www.fao.org/fishery/statistics/global-aquaculture-production/query/en.*

$1.37
BILLION
US aquaculture production in 2013

$157
BILLION
Estimated annual value of global aquaculture production in 2013

Photo, front cover: Mark Drawbridge
Illustrations: shorenated and Smitt777/iStock/Thinkstock

ABOUT WRAC

The Western Regional Aquaculture Center (WRAC) is one of five regional aquaculture centers under USDA/NIFA (U.S. Department of Agriculture/National Institute of Food & Agriculture). WRAC serves the 12 states in the western region—Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

Mission

To support aquaculture research, development, demonstration, and education to enhance viable and profitable US aquaculture production for the benefit of consumers, producers, service industries, and the American economy.

Unique Features

Industry-driven: Seeks industry input to address priority needs of growers; focuses on applied projects and disseminating new knowledge and best practices for maximum impact.

Rigorous science: Shares expertise and facilities within the region to accelerate scientific problem solving, thereby optimizing resource efficiencies and avoiding duplication of effort.

Collaborations: Leverages in-kind and monetary contributions from partners; integrates research, extension, and industry efforts to support productivity, new jobs, and businesses.

How does WRAC work?

With broad representation throughout the western region, WRAC's governance groups include:

Board of Directors (Board): Primary policy-making body for WRAC. The Board reviews research and outreach projects recommended for funding and authorizes their inclusion into the annual Work Plan submitted to USDA.

Industry Advisory Council (IAC): Provides input regarding the needs and priorities of the regional aquaculture industry with respect to research, outreach, and development programs. The IAC is composed of representatives from the aquaculture industry and associated services within the 12 western states.

Technical Committee (TC): Composed of two subcommittees:

- The ***Research Subcommittee*** includes representatives from participating research institutions, state or territorial public agencies as appropriate, nonprofits, and private institutions.
- The ***Extension Subcommittee*** draws from state Extension Services—both Land Grant and Sea Grant—for diverse representation.

The IAC and TC work jointly to make recommendations to the Board regarding new and continuing regional projects, project modifications, and project terminations.

ACKNOWLEDGMENTS

WRAC gratefully acknowledges the contributions made by the principal investigators, participating scientists, students, staff, and industry and outreach experts involved in all of the projects. They are the backbone of the diverse array of research and outreach projects funded through WRAC. We particularly appreciate the assistance of the chairs of our Board, IAC, and TC, and those serving as project monitors.

We also thank the scientists and aquaculturists from across the country who contribute their expertise and valuable time to review WRAC project proposals and publications. Without their help, it would be impossible to maintain the high quality of this program.

Additionally, we thank the School of Aquatic and Fishery Sciences in the College of the Environment at the University of Washington for serving as the host institution for WRAC.




WRAC Project Highlights

September 1, 2013–August 31, 2014

Full annual reports available at:
depts.washington.edu/wracuw/research/current_research.html

1 Optimizing the Larval Nutrition of Marine Finfish Aquaculture Species Along the West Coast

Annual Progress Report (project start date & duration: 2011, 3 years)

PRINCIPAL INVESTIGATORS: Mark Drawbridge, *Hubbs-SeaWorld Research Institute*; Michael Rust, *NOAA Fisheries, Northwest Fisheries Science Center*; Chris Langdon, *Oregon State University*; Rick Barrows, *USDA/ARS-Hagerman Fish Culture Experiment Station*

Outreach Representative: Fred Conte, *University of California Davis*

Industry Advisor: Jim Parsons, *TroutLodge*

Project Monitor: Ken Cain, *University of Idaho*

ISSUE: With an ever-expanding range of issues, including extensive capture fisheries closures, a large national seafood trade deficit, and heightened awareness of food security, there is a strong impetus for the western region to develop sustainable marine finfish aquaculture. Because marine fish larvae are challenging to rear, the larval-phase culture is widely recognized as key to viable commercial production.

RESPONSE: The goal is to increase growth, fitness, and survival of two species of marine finfish—white seabass and California yellowtail—that have excellent potential for commercial aquaculture. Studies focused on optimization of feed types and composition, and delivery methods. Larval-rearing success measures include culture efficiency (e.g., reduced costs) and performance (growth, survival, and quality).

RESULTS: Researchers showed the value of taurine supplementation in early larval rearing of California yellowtail and effective delivery methods for live feeds and microdiets. Similarly, addition of spirulina to microdiets improved larval performance, suggesting it might be another valuable ingredient for marine fish microdiets. Studies showed the utility of two novel food types—alginate complex and larvel extruded particles—that can be used in open formula diet optimization. Researchers have also identified effective stimulant compounds that enhance feeding success and help reduce weaning times significantly.

IMPACTS: The information collected has made a significant impact on the production protocols for white seabass and California yellowtail. Survival rates for both species from egg to juvenile fish are at historically high levels. Findings and approaches should translate to other marine finfish species in commercial development in the USA. Further trials and a comprehensive workshop are planned for 2015.

Photos: Courtesy of Mark Drawbridge

2 Environmental and Endogenous Factors Affecting Egg Quality and Caviar Yield in Farmed Sturgeon

Annual Progress Report (project start date & duration: 2011, 4 years

PRINCIPAL INVESTIGATORS: Serge Doroshov, Bernard May, Ermias Kebreab, *University of California Davis*; Barbara Rasco, *Washington State University*; Molly Webb and Chris Guy, *USFWS, Montana State University*; Terry Patterson, *College of Southern Idaho*

Outreach Representative: Fred Conte, *University of California Davis*

Industry Advisors: Ken Beer, *The Fishery*; Linda Lemmon, *Blind Canyon Aqua Ranch*; Leo Ray, *Fish Breeders of Idaho;* Shaoching Bishop, *Sterling Caviar*, LLC

Project Monitor: Jason Mann, *EWOS Canada Ltd*

ISSUE: Sturgeon farming in the western region is a thriving and growing industry. Because both the quality and yield of caviar are key factors in the continued economic viability of this industry, it is important to evaluate the elements that impact these key factors.

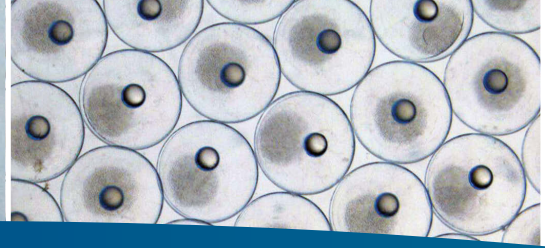
RESPONSE: Researchers, in collaboration with farms in California and Idaho, are conducting feeding trials to determine the effects of high- and low-energy diets on: 1) roe yield and caviar quality, 2) energy partitioning and deposition of fat and protein in the ovary of pre-pubertal fish, 3) chemical and sensory properties of the caviar, 4) chemical composition and adiposity of the ovary, and 5) roe yield. The genetic component of the study will focus on the effect of relatedness on caviar yield and quality.

RESULTS: After an additional year on the low-energy diet, sampling of the pre-pubertal sturgeon indicates no effect of diet on body or gonad growth due to high variability between individuals. Genetic analyses revealed that one male and one female were responsible for producing more than half of the fish sampled. This finding is important for sturgeon culturists who want to develop a management strategy to maintain multiple, genetically diverse families. The sampling of age 8 caviar females revealed that fish fed the high-energy diets had lower yields of caviar and were depositing large quantities of ovarian fatty adipose tissue lobes. Researchers developed a lexicon collection of definitions and standardized references for the sensory evaluation of caviar that has been successfully used to differentiate caviar samples harvested from sturgeon fed different diets. It was shown that overall acceptance of caviar was driven by texture, flavor/taste (sea fresh and butter flavors), tactile firmness, and black color.

IMPACTS: Based on the outcome of the project, the sturgeon industry will be able to determine how caviar yield and quality can be affected by low- and high-energy diets and genetic relatedness, and also may be able to develop a broodstock mating plan to reduce ovarian adiposity.

Photos: Fred Conte; Caviar box inset: Courtesy of Molly Webb






3 Determination and Practical Application of Egg Quality Measures Toward Reliable Culture of High-Value Marine Finfish Species

Annual Progress Report (project start date & duration: 2011, 4 years)

PRINCIPAL INVESTIGATORS: Kevin Stuart, *Hubbs-SeaWorld Research Institute*; Ronald B. Johnson, *NOAA NMFS Northwest Fisheries Science Center*; Frederick Goetz, *NOAA NMFS NWFSC, Reut Division, Manchester Research Station;* John Hyde, *NOAA NMFS Southwest Fisheries Science Center*

Outreach Representative: Paul Olin, *California Sea Grant, Extension Program, University of California San Diego*

Industry Advisor: Jim Parsons, *TroutLodge*

Project Monitor: James Nagler, *University of Idaho, Department of Biological Sciences and Washington State University/University of Idaho Center for Reproductive Biology*

ISSUE: As capture fisheries on the West Coast are under pressure, and the need for sustainable alternative sources of marine finfish increases, it is critical to develop best management practices for marine finfish producers. In addition, the success rate for rearing high-value marine finfish species such as California halibut, California yellowtail, and sablefish is highly variable.

RESPONSE: The goals are to: 1) develop simple predictive egg quality measures, 2) mitigate or eliminate potential causes of poor quality eggs in multiple finfish species, and 3) determine how various culture-related factors affect those egg characteristics. Researchers will use this information to develop effective management practices.

RESULTS: This project has completed proximate analysis (moisture, protein, and lipid content) and fatty acid analysis on eggs from wild and first generation cultured (F1) broodstock of California yellowtail (CYT) over multiple spawning seasons. Researchers determined that wild broodstock eggs have slightly less lipid than F1 CYT broodstock eggs. Fatty acid analysis showed that linoleic acid tends to be higher in eggs from good spawn events than from poor spawn events. Parentage analysis on a resident wild CYT broodstock population at Hubbs-SeaWorld Research Institute showed that 2013 and 2014 spawning events typically involved a single female and multiple males. It was determined that one female was contributing to a large number of these events, and the eggs produced were typically low in quality. The hope is that removal of this female will improve overall egg quality and allow more females to contribute to the spawn events.

IMPACTS: The information collected in this project has the potential to make significant impacts in the aquaculture industry as it relates to egg quality. The results of this work and the associated methodologies are expected to be transferable to the culture of other marine and freshwater species throughout the United States.

Photos: Mark Drawbridge and Kevin Stuart

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

Annual Progress Report (project start date & duration: 2013, 4 years)

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

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 project goal 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: The hypothesis that cutthroat trout prefer a sinking feed will be tested using one feed produced in three forms (flake, sinking, and floating pellets). Initially, delivery methods will be analyzed for intake and growth of the fish. Next, researchers will compare existing commercial diets that have the desired pellet behavior, and then evaluate the nutritional requirements for juvenile cutthroat trout. Following the first three stages, a comparison of best-performing diets will be conducted in the laboratory and on-farm field trials along with cost-benefit analysis. The last steps of the project will include dissemination of final findings for use by stakeholders.

RESULTS: To date, the findings regarding feed type and how well juvenile fish respond are useful to the research team as they move forward with the remainder of the objectives. Because preliminary results indicate that flake feeds are not ideal for juvenile cutthroat trout development, this information is of potential interest to the aquaculture industry.

IMPACT: Due to a delay in funding and the launch of the project, the only impact to report is the positive results of the quality of the fish following non-flake feeding protocols. Potential impacts to the cutthroat trout industry include a reduction in time and cost of feed when the feed type and nutritional requirements are identified.

Photos: Courtesy of Christopher Myrick, Matt Powell, Biswa Patro, Cheyenne Owens

5 Profitable and Biosecure Rock Scallop Culture for the West Coast

Annual Progress Report (project start date & duration: 2013, 4 years)

PRINCIPAL INVESTIGATORS: Paul G. Olin, *University of California Sea Grant Extension Program, UCSD/Scripps Institute of Oceanography*; Carolyn Culver, *UC Sea Grant Extension Program*; Jonathan P. Davis, *Puget Sound Restoration Foundation*

Collaborating Scientist: Brent Vadopalas, *University of Washington*

Outreach Representative: Ray RaLonde, *Alaska Sea Grant*

Industry Advisor: Jeff Hetrick, *Alutiiq Pride Shellfish Hatchery*

Project Monitor: Fred S. Conte, *University of California Davis*

ISSUE: A viable shellfish industry in the United States is critical to maintain rural economies that are dependent on marine resource development and working waterfronts. Shellfish aquaculture is a low trophic level means of seafood production that provides many benefits to coastal communities and the environment, while at the same time increasing the supply of locally produced safe and nutritious seafood.

RESPONSE: The overall goal is to advance marine aquaculture along the West Coast by demonstrating production techniques for a new, competitive, and biosecure product—the purple-hinge rock scallop, *Crassadoma gigantea*. Researchers aim to greatly expand the geographic range of scallop culture, reduce genetic interactions between farmed and wild populations, and compare culture techniques to determine the most efficient and profitable way to culture rock scallops. There is also a strong desire to develop native species for aquaculture to diversify the shellfish industry and to avoid concerns about the use of non-native species.

RESULTS: We produced diploid (2N) seed, and identified bottlenecks in larval and nursery phases that decrease production. We refined larval production systems, nursery protocols, and dietary regimens to resolve apparent bottlenecks. Additional work is needed to increase survival and the quantity of seed produced. The triploid (3N) induction methods developed this year can be used in commercial production, although further optimizations will likely increase yields.

IMPACTS: The project has generated 2N and 3N seed and identified larval and nursery bottlenecks that decrease production. Ongoing refinements of hatchery protocols and training are in place to improve seed production. Future work on production of tetraploids is planned.

Photos: Courtesy of Brandon Stevens

6 Efficient, Rapid Assay for Predicting the Growth Rate of Aquaculture Species Based on Metabolic Rate of the Fertilized Egg

Annual Progress Report (project start date & duration: 2013, 2 years)

PRINCIPAL INVESTIGATORS: Benjamin Renquist, *University of Arizona;* Kenneth Overturf, *USDA/ARS-Hagerman Fish Culture Experiment Station*

Outreach Representative: Gary Freitag, *University of Alaska*

Industry Advisor: Leo Ray, *Fish Breeders of Idaho*

Project Monitor: Matt Powell, *University of Idaho*

ISSUE: The quick, effective selection of fish with the most genetic potential for growth could have a robust and rapid effect in aquaculture. Growth in culture conditions is frequently based more upon acquisition of food than on the genetic potential of the individual for growth. The assay technology used in this project exploits the known relationship between growth and metabolic rate to individually select embryonic fish with the greatest genetic potential for growth. Because of high numbers of offspring produced by fish and the short intervals of time between new generations, this project proposes to rapidly alter the genetic potential for growth in farmed fish species.

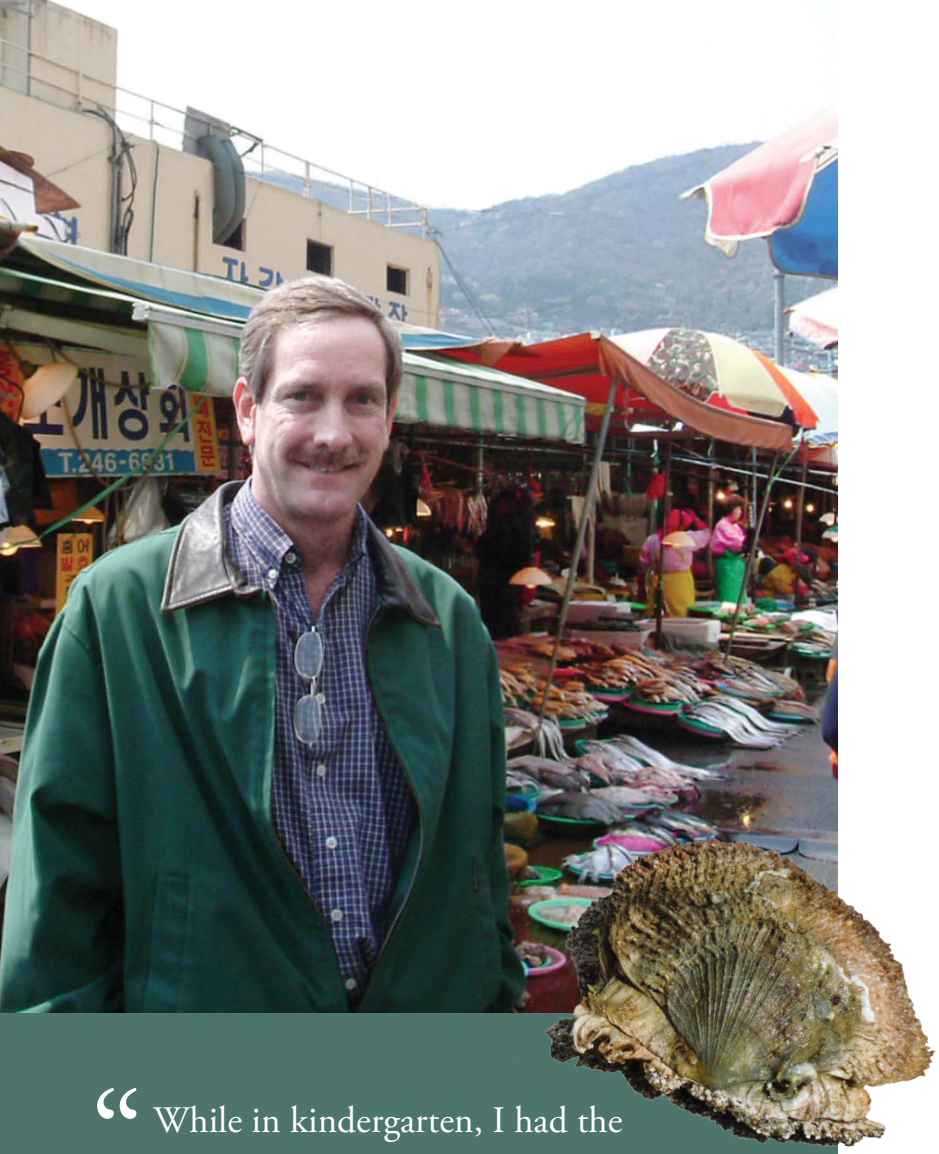
RESPONSE: The goal is to establish the validity of measuring metabolic rate of embryonic fish to predict the genetic or epigenetic potential for growth. If this assay technology can predict growth in aquacultured fish, it may be used to:

1. Identify broodstock that pass along the highest potential for growth to their offspring.
2. Identify genetic lines that best improve potential for growth.
3. Evaluate husbandry practices (e.g., nutrition, water temperature, salinity) that may modify the epigenetic potential for growth.

RESULTS: To date, we have shown that tilapia embryos with a high metabolic rate grow up to 30% more quickly than embryos with a low metabolic rate. This could prove extremely useful in the selection of broodstock.

IMPACTS: With the ability to measure thousands of fish per day, this assay provides a method for tilapia producers to rapidly assess and improve their stocks' genetic potential for growth.

Photos, left and center: Courtesy of Benjamin Renquist; Photo, right: Toa55/iStock/Thinkstock



> “While in kindergarten, I had the opportunity to go deep sea fishing off the coast of Virginia and became enthralled with sea life after seeing a large bluefin tuna streaking through the water.”

Interview with Paul Olin

Paul Olin works at California Sea Grant as an aquaculture specialist. He has served WRAC as a researcher, extension specialist, and leader in aquaculture development. We look forward to his continued involvement with WRAC.

Please tell us about your background and early career choices, and how you got your start in marine science and aquaculture.

I was born in San Juan, Puerto Rico, and attended six different elementary schools in Virginia, Pennsylvania, Florida, and California before my family settled in northern Virginia just west of Washington, DC. After earning a BS in Biology at the University of Miami, I worked at a manatee research facility on the west coast of Florida and then for two years as a civilian oceanographer for the Navy, spending most of that time at sea.

I went on to get an MS at UC Davis and a PhD at the University of Hawaii, after which I conducted an international training program in shrimp aquaculture for a few years and then accepted a position with Hawaii Sea Grant as the state’s aquaculture specialist for four years.

What sparked your first interest in marine sciences?

While in kindergarten, I had the opportunity to go deep-sea fishing off the coast of Virginia and became enthralled with sea life after seeing a large bluefin tuna streaking through the water. This interest was amplified when I lived in Monterey, California, in the third grade, and I have pursued it ever since.

Can you describe your position at California Sea Grant?

In 1994, I relocated from Hawaii Sea Grant to the mainland as a marine advisor for California Sea Grant, where I worked to improve water quality, assist shellfish growers, and contribute to the recovery of endangered coho salmon and their habitat. In 2001, I was selected to be the director of the California Sea Grant Extension Program and served in that capacity until 2010 when the program moved to Scripps Institution of Oceanography, and I returned to my role as an aquaculture specialist. In this role, I have become more involved with aquaculture policy and offshore aquaculture.

Photos: Courtesy of Paul Olin

Would you describe projects of which you are most proud?

I contributed to the establishment of an industry sector in Hawaii—raising Chinese catfish—developing techniques to hormonally induce spawning and raise larvae. I also established a quarantine system for ornamental fish to create lines of high health broodstock that were free of pathogens of concern. These were provided to growers to stimulate the culture of ornamental fish in the state.

I educated California ranchers about water quality as it relates to freshwater fish habitat, concerns about ammonia, and coliform contamination. (At the time, the shellfish industry in Tomales Bay was suffering from regular harvest closures due to coliform contamination.) These efforts helped defuse a very contentious relationship that was developing between the ranchers and shellfish growers.

I also helped create and served on the Western Regional Panel on Aquatic Invasive Species. I'm also proud of my contributions to the recovery of endangered coho salmon in the Russian River.

One of the most enjoyable activities I've been involved in was assisting a number of Korean universities to create the Korea Sea Grant Program in 2007. This was a great cultural experience and led to many good friendships that continue today.

On a personal note, I'm very proud of my two children, Lauren and Marshall, who are finishing up graduate programs in Philosophy, Neuroscience and Psychology; and Law respectively.

Does any project during your career stand out as a favorite?

I greatly enjoyed creating and overseeing the International Aquaculture Training Program at the University of Hawaii. The training significantly enhanced the lives and careers of many people and resulted in capacity building that facilitated the development of shrimp aquaculture in Thailand, Indonesia, Burma, and the Philippines. One trainee, Toto Winanto, now manages the largest shrimp hatchery in the world.

How would you compare aquaculture research when you were just starting out with current research?

The advances in research and the industry have been phenomenal. When I began my career, there was one annual aquaculture conference sponsored by the World Aquaculture Society that was attended by a few hundred people. Now, there are dozens of conferences and thousands of research presentations all over the world. Advances in nutrition, disease diagnosis and treatment, engineering, and husbandry have enabled industry growth. I suspect we will see a lot more of this, and I hope to see significant growth in US production.

"I think WRAC investments will continue to contribute significantly to help aquaculture production grow in the United States."

What are your thoughts about the future of aquaculture research, the aquaculture industry, and WRAC?

Reliable methods to produce fingerlings of species like sablefish, California yellowtail, and tuna would open the door to a large production capacity for finfish on the west coast. There will always be demand for research in health management, genetic selection, and nutrition. I think WRAC investments will continue to contribute significantly to help aquaculture production grow in the United States.

What are your plans for the future?

I hope to facilitate the development of an industry sector, raising purple-hinge rock scallops up and down the West Coast and be able to count this as a WRAC success story. I also look forward to helping in the creation of offshore net-pen culture of finfish in California.

Spotlights on the West

H. Randall Robinette, Board of Directors

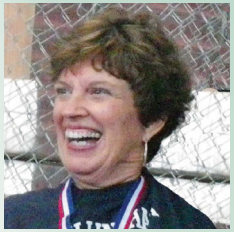
Respected as a scientist, administrator, and champion for aquaculture, Dr. Randy Robinette recently retired from the WRAC Board of Directors. He will be missed, but his work lives on in the leadership and policy development that he provided.

This is not Randy's first retirement—he retired from Mississippi State University (MSU) in 1999, where he was on faculty for more than 26 years and department head for six. While at MSU, he taught courses in limnology and finfish aquaculture and his research focused primarily on channel catfish practical nutrition, hybrid striped bass, and *Macrobrachium rosenbergii* culture.

Randy then became head of the Department of Fish, Wildlife and Conservation Biology at Colorado State University (CSU) and in 2007, he served as research associate dean for the CSU College of Natural Resources during his transition year to another retirement. Randy has also served as president of the Fish Culture Section of the American Fisheries Society. He is currenty a private consultant dealing with aquaculture feeds.

Best wishes Randy from everyone at WRAC!

(*Source: Mississippi State University web*)



Debbie Granger, former Program Manager

Debbie Granger moved on from her role as WRAC program manager, but there is no retirement for Debbie! She continues to work on a large-scale waterfront development project in Bellingham, WA, her hometown. Both she and her husband Pete also remain active in the commercial salmon fishing industry. While at WRAC, Debbie was instrumental in the development of program management tools, website re-design, growth in committee membership, and many organizational upgrades. Debbie cares deeply about all of the people that make up WRAC and the important work it supports.

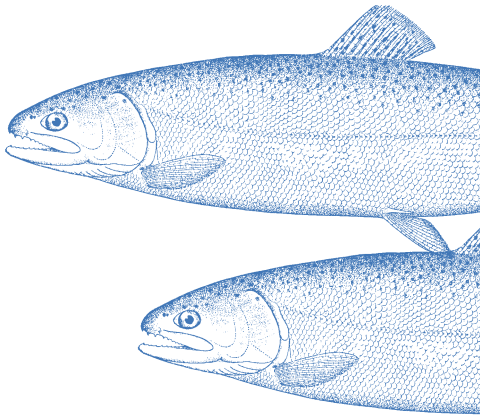
All the best Debbie in your next set of adventures!

Julie Hahn, Program Manager

In June 2014, Julie was hired and spent several weeks training with her predecessor, Debbie Granger. The change of WRAC's program managers went very smoothly thanks to Debbie's support and mentorship and Julie's experience in research and outreach proposal development and administration. Julie is aware of important aquaculture issues, having worked for nearly 10 years in diverse roles at Washington Sea Grant. Julie said, "This position is an opportunity to work with the dedicated people who conduct research and teach about the importance of aquaculture." You can contact Julie at jkhahn@uw.edu or 206-685-2479.

Welcome aboard, Julie!

Photos: Courtesy of MSU web, Pete Granger, Courtesy of Julie Hahn



In The Press & At The Podium

WRAC-funded projects from 9/1/12–8/31/14

PUBLICATIONS

Conte FS, Ahmadi A. 2012. Evaluation of fecal coliform samples collected from Oakland Bay, Washington using a new model for estimating the ninetieth percentile criteria for evaluating shellfish-growing water. *Journal of Water Resources Planning and Management*. 75(3):16–22.

Hooley CG, Barrows FT, Patterson J, Sealey WM. 2014. Examination of the effects of dietary protein and lipid levels on growth and stress tolerance of juvenile tilapia (*Oreochromis niolticus*). *Journal of the World Aquaculture Society*. 45(2):115–126 DOI: 10.1111/jwas.12110

Stuart KR, Rotman FJ, Drawbridge MA. 2012. Larval rearing advancements for yellow tail amberjack (*Seriola lalandi*) in Southern California. *Bull Fish Res Agen.* No.35, 15–21.

Talbott MJ, Servid SA, Cavinato AG, Van Eenennaam JP, Doroshov SI, Struffenegger P, Webb MAH. 2014. Confirmation of ovarian homogeneity in post-vitellogenic cultured white sturgeon, *Acipenser transmontanus*. *Fish Physiology and Biochemistry* 40:1–7.

Wheat E, Ruesink JL 2013. Commercially-cultured oysters (*Crassostrea gigas*) exert top-down control on intertidal pelagic resources in Willapa Bay, Washington, USA. *Journal of Sea Research* 81: 33–39.

Yang S, Wheat EE, Horwith MJ, Ruesink JL 2013. Relative impacts of natural stressors on life history traits underlying resilience of intertidal eelgrass (*Zostera marina* L.). *Estuaries and Coasts* 36(5):1006–1013.

MASTER'S THESES

Ham B. 2014. The evaluation of pellet type-preference and dietary soy sensitivity in Snake River cutthroat trout (*Oncorhynchus clarkii*). MS thesis. Montana State University, Bozeman, MT.

Ramotar BP. 2013. Examination of the effects of dietary protein and lipid levels in and effects of alternative ingredients practical diets for tilapia *Oreochromis niloticus*. MS thesis. University of Arizona, Tucson, AZ.

PRESENTATIONS

Betiku OC, Gaylord TG, Barrows FT, Yeoman CJ, Duff GC, Sealey WM. Growth performance of rainbow trout (*Onchorhynchus mykiss*) fed animal and plant protein blend feeds. Western Regional Sectionals, Animal and Dairy Sciences. Bozeman, MT, June 2013.

Conte FS, Ahmadi A. Evaluation of fecal coliform samples from Pensacola Bay, Florida using Pearl sanitation model. World Conference on Computers in Agriculture (WCCA 2012), National training Institute of Farmers' Organization. Taipei, Taiwan. September 2012.

Craft CD, Myrick CA, Gaylord TG, Sealey WM, Barrows FT. Performance of rainbow trout fed on alternative protein diets-growth, oxygen consumption and sensory characteristics. US Trout Farmers Annual Meeting, September 6–8, 2012, Denver, CO.

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PRESENTATIONS *continued*

Fornshell G, Sealey WM, Gaylord TG, Barrows FT, Myrick C. Alternative protein diets for rainbow trout: Performance on a commercial trout farm. Idaho Aquaculture Association Meeting, Twin Falls, ID. June 2013.

Fornshell G, Sealey WM, Gaylord TG, Barrows FT, Ross C, Myrick C. Alternative protein diets for rainbow trout: Performance on a commercial trout farm. MidSnake Water Users Meeting, Twin Falls, ID. June 2013.

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Early rearing of cutthroat trout. Technical Report. Compiled by Fornshell G, Myrick C. Participants: Myrick C, Brandt M, Barrows R, Cline K. Fornshell G, Kindschi G, Webb M, Kappenman K, Liley J. 2013.

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