

Waterlines

NEWSLETTER OF THE WESTERN REGIONAL AQUACULTURE CENTER

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

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What's inside

Together, we work to implement WRAC's mission of *supporting 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.*

In this issue of *Waterlines*, we are pleased to showcase aquaculture news and events throughout the western region. We focus on WRAC's research and outreach projects and also feature two people who have made significant contributions to the growth of aquaculture in our region. Two brief articles describe the updated National Aquaculture Policy and the revised USDA Dietary Guidelines.

With the increased national emphasis on healthy diets, food security, and sustainability, we need to continue working together to support the development and enhancement of our domestic aquaculture industry.



United States Department of Agriculture
National Institute of Food and Agriculture

PHOTOS: COURTESY OF SEABEAR COMPANY AND CLEAR SPRINGS FOODS

WRAC Research & Outreach

Projects currently funded by WRAC

Aquarius 3.0

In a previous WRAC project, researchers developed **Aquarius 2.0**, a software program that uses accumulated rainfall and fecal coliform data to evaluate hypothetical and proposed closure regulations for shellfish harvest. In this recently funded WRAC project, researchers will add a third critical element, tidal activity, to the software program. Tidal activity affects the timing of water sampling and the concentration of fecal coliform in shellfish growing areas. **Aquarius 3.0** will provide public health agencies and industry with accurate and timely information to evaluate rainfall closure regulations.

Coldwater disease prevention and control through vaccine development and diagnostic improvements

Coldwater disease (CWD) is one of the most significant disease problems in commercial trout aquaculture worldwide. The goal of this project is to evaluate strategies that would aid in the development of more effective ways of managing CWD at aquaculture facilities. Project researchers have developed diagnostic improvements that have resulted in the correlation of assays to disease risk in progeny from infected broodstock. They also have developed a vaccine that could potentially save the domestic trout industry more than \$20 million annually. The vaccine is currently undergoing commercial trials.

Cost-effective, alternative protein diets for rainbow trout that support optimal growth, health, and product quality

With the rapid rise in ingredient costs and the finite source of fish meal, alternative aquafeed ingredients are necessary to minimize cost. An improved understanding of ingredients also will improve formulation security and help buffer price fluxes by providing nutritionists with a variety of ingredients to choose from that meet nutrient demands when there is competition for high protein ingredients or an ingredient becomes unavailable. The aquaculture industry will be able to formulate trout diets using the ingredients tested on an equal digestible nutrient basis. The resulting data will provide an increased understanding of the amino acid needs of trout.

The amino acid content and the availability of commercially available alternative feed ingredients will help the industry produce cost-effective feeds while maintaining fish growth, health, and product quality.

Determining ripeness in white sturgeon females to maximize yield and quality of caviar

The goal of this study is to develop a less invasive, faster, and better predictor of maturity than oocyte polarization index (PI) in sturgeon. This will allow farms to select white sturgeon during their optimal caviar harvest time, when females have the greatest yield and highest quality caviar as assessed by firmness, flavor, and shelf life. An accurate predictor of maturity will also prevent the slaughter of fish that have started ovarian follicular atresia and allow them to be used for caviar production after the second ovarian cycle.

To date, study results show that abdominal scans by short wavelength near infrared spectroscopy (SW-NIR) and spectral analysis of plasma by Fourier transform infrared spectroscopy (FT-IR) can determine stage of maturity and may be useful as an alternative method in lieu of biopsy and the oocyte PI for pre-screening females prior to harvest. These new methods are currently being tested and refined under commercial conditions.

Environmental and endogenous factors affecting egg quality and caviar yield in farmed sturgeon

At least ten countries in Europe, Asia, and North and South America are now farming sturgeon for caviar. The increasing competition on the world market presents a challenge to the sturgeon farms of the western region, who pioneered caviar production in the United States. To compete successfully, sturgeon farms must be efficient and produce high quality caviar. However, sturgeon farmers in California and Idaho observe highly variable roe yield in mature sturgeon, associated with accumulation of fat in the ovaries. Environmental, genetic, and developmental factors can all affect caviar yield and quality, but the role of these factors is not well understood. This collaborative study—of four states and four sturgeon farms—is investigating these factors and their effects on ovarian adiposity, roe yield, and caviar quality.



Global analysis of eelgrass (*Zostera marina* L.) standing stock and yield

West Coast aquaculture will benefit from environmental practices that are compatible with healthy populations of eelgrass (*Zostera marina* L.). Research has documented the capacity of cultured shellfish to filter water, which helps maintain light availability for eelgrass. However, there is an ongoing science and management discussion about how to define eelgrass “health.” Eelgrass varies in density, size, annual variation in biomass, and growth. These variations are well-recognized, but have not recently been summarized, and causal mechanisms have never been explored.

This project will conduct a meta-analysis of global variation in eelgrass production and yield, allowing comparison of West Coast eelgrass to populations worldwide. The review should also serve as scientific support for expanding the conversation about eelgrass indicators to include dynamic components of growth and turnover, rather than simply static metrics of area covered or density of stems.

Optimizing dietary protein and energy utilization to improve production efficiency of tilapia in the western United States

Tilapia feed prices have increased dramatically in recent years due to increased commodity costs, and feed costs for tilapia growers typically comprise 50%–60% of production costs. Project researchers are working to identify formulations that support the rapid growth rates and immunological demands of tilapia cultured in the high-intensity culture systems used in the western region. They are formulating experimental diets at different protein levels; the diets contain minimum levels of fish meal and a constant ratio of animal-to-plant protein sources at all protein levels. Lipid levels meet the essential fatty acid requirements of tilapia. Vitamins that have been reported to improve performance of tilapia in high-intensity systems will be added to the diet

formulation(s) showing the most promise. Water quality characteristics (dissolved oxygen, temperature, pH, ammonia, and nitrates), will be determined and recorded on a regular basis.

Optimizing the larval nutrition of marine finfish aquaculture species along the West Coast

Commercial-scale production of marine finfish in the United States has been demonstrated for only a handful of species, and the levels of production pale in comparison to ocean finfish farming overseas. Extensive fisheries closures, an exorbitant national seafood trade deficit, and heightened awareness of food security provide a strong impetus for development of a sustainable marine aquaculture industry on the West Coast.

Marine fish larvae are typically highly sensitive and challenging to rear. Success in the larval rearing phase of culture is widely recognized as the key to economically viable commercial production. Because marine finfish farming is relatively new and each species tends to respond differently in culture, our understanding of larval nutritional requirements and feeding behavior is generally poor. This project seeks to develop and apply innovative larval feeds and feeding techniques to determine if these reduce larval mortality. ■

Above: Farmed sturgeon.

PHOTO: COURTESY OF BARBARA RASCO

5th National Aquaculture Extension Conference

—Gary Fornshell, Extension Educator, University of Idaho

Although it was hot and humid in Memphis in June, nine Extension Educators from WRAC made the trek there for the fifth National Aquaculture Extension Conference. The conference, held every four years, was hosted and organized by Jimmy Avery, Mississippi State University, and Ron Blair, University of Tennessee, and partially supported by WRAC. The two-day meeting was packed with panel discussions, presentations, and posters—demonstrating the impressive scope of work being done by Regional Aquaculture Centers and Land and Sea Grant Extension programs.

The first day was devoted to panel sessions covering a variety of topics, including USDA/NIFA and NOAA Sea Grant discussions about the opportunities and outlook for aquaculture Extension programming.

Gary Jensen, National Program Leader for Aquaculture, said, “The unique aspect of Extension is that it has few boundaries or limitations for imagination and innovation to solve real-world problems as they emerge. The ability to be responsive to real-life problems and constraints across a broad spectrum of clientele needs requires constant retooling and management of limited resources.”

Steve Harbell, Washington Sea Grant and WRAC Board member, stated, “There are a number of opportunities to enhance Extension efforts in the West. We are reviewing our proposal development process to strengthen the relevance and application of project work.... WRAC will continue to serve aquaculture industry interests, support national issues, enhance the application of project results, and focus resources in areas of high priority and potential.”

Rossana Sallenave, New Mexico State University, moderated the panel on Extension’s role in federal programs, which focused on federal assistance programs that compensate for

losses due to natural disasters, increased foreign competition, and high feed prices. Extension specialists have been asked to help with the implementation of these programs.

The first day concluded with *Extension’s Role in Combating Misconceptions about Aquaculture*. Tim Miller-Morgan, Oregon State University, moderated the panel that included Harbell and Gary Fornshell. One area rife with misconceptions and confusion is seafood knowledge. Our nation’s low seafood consumption can be explained in part by concerns and confusion about seafood safety, handling, and cooking. Many of these concerns result from inaccurate and sensationalized media reports. American consumers also are confused by conflicting information from governmental agencies and private organizations. In response, University of Idaho Extension has developed a curriculum to help consumers feel more confident about buying and preparing seafood (see *Waterlines*, Winter 2010).

On the second day, Paul Olin, UC San Diego, broached the controversial subject of genetically modified organisms. After reviewing the 15-year process that AquaBounty Technologies has gone through to seek approval of genetically modified salmon, Paul concluded, “Despite this rigorous scientific review, there remains considerable public controversy regarding the potential for FDA approval.... As a result, 11 senators signed a request that FDA stop the process for approving genetically modified AquaAdvantage™ Atlantic salmon. The manner in which this review... has progressed has stymied American innovation in this promising sector of animal biotechnology.”

One of the most informative presentations was given by Ray RaLonde, University of Alaska, during the *Advancing Economic Development—Extension Case Study Analysis* panel.

Attendees at the National Aquaculture Extension Conference.

PHOTO: LAURA TIU



His efforts to develop shellfish aquaculture as a response to dire economic conditions in rural southeast Alaska began in the early 1990s. RaLonde said, "Successful economic development requires patience, timely and appropriate response to opportunities, establishing trusted partnerships, devotion, and ability to share the vision." Through his efforts, by 2003, available farm acreage grew from 0 to 1,346 acres. Since then, Extension has developed technical training programs, conducted applied research on shellfish growout techniques, directed a financial management training for farmers, developed farming economics models, monitored for harmful algal blooms, and lead research to improve seafood quality and safety. Collaborative research projects with Alaska Department of Fish & Game and Alaska Department of Environmental Conservation are in progress, and interest in shellfish aquaculture as a rural economic opportunity continues to grow.

Jan Auyong, Oregon State University, submitted a poster, *Using Pachyderm as an Exploratory Learning Complement to Aquatic Biotechnology Curriculum*. According to Auyong, "Aquaculture Extension services should be committed to providing high quality scientific information in a manner easily understood by all individuals, and especially in ways that are sensitive to all learning styles. Using Pachyderm software, an open-source multimedia development application that provides an easy way to create highly engaging interactive modules for websites and presentations, we can build learner-driven, multimedia stories that combine text, graphics, audio, and video." Gary Freitag, University of Alaska, submitted a poster highlighting the OceansAlaska Marine Science Center Mariculture Research and Training Center, which focuses on research, development, demonstration, and training projects that are catalysts for the mariculture industry throughout Alaska.

I believe I can speak for all WRAC attendees that the conference was well worth attending. The information and ideas presented will help all of us to improve our Extension programming. Plus it was a lot of fun. ■



National Aquaculture Policy Effort

—the following is excerpted from a NOAA press release, June 9, 2011

The Department of Commerce and NOAA released national sustainable marine aquaculture policies to meet the growing demand for healthy seafood, create jobs in coastal communities, and restore vital ecosystems. Currently, 84% of seafood consumed in the United States is imported, leading to the \$9 billion trade deficit in seafood. Further, more than half of the imported seafood is aquaculture raised.

Commerce Secretary Gary Locke (now US Ambassador to China) said, "Encouraging and developing the US aquaculture industry will result in economic growth and create jobs at home, support exports to global markets, and spur new innovations in technology to support the industry."

"Sustainable domestic aquaculture can help us meet the increasing demand for seafood and create jobs in our coastal communities," said Jane Lubchenco, Undersecretary of Commerce for Oceans and Atmosphere and NOAA Administrator.

The new aquaculture policies, which reflect the public comments received after draft policies were released in February, focus on:

- encouraging and fostering sustainable aquaculture that increases the value of domestic aquaculture production and creates American business, jobs, and trade opportunities.
- making timely management decisions based on the best scientific information available.
- ensuring aquaculture decisions protect wild species and healthy coastal and ocean ecosystems.
- working with partners domestically and internationally.
- promoting a level playing field for US aquaculture businesses engaged in international trade, by working to remove foreign trade barriers and enforcing our rights under US trade agreements.

The complete policies are available at:
http://aquaculture.noaa.gov/us/aq_policies.html ■

An interview with... Rebecca Cooper



PHOTO: COURTESY OF R. COOPER

—Chris Yoder
former Intern, WRAC

I have known Rebecca Cooper since 2004. I quickly came to respect and appreciate her contribution both to Colorado aquaculture and the work of WRAC. So much so, that when she mentioned resigning from the IAC, I had no shame in exerting some pressure on her to continue at least for another year or two, which she did, fortunately for us. In addition to her exceptional contributions to the IAC, Rebecca has also been an active participant in several WRAC research projects.

—Graham Young, Executive Director, WRAC

Please tell us a bit about yourself, your background, and your family.

I was born in Maryland on our family farm—a small general farm and orchard. After graduating from the University of Maryland, I worked for the Maryland Natural Resources Institute as a field assistant. Next, I went to Arkansas State University, where I received a MS in biology. My thesis was a food study of the mottled sculpin in the North Fork of the White River, Missouri. After earning my master's, I taught high school biology and then moved to Colorado to work at National Jewish Hospital as an immunology lab technician. As much as I enjoyed immunology, I was too much of an outdoors person to stay in lab work, so I took an interim job on a recreation cattle ranch in Wyoming and that is where I met my husband in the late 1970s.

How did you get your start in aquaculture sciences?

I married into it. My husband, Ken Cline, is a second generation trout farmer. His father, Kenneth Cline Sr., bought a small trout farm in Boulder, Colorado, after returning from service in World War II.

Ken Jr. and his younger brother took over the family business soon after we were married, and I started working for the family farm, doing just about anything that was needed. Eventually, my main job was working with our customers, taking orders, discerning the needs of their ponds and streams, and solving their problems.

Did you only rear trout?

No, we also sold warm-water fish (largemouth bass, catfish, blue gills, and forage fish such as fathead minnows) to customers east of the mountains who had warm water ponds.



How has WRAC research benefited the industry in the western region?

WRAC research has been instrumental in getting the sturgeon industry on sound footing and providing needed research on environmental concerns of the shellfish industry. Two recently completed research projects, “The Economic Contribution of the Private Recreation-Based Aquaculture Industry in the Western United States,” and “Development and Evaluation of Starter Diets and Culture Conditions for Three Subspecies of Cutthroat Trout” are very important to fish farmers in the West who support recreational fishing industries. I consider these two my “special children.”

During my husband’s time on the Industry Advisory Council (IAC), he tried to convince WRAC that an economic study was needed. At that time, no economists were on the Research Subcommittee and this type of study was not considered “researchable.” Eventually, Gunnar Knap, an economist from Alaska, was added to the Research Subcommittee, so, by the time I came on board, the climate had changed. It took a couple of cycles before a good problem statement was written and quality research proposals were received. People outside of WRAC who have read the results of the economic impact study have been very impressed. Now we can take these results to those who regulate our industry.

What do you want people to remember about your contributions to the aquaculture industry and WRAC?

I really don’t know how to answer this question since I never considered what I wanted people to remember! I do know that, in Colorado, I kept aquaculture on the radar for the agricultural community by constantly reminding them that aquaculture is agriculture. I participated in meetings and served on various committees and working groups that might have an impact. I am also pleased with the reception of the Colorado Aquaculture Association newsletter, *The Fishline*. I have been its editor since May 1994 and it is available to anyone interested in aquaculture. Within WRAC, I may be remembered for asking questions at meetings that others were afraid to ask.

You’ve been involved with WRAC since its founding in the late 1980s. What changes have you seen? How has WRAC evolved?

I have served on WRAC’s IAC for nine years. So it is a bit of a misconception that I have been around since WRAC’s inception. It probably *seems* that I have been there since the beginning! During these nine years, WRAC went through the process of replacing Dr. Ken Chew, the first WRAC director. Fortunately, Dr. Graham Young was found to fill the vacancy after Dr. Chew retired, and shortly thereafter, a new Program Manager, Debbie Granger, was hired for the administrative office. The Young-Granger team is taking WRAC into a promising new growth phase.

My husband remembers that, early on, industry would only have about an hour before WRAC meetings to prioritize research needs. He notes, “The most important concept fought for in the early days by IAC members was to ensure that industry had meaningful input into setting priorities for research.”

When I became a member of the IAC, we had a day-long pre-meeting a month before the WRAC priority setting meeting. This is still the policy and should never be abandoned. In order for IAC to function well, all of its members need to know each other and about each other’s industries, and they need to develop a good working relationship.

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

Over time, it seems that WRAC has been moving from “How to raise a species?” toward research aimed at protecting aquaculture, including reducing phosphorus in discharge water and satisfying other environmental concerns. And, of course, research will continue to try to answer the question that seems to be asked at every priority setting meeting: “How can we raise more product on less water” and how can we meet this goal (whatever the current regulatory concern is)?

What are your plans for your future involvement with aquaculture in the West?

I plan to continue as editor of *The Fishline* and to promote aquaculture when the opportunity arises. I will also continue to listen to fish farmers and help identify research needs. ■

IN MEMORY OF JUSTIN TAYLOR

February 16, 1921–February 21, 2011

—Bill Dewey, Taylor Shellfish Farms, Director of Public Policy & Communications

I knew Justin for close to 40 years. His demeanor and way of dealing with people set the example for me in many ways.

I told him many times he was a self-made naturalist! Bill's tribute is a testimony to Justin's legacy and his compassion for Washington's shellfish industry.

—Kenneth K. Chew, Former Director, WRAC

Justin Taylor, a giant in the shellfish community, passed away suddenly on February 21, 2011. He lived a full and vibrant life right up until his death. Patriarch of Taylor Shellfish Farms, Justin was recovering from a bout with pneumonia, when an allergic reaction and, ultimately, according to his doctor, a heart attack ended his life.

Until his illness, Justin was typically in the office daily or working on the shellfish beds at low tide. The week before he died, Justin had turned 90 years old. Instead of celebrating his birthday, hundreds of people turned out for a service on February 26—to celebrate his life. He was memorialized in articles in *The Seattle Times*, *The Olympian*, and *The Wall Street Journal*—a testament to Justin's legacy.

Born in Shelton, Washington, on February 16, 1921, Justin helped build Taylor Shellfish Farms into the largest shellfish-farming business in the country. Today, the business employs roughly 500 people on 9,000 acres of tidelands, in processing and distribution facilities, hatcheries, and nurseries in the US, Canada, Hong Kong, and Fiji.

During my 20 years managing public affairs for Taylor Shellfish Farms, Justin became a wonderful friend and mentor. He was a humble pioneer in the shellfish industry and one of the last surviving of a generation that led the historic battles against the pulp mills and their oyster killing effluent and the introduction of the Japanese oyster to US West Coast waters. He taught us all—not just about growing shellfish and protecting water quality—but also about being quality human beings.

Justin's work ethic and wisdom were exceptional. He instilled some wonderful values, not just in his family, but in all of us who were honored to know him. Without question he shaped who I am today.

In addition to his professional accomplishments, Justin was married for 55 years to Carol Hunter Taylor, and together they raised three outstanding children, Bill, Paul, and Janet. Justin was a Navy veteran, serving on the *USS Texas* during World War II. He endured enemy fire at Normandy, Iwo Jima, and Okinawa, and served again on a Navy oil tanker during the Korean War.

I always looked forward to conversations with Justin, in particular when he'd stop by my corner of the office to visit. He would often ask a personal question such as how things were going on my farm or with my boys; then he would ask for an update on a particular issue and always share his latest insights and concerns. His thoughtfulness and wisdom were immense.

Many of the condolences that poured in following Justin's death captured the impact of his life. Longtime friend and scientist Jack Rensel called him "a great believer in aquaculture and in the importance of water quality to humans and nature." Rensel also said that "Justin set a sterling example of how to conduct oneself, be a great businessman, but never profit from the misfortune of another."

Justin had that rare sixth sense when he walked onto a beach. Rensel noted that "Justin was more astute than many trained scientists." With that sixth sense, Justin observed the shellfish crops, their growth rate, which predators were eating the shellfish, what needed to be done to improve the production of the bed, whether new clam seed had recruited to the beach, and so on. That sixth sense didn't just tell Justin how the shellfish were doing. He used it to observe everything about the tideflat and surrounding watershed.

Justin was clearly in his element on the beach. When the tide was out, you knew where to find him with shovel or

rake in hand, working and observing. Brett Bishop of Little Skookum Shellfish Growers said: “I would look out and see Justin in the bay, and I would feel everything is all right in the world.” Bishop also noted that Justin’s “approach to life was one shovelful at a time, and he achieved incredible things, just working away at the task at hand.”

Blain Reeves with Washington’s Department of Natural Resources said, “Mr. Taylor’s significant contribution toward cleaning up the Sound, advancing shellfish cultivation practices, and being an amazing human being are basically folklore for many here, and we are all remembering and grieving the loss of this amazing Pacific Northwest icon.”

Justin’s passion for growing shellfish and the health of the Puget Sound was unmatched.

His concern for the health of Puget Sound increased in recent years as he observed more and more startling changes. The flounder, so plentiful in South Sound when Justin was a boy, were gone. Most recently, and very disturbing to Justin, was the disappearance of shore crabs from the beaches of the South Sound. These changes greatly disturbed him and he sounded the alarm to anyone who would listen. In the final hours of his life as he lay in bed talking with his son Bill, the health of Puget Sound and his concern for it were among the things he spoke of.

Many years ago I proudly joined Justin’s quest to sound this alarm. Together, we shared scientific papers, articles, observations, and we strategized about how to make his message heard. In the fall of 2009, impatient with our lack of progress in making the world aware, Justin took it upon himself to write to the Governor. He began: “Dear Governor Christine.” He mentioned it to me matter-of-factly after he had done it. “Oh, by the way,” he said and shared the letter.

Justin also saw how excess nutrients from development were negatively impacting the Sound and he knew from all his reading that shellfish were potentially part of the solution. Justin had done the calculations for Puget Sound and knew exactly how many pounds of shellfish needed to be grown in order to remove all of the nitrogen being contributed by people. He said in his letter to the Governor, “It is a win-win. Create jobs AND clean up the Sound.”

“For crying out sweetly, when are they going to get it?!” he would say in his best slightly raised voice.

One of our favorite demonstrations we use to convey Justin’s message that shellfish are part of the solution is putting two aquariums side by side, with seawater and algae



Justin Taylor out on the shellfish beds.

PHOTO: COURTESY OF TAYLOR SHELLFISH FARMS

in both, then putting shellfish in one of them. Within half an hour the one with shellfish is crystal clear, while the other is still murky with algae. It is an “ah ha” moment for all who see it, and we’ve done it hundreds of times.

Perhaps most significantly we did it last October when Governor Gregoire joined Justin, Bill, Paul, Paul’s daughter Brittany, and me for lunch at Xinh’s Clam & Oyster House. Congressman Dicks was there as well as a number of agency directors and staff. The tables were set up in a big square and in the middle were the aquariums.

Justin with all of his passion was able to tell the Governor firsthand his observations about the Puget Sound’s declining health. The shellfish in the aquariums performed flawlessly showing what they could do to help clean it up. And fifth generation Brittany did her Grandpa proud sitting by his side and telling the Governor how important it was for her to be able to carry on the family tradition of growing shellfish.

When we got back to the office, Justin was beaming and told his son Bill that it was one of the best meetings he’d ever been to. The Governor sent a letter to read at Justin’s memorial commemorating his contributions to the industry and water quality.

Justin once told reporter John Dodge. “Some people climb mountains, I walk mudflats.” My aspiration is to someday join Justin’s elite club of mudflat conquerors. ■

Viral Hemorrhagic Septicemia (VHS) Virus

Potential threat of Great Lakes VHS virus in the Western United States



What is VHS and where is it found?

Viral hemorrhagic septicemia (VHS) is a disease caused by a virus (VHSV). Different strains infect marine and freshwater fish species, as well as affecting individual species differently.

Several strains of VHSV occur in Europe. One group of strains (type I) may cause disease outbreaks in the European trout industry, while others affect marine fish.

In North America, VHSV was first detected in 1988. West Coast strains (type IVa) occur commonly and can cause disease in marine fish, but appear to have low virulence for salmon and trout.

The Great Lakes strain of VHSV (type IVb) was first detected in 2003. It has now been found in many freshwater fish species in the Great Lakes, and has caused disease outbreaks in popular sport fish and baitfish, resulting in large-scale fish die-offs and new regulatory restrictions for aquaculture throughout the region.

Can VHSV infect people?

No, the virus does not affect humans. Fish carrying the VHSV are safe to eat and to handle.

What does a fish infected with VHS look like?

Disease signs can include inactive or overactive behavior, pale gills and internal organs, bloated abdomen, bulging eyes, bleeding (hemorrhage) on body and internal organs, dark body color, and fluid in the body cavity. On the other hand, infected fish can look healthy, with no disease signs; these are called carriers.

What fish can become infected?

VHSV has been detected in 28 species of fish from the Great Lakes region, including several important recreational species such as muskellunge, yellow perch, largemouth bass, and freshwater drum (for a complete list, see the USDA-APHIS website: <http://www.focusonfishhealth.org/regulations.php>). Several of these species exist as free-ranging populations in the West and could act as carriers and maintain the virus if it was introduced.

—Jerri Bartholomew, Oregon State University

—Gael Kurath and Evi Emenegger,
US Geological Survey Western Fisheries Research Center

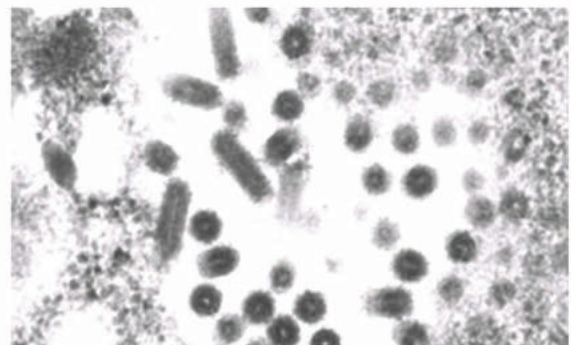
Has VHSV been found in any commercially raised fish in North America?

No, as of now, detections have only occurred in wild or free-ranging fish.

How is VHSV spread and what regulations are in place to limit the spread of the virus?

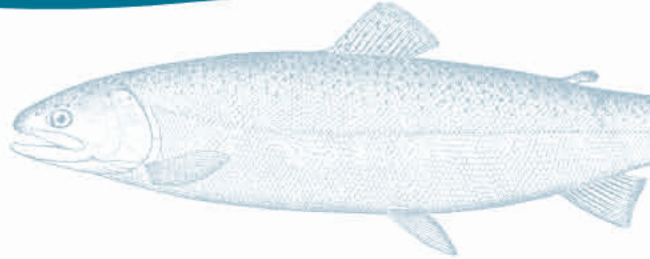
The exact route of VHSV introduction into the Great Lakes is uncertain, but possible routes include baitfish movement, activities associated with recreational fishing, ballast water, or natural fish migrations. The same routes could move the virus into the western US and should be carefully controlled.

Current restrictions on movement of fish are available on the USDA-APHIS website. To move living VHS-susceptible species, documentation must be obtained from an appropriate state, tribal, or federal authority for aquatic animal health, stating that the fish have tested negative for the virus under existing national or international standards. National standards for inspection of fish for VHSV are detailed in the *AFS-Fish Health Section/US Fish and Wildlife Service Blue Book*, produced by the American Fisheries Society and available at its online bookstore.



VHS virus.

PHOTO: MOHAMMED FAISAL



What precautions are being taken to limit spread of the virus to aquaculture facilities?

In addition to regulations described above, education workshops and increased biosecurity procedures have been provided for Extension agents and fish farm staff throughout the western region. Instructional material from workshops for fish farmers and Extension agents is available from WRAC. Other sources of information on biosecurity can be found on the following websites: <https://campus.uwsp.edu/sites/cols-ap/nadf/Workshops/Forms/AllItems.aspx> and <http://www.ncrac.org/Topics/biosecurityfactsheet.htm>

Is VHSV present in the western US?

Yes, VHSV has been isolated since the 1980s from several marine fish, such as Pacific herring, and it is occasionally detected in adult Pacific salmon returning to coastal watersheds.

What is the difference between VHSV from the Western US and the Great Lakes?

The VHSV found in Pacific watersheds (type IVa) is the same species as Great Lakes VHSV (type IVb), but a different sub-group that has never caused disease in freshwater fish. The Great Lakes VHSV has caused epidemics in freshwater fish, but has never been found west of the Great Lakes region.

Studies have not shown a biological difference between the Pacific and Great Lakes strains. This suggests that the Great Lakes epidemics are due to recent introduction of the virus into a large freshwater ecosystem with abundant susceptible fish hosts, and that western producers should take measures to prevent introduction of either VHSV IVa or IVb into their facilities.

What do we know about susceptibility of aquaculture fish species in the West?

Research has shown that rainbow trout and Chinook salmon are largely resistant to disease from Great Lakes VHSV, but they can become infected and carry the virus. Other salmonids, including coho salmon, Atlantic salmon, and brook and brown trout are also relatively resistant to disease, but their carrier potential is uncertain.

General Websites of Interest

Focus on Fish Health–VHS <http://www.focusonfishhealth.org/>
 USDA APHIS Newsroom. Viral Hemorrhagic Septicemia. http://www.aphis.usda.gov/newsroom/hot_issues/vhs/vhs.shtml

Susceptibility of various fish species to different types of VHS virus

Fish Species	Great Lakes VHSV Type IVb	Atlantic Coast VHSV Type IVb	Pacific Coast VHSV Type IVa	European VHSV Type I
Rainbow trout	Low	Low	Low	High
Chinook salmon	Low	Low	Low	Medium
Yellow perch	High	High	High	Low
Pacific herring	Medium	Medium	High	Medium



Integrating Biology & Economics into Recreational Fishery Management

—Daniel B. Deisenroth, Assistant Professor, Cal State-Stanislaus
Craig A. Bond, Professor, Colorado State University

Trout stocking is perhaps the most widely used tool for managing recreational fisheries in the Mountain West. It is also costly. In light of recent budget cuts in many western states, a question many managers ask is “how many fish should be stocked?”

Economists have struggled for years to figure out the value of fish stocking in the West. Answering this question can be difficult because the effect of fish stocking is not always constant. Often, economists ask anglers something along the lines of “what would you be willing to pay to have your catch rates increased by 25%?” Then, assuming that fish stocking will increase catch rates in some linear fashion, economists infer the value of stocking on a per-fish basis. The problem with this approach is that the effect fish stocking has on catch rates depends on a number of factors, including the biology of the fishery and the number of anglers who are present at that fishery.

In order to address this issue, researchers at Colorado State University have constructed a bioeconomic model of trout stocking that accounts for the fact that fish populations respond to angler pressure and that angler pressure responds to fish populations. Thus, the model can predict what sort of effect a stocking event will have on the fishery over time and can also be used to prescribe what the optimal fish stocking

levels will be, given the bioeconomic nature of the system.

Although the model is currently in the preliminary stages of construction, there have been several key results already. First, in certain areas, because anglers have many fishing opportunities within close proximity, current fish stocking at any one site may be inefficiently high. Second, in failing to account for the full bioeconomic nature of the fishery, resource managers may inadvertently over- or under-stock certain fisheries. This can lead to inefficient outcomes, where anglers are unnecessarily dissatisfied with the fishery or where the benefits of stocking are outweighed by the costs.

As this model is further developed, researchers anticipate that the results will be applicable to several major recreational fisheries in the Mountain West, particularly in California, where fish stocking in high mountain lakes has been found to come at the detriment of the critically endangered Mountain Yellow-Legged Frog. Research such as this will help resource managers make decisions that take into consideration the trade-offs between the needs of the ecosystem and the needs of recreational anglers.

Above: Daniel Deisenroth, one of the authors of this article, enjoying a sunny day.

PHOTO: NORIKO DEISENROTH



Revised USDA Dietary Guidelines

two servings of seafood per week recommended

—Chris Yoder, former Intern, WRAC

In an effort to address rising obesity rates in adults and children, and the critical healthcare costs associated with waistline expansion, the *2010 Dietary Guidelines for Americans* suggest a careful eye on portion size as well as an increased consumption of particular beneficial foods, including seafood.

The *Dietary Guidelines for Americans*—jointly issued by the USDA and US Department of Human and Health Services (HHS) every five years since 1980—was created as a go-to source for American consumers, so they could take nutrition and health into their own hands.

The revised guidelines have some marked changes: Americans are encouraged to adopt healthier approaches to eating, including: being aware of “screen-time” snacking; increasing consumption of plant-based foods such as vegetables, legumes, fruits, and nuts; and moving to 1% or fat-free milk. However, one of the most necessary changes—in WRAC’s opinion—was the new quantitative recommendation for seafood. Under the new guidelines, an intake of 8 oz. (two servings) or more a week of seafood—ideally around 20% of the total protein intake—is suggested. Previously, the guidelines had only recommended the twice-a-week rule for pregnant mothers, as fish (particularly oily fish high in omega 3s) has been unequivocally shown to be crucial in the prenatal development of the brain and eyes. But now, the USDA and HHS recommend that all Americans eat at least two servings per week.

Addressing the fears and misinformation surrounding the dangers of methylmercury in seafood, the 2010 guidelines state: “Consistent evidence shows that the health benefits from consuming a variety of seafood in the amounts recommended outweigh the health risks associated with methylmercury.... Benefits are maximized with seafood higher in EPA and DHA but lower in methylmercury. In addition, eating a variety of seafood is likely to reduce the amount of methylmercury consumed from any one seafood type.” The report goes on to recommend a number of oily fish popular in the United States, including trout, sardines, salmon,

anchovies, Pacific oysters, and Pacific mackerel.

This is great news for the health of the American public and the American aquaculture industry. With wild stock populations of particular fish species slipping lower and lower while human populations continue to rise, aquaculture and aquaculture research, such as the kind implemented by WRAC, can perform an environmentally necessary service by providing the growing populace with farmed heart-healthy fish protein.

Through work on more cost effective and healthier cultivation habits, sustainable aquaculture/hydroponic systems, and wild stock replenishment, WRAC, and other programs like it, can step forward and offer sustainable solutions to the vexing problem of eating more fish for one’s heart while ensuring the continuation of healthy levels of aquatic life. With more and more consumers becoming interested in terms like “sustainable” and “locally grown,” and many local mega-marts jumping on the sustainability wagon (e.g., Safeway has partnered with Fishwise to develop sustainable seafood counters at their stores, while Walmart has made strides to carry only seafood that meets the Marine Stewardship Council’s qualifications for sustainability), aquaculture is in a unique position to offer its sustainable and heart-healthy services to an eager public. Local, job-creating American aquaculture has nowhere to go but up.

It’s no surprise that eating fish is good for you. Nor is it shocking that American aquaculture has sustainable solutions up its sleeve for the seafood consumer. By merging both the demand for recommended and environmentally friendly fish and the evolving sustainability of farmed fish, American aquaculture can create a great partnership. Together, consumer demand and aquacultural supply have the opportunity to increase the American public’s health and the health of our aquatic communities. It’s a win-win opportunity!

Visit the website <http://www.choosemyplate.gov> for the US Dietary Guidelines. Also, see the National Fisheries Institute’s website: www.aboutseafood.com for comprehensive and helpful information and tips on seafood consumption. ■

WRAC on the move

BULLETIN—*Nutrient Requirements of Fish*

—Ron Hardy

In 2009, the National Research Council convened a committee to revise the *Nutrient Requirements of Fish* bulletin published by National Academies Press (NAP) in 1993. The committee, an international group of ten experts, completed the new bulletin in early 2011.

Because a tremendous amount of knowledge had accrued on the topic of fish nutritional requirements since 1993, the new bulletin summarizes this knowledge and covers more species of fish and, for the first time, shrimp. In addition, the 2011 bulletin includes discussion about two important issues associated with improving the sustainability of aquaculture: 1) replacing feed ingredient sources from marine resources, mainly fish meal and fish oil, and 2) reducing the environmental effects of aquaculture by nutritional means. The bulletin also includes a chapter describing critical research needs for the future.

This 2011 bulletin, *Nutrient Require-*

ments of Fish and Shrimp, represents a significant effort on the part of committee members and will be a welcome addition to the resources available for aquaculture practitioners around the world.

The bulletin is available at: http://www.nap.edu/catalog.php?record_id=13039 <http://www.nap.edu/catalog.php?record_id=13039>. And, as a special offer, NAP is offering a 25% discount off the list price. Please enter promotional code FFISH in the NAP shopping cart to take advantage of the discount.

NAP also offers examination copies for professors considering a title for course adoption. To request an examination copy, please visit: https://cart.nap.edu/cart/exam_copy.html <https://cart.nap.edu/cart/exam_copy.html> ■

Ron Hardy is the Director of the Aquaculture Research Institute and the Hagerman Fish Culture Experiment Station and Professor in the Department of Animal and Veterinary Sciences, University of Idaho.



WATERLINES FALL 2011

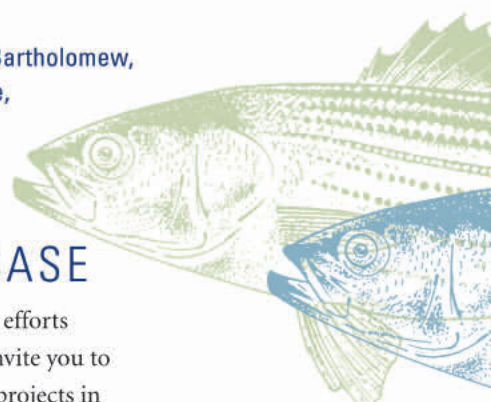
Ken Chew, former Executive Director of WRAC and Professor Emeritus at the University of Washington, shares with the WRAC Board of Directors and his wife Maegan, a personal story of his recent trip to China where he was able to visit his family's former home.

PHOTO: DEBBIE GRANGER





WRAC Board of Directors at NOAA Manchester Lab. Left to right: Kevin Fitzsimmons, Jerri Bartholomew, Steve Harbell, Chris Wilson, Walt Dickhoff, Ray RaLonde, Graham Young, Rossana Sallenave, Randy Robinette, Jeff Hetrick PHOTO: DEBBIE GRANGER



WRAC BOARD MEETING

The WRAC Board of Directors toured the Northwest Fisheries Science Center’s Manchester Research Station (Station), following its meeting on May 10, 2011, in Seattle. The Station, on Clam Bay in western Puget Sound, provides scientific leadership in the development of environmentally sound aquaculture technologies and conservation of fish stocks. The Station has state-of-the-art facilities, including the largest floating marine net-pen research complex on the West Coast and NOAA Fisheries’ largest single-pass saltwater system, with the capacity to UV-sterilize 1,500 gallons per minute. <http://www.nwfsc.noaa.gov/research/facilities/manchester.cfm>

AWARDS & HONORS

While a graduate student at Colorado State University (CSU) last year, Daniel Deisenroth received a \$2000 scholarship from the College of Agriculture at CSU and a \$270 travel grant from the Agricultural and Applied Economics Association.

WEBSITE SHOWCASE

As we work to showcase aquaculture efforts throughout the western region, we invite you to send us your photos and updates of projects in your area. We’re hoping to feature new research and outreach projects on a quarterly basis. Please email your news to dgranger@uw.edu

UPCOMING CONFERENCES

November 6–9, 2011
Goal 2011: Global Outlook for Aquaculture Leadership
Grand Hyatt Santiago, Santiago, Chile
<http://www.gaalliance.org/GOAL2011/>

December 6–8, 2011
Northwest Fish Culture Conference
Spawning New Ideas—Thinking Outside the Hatchery
Victoria, Conference Centre, Victoria, British Columbia
<http://www.aquaculturenorthamerica.com/event/northwest-fish-culture-conference/>

February 29–March 2, 2012
Aquaculture America 2012
Bringing all Players to the Table
Paris Las Vegas, Las Vegas, Nevada USA
<https://www.was.org/WasMeetings/meetings/Default.aspx?code=AA2012>



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

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