Waterlines

NEWSLETTER OF THE WESTERN REGIONAL AQUACULTURE CENTER

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

SPRING 2010

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Photo: Blue King Crab.
COURTESY OF
ALASKA SEA GRANT

United States Department of Agriculture

National Institute of Food and Agriculture

A WRAC welcome

As the West welcomes spring with all its new foliage and warmth, WRAC is eager to share with you two updated and redesigned items that keep you informed about WRAC research and outreach activities and highlight aquaculture news and events throughout the West.

- *Waterlines*—We've upgraded to a full-color format to appeal to a wider audience
- *Website*—Visit us at *fish.washington.edu/wrac*

We hope you enjoy the "new" *Waterlines* and website. As always, please let us know if ou have any suggestions as to content or format of the newsletter and the website.

Thank you. We look forward to working with you in the future. *Happy Spring.*

Graham Young, *Executive Director*

Debbie Granger, *Program Manager*

WRAC on the move

As WRAC works to implement the 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,* we are pleased to showcase news and events regarding aquaculture within the western region of the United States.

AQUACULTURE AMERICA 2009 & 2010

It is important for WRAC members to attend and give presentations at regional, national, and international conferences. In addition to WRAC sponsoring the Aquaculture America conferences, members of its committees present results of their research, moderate panel discussions, give keynote addresses, and present posters.

At Aquaculture America 2009, Mariah Talbott, a graduate student at Montana State University, won the Best Student Speaker award for her work with Dr. Molly Webb on the WRAC-funded project, "Determining ripeness in white sturgeon to maximize yield and quality of caviar." Congratulations, Mariah—WRAC and the "Sturgeon General" are proud of you!

WRAC committee members who presented at Aquaculture America 2010 included Kevin Fitzsimmons, Ron Hardy, Fred Conte, Jim Gibbons, Gary Fornshell, Ted Smith, Barbara Rasco, Chris Nelson, Rick Barrows, Walt Dickhoff, Ken Beer, John Colt, Jim Parsons, Jim Nagler, RaRaLonde, Wendy Sealey, Mark Drawbridge, Craig Bond, and Ken Overturf. ■

Dr. Fred Conte shares the poster decribing the Aquarius Version 2.0 software program (see story, page 7).

PHOTO: DEBBIE GRANGER

Dr. Molly Webb (left), Bozeman Fish Technology Center, presents graduate student Mariah Talbott with the Best Student Speaker award at Aquaculture America 2009.

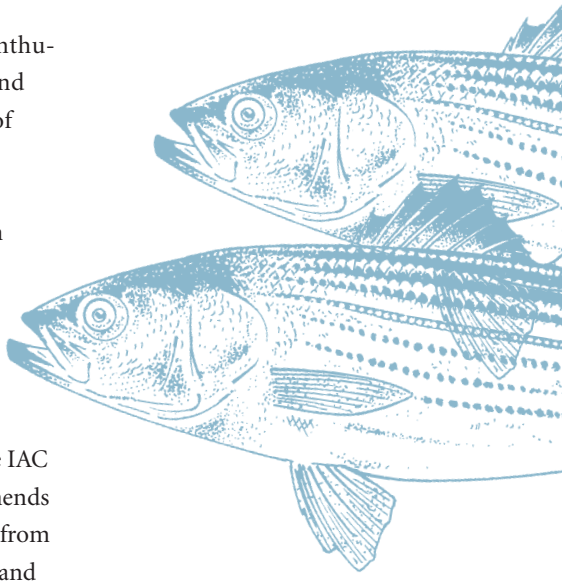
PHOTO: COURTESY OF M. WEBB

WRAC Board of Directors at Los Lunas Silvery Minnow Refugium.

PHOTO: JULIE MAAS

WRAC BOARD MEETING

In November 2009, the WRAC Board of Directors held its semi-annual meeting in Albuquerque. (Meeting locations rotate throughout the 12 states within the western region.) Following the day-long meeting, members were treated to a half-day field trip to the Los Lunas Silvery Minnow Refugium, where Dr. Douglas Tave and his team enthusiastically shared the important work and significant commitment that the state of New Mexico and the Interstate Stream Commission are making to restore the silvery minnow to streams and rivers in the southwestern United States. ■



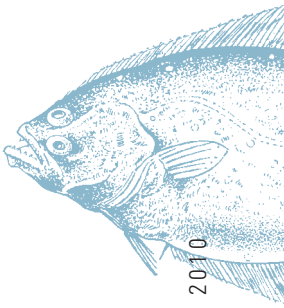
WRAC EXPANDS IAC MEMBERSHIP

In recognition of the vital contribution of the Industry Advisory Council (IAC) to the success of WRAC, the Board of Directors recently voted to expand IAC membership from nine to twelve.

With representation from all geographic regions (coastal, intermountain, mountain, and desert) and all sectors of the aquaculture industry (finfish producers, shellfish producers, suppliers of goods and services, and marketing and distribution firms), the IAC is the voice of the industry for WRAC.

The term of service is three years. The IAC meets at least once each year and recommends to the Board current needs and priorities from an industry perspective, and also reviews and recommends action regarding new and continuing regional research and outreach projects.

We invite and encourage nominations to fill the three additional seats on the IAC. Please visit the WRAC website at *http:// fish.washington.edu/ wrac/aboutus/organization* for specifics regarding current IAC members. We look forward to this increased industry participation. ■



A "miniature" version of our redesigned website .

around

Kevin Fitzsimmons is a renowned aquaculture scientist (not to mention, a member of WRAC's Board of Directors). He took time out of his busy teaching schedule at the University of Arizona and traveling the world for his research to speak with *Waterlines* about his life and contributions to the aquaculture community.

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

I was born in Tucson, Arizona, but, as an Air Force brat, moved many times during my youth. By the time I earned my PhD, I had attended 17 different schools. For Christmas last year, my mom, for fun, gave me a framed list of all the schools. [My wife] Linda and I have two boys: Mike is finishing his master's at University of Texas and Patrick is a junior at the University of Arizona in Political Science and Army ROTC.

Tilapia harvest in Mbout, Mauritania.
COURTESY OF K. FITZSIMMONS

How did you get your start in aquaculture sciences?

My undergraduate and master's degrees were in Marine Biology. I was a great fan of Jacques Cousteau; I still have all his books. One day in class, one of my professors mentioned that good jobs could be found in aquaculture, which involved feeding people, replacing overfished resources, and yet still doing marine biology. It made perfect sense to me.

What is your area of expertise within aquaculture?

My greatest interests are in tilapia culture and integrated farming systems. Tilapia is one of the star performers globally. As the "aquatic chicken," tilapia is turning out to be all things to all people. Farmers like it, processors like it, retail and restaurants like it, environmentalists like it, and, best of all, consumers love it.

Integrated farming systems—utilizing the effluents from aquaculture to irrigate agricultural crops or "extractive" aquatic crops (bivalves, seaweeds, or aquatic plants)—will be the best path to sustainability and profitability in coming years. We have used tilapia most often, but have also worked with shrimp and seaweeds in marine systems.

the world with Fitz

Opposite page: Map indicates the places Fitz has visited to work on aquaculture projects.

Fitz (left) with Merle Jensen, Professor Emeritus, University of Arizona, and former WRAC Board Member, in Rosso, Mauritania.

COURTESY OF K. FITZSIMMONS

You are a frequent traveler, assisting other countries with their aquaculture projects. How did you first get started in traveling to other countries?

I actually started traveling and working in aquaculture in high school. My family has a place in Puerto Peñasco, Mexico, four hours from Tucson, very near to where the University of Arizona started its experimental shrimp farm in the 1970s.

With which countries have you worked?

I checked on my Facebook map and the list includes 61 countries now. Travel for 2009 included the Philippines, Malaysia, Indonesia, Thailand, India, Mexico, Guatemala, New Caledonia, Guyana, and China.

What agencies contract with you?

The group I have worked with most closely for many years is the Aquaculture Fisheries Collaborative Research Support Program (AquaFish CRSP), which is supported by the US Agency for International Development. AquaFish CRSP has developed a global network of institutions paired with US universities. I also have worked with the Chinese Department of Agriculture for many years to assist their tilapia industry, and I travel two to three times a year to various locations within China.

What is your area of focus with these countries?

Most of the focus has been on tilapia and sustainability issues. As other countries develop their industries, they want to ensure that they protect their environments and meet the various international conventions being developed to improve seafood quality, safety, and sustainability.

Your travels are often to underdeveloped countries. What are your more memorable travel experiences?

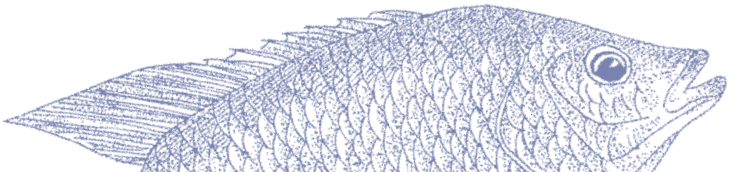
In 2008, I spent a week in Mauritania, in West Africa between Morocco and Senegal. It took two days to cross the Sahara to get to the Senegal River Valley where they had irrigation systems and native tilapia. We discussed several options for rearing fish in cages and ponds in the irrigation waters and fertilizing vegetable gardens with the effluent. We spoke with several groups (mostly women's cooperatives), local leaders, and the lone Peace Corps volunteer we found in the hinterland. We were invited to Mauritania and accompanied by the US-educated son of the recently elected president. The night before we left, there was gun fire around the US Embassy. A few days after we left, the president was overthrown by a military coup and the family put under house arrest. As you can imagine, there was no follow-up trip. Footnote: the family was quickly released from house arrest, except for the president, who was released in mid-2009, after the military coup leader was elected in a military-conducted election.

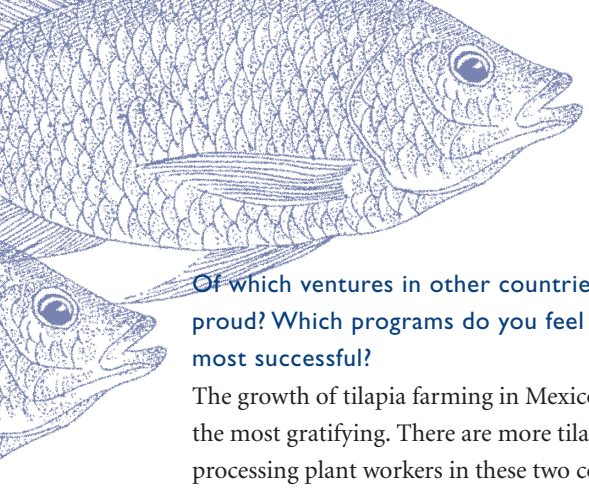
Also, in the 1990s, while working on a tilapia farm in Colombia, a gun battle involving several dozen people, half in uniforms and half not, broke out across a street when I was in a parking lot.

And, last week in New Caledonia, a sea turtle came over to check me out while I was in scuba gear.

What changes have you observed within the aquaculture arena in your years of working abroad?

One of the most fascinating aspects is the scope and breadth of the industry abroad. They grow so many more species in many more production systems than we do in the United States. More important is the speed of development of new systems; the scope of investment is much greater than in the United States.





Of which ventures in other countries are you most proud? Which programs do you feel have been the most successful?

The growth of tilapia farming in Mexico and China is the most gratifying. There are more tilapia farmers and processing plant workers in these two countries than in the entire aquaculture industry in the United States. A close second is my work with aquaculture restoration in Banda Aceh, Indonesia, since the tsunami. The shrimp industry was already in trouble there before the tsunami struck. Since then, we have focused the restoration work on sustainable polyculture and integrated systems. Using tilapia, seaweeds, grouper, and mudcrab culture, and mangrove restoration, we have helped shrimp farmers become more profitable and sustainable and we have increased food supplies, food safety, and export diversity.

How does aquaculture within the US compare with aquaculture endeavors in other parts of the world?

US aquaculture compares favorably in some respects and some species. We have some leading-edge scientists and technologies and some production systems that are top notch. But in many others aspects, we lag far behind. Our diversity of species is low, the scope of farms is relatively small, and we have only a handful of vertically integrated operations. Europe, Japan, and Korea have many more top-level scientists and labs than we do. China's industry is two orders of magnitude greater than ours. We have excellent breeding programs for rainbow trout, channel catfish, white sturgeon, white shrimp, and Pacific oysters, but that is about it. The really big aquaculture crops: carp, tilapia, salmon, seaweeds, basa, flounders, sea bass, sea bream, yellowtail, cods, mussels, pearls, and clams, all have sophisticated breeding programs conducted abroad. And we are missing out totally on tuna, which will be the next huge sector.

What is your response to the sometimes-heard criticism that US aquaculture scientists should not be supporting industry development in other countries that could become competitors to the US industry?

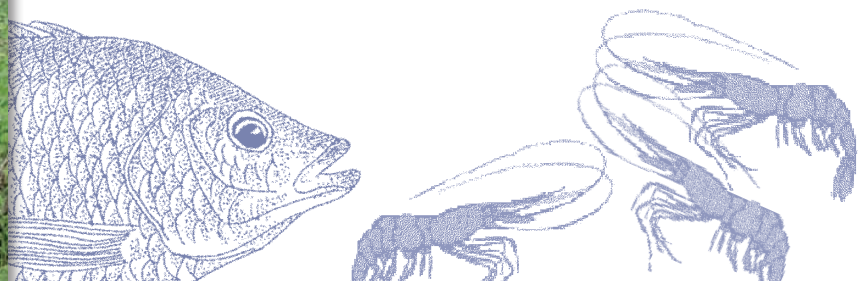
This criticism mostly comes from people who have not been outside the United States to see the international industry. We almost always learn more than we have to share when abroad. The Norwegians alone have developed as much high technology as the US. The Chinese were doing aquaculture for a millennium before the US was founded. Not a single US scientist was involved in the Genetically Improved Farmed Tilapia (GIFT) program, which won the World Food Prize in 2005. Canada's salmon industry is ten times the size of ours.

The anemic state of US commercial aquaculture is due to our limited investment, nothing more. Production costs are higher in Japan, Norway, and Korea, and all have bigger industries than the United States. The European Union (EU) has strict environmental restrictions, but has salmon, sea bass, sea bream, trout, and tuna farms. Vietnam grew its catfish industry to four times the size of the United States', while our catfish farmers argued whether it was really a catfish or not. Catfish farmers complain about imports from Vietnam, not realizing that the United States is one of Vietnam's minor markets, after Russia, the EU, Mexico, China, and the Vietnamese who eat the majority of the fish.

The United States needs to invest more in technology, science, and extension support for US farmers. But US farmers also need to be willing to invest more of their own money to catch up, travel to other countries to see how they are successful, and import technology and know-how from abroad. ■

Fitz holding tilapia at the Aquaculture Research Center, Paulo Afonso, Salvador, Brazil.

COURTESY OF K. FITZSIMMONS



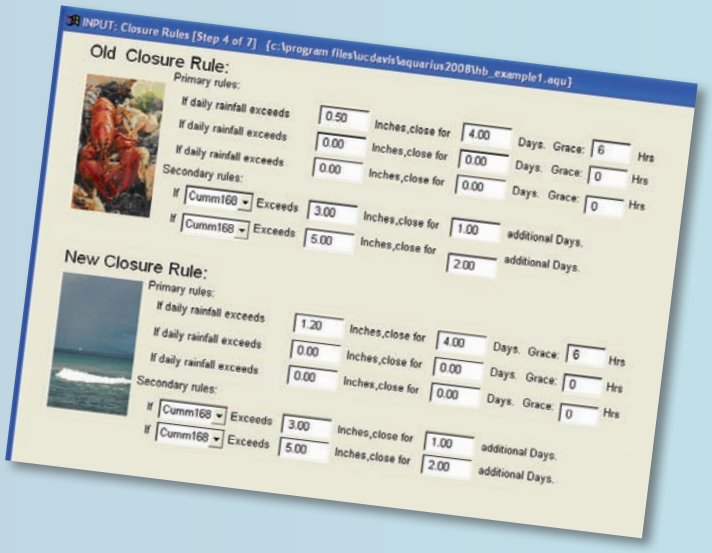
Age of aquarius

—Fred Conte, University of California Davis

Aquarius v.2.0 was developed for state and federal health agencies and the commercial shellfish industry in a cooperative effort between the University of California Davis (UCD) and the California Department of Public Health. The program evolved from Aquarius v.1.0, which was the first simulation and statistical software tool developed to directly evaluate sanitation related, rainfall closure rules for conditionally approved harvest areas, and to perform a series of "what-if" scenarios for selected multiple variables. At the request of public health agencies, a total of 15 features were added to expand the program's analytical power and to increase margins of safety for shellfish consumers. Funding for the research was provided by UCD and WRAC.

Program Description

The simulation software examines existing regulatory rules that govern the opening and closing of shellfish harvest in "conditionally approved" growing areas (harvest zones that are open or closed based on predictable events and environmental studies). For example, an area may be closed for three days after 1.75 inches of rain, based on tidal exchanges required to flush fecal coliform bacteria (a pathogen indicator organism) from the bay to a level that meets National Shellfish Sanitation Program standards.

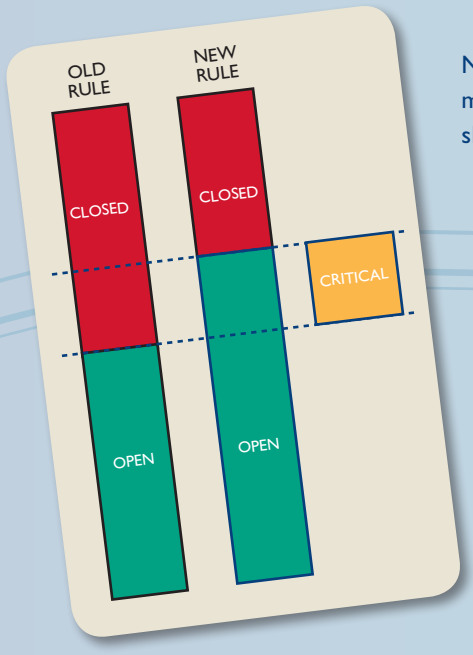


Diagrammatic representation of fecal coliform sampling during the critical period in a scenario that would relax the rainfall closure rule.

Aquarius is designed to analyze up to 30 variables between an existing closure rule and a hypothetical new closure rule. It can analyze unlimited rainfall data for a given region and access a multiple fecal coliform database. It also can analyze a combination of shellfish growing sites or run comparisons between combinations of multiple growing sites. The program includes two statistical sample size programs, improved data filtration options, and the inclusion of additional parametric and non-parametric statistical analyses that increase the reliability of the decision-making process necessary for public health objectives.

Program Impacts

Aquarius v2.0 has had three major impacts. It has replaced regression analysis, which requires a high degree of subjective interpretation as the statistical tool of choice, with the T-tests, thereby providing a more objective alternative. It defines a critical period in which samples must be taken—when the site is closed under the old rule, but open under the proposed new rule. And third, it reduces the time required to perform analysis from weeks and months to hours or minutes. ■



New rule opens more days for shellfish harvesting.

the dea

adliest catch?

—Doug Schneider, Science Writer, Alaska Sea Grant

Seward, Alaska—It might seem odd that the world's only king crab hatchery is located in Alaska, home to the TV series on deep-sea crab fishing, *Deadliest Catch.*

In this popular cable program, hearty skippers and their courageous crews land boatloads of opilio, or snow crab, in the frigid waters of the Bering Sea. But while Bering Sea snow crab stocks are at present open to fishing, stocks of other crab—such as red and blue king—have not fared so well. In Kodiak, for example, there's been no red king crab fishery since 1982. And in waters around the Pribilof Islands in the Bering Sea, blue king crab stocks have been declining for more than a decade.

Understandably, fishermen want to see the stocks recover. To help, regional fishermen's groups, NOAA Fisheries, the Alutiiq Pride Shellfish Hatchery, Chugach Region Resources Commission, the University of Alaska Fairbanks (UAF) School of Fisheries and Ocean Sciences (SFOS), and Alaska Sea Grant joined together in 2006 and launched the Alaska King Crab Research, Rehabilitation and Biology program, or AKCRRAB.

Buoyed by initial funding from NOAA, Alaska Sea Grant, and UAF, the program's goal is to improve understanding of the biological requirements of hatching and raising juvenile king crab in a large-scale hatchery setting. This includes surmounting the technical hurdles of ensuring clean, cold water; adequate food and light; and other conditions necessary for optimal growth and survival of newly hatched crab.

Progress at the Alutiiq Pride Shellfish Hatchery, which serves as a center for research on hatchery production, has been steady. Research on king crab growth, survival, and other issues also is being conducted in Juneau and Kodiak, Alaska, and Newport, Oregon.

Last year, biologists oversaw the successful hatch and growth of more than 100,000 larvae to the juvenile stage, the stage that most likely would be released into the wild. This year (the fourth year of production trials), scientists expect at least as many juveniles to grow from larvae hatched from wild adult red and blue king crab broodstock that is being cared for by the UAF/SFOS Seward Marine Center. Researchers expect the eggs to begin hatching in APring 2010.

To be clear, there is, as yet, no actual plan to release hatchery-born king crab into the wild. Before such approvals can be given by state officials, more research is needed to better understand the potential impacts of such a release on the existing wild stocks. Researchers say the work to date has been aimed at developing tools and know-how so that fishery managers and policy makers can make informed decisions on how to proceed.

To learn more about the project, visit *http://seagrant.uaf.edu/research/projects/initiatives/king_crab/general.* ■

left: Alaska Sea Grant Marine Advisory agent Heidi Herter and Little Diomede Island resident Opik Akinga pull a crab pot up through the ice in an effort to capture female blue king crab with ripe eggs. PHOTO: DEBORAH MERCY and ALASKA SEA GRANT

top: A glaucothoe—a transitional stage between the larval and juvenile stages of king crabs. right: University of Alaska Fairbanks graduate student Isaac Swiderski introduces red king crab from Kodiak to their new home in Seward. PHOTOS: COURTESY OF JASON WETTSTEIN, ALASKA SEALIFE CENTER

A TAIL OF TWO

COLDWATER DISEASE RESEARCH

—Kenneth Cain, University of Idaho and Douglas R. Call, Washington State University

Coldwater disease research has the potential to provide substantial economic impact to aquaculture in the region and beyond. Two collaborative projects underway at the University of Idaho (UI) and Washington State University (WSU) have been aimed at reducing fish mortality that is caused by coldwater disease (CWD). The causative agent of CWD, *Flavobacterium psychrophilum*, is a gram-negative bacterium that produces an acute septicemic infection in salmonids (Woods & Yasutake 1956) and a few other species (Lehman et al., 1991). The disease typically occurs at low temperatures, and infected fish may exhibit a range of clinical signs, including large open lesions on the caudal peduncle (tail area). Coldwater disease results in high mortalities and millions of dollars of losses to both the private and public aquaculture sectors.

This research has the potential to impact the private aquaculture industry and state, federal, and tribal hatchery programs that release steelhead and salmon for sport fisheries and stock recovery. Increasing the survival of fish at the hatchery will have direct impact on food fish producers and likely increase revenue to states within the region.

We have commercialized one product (an antibody-based disease diagnostic tool) that improves our ability to detect the causative agent of CWD. We are using this diagnostic tool to develop ways to reduce the overall prevalence of CWD by screening and removing heavily infected fish from the hatchery population.

Recently, the UI signed a license agreement with a commercial company (Immounoprecise Antibodies, Inc.) to produce and distribute this tool to researchers, diagnostic laboratories, and aquaculture facilitites worldwide.

The other product that we are developing is a fish vaccine to prevent CWD. We have produced a potential vaccine that the UI is patenting. The unique aspect of this product is that it appears we will be able to mass vaccinate large numbers of fish by immersing them into this vaccine. This is the only practical way to immunize large numbers of fish, but until now it has not been possible for this disease.

We have established a partnership with a Seattle-based company (Aquatic Life Sciences), which is in the process of mass producing this vaccine for use in field trials this spring. If the field trials prove successful, then the company will have the option to license the patent rights to this vaccine. We are also working on many different vaccine formulations for CWD should the current product fail to protect fish in the field.

Other researchers involved in this project include Scott LaPatra, Clear Springs Foods; Gary Fornshell, UI Extension; and Jim Parsons, Troutlodge, Inc.

Funding support for this research has been provided in part by WRAC and the UI/WSU Aquaculture Initiative. ■

Photos, l to r: *Flavobacterium psychrophilum*, fish infected with *F. psychrophilum*, fish with Strawberry Disease lesions

PHOTOS: KENNTH CAIN, KENNETH CAIN, DOUGLAS CALL

DISEASES

STRAWBERRY DISEASE RESEARCH

—Douglas R. Call, Washington State University; Kevin R. Snekvik, Washington State Animal Disease Diagnostic Lab; and Kenneth D. Cain, University of Idaho

Strawberry Disease in rainbow trout was first described in Washington State in the 1950s. More recently, two related conditions have been described in Europe (Red Mark Syndrome and Warm Water Strawberry Disease). In all cases, the disease presents with bright red, raised inflammatory lesions on the skin (see photo above) and these lesions are most evident on market-sized trout.

Strawberry Disease creates problems for aquaculture farmers in that it impacts the fishes' appeal to consumers and, though not fatal, increases the amount of time and resources needed before the fish are ready for sale after being ill. While the condition can affect up to 80% of fish within a raceway, it appears responsive to treatment with oxytetracycline (an antibiotic used widely for human and veterinary treatments). However, the time required for normal recovery and the withholding time required for antibiotic treatment pose significant costs to trout producers.

Despite the long history of Strawberry Disease, little is known about its cause. Work in the 1960s suggested that this condition is transmissible, and work in the 1980s found no obvious link between Strawberry Disease and husbandry practices. In 2006, our group was funded to examine this condition using a culture-independent, molecular cloning technique. To do this, we used polymerase chain reaction to amplify short stretches of chromosomal DNA that are shared by all bacteria. This process produced a pool of amplified products from any bacteria that might be present in a lesion. We then examined individual products to identify bacteria based on unique DNA sequences found between the conserved regions of the DNA sequence. As a result of this analysis, we detected the presence of a Rickettsia-like organism (RLO) in Strawberry Disease lesions.

We have now examined 56 fish using a more specific molecular assay and found a highly significant association between Strawberry Disease lesions and the presence of the RLO sequence. These efforts have also found the RLO sequence in lesions from wild trout that are consistent with Strawberry Disease. Further work has shown a significant correlation between lesion severity and the number of RLO copies present in the lesions. While this data shows a strong correlation between RLO and Strawberry Disease, more work is needed to demonstrate causation. Therefore, efforts are underway to culture this organism using a variety of cell lines. Finally, as assays are developed and causation is affirmed, research will be directed to find the mechanism of transmission so that working solutions can be developed to control Strawberry Disease at the production level.

Contributors to this work have included Sonja Lloyd (University of Texas, Galveston), Scott LaPatra (Clear Springs Foods, Inc.), and Sophie St-Hilaire (Idaho State University).

This work was supported in part by Washington State University and the University of Idaho Aquaculture Initiative and the College of Veterinary Medicine Agricultural Animal Health Program. ■

alternatives to fishmeal

Fishmeal, a commercial product made from whole fish, and bones and offal from processed fish, is used as a high-protein supplement in aquaculture feed. Because aquaculture is the fastest growing sector of food production in the world, pressure on forage fisheries to produce aquaculture feed is a significant concern.

Aquaculture at an Impasse

Global fishmeal production will soon be inadequate to supply the protein needed to produce fish feed in commercial aquaculture. Each year for the past 15 years, global aquaculture production has consistently increased by 8.8%, making it the fastest growing sector of animal production. During the same period, total landings from wild fish stocks averaged about 92 million metric tons (mmt), of which an average of 64 mmt was consumed directly and 28 mmt was used to produce fishmeal and oil for animal and fish feeds.

Wild harvests vary from year to year, but overall, landings have not increased for 15 years and are not likely to increase beyond the current range of 89–98 mmt. This means that fishmeal and fish oil production have also been more-or-less static over the past 15 years; this fact causes concern within the aquaculture feed industry.

Future demand for fisheries products can only be met by increased aquaculture production. Just to maintain current world per-capita fish consumption of 16.7 kg will require aquaculture production to increase by as much as 40 mmt in the next 20 years. Some of this increase will be through higher production of fish species that do not require direct feeding, but a significant proportion (41.6% according to the Food and Agriculture Organization of the United Nations [FAO], 2006) will consist of farmed fish species that require feed inputs.

Aquaculture feed production is expected to increase to 36 mmt by 2015; it was 4 mmt in 1994 (Tacon, 2008). The net result is clear: there is not enough fishmeal produced each year to supply protein for fish feeds needed in the near future unless the percentage of fishmeal in aquaculture feeds is reduced and alternate protein sources are used to supply the balance of protein needed to support growth, health, and welfare of farmed fish.

Sustainability of feed ingredients

There has long been concern about the dependence of finfish and crustacean producers on fishmeal as the main protein source in aquaculture feeds. Since the mid-1990s, WRAC has funded research projects to evaluate alternative proteins and oils.

The knowledge gained by WRAC and others has allowed fish-feed formulators to modify feed composition and reduce fishmeal levels. However, although the percentage of fishmeal in feeds has been reduced, the amount of fishmeal used each year has actually increased because of the rapid growth of aquaculture and the subsequent need to produce more fish feed (Naylor et al., 2009). For example, tilapia, carp, and catfish growers can eliminate fishmeal from grower feeds with little impact on the growth and economics of production, but they still use fishmeal in feeds for fry and fingerlings. Even though the proportion of feed consumed by a farmed tilapia, carp, or catfish at the fry and fingerling state is less than 3–5% of the total amount of feed consumed up to harvest, the sheer numbers of these fish raised in the world require millions of metric tons of fishmeal—more than is consumed by farmed salmon or shrimp.

Positive steps forward

Although there is still much work to be done in order to find permanent solutions to the problem, aquaculture scientists from around the world are stepping up and affecting positive change in the realm of aquaculture feed. WRAC-funded research in Idaho has let to the development of low or zero-fishmeal feeds for rainbow trout that support growth nearly as well as conventional fishmeal-based feeds.

In the shrimp farming industry in Asia, production has shifted quickly over the past few years from the carnivorous tiger shrimp, *Penaeus monodon,* to the omnivorous white-legged shrimp, *Litopenaeus vannamei.* This transition has resulted in increased white shrimp production without increasing overall fishmeal use.

Lowering fishmeal levels in feeds for marine fish species has been less successful, however. This problem is exacerbated by the ban on use of recovered animal proteins, such as poultry

in aquaculture diets

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

COURTESY OR R. HARDY

Ron Hardy (center) at the International Symposium of Chinese Scientists in Fish and Shellfish Nutrition. Beijing, September 2008, where he was an invited keynote speaker.

Hardy, Chair of WRAC's Board of Directors, is a world-renowned expert in aquaculture, fish nutrition, and feed production. His research interests include developing sustainable feed sources for the global aquaculture industry. He has traveled extensively—consulting, giving lectures, and working on behalf of international organizations. He has also productively engaged with NGOs to address issues in environmental sustainability of aquaculture.

On April 22, 2010, Hardy will be the invited speaker for the second Kenneth K. Chew Professorship lecture at the University of Washington. His talk, "Aquaculture Needs You! Putting solid science into the sustainable aquaculture debate," focused on the need for research and scientific knowledge in order for aquaculture to meet the challenge of sustaining human health and ecological viability.

by-product meal, in European Union countries. Such protein ingredients can partially replace fishmeal in feeds for marine species that require high-protein feeds.

Fishmeal in the future

Pressure to reduce fishmeal used in feeds for aquaculture will continue. Supply and demand imbalances as well as concerns from non-governmental organizations (NGOs) about the ecological sustainability of harvesting low trophic-level fish to make fishmeal guarantee that this is not a dilemma that will simply fade away. Many NGOs are concerned that demand for fishmeal to produce aquaculture feed needs will result in increasing and non-sustainable harvest of low trophic-level forage fish upon which many higher trophic-level organisms in the marine environment depend.

Although most of the fisheries targeting forage fish for fishmeal and oil production have strict harvest limits based upon estimations of sustainable yield, these limits do not consider large-scale ecosystem effects and impacts of such harvest on higher trophic levels in the marine environment. Therefore, they argue, harvest limits should be based on ecosystem health. However, the definition of ecosystem health is not a measure that lends itself to quantitative analysis and makes it unlikely that catch restrictions based on these criteria will be adopted.

Even though aquaculture production has exploded in the past decade, there is little evidence that increased demand for fishmeal by aquafeed producers has caused higher landings of fish species used in fishmeal production, except in some areas of Southeast Asia and China where forage fish are fed directly to farmed marine fish (Tacon and Metian, 2008). Increased use of fishmeal by the aquaculture feed industry has been accompanied by lower use by other sectors, mainly the poultry and swine feed industries. The net result has been diversion of fishmeal from livestock and poultry feeds to aquaculture feeds.

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If health is your wish...

EATING FISH IS GOOD FOR YOU

—Chris Yoder, Intern, WRAC

It's no secret that the average amount of seafood consumed by Americans is less than in the rest of the world. Adult Americans consume around 16 pounds per capita per year, while in China, for example, the average is around 45 pounds. Multiple studies and surveys have found that less than half of the US population reports eating the FDA recommended two servings of fish per week; in fact, an independent marketing research firm found that, in 2004, 17% of Americans reported consuming fish only once a month!

It could be argued that the price or the lack of variety in local supermarkets deters many shoppers. However, these factors are dependent on market demand (if more people consistently buy seafood then the variety and cost will react accordingly). And, neither reason completely explains the aversion to fish that the majority of Americans demonstrate.

What is influencing the average American consumer to avoid one of the healthiest proteins on earth? Fish, especially oily fish such as salmon, sardines, and trout, are high in omega-3 fatty acids, which have been shown to have numerous health benefits. Many researchers and commentators suggest that a major reason for Americans' aversion to fish is the proliferation of messages regarding seafood risks and benefits.

For every article, such as the recent study conducted at King's College in London that found that fish consumption decreased the prevalence of dementia, there is a counterpoint, such as Dr. Mehmet Oz's recent assertion on his television show (*The Dr. Oz Show*) that mercury levels in all seafood were concerns for "all of us" and direct contributors to the as-of-yet unknown disease of "fish fog" (aka mercury poisoning). And, while the National Fisheries Institute has already rebutted Dr. Oz's statements and labeled them as "fear mongering," the sad fact remains that many Americans will not take the next step to question these types of assertions. Many Americans simply choose apathy over educated action and, in turn, don't eat the fish that they need for a healthy diet.

What are the facts? Is Dr. Oz right? He is correct in asserting that mercury can be found in all fish; however, the majority of it is naturally occurring (the product of undersea volcanic activity, etc.). Yes, there is mercury working its way into natural cycles because of corporate pollution. However, the FDA and EPA maintain that "for most people, the risk from mercury by eating fish and shellfish is not a health concern." They caution that pregnant or nursing mothers should take caution to avoid older and larger fish that have had a chance to accumulate mercury; in particular, the EPA warns against eating shark, swordfish, tilefish, and king mackerel if one is pregnant, cxcnursing, or may become pregnant.

Unfortunately, in our society, which tends to favor the sensational over the practical, the information about the necessity of eating fish often becomes lost within the overblown reporting on the risks of mercury.

Yet, without the omega 3s and proteins found in fish, the average American's diet may result in a greater risk for heart-related illnesses. Ironically, scientists are finding that the decision to avoid seafood because of the fear of mercury actually can cause more damage. In an article in the *Journal of the American Medical Association*, the conclusion was made, that: "Based on strength of evidence and potential magnitudes of effect, the benefits of modest fish consumption (1–2 servings/wk) outweigh the risks among adults and, excepting a few selected fish species, among women of childbearing age. Avoidance of modest fish consumption due to confusion regarding risks and benefits could result in thousands of excess CHD [coronary heart disease] deaths annually and suboptimal neurodevelopment in children." hAnother article, published in the *Public Library of Science*, found that as many as 84,000 preventable deaths a year could be attributed to an omega 3 deficiency; that's more than the number of preventable annual deaths attributed to a diet high in trans fats (82,000)! Americans' avoidance of fish and its heart healthy nutrients is becoming a health epidemic with much graver consequences than catching Dr. Oz's phantom fish-fog, but few Americans seem to know, or be concerned, about it.

It's a confusing market out there for the consumer but, by avoiding fish altogether, many Americans put themselves in greater peril than before. By telling the truth about seafood's health benefits, perhaps we can deflate the fear mongering of some whose motives are just plain "fishy." ■

eat fish

SEAFOOD CURRICULUM

—Marlene Fritz, Educational Communications, University of Idaho

Two University of Idaho Extension educators say the health benefits of eating fish are overwhelming, but at just over 60% of the American Heart Association recommendations, US per capita consumption is underwhelming. That's why Extension aquaculture educator Gary Fornshell and Extension nutrition educator Rhea Lanting developed a four-lesson curriculum, "Seafood at Its Best," to help nutrition educators, dieticians, and food-service and outreach professionals boost the nation's appetite for seafood.

"Seafood is an essential part of a healthy lifestyle," said Lanting. Its proteins, vitamins, and fatty acids contribute to improved cardiovascular and neurological health, and—if broiled, barbecued, microwaved, or steamed without rich condiments—it's generally lower in fat than other animal proteins.

The two educators say many consumers are confused about the perceived versus actual risks of mercury and other contaminants in seafood and aren't quite sure how to select, handle, store, or prepare fish and shellfish. The science-based, peer-reviewed curriculum discusses each aspect in detail, identifies healthy substitute ingredients for seafood recipes, and includes instruction for making foiled fish and fish tacos with mango salsa. When Fornshell and Lanting tested the curriculum with a 40-person pilot class, participants vowed to increase their weekly servings of seafood to at least two or three, compared with the national average of one.

"Seafood at Its Best" won its authors invitations to address a Seafood Professional Development Workshop in Maine, an Aquaculture meeting in Seattle, and the World Aquaculture Conference in Mexico. It's available as a CD for $35, plus shipping and handling, by calling 208-885-7982, faxing 208-885-4648, writing *calspubs@uidah.edu* or visiting *http://info.ag.uidaho.edu/catalog*. Each of its four lessons includes lecture notes, suggested activities, a PowerPoint presentation, references, and evaluation tools. ■

Rhea Lanting, University of Idaho Extension Nutrition Educator, demonstrates easy fish preparation.

COURTESY OF M. FRITZ

FISH TACOS & MANGO SALSA

2 trout, catfish, or tilapia fillets, 3 to 4 oz. each
1 teaspoon olive oil
juice of small lime
salt and pepper
2 small whole wheat tortillas or 4 corn tortilla
other toppings: 1 cup green cabbage, thinly sliced
½ cup adocado, sliced
1 red bell pepper, thinly sliced

Coat fish on both sides with olive oil, lime juice, salt, and pepper. Place on broiler tray and refrigerate while you prepare salsa and other toppings. Broil fish on high for 4 to 5 minutes until fish flakes. Place fish on warm tortilla, top with salsa and toppings.

For the Mango Salsa:
Mix together the following ingredients:
¼ pound tomatillos, husks removed, chopped
1 bunch cilantro, stems removed, Chopped
2 small mangos, peeled and chopped
1 large clove garlic, diced
salt and pepper to taste
1 or 2 jalepeños, seeded and diced (optional)

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