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USGS Western Fisheries Research Center

2015 Annual Science Brief

U.S. Department of the Interior
U.S. Geological Survey

Front Cover Images:

1. Antennas deployed in the Wind River to monitor movements of fish that have been tagged with Passive Integrated Transponder (PIT) tags. The need to track fish movements in large streams over extensive areas has extended this current technology to new levels. Photo credit: Ian Jezorek, USGS.

2. Juvenile rainbow trout (*Oncorhynchus mykiss*). Photo by Gary Winans, NOAA Fisheries.

Front Inside Cover Image:

Little White Salmon River adjacent to the Columbia River Research Laboratory. Photo credit: Lisa Weiland and Rachel Reagan, USGS.

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Top Row:

1. Individual epithelial cells on the skin of a juvenile Chinook salmon have finger-print-like microridges, which help mucus adhere to the surface. A mucous cell seen in the center of the photo is discharging mucus. Scanning electron micrograph by Carla Conway, USGS.

2. Otoliths are hard structures located in the brain cavity of fish. These structures are formed by buildup of calcium carbonate within the gelatinous matrix that produces light and dark bands similar to the growth rings in trees. The width of the bands corresponds to environmental factors such as temperature and food availability. Photo by USGS.

3. Scanning electron micrograph of an ectoparasitic fluke, *Gyrodactylus* sp. on goldfish skin. Note the hooks along the margin of the attachment organ. Photo by Diane Elliott, USGS.

Bottom:

Sockeye salmon. Photo courtesy of Milton Love; Marine Science Institute, University of California Santa Barbara, CA.

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Greetings from all of us at Western Fisheries Research Center (WFRC)! 2015 was a good year, filled with exciting science collaborations, accomplishments, and developing new partnerships. In May, we completed our Strategic Science Plan, outlining our center-wide capabilities and science directions. The plan helps to demonstrate our Center's capacity and guide our future science directions as we work with partners. Our scientists have work throughout the western U.S., as well as collaborations across the U.S. and Internationally. We are recognized for research on fish disease, fish passage and restoration following dam removal, but our research and expertise also extends into many other fisheries themes. We continue to be responsive to emerging issues and develop innovative tools and approaches that can help us to understand our changing aquatic world. In October, we held a retreat for principal investigators across the Center to meet, share their science and capabilities, and discuss collaborations. Working across the landscape can be challenging, so it was great to get together and learn more about each other. We gained an appreciation for the diverse skills and talent in this Center. A highlight from 2015 was a visit from U.S. Department of the Interior Secretary Sally Jewell and U.S. Representative Suzan DelBene (WA 1st District). While visiting the WFRC, Jewell and DelBene participated in a panel discussion on climate change and natural disasters, toured the WFRC, and visited with scientists. We gave a tour of the Seattle headquarters and laboratories—state of the art facilities for conducting experiments that explore factors that influence fish biology, fish behavior, fish genetics, disease resistance, infection processes, pathogen virulence, and transmission of pathogens— and talked about research at WFRC. Jewell and DelBene engaged in discussions along the tour with scientists working on habitat restoration, aquatic animal health, and immune response. We were happy to host the visit, meet these special guests, and share our science!

In this brief we feature some of our current work and highlight our accomplishments for the year. We hope you find this report useful and feel free to contact us for further information. We look forward to hearing from you and working with you this coming year.

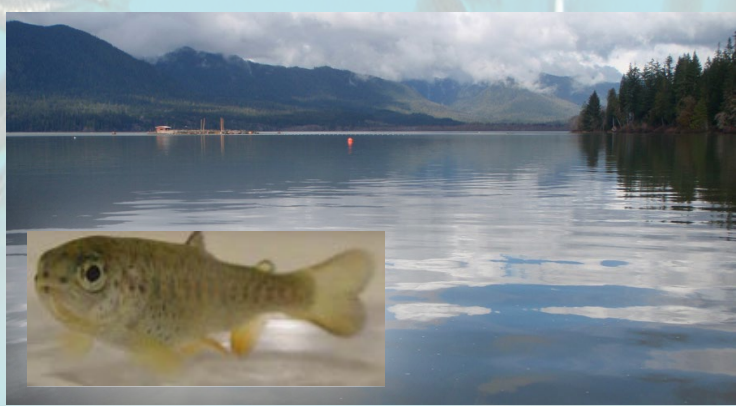
Jill Rolland, Sc.D., Center Director

The mission of the WFRC is to provide the scientific understanding and innovative technology needed to support sound management and conservation of our nation's natural resources, with an emphasis on aquatic ecosystems, fisheries biology, and fish health. Our goal is that natural resource managers, policy makers, and the scientific community will recognize the WFRC as a premier source of objective and socially-relevant scientific information. To achieve this goal, the WFRC will maintain a highly skilled and adaptive workforce and infrastructure in order to be responsive to changing and emerging issues in aquatic ecosystems and fisheries biology. A priority for the WFRC is to provide the results of scientific research to resource managers in an effort to support informed decision making.

We are staffed by 110 federal employees (64 permanent, 39 term, 7 temporary), and 38 non-federal employees. Our WFRC scientists work from four locations in two western states. Laboratories are located in Seattle, on Marrowstone Island, in the Columbia River Gorge, Washington, and in Klamath Falls, Oregon. The Center is one of 16 USGS science centers engaged in biological research on critical natural resource issues facing the nation. Our research includes work in habitats that encompass rivers, streams, lakes, estuaries and marine environments. We help in recovery of imperiled species ranging from threatened populations of Pacific salmon to endangered desert fishes. We are concerned with fish diseases, and with the multiple stresses imposed by human activities such as water and land development, grazing, mining, and harvest on aquatic ecosystems. We study aquatic invasive species—organisms that can alter natural habitats and harm native populations – to help control or mitigate their spread and effect. We are innovative, helping devise new technologies to better manage hatcheries and care for wild fish populations, using state-of-the-art approaches ranging from molecular genetics to decision support computer models. We are collaborative and multidisciplinary in approach, and our scientists are well known in the national and international fisheries community.

Infectious disease is increasingly recognized as an important component of all natural aquatic and terrestrial ecosystems, affecting both population dynamics and ecosystem function. While diseases in captive aquatic animals are relatively easily observed and studied, impacts among populations of free-ranging fishes often go unobserved and are difficult to study. In addition, natural populations of fish are threatened by novel emerging diseases due to factors such as increased commercial aquaculture, global trade, ecosystem alterations, and a changing environment. The fish disease program at WFRC includes a mix of basic and applied science focused on understanding the factors that control the distribution and severity of infectious diseases affecting both hatchery and wild fish. Aquatic health research at the Seattle laboratory includes work in virology, bacteriology, immunology, histology, molecular biology/genetics, fish pathogen ecology, epidemiology, and evolution, and genetics. We continue to develop methods and tools to understand the spread of disease in fish and help inform managers.

Researchers at the WFRC Seattle laboratory have been conducting research including genetic typing of a fish virus, Infectious Hematopoietic Necrosis Virus (IHNV). The virus infects both adult and juvenile salmonids in the Western U.S., but causes disease and frequently high mortality in juvenile fish reared in hatcheries. Portions of the research involve studies to identify factors that control the virulence of the virus in differing species or stocks of salmonids, including drivers of emergence and displacement events in steelhead trout in western North America. One factor that could affect the susceptibility of fish to IHNV is a reduction of genetic variation in the population. A recent study, published in *Diseases of Aquatic Organisms*[1] by Marine Brieuc of the University of Washington, WFRC scientists and collaborators, investigated the genetic variation underlying IHNV resistance among steelhead trout populations. A second study published in *Virus Evolution*[2] by USGS Post-doctoral researcher Rachel Breyta and collaborators found that increasing virulence was associated with serially emergent virus strains of IHNV in steelhead trout. Understanding the mechanisms of host resistance to pathogens will allow insights into the response of both hatchery and wild populations of salmonids to the emergence of new pathogens.



At the WFRC's Marrowstone Marine Field Station (MMFS), Paul Hershberger and colleagues have been investigating diseases in marine fishes. In a recent issue of the *Canadian Journal of Fisheries and Aquatic Sciences*,[3] Hershberger and collaborators investigated the principles underlying the ecology of

viral hemorrhagic septicemia (VHS) in Pacific herring. Outbreaks of VHS occur periodically and are often associated with observed fish kills that can have population-level impacts on various stocks of herring throughout the NE Pacific Ocean, including Prince William Sound. Based on a combination of field studies, controlled laboratory experiments, and previously unpublished observations, the scientists identified principles that govern the epizootiology of VHS in Pacific herring and provide a basis for assessing risk factors in certain marine fish populations. Articles in *Journal of Fish Diseases*[4] and *Journal of Aquatic Animal Health*[5] also feature research by WFRC scientists and collaborators focused on the effects of a parasite *Ichthyophonus* sp. in Pacific herring in coastal waters.

Recent concerns with sea star wasting disease have brought scientists from around the country together to study one of the largest known natural outbreaks of a marine disease. Sea stars are currently dying at dramatic rates across the West Coast from Baja California in Mexico to Alaska with the potential to substantially alter marine ecosystems. Tragically, sea star wasting disease is not specific to a single species as more than 20 types of sea stars have been found to be affected. USGS scientists at the MMFS have been working with collaborators to study this new epidemic and find the cause of sea star deaths.

In 2015, WFRC researchers published 39 peer reviewed journal articles, 11 USGS science products, and 5 Cooperator reports.

To learn more about what scientists are finding out about sea star wasting disease, check out PLOS One DOI:10.1371/journal.pone.0133053.[6]

Scientists leading work in aquatic animal health include Dr. James Winton, Dr. Paul Hershberger, Dr. Maureen Purcell, Dr. Gael Kurath, Dr. Diane Elliott, Dr. John Hansen, Eveline Emmenegger, and William Batts.

Understanding how our ecosystems are changing will be critical for making decisions and finding strategies that can support our aquatic resources. Ecosystems and the benefits they provide are continually changing in response to physical, environmental, and biological conditions. Identifying and understanding human- and naturally- induced stresses to ecosystems at multiple spatial and temporal scales is needed. In the western U.S., dam construction, channelization of waterways, invasive species, agriculture, mining, and urbanization have resulted in changes to habitat and water quality. Recent projections for the upcoming century point to rapid alterations of climate that will affect water temperatures, sea level rise, and seasonal river flows, resulting in changes to fish and wildlife habitats and migratory patterns. Scientists at WFRC work with a variety of partners to investigate changes in ecosystems, evaluate alternatives, and provide science to support management decisions.

Scientists from WFRC have been working in the Willamette River Basin to evaluate ways to reduce impacts of flood risk management and hydropower on fish populations. The Willamette Valley Project in western Oregon (operated by the U.S. Army Corps of Engineers, USACE), includes a series of 13 dams that provide both flood-risk management and hydroelectric power production. In 2008, the National Oceanic and Atmospheric Administration (NOAA) determined these dams to be jeopardizing the sustainability of anadromous fish stocks listed under the Endangered Species Act (ESA) in the Willamette River Basin and required the USACE to make improvements to reduce impacts on Chinook salmon and steelhead. Scientists from WFRC's Columbia River Research Laboratory (CRRL) are working with the USACE to evaluate structural and operational changes at two dams (Detroit and Cougar dams) designed to improve fish passage and survival. John Beeman and Toby Kock are using acoustic telemetry to study the behavior of juvenile Chinook salmon and steelhead passing through Detroit reservoir and dam as they migrate seaward. In a recent *USGS series report*[7], researchers found that the primary factors affecting dam passage rates were seasonal dam operating conditions, which involved the use of a spillway, and time of day. This work, built on a previous evaluation, is published in a 2014 *USGS series report*[8] describing in detail what affects fish passage at the dam. Based on fish behavior in the reservoir, they found that a properly-designed surface passage route could be a viable downstream passage alternative for juvenile Chinook salmon and steelhead at Detroit Dam.

The San Francisco Bay and Sacramento-San Joaquin Delta form one of the largest estuaries in the U.S. and provides water to more than 25 million California residents and farmlands. It is also home to many birds, wildlife, and fish, but changes in this ecosystem have caused some species to become low in number and listed under the ESA. The WFRC has been researching survival, abundance, and migration dynamics of juvenile Chinook salmon in the Sacramento – San Joaquin River Delta (Delta). The WFRC's expertise in both animal telemetry and quantitative modeling and analyses was used to help understand how water management actions affect juvenile salmon populations in the complex network of natural and manmade channels

forming the Delta. These studies involved a team of interdisciplinary scientists and experts from the WFRC, USGS California Water Science Center, University of California Davis, NOAA Southwest Fisheries Science Center, California Department of Water Resources, U.S. Fish and Wildlife Service (FWS), and Bureau of Reclamation (BOR). Together, scientists are learning more about survival and migration routing of juvenile Chinook salmon in the Delta and are providing a science-based strategy to reinforce the reliability of California's water supply while preserving and restoring the Delta ecosystem. Russell Perry and collaborators have been developing a model that combines fish entrainment and hydrodynamic data to evaluate the effects of alternative water management actions on fish entrainment into the interior Delta (an area with poor survival of juvenile Chinook salmon). They found that the probability of fish entrainment into the interior Delta at key river junctions depended strongly on the river flow and tidal stage at the time of fish arrival at the river junction. Results from this study were published in the journal *Transactions of the American Fisheries Society*[9]. In addition, altering water diversions during specific times of the day can allow managers to use diversions and also reduce fish entrainment into the interior Delta according to a study published in *River Research and Applications*[10] by John Plumb and colleagues. Plumb looked at experiments where acoustic-tagged fish were released upstream of a diversion, the Delta Cross Channel diversion and modeled arrival times and entrainment probabilities in relation to flow from upstream, change in flow, and water temperature.

In 2015, WFRC researchers submitted 80 research proposals and were successfully awarded 72- yielding $6.7 million in research funding.

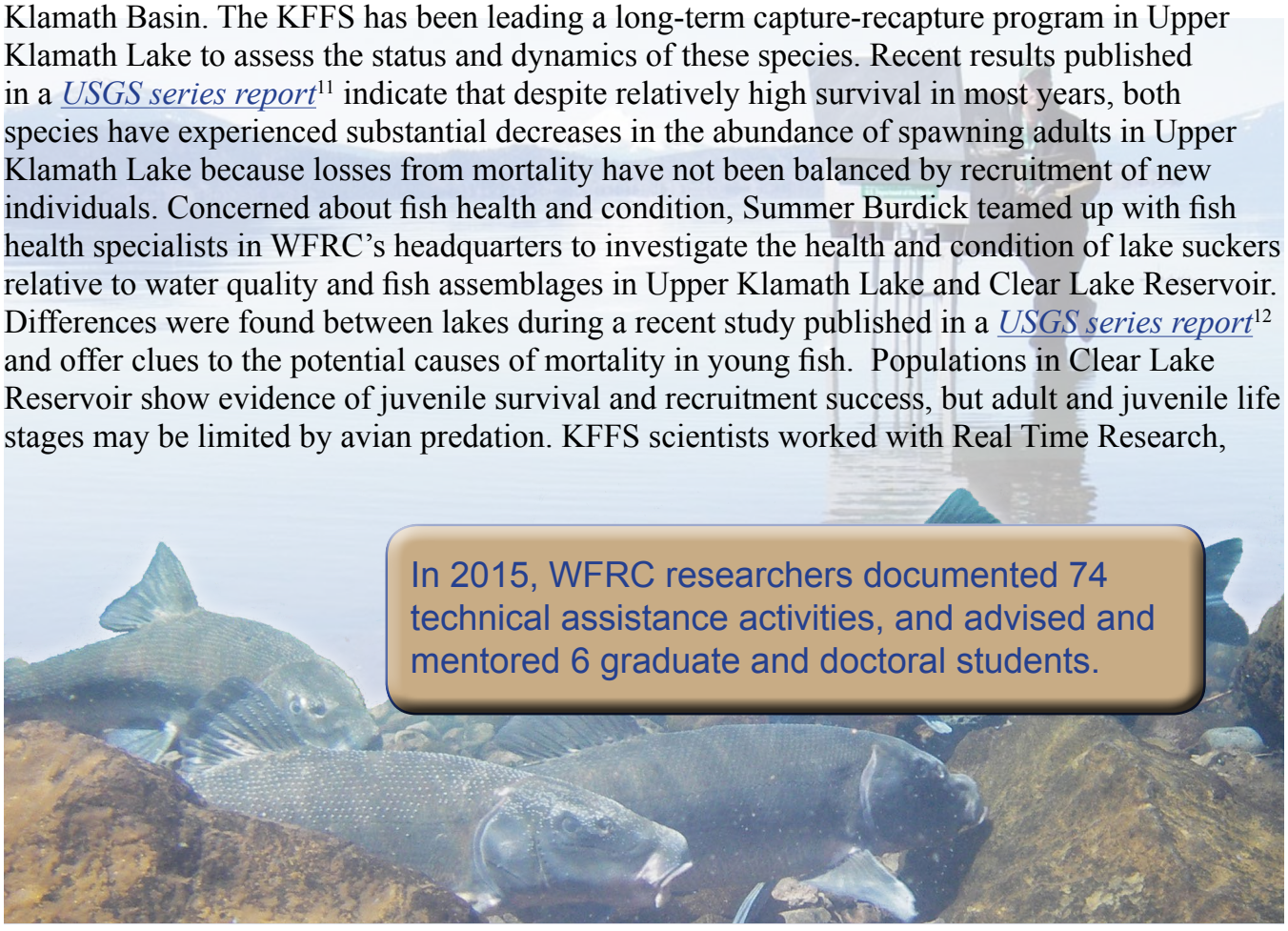
To learn more about how water diversion is affecting juvenile Chinook salmon in the Delta, check out Transactions of the American Fisheries Society, 144(3): 445-455.[9]

Scientists leading work in the Willamette River Basin include John Beeman, Noah Adams, and Toby Kock.

Scientists leading work in the Bay-Delta include Dr. Russell Perry, Dr. Jason Romine, Adam Pope, Theresa Liedtke, and Noah Adams.

Providing science to support ecosystem restoration and species recovery is an important role at WFRC. The Pacific Northwest and Intermountain West contain abundant natural resources that sustain significant economic, cultural, societal and ecological values. As a result of large habitat loss and modifications from a variety of factors, some of these valued resources have been diminished, leading to listings under the ESA. Managers are often tasked with reversing or changing current ecosystem processes to re-establish historical or preferred patterns. These efforts vary in focus and include broad-scale bio-physical processes as well as individual species that have legal protection or significant economic value, for example restoration projects focused on several species or subspecies of Pacific salmon. The USGS has a role in ensuring that the efforts of natural resource managers are informed with the latest and most relevant science. Science driven support of habitat restoration and species recovery contributes towards conservation, restoration, and sustainability of biological diversity.

Scientists at WFRC's Klamath Falls Field Station (KFFS) are working with partners to address several high priority research areas for fisheries issues in the Upper Klamath Basin. Providing adequate water of sufficient quality to meet ecosystem needs has proven to be a delicate balancing act, and prolonged drought has further exacerbated water management challenges. Understanding the effects of water management on water quality and quantity are critical to efforts to recover species listed under the ESA. Lost River and shortnose suckers are federally endangered catostomids (lake suckers) that are endemic to large water bodies in the Upper Klamath Basin. The KFFS has been leading a long-term capture-recapture program in Upper Klamath Lake to assess the status and dynamics of these species. Recent results published in a *USGS series report*[11] indicate that despite relatively high survival in most years, both species have experienced substantial decreases in the abundance of spawning adults in Upper Klamath Lake because losses from mortality have not been balanced by recruitment of new individuals. Concerned about fish health and condition, Summer Burdick teamed up with fish health specialists in WFRC's headquarters to investigate the health and condition of lake suckers relative to water quality and fish assemblages in Upper Klamath Lake and Clear Lake Reservoir. Differences were found between lakes during a recent study published in a *USGS series report*[12] and offer clues to the potential causes of mortality in young fish. Populations in Clear Lake Reservoir show evidence of juvenile survival and recruitment success, but adult and juvenile life stages may be limited by avian predation. KFFS scientists worked with Real Time Research,

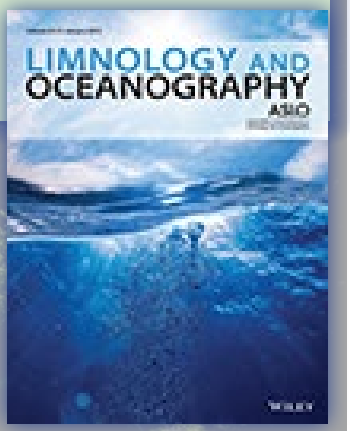


In 2015, WFRC researchers documented 74 technical assistance activities, and advised and mentored 6 graduate and doctoral students.

Inc. to investigate avian predation and found that predation in Clear Lake can be a substantial source of adult annual mortality. Finally, Summer Burdick and colleagues addressed concerns about spawning activity of Lost River suckers being affected by varying water levels. Results in a recent article in *North American Journal of Fisheries Management*[13] indicate that spawning habitat is reduced during low water levels, which may exacerbate factors that are limited recruitment into the population in Upper Klamath Lake.

Researchers across WFRC continue to evaluate the effects of dam removal and how ecosystems recover. As mentioned in *Science*,[14] dams have been taken down in increasing numbers as they have filled with sediment, become unsafe or inefficient, or otherwise outlive their usefulness. Jeff Duda has been involved in research efforts in the Elwha River, following the Nation's largest dam decommissioning. His work is highly collaborative, and involves developing monitoring and evaluation data for freshwater, estuarine, and marine ecosystems. As the ecosystem continues to change and fish begin to re-colonize habitats that were blocked off for over 100 years, researchers learn more about both physical and biological processes. Jeff Duda and collaborators have been investigating the rapid changes in marine-derived nutrients, food webs, and water quality since dam removal. Results from their work were recently published in *Biological Conservation*.[15] WFRC has a number of other research evaluations related to dam removal throughout in the Pacific Northwest, including Powerdale, Condit, and Hemlock dams. As we continue to play an important role in providing evaluations and scientific support on projects of varying scales, we gain a broader perspective that will help guide future efforts in both dam removal as well as ecosystem recovery.

To read more about the effects of dam removal and rapid changes in water quality during dam removal, check out Limnology and Oceanography, 60(5): 1719-1732.[16]



In 2015, WFRC researchers gave 57 professional presentations to the public and science audiences throughout the U.S. and the world.

Scientists leading work on federally endangered catostomids out of the Klamath Falls Field Station include Eric Janney, Summer Burdick, and Dr. David Hewitt.

Scientists leading work in dam removal and ecosystem recovery include Jeff Duda, Dr. Patrick Connolly, James Hatten, and Eric Janney.

The WFRC enjoys partnering with an extended network of clients, colleagues, co-investigators, and customers. Our partners include DOI agencies such as the FWS, BOR, USACE, and the National Park Service, tribal governments, and non-government organizations such as the Nature Conservancy, the Lower Columbia River Estuary Program, and the Puget Sound Partnership.

The WFRC brings to its many partnerships expertise, research capabilities, and an unbiased approach to conducting and reporting results. Our partners bring natural resource problems, management perspective and relevance, and questions that challenge our research scientists. Partnerships are important to WFRC and our scientists are working with partners to conduct integrated and inter-disciplinary research needed to address complex scientific questions and challenges.

In 2015, Jeff Duda was awarded an Excellence in Restoration Award from the NOAA Restoration Center, along with co-recipients and partners George Pess (NOAA) and Roger Peters (FWS) for their work on development and implementation of monitoring and adaptive management guidelines for the Elwha River restoration project. In addition, Jeff is also collaborating with USGS scientists from multiple USGS centers, with funding from the Community of Data Integration, to update a currently static database making it a more dynamic, interactive element within USGS ScienceBase. Users will be able to locate, interact with, and upload new scientific information about dam removal studies.

Russell Perry has joined the USGS Bay-Delta Science Planning Team. He and other researchers at the WFRC's CRRL have been collecting data and providing information to support agency decisions and directions in the Bay-Delta, where both the state and federal agencies are working intensively to define a science-based strategy to reinforce California's water supply reliability while preserving and restoring the Bay-Delta ecosystem. The science planning team —developed by the USGS Pacific Region Bay-Delta Executive Board —is intended to assist involved USGS science centers and the regional office in coordinating USGS research in the Bay-Delta, and in developing advice and priorities for future studies.

Our collaborations extend internationally as we engage in active scientific collaborations, provide technical assistance, cooperate as members of working groups, and serve on international technical commissions (e.g. Food and Agriculture Organization of the United Nations, the World Organization for Animal Health (OIE), and International Commission for Taxonomy of Viruses). In 2015, our Center hosted international visitors and were invited to participate in a number of international activities.

John Beeman traveled to Vientiane, Laos in Southeast Asia, along with Dave Hand from the FWS as co-leads of the Fish Migration Team, a project of DOI's International Technical Assistance Program. Beeman, Hand, and others specializing in fish ecology and fish genetics, were tasked with assessing the existing state of knowledge related to Mekong River fish migration behavior and craft a long-term research agenda to better inform future sustainable hydropower development, fish passage threshold development, and sustainable fish harvest.

Diane Elliott was invited to Puerto Varas, Chile, to present at a workshop on salmonid bacterial kidney disease (BKD). The workshop focused on strategies for improved management of BKD in cultured salmonid fishes in Chile. The WFRC is the OIE reference laboratory for this globally important disease, which occurs in both wild and cultured salmonids and causes significant fish losses in Chilean aquaculture. Scientists at WFRC have developed and validated several of the standardized assays used for BKD diagnosis, as well as one of the methods most widely practiced in aquaculture and conservation hatcheries for preventing transmission of the causative pathogen, *Renibacterium salmoninarum*, from parent fish to their progeny.

Jim Winton traveled to Shenzhen, China, to meet with staff of the Key State Laboratory of Aquatic Animal Diseases as part of an international project funded by the OIE. The WFRC is currently the sole OIE Reference Laboratory for infectious hematopoietic necrosis (IHN), a virus disease of salmonid fish that was originally endemic only to North America, but has emerged to become a significant problem affecting coldwater aquaculture in Asia. The goal of the project is to provide the training and experience to allow the Key State Laboratory of Aquatic Animal Diseases to be designated as a new OIE Reference Laboratory for IHN.

Sharing our science and engaging our youth is important at WFRC. Scientists serve as advisors, participate in schools, and engage in activities with youth ranging from elementary school through college. We participate in programs that promote diversity and provide opportunities in fisheries science. In 2015, researchers throughout the Center participated in a number of educational outreach activities.

WFRC Center Director Jill Rolland hosted students from Western Washington University involved in the Multicultural Initiative in the Marine Sciences: Undergraduate Participation (MIMSUP) program. Funded by the National Science Foundation, MIMSUP is designed to increase diversity within the next generation of marine scientists by recruiting students from underrepresented groups (i.e., Native Americans, Alaskan Natives, African Americans, Latino/Hispanics and Pacific Islanders).

Scientists provide talks and participate in workshops that teach about fisheries topics and careers in science. In 2015, research ecologist Jeff Duda presented a workshop at a Northwest Scientific Association meeting on best practices for submitting manuscripts for peer review to graduate students and professionals.

Noah Adams and other WFRC scientists participated in a reenactment of the voyage of Lewis and Clark. About 50 Stevenson High School students (Stevenson, WA) made the journey in kayaks over a 4-day period. The WFRC participated throughout the trip by providing information about the Columbia River, its ecosystem, and how it has changed since the time of Lewis and Clark's journey. The scientists also discussed career opportunities with federal agencies and highlighted some of the work the USGS does to help inform management of resources the river provides (hydropower, fisheries, irrigation, transportation, and recreation, etc.).

WFRC scientists visited classrooms to share their science and discuss their work. Summer Burdick gave a talk to students in a fisheries class at Chiloquin School (Chiloquin, OR). The fisheries program at Chiloquin School, which is primarily attended by tribal students, is a community and tribal supported program to foster interest in natural resources sciences among 8th to 12th grade students. Summer's presentation focused on fish ecology and fisheries issues in the Klamath Basin and was followed by a tour of the Klamath Tribal Fish Research Facility, where USGS scientists conduct research on factors effecting survival of juvenile endangered suckers. Roz Lehner and Lynn "Chip" Applegate introduced students to fisheries science and discussed scientific professions to 75 first graders at Meridian Park Elementary School (Seattle, WA).

WFRC scientists participate with university students, serving as advisors, providing talks, and participating in research. Scientists in the Center are involved with the Fisheries program at the University of Washington, as student advisors and speakers. University of Washington graduate student Daniel Hernandez, a graduate of MIMSUP, is currently conducting his thesis research at the WFRC. WFRC scientists also serving on graduate committees at Washington State University and Oregon State University.

Honors

WFRC Scientist Receives Distinguished Service Award in Fish Health

In 2015, WFRC scientist Diane Elliott was awarded the S.F. Snieszko Distinguished Service Award at the American Fisheries Society (AFS) Fish Health Section annual meeting in Ithaca, New York. The S.F. Snieszko Distinguished Service Award, considered the highest award given by the Section to a fish health professional, is presented to individuals to honor their outstanding career accomplishments in the field of fish health. Elliott is the third woman to receive this award and the fifth recipient from the WFRC. There have been 38 total previous recipients since it was first awarded in 1979.

Diane Elliott, center, the 2015 S.F. Snieszko Distinguished Service Award winner, with previous recipients who attended the Fish Health Section's annual meeting. Left to right: Ron Thune, Paul Bowser, Elliott, Ted Meyers, and Vicki Blazer. Janice Plante photo. Fish Farming News, Aquaculture's National Newspaper – Volume 22 – Issue 4 – 2015 – A Compass Publication. Permission to use photo granted by Richard W. Martin, Editor and Publisher, FFN, April 19, 2016.

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Image 1. Jeff Duda was awarded an Excellence in Restoration Award from the NOAA Restoration Center, along with co-recipients and partners George Pess (NOAA) and Roger Peters (FWS). Photo by Amilee Wilson, NOAA.

Image 2. Puget Sound. Photo by W.D. Woodson, USGS.

Image 3. Collin Smith, fishery biologist and Ryan Tomka, biological technician collecting phytoplankton samples to assess carbon and nitrogen ratios in the food web within central Puget Sound to evaluate the effects of urbanization on the nearshore ecosystem. Photo by Lisa Gee, USGS.

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Image 1. USGS scientist John Beeman (center) with fishery scientists from Laos (left: Phousone Varasane, National University of Laos, right: Vannida Boualaphan, Laos Living Aquatic Resources Research Center) during a tour of Bonneville Dam, Columbia River, Oregon, February 18, 2016. Photo by Jon Rerecich, USACE.

Image 2. WFRC research scientist Dr. James R. Winton meeting with Dr. Zhao Zhen Shuan, Director General of the Shenzhen Entry-Exit Quarantine Bureau of the People's Republic of China. The meeting served to initiate a laboratory twinning project funded by the World Organization for Animal Health. Photo courtesy of the Shenzhen Entry-Exit Quarantine Bureau.

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Image 1. University of Washington graduate student Daniel G. Hernandez, a graduate of MIMSUP, who is conducting his thesis research at the WFRC. Photo by Gael Kurath, USGS.

Image 2. Joe Acosta, U.S. Forest Service engineer, assesses a recently replaced culvert in Siuslaw National Forest. Many culverts are barriers to fish passage and need to be replaced to improve passage and connectivity. USGS Rachel Reagan, a biologist and Pathways Career Intern at WFRC, recently completed her graduate work focused on prioritizing barrier removals at Oregon State University in the Fisheries and Wildlife Department. Photo by Rachel Reagan, USGS.

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Image 1. Histological sections of Pacific herring heart (top). Dark purple specific DNA staining identifies the *Ichthyophonus* parasite. Red-spotted newt skeletal muscle (bottom) after CISH staining. No specific DNA staining in a parasite previously identified as *Ichthyophonus.* (Background)

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Image 1. Boats along the bank of the Mekong River. Photo by John Beeman and Matthew Anderson, USGS.

Image 2. Fish at a local market at Luang Prabang, Laos. Photo by John Beeman and Matthew Anderson, USGS.

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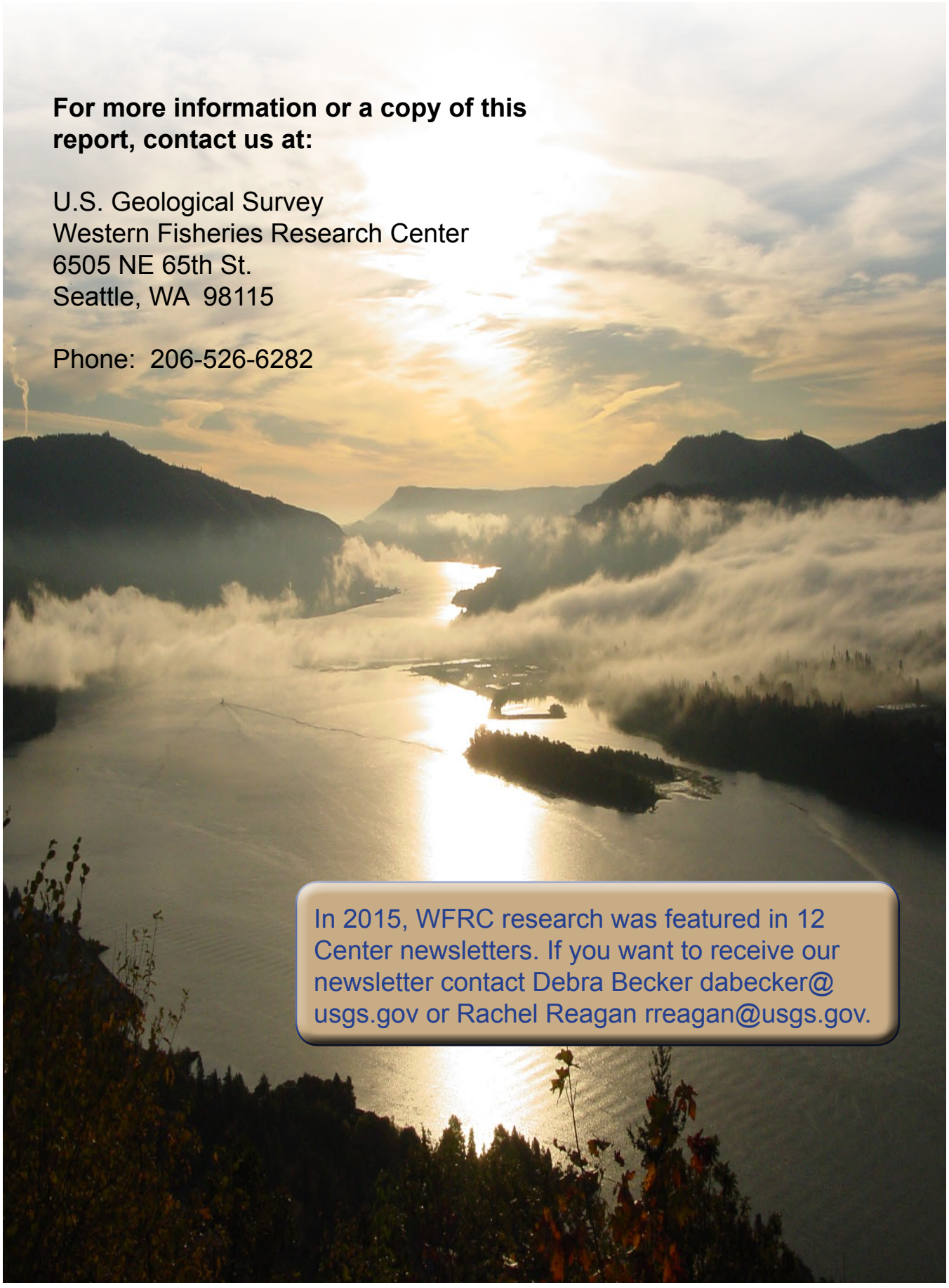
Image 1. Columbia River sunrise. Photo by Glen Holmberg, USGS.



For more information or a copy of this report, contact us at:

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In 2015, WFRC research was featured in 12 Center newsletters. If you want to receive our newsletter contact Debra Becker dabecker@usgs.gov or Rachel Reagan rreagan@usgs.gov.

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