California Cooperative Fish & Wildlife Research Unit

California Redwood image designed by Yoshiko Yamamoto
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2013 Coordinating Meeting

May 14, 2013
Humboldt State University
1 Harpst Street, Arcata, CA

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Humboldt State University, Behavioral & Social Sciences Building, room 508

AGENDA

Introductions and Welcome (Chair, Joe Margraf) ……...……9:00
Additions to the Agenda
Approval of 2012 Meeting Minutes

Cooperator Reports and Research Needs ……..……...……9:15
Each Cooperator is given the opportunity to speak about current issues and research needs within their organization as they relate to the mission and operation of the Cooperative Research Unit.

Unit Research Summary
Completed Projects Review (Duffy & Wilzbach) ……..……..…. 11:15

Lunch catered ……..……... 11:45

Unit Research Summary (continued)
Research Presentation (Tancy Moore) …….…… 1:00
Current Research Projects Review (Duffy & Wilzbach) …….……... 1:45
New Research Projects (Duffy & Wilzbach) …….…... 2:00

Unit Program Review ……. 2:30
University Service and Technical Assistance
Cooperative Agreement and Program Direction
Accomplishments
Facilities and Equipment
Financial Status

Adjourn ……. 2:45

2012 Coordinating Committee Meeting Minutes

Wednesday, May 9, 2012

The annual coordinating meeting was held at Humboldt State University, 1 Harpst Street, Arcata, California. The meeting began at 9:05 am and concluded at 2:50 pm.

In attendance:

Chris Adams, CA Cooperative Fish & Wildlife Research Unit

Philip Bairrington, CDFG-Arcata

Russ Bellmer, CDFG-Sacramento

Walt Duffy, Unit Leader, CA Cooperative Fish & Wildlife Research Unit

Leslie Farrar, CA Cooperative Fish & Wildlife Research Unit

Nancy Finley, USFWS-Arcata

David Hankin, HSU-Fisheries Department

Joe Margraf, USGS Western Region

Steven Smith, HSU-CNRS

Nick Som, USFWS-Arcata

Margaret Wilzbach, Assistant Unit Leader, CA Cooperative Fish & Wildlife Research Unit

Steve Smith served as chair and opened the meeting. The agenda was reviewed and a change was requested to add a brief cooperator's meeting immediately following the main meeting. Minutes of the 2011 meeting were reviewed with the suggested restructuring of budget to show break down by funding agency, all agencies grouped together with a sub total and alpha order instead of from newest to oldest (suggested by Russ Bellmer). No other additions or corrections (Russ Bellmer motioned and Joe Margraf seconded).

COOPERATOR REPORTS

Report from Joe Margraf, USGS

- Federal budget: This is the second year of continuing resolutions with no real budget for the past two years. Chances of a budget this year are low being an election year. The good news is that the base budget three years ago allowed the bureau to fill vacancies and 26 new people were hired in the last two years. There are still some remaining vacancies. The bad news is that the continuing resolutions contain language to reduce budget which translates to unit discretionary funds having been reduced from $20,000 to $8,000 this year. If funds are needed for vehicle replacement, the minimum amount is $5,000 which leaves the units with essentially $3,000 to spend. Next year base funds are expected to be further reduced, which will probably result in accruing vacancies again. He does have some discretionary funds to which the priority is safety needs with the second priority being project critical needs to bridge unit funds.

- In the surrounding states, Arizona has a vacancy in the assistant leader position. John Bissonette, unit leader for Utah will be retiring June 2012. There are a couple more retirements expected in the West in the next couple of years.

- Walt Duffy was presented a certificate and pin for 30 years of service. Walt thanked Joe Margraf and wanted to welcome Nick Som to the university last fall who has already been of assistance to our students and is serving on one of our graduate committees.

Report from Nancy Finley, USFWS-Arcata

- USFWS does not yet have a budget but has a known cut to its Fisheries allocation of $150,000. This cut is less than expected. It appears the remaining program areas will be about status quo from last year. We were told to plan for a 3% decrease. Next year is expected to be a different story, but unknown at this time.

- The Red Bluff office of Ecological Services (ES) was closed last year. They have retained the fisheries component but not the ES component. Our office picked up Mendocino National Forest as well as the BLM lands and was given funds for the positions, but no positions. Eventually they were able to hire two people, looking into growing students into the positions. Student Career Experience Program (SCEP) has been a great program, but this program is ending and another type of program is beginning soon. Some of the new program changes are limits in types of hires and no non-competitive hiring. Nancy will send announcement when she gets the details of the replacement program to SCEP. The most recent hire is Nick Som as statistician/biometrician. They are looking into hiring a data manager at this time. Randy Brown is on extended leave.

- Recent projects include hatchery review which is in draft form. The report is final and is awaiting comments for external review. There are heavy expectations from the tribes for significant changes in how the hatchery will be managed. Klamath fall chinook run size projected to be 381,000 fish and the potential for disease is anticipated. Have convened meetings with the Bureau of Reclamation and NOAA to avoid another disease event like occurred in 2002. This year attempts are being made to avert conditions that might be

negative by being more assertive on water flow decisions. Water users will be impacted and the plans will be announced by the end of May.

- Trinity River management budgets are getting tight. Phase I review: Restoration Activities moving to Phase II activities with a report expected sometime this summer. This is headed by the science advisory board with an outside consulting agency (Seattle). Prioritization of research projects will also be done to fit into the budget that is available.

- Klamath Basin Restoration Agreement is waiting for legislation, secretarial determination, has been delayed. The scientific overview report is nearly completed. Discussed some use of DIDSON instrumentation of the lower Klamath River. Yurok Tribe taking lead on monitoring, KFAT group and other groups meeting on the same topic. Want to know if fish are moving or stacking up. There will be some disease monitoring to be preventative. Discussion among the group regarding DIDSON units that could be loaned; Joe suggested that people coordinate through Walt to be consistent. Nancy would like to see coordination of efforts and a technical discussion, peer review and broader buy-in. Currently suggesting two flows to be preventative and also a catastrophic flow if needed.

- Nick Som has been working on Klamath production runs and fish health work too.

<u>Report from Philip Bairrington, CDFG-Arcata</u>

- Smith River: Justin Garwood is working on the Smith River monitoring plan, completed a REDD survey this past winter showing phenomenal numbers. Plans to have a life cycle monitoring (LCM) station at Mill Creek and at west branch and east fork for down-migrant juveniles. Contemplating putting a DIDSON at mouth of Mill Creek on the Smith to monitor coho. The past two years there were two DIDSON units around the county boat ramp which counted 38,000 fish which worked well. They were able to monitor the units 24/7 during the October – March sampling every 20 minutes with the ability to process data real time. They had a system of getting the two units to communicate saving travel back and forth to either side of the river. This also protected the equipment against vandalism by spending the nights there. This was a great system, but now will sample less to reduce costs due to economic reasons. Garwood also submitted proposal for snorkel surveys in the summertime.

- Redwood Creek: Prairie Creek is coho territory wants to see full life cycle monitoring station there. Redd surveys are already going on and they have been working with the Coop Unit's grad student, Matt Metheny, on his DIDSON work there.

- Mad River: Had a proposal to do Redd surveys and fish counting that didn't get funded, but the Wildlife & Sport Fish Restoration Program had some temporary funds for which concept papers were submitted and are waiting to hear on those. They plan to develop an "expert team" that will migrate around servicing Mad River, Upper Redwood Creek and Orick to service units. Due to Walt's retirement, they are looking to take over the Coop Unit's projects with Mike Sparkman taking the lead.

- Humboldt Bay: Mike Wallace and Seth Ricker are working in this area looking at rearing habitat of coho in the sloughs. There are other organizations interested in this

work. Seth is transitioning to be the coordinator of the Northern Regional Coastal Monitoring plan which includes the Eel River and Mendocino coast. Sean Gallagher wraps up a number of streams together on the Mendocino coast and there is a DIDSON unit functioning on Pudding Creek. Was successful in obtaining occupancy on the lower portions of the Eel River for Redd surveys.

Report from Russ Bellmer, CDFG-Sacramento

- The department has accepted DIDSONs; there was a huge request for the units (87) but the order was culled down to about half for deployment and training purposes. The Coop Unit provided some training for the initial deployment which worked out well. The second order has been held up in procurement which has delayed deployment southwards. They are looking for suitable sites that employ biology, structure, security and ability to service the units once they are deployed. There are proposals for Russian River basin-wide framework; also locations in Marin, San Mateo, Santa Barbara counties are being planned. The two DIDSONs deployed on the Ventura River and Topanga Canyon Creek were placed more for practical and training purposes.

- Pete Adams and others compiled a publication for California Fish & Game Bulletin (#180, see http://libraries.ucsd.edu/apps/ceo/fishbull/) which is a summary of their statewide coastal monitoring plan. Monitoring plans have been expanded to include Central Valley so that Valley plans are consistent with Coastal methods and procedures (with some exceptions). CDFG expects this to greatly improve state-wide monitoring plans for salmonids (including steelhead). The report has been heavily scrutinized with good support with the review comments. There is another plan out for the Central Valley steelhead and Chinook plans. The project plans to repeat the Hallick experiment with an upgraded statistical approach.

- Chuck Bonham was appointed Director in September 2011. He has instituted a Salmonid Vision Team with Kevin Shaeffer as lead and a Science Vision Team to bring back the science into CDFG. Stafford Lehr is a new Branch Chief of the Inland Fisheries Branch. Dan Yparraguirre is the Acting Deputy Director of Wildlife Division. Much of the leadership consists of HSU Alums.

- A new document published April 2012, California Fish & Wildlife Strategic Vision: Recommendations for Enhancing the State's Fish & Wildlife Management Agencies (see http://www.vision.ca.gov/docs/CFWSV_Booklet_120423_Adobe10_100ppi.pdf) emphasizes collaborative multi-agency work using integrated resource management and program efficiencies.

- Council on Ocean Affairs, Science and Technology (COAST) internship program (see: http://www.calstate.edu/coast/funding/student_Intern_2012_rfa.shtml) had ten positions located all over the state, filling eight of them. Five HSU students applied and 2 were placed for this summer. These are paid a stipend of $2,500 for a ten week summer program. Steve Smith will alert folks to the program when the announcement comes out. Applications are due in March.

- Fisheries Restoration Grant Program (FRGP) http://www.dfg.ca.gov/fish/Administration/Grants/FRGP/ had $60 million in

requests this year which means that 4x the proposals were submitted than can be funded.

Report from Steve Smith, HSU-CNRS

- Budget was level last year. HSU has been positioning itself for a long-term reduction in budget. HSU levied a "material, services and facilities" fee of $140 per semester per student, supplying about $2M, of which $1M goes to CNRS. Approximately 3/4 of these funds are used to offset funding for technicians for programs that are not typical in the college—e.g. hatcheries and greenhouses.

- Over the past five years enrollment has grown 11%. Of that growth 79% are CNRS students which have higher cost programs. HSU's strategic plan is to grow lower cost programs. In Wildlife alone the growth is 65% with 430 majors. Environmental Science and Resource Engineering are other high growth programs. Close to 20% of students that apply to HSU are applying to the Biology program which has 1,200 students. HSU historically has hired 15-20 new faculty a year. Re-hires have been reduced to about seven per year as a means of addressing budget shortcuts. This year 20 tenure track positions were approved to be funded, five of which were in CNRS. The variable is the election in November. Tuition is not expected to be raised any further at this time.

- Impacted programs are one of the ways that the standards of students being admitted can be raised. There has been some discussion at the university of implementing this in a few programs. Steve is interested in a new school of Marine and Aquatic Sciences which would include fisheries, oceanography and aquatic sciences working in collaboration. A masters of Marine Science is the ultimate goal as a multi-disciplinary process.

Report from Dave Hankin, HSU-Fisheries Department

- Due to the upcoming retirements in the department, Dave Hankin has been asked to chair for the upcoming year. Dave is already at half time as part of his early retirement (FERP). Gary Hendrickson is retiring and a temporary faculty hire has been approved. Kristine Brennemen is starting her early retirement (FERP) starting fall 2012. Tim Mulligan has half of next year off and then will start his FERP. Eric Loudenslager is retiring January 2013. Priorities for the department are to cover the teaching requirements.

- The Fisheries curriculum has been slimmed down and restructured so that students get into the program earlier. This has increased retention.

- The Marine Lab has completed its infrastructure improvements with funding from NSF and donations. New video monitors, tanks, aquarium room, zooplankton labs have been designed for longevity.

- Marine Life Protection Area (MLPA) regulatory process is underway. Proposals will be due later in the year for baseline monitoring systems which means about $4 million for the North Coast region. Dave is working with the Yurok Tribe on a proposal.

Review of current, completed projects and review of new projects

Walt Duffy and Margaret Wilzbach reviewed the current projects completed in the last year as well as ongoing projects, and introduced five new research projects to be approved:

New project review:

1) Ecology and distribution of coastal cutthroat trout in Northern California
2) Effects of riparian canopy opening on aquatic productivity
3) Strategic planning for restoration of the upper Klamath River Basin under climatic uncertainty
4) Functional assessment of riparian/wetland communities in the Whiskeytown National Recreational Area
5) Evaluating grassland and wetland ecosystems in the northern Great Plains RWO 85

Joe Margraf nominated to approve the projects unanimously as described, and Russ Belmer seconded the motion. All approved.

UNIT RESEARCH SUMMARY

Chris Adams, Fisheries Biology master's student, presented on" Survival and habitat use of juvenile coho salmon in the Shasta River" a portion of his master's thesis.

2012 ANNUAL COORDINATING MEETING

Next year's meeting was set for Tuesday, May 14, 2013 via email after the meeting.

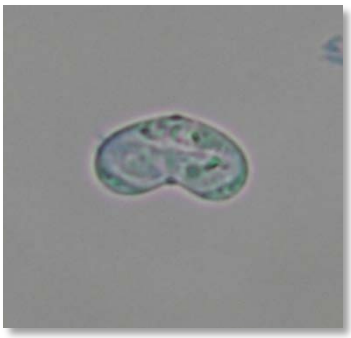
CLOSING

Steve Smith motioned for the meeting to be adjourned. Russ Bellmer seconded. The meeting was adjourned at 2:50 pm.

REVIEW OF PROJECTS COMPLETED IN 2012

DISEASE REDUCTION IN KLAMATH RIVER: PRODUCTION OF MYXOSPORES OF *CERATOMYXA SHASTA* IN CHINOOK SALMON CARCASSES

Investigator:	Dr. Gary Hendrickson, HSU Fisheries Biology Nick Campise, MS student
Duration:	August 2010 to December 2012
Funding:	National Oceanic and Atmospheric Administration Subgrant from Oregon State University ($70,142)



***Ceratomyxa Shasta* myxospore**

Ceratomyxa shasta is a myxosporean parasite of salmonids in the Pacific Northwest of North America. Its high prevalence and virulence in out-migrant juvenile fish threatens the long-term survival of salmon in the Klamath River. Before infecting fish, *Ceratomyxa shasta* necessarily infects the polychaete worm, *Manayunkia speciosa*. Infection is initiated when the worm ingests the parasite myxospore. Infection in the worm culminates in the development of the actinospore life stage of the parasite, which is infective to fish. Quantity of spores produced by each host type has been a topic of intense interest to researchers. Logic would suggest that quantity of parasites released into the watershed would be directly related to incidence of infection and magnitude of disease related fish mortality in the basin.

Although concerns have been primarily related to infection in juvenile salmon, parasite surveys conducted on post-spawned Chinook salmon carcasses have identified fish that harbor large quantities of potentially viable myxospores. We conducted three experiments to describe the role that carcasses play in *Ceratomyxa shasta* life history, which included:

1. measuring the number of parasites shed over a 30-d period from infected carcasses held in experimental chambers placed in the Klamath River;
2. establishing the persistence and development of *Ceratomyxa shasta* myxospores in infected fish intestinal contents which were incubated in the lab at varying temperatures;
3. evaluating the effect of carcass size, sex, and level of decomposition on myxospore abundance in fish intestinal contents.

In the first experiment, *C. shasta* DNA was not detected in any water sample collected. Results were unexpected, and may reflect insufficient time for myxospore development or light infection levels, or cool water temperature.

In the second study, sub-yearling Chinook salmon were held in the Klamath River for 72 h to expose them to *C. shasta* actinospores at a site known to be highly infections to sentinel fish. Exposed and control fish from the Iron Gate Hatchery were transported to rearing tanks at Humboldt State University, where they were held at 8^0 or 20^0 C. Intestinal contents were collected from fish sampled at 0, 5, 10, and 15 d post exposure. Intestinal contents were then

incubated at cool or warm temperature, and myxospore density estimated at varying days (1-56d) after extraction from the fish. The very low densities of myxospores that were observed is consistent with a hypothesis that myxospore production in fish terminates near the time of host death, and released for only a short period of time.

In the third study, intestines were collected from post-spawning Chinook salmon carcasses from 4 sampling sites in the Klamath Basin and myxospore densities were estimated from hemocytometer counts at 400x magnification. Relationships were assessed between myxospores and carcass attributes, including fork length, sex, decomposition rank, date, and location. Among the models tested, location and carcass decomposition level best predicted the probability of myxospore detection.

The final report for this project is available at http://www.humboldt.edu/cuca/documents/reports/DiseaseReductionKlamth1final.pdf. The master's thesis of graduate student Nick Campise is in progress.

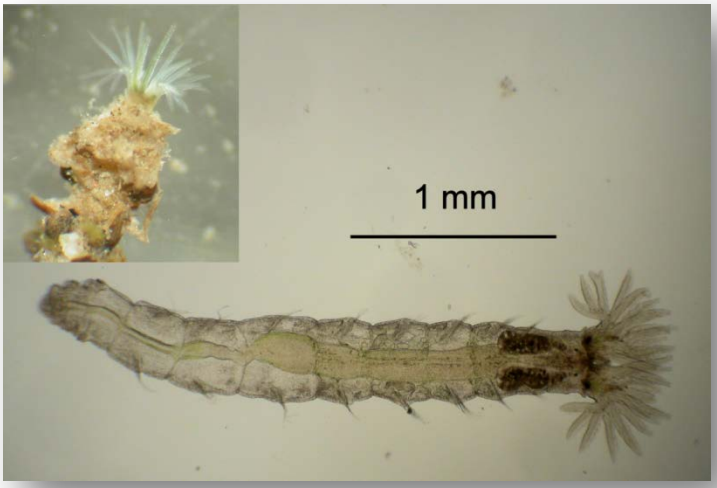
MYXOZOAN FISH DISEASE RESEARCH AND MONITORING

Investigator:	Dr. Margaret Wilzbach, CACFWRU
	David Malakauskas, PhD student, Michigan State University
Duration:	October 2009 to December 2013
Funding:	National Fish and Wildlife Foundation ($101,803)

Flume used in evaluating flow effects on polychaetes. An acoustic doppler velocimeter was placed above polychaetes on test substrates to measure velocity profiles.

We quantified microscale flow forces and their ability to entrain the freshwater polychaete, *Manayunkia speciosa*, the intermediate host for 2 myxozoan parasites (*Ceratomyxa shasta* and *Parvicapsula minibicornis*) that cause substantial mortalities in salmonid fishes in the Pacific Northwest. In a laboratory flume, we measured the shear stress associated with 2 mean flow velocities and 3 substrates and quantified associated dislodgement of polychaetes, evaluated survivorship of dislodged worms, and observed behavioral responses of the worms in response to increased flow. We used a generalized linear mixed model to estimate the probability of worm dislodgement for treatment combinations of velocity (mean flow velocity = 55 cm/s with a shear velocity = 3 cm/s, mean flow velocity = 140 cm/s with a shear velocity = 5 cm/s) and substrate type (depositional sediments and analogues of rock faces and the filamentous alga, *Cladophora*). Few worms were dislodged at shear velocities <3 cm/s on any

substrate. Above this level of shear, probability of dislodgement was strongly affected by both substrate type and velocity. After accounting for substrate, odds of dislodgement were 8× greater at the higher flow. After accounting for velocity, probability of dislodgement was greatest from fine sediments, intermediate from rock faces, and negligible from *Cladophora*. Survivorship of dislodged polychaetes was high. Polychaetes exhibited a variety of behaviors for avoiding increases in flow, including extrusion of mucus, burrowing into sediments, and movement to lower-flow microhabitats. Our findings suggest that polychaete populations exhibit high resilience to flow-mediated disturbances.



***Manayunkia speciosa* is the intermediate host for myxozoan parasites *Ceratomyxa shasta* and *Parvicapsula minibicornis* which are responsible for substantial mortality among juvenile Pacific salmon in the Klamath River basin. Pictured is an adult worm without its tube. Inset: an adult worm inside of its tube in a feeding posture.**

A manuscript describing the research is in press in the journal Freshwater Science, which is co-authored by David Malakauskas, Sarah Willson, Peggy Wilzbach, and Nicholas Som.

Research constituted the Ph.D. research of David Malakauskas at Michigan State University, who defended his thesis in April 2013.

The final report for his project can be accessed at http://www.humboldt.edu/cuca/documents/reports/Myxozoan%20Fish%20Disease%20Final%20ReportA.pdf

REVIEW OF CURRENT RESEARCH PROJECTS

ASSESSING THE BENEFITS OF USDA CONSERVATION PROGRAMS IN THE UPPER KLAMATH RIVER BASIN & CENTRAL VALLEY OF CALIFORNIA ON ECOSYSTEM SERVICES (RWO 84)

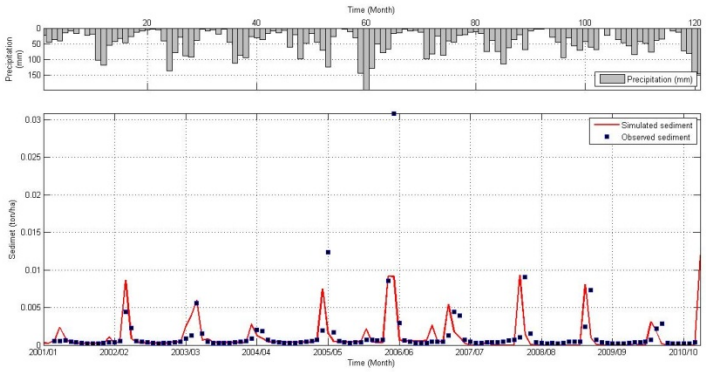
Investigator:	Dr. Walter Duffy, CACFWRU
	Dr. Sharon Kahara, HSU Wildlife Dept.
	PhD student, Rosemary Records, CSU
	MS student, TBD
Duration:	September 2011 to August 2016
Funding:	USDA, Natural Resources Conservation Service ($212,262)

This research will be part of the U.S. Geological Survey's Science Initiative, Integrated Landscape Monitoring (ILM) Initiative. This is an initiative to develop monitoring and modeling tools to evaluate the influence of U.S. Departments of Agriculture (USDA) and Interior conservation programs on diverse ecosystem services.

Our objectives in this research are: 1. to prepare the necessary geospatial data layers (land use, land cover, soil type, precipitation, air temperature) needed for applying geospatial models in the Upper Klamath Basin and the Central Valley, 2. to develop algorithms relating ecosystem services (amphibian habitat, waterfowl habitat, pollinator habitat, water storage) to geospatial data layers, and 3. evaluate the water quality benefit of USDA conservation programs in the Upper Klamath Basin and Central Valley.

Progress: We have downloaded climate data and developed a SWAT model (Soil and Water Assessment Tool) for the Sprague River Basin and begun analyses comparing nutrient loading to Upper Klamath Lake under current conditions and with future climate (see figure below). We plan to use SWAT to 1. evaluate the effect of restored wetlands on water quality in Upper Klamath Lake, 2. evaluate the water quality response to increasing wetland restoration and best management practices, 3. optimize spatial distribution of restored wetlands and other BMPs, and 4. to forecast how changing climate may affect the water quality benefit of restoration.

During the past year, we continued developing conceptual models for amphibian habitat, waterfowl habitat, pollinator habitat, water storage and have made progress on constructing algorithms describing the response of these ecosystem services to USDA Wetland Reserve Program easements.



Sediment runoff to the North Fork Sprague River. Simulated data are represented by the red line, observed data by black circles. Precipitation is shown at the top of the figure.

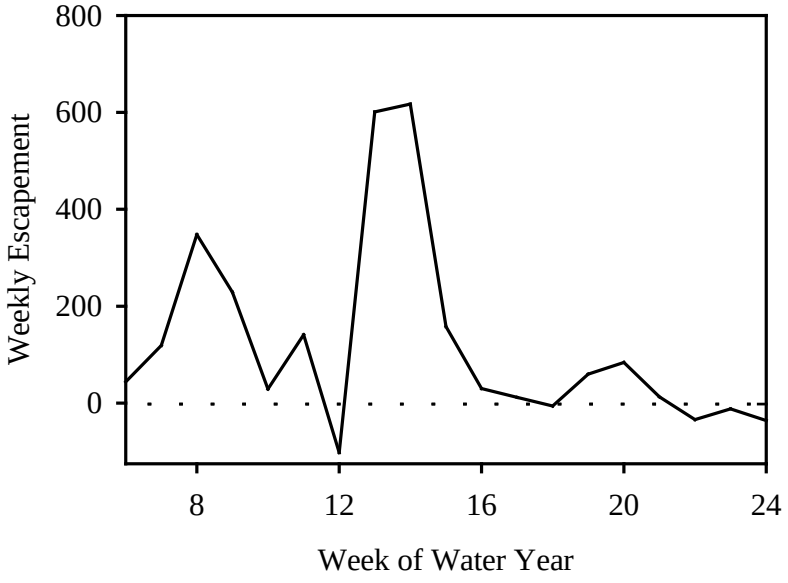
ESTIMATING SALMON AND STEELHEAD ESCAPEMENT TO REDWOOD CREEK USING A DUAL FREQUENCY IDENTIFICATION SONAR (DIDSON) IMAGING SYSTEM

Investigators:	Dr. Walter Duffy, CACFWRU
	Matthew Metheny, MS Student
Duration:	April 2011 to March 2014
Funding:	California Department of Fish and Wildlife/FRGP ($84,765)

The Redwood Creek watershed in Humboldt County is considered an important watershed for anadromous salmonids in northern California. It supports self-sustaining populations of coho salmon, Chinook salmon, steelhead and coastal cutthroat trout in addition to other native fishes.

Our objective in this study is to use a dual frequency identification sonar (DIDSON) imaging system to estimate escapement of adult salmon and steelhead in Redwood Creek. Specific objectives are: 1. to estimate escapement of coho salmon, Chinook salmon, steelhead and coastal cutthroat trout to Redwood Creek during 2011-2013, 2. refine logistic models used to assign species to targets, and 3. develop protocols for management of data gathered with the DIDSON.

The DIDSON was installed in Redwood Creek in November 2011 and was operated through May 2012. The DIDSON was operated almost continuously through late-February when a series of large storms forced us to retrieve the equipment for several periods. Through March 15, 2012, we estimated that 2,533 adult salmon and steelhead entered Redwood Creek (Figure 1). Using four different species classification models, we estimated the escapement of Chinook salmon to be 1,223 – 1,849 fish, escapement of coho salmon (456-1,040) was somewhat less and steelhead (228-303) were lowest.



Weekly escapement of salmon and steelhead to Redwood Creek during the 2011/2012 spawning season.

EVALUATING GRASSLAND AND WETLAND ECOSYSTEMS IN THE NORTHERN GREAT PLAINS (RWO 85)

Investigators:	Dr. Walt Duffy, CACFWRU
	Dr. Matt Johnson, Wildlife Department
	Dr. Ned Euliss, Wildlife Department/USGS
	Russ Bryant, MS Student
	MS Student (TBD)
Duration:	September 2011 – December 2016
Funding:	U.S. Geological Survey ($175,000)

The U.S. Geological Survey (USGS), Northern Prairie Wildlife Research Center (NPWRC) is engaged in an on-going research effort to better understand grassland, wetland, and riverine ecosystems and their associated biotic communities in the northern Great Plains (NGP). NPWRC's research programs specifically focus on identifying and understanding threats to NGP ecosystems and developing and evaluating conservation measures that abate those threats. The first phase of this research will investigate native bee pollinators, land use and agricultural pesticides.

It is widely known but often ignored that pollinators are critical to sustain healthy ecosystems and prosperous human populations. However, a report on the Status of Pollinators in North America, combined with intense media coverage of honey bee colony collapses beginning in 2006, sparked a renewed and widespread interest in the role of honey and native bees in the pollination of agricultural crops, maintaining functioning ecosystems and enhancing biodiversity. Additionally, a recent report demonstrates that the need for pollination is on the increase at the same time that pollinator numbers and insect pollinated plants are declining. Agricultural practices, urban development, and fallow land-use practices have disrupted habitat for bees, both in terms of essential nutrition provided by forage and nesting sites, especially for native bees. Pesticides are a concomitant problem that can have detrimental effects on bees when they forage on contaminated flowers. Healthy pollinator populations depend on landscapes that provide ample and nutritious sources of non-contaminated pollen and nectar-yielding flowers. However, no field studies have quantified the availability of specific flowers or cover types across the landscape or the influence these factors have on the health of thousands of native pollinators.

Objectives for this first phase of research are:

1. Evaluate and compare abundance and diversity of native pollinators within native prairie FWS lands and CRP lands.
2. Document foraging behavior, vegetation visited, and the pollen diet of native pollinator species.
3. Document the seasonal changes in the vegetation community and pollinator populations.
4. Evaluate risk from agrichemical contamination of pollen on native prairie FWS lands and CRP lands.

Progress: Russ Bryant has completed a proposal that was approved by his academic committee and a USGS science review panel. He has completed the first year of data collection, is beginning the second year of field work and has made two presentations on his research.

GENE FLOW AND HYBRIDIZATION OF COASTAL CUTTHROAT TROUT WITH STEELHEAD ACROSS SUB-BASINS OF THE SMITH RIVER, CALIFORNIA

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Dr. Walter Duffy, CACFWRU
	Sam Rizza, MS Student
Duration:	Jan 2013 to May 2015
Funding:	California Department of Fish and Wildlife/Heritage and Wild Trout

Cutthroat trout (*Oncorhynchus clarki*) and rainbow trout (*Oncorhynchus mykiss*) are believed to have diverged from a common ancestor nearly two million years ago, at the beginning of the Pleistocene. While most other subspecies of cutthroat trout dispersed further inland and subsequently evolved in isolation from rainbow trout, the coastal cutthroat (*O. clarki clarki*) coevolved with the coastal subspecies of rainbow trout, (*O.mykiss irideus*), or steelhead, throughout its range from northern California to southern Alaska. While hybrids between coastal cutthroat trout and steelhead are fully fertile, reproductive isolation between them has been largely maintained over geologic time because of evolved differences in selection of spawning locations. Natural hybridization has been documented mostly in settings where habitat is limited and run-times overlap. Stocking of non-native hatchery rainbow trout and habitat disturbance, however, has increased the potential for hybridization.

Conservation of coastal cutthroat populations requires a reliable means of identifying the fish in the field when they co-occur with steelhead or hybridized individuals, as fisheries management decisions are usually based on abundance estimates that rely heavily on visual identifications. Classification of morphologic characteristics paired with computer-aided morphologic analyses that compare body type with habitat preference have proven useful in differentiating species among assemblages of juvenile coastal cutthroat trout, steelhead, and their hybrids. Statistical classification models have primarily been used on juveniles, a life stage where phenotypic traits are most similar among the fishes. This study will focus on adult stages and attempt to define hybrid phenotypic characteristics from adult cutthroat trout and steelhead to improve field identification.

Objectives of this study are:

1. to determine incidence of hybridization between coastal cutthroat trout and steelhead in the Smith River, and assess cutthroat trout gene flow between 5 sub-basins. Fish will be captured by hook and line, measured and photographed, and tissue and scale samples will be collected. Genetic analyses of tissue samples will be processed in the NOAA Southwest Fisheries Science Center in Santa Cruz;

2. to create a classification model to estimate species identity in the sub-basins from phenotypic characteristics following methods of Rohlf (2001);

3. to establish the field identification error rate of adult cutthroat trout, steelhead, and their hybrids from genetic analysis and the classification model.

GENETIC ANALYSIS OF TIDEWATER GOBY TISSUE SAMPLES BY HSU COOPERATIVE UNIT (RWO 83)

Investigator:	Dr. Andrew P. Kinziger
	Conrad Newell, MS Student
Duration	May 2011 to May 2014
Funding	U.S. Fish & Wildlife Service ($73,004)

Tidewater goby are hypothesized to fit a classic metapopulation model of structuring. A classic metapopulation consists of a set of isolated populations that experience periodic extinction and colonization. Presence/absence data from repeated visits to a given field site have been the primary tool for assessing metapopulation dynamics. However, field surveys may erroneously imply metapopulation dynamics when extinction results from nondetection rather than a true extinction event. It is likely that imperfect detection is biasing extinction and colonization estimates in tidewater goby. Tidewater goby express an annual life cycle that results in dramatic variation in abundance between years. Further, it is difficult to confirm extinction without error in many instances because habitat areas can be large (e.g., 1085 ha). Confirming extinction and colonization dynamics is critical because metapopulation models imply operation of much different ecological and evolutionary processes in comparison to other population models and thus mandate use of different management and conservation approaches.

The goal of this project is to use genetic and field survey approaches to robustly describe he metapopulation dynamics of tidewater goby in the North Coast Management Unit, including descriptions of patterns of local population extinction, colonization, and migration. First, we will estimate extinction and colonization rates from presence/absence data collected on a time series. To do this we plan to implement occupancy modeling sampling designs and statistical approaches that account for imperfect detection probabilities. Second, for a subset of sites we defined a temporal genetic sampling scheme aimed at detecting within population genetic revolutions associated with extinction and colonization events. Lastly, we plan to conduct a genetic analysis on a comprehensive set of spatial collections to assess the scale of connectivity among geographically isolated populations of tidewater goby in our study region.
We have made significant progress assembling a presence/absence field survey database for tidewater goby. The matrix was assembled from several sources: 1. Greg Goldsmith 2002-2010

surveys, 2. 2006 USFWS surveys for McCraney thesis, 3. 1996 and 1997 surveys by Charlie Chamberlain (USFWS), and 4. Big Lagoon Mark Recapture 2008-2010, and 5. USFWS 2010 tidewater goby surveys. Data are presence/absence by seine haul (standardized by use of a "goby seine"). The field survey presence/absence data matrix contains a listing of 84 sites surveyed in the northcoast region. However, not all locations have multi-year detection histories. A preliminary visual inspection of the data suggest Tillas slough, McDaniel slough, and Jacoby Creek have detection histories suggesting extinction and followed by subsequent colonization. (Interestingly, the genetic data suggests otherwise). At the 101 ditch site there is an extinction (with no colonization). At Tenmile extinction is suggested but the population at this site has been detected in surveys not included in this analysis. At Elk River there is a colonization. So, naive inspection, without consideration of detection probabilities, does suggest some extinction and colonization for northcoast tidewater goby populations. However, the relative level of extinction and colonization in the northcoast region is much less than has been recorded for southern California populations of the species. Presence/absence data from field surveys recorded on a time series indicate extremely high site-specific annual extinction (0.37) and colonization rates for tidewater goby (0.48) for tidewater goby from southern California lagoons. These preliminary results should be treated with caution until a thorough analysis has been performed using an occupancy modeling framework. We have also made significant progress in the temporal and spatial genetic analyses (objectives 2 and 3 above). Field collections, microsatellite genotyping assays, and preliminary data analyses are underway.

HABITAT USE, MOVEMENT, AND SURVIVAL OF JUVENILE COHO SALMON IN THE SHASTA RIVER

Investigators: Dr. Margaret Wilzbach, CACFWRU
Chris Adams, MS Student
Duration: September 2010 to July 30, 2013
Funding: California Trout, INC. ($20,000)

Solar-powered remote detection sytem on the Shasta River. Photo by Chris Adams.

The Shasta River, a highly productive spring fed system in a high desert setting, provides unique habitat for anadromous salmonids and historically supported large numbers of coho salmon. However, hydrology of the river has been greatly influenced by irrigation practices, and the population status of the federally endangered coho salmon in the Shasta River is now dire. The California Department of Fish and Game began studies of summer rearing habitat and seasonal movements of Shasta River juvenile coho salmon using PIT tags and remote detection systems in 2007. This

research continues the effort, to evaluate habitat use, movement, and reach-specific survival of the 2010 cohort. Research constitutes the master's thesis research of Chris Adams, who defended his thesis in March 2013. Chris is working on the final stages of thesis completion.

An abstract of his thesis follows: Movement and survival of juvenile coho salmon (*Oncorhynchus kisutch*) were assessed at a watershed scale using PIT tags and a network of instream antennas in the Shasta River, a highly productive tributary of the Klamath River in interior northern California. I developed and used a multi-state mark-recapture model to estimate apparent survival, movement, and detection probabilities of tagged juvenile coho salmon during the summer (May-October) and winter (November-March) periods in four segments of the upper Shasta River watershed in 2011-2012. Both upstream and downstream movements of age-0 coho salmon tagged in the upper Shasta River occurred in early summer. These included movements to rearing areas up to nine kilometers upstream, as well as outmigration from the Shasta River. Apparent survival estimates over the summer ranged from 0.40 (95%CI 0.22-0.61) to 0.74 (95%CI 0.54-0.88). Substantial redistribution among upper Shasta River rearing areas occurred in late fall. Apparent survival estimates over the winter ranged from 0.48 (95%CI 0.38-0.58) to 1.0. Reach-specific estimates of apparent survival were made for outmigrating age-1 smolts from the upper Shasta River to the Klamath River in the spring of 2012 using a Cormack-Jolly-Seber mark-recapture model. Apparent survival of outmigrating smolts from Shasta River Kilometer 46 to the Klamath River was 0.88 (95%CI 0.76-0.95). Juvenile coho salmon in the upper Shasta River displayed rapid growth rates, with young of the year reaching 100 mm fork length by their first June.

KLAMATH REMS, FISHERIES (RWO 82)

Investigators:	Dr. Walter Duffy, CACFWRU
	Dr. Margaret Wilzbach, CACFWRU
	Christopher Olie Smith, MS Student
Duration:	September 2008 to September 2013
Funding:	U. S. Geological Survey ($60,375)

Declining populations of Pacific salmon (*Oncorhynchus* spp.) in the Klamath River have led to concerns about water quality in the river. Water temperature in the river during summer months often approaches or exceeds physiological tolerance limits of most Pacific salmon

Lower Klamath River

species. Reliance of these fish on cold water has been studied extensively. While temperatures at which the physiological performance of Pacific salmon is optimal is typically 14.0 - 17.0 ◦C, salmon are also frequently found occupying habitats where water temperatures reach 23.0 - 24.0 ◦C on a daily basis. Much of the variation in tolerance to warmer water temperature in Pacific salmon is attributed to acclimation temperature.

In the Klamath River, water temperature regularly exceeds 25.0 ◦C during July and August. Pockets of cool water that form at tributary mouths are believed to be critical to the survival of Pacific salmon during these periods. Re-analysis of data gathered by the Yurok Tribe during 1998 confirms use of cool water patches at temperatures > 22.0 ◦C, but also reveals a strong temporal component in use. Furthermore, spatial distribution of refuges having high abundance (> 1000 juvenile Chinook salmon) are clumped at a few stream mouths. The periodicity in heavy use of cool water patches by Chinook salmon and their spatial clumping at limited sites suggest that habitat selection is governed by more than water temperature alone. Objectives of this study, which is a part of a larger USGS research effort (River Ecosystem Models and Science [REMS]), are to compare feeding behavior, food availability, and temporal patterns of habitat use by juvenile Chinook salmon and coho salmon among a representative cool water patch, adjacent mainstem warm water, and tributary mouth in the lower Klamath River.

In June 2010, field research began with the installation of an array of 6 passive integrated transponder (PIT) tag antennas and a MUX were set up. Two of the antennas were placed in a pool near the mouth of Independence Creek, and 4 were placed in the cold-water mixing zone in the Klamath created by the outflow of the creek. Between July and September of 2010, 620 juvenile salmon (534 Chinook, 72 coho, and 14 steelhead) were tagged with PIT tags and re-released. These tagged fish (as well as other tagged fish released by other researchers upstream) were recorded over 24,000 times by the array of antennas. Feeding rates for 508 individual fish were assessed during snorkel surveys during both high and low main-stem temperatures, by visually observing and counting individual feeding events for a period of up to 5 minutes per fish. Gut fullness was measured using gastric lavage on 281 fish from both the tributary pool, and the cold-water mixing zone habitats. Additionally, 39 separate drift and benthic samples were taken using drift nets as well as Serber samplers, at both high and low water temperatures. Water temperature was monitored hourly on a 24 hour basis using a total of 50 remote temperature loggers distributed in the tributary pool, the cold water mixing zone, and upstream of the mixing zone in the Klamath.

Due to the later than usual water year, the 2011 field season equipment was installed at the end of July. The same locations were used for all equipment except the two PIT tag antennas in the pool area of Independence Creek which were placed in the middle of the pool as opposed to the outflow in order to more effectively read tags of fish present in the pool. During the 2011 season, 334 additional PIT tags were placed in coho and Chinook (steelhead were excluded during the second season). In addition to these tags, 423 coho were tagged by collaborating Karuk biologists in the pool habitat. Due to altered antenna placement, these fish were recorded over 80,000 times by the array between August and October. Gut contents were measured from 164 coho and Chinook using gastric lavage, and drift invertebrate density was measured with 67 samples using drift nets at three locations at two different times of day. As in the previous season, water temperature was monitored hourly on a 24 hour basis using a grid of

50 temperature loggers in 3 different sites as before. During twice daily snorkel surveys, we observed the feeding rates of 331 coho and Chinook.

Data has been collected from several agencies in the Klamath River basin and has been formatted for analysis. Non-parametric tests have shown a significant difference in food availability between the pool habitat and the mainstem mixing zone, and there appears to be an interaction with time of day. The altered placement of the antennas in the pool allowed for a better ability to record movement between sites, and a multinomial model is being constructed to test for the effects of several predictor variables. The multinomial model has been mostly constructed in R, and has been test run with some success on subsets of the data. Currently work is being done to de-bug the R code for the multinomial model as well as to use more non-parametric tests (Wilcoxon and Kruskal-Wallace) to test for feeding differences between species, locations, and times of day/temperatures. Future work will be directed toward the reporting of these analyses once they have been completed.

PRAIRIE CREEK SUB-BASIN LIFE CYCLE MONITORING PROJECT

Investigators:	Dr. Walter Duffy, CACFWRU
	Tancy Moore, MS Student
Duration:	April 2011 to August 2014
Funding:	California Department of Fish and Wildlife/FRGP ($208,769)

The Prairie Creek sub-basin of Redwood Creek supports self-sustaining populations of coho salmon, Chinook salmon, steelhead and coastal cutthroat trout in addition to occasional chum salmon. It has been recognized as an excellent "field laboratory" for the study of anadromous salmonids in California by the Coastal Watershed Planning and Assessment Program. Studies of fisheries in the Prairie Creek sub-basin began in the late 1940's and extend to the present. Nearly continuous estimates of adult salmon returning to Prairie Creek have been made since 1990, while estimates of juvenile abundance and smolt production have been made each year since 1998.

The objective of this project is to 1. examine the importance of the unmonitored lower reaches of Prairie Creek to overwintering juvenile coho salmon, 2. compare overwinter growth rates, survival, and outmigration timing of juvenile coho salmon that overwinter in Upper and Lower Prairie Creek, 3. monitor movement of juvenile coho salmon between Upper and Lower Prairie Creek throughout the winter and spring months, and 4. compare the age structure of juvenile coho salmon in Upper and Lower Prairie Creek.

In fall 2012 we installed two remote PIT tag antenna arrays in Prairie Creek, one approximately mid-basin and another at the mouth of the stream. After these antenna were functioning, we sampled coho salmon throughout Prairie Creek and in four tributary streams. Sampling was designed to distribute PIT tags in coho salmon throughout the basin, consistent with other Life Cycle Monitoring Stations.

MS student Tancy Moore has been recording movement of coho salmon past antenna from September 2012 through the present. She is also gathering data on size of PIT tagged coho salmon smolts captured at a downstream migrant trap located at the mouth of Prairie Creek.

REDWOOD CREEK JUVENILE SALMONID (SMOLT) ABUNDANCE PROJECTS 2009-2014

Investigators:	Dr. Walter Duffy, CACFWRU
	Michael Sparkman, CDFG
Lower RC Funding:	California Department of Fish and Game/FRGP ($261,577)
Duration:	June 2009 to March 2014
Upper RC Funding:	California Department of Fish and Game/FRGP ($166,835)
Duration:	June 2009 to March 2014

The Fisheries Restoration Grant Program funded these two projects to continue gathering long-term status and trends data on salmon and steelhead smolt production from upper and lower Redwood Creek.

In 2012, data were collected to determine the population size, status, and trends of coho salmon, Chinook salmon, cutthroat trout, and steelhead in Redwood Creek. Mark-recapture techniques were used to determine population estimates. The study was designed to be long term and also encourages research and monitoring of adult populations that, when combined with the current smolt study, would allow estimates of marine and freshwater survival to be made.

Modified rotary screw traps were deployed in April and operated continuously until mid-August. Traps was checked daily. All fish captured were identified to species at age, counted and any trap efficiency trial marks were recorded. Population estimates (weekly and seasonal) were determined using multiple trap efficiency trials using peer reviewed methods (Figure 1). Fork lengths were recorded daily and weights were recorded every other day. At the upper trap, randomly selected fish were PIT tagged and released downstream of the trap site to investigate travel time and growth during downstream migration, and to investigate residence time in the estuary via Redwood National Park's sampling in the estuary. Stream temperature was recorded every half-hour using optic stowaway temperature probes.

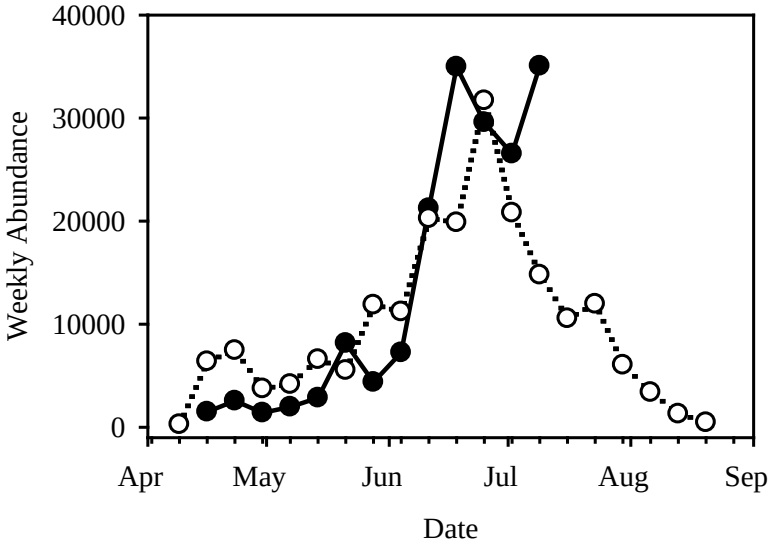


Figure 1. Weekly population abundance of Chinook salmon smolts migrating through lower Redwood Creek in 2012 (filled circles) relative to average during 2004-2011 (open circles).

NEW RESEARCH PROJECTS REVIEW

DISTRIBUTION AND RELATIVE ABUNDANCE OF JUVENILE COHO SALMON IN THE REDWOOD CREEK BASIN, HUMBOLDT COUNTY, CALIFORNIA

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Dr. Walter Duffy, CACFWRU
	Michael Sparkman, CDFW
Duration:March :	2014 to March 2017
Funding:	California Department of Fish and Wildlife/FRGP ($49,348)

The objective of this study is to determine the spatial distribution and relative abundance of juvenile coho salmon in the Redwood Creek basin.

Sampling will be conducted using snorkel surveys in sections of stream (reaches) selected according to a spatially balanced, randomized sampling design. The project design will allow us to make statistical inferences about the entire basin based on data collected in the selected survey reaches. A sampling rate of 50% will be achieved by snorkeling every second pool within each survey reach. Surveys will be performed by a team of two individuals trained to identify juvenile coastal salmonids and designate habitat types as described. Each 2-3 kilometer (1.2-1.8 mile) reach will be surveyed in two phases. One or two days before snorkeling, the survey team will classify the reach into pool, riffle, and run habitat units. Every second pool throughout the entire reach (snorkel survey units), will be marked with flagging at the top and bottom. Specific habitat data, including maximum depth, length, width, and an estimate of cover complexity will be collected for every snorkel survey unit. Visibility will be estimated on the day of the snorkel survey.

Two divers will estimate counts of juvenile coho salmon independently. To ensure independent counts and allow pools to equilibrate after the first pass; divers will maintain a distance of one pool apart. In addition to counting juvenile coho, divers will note the presence of any other salmonids observed. All survey data will be electronically recorded with waterproof Meazura™ Ruggedized Digital Assistants (RDAs). Occupancy models will be used to determine percent of the area occupied.

FEEDING AND GROWTH OPPORTUNITIES FOR JUVENILE COHO SALMON AND STEELHEAD IN DRY CREEK, CALIFORNIA

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Andrea Dockham, MS Student
Duration:	January 2013 – December 2015
Funding:	Sonoma County Water Agency (student stipend)

The National Marine Fisheries Service determined that operation of the Warm Springs Dam on Dry Creek, a 22-km tributary of the Russian River in Sonoma County, CA., threatens survival of juvenile coho salmon and steelhead; the agency issued a Biological Opinion requiring improvements to salmonid habitat. Cold water released from the dam provides ideal

temperatures for the salmon, but the high velocity of water released from the dam is problematic. The Biological Opinion mandated the creation of pools, backwaters and side channels to provide rearing habitat for young fish, and the Water Agency and US Army Corps are investing $40 - 50 million in habitat enhancement over the next 10 years. While specific enhancements are being constructed to provide flow refuges, the extent to which the enhancements will contribute to meeting the food needs of the fish is unknown. This study will provide a baseline of macroinvertebrate data to help evaluate the habitat enhancements, and examine how feeding and growth opportunities for juvenile steelhead and coho salmon vary along the length of Dry Creek.
The Sonoma County Water Agency is supporting the thesis research of master's student Andrea Dockham through a stipend to Andrea, and are providing her with logistical support.

Project objectives are to:

1. document habitat-specific density, biomass, and taxonomic composition of benthic invertebrate assemblages in enhanced and unenhanced reaches of Dry Creek;

2. compare benthic assemblage composition with diet composition of yearling fishes to assess prey availability;

3. construct a bioenergetic budget to evaluate the relative importance of prey availability in accounting for observed differences in fish growth among the stream reaches.

FUNCTIONAL ASSESSMENT OF RIPARIAN/WETLAND COMMUNITIES IN THE WHISKEYTOWN NATIONAL RECREATIONAL AREA

Investigators:	Dr. Walt Duffy, CACFWRU
	Dr. Sharon Kahara, Wildlife Department
	MS Student (TBD)
Duration:	September 2012 – August 2014
Funding:	National Park Service

Note: Cooperators approved this proposal in 2012. However, NPS changed the RFP and delayed funding decisions until spring 2013.

Whiskeytown National Recreation Area consists of Whiskeytown Lake and 39,000 acres surrounding the lake that support a diverse assemblage of wetland and riparian habitats. Little information currently exists for management is available concerning the distribution, condition, or trend of wetlands in these three national park units. Existing wetland information is currently limited to National Wetland Inventory (NWI) maps derived from coarse-scale 1980's aerial photographs. These maps typically overlook scattered small wetlands such as vernal hillside seeps that are among the most vulnerable to impacts. Moreover, these maps provide no information on condition of wetlands in the parks. Wetlands in the parks are immediately vulnerable to a range of cumulative impacts, including non-native species invasions, air-

borne or water-borne pollutants, hydrologic alterations, and excess visitor use. This project will address these information needs and threats by assessing condition and function in a priority-based probabilistic sample of wetlands in the three parks.
Objectives of this project will be to provide:

1. corrections and additions to existing NWI maps,
2. management recommendations specific to individual wetlands in the park,
3. strategies for addressing larger scale wetland conservation issues (e.g., non-native species),
4. a quantitative baseline essential for future monitoring of wetland condition,
5. classifications of wetland site potential, and
6. location of degraded wetlands in need of restoration.

The synthesis of information proposed in this project will help managers take a strategic rather than reactive approach to mitigating threats to park wetlands, and to better determine the spatial and temporal scales at which to attack the problem(s).

HABITAT SPECIFIC GROWTH, MOVEMENT, AND SURIVIVAL OF JUVENILE COHO SALMON IN FIVE NORTHERN CALIFORNIA STREAMS

Investigators:	Dr. Margaret Wilzbach, CACFWRU Dr. Walter Duffy, CACFWRU John Dieber-Hanson, MS student Other graduate student TBD
Duration:	January 2013-March 2015
Funding:	California Department of Fish and Wildlife/Coop Unit Support ($135,000)

State Fisheries biologists and the California Fish and Wildlife Coop Unit have been independently conducting coho salmon and steelhead life cycle monitoring in five streams in northern California (Prairie, Freshwater, Mill, Caspar, and Pudding creeks) for a series of years. However, no attempt has been made to coordinate monitoring components, or integrate experimental design to provide inference into the commonality of limiting factors or the value of specific restoration treatments.

An important aspect of salmon life cycle monitoring is developing an understanding of the relationships between habitat and salmonid survival to help interpret regional trends and direct effective restoration actions. Evaluation of this life cycle monitoring data to date suggests that density dependence occurs in freshwater life stages and that high winter flows often limit coho salmon populations. This finding and results of work on coho salmon growth suggests that over-winter survival and low summer growth are major factors limiting coho salmon production in at least some northern California streams. With recent evidence that that juvenile coho salmon are dependent on multiple freshwater habitats, even within a single watershed, a hierarchical approach to evaluating habitat use and survival must be employed.

CACFWRU and CDFW biologists (including Ricker: Freshwater Creek, Garwood: Mill Creek, Gallagher: Pudding and Caspar Creeks) have agreed to standardize sampling protocols and coordinate research efforts to enable assembly of a region-wide database on habitat limitations to guide stream restoration.

Objectives of this collaborative project are to:

1. Determine habitat specific abundance, growth, survival, and movement of juvenile coho salmon in five creeks each year during summer, fall, and winter;

2. PIT tag juvenile coho salmon in specific habitats throughout Caspar, Freshwater, Mill, Prairie, and Pudding creeks in summer, fall, and winter and record their length and weight;

3. Install remote PIT tag antenna arrays in the middle- and outlet of each watershed to monitor redistribution within each watershed, as well as smolt migration;

4. Use smolt traps and PIT tag antenna detections to document migration timing, abundance, and survival tied to habitat units and habitat data;

5. Estimate habitat specific over summer and overwinter growth rates, survival, and migration timing of juveniles and smolts in each stream; and

6. Investigate relationships between survival, growth, habitat types & habitat complexity.

LOWER AND UPPER REDWOOD CREEK JUVENILE SALMONID (SMOLT) ABUNDANCE

Investigators:	Dr. Margaret Wilzbach, CACFWRU Dr. Walter Duffy, CACFWRU Michael Sparkman, CDFW MS Student (TBD)
Duration:	March 2014 to March 2017
Funding:	California Department of Fish and Wildlife/FRGP ($449,862)

This project will continue a long-term study on the abundance of coho salmon, Chinook salmon, steelhead trout, and cutthroat trout smolts emigrating from the Redwood Creek watershed. Rotary screw traps will be located river mile 4 and 33 that will allow for estimation of smolt population abundances from the upper and lower basin, as well as travel times between traps. Estimates of smolt abundances will represent production from 37 miles (upper) and 93 miles anadromous habitat. This study planned to continue for more than 20 years to fully encompass biological and environmental variability within the watershed, and to detect any changes attributable to climate change. This study will include determining baseline and status/trend population information for coho salmon, Chinook salmon, steelhead trout, and cutthroat trout smolts that may be used to identify factors limiting species recovery and to identify restoration needs in the basin. Abundance and size of yearling coho salmon smolts emigrating from Prairie Creek may be used as the benchmark for other streams since Prairie Creek is in near pristine condition. Protocols used in this study are in compliance with the California Coastal Salmonid

Population Monitoring (CDFG Fish Bulletin 180), supported by the SONCC coho salmon draft recovery plan (NMFS 2012), and have been peer reviewed by CDFG Biometrician (Phil Law). The rotary screw traps will be set each year in March and operated continuously until August, dependent upon trap catches and the migration periods. Population estimates (by week and season) will be determined using marking-recapture techniques 2 – 5 times per week to account for changes in stream flow and subsequent changes in trapping efficiencies. Marked fish are taken upstream and released at night, and most are recaptured sometime before the trap is checked at 0900. Genetic samples will be taken from each species at age weekly. Age composition of each species will be determined using length frequency data and periodic aging using scales. Stream water temperature will be recorded every half hour using data loggers.

MONITORING ENDANGERED TIDEWATER GOBY USING ENVIRONMENTAL DNA IN WATER SAMPLES(RWO 86)

Investigators:	Dr.Andrew P. Kinziger
	Molly Schmelze, MS Student
Duration:	December 2012 to December 2013
Funding:	U.S. Fish & Wildlife Service ($23,550)

The objective of this project is to develop protocols for detecting tidewater goby presence/absence in water samples. There are two primary phases, 1. development of laboratory protocols including methods of DNA extraction from water samples and a tidewater goby specific polymerase chain reaction (PCR), and 2. controlled laboratory tests with tidewater goby held at known density. Progress to date includes development of three tidewater goby specific PCR reactions, two PCRs applicable to populations north of Fort Bragg and one PCR applicable to all populations north of Point Conception. All PCR reactions amplify tidewater goby but also amplify DNA from its sister taxon, arrow goby. PCR products indicative of tidewater goby can be identified with standard dye terminator cycle sequencing of PCR products. Next steps include development of protocols to extract DNA from water samples and controlled laboratory trials.

PRAIRIE CREEK JUVENILE SALMONID (SMOLT) ABUNDANCE PROJECT

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Dr. Walter Duffy, CACFWRU
	MS Student (TBD)
Duration:	Mar 2014 – Mar 2017
Funding:	California Department of Fish and Wildlife/FRGP ($224,931)

This project will continue the long-term monitoring of juvenile salmonid populations in Prairie Creek that has been in place since 1998. The Prairie Creek sub-basin of Redwood Creek is a stronghold for coho salmon production within the basin, and serves as an important reservoir for recovery of salmonids within Redwood Creek. The Prairie Creek sub-basin is a life cycle monitoring station as described in the CDFW's California Coastal Salmonid Monitoring Plan, as it combines monitoring of juveniles and smolts with estimates of returning adults from redd counts.

The objectives of this project are two-fold: 1) to estimate over-winter growth and survival of juvenile coho salmon within reaches of Prairie Creek; and 2) to estimate smolt population abundances for coho salmon, Chinook salmon, steelhead trout and cutthroat trout in Prairie Creek.

This project will be conducted in conjunction with CDFW biologist Michael Sparkman, who will run the smolt trap operation. Smolt trapping data from Prairie Creek with be combined with similar data from Redwood Creek upstream of the confluence with Prarie Creek to get a basin wide estimate of smolt production from Redwood Creek. PI's will supervise the research of an HSU graduate, who will study over-winter growth and survival. Survival will be estimated by PIT-tagging juveniles in the fall, and subsequently detecting the tagged fish with remote antennae and direct capture with the smolt trap.

WATER SUSTAINABILITY and CLIMATE in the UPPER KLAMATH RIVER BASIN

Investigators:	Dr. Walt Duffy, CACFWRU
	Dr. Michael Hughes, Oregon Institute of Technology
	Dr. Mazdak Arabi, Colorado State University, Engineering
	Dr. Steve Fassnacht, Colorado State University, Natural Resources
	PhD Student, Rosemary Records, CSU
	MS Students (TBD)
Duration:	July 2014 – June 2018
Funding:	National Science Foundation

The Upper Klamath River Basin is realizing that the future availability and quality of water is uncertain. This uncertainty in forecasting water resources is a current problem that is anticipated to worsen with climate change. While uncertainty about water resources is acute in the Upper Klamath River Basin, it is representative of challenges facing by river basins and communities throughout the western USA.

Challenge: Ensure the Upper Klamath Basin has an adequate supply of good quality water to meet future human and ecosystem needs as climate changes and becomes more variable.

Objective: Develop a theoretical framework that allows for a greater understanding of and the capacity to predict interactions between the water availability in in the Upper Klamath Basin and land use changes, domestic and industrial water demands, ecosystem function and services and climate change. The framework will consist of a series of integrated models informed with both place-based research within the basin and existing data. While this framework will include linkages between physical, biological

and social elements in the Upper Klamath Basin so as to provide specific guidance there, the inclusion of linkages between basic elements of the ecosystem will also insure the framework can be extrapolated to other basins in the western USA.

Proposed Research: The research will gather place based data and develop models that incorporate linkages and feedbacks among atmospheric, terrestrial, aquatic, biotic and social processes so as to forecast future changes in water availability and water quality in the Upper Klamath Basin. Important model components and processes are:

1. Climate variability and change,
2. Land use and management,
3. Wetland water quality ecosystem functions,
4. Human activity on water systems on decadal to centennial scales,
5. Determining how our built water systems, and their governance, can be made more reliable, resilient and sustainable, and
6. The effect changes climate, land use and human activity on biogeochemical cycles, water quality, long-term chemical transport and transformation.

UNIT PROGRAM REVIEW

PROGRAM DIRECTION

Duffy will retire in February 2014 and has begun to reduce new commitments. Although he will remain engaged, the Unit will experience a temporary lull in activities he has been responsible for. This period is, however, an opportunity for cooperators to discuss future Unit program direction and is consistent with the Cooperative Agreement being due for periodic (5-year) review.

California Department of Fisheries and Wildlife provided funding for a period of three years to cover Unit operations and support graduate student research. Their contribution is sincerely appreciated.

Funding from the national CRU program was reduced to $8,000 this FY. For the first time in many years, none of these funds may be placed in a vehicle fund. Thus, our ability to manage the Unit's small vehicle fleet is uncertain.

Leslie has made great progress in contract administration and has also contributed to student guidance for both the Unit and CNRS (see below).

Facilities and Equipment:

We continue to appreciate the outstanding facilities provided by HSU. No major equipment was acquired during the past year.

UNIVERSITY SERVICE AND TEACHING

Courses Taught

Restoration Ecology of Riverine Fish (3 units)	Duffy	Spring 2013
Ecology of Running Waters (3 units)	Wilzbach	Fall 2012

Graduate Student Major Advisor

Duffy	Philip Colombano – MS Fisheries, Humboldt State University Brian Poxon – MS Fisheries, Humboldt State University Matthew Metheny - MS Fisheries, Humboldt State University Stephen Zipper - MS Fisheries, Humboldt State University Tancy Moore - MS Fisheries, Humboldt State University
Wilzbach	Chris Adams – MS Fisheries, Humboldt State University Mark Ashenfelter –MS Fisheries, Humboldt State University Andrea Dockham-MS Fisheries, Humboldt State University David Malakauskas – PhD Entomology, Michigan State University Sam Rizza – MS Fisheries, Humboldt State University Christopher "Olie" Smith – MS Fisheries, Humboldt State University

Graduate Committee Service (unit scientists serve as members, not major advisors)

Duffy	Rosemary Records – PhD Environmental Engineering, Colorado State University Sam Rizza - MS Fisheries, Humboldt State University
Som	Tancy Moore - MS Fisheries, Humboldt State University
Wilzbach	Shari Anderson – MS Fisheries, Humboldt State University Scott Benson – MS Fisheries, Humboldt State University Jeffrey Hayes – MS Forestry, Humboldt State University Matt Metheny – MS, Fisheries, Humboldt State University Meiling Roddam – MS Fisheries, Humboldt State University Steven Zipper – MS Fisheries, Humboldt State University

OTHER UNIVERSITY SERVICE

Duffy	Guest lecture, Principles of Restoration, Environmental Management & Protection
Wilzbach	Chair, Tuition Waiver Committee, College of Natural Resources and Sciences, Humboldt State University, 2007 to present Member, Graduate Advisory Council
Farrar	Edited and updated the Coop Unit Student Handbook Edited and updated the CNRS Handbook for 2013 Updated and maintained the Unit's University web page and USGS web page

THESES OF UNIT-SPONSORED GRADUATE STUDENTS

Adams, C. 2013. Survival and movement of juvenile coho salmon (*Oncorhynchus kisutch*) in the Shasta River, California. M.S. Thesis, Humboldt State University, Arcata, CA.

Ashenfelter, M. 2012 Movement of resident rainbow trout (*Oncorhynchus mykiss*) transplanted below barriers to andromy in Freshwater Creek, California. M.S. Thesis, Humboldt State University, Arcata, CA. 41 pp.

Colombano, P. 2012. Response of coastal stream habitat and juvenile steelhead to the Honeydew Fire in Humboldt County, California. M.S. Thesis, Humboldt State University, Arcata, CA.

Metheny, M. 2012. Use of Dual Frequency Identification Sonar to estimate salmonid escapement to Redwood Creek, Humboldt County, California. M.S. Thesis, Humboldt State University, Arcata, CA.

Poxon, B. 2012 An Investigation into the efficiency of observers to visually detect adult salmon spawning in the Prairie Creek watershed, Humboldt County, California. M.S. Thesis, Humboldt State University, Arcata, CA.

TECHNICAL ASSISTANCE

Duffy — Department of Fish and Wildlife, serves as Chair of the Fishery Restoration Grants Program, Peer Review Committee.

Department of Fish and Wildlife, serves as a member of the California Advisory Committee on Salmon and Steelhead.

Department of Fish and Wildlife, serves as the science representative on the coho salmon recovery team.

U. S. Geological Survey, member of the Klamath Basin Leadership Team.

US EPA, member of team assembled to review wet meadow wetland rapid assessment protocols.

Wilzbach — Department of Fish and Wildlife, serves as an alternate member of the California Advisory Committee on Salmon and Steelhead.

Department of Fish and Wildlife, serves as an alternate science representative on the coho salmon recovery team.

SCIENTIFIC PUBLICATIONS

Duffy, W.G., P. Garone and others. 2013. Wetlands. Pages xx – xx in E. Zavaleta and H. Mooney, editors, Ecosystems of California. University of California Press, Berkeley, California (in press).

Groff, L.A., Duffy, W.G., Kahara, S.N. and Chapin, S.J. 2012. Temporally irregular breeding of western spadefoot toads (*Spea hammondii*) in managed wetlands. Northwestern Naturalist 93:79-83.

Kahara, S.N., W.G. Duffy, R. DiGaudio and R. Records. 2012. Climate, management and habitat associations of avian fauna in restored wetlands of California's Central Valley, USA. Diversity *4*:396-418; doi:10.3390/d4040396.

Malakauskas, D.M. and M.A. Wilzbach. 2012. Invertebrate assemblages in the lower Klamath River, with reference to *Manayunkia speciosa*. California Fish and Game 98(4):214-235.

Malakauskas, D.M., S.J. Willson, M.A. Wilzbach, and N.A. Som. 2013. Flow variation and substrate type affect dislodgement of the freshwater polychaete, *Manayunkia speciosa*. Freshwater Science, *in press*.

Wilzbach, M.A., M.J. Ashenfelter, and S. Ricker. 2012 Movement of resident rainbow trout transplanted below a barrier to anadromy. *Transactions of the American Fisheries Society, 141:294-304.*

PAPERS PRESENTED

Adams, C. and M. A. Wilzbach. 2013. Movement and surival of juvenile coho salmon in the Shasta River. Annual Meeting, Salmonid Restoration Federation, April 2013, Fortuna, California.

Duffy, W.G. and M. Metheny. 2013. Life cycle monitoring and DIDSON cameras: promise and pitfalls. Annual Meeting, Salmonid Restoration Federation, April 2013, Fortuna, California.

Duffy, W. G. 2013. Life history diversity in northern California fishes. Plenary presentation, American Fisheries Society, California-Nevada Chapter Annual Meeting, April 2013, Davis, California.

Malakauskaus, D.M., S.J. Willson, M.A. Wilzbach, and N.A. Som. 2012. Effect of flow manipulation on polychaete dislodgement in a laboratory flume. Annual Meeting, American Fisheries Society, August 2012, St. Paul, Minnesota.

Wilzbach, M.A. and D.M. Malakauskas. Invertebrate Assemblages in the lower Klamath River with reference to *Manayunkia speciosa*. Annual Klamath River Fish Health Conference, April 2013, Fortuna, California.

UNIT STAFF

Walter Duffy, Unit leader
Peggy Wilzbach, Assistant Unit Leader
Leslie Farrar, Unit Administrative Support

Research Associates and Cooperators
Sharon Kahara
Nick Som, Affiliate Scientist
Sarah Willson

Graduate Student Assistants
Chris Adams
Russ Bryant
Nick Campise
Andrea Dockham
David Malakauskas, PhD, MSU
Matt Metheny
Tancy Moore
Rosemary Records, PhD, CSU
Sam Rizza
Christopher Olie Smith
Stephen Zipper

Student Technicians
Charles Boone
Sage Gang-Halvorson
Mike Griffin
David Kissling
Amy Patten
Ann Thompson

Technicians
Seth Bowman
Rebecca Dutra
Charles Flower
Daniel Geist
Melissa Gordon
Andrew Lillejord
Duane Linander
Todd Newhouse
Laurel Osborn
Roderick Park
Matthew Settelmayer
Dominic Vitali