California Cooperative Fish & Wildlife Research Unit

Original painting by Chris Adams, former Coop Unit student, M.S. Fisheries 2013

2015 Coordinating Meeting

May 5, 2015

Humboldt State University

Table of Contents

Agenda……...……...……..3

2014 Coordinating Committee Meeting Minutes…….....…….…….5

Review of Projects Completed in 2014
Genetic Analysis of Tidewater Goby tissue samples by HSU COOP Unit (RWO 83)……...11
Redwood Creek life cycle monitoring (adult Steelhead escapement) – DIDSON 2013-15……...12

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)…….....…13
Evaluating grassland and wetland ecosystems in the Northern Great Plains (RWO 85).....15
Assymetric introgression between Coastal Cutthroat Trout and steelhead
in the Smith River Basin...……..…….……..…….16
Distribution and relative abundance of juvenile Coho Salmon in the Redwood
Creek basin, Humboldt County, California……..……..……...……..18
Comparison of benthic invertebrate community structure and diet composition of steelhead
(*Oncorhynchus mykiss*) in Dry Creek, California……..……...……...……..19
Overwinter survival, movement, and growth of juvenile Coho Salmon in relation to
large woody debris and low velocity habitat in northern California Streams……..20
Lower and Upper Redwood Creek juvenile salmonid (smolt) abundance.……...…….....21
Prairie Creek juvenile salmonid (smolt) abundance...…….…...…….22
Redwood Creek life cycle monitoring (adult steelhead escapement) – DIDSON 2015 – 17….....23
Prairie Creek Fisheries and Aquatic Ecosystem Synthesis…….24
Phase II: Monitoring the endangered Tidewater Goby using environmental DNA
in water samples: Field tests (RWO 87)……....25
Export of invertebrate drift from headwater streams…….27

Review of New Research Projects
Research and development in support of the Klamath Basin Stream Salmonid Simulator
S3 Model (RWO 88)……...…..29
Eel River monitoring plan……..……..…....30
Redwood Creek DIDSON adult steelhead monitoring 2016 - 2018……..….31
Redwood Creek DIDSON adult Coho Salmon monitoring 2016 – 2020…….....32
Lower Redwood Creek salmonid smolt abundance 2017……..…….32
Prairie Creek Coho Salmon 2016 - 2019……..…….….….34
Townsend's Big Eared Bat statewide assessment……..…..35
Rangewide Giant Kangaroo Rat surveys…….….…36
Characterizing the diet of Marbled Murrelets with next generation sequencing…….….….37

Unit Program Review
Program Direction…….……....39
Facilities, Equipment, Service and Teaching, Other University Service……..…....40
Theses of Unit Sponsored Graduate Students…….…….41
Student Awards, Presentations……...…41
Technical Assistance, Scientific Publications……....42
Unit Students and Staff…….…….…..45

California Cooperative Fish & Wildlife Research Unit
2015 Coordinating Meeting

May 5, 2015

Humboldt State University, Harry Griffith Hall, room 217

AGENDA

Introductions and Welcome (Chair, Joe Margraf).....9:00

Additions to the Agenda

Approval of 2014 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 (Wilzbach) 11:15

Lunch catered.....11:45

Unit Research Summary (continued)

Student Research Presentation (Deibner-Hanson) 1:00

Current Research Projects Review (Wilzbach) 1:30

New Research Projects (Wilzbach) 2:00

Unit Program Review 2:30

Cooperative Agreement and Program Direction

University Service and Technical Assistance

Accomplishments

Facilities and Equipment

Financial Status include discussion of Coop support from CDFW

Adjourn.....2:45

Executive Session

California Cooperative Fish & Wildlife Research Unit
2014 Coordinating Committee Meeting Minutes
Wednesday, June 11, 2014

The annual coordinating meeting was held at Humboldt State University, 1 Harpst Street, Arcata, California. The meeting began at 9:10 am and concluded at 3:30 pm.

In attendance:

Philip Bairrington, CDFW, Arcata

Russ Bellmer, CDFW, Sacramento

Bruce Bingham, USFWS, Arcata

Leslie Farrar, CA Cooperative Fish & Wildlife Research Unit

Nick Hetrick, USFWS, Arcata

Andrew Kinziger, HSU, Fisheries Department

Tony LaBanca, CDFW, Arcata

Joe Margraf, USGS Western Region

Steven Smith, HSU, CNRS

Sam Rizza, CA Cooperative Fish & Wildlife Research Unit

Micaela Szykman Gunther, HSU, Wildlife Department

Peggy Wilzbach, Unit Leader, CA Cooperative Fish & Wildlife Research Unit

Rick Zechman, HSU, CNRS

Joe Margraf served as chair and opened the meeting. Introductions were made. The agenda was reviewed and a request was made to add an executive session immediately following the main meeting as a standing agenda item. Minutes of the 2013 meeting were reviewed and approved with no additions or changes.

COOPERATOR REPORTS

Report from Nick Hetrick, USFWS, Arcata

- Bruce Bingham, the new field supervisor, was hired this past year.
- The past year had budget challenges resulting from sequestration and limited staffing capability; and process changes in funding for the Klamath and Trinity rivers were implemented.
- Juvenile fish health in the Klamath River has been monitored by technicians. There was a pulse flow release with the full crew out to assess effectiveness in alleviating disease incidence in salmonid populations. The agency has accumulated 23 years of monitoring on the Trinity and 11 years on the Klamath rivers. The Klamath Basin Regional Agreement (RBRA) legislation went to the Senate last week.
- The agency has been working on Pacific lamprey retrofits for passage and has been having success with low cost retrofits.
- Trainings have been offered that other agencies have participated in.
- Lease of current building is expiring in November 2014; USFWS is looking for a new location and considering a site at HSU at the Samoa Blvd which has potential as a research and technical park.

Report from Steve Smith, HSU-CNRS

- HSU will have a new president, Lisa Rossbacher, starting July 1st. The provost position has also been vacated and there will be an interim provost while the search is conducted for a permanent replacement. Steve expects changes to come with the new leadership.
- Enrollment growth in majors in CNRS is up over 25% in the past 5 years and is increasing faster than enrollment in the other two colleges. There have been no increases in base budget or in faculty. Next year there will be an increase in the base budget. Last year five faculty searches were conducted in the college including one new faculty hire in Fisheries, which will invigorate the program. Fisheries enrollment has fallen to 83 majors; Steve would like to see this number rise to 100.
- Eric Bjorkstedt, NOAA scientist and adjunct professor, has received additional funding to contract with the research vessel. Sabine Mader, Hatchery Manager, has conducted the first sale of cultured cutthroat trout, which will allow cash flow into the hatchery to continue improvements being made in the facility.

Report from Andrew Kinziger, HSU-Fisheries Department

- Andrew assumed the position of Chair of the Department in May; past chair Dave Hankin is enrolled in the early retirement program. Rafael Cuevas-Uribe, new Fisheries faculty hire, will start this fall. He brings aquaculture expertise to the department and the program.

Report from Micaela Szykman Gunther, HSU – Wildlife Department

- Micaela has assumed the role of Chair of the department and is interested in learning more about the Coop Unit.
- In the past eight years since she has been in the department, the Wildlife program has grown to 480 majors which has doubled in size. There have been no new faculty hires during this enrollment growth. Most graduates are obtaining employment in their major, reflecting the strong skills obtained at HSU. Students show strong interest in working as interns and the department would enjoy collaborating with CDFW.

Report from Joe Margraf, USGS

- Joe reviewed the history of the Coop Units for the group. In the 1980's most units were combined into Fish and Wildlife Units. There are only five units remaining that are designated as Fish only, of which California is one. It takes a congressional act to add Wildlife to the unit which is probably not going to happen at this time. The unit can, however, work collaboratively with the Wildlife Department.
- Federal budget: The budget for Cooperative Research Units program is almost entirely allocated to salaries (92%), and the 8% sequestration cut has resulted in an inability of the USGS to provide operating funds for a second consecutive year. This action has allowed the program to retain staff but there are no funds for anything else. The chief position has been operating with a rotating acting the past year. The position has been advertised and interviewed with the plan to have a new chief in place this fall. Kevin Whelan, who had been serving as deputy chief, took the position of a regional supervisor which was vacated by a retirement, and this leaves the deputy chief position vacant.
- Peggy will remain as Unit Leader until funding becomes available to rehire. It is uncertain just when this will happen as vacant positions are filled based on timing and priority. Joe suggests that the cooperators, led by HSU, develop a wish list for expertise for the position so that when funding becomes available, we will be poised to post the job announcement. USGS only advertises through USA Jobs, but the university can advertise in other venues at their own expense if desired. This is a federal position and USGS will handle the aspects needed to satisfy those requirements.

Report from Russ Bellmer, CDFW-Sacramento

- A DIDSON workshop was convened at the California Nevada American Fisheries Society Annual meeting in March, 2014 in Sacramento. The workshop was well attended, and generated two hours of discussion. The department has four of the latest versions of DIDSON cameras ready to deploy in the field for remote monitoring of salmon escapement.
- The Fisheries Restoration Grant Program (FRGP) grant process is now in internal review and expects awards to be signed in February 2015. The program is looking for a replacement for Walt Duffy on the peer grant review committee. Send nominations to Patty Forbes in Sacramento.

- Council on Ocean Affairs, Science and Technology (COAST) internship program (see: http://www.calstate.edu/coast/about/) had six positions located geographically from Los Angeles to Fort Bragg. One HSU student applied. The program is advertised through the CSU system.

- Coho Salmon Habitat Enhancement (Coho HELP Act) went into effect in January 2013. The program allows organizations to request approval from CDFW for a "Coho Salmon habitat enhancement project", defined as a restoration project in a region described in an adopted state or federal Coho Salmon recovery plan with the primary purpose of accomplishing one or more of the following: removal of road crossings/culverts which prevents or impedes the passing of fish, restoration of eroded or denuded stream banks, and wood placement that benefits naturally reproducing fish stocks.

- Increased scrutiny by auditors is in place for all projects. The director is in favor of more partnerships.

- Handouts were distributed of: 1. Fish Bulletin 180: California Coastal Salmonid Population Monitoring: Strategy, Design and Methods; 2. COAST 2013 Annual Report; and 3. California Coastal Monitoring Program for Salmon and Steelhead.

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

- Has been approached by the Service Learning Center at HSU regarding internships and may have something in place by this fall. His office has been working with green sturgeon data in the northern region.

Review of current, completed projects and review of new projects

Peggy Wilzbach reviewed the current projects completed in the last year as well as ongoing projects, and introduced four new research projects to be approved:

New project review:

1. Redwood Creek life cycle monitoring (adult steelhead escapement) DIDSON 2013 - 2015
2. Redwood Creek life cycle monitoring (adult steelhead escapement) DIDSON 2015 - 2017
3. Prairie Creek fisheries and aquatic ecosystem synthesis
4. Phase II: Monitoring the endangered Tidewater Goby (*Eucyclobius Newberryi*) using environmental DNA in water samples: field tests

Joe Margraf nominated to approve the projects unanimously as described. All approved.

Two other projects were mentioned that have been proposed to the Coop Unit this week, which has not allowed time to prepare written materials for review. Margraf suggested that Peggy develop proposals with cooperators and share them via email for approval.

UNIT RESEARCH SUMMARY

Sam Rizza, Fisheries Biology master's student, presented on "Coastal Cutthroat Trout hybridization and gene flow across sub-basins of the Smith River" a portion of his research in preparation for his master's thesis project.

2014 ANNUAL COORDINATING MEETING

Next year's meeting was set for Tuesday, May 12, 2015 via email after the meeting.

CLOSING

Joe Margraf motioned for the meeting to be adjourned. Russ Bellmer seconded. The meeting was adjourned at 3:30 pm. An executive session followed immediately afterward.

REVIEW OF PROJECTS COMPLETED IN 2014

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

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

Tidewater Goby (Eucyclogobius newberryi)

The endangered Tidewater Goby (*Eucyclogobius newberryi*) is a small fish (maximum total length 60 mm) restricted to discrete brackish water lagoons and bay habitats along the California coast. Site occupancy histories recorded on a time series suggest that southern California Tidewater Goby populations experience periodic extinctions and colonizations consistent with the metapopulation model.

We generated Tidewater Goby presence/absence histories for 99 sites across the northern extent of the species range in Curry County, Oregon, and Del Norte, Humboldt and Mendocino counties, California. Site occupancy histories of Tidewater Goby were tabulated on an annual basis between 1897 and 2013 using our own field surveys, published papers, museum vouchers, and unpublished reports. Analysis shown that detection probabilities for Tidewater Goby are about 0.50 and that extinction and colonization rates are very low for northern California populations of Tidewater Goby. Similarly, comparison of genetic diversity metrics, allele frequencies, and individual assignments across temporal collections indicated stability through time in all sites we examined, consistent with the absence of extinction and colonization dynamics. Our findings indicate that northern California populations do not conform to a metapopulation model of population dynamics and instead are composed of series of highly isolated populations occurring linearly along the California coast.

A final report describing these findings has been submitted to the USFWS. Additionally, a manuscript titled "Temporal genetic analysis of the endangered Tidewater Goby: metapopulation dynamics or drift in isolation?" is currently in review for publication in Molecular Ecology. The results of this work have also been disseminated at public presentations on the HSU campus, UC Santa Cruz, and at the CAL-NEVA AFS conference.

The final report is available at http://humboldt.edu/cuca/research.html.

REDWOOD CREEK LIFE CYCLE MONITORING (ADULT STEELHEAD ESCAPEMENT) – DIDSON 2013-2015

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Matthew Metheny, Research Associate
Duration:	June 2013 – March 2015
Funding:	California Department of Fish and Wildlife ($24,569)

Dual frequency identification SONAR **(**DIDSON) was deployed in Orick, CA until 31 May 2014 and used to estimate an escapement of 6,448 adult salmonids entering Redwood Creek to spawn between 22 November 2013 and 18 March 2014. Video footage captured a non-replicated systematic sample of 20 minutes per hour to estimate escapement of total fish, without species designation. Variance estimation was used to develop 95% confidence intervals of +/- 1,607 total salmonids. Census-based error analysis was used to develop a confidence index of +/- 1,288 total salmonids. Live fish observations from California Department of Fish and Wildlife spawning surveys in the basin were used to model species apportionment of the DIDSON counts. Of the unidentified salmonids passing the DIDSON, 2,175 were estimated to be Coho Salmon (*Oncorhynchus kisutch*), 3,487 as Chinook Salmon (*Oncorhynchus tshawytscha*), and 787 as steelhead (*Oncorhynchus mykiss*). Performance of the DIDSON was inferred by comparing five years of sonar counts with results of other adult salmon monitoring efforts in the Redwood Creek basin. We compared five years of spawner survey redd abundance estimates and DIDSON adult estimates. Values were 1.60-3.09 (mean=2.12) DIDSON fish corresponding to each estimated redd for Coho Salmon, 1.74-9.38 (mean=4.6) DIDSON fish/redd for Chinook Salmon, and 2.57-9.60 (mean=6.0) DIDSON fish/redd for steelhead. Comparing DIDSON escapement estimates of adults with smolt population estimates from rotary screw traps resulted in smolt per adult values of 23-34 for age 1+ Coho Salmon, 54-207 for age 0+ Chinook Salmon, 43-110 for age 1+ steelhead, and 7-12 for age 2+ steelhead. Additional DIDSON video data was gathered at the site through June 2014, and archived.

The final report is available at: http://humboldt.edu/cuca/research.html. A manuscript for journal submission is in preparation.

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. Sharon Kahara, HSU Wildlife Dept.
	PhD student, Rosemary Records, CSU
Duration:	September 2011 to June 2015
Funding:	USDA, Natural Resources Conservation Service ($212,264)

This research is 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.

Objectives in this research are to: 1) 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) 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: During the past year, we assessed the impact of the ongoing drought on habitat quality for waterfowl, shorebirds and upland birds in California's Central Valley. Contrary to expectations, results indicated a mixed response. Waterfowl habitat remained fairly stable, while shorebird habitat declined and upland bird habitat increased between the two time periods. Waterfowl habitat in the CCV is already minimal (<2% of the overall landcover). Despite the drought and associated cut-backs in water allowances, wetland managers used whatever water resources available to sustain adequate hydrology for the millions of birds that overwinter in the CCV. Shorebirds on the other hand are not widely targeted for management and therefore do not enjoy the same degree of consideration when it comes to their habitat needs. Shorebird habitat in 2013 was six times less abundant than in 2007.

We submitted a manuscript describing the impacts of wetland management during severe drought on breeding bird habitat use. Our results indicate that restored wetland habitat design may bolster habitat use through the establishment of vegetation mosaics. Sites that exhibited a variety of different vegetation patches tended to support a greater variety of avian species and therefore may be more resilient despite climate driven fluctuations in hydrology.

We completed linkage of the SWAT model and the groundwater model MODFLOW, and tested the ability of the linked model to better simulate groundwater flow in the Sprague River basin. This is an important step in better representing riparian processes. The manuscript was submitted for review to Journal of Hydrology in 2014; we expect publication with minor revisions later this year.

A spatial statistical model was used to evaluate important geographic and hydrologic controls on total phosphorus in the Sprague River watershed of Upper Klamath Lake, including the possible influence of riparian zones. This was an exploratory analysis intended to improve understanding of the watershed for later dissertation research. Results were presented at the American Geophysical Union Fall Meeting. Scenarios of streamflow under future climate in the Sprague River basin were also modeled to evaluate potential changes in return periods of floods required to sustain riparian vegetation. This was also an exploratory analysis intended to improve understanding of the watershed for later dissertation research. Results were presented at the AGU-Hydrology Days conference at Colorado State University.

The thesis research of R. Records was accepted for publication. The work uses the Soil and Water Assessment Tool (SWAT) to evaluate the water quality benefits of riparian areas in the Sprague River, Upper Klamath River Basin in the past, and under potential future climate.

Pasture in the Wood River watershed adjoining the Sprague River watershed.

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
Duration:	September 2011 – December 2015
Funding:	U.S. Geological Survey ($195,000)

The Northern Great Plains is critical for building honey bee colony health and population size to meet the pollination needs of crops elsewhere in the U.S.

The U.S. Geological Survey (USGS) and Northern Prairie Wildlife Research Center (NPWRC) are 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. This phase of the research investigates native bee pollinators, land use and agricultural pesticides.

Although frequently overlooked, pollinators are critical to sustain healthy ecosystems and prosperous human populations. 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. Awareness of the need for pollination is currently increasing at a time when pollinator abundance 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, and disease among bees can spread from external parasites. 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 phase of research are to:

1. evaluate and compare abundance and diversity of native pollinators within native prairie U.S. Fish & Wildlife Service (USFWS) lands and Conservation Reserve Program (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; and
4. evaluate risk from agrichemical contamination of pollen on native prairie FWS lands and CRP lands.

R. Bryant has completed the data collection and is beginning the data analysis; he anticipates having a completed thesis in December 2015. He has given oral presentations on his findings at the Western Section of the Wildlife Society 2014 Annual Meeting in Reno, Nevada, and at the 2014 Natural Capital Project Annual Meeting in Palo Alto, California.

ASSYMETRIC INTROGRESSION BETWEEN COASTAL CUTTHROAT TROUT AND STEELHEAD IN THE SMITH RIVER BASIN, CALIFORNIA

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

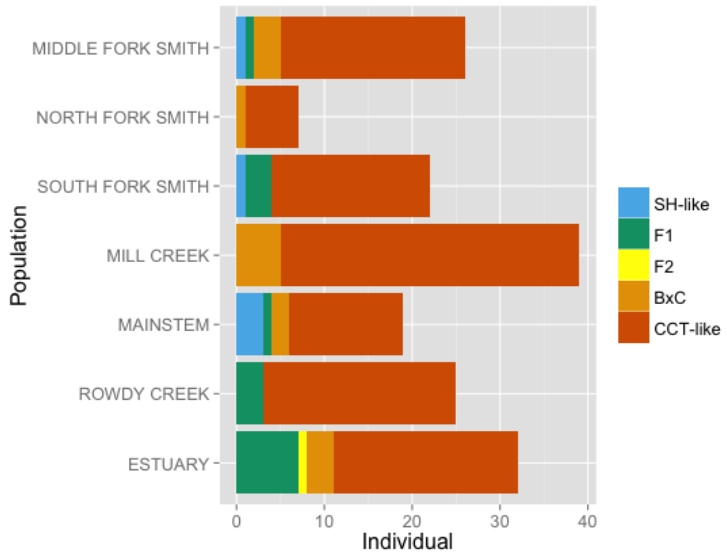
Cutthroat Trout (*Oncorhynchus clarki*) and Rainbow Trout (*Oncorhynchus mykiss*) are believed to have diverged from a common ancestor nearly two million years ago, at the beginning of the Pleistocene. While most other subspecies of Cutthroat Trout dispersed further inland and subsequently evolved in isolation from Rainbow Trout, the Coastal Cutthroat Trout (*O. clarki clarki*) coevolved with the coastal subspecies of Rainbow Trout, (*O.mykiss irideus*), or anadromous steelhead, throughout its range from northern California to southern

Coastal cutthroat trout

Alaska. While hybrids between Coastal Cutthroat Trout and steelhead are fully fertile, reproductive isolation between the two species is believed to have been 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, have increased the potential for hybridization.

Objectives of this study are to determine the extent of introgression between Coastal Cutthroat Trout and steelhead in each of 7 sub-basins of the Smith River, to characterize the shape of the introgression within the hybrid zone, and to assess morphological expression of hybrids over the range of introgression. The goal of the latter objective is to improve visual field identification.

During the summer of 2013, 888 putative Coastal Cutthroat Trout, steelhead, and their hybrids were sampled. Tissue samples were collected from all individuals and were genetically analyzed this past year at the NOAA genetics lab in Santa Cruz. A panel of 66 diagnostic single nucleotide polymorphisms (SNPs) were used to assess individual, population, and genomic introgression. Rizza has analyzed the data, and summarized findings in his thesis, which will be defended during the spring 2015 semester. Only 2% of the sample was identified as F1 hybrid individuals. Cutthroat Trout or steelhead with at least one alternate allele comprised 18% of the fish sampled. Introgression was strongly asymmetrical, favoring steelhead introgression into the Cutthroat Trout genome. Genome-wide variation was found across loci and linkage groups, suggesting that loci or regions are under selection pressure. While the majority of genetically identified steelhead and Cutthroat Trout were morphologically distinct, introgressed individuals exhibited intermediate physical characteristics and could not be reliably distinguished. Findings were presented at the 2015 Meeting of the CAL-NEVA Chapter of the American Fisheries Society.



Number of sampled hybrid or introgressed individuals per sub-basin by genotype class. SH-like- SH possessing one or two alternate alleles (no SH-like individuals with more than two alternate alleles were sampled), F1-first-generation hybrid, F2 second-generation hybrid, Bxc-backcrossed to CCT, CCT like- CCT possessing one to five alternate alleles.

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

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Teri Moore, CDFW
Duration:	June 2013 to March 2016
Funding:	California Department of Fish and Wildlife/FRGP ($48,866)

The objective of this study is to evaluate the spatial distribution and relative abundance of juvenile Coho Salmon in the Redwood Creek basin.

Snorkel surveys were conducted in summer 2014 in a spatially balanced set of 19 stream sections in Redwood Creek and several of its tributaries. Each survey reach was systematically sub-sampled based on specific habitat criteria For streams averaging less than (<) three meters (m) wetted width, potential sampling units included all pools with surface area greater than (>) three m^2 and depths > than 0.3m. For streams averaging > three m wetted width, potential sampling units included all pools with surface area > than six m^2 and depths > than 0.3 m.

Biological data were collected in every second qualifying pool with two independent dive passes along the entire length of each survey reach. For each sampling unit (pool), the primary and secondary diver recorded all salmonids observed by species, stage, and age class. Other species were noted and counted if possible. Divers maintained a distance of one pool apart to ensure independent counts and allow pools to equilibrate after the first pass. After completing his/her dive pass, the secondary diver collected the physical habitat information for each pool, including: habitat type (main channel pool, lateral scour pool, backwater pool or flatwater), total length (m), average width (m), maximum depth (cm), large woody debris count, estimated cover quality (1=none, 2=poor, 3=average, 4=good, 5=excellent), estimated instream shelter (estimated as the area of the unit surface area in square meters containing shelter), and standardized GPS coordinates (UTM: NAD83 Zone 10N).

We will use models in the USGS program "PRESENCE" to estimate occupancy rates for juvenile Coho Salmon in the Redwood Creek basin. The information obtained during this survey will be used to evaluate trends in spatial structure of Coho Salmon within the basin, and to identify habitat characteristics that influence distribution patterns.

Juvenile Coho Salmon

COMPARISON OF BENTHIC INVERTEBRATE COMMUNITY STRUCTURE AND DIET COMPOSITION OF STEELHEAD (*Oncorhynchus mykiss*) 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)

Dry Creek, located in Sonoma County, is a major producer of salmonids in the Russian River watershed because of its year round release of cold clear water from Warm Springs Dam. However, morphological changes associated with the dam, including channel incision, armoring of the streambed, high current velocities, and bank erosion, have reduced habitat availability for rearing fish and potentially, the community structure of benthic invertebrates. In this project we are comparing the structure of benthic invertebrate assemblages and diets of juvenile steelhead among four stream reaches differing in distance from the dam, with an expectation that differences in invertebrate abundance would track previously documented differences in fish growth. Data analysis showed that structure of invertebrate assemblages differed between seasons and among reaches. However, patterns of relative abundance of the most common taxa were not similar between steelhead diets and the invertebrate benthos, suggesting that benthic composition did not adequately represent prey availability. Reaches did not differ in biomass or abundance of diet items, or in percent dominance of the three most abundant taxa found in diet samples. Differences in relative condition of the fish among reaches may reflect reach-specific differences in energetic costs of feeding and maintaining position.

Diet sampling using gastric lavage

Research results have been presented at two conferences, and a draft thesis has been prepared.

OVERWINTER SURIVIVAL, MOVEMENT, AND GROWTH OF JUVENILE COHO SALMON IN RELATION TO LARGE WOODY DEBRIS AND LOW VELOCITY HABITAT IN NORTHERN CALIFORNIA STREAMS

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

Surveying large woody debris in west branch of Mill Creek, CA.

This thesis research will evaluate how emigration, survival, and growth of juvenile Coho Salmon relate to features of overwinter habitat in three basins of central and northern California. The study is a component of a larger effort to coordinate sampling methods and data analysis among California Department of Fish & Wildlife (CDFW) and Humboldt State University (HSU) scientists who have been independently monitoring Coho Salmon in coastal northern California for a series of years. A goal of this collaborative effort is to develop an understanding of relationships between habitat and survival of juvenile Coho Salmon to help interpret regional trends and direct effective restoration actions. Comparison of overwinter survival among multiple basins characterized by different land use and habitat type may allow assessment of the commonality of factors limiting freshwater survival of Coho Salmon at the southern edge of their distribution.

Specific objectives are to:

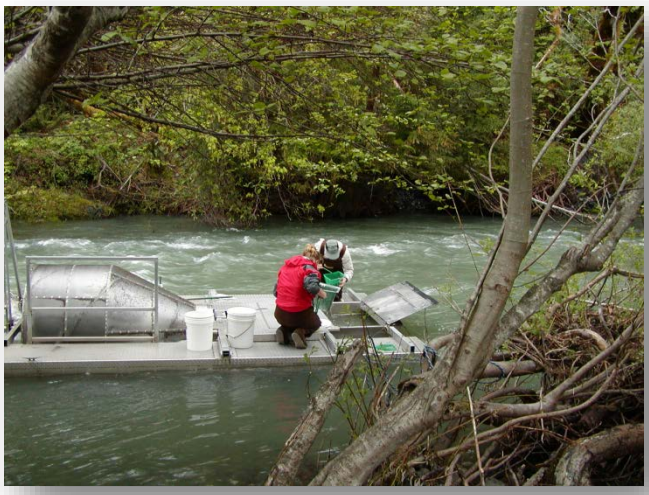
1. compare overwinter survival, emigration, and growth of juvenile Coho Salmon between fall tagging and spring outmigration among individual reaches and basins in northern California; and
2. evaluate relationships between overwinter survival, emigration, and growth with volume of large woody debris (LWD), low-velocity rearing area and off-channel habitat units among basins and reaches.

Fish movement, growth, and survival will be estimated from fall tagging, PIT antenna operation and outmigrant trapping data that is being collected by CDFW and Coop Unit crews in each of the three streams. LWD and low velocity habitat surveys have been recently completed, which will allow comparison of data with juvenile Coho Salmon population parameters. Multi-state models will be developed to estimate movement and survival of juvenile Coho Salmon within each of the streams, and compare models among streams to evaluate the significance of winter habitat features.

Thesis completion is expected in December 2015.

LOWER AND UPPER REDWOOD CREEK JUVENILE SALMONID (SMOLT) ABUNDANCE

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Michael Sparkman, CDFW
Duration:	June 2013 to March 2017
Funding:	California Department of Fish and Wildlife/FRGP ($224,818)



Rotary screw trap in upper Redwood Creek

This project continues for the 12th consecutive year a smolt trapping effort to estimate the abundance of Coho Salmon, Chinook Salmon, steelhead, and Cutthroat Trout smolts emigrating from the Redwood Creek watershed. Rotary screw traps are deployed during the spring/summer emigration period (March – August) at river mile 4 and 33 to allow for estimation of smolt population abundances from the upper and lower basin, as well as travel times between traps. Estimates of smolt abundances represent freshwater production from 37 miles (upper) and 93 miles of anadromous habitat.

The long term goal of the study is to monitor the status and trends of outmigrating juvenile salmonid smolts in Redwood Creek in relation to watershed conditions and restoration activities in the basin; provide data for Viable Salmonid Population Analysis; and to combine smolt information with counts of returning adult salmon to make Redwood Creek a life cycle monitoring station. Population abundances of Pacific Salmon can vary dramatically from year to year because of changes in ocean survival associated with both cyclic and non-cyclic changes in ocean conditions. This variability can obscure species recovery through watershed restoration, or further population decline. The combination of smolt estimates with counts of returning adult salmon allows separate estimation of freshwater and ocean survival.

Protocols used in this study are in compliance with the California Coastal Salmonid Population Monitoring (CDFW Fish Bulletin 180) and supported by the SONCC Coho Salmon draft recovery plan (NMFS 2012). Population estimates (by week and season) are 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 are taken from each species at age category weekly. Age composition of each species are determined using length frequency data and from periodic aging using scales. Stream water temperature is recorded every half hour using data loggers.

Analysis to date has shown the absence of a temporal trend in yearly population abundance for 0+ and 1+ Chinook Salmon, 0+ and 1+ Coho Salmon, 2+ steelhead, and Coastal Cutthroat trout. Abundance of 1+ steelhead has declined over the years of study, as has their average size (fork length and mass). Average size of 0+ Chinook Salmon and 0+ Coho Salmon was inversely related to population abundance, suggesting density-dependent effects.

Results from this last year are summarized in: Sparkman, M. D., R. Park, L. Osborn, and M. Griffin. 2015. Upper-Lower Redwood Creek juvenile salmonid (smolt) abundance project, study year 2014: a report to the Fisheries Restoration Grants Program (Project No. P1210322). CDFW AFRAMP, study 2a7: 81 p.

PRAIRIE CREEK JUVENILE SALMONID (SMOLT) ABUNDANCE PROJECT

Investigators:	Dr. Margaret Wilzbach, CACFWRU Peter Drobny, MS Student
Duration:	June 2013 – March 2017
Funding:	California Department of Fish and Wildlife/FRGP ($268,236) and Coop Unit Fund

Snorkeling in Prairie Creek

This project continues 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.

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 population abundances of Coho Salmon, Chinook Salmon, steelhead, and Cutthroat Trout in Prairie Creek as they migrate towards the estuary and Pacific Ocean.

The project is conducted in cooperation with CDFW biologist Michael Sparkman, who is running the smolt trap operation. Smolt trapping data from Prairie Creek will be combined with similar data from Redwood Creek upstream of the confluence with Prairie Creek to get a basin wide estimate of smolt production from Redwood Creek. We are estimating overwinter survival by PIT-tagging juveniles in the fall, and subsequently detecting the tagged fish with remote antennae and direct capture with the smolt trap.

MS student Peter Drobny is using project data to evaluate the relationship between overwinter survival of juvenile Coho Salmon with intra- and interspecific salmonid densities in late summer. Peter has completed two seasons of field work and is currently developing an N-mixture model to estimate pool-specific salmonid densities. His expected thesis completion date is December 2015.

REDWOOD CREEK LIFE CYCLE MONITORING (ADULT STEELHEAD ESCAPEMENT) DIDSON 2015 – 2017

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Matthew Metheny, Research Associate
Duration:	July 2015 – March 2017
Funding:	California Department of Fish and Wildlife/FRGP ($27,342)

DIDSON deployed in Redwood Creek

This project will use a DIDSON sonar imaging system to estimate the number of adult steelhead migrating into and out of Redwood Creek during the 2015/2016 spawning season, to provide status and trend information for this ESA-listed fish. A DIDSON has been deployed on Redwood Creek since 2009 to test its potential for monitoring escapement of adult salmon. Previous research has demonstrated that analysis of images captured by DIDSON can be used effectively to enumerate migrating salmonids over a wide range of conditions. When combined with existing smolt monitoring data (CDFW

AFRAMP), these data will allow smolt to adult and adult to smolt survival to be estimated. The project will also describe migration timing of steelhead in Redwood Creek, and evaluate relationships with environmental conditions (streamflow, temperature, tides) using standard statistical techniques.

Project funds have recently been awarded.

PRAIRIE CREEK FISHERIES AND AQUATIC ECOSYSTEM SYNTHESIS

Investigators:	Dr. Margaret Wilzbach, CAFWRU
	Matthew Metheny, Research Associate
Duration:	June 2014 - September 2015
Funding:	Redwood National Park ($10,283)

Prairie Creek drains old growth redwood forest

The 104 km^2 Prairie Creek watershed is almost entirely situated within the Redwood National and State Parks, which is a World Heritage Site and part of the California Coast Range Biosphere Reserve. Although the lower half of the watershed has been impacted by highway construction, timber harvest, and other land use, the creek in the upper watershed flows through undisturbed forest of late seral coast redwood and provides outstanding habitat for fisheries and aquatic resources. The upper watershed often serves as a reference site in studies evaluating land use impacts on aquatic resources. Prairie Creek and its tributaries support

populations of Chinook Salmon, Coho Salmon, steelhead, Coastal Cutthroat Trout and other valued fishes and aquatic vertebrates.

Many studies of watershed conditions, stream habitat and aquatic resources have been conducted in the Prairie Creek watershed over the last 50 or more years, by diverse groups including university researchers, federal and state agency scientists, and others. However, many of the data from these studies remains buried in files and reports which are not publicly available. The overall objective of this project is to identify and locate existing datasets, and to synthesize information on fisheries and aquatic resources into a "State of the Knowledge" report. The information will be used to evaluate fisheries health and function of sub-watersheds and guide restoration opportunities/alternatives in lower Prairie Creek.

Specific objectives are to:

1. identify and locate historic and current datasets, reports, theses, and publications on fisheries and aquatic resources in Prairie Creek, including maps and GIS data;
2. compile available electronic data in its native format, and compile digital copies of bibliographic references;
3. develop an annotated bibliography on fisheries and aquatic ecosystems in Prairie Creek which includes study reach location, study dates, focus of study and type of data collected (e.g. fish habitat, water quality, species- and life stage-specific), and key findings of the study;
4. synthesize the fisheries and aquatic information into a "State of the Knowledge" report for the Prairie Creek watershed. The report will identify:
    a) factors believed to limit fish and aquatic production, with a focus on salmonid species; and
    b) information gaps, spatially within the watershed and life-stage and species-specific. The report will also provide a prioritized list of information needs and suggest studies to fill data gaps.

To date, approximately 300 references have been identified and scanned, and bibliographic information has been entered into the Zotero research tool.

PHASE II: MONITORING THE ENDANGERED TIDEWATER GOBY (*EUCYCLOBIUS NEWBERRYI*) USING ENVIRONMENTAL DNA IN WATER SAMPLES: FIELD TESTS

Investigator:	Andrew Kinziger, HSU Fisheries Department
	Margaret Wilzbach, CACFWFRU
	Molly Schmelzle, MS Student
Duration:	January 2015 to December 2017
Funding:	USFW ($33,019)

This research examined the application of environmental DNA (eDNA) as a non-invasive and sensitive monitoring tool for endangered Tidewater Goby in aquatic habitats located along northern California's coastline. Specifically, an eDNA approach was compared to traditional seining methods and analyzed within a statistical framework that allowed for direct comparison between method specific detection probabilities. Numerous experimental and

Sampling water for eDNA.

empirical studies have shown that eDNA can detect a range of freshwater and select marine species. However, these studies neither quantitatively nor explicitly addressed the performance advantage of eDNA approaches for detecting rare and cryptic species over traditional field methods using detection probability estimates.

eDNA techniques were additionally evaluated across a range of coastal habitats, including lagoons, sloughs, and estuaries and over the entirety of the north coast region to indicate the strength of eDNA to be applied at large geographical scales and within a diversity of tidal habitats. An auxiliary objective was to use quantitative polymerase chain reaction (qPCR) to estimate relative site abundance from eDNA water samples using standard curve analysis. Biologically relevant covariates were also statistically assessed both as effects for detection and DNA concentration. A species specific qPCR genetic assay was developed for north coast Tidewater Goby populations and was tested exhaustively against ten common co-occurring species.

At 29 sites, a total of 254 paired seine hauls and water samples were collected for eDNA analysis. The number of paired collections at each location depended on habitat size and site characteristics, ranging from two to 23 samples taken at equal intervals. Each water sample was tested for Tidewater Goby DNA using six replicate qPCR assays designed specifically to tidewater goby. A multimethod occupancy analysis was performed to evaluate method specific detection probabilities, (p_{eDNA} and p_{seine}) using all detection history data for inference. Overall detection for eDNA was compared to for seining. The probability of detection using eDNA methods was double the rate of detection for seining within a framework accounting for imperfect detection. An eDNA approach detected Tidewater Goby at 19 locations as opposed to 14 with seining, including two locations where they have not been detected previously, two extant locations where they were not detected with a seine haul, and one location considered to be locally extirpated based upon previous field surveys. The results indicate that eDNA is a highly sensitive and efficient monitoring technique compared to traditional field sampling methods. An eDNA approach will benefit tidewater goby monitoring efforts and better inform management of its distribution and relative abundance. The Tidewater

Davis Lake. California.

Goby's endangered status and occurrence in difficult to sample habitat warrants significant consideration and eDNA techniques offer a new monitoring future.

A final report and a Master's thesis are being prepared based upon this research. This research will presented at the American Fisheries Society national conference to be held in August 2015.

EXPORT OF INVERTEBRATE DRIFT FROM HEADWATER STREAMS

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Jon Hollis, MS Student
Duration:	January 2015 – December 2016
Funding:	Green Diamond Resources Company ($48,900)

The great majority of the total length of river networks is comprised of low-order, headwater streams. Populations of salmonid fishes are often unable to maintain year-round residence in these small streams, because the streams have insufficient water volume or physical barriers are present. In downstream fish-bearing reaches, however, fish may supplement their food supply with drifting invertebrates exported from fishless headwaters. This subsidy of live macroinvertebrates and detrital material from headwater streams can be substantial. However, the extent to which subsidies from fishless headwaters are actually used by fish and contribute to biological production in downstream reaches has not been established.

Headwater streams provide downstream habitats with nutrients, live prey, and organic matter

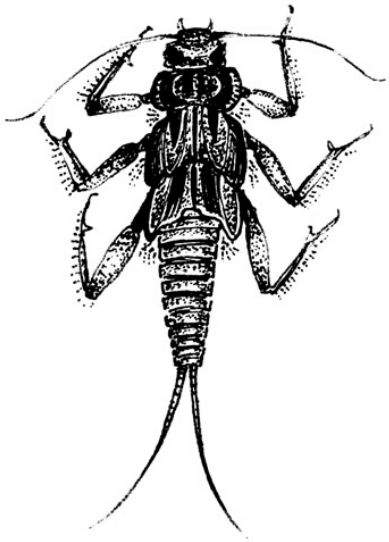
Objectives of this study are to:

1. quantify the magnitude, composition, and energy content of invertebrate subsidies of terrestrial and aquatic origin from fish-less headwater streams to downstream fish-bearing waters at different times of year and from streams differing in riparian canopy; and

2. evaluate use of these invertebrate subsidies by fish and their potential contribution to fish growth.

Invertebrate drift and benthic samples will be collected seasonally (spring, summer, fall, winter) from headwater streams in the lower Klamath River basin. Drift will be collected over a 24-h period during each sampling event. Samples will be preserved, measured and identified to lowest feasible taxonomic resolution in the laboratory, and energetic content of samples will be estimated from taxa-specific regressions of length and mass. Diets of juvenile salmonids in downstream reaches will be sampled by gastric lavage to compare taxonomic composition between drift and fish diet samples. The potential contribution of the invertebrate subsidy to fish growth will be approached through bioenergetic modeling.

Research will constitute the thesis research of Fisheries MS student Jonathan Hollis. The study is part of a larger multidisciplinary project investigating stream ecosystem response to riparian management, and includes scientists from Green Diamond Resource Company, Humboldt State University, Oregon State University, and the U.S. Forest Service. Jon is developing his thesis proposal and will begin field sampling in summer 2015.



Stoneflies are common inhabitants of invertebrate assemblages in headwater streams

NEW RESEARCH PROJECTS REVIEW

RESEARCH AND DEVELOPMENT IN SUPPORT OF THE KLAMATH BASIN STREAM SALMONID SIMULATOR S3 MODEL (RWO 88)

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Dr. Nicolas Som, USFWS
	David Stewart, Research Associate
Duration:	October 2014 – December 2015
Funding:	USFWS ($161,239)

The Stream Salmonid Simulator (S^3) Model is a Decision Support System being developed by the U.S. Fish and Wildlife Service, in close collaboration with the U.S. Geological Survey Columbia River Research Laboratory, Dr. Thomas Hardy from Watershed Systems Group, Inc., and Texas State University. An S^3 model in development for the Klamath River represents a synchronized series of sub-models that reflect the array of physical and biological processes that interact to affect the growth, movement, and survival of fish at a given life stage. A benefit to this method of model construction lies in the ability to update sub-models as new data, new analyses, or new scientific discoveries arise. The S^3 model is constructed to: 1) link habitat and flow to population dynamics; 2) operate on spatial scales fine enough to capture habitat quality gradients within the basin; and 3) run on temporal scales that capture variability resulting from flow management actions.

The current S^3 model tracks causes of mortality throughout the sub-adult life history of Chinook salmon (redd scour, habitat limitations, disease, water quality, etc.) over time within the 233-mile section of the main stem Klamath River spanning from Keno Dam in Oregon to its confluence with the Pacific Ocean in California. The model is being extended into the Trinity Basin, with the addition of an ocean component and IBM-type upstream adult migration sub module. These improvements will transform the S^3 model into a basin-wide, full life cycle model. Future development of the S^3 model will also include its expansion to incorporate Coho Salmon, as requested by NOAA Fisheries and the Bureau of Reclamation.

Specific objectives of this component of the project include:

1. evaluating best practices for assigning flow-to-habitat relationships for large river systems such as the Klamath; and

2. developing a Coho Salmon movement sub-model for use within the S^3 model that accurately reflects the diverse movement and life history strategies exhibited by the species.

This work will be undertaken by a post-doctoral researcher (Stewart), who will start work in June 2015.

EEL RIVER MONITORING PLAN

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Matthew Metheny, Research Associate
Duration:	August 2014 – July 2015
Funding:	California Trout, Inc. ($5,022)

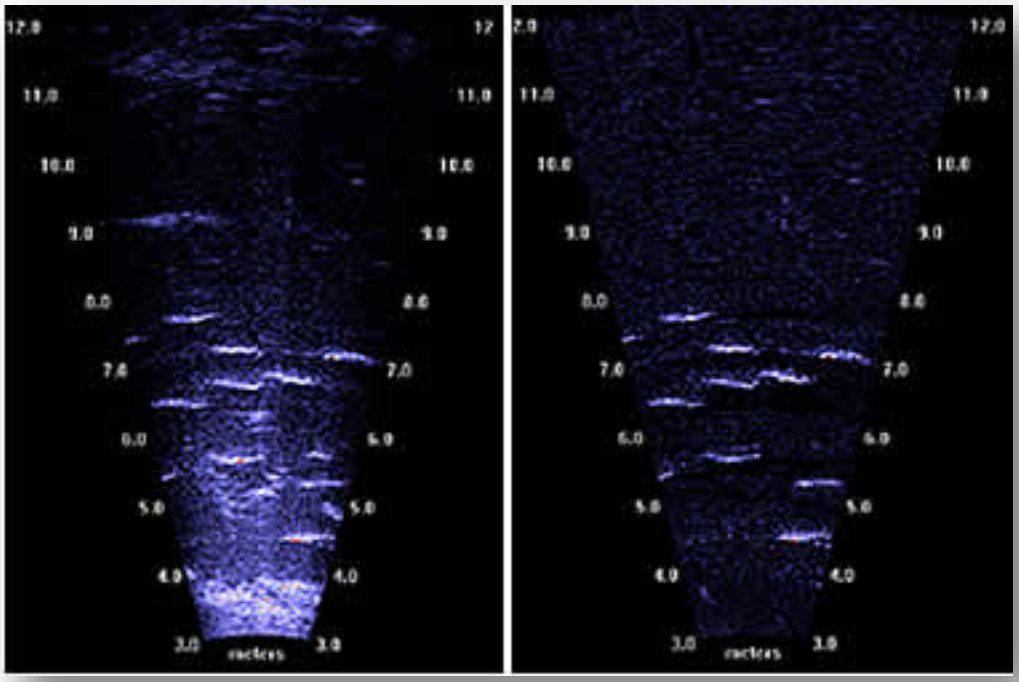
California Trout (Cal Trout) and the Eel River Forum are in the process of drafting and editing the Eel River Action Plan. The final Action Plan will include a chapter describing ongoing and proposed basin-wide monitoring of watershed health. Monitoring components include fisheries, water quality, and citizen-based monitoring. The objective of this project is to assist in identifying and summarizing on-going monitoring activities, and to recommend monitoring to fill information gaps.

Matt Metheny will coordinate with Darren Mierau of Cal Trout and several state and federal agency staff who participate in the Eel River Action Plan monitoring subcommittee, to revise the existing draft Action Plan Monitoring chapter. This task will include participating in discussions with subcommittee members to receive input and direction, reading available documents from northern California and Pacific Northwest watershed programs on monitoring plans and methods, writing draft sections of the monitoring chapter for review by subcommittee members, and revising draft sections until the chapter is complete. This writing and editing task will be performed on a time and materials basis.

REDWOOD CREEK DIDSON ADULT STEELHEAD MONITORING 2016-2018

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Mathew Metheny, Research Associate
Duration:	June 2016 – March 2018
Funding:	California Department of Fish and Wildlife/FRGP ($75,694)

The objective of this proposed study to the Steelhead Report Card Program is to estimate adult escapement of steelhead and other salmon to Redwood Creek during the 2016 - 2017 adult migration season using a DIDSON sonar system in the mouth of the creek.



DIDSON sonar image with (right) and without (left) filter to block background noise

Experimental use of a DIDSON sonar camera has been shown to provide reliable estimates of salmon escapement which can circumvent some of the limitations of spawner surveys and other methodologies for estimating adult abundance. Steelhead redds are particularly difficult to detect with walking surveys, because of the short redd residency time of steelhead and because spawning gravels have been cleansed by winter flows. DIDSON equipment can be operated at higher flows than most weirs, detections are not limited by water transparency, and operation of the equipment is less labor-intensive.

REDWOOD CREEK DIDSON ADULT COHO SALMON MONITORING 2016 – 2020

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Matthew Metheny, Research Associate
Duration:	June 2016 – March 2020
Funding:	California Department of Fish and Wildlife/FRGP ($288,417)

DIDSON sonar technology has great promise for counting adult salmonids in locations where other methods fail, but the correct assignment of species identity to DIDSON images is problematic in locations, such as Redwood Creek, where multiple salmonid species are present and run timing overlaps.

The objective of this proposed study is to estimate adult escapement of Coho Salmon and other salmon to Redwood Creek during the 2016, 2017, and 2018 spawning seasons using a DIDSON sonar system in the mouth of the creek. A MS thesis project will evaluate morphometric analysis as a tool for differentiating salmonid species in DIDSON images. The archival collection of Redwood Creek DIDSON images, and other DIDSON data sets will be analyzed to determine if aspects of the images can be used to identify species. Redwood Creek DIDSON data contains 1,000s of images which can be confirmed as Chinook Salmon or steelhead based on differences in run timing. Image attributes will be compared to each other, and observable differences noted. Images of Chinook Salmon and steelhead will then be compared to putative images of Coho Salmon to identify unique aspects of Coho Salmon images. Images of positively identified Coho Salmon for Redwood Creek will be gathered by applying radio telemetry tags to Coho Salmon below the DIDSON site, and using a radio telemetry receiver at the DIDSON site. By syncing detections from the radio tag receiver with the DIDSON sonar images, the exact times when Coho Salmon are present can be isolated. The isolated Coho Salmon DIDSON images will then be compared to steelhead and Chinook Salmon images to determine if species can be reliably distinguished in DIDSON imagery when run timing overlaps.

LOWER REDWOOD CREEK SALMONID SMOLT ABUNDANCE 2017

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Michael Sparkman, CDFW
Duration:	July 2016 – May 2018
Funding:	California Department of Fish and Wildlife/FRGP ($209,583)

This proposed project will continue a long term study on the abundance of Coho Salmon, Chinook Salmon, steelhead trout, and Cutthroat Trout smolts emigrating through lower Redwood Creek. We plan on conducting this study for over 20 years to fully encompass biological and environmental variability within the watershed and to detect changes attributable to climate destabilization. The major goal is to continue determining baseline and status and trend information for Coho Salmon, Chinook Salmon, steelhead trout, and Cutthroat Trout which can be used to identify factors limiting species recovery and identify restoration needs in the basin (research/management question). The status/trend information can be used to assess the response of smolt populations to watershed restoration efforts and can also be used in population viability analysis.

This study will play an essential role in making Redwood Creek a life cycle monitoring station by enumerating smolts at the population level. The DIDSON sonar count of adults in Redwood Creek will also be used in the life cycle monitoring study, and rely upon the smolt work to provide abundances so that we may determine smolt to adult, and adult to smolt relationships, in addition to assessing freshwater conditions and marine survival of juveniles (comprehensive monitoring strategy). The study in lower Redwood Creek will monitor smolt abundance from a total of 93 miles of anadromous habitat, which are surrounded by 152,000 acres of forested lands. The study in lower Redwood Creek is very important because data encompasses all smolt production within Redwood Creek with the exception to the smolt production in Prairie Creek, which is tributary to Redwood Creek downstream of the study site in lower Redwood Creek.

Smolt abundance will be tracked using a rotary screw trap deployed in the creek during spring and summer 2016. Data will be collected on abundance structure (abundance by age class), life history attributes (e.g., age at smolting, degree of smolting, size of fish), and genetic samples will be obtained for analysis by the National Marine Fisheries Service. Mark-recapture experiments will be used to estimate trap efficiency.

PRAIRIE CREEK COHO SALMON 2016 - 2019

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Michael Sparkman, CDFW
Duration:	July 2016 – May 2018
Funding:	California Department of Fish and Wildlife/FRGP ($419,762)

Juvenile Coho Salmon

Prairie Creek supports most of the Coho Salmon found within the Redwood Creek basin, and is considered a stronghold for adult and juvenile Coho Salmon. This project will determine the current smolt population abundance and overwinter survival of juvenile Coho Salmon within Prairie Creek. This information is a key priority for the CDFW Coastal Salmonid Monitoring Plan and the NMFS SO/NCC Coho Salmon recovery plan. Determination of over-winter survival for juvenile Coho Salmon is also a key priority, since overwinter survival has often been found to be a limiting factor to population growth. Our smolt and overwinter survival data in Prairie Creek can be used as a benchmark for comparisons of similar data collected in more degraded streams because Prairie Creek is still in a relatively pristine condition.

Smolt population abundances will be determined using a rotary screw trap and mark/recapture methods, and overwinter survival will be determined by tagging juvenile Coho Salmon in the fall with pit tags, and monitoring movement of the fish through a pit tag antennae array. Both the antennae and the trap will detect or recapture a portion of the tagged juveniles. The methods employed will be similar to methods used from YR 2011 to the present, allowing us to examine trends in smolt abundances. This study is designed contribute to long term monitoring to allow assessment of environmental/biological variability within coastal northern California. This project will play a key role in the Prairie Creek and Redwood Creek life cycle monitoring station by determining smolt abundances, in conjunction with redd counts in Prairie Creek, and adult counts in lower Redwood Creek using DIDSON sonar technology. CDFW and NMFS will use data from this project to assess Coho Salmon recovery and restoration needs. Project data will be used in a graduate student thesis.

TOWNSEND'S BIG EARED BAT STATEWIDE ASSESSMENT

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Dr. Joseph Szewczak, Biology, Humboldt State University
	Dr. Mike Morrison, Texas A & M University
Duration:	April 2015 – June 2016
Funding:	California Department of Fish and Wildlife/USFWS ($129,799)

Joe Szewczak in the field with student

The goal of this project is to provide information that can be used to update the status of Townsend's big-eared bat (*Corynorhinus townsendii*) in California, including an evaluation of historic data and the conducting of new surveys of distribution and abundance.

Specific project objectives include:

1. gather all existing data on the distribution, abundance and site characteristics of the bat;
2. conduct re-surveys of historic sites for current occupancy; and
3. conduct surveys in a selection of habitat occupancy and abundance.

The sampling scheme has two primary components. First, all historic roost sites (maternity and hibernacula) that may be currently operational (e.g., those which have not be abandoned because of mine closure) will be surveyed for current activity and condition. Second, a stratified random sampling scheme will be used to generate a probabilistic model of bat occupancy and abundance across its range in California. An adaptive sampling scheme will then be used for the occupancy survey.

RANGEWIDE GIANT KANGAROO RAT SURVEYS

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Dr. Tim Bean, Wildlife Department, Humboldt State University
Duration:	October 2015 – October 2018
Funding:	California Department of Fish and Wildlife/USFWS ($117,647)

Juvenile Giant Kangaroo Rat (Dipodomys ingens). Photo credit: Nathan Alexander

The giant kangaroo rat, *Dipodomys ingens,* is a state- and federally-endangered burrowing species of rodent endemic to California. In many areas, they are the main prey for the federally-endangered and state-threatened San Joaquin kit fox. Their burrows provide habitat for the federally- and state-endangered blunt-nosed leopard lizard and the federal species of concern and state-threatened San Joaquin antelope squirrel. In addition, their burrowing activities appear to promote federally- and state-endangered California jewelflower and San Joaquin wooly-threads. The giant kangaroo rat is at the center of an endangered ecosystem. Monitoring the species is therefore of high priority throughout the Recovery Plan for Upland Species of the San Joaquin Valley. As of the five year review in 2010, the status of the rat in these satellite colonies was unknown; the most recent surveys occurred in the late 1980s. Range-wide surveys will help guide conservation and project planning, especially in light of the increasing number of renewable energy projects proposed for the region.

Project objectives are to:

1. examine aerial photographs and satellite imagery within potential habitat to digitize active burrows or burrow mounds;

2. evaluate use of fecal pellets from live-trapped kangaroo rats as a means of detecting kangaroo rat presence and establishing species identity; and

3. use in situ surveys for kangaroo rat occupancy to detect changes in population size in the Carrizo Plain.

CHARACTERIZING THE DIET OF MARBLED MURRELETS WITH NEXT GENERATION SEQUENCING

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Dr. Richard Golightly, Wildlife Department, HSU
	Dr. M. Z. Peery, Forest and Wildlife Ecology, U. of Madison-Wisconsin
Duration:	2015 – 2018
Funding:	California Department of Fish and Wildlife ($314,739)

Marbled murrelets (*Brachyramphus marmoratus*) are highly threatened in California due to nesting habitat loss, nest predation, and changes in prey resources. While extensive habitat management and predator control programs have been implemented by the state and federal agencies responsible for murrelet conservation, considerably less attention has been paid to the management of prey resources in the marine environment. Importantly, the Marbled Murrelet Recovery Implementation Team recently identified "changes in marine forage" as one of the two most important mechanisms responsible for low sustained murrelet recruitment in California. Indeed, murrelet reproductive success is tightly coupled with the availability of potential prey species and reproductive failure is regularly observed when potential prey is scarce. Moreover, murrelets in California currently forage on lower-trophic level (and less energetically-valuable) prey than they did in the late nineteenth century based on stable isotope analyses – an observation that may in part explain chronically low recruitment in the region.

Understanding how changes in the marine environment threaten marbled murrelets and their foraging resources in California is challenged by a lack of basic dietary information. Dietary information for murrelets is scarce because of the species' secretive inland nesting habits, which make monitoring prey delivered to nests nearly impossible. As a result, murrelet dietary studies in California are either anecdotal, based on stable isotope analyses that do not provide species-level identifications, correlations between at-sea locations and fish schools, or simply based on fish samples collected in at-sea areas used by murrelets. The lack of species-specific dietary information for marbled murrelets is frequently cited in recovery documents as one of the major obstacles preventing management of specific prey resources needed for maintaining viable murrelet populations.

Excitingly, new next-generation-sequencing (NGS) technologies provide a promising tool for characterizing marbled murrelet diet at the species level. NGS methods allow for the sequencing of massive amounts of prey DNA fragments collected from predator fecal material without very time consuming and expensive cellular cloning procedures. These methods have been successfully applied to dietary analyses of a range of predator species, most notably marine species such as Australian fur seals, Steller's sea lions, and little penguins. As a consequence, NGS methods finally provide scientists and managers with a vetted and much needed tool for characterizing the diet of marbled murrelets, and ultimately informing the management of marine resources in a manner that could help recover this species.

Objectives of the proposal are to characterize the species-level diet of marbled murrelets in California using fecal material collected from individuals captured at sea. Murrelet diets will be sampled in central and northern California during the breeding (May) and molting (September) periods. Prey DNA extracted from fecal material will be amplified and sequenced using NGS methods, and prey species will be identified using available reference DNA sequence data.

UNIT PROGRAM REVIEW

PROGRAM DIRECTION

The California Unit is pleased to welcome Dr. John Organ as the new Chief of the USGS Cooperative Research Units Program. Dr. Organ assumed the helm in August 2014. He served as Chief of Wildlife and Sport Fish Restoration for the Northeast Region of the U.S. Fish and Wildlife Service from 2005 to 2014, and worked in the USFWS's Ecological Services and National Wildlife Refuge programs during his 35 year career. Dr. Organ has announced plans to visit each of the Coop Units, and has scheduled an all-hands meeting of Coop Unit staff for next winter. His support in prioritizing the California Coop Unit for funding of the vacant Assistant Leader position has been pivotal.

With approval from the university and CDFW, the USGS formally appointed Wilzbach as Unit Leader of the CA Unit. Authorization to initiate the search for an Assistant Unit Leader was approved by USGS and the position is in process of being advertised. We will be searching for an individual with a research focus on the ecology and conservation of salmonid fishes and their freshwater habitats. The position announcement will be posted on the USAJobs for a 60-day period. We anticipate reviewing applicant files and interviewing during the fall semester 2015.

An updated Cooperator Agreement for the continued operation of the California Cooperative Fish and Wildlife Research Unit by the USGS, HSU, CDFW, WMI, and USFWS has been reviewed and approved by all cooperators, and is in process of obtaining necessary signatures. Once finalized, the terms of the agreement will be next reviewed after 5 years.

The contract for the Coop Unit Fund from CDFW for basic operational expenses and graduate student support was amended to extend to March 2017. Budget categories were revised to better reflect actual need.

Our research effort will be boosted in June 2015 with the addition of post-doctoral associate, David Stewart. David will be working closely with Nick Som, USFWS, to extend the Klamath River Stream Salmonid Simulator Model to incorporate Coho Salmon and to evaluate best practices for assigning flow-to-habitat relationships for the Klamath River. The Unit is pleased as well to expand its research program to begin to address conservation needs of small mammals within the state. In addition to a new project to assess the status of big eared bats with HSU researcher Joe Szewczak, we are expecting to initiate a project this year with HSU wildlife biologist Tim Bean, to monitor the population status of the giant kangaroo rat. We are looking forward to exploring opportunities to expand our fisheries research to address the needs of inland fisheries within the state.

Leslie continues to contribute to guidance of Unit and CNRS students in addition to providing administrative support to the Unit. She is an active participant in the Institute for Student Success, and in discussion groups focused on understanding student needs. She attended and received trainings for federal travel and other web-based USGS functions.

FACILITIES AND EQUIPMENT

We appreciate the outstanding facilities provided by HSU. The unit received a ROV Max Rover this past year from the US Naval Facilities Engineering and Expeditionary Warfare Center at Port Hueneme, California. The ROV will be used by HSU faculty and students for research and education. The recent donation to the Unit of a Boston Whaler by USFW Service has been in use at the HSU Marine Lab.

UNIVERSITY SERVICE AND TEACHING

Courses Taught

Ecology of Running Waters (3 units)	Wilzbach	Fall 2014
Modern Statistical Modeling (4 units)	Som	Spring 2015

Graduate Student Major Advisor

Wilzbach
John Deibner-Hanson – MS Fisheries, Humboldt State University
Andrea Dockham - MS Fisheries, Humboldt State University
Peter Drobny - MS Fisheries, Humboldt State University
Sam Rizza – MS Fisheries, Humboldt State University
Jon Hollis – 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
Russ Bryant - MS Wildlife, Humboldt State University

Som
John Deibner-Hanson – MS Fisheries, Humboldt State University
Peter Drobny – MS Fisheries, Humboldt State University
Justin Alvarez – MS Fisheries, Humboldt State University

Wilzbach
Justin Alvarez – MS Fisheries, Humboldt State University
Scott Benson – MS Fisheries, Humboldt State University
Emily Ferrell – MS Environmental Science & Mgmt, Humboldt State University
Molly Gorman - MS Fisheries, Humboldt State University
Jeffrey Hayes – MS Forestry, Humboldt State University
Michelle Krall – MS Fisheries, Humboldt State University
Alexander Wick – MS Forestry, Humboldt State University
Steven Zipper – MS Fisheries, Humboldt State University

OTHER UNIVERSITY SERVICE

Wilzbach Member, IACUC

Farrar Updates and maintains the Unit's University and USGS web pages; attended Tribal Worldview and Context seminar; member of Fisheries evacuation team.

THESES OF UNIT-SPONSORED GRADUATE STUDENTS

Benson, S. 2014. *Ceratomyxa Shasta*. Timing of myxospore release from juvenile Chinook Salmon. M.S. Thesis, Humboldt State University, Arcata, CA.

Campise, N. 2014. Production of the myxosporean parasite, *Ceratomyxa Shasta*, in fall-run Chinook Salmon carcasses in the Klamath River. M.S. Thesis, Humboldt State University, Arcata, CA.

Moore, T. 2014. Overwinter survival and redistribution of juvenile Coho Salmon *Oncorhynchus kisutch*, in Prairie Creek, California. M.S. Thesis, Humboldt State University, Arcata, CA.

Zipper, S. 2014. Use of riparian wetlands by larval Lost River, shortnose, and Klamath largescale suckers in the Sprague River, Oregon. M.S. Thesis, Humboldt State University, Arcata, CA.

STUDENT AWARDS

Deibner-Hanson, John

State University Grant

Dockham, Andrea

Sonoma County Water Agency

Drobny, Peter

Danielle Plumb Zumbrun Memorial Scholarship
Marin Rod and Gun Club
State University Grant

Hollis, Jon

Founding Fisheries Faculty Scholarship

Rizza, Sam

Danielle Plumb Zumbrun Memorial Scholarship
State University Grant

PRESENTATIONS

Dockham, A. and M. A. Wilzbach. Comparison of benthic invertebrate community structure and diet composition of steelhead trout (*Oncorhynchus mykiss*) in Dry Creek, California. Poster presentation at 21st Annual Meeting California Aquatic Bioassessment Workgroup, 1st Annual California Chapter Society of Freshwater Science. 2014.

Dockham, A., and M. A. Wilzbach. Comparison of benthic invertebrate community structure

and diet composition of steelhead trout in Dry Creek, California. Presentation at 33rd Annual Salmonid Restoration Conference, Salmonid Restoration Federation Meeting, Santa Rosa, California. 2015.

Duffy, W. G. Prairie Creek sub-basin life cycle monitoring, 1998-2013. Oral presentation, Redwood Creek Symposium, Redwood National Park, Orick, CA. October 2014.

Records, R. et al. Hydrological trends in a high alpine watershed in Rocky Mountain National Park. Poster presentation at American Geophysical Union Fall Meeting, San Francisco, California. December 2014.

Records, R. et al. Hydroclimate and landscape controls on phosphorus loads to hypereutrophic Upper Klamath Lake, Oregon. Poster presentation at American Geophysical Union Fall Meeting, San Francisco, California. December 2014.

Rizza, S., A. P. Kinziger, J. C. Garza, and M. A. Wilzbach. Assymetric introgression between Coastal Cutthroat Trout and steelhead in the Smith River Basin, California. Oral presentation at the Annual Meeting of the CAL-NEVA Chapter of the American Fisheries Society. Santa Cruz, California. April 2015.

Wilzbach, M. A. Role and source of macroinvertebrates in fish growth. Oral presentation, Riparian Summit Conference. Korbel, California. April 2015.

TECHNICAL ASSISTANCE

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.

Review of Oregon Department of Environmental Quality protocols for aquatic macroinvertebrate-based assessment of water quality impairment for Plum Creek Timber Company.

SCIENTIFIC PUBLICATIONS

Danehy, R., M. A. Wilzbach, Young, M. et al. 2014. Regional specific interactions of forests and fish. *in* Danehy, R. and A. Dolloff (eds.). Reflections on forest management: can fish and fiber coexist? American Fisheries Society, Bethesda. In review.

Hodge, B., M. A. Wilzbach, and W. G. Duffy. 2014. Potential fitness benefits of the half-pounder life history in Klamath River Steelhead. Transactions of the American Fisheries Society. In press.

Hodge, B., M. A. Wilzbach, R. M. Quiñones, and J. A. Hobbs. Life history diversity in Klamath River steelhead. In review.

Kahara, S. N., W. G. Duffy, R. DiGaudio and R. Records. 2014. Avian response to hydrological management of restored wetlands in California's Central Valley, USA. In review.

Records, R. M., M. Arabi, S. R. Fassnacht, W. G. Duffy, M. Ahmadi, and K. C. Hegewisch (2014), Climate change and wetland loss impacts on a western river's water quality, Hydrol. Earth Syst. Sci., 18, 4509–4527, doi:10.5194/hess-18-4509-2014.

Records, R. M., et al. In review at Journal of Hydrology. 2014. Enhanced Assessment of Surface-Subsurface Hydrologic Processes at the Watershed Scale by coupling SWAT and MODFLOW.

Records, R. M., et al. Large snowmelt versus rainfall events in the mountains. 2014. Journal of Geophysical Research: Atmospheres.

Records, R. M., et al. 2014. Computational Procedure for Evaluating Sampling Techniques on Watershed Model Calibration. Journal of Hydrologic Engineering.

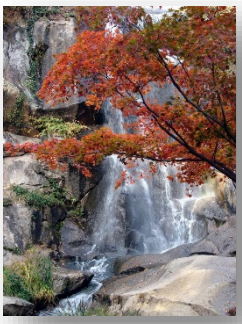
Records, R. M., et al. 2014. Impact of climate change on diffuse pollutant fluxes at the watershed scale. Hydrological Processes.

Wible, T. C., R. T. Bailey, M. Arabi, and R. M. Records. Submitted to Journal of Hydrology. Enhanced Assessment of Surface-Subsurface Hydrologic Processes at the Watershed Scale by coupling SWAT and MODFLOW.

UNIT STAFF

Margaret Wilzbach, Unit Leader
wilzbach@humboldt.edu

Leslie Farrar, Unit Administrative Support
leslie.farrar@humboldt.edu



RESEARCH ASSOCIATES AND COOPERATORS

Sharon Kahara
Nick Som, Affiliate Scientist
Matt Metheny

GRADUATE STUDENT ASSISTANTS

Russ Bryant, Wildlife

Andrea Dockham, Fisheries

Jon Hollis, Fisheries

John Deibner-Hanson, Fisheries

Peter Drobny, Fisheries

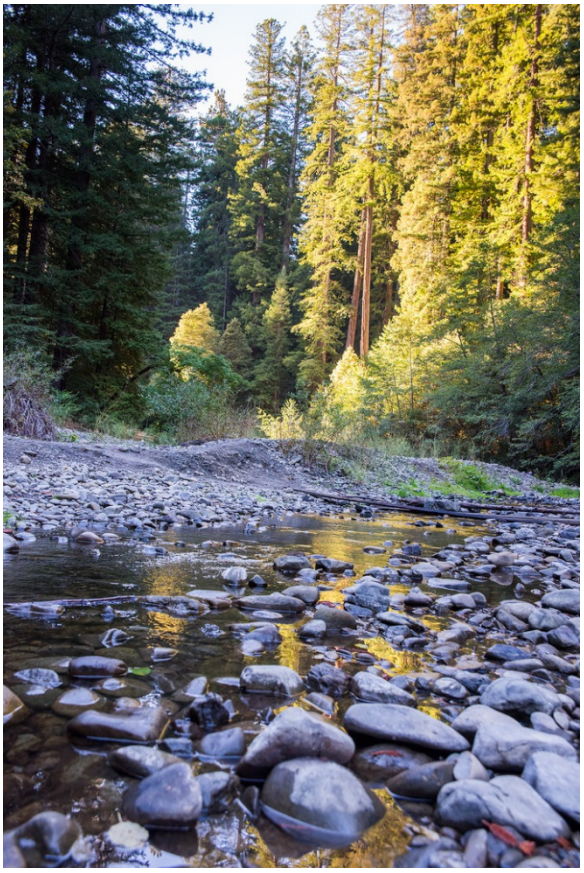
Sam Rizza, Fisheries

Rosemary Records received her MS degree in 2013 and is pursuing her PhD at CSU in the Geosciences department, Watershed Science Program.

Tancy Moore, MS Fisheries, currently working for NOAA.

Student Technicians

Dylan Keel
Chris Fabian
Spencer Lejins
Rachel McCain
James Schwartz
David Kissling

Technicians

Jaspir Amir
Elizabeth Beilke
Charles Boone
Seth Bowman
Adam Canepa
Olivia Carter
Melissa Gordon
Maia Grodin
Steven Holt
Andrew Lillejord
Sherry Mason
Todd Newhouse
Laurel Osborn
Roderick Park
Anthony Scheiff
Matthew Settelmayer
Benjamin Sheppard
Nicholas Van Vleet
Dominic Vitali