California Cooperative Fish & Wildlife Research Unit

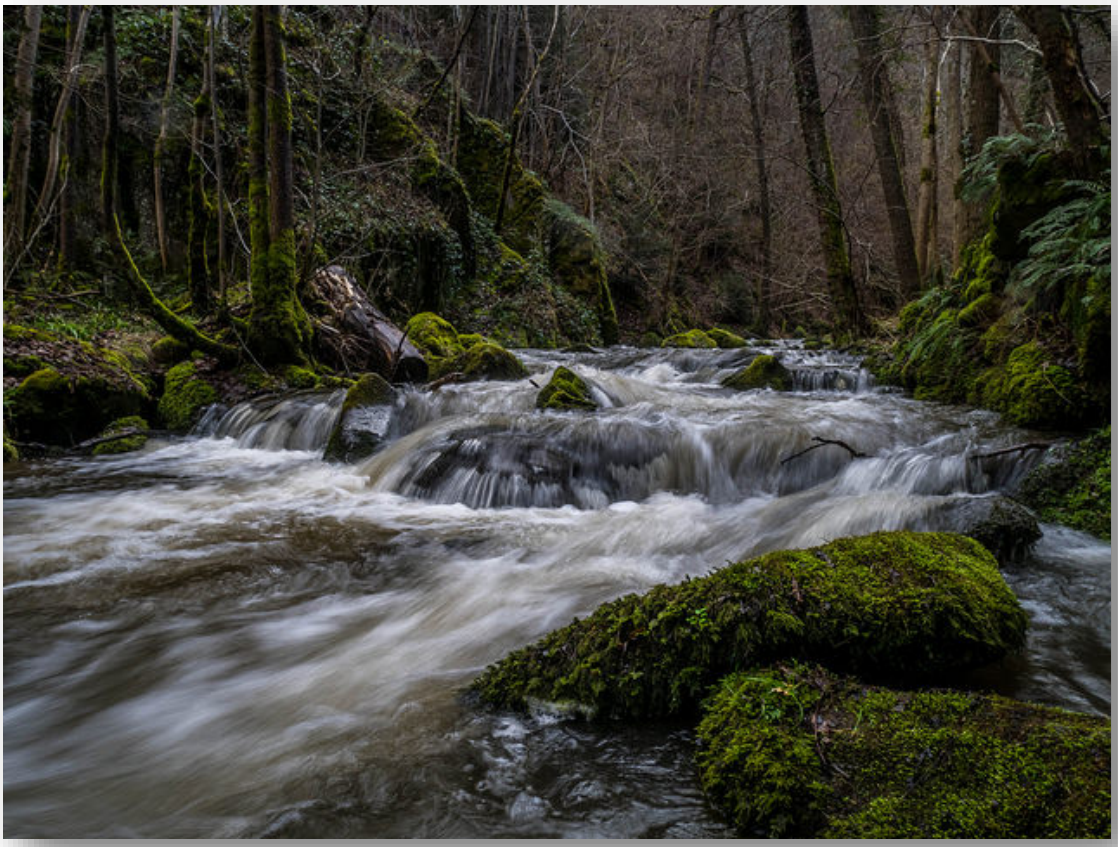

Photo credit: Gwenole Camus

2017 Coordinating Meeting

May 9, 2017

Humboldt State University

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California Cooperative Fish & Wildlife Research Unit
2017 Coordinating Meeting

May 9, 2017
Humboldt State University, BSSB room 508

AGENDA

Introductions and Welcome (Chair, Kevin Whalen) 8:30

Additions to the Agenda

Approval of 2016 Meeting Minutes

Unit Program Review 8:45

Program Direction

Facilities and Equipment

University Service and Technical Assistance

Accomplishments

Financial Status

Unit Research Summary 9:30

Completed Projects Review

Current Research Projects Review

New Research Projects

Cooperator Reports and Research Needs 10:30

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.

Adjourn 12:30

Executive Session

Optional meeting of voting representatives in absence of Coop Staff.

California Cooperative Fish & Wildlife Research Unit
2016 Coordinating Committee Meeting Minutes
Tuesday, May 10, 2016

The annual coordinating meeting was held at Humboldt State University, 1 Harpst Street, Arcata, California. The meeting began at 8:30 am and concluded at 12:00 pm.

Please note the following abbreviations in these minutes:

CDFW: California Department of Fish and Wildlife
HSU: Humboldt State University
CNRS: College of Natural Resources and Sciences at Humboldt State University
USGS: United States Geological Survey
USFWS: United State Fish and Wildlife Service
FRGP: Fisheries Restoration Grants Program, administered by CDFW

In attendance:

Philip Bairrington, CDFW, Arcata

Russ Bellmer, CDFW, Sacramento via conference call

Leslie Farrar, CA Cooperative Fish & Wildlife Research Unit

Micaela Szykman Gunther, HSU, Wildlife Department

Mark Henderson, CA Cooperative Fish & Wildlife Research Unit

Andrew Kinziger, HSU, Fisheries Department

Joe Margraf, USGS Western Region Cooperative Research Units Program

Lynn Roberts, USFWS

Greg Schrott, USFWS

Steven Smith, HSU, CNRS

Nick Som, USFWS, Arcata

Peggy Wilzbach, 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 with the suggestion to move the Executive Session to the beginning of the

meeting. Executive session was held, and the meeting reconvened afterwards. Minutes of the 2015 meeting were reviewed and approved with no additions or changes.

UNIT PROGRAM REVIEW

Mark Henderson was introduced as the new Assistant Unit Leader who joined the Unit in April. He brings a background of a quantitative fisheries ecologist. Chris Manhard joined the Unit in January as a postdoc working with Nick Som, USFWS. Leslie continues to ably support the administrative needs of the Coop, as evidenced by her online submission of three Coop proposals to the CDFW FRGP program while Peggy and Mark were at the All Hands Meeting. Proposals originating from the university are normally submitted by the Sponsored Programs Foundation. Allowing Leslie to submit Coop Unit proposals in its stead is a measure of the confidence the Foundation holds in Leslie's competence. We send our best wishes to departing Dean Steve Smith and look forward to building a strong relationship with the new Dean.

Peggy and Mark attended the USGS Cooperative Research Units All Hands Meeting in March of this year in Santa Fe, NM. One of the central themes of the meeting was the need to enhance the science capacity for conservation planning and implementation at a landscape level through collaborative partnerships. Since the meeting, contact was made with Larry Rabin, Assistant Regional Director for Science Applications with the US Fish and Wildlife Service Pacific Southwest Region, who has responsibility for FWS work related to Landscape Conservation Cooperatives. Plans are to meet with him in Sacramento in the near future. The Unit was disappointed that FRGP proposals submitted last year were not funded. The Unit is actively expanding our program into wildlife research areas with current projects and some planned for the future.

The financial status of the Unit was reviewed. Unit is waiting for funds from CDFW for 2016. Percentages of cooperator support to the Coop research program for FY 15-16 include 43% CDFW, 16% USFWS, 9% USGS and 8% USDA. Contribution of cooperators to Coop Unit operations includes 64% USGS, 32% HSU, and 4% CDFW.

University service, technical assistance, accomplishments, facilities and equipment were briefly outlined and are described in the Annual Report.

Review of current, completed projects and review of new projects

Attendees were referred to the Annual Report for a description of current and completed projects from May 2015-April 2016, and invited to raise questions on any of these. Peggy Wilzbach introduced five new research projects to be approved:

New project review:

1. Habitat selection in an arctic seabird; implications for climate change
2. Develop a Tidewater Goby survey method using environmental DNA
3. Redwood Creek Chinook Salmon monitoring and life cycle model
4. Humboldt Bay Coho monitoring
5. Life cycle monitoring of Coho Salmon in Prairie Creek

Use of the term "monitoring" as opposed to "research" was discussed, and Coop scientists were advised to avoid use of the term monitoring in project descriptions. The term monitoring was used in current proposals to the CDFW FRGP program, as this was the project type in the FRGP solicitation for which funding is sought. Coop Unit graduate students have used monitoring data to conduct question-based research and trend analysis.
Joe Margraf nominated to approve the projects as described. Russ Bellmer voiced conditional approval for monitoring projects to include "coordination" with CDFW, Fisheries Branch on each research component as they are developed. All approved.

COOPERATOR REPORTS

Report from Steve Smith, HSU-CNRS

- HSU's new Provost, Alexander Enyedi, started January 2016.
- Enrollment has flattened the past couple of year within the College of Natural Resources and Sciences. The flattening was intended, implementing minimum high school GPA of 3.2 or greater within the Departments of Wildlife, Biology, Botany, and Zoology. To date, impaction has not affected diversity of the student body in CNRS programs. Fisheries enrollments have remained stable. The Department is staffed with six faculty.
- Wildlife now has 8 tenure track faculty and was approved for an expansion hire this past year. The Fisheries to Wildlife ratio is largely typical for programs nationwide.
- Steve is retiring from his position as Dean, and will enter the early retirement program (FERP) to teach Mammalogy in the fall.

Report from Andrew Kinziger, HSU-Fisheries Department

- Dramatic changes are ahead in the administration at HSU, due to many retirements.
- The graduate program enrollment is about 15 students. New recruitment strategies are being implemented. These include developing articulation agreements with junior colleges that have hatchery technician programs, and telephoning incoming freshmen who have declared Fisheries as their intended major. Currently 45 students have applied for fall 2016 admission. The new Klamath Connection program is providing a place-based learning community which may enhance enrollment.
- Two faculty members are in early retirement program. The department will seek to recruit a replacement next year for its marine fish ecologist.

Report from Micaela Szykman Gunther, HSU – Wildlife Department

- New faculty hires have brought their number to eight. The most recent is a conservation biologist. Their program is operating under impaction. The success of the Klamath Connection under the leadership of Wildlife and Biology faculty was very successful this past year. It enrolled 65 students and plans to include 150 students next year; subsequent plans are to involve all of the CNRS departments in the program.

- The Wildlife Department would like to see improved communication regarding upcoming proposal deadlines from CDFW. Sometimes the notification is not broadly distributed, which leaves little time to write a proposal. Coordination with local CDFW is encouraged.

Report from Nick Som, USFWS, Arcata

- Nick Hetrick was unable to attend this year as he had a conflict with another meeting in Redding today.

- Work on Klamath Hydroelectric settlements has occupied the majority of the work this past year. The settlement would remove dams with private rather than federal funding. Dam removal will be paid for by the rate payers of California and Oregon, with dam removal to start in 2020. Research needs continue to be salmonid-based on the Klamath and Trinity rivers, and also include needs relative to water management and restoration activities.

- Chris Manhard started in January this year. He replaced the previous postdoc who left shortly after he was hired. Chris will have an association with USFWS and the Coop Unit, working on salmonid modeling in the Klamath River. Chris has been very productive and has developed a tributary water temperature model and a new Coho Salmon growth model. Nick would like Chris to interact closely with the University community, possibly including teaching a seminar periodically.

- Nick enjoys teaching at HSU Statistics 410/510, provides service on graduate student committees and provides students with statistical guidance.

Report from Lynn Roberts, USFWS, Arcata

- Lynn was invited to attend the meeting today by Bruce Bingham, field supervisor for wildlife, who was unable to attend today. USFWS does receive funding that is released May and early June at end of fiscal year. Opportunities to provide funding for research interests for projects presently on hold are concerned with listed species in five counties. Lynn provided a handout of the federally listed species within the jurisdiction of the Arcata Fish and Wildlife Field Office that they are most interested in funding. This list includes amphibians, birds, fishes, mammals, invertebrates and plants. Current priorities are butterfly, marten and marbled murrelet projects.

- A meeting has been arranged with HSU Wildlife faculty to discuss potential research collaborations.

Report from Greg Schrott, USFWS, Arcata

- Greg was hired in June 2015 to lead a 10-year Strategic Habitat Conservation (SHC) program which focuses on taking an adaptive management approach to conservation planning and delivery at large landscape scales. He partners with US Forest Service, National Park Service, Tribes, and state wildlife agencies, and is setting up a team to service the Klamath Basin region. The region which is one of five within the state, and it has three parallel components: Klamath fisheries restoration monitoring; wetlands; and terrestrial. The team has started at the coast and will gradually move up the basin as

times goes on. Planning is ongoing to secure increased funding and in developing relationships and partner groups for species, processes and foci of interest.

Report from Joe Margraf, USGS

- Budget remains stagnant, which influences ability to hire and to fill vacancies. Sequestration resulted in an 8% cut and a budget has not been passed, remaining at status quo. Current vacancy rate within the national Cooperative Research Units program is 27 scientists. Attempts are being made to fill approximately every third position. Operating expenses have not been provided to the units since 2012 – 2013. The only funds available are for mandated safety obligations and startup funds.

- The National Cooperator's Coalition is taking the lead in lobbying Congress with the priority of fully funding the program. Cooperative Units are currently in 38 states and several states without coop units have lobbied for a unit to be established within their state. Authorization to obtain a third member to staff the California Unit will require Congressional approval.

- Joe announced his retirement effective January 31, 2017. He will assume the Presidency of the American Fisheries Society August 2016.

Report from Philip Bairrington, CDFW - Arcata

- Mad River Hatchery Monitoring Plan has been submitted in 2014 to NOAA for processing; review has been done and the public comment phase has been extended to 5/19/2016. He is hoping for final approval by July 2016 on this project that was initiated in 2005.

- The department has a working group on drones. Potential for research is promising. Questions regarding certification can be directed to their office.

- FRGP has become more restrictive in that the grantee cannot be associated with CDFW. Phil is working on developing the Coastal Monitoring Plan Proposal for the north coast region, which combines the study areas together. He is looking for a new funding source to operate and expects it to be a two year process to implement.

- A DIDSON report, "Dual Frequency Identification Sonar (DIDSON) deployment and preliminary performance as part of the California Coastal Salmonid Monitoring Plan," was released last month.

Report from Russ Bellmer, CDFW-Sacramento

- CDFW is now accepting proposals for Proposition 1 Restoration Grant Programs due June 24, 2016. Information can be found at the CDFW website.

- New executive director of the California Fish and Game Commission, Valerie Termini, was hired to start May 16, 2016.

- Priorities of CDFW are the priorities of the Prop 1 funding: establishing more reliable water supplies, restoring important species and habitat, and creating a more resilient,

sustainably managed water resources system (water supply, water quality, flood protection and environment) that can better withstand inevitable and unforeseen pressures in the coming decades. Other big picture examples of research needs are: 1. Fish above rim dams, 2. Relocation and rescue, 3. Fish response to restoration activities, 4. Fish predation, and 5. Fish on flood plains.

2017 ANNUAL COORDINATING MEETING

Next year's meeting was set for Tuesday, May 9, 2017.

CLOSING

A call was made and approved to adjourn the meeting. The meeting adjourned at 12:00 pm.

REVIEW OF PROJECTS COMPLETED IN 2016

OVERWINTER SURVIVAL, 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 Deibner-Hanson, MS student
Duration: January 2013 - March 2016
Funding: California Department of Fish and Wildlife/Coop Unit Support ($135,000)

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

The primary objectives of the thesis research were (1) to assess the variability in overwinter survival of stream-dwelling juvenile Coho Salmon across coastal California streams which vary in land use history and habitat quality and (2) to evaluate the role of instream fish habitat (instream large woody debris and low-velocity refugia) in predicting reach- and basin-specific overwinter survival. Potential bias caused by juvenile Coho Salmon who emigrated early from the freshwater stream habitat before winter ended was first assessed. A specific type of capture-recapture model was used to estimate survival probabilities while accounting for early emigration and detection. Initial modeling was augmented using Bayesian statistical modeling software to facilitate the use of mixed effects models, which accounted for unexplained variability in survival among coastal Coho Salmon populations in northern California.

The study area consisted of Freshwater Creek, tributary to Humboldt Bay, Prairie Creek, tributary to Redwood Creek, and Mill Creek, tributary to Smith River. Although the two most pristine reaches in the study area (upper Prairie Creek, lower Mill Creek) had relatively high volumes of large woody debris, the pattern across the study area was not clearly correlated with land use history. Freshwater and Prairie Creek showed larger areas of low-velocity rearing habitat than Mill Creek. Initial modeling results showed occasions of high variability in early emigration among basins and years lending support the use of the augmented modeling

approach. Bayesian modeling uses an iterative process which involved long model runs to derive the estimates used to explain the Coho Salmon habitat-survival relationships.

This project is currently in its final stages with results expected in May 2017.

GIANT KANGAROO RAT POPULATION MONITORING IN PANOCHE VALLEY

Investigators:	Dr. Tim Bean, Wildlife Department, Humboldt State University
	Dr. Margaret Wilzbach, CACFWRU
	Nathan Alexander, MS Student
Duration:	November 2015 – June 2016
Funding:	California Department of Fish and Wildlife ($20,939)

The giant kangaroo rat (*Dipodomys ingens*) is a species of burrowing, granivorous rodent in the heteromyid family. The species is listed as endangered under the Federal and California Endangered Species Acts. Due to the ongoing, historic drought in California, giant kangaroo rat populations have declined across their range. This decline is associated with an almost complete lack of vegetation and therefore food resources for the species.

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

We tested the effectiveness of supplemental feeding to sustain or increase giant kangaroo rat populations on nine paired plots across their remaining range. In fall 2015 we provided wild birdseed mix *ad libitum* on 9 paired experimental and control plots, three each in the Carrizo Plain National Monument, Lokern Ecological Reserve, and Ciervo-Panoche Natural Area. Population size was estimated in the summer of 2015 and spring 2016 using live trapping for three to five consecutive nights. Population sizes were estimated using mark-recapture models, and overall effect size was calculated using Hedge's *d*.

Supplemental feeding increased giant kangaroo rat population size by a mean of 19 individuals (95% Confidence Intervals = 6 to 32). Eight of the nine plots had increases greater on the experimental plots than on the controls. Supplemental feeding had no observed effect on body weight or reproductive status. Most small mammal species declined on plots where giant kangaroo rats increased, however on three plots in the Carrizo Plain, short-nosed kangaroo rat (*Dipodomys nitratoides brevinasus*) populations also appeared to increase in response to supplemental feeding.

Supplemental feeding appears to be an effective tool for sustaining or increasing giant kangaroo rat populations in times of drought. In comparison to captive breeding, supplemental feeding

may be a more effective, efficient, and less invasive measure for sustaining small and decreasing populations of small mammals in arid systems. The precise mechanisms by which supplemental feeding increased giant kangaroo rat populations ought to be further investigated. Supplemental feeding may also be used to re-establish extirpated populations within their existing range to ensure site fidelity and increase abundance. Reliable, consistent measurements of seed bank availability would be an important tool for understanding the role that food resources play in causing kangaroo rat population declines.

Results from this study will be included in a larger paper on the effects of the drought on native wildlife in the San Joaquin Valley. This manuscript is in preparation, with a target journal of *Nature Climate Change*.

REVIEW OF CURRENT RESEARCH PROJECTS

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
	Christopher Manhard, Research Associate
Duration:	October 2014 – December 2017
Funding:	USFWS ($161,239)

The Stream Salmonid Simulator (S3) 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 S3 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 S3 model is being 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.

As the Coho S3 model will be driven by environmental data, a necessary component of this project was compiling existing temperature and flow data in the Klamath Basin. To date, an extensive search of the available temperature and flow data in the mainstem and in the tributaries that support Coho Salmon was conducted. Next, these data were fit to statistical models to estimate temperature and flow where missing. The complete temperature and flow data were organized into analysis-ready spreadsheets. When combined with the mainstem temperature model that has already been developed, this will provide all of the environmental data necessary to run the Coho S3 model.

Development of population dynamics submodels: Most of the submodels that will comprise the Coho S3 model have been developed. These submodels capture the major processes that drive the dynamics of Klamath Basin Coho Salmon. For each submodel listed below, appropriate data was sought and found, these data underwent quality-assurance and quality-control measures, the data was analyzed via appropriate statistical models, and then computer functions were written to implement the submodels in the S3 framework. To date, submodels for the following processes have been completed:

1. Adult migration timing in the Scott River, Shasta River, and Bogus Creek
2. Parr and smolt emigration timing in the Scott and Shasta Rivers
3. Mainstem migration rates for parr redistributing during summer and winter
4. Thermal refugia entry timing during the summer redistribution period
5. Winter emigration timing during the winter redistribution period
6. Flow refugia entry timing during the winter redistribution period
7. Smolt emigration timing for small tributaries
8. Freshwater productivity in the Scott and Shasta Rivers

9. Overwinter survival and winter emigration rates
10. Ration- and temperature-dependent growth

Deliverables: We have submitted a manuscript to the Canadian Journal of Fisheries and Aquatic Sciences (CJFAS), which details the development and application of the ration-dependent growth model. The manuscript has been favorably reviewed by one reviewer, but is still awaiting the comments of a second reviewer. A draft technical report detailing the analytical methods for estimating environmental conditions has been completed. A technical report detailing the analytical methods for the freshwater productivity, migration timing, and overwinter survival models is currently being drafted and will be completed by mid-April 2017. Detailed write-ups of all methods and results for each of the models described above have been completed, and the abstract, introduction, and discussion of a report describing these analyses will be completed by the end of April.

Additional accomplishments: A presentation on many of these analyses was given at the Klamath and Trinity Modeling Workshop in October (Eureka, CA). The post-doctoral employee also gave a seminar in the Humboldt State University Fisheries Lecture Series during Fall of 2016.

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)

Redwood Creek (RC), a 7th order stream in Humboldt County, Northern California, makes sizeable contributions to the California Coastal (CC) Chinook Salmon Evolutionary Significant Unit (ESU), Southern Oregon/Northern California Coasts (SO/NCC) Coho Salmon ESU, and the Northern California (NC) steelhead Distinct Population Segment. Objectives of this project were to: 1) estimate juvenile Coho Salmon smolt abundances, and 2) estimate juvenile Chinook Salmon and steelhead smolt abundances in the 152,00 acre basin of Redwood Creek in 2014, 2015, and 2016, representing the 11-13th consecutive years of smolt trapping. The rotary screw trap was located in lower Redwood Creek at river mile 4, above the confluence of Prairie Creek, and operated daily during the spring migration season from late March to late summer each year. Smolt abundance estimates of Coho Salmon and other salmonid species (Chinook Salmon, steelhead, and Cutthroat Trout) were generated on a weekly and seasonal basis by age class and species using mark-recapture methods. Samples of captured fish were measured for fork length (mm) daily, and weight (g) was taken every other day. The long term goal of the project is to evaluate status and trends of out-migrating juvenile salmonid smolts in Redwood Creek in relation to watershed conditions and restoration activities in the basin, and to provide data for Viable Salmonid Population Analysis.

Low abundances over the 13 year period of monitoring indicated that 1+ Chinook Salmon are relatively rare in RC. In 2016, population abundances (with 95% confidence intervals) equaled 29,319 (24,272 – 34,366) for 1+ steelhead, 8,433 (6,074 – 10,792) for 2+ steelhead, 180 (121 – 239)

for 0+ Coho Salmon, 144 (79 – 209) for 1+ Coho Salmon, and 237 (154 – 319) for juvenile Coastal Cutthroat Trout. Considerably more 1+ steelhead emigrated downstream than 2+ steelhead each study year, suggesting stream habitat conditions are limiting the abundance of the older age class, or favoring a change in the life history to a younger smolt age. Although estimates of 1+ Coho Salmon smolts in 2015 was the highest of record, abundances across all years (2004 – 2016, N = 33 – 1,923) were consistently and alarmingly low. The abundances of 1+ steelhead, 2+ steelhead, and juvenile Coastal Cutthroat Trout in 2016 were 48 - 71% less than abundances in

Downstream salmonid migrants in Redwood Creek.

2015, and suggest the drought in 2015 reduced survival for migrants in 2016. The two most important months for migration in 2016 were April-May for 1+ Chinook Salmon and 1+ Coho Salmon, May-June for 0+ Chinook Salmon and 2+ steelhead, and June-July for 1+ steelhead, 0+ Coho Salmon, and juvenile Coastal Cutthroat Trout.

Study year was not correlated with yearly population abundances for 0+ Chinook Salmon, 1+ Chinook Salmon, 0+ Coho Salmon, 1+ Coho Salmon, 1+ steelhead, 2+ steelhead and juvenile Coastal Trout ($p > 0.05$). An inverse relationship was found between the average size (FL, Wt) of 0+ Chinook Salmon and 0+ Coho Salmon over study years with population abundance ($p < 0.05$), suggesting density-dependent population regulation.

Products:

Sparkman M.D.[1], R. Park[2], M. Gordon[2], and M.A. Wilzbach[2]. 2017. Upper/Lower Redwood Creek juvenile salmonid (smolt) abundance project, study years 2014-2016: Final Report to the Fisheries Restoration Grants Program, Project No. P1210322).

Sparkman M.D., R. Park, L. Osborn, and M. Griffin. 2015. Lower Redwood Creek juvenile salmonid (smolt) abundance project, study year 2014: a report to the Fisheries Restoration Grants Program (Project No. P0810509). CDFW AFRAMP, study 2a7: 87 p.

Sparkman M.D., R. Park, L. Osborn, S. Holt, and M.A. Wilzbach. 2016. Lower Redwood Creek juvenile salmonid (smolt) abundance project, study year 2015: a report to the Fisheries Restoration Grants Program (Project No. P1210322). CDFW AFRAMP, study 2a7: 85 p.

PRAIRIE CREEK JUVENILE SALMONID (SMOLT) ABUNDANCE PROJECT

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

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. It serves as a life cycle monitoring station as described in the CDFW's California Coastal Salmonid Monitoring Plan, as it combines monitoring of salmonid juveniles and smolts with estimates of returning adults from redd counts. This project continued the long-term monitoring of juvenile salmonid populations in Prairie Creek that has been in place since 1998. The focus of this project from 2014-2016 was to estimate overwinter survival (apparent) and growth of juvenile Coho Salmon, and estimate population abundances of Coho Salmon, Chinook Salmon (*O. tshawytscha*), steelhead trout (*O. mykiss*), and Cutthroat Trout (*O. clarki clarki*) smolts emigrating from the Prairie Creek basin in 2015.

Juvenile Coho Salmon in Prairie Creek were marked with PIT tags each fall to monitor fall/winter redistribution and estimate overwinter survival and growth. The Cormack-Jolly-Seber model and Program MARK were used to estimate overwinter survival each year using plate and loop designed PIT tag antenna arrays and rotary screw trap captures. A separate estimate of overwinter survival was made using the rotary screw trap and mark/recapture experiments. Only a small percentage (3-6%) of the PIT tagged juvenile Coho Salmon were detected migrating past the lower antenna during fall and winter before the smolt trap was deployed. Apparent overwinter survival of juvenile Coho Salmon ranged from 30-40% over the years of study, with PIT tagged based and trap derived estimates providing similar values. Survival estimates were in the range of survival values reported from other studies in the Pacific Northwest. PIT tagged juvenile Coho Salmon experienced 0.14-0.18 mm increase in length per day. M.S. student Peter Drobny defended his thesis March 2016, evaluating the effects of fish length, habitat attributes, and densities of Coho Salmon and trout on overwinter survival of juvenile Coho Salmon. He found that survival increased with fish length and decreased with intraspecific density. Neither densities of small (<150 mm) or large trout or habitat attributes had a detectable effect on survival.

The project was conducted in cooperation with CDFW biologist Michael Sparkman, who supervised the smolt trap operation. A five foot diameter rotary screw trap was operated

during the smolt migration season each spring. In 2016, it captured 329 0+ Coho Salmon, 11,355 1+ Coho Salmon, 10,900 0+ Chinook Salmon, 3 1+ Chinook Salmon, 939 0+ trout, 2,288 1+ steelhead trout, 783 2+ steelhead trout, 1 0+ Pink Salmon, and 2,398 juvenile Coastal Cutthroat Trout to total 28,996 individuals. An additional 35 adult Coastal Cutthroat Trout (FL > 250 mm) and two Eulachon (*Thaleichthys pacificus*) were also captured. Number of PIT tagged 1+ Coho Salmon captures equaled 168, and comprised 1.4% of the total 1+ Coho Salmon catch. The population abundance (with 95% CI's) of 0+ Coho Salmon equaled 1,601 (1,033 – 2,169), and for 1+ Coho Salmon equaled 21,536 (20,260 – 22,813). Population abundances equaled 22,562 (20,795 – 24,328) for 0+ Chinook Salmon, 7,786 (7,023 – 8,549) for 1+ steelhead trout, 4,520 (3,513 – 5,527) for 2+ steelhead trout, and 8,572 (7,425 – 9,719) for juvenile Coastal Cutthroat Trout. Trends in smolt abundances from 2011 – 2015 were not significant ($p > 0.05$), except for 1+ steelhead trout, which showed a positive increase over time ($p < 0.05$). The two most important months for migration in 2015 were March/April for 0+ Coho Salmon and 2+ steelhead trout, March/May for 0+ Chinook Salmon, and April/May for 1+ Coho Salmon, 1+ steelhead trout, and juvenile Coastal Cutthroat Trout.

Daily captures and weekly population abundances of PIT tagged 1+ Coho Salmon closely reflected the pattern for the population of 1+ Coho Salmon smolts for the second year in a row, and indicate that PIT tagging juvenile Coho Salmon did not affect migratory behavior during the smolt migration period.

Products:

Drobny, P. 2016. Influence of intra- and inter-specific salmonid densities and habitat on overwinter survival of juvenile Coho Salmon in Prairie Creek. MS thesis. College of Natural Resources and Sciences, Humboldt State University, Arcata, CA.

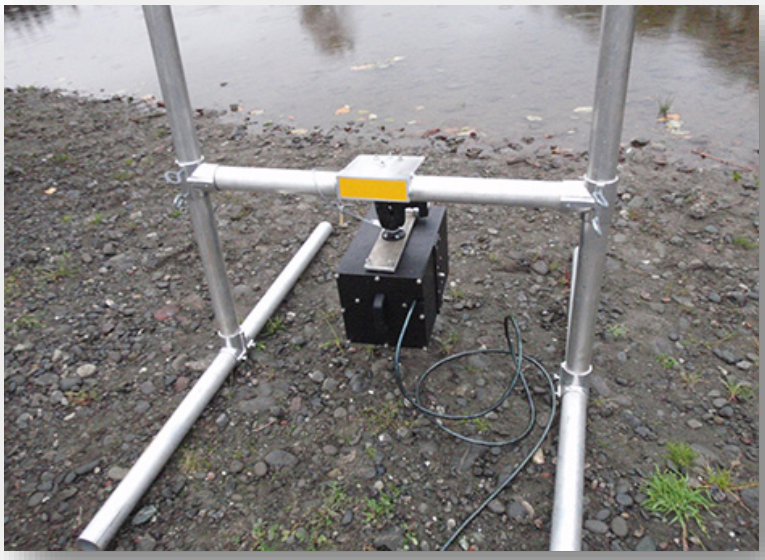
Wilzbach, M.A., M.D. Sparkman, N. Van Vleet, B. Sheppard, and M. Settelmayer. 2017. Overwinter survival and smolt abundances of Coho Salmon in Prairie Creek, California: 2014-2016. Final Report to the California Department of Fish and Wildlife Fisheries Restoration Grants Program, Project No. P1210321, 105 pps.

Fall sampling in Prairie Creek.

Wilzbach, M.A., M.D. Sparkman, P.Y. Drobny, M.E. Gordon, and C.M.G. Boone. 2016. Prairie Creek Monitoring Project, 2015 Season: a report to the Fisheries Restoration Grants Program Project P1210321. 98 pg.

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 ($27,241)



DIDSON camera mounted on stand. Photo credit: CDFW

We deployed dual frequency identification SONAR **(**DIDSON) in Orick, CA to estimate a minimum escapement of 2,186 (+/- 329) adult salmonids entering Redwood Creek to spawn between 15 November 2015 and 29 March 2016. Estimates were based on a census of all available video when conditions allowed use of video compression software, and otherwise, a non-replicated systematic sample of 20 minutes per hour, with no species designation. 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, 144 were estimated to be Coho Salmon *(Oncorhynchus kisutch)*, 1,839 as Chinook Salmon *(Oncorhynchus tshawytscha)*, and 203 as steelhead *(Oncorhynchus mykiss*). Since no adjustments were made for days when the camera was inoperative, the estimates are likely biased low. Comparison of adult returns to Redwood Creek between DIDSON and redd expansion methods over 6 years of operation indicated that annual DIDSON estimates were usually larger than redd estimates, particularly for steelhead, except during seasons of extended DIDSON downtime. Migration timing of fish was not well predicted by discharge, temperature, or highest daily tidal height. Escapement estimates of Chinook Salmon, Coho Salmon, and steelhead did not experience drastic reductions during six years of operation.

Products:

Metheny, M., M. Sparkman, and M. Wilzbach. 2017. Sonar estimation of adult salmonid abundance in Redwood Creek, Tributary to Pacific Ocean, Humboldt County, California 2015-2016. Report for California Department of Fish and Wildlife Fisheries Restoration Grants Program (Project Number: P1410549). U.S. Geological Survey, California Cooperative Fish and Wildlife Research Unit, Humboldt State University, 1 Harpst St. Arcata, CA.

MONITORING THE ENDANGERED TIDEWATER GOBY (*EUCYCLOBIUS NEWBERRYI*) USING ENVIRONMENTAL DNA IN WATER SAMPLES: FIELD TESTS (RWO 87)

Investigator: Andrew Kinziger, HSU Fisheries Department
Margaret Wilzbach, CACFWRU
Chad Martel, MS Student
Duration: January 2015 to December 2018
Funding: USFWS ($92,255)

The Tidewater Goby (*Eucyclogobius newberryi*) is listed as endangered under the U.S. Endangered Species Act. The Tidewater Goby inhabits disjunct brackish/freshwater lagoons and estuaries that are positioned linearly along the California coast, separated by 1-20 km (Swift 1989). Approximately 16% of the 135 historically documented populations are extirpated and an estimated 50% of the remaining populations are considered vulnerable to extinction because of habitat loss (USFWS, 2014). Since the species was listed as endangered in 1994, there have been no coordinated and standardized range-wide surveys to determine the number of sites occupied by the species throughout its geographic range. Further, Tidewater Goby are believed to follow a traditional metapopulation model where isolated populations are subject to periodic extinctions and then subsequently colonized from nearby locations. While the metapopulation model has become the paradigm for Tidewater Goby, recent studies suggest that metapopulation processes may not be operating throughout the entire species range.

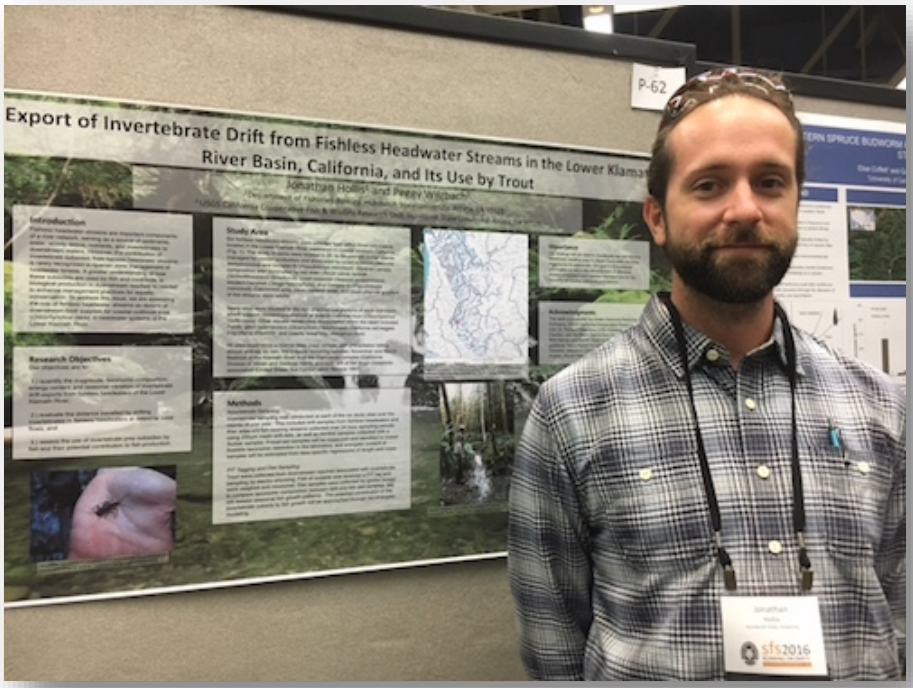
Tidewater Goby.

The objective of this project is to conduct an eDNA survey for Tidewater Goby across the species range in coastal California. This project will provide the first standardized range-wide surveys for Tidewater Goby since the species was listed as endangered in 1994. Further, this project will be combined with ongoing surveys from other projects, allowing range-wide eDNA monitoring across two years. These data will be used for assessment of metapopulation processes across the species range (e.g., extinction, colonization, and detection rates) using a multi-season occupancy analysis. This study is critical for determining whether downlisting of Tidewater Goby may be warranted. According to the Tidewater Goby Recovery Plan, downlisting may be considered when a "metapopulation viability analysis" indicates that each Recovery Unit is viable.

EXPORT OF INVERTEBRATE DRIFT FROM HEADWATER STREAMS

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Jon Hollis, MS Student
Duration:	January 2015 – June, 2017
Funding:	Green Diamond Resources Company ($53,900)

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. Fishless headwater streams are critical components of a river network, serving as a source of sediments, water, woody debris, nutrients, and invertebrates to downstream waters. However, the importance of the invertebrate subsidies provided by fishless headwater streams is often underappreciated. A greater understanding of how these subsidies are used by fish and



John Hollis displaying his poster.

contribute to biological production in downstream reaches is needed to enhance riparian management practices. To address this issue, we are assessing the role of fishless headwater streams as donors to downstream food supplies for Coastal Cutthroat Trout (*Oncorhynchus clarki*) in headwater systems of the lower Klamath River. From June 2015 through April 2016 we sampled invertebrate drift from six fishless headwaters located in the sub-basins of Tectah Creek, Ah Pah Creek, and Tarup Creek. We also collected drift samples and trout diet samples from adjacent fish-bearing stream reaches.

Our objectives are to:

1) quantify the magnitude, taxonomic composition, energy content and seasonal variation of invertebrate drift exports from fishless headwaters of the Lower Klamath River;
2) evaluate the distance travelled by drifting invertebrates in fishless headwaters at seasonal base flows; and
3) assess the use of invertebrate prey subsidies by fish and their potential contribution to fish growth.

Field sampling has been completed and laboratory analysis is underway. The research constitutes 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, involving scientists from Green Diamond Resource Company, Humboldt State University, Oregon State University, and the U.S. Forest Service.

Products:

Hollis, J. and M.A. Wilzbach. Export of invertebrate drift from fishless headwater streams in the lower Klamath River Basin, California, and its use by trout. Poster presentation, Annual Meeting, Society for Freshwater Science, Sacramento, CA. May 21-26, 2016.

Hollis, J. and M.A. Wilzbach. Export of invertebrate drift from fishless headwater streams in the lower Klamath River Basin, California, and its use by trout. Poster presentation, Coast Redwood Forest Symposium, Fortuna, CA. September 13, 2016.

TOWNSEND'S BIG EARED BAT STATEWIDE ASSESSMENT

Investigators:	Dr. Joseph Szewczak, HSU Wildlife Department
	Dr. Mike Morrison, Texas A & M University
	Dr. Margaret Wilzbach, CACFWRU
Duration:	April 2015 – December 2017
Funding:	California Department of Fish and Wildlife/USFWS ($129,799)

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) were surveyed for current activity and condition. Second, a stratified

random sampling scheme was used to generate a probabilistic model of bat occupancy and abundance across its range in California.

The last season of winter hibernaculae survey has been completed. A few sites are left to wrap up the complete survey. Data are being compiled for full project analysis and report generation.

Joe Szewczak in the field with student.

HABITAT SELECTION IN AN ARCTIC SEABIRD: IMPLICATIONS FOR CLIMATE CHANGE

Investigators:	Dr. Mark Colwell, HSU Wildlife Department
	Dr. Margaret Wilzbach, CACFWRU
	Aaron Gottesman, MS Student
Duration:	September 2015 – December 2019
Funding:	USGS, Alaska Science Center ($40,225)

Semipalmated Sandpipers (*Calidris pusilla*) are one of the most abundant shorebirds in the Western Hemisphere, and breed widely across the North American arctic. As one of the 233 bird species deemed most in need of conservation action by the North American Bird Conservation Initiative, the Semipalmated Sandpiper population is currently of interest due to unaccounted declines in staging numbers over the past 35 years and for potential of an overall population decline in response to climate changes in the Arctic. In the past three decades,

accelerated warming and expansion of the growing season has led to altered vegetative composition of the tundra to favor tree and shrub growth and reduction of grasses and sedges. Effect of these changes on habitat use in the breeding grounds of this bird are unknown. The objective of this research is to characterize habitat use of the Semipalmated Sandpiper in the Colville River Delta in the arctic slope of Alaska to determine wetland features associated with habitat selection and use.

Semipalmated Sandpiper (Calidris pusilla) in breeding plumage.

We collected habitat data (micro-elevation, soil moisture, vegetation cover abundance, landforms) at 267 nest sites and 300 random sites. Vegetation composition at shorebird nest sites has been analyzed. We have also created initial habitat suitability models from breeding occurrence records of Semipalmated Sandpiper and a suite of bioclimatic variables for current climatic conditions and future projections.

Products:

Gottesman, A., T. Bean, D. Ruthrauff, and M. Colwell. 2017. Shorebird nest site habitat composition: implications for climate change. Oral presentation, Annual Meeting of the Western Section of The Wildlife Society, Reno, NV, February 2017.

DEVELOP A TIDEWATER GOBY SURVEY METHOD USING ENVIRONMENTAL DNA

Investigators:	Dr. Andrew Kinziger, HSU Fisheries Department
	Dr. Margaret Wilzbach, CACFWRU
	Michael Sutter, MS Student
Duration:	March 2016 – September, 2018
Funding:	Cal Trans ($88,183)

Caltrans Districts 1, 4, 5, 7, 11, and 12 are often required to initiate Endangered Species Act (ESA) Section 7 consultations with U.S. Fish and Wildlife Service (USFWS), on behalf of the Federal Highway Administration (FHWA), for projects that may affect the federally listed Tidewater Goby, a fish species whose current range is patchy and fragmented along the entire coastline of California. Current field survey approaches required by USFWS have relatively low detection rates for Tidewater Goby. Researchers at Humboldt State University (HSU) are in the initial stages of developing an innovative approach for monitoring Tidewater Goby using environmental DNA (eDNA) techniques. Analyses to date have indicated that eDNA approaches have nearly doubled the detection probability in comparison with traditional survey approaches for Tidewater Goby. The objective of this project is to continue to develop eDNA approaches for monitoring Tidewater Goby presence/absence. The goal is to provide

USFWS an innovative and improved set of tools for detecting Tidewater Goby. The new eDNA technique will help the USFWS develop a survey protocol that detects Tidewater Goby with higher confidence. Ultimately, improved survey techniques will help Caltrans save money and avoid delays during maintenance and construction by minimizing endangered species consultations to those situations where they are necessary.

While the results to date indicate that eDNA approaches are much more sensitive for detecting Tidewater Goby than traditional seining techniques, eDNA approaches have not been tested to the extent necessary to illustrate their efficacy for presence/absence detection or abundance estimation of Tidewater Goby. To date accomplishments of this project include (i) development of standard operating procedures for water filtration for eDNA analysis, (ii) development of quantitative Polymerase Chain Reaction (qPCR) assays allowing for range-wide detection of

Michael Sutter in the field collecting water samples.

Tidewater Goby using eDNA approaches, and iii) completion of field collection of over 500 water samples from coastal California habitats likely to contain Tidewater Goby ranging from San Diego County to Del Norte County. During the coming months these water samples will be tested for Tidewater Goby eDNA and the data analyzed using occupancy modeling.

REDWOOD CREEK CHINOOK SALMON MONITORING AND LIFE CYCLE MODEL

Investigators:	Dr. Margaret Wilzbach, CACFWRU Dr. Mark Henderson, CACFWRU MS Student
Duration:	July 2017 – June 2020
Funding:	California Department of Fish and Wildlife/FRGP ($681,055)

This project will continue monitoring adult and juvenile salmonids in Redwood Creek to provide sufficient data to build a life cycle model for the Chinook Salmon population. The objectives of this project are to: 1) enumerate total numbers of Chinook returning to spawn in the Redwood Creek basin using DIDSON sonar; 2) conduct spawning ground surveys in Redwood Creek above Prairie Creek to estimate total numbers of redds which are constructed; and 3) install and operate a rotary screw trap in Redwood Creek to monitor the abundance and condition of juvenile salmonids outmigrating from Redwood Creek. Data on smolt and adult abundance will be combined into a life-cycle model to estimate freshwater and marine survival rates, and assess the impact of restoration efforts and climate change on the abundance of the Chinook Salmon population in Redwood Creek. Continuation of this life cycle monitoring station, and the development of a life-cycle model for this population, will directly support the CDFW/NMFS Coastal Salmonid Monitoring Plan and recovery plans for California Coastal Chinook Salmon.

Recruitment of a graduate student who will develop the life cycle model has begun.

HUMBOLDT BAY COHO MONITORING

Investigators:	Dr. Darren Ward, HSU Fisheries Department Dr. Margaret Wilzbach, CACFWRU MS Student
Duration:	August 2017 – July 2020
Funding:	California Department of Fish and Wildlife/FRGP ($966,547)

This project will use spawning ground surveys in tributaries of Humboldt Bay to establish the regional status and trends of adult salmonid abundance, and continue to operate a life cycle monitoring station (LCS) in Freshwater Creek. Sampling infrastructure and established sampling programs at Freshwater Creek include a weir that functions as a trap for both juveniles and adults and PIT tag antennas in several locations throughout the watershed. The LCS at Freshwater Creek will continue 15 years of monitoring clearly showing a long-term declining trend in adult Coho Salmon abundance. As habitat restoration and enhancement projects proceed in the Humboldt Bay watershed, ongoing monitoring will provide insight into the response of Coho Salmon populations to these conservation efforts.

Monitoring efforts for Coho Salmon at the Freshwater Creek LCS focus on population abundance and survival rates within the basin. However, long-term trends in population dynamics, particularly extinction risk, for Freshwater Creek may depend on interactions with Coho Salmon populations outside the basin. This project will incorporate juvenile tagging and detection efforts in streams adjacent to Freshwater Creek to characterize dispersal among tributaries and use these parameters, in combination with estimates of population synchrony

across basins from the time series of escapement data, to evaluate potential metapopulation dynamics of Humboldt Bay tributaries. In addition, the expanded tagging and detection efforts will allow us to compare life history diversity across basins that differ in habitat and restoration status.

Recruitment for a graduate student for this project has begun.

LIFE CYCLE MONITORING OF COHO SALMON IN PRAIRIE CREEK

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Dr. Mark Henderson, CACFWRU
	MS Student
Duration:	June 2017 – March 2020
Funding:	California Department of Fish and Wildlife/FRGP ($629,357)

This project will continue the long-term monitoring of adult and smolt abundances of the Coho Salmon population in Prairie Creek, a northern California watershed which is internationally renowned and managed for its old-growth stands of ancient coast redwoods and their plant and animal inhabitants. Long-term monitoring in Prairie Creek provides information essential for developing management strategies to ensure population viability of its Coho Salmon, and in providing a benchmark for evaluating salmon recovery in regional streams which have experienced a greater intensity of disturbance. The project is complemented by physical habitat and water quality monitoring by Redwood National and State Parks, facilitating evaluation of habitat-productivity relationships.

The project purpose is to contribute to life cycle monitoring of the Coho Salmon population in Prairie Creek. Specific objectives are to: 1) estimate abundance of returning adults, based on walking surveys during the spawning season to enumerate live fish, carcasses, and redds; 2) estimate abundance of smolts emigrating from Prairie Creek, using mark-recapture methods based on tag detections at stationary antenna arrays and capture in a rotary screw trap; and 3) estimate freshwater and marine survival rates, and evaluate predictive relationships between freshwater survival and growth with habitat attributes. Marine survival will be estimated from adult abundance estimates and detection of tagged fish among the returning adults at antenna stations. Freshwater growth and survival of juvenile fish will be estimated from capture of tagged fish in the smolt trap and from antenna detections. Relationships between habitat attributes and freshwater production will be evaluated through model selection.

Recruitment for a graduate student for this project has begun.

NEW RESEARCH PROJECTS REVIEW

COMPARATIVE HABITAT USE OF ESTUARINE HABITATS

Investigators:	Dr. Mark Henderson, CACFWRU
	Dr. Margaret Wilzbach, CACFWRU
	Hannah Coe, MS student
Duration:	September 2016 – August, 2018
Funding:	Confluence Environmental Company, NOAA ($53,368)

Oyster aquaculture has been a commercial presence in Humboldt Bay for nearly 60 years, and has experienced changes in scope and methodology as the industry has grown. The traditional method of bottom-culture oyster beds has been phased out, with longline oyster aquaculture being a common replacement. Much of the ideal habitat for growing oysters on longline is also prime habitat for eelgrass. Eelgrass beds provide many ecosystem functions, including the supply of food sources for permanent and transient estuarine inhabitants, stabilization of coastal sediments, and nursery ground for fish and invertebrates. There is concern that the placement of longlines over eelgrass beds will negatively impact the health of these beds, resulting in a decrease or loss of the services provided by eelgrass. However, shellfish aquaculture does provide its own variety of ecosystem services, such as improved water quality, prey resources, and habitat structure. Numerous studies have documented differences in species diversity and abundance in habitats with and without oyster culture; however, most of these have focused upon bottom culture methods. With the relatively recent transition to aboveground longline aquaculture, there is a need to investigate how off-bottom culture affects species use and abundance. This research will evaluate how epibenthic and benthic invertebrate communities are affected by the presence of longline oyster aquaculture.

Oyster longlines in Humboldt Bay.

Specific objectives are to:

1. compare macroinvertebrate assemblages between four habitat types: a) mudflat with longlines, b) eelgrass with longlines, c) mudflat without longlines, and d) eelgrass without longlines.
2. understand how benthic and epibenthic communities are affected by the presence of longline oyster aquaculture in Humboldt Bay.

This research is a part of a larger study investigating the impacts of longline oyster aquaculture on fish and invertebrate species use and abundance in Humboldt Bay, and whether these differences have an effect on the overall food web ecology of the Bay. Field work is slated to begin in June 2017, with quarterly invertebrate sampling for one year.

GIANT KANGAROO RAT MONITORING

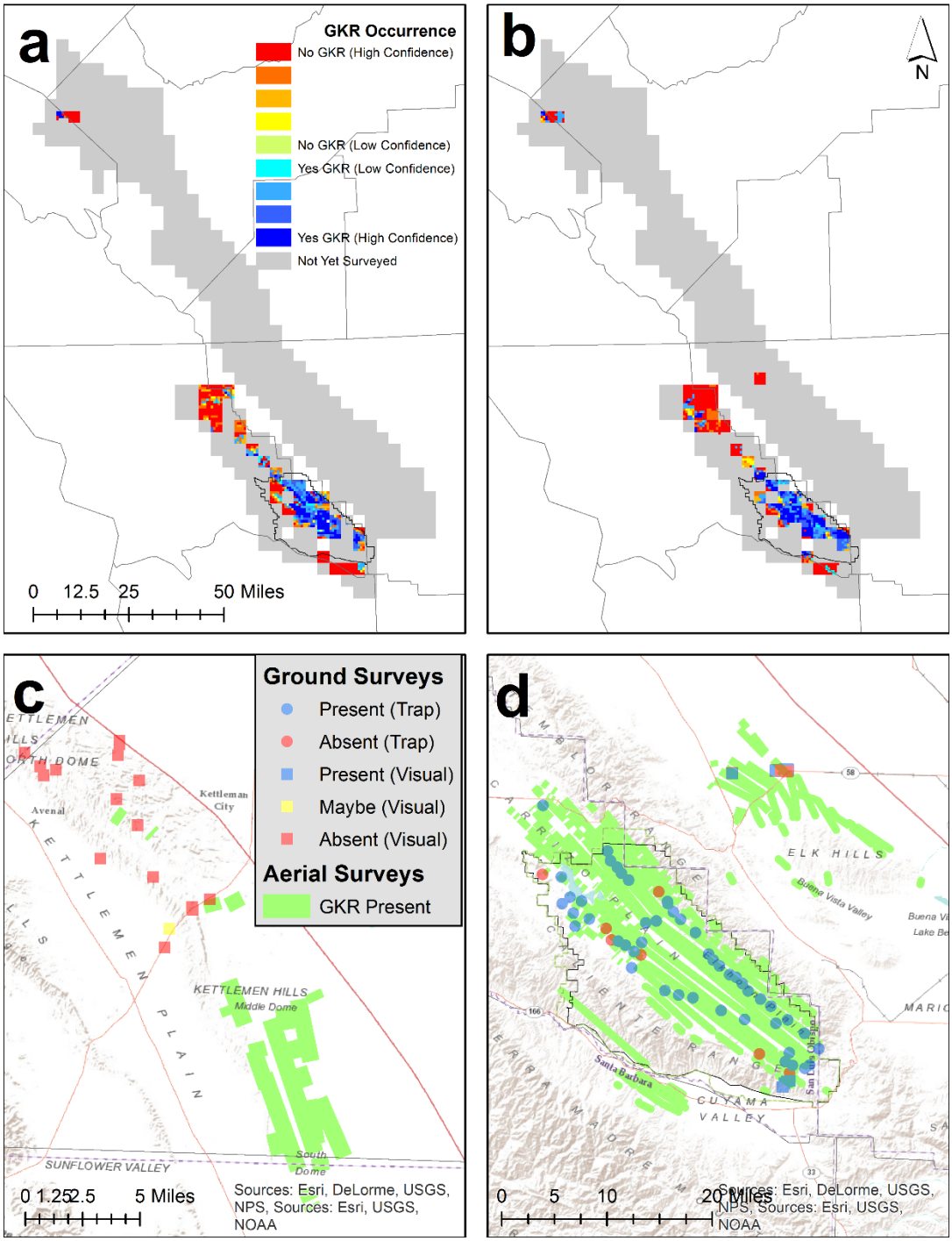
Investigators:	Dr. Tim Bean, HSU Wildlife Department
	Dr. Margaret Wilzbach, CACFWRU
	Alyssa Semerdjian, MS Student
Duration:	March 2016 – December, 2018
Funding:	California Department of Fish and Wildlife ($117,610)

Giant kangaroo rats (GKRs) have significantly recovered since being listed as state- and federally-endangered (United States Fish & Wildlife Service 1987) thanks to conservation efforts from USFWS, CDFW, researchers from the Endangered Species Recovery Program, and non-profit organizations (in particular The Nature Conservancy). However, little information is available about smaller populations throughout GKR range, and while the Carrizo Plain Ecosystem Project offers important demographic information on a core population, less monitoring is occurring at the periphery. Due to the ongoing drought, and concerns over long-term permanent changes in climate within GKR habitat, there is a critical need to understand population dynamics within all GKR colonies across their range. Objectives for this project are:

1. Identify potential giant kangaroo rat habitat based on habitat models and aerial and satellite imagery
2. Document giant kangaroo rat occurrence throughout their potential range
3. Develop monitoring methods based on existing demographic data and aerial surveys of population extent.

As of January 17, 2017, we have established a program relying on undergraduate research assistants to systematically survey aerial and satellite imagery for visible GKR burrows. To date, we have surveyed 460km^2 of aerial imagery for GKR sign. In December 2016 and January 2017, we discovered additional GKR occurrences outside of the historical range; we have added these areas to our survey and re-prioritized areas to be surveyed.

A two-person field crew spent May, June, and July 2016 trapping accessible GKR sites in the southern portion of their range to document occupancy and test multiple non-invasive survey methods for detecting GKR presence. They also conducted visual surveys on the ground to find additional areas of giant kangaroo rat activity. Graduate student Alyssa Semerdjian will compare these approaches with her trapping data to optimize a non-invasive survey design for the species. This method will be tested in summer 2017.



Panels (a) and (b) show current results of surveys of aerial and satellite imagery for signs of giant kangaroo rat activity. Research interns were trained to identify GKR sign and rank each 1km cell as either "present" or "absent" with a confidence from 0-5. Aerial surveys, live trapping, and visual surveys on the ground were conducted May-November, 2016 (c and d).

CHARACTERIZING THE FORAGING ECOLOGY OF MARBLED MURRELETS

Investigators:	Dr. Richard Golightly, HSU Wildlife Department
	Dr. Margaret Wilzbach, CACFWRU
Duration:	September 2016 – June, 2018
Funding:	USFWS ($9,775)

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. 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.

Marbled murrelet. Photo by Tom Benson

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. Application of NGS methods has the potential to provide scientists and managers with a valuable tool for characterizing the diet of marbled murrelets, ultimately informing the management of marine resources in a manner that could help recover this species.

The objective of this collaborative demonstration project is to evaluate the feasibility of using NGS methods to characterize the species-level diet of marbled murrelets in California from fecal material. This project involves the capture of a small number of birds at sea, along the coast next to nesting habitat in the Santa Cruz Mountains, to obtain samples of fecal material from them before releasing the birds back to sea. The fecal materials will be analyzed in the lab of M.Z. Peery at UWA. Prey DNA will be extracted from the fecal material, and amplified and sequenced using NGS methods. Prey species will be identified using available reference DNA sequence data. The genetic analysis component of the project is funded by the nonprofit organization Save the Redwoods League through an agreement with the University of Wisconsin.

LINKING PREDATION MORTALITY TO PREDATOR DENSITY AND SURVIVAL IN THE SACRAMENTO - SAN JOAQUIN DELTA

Investigators:	Dr. Mark Henderson, CACFWRU
	Christopher Loomis, MS student
Duration:	January 2017 – December, 2018
Funding:	UC Santa Cruz, CDFW ($58,500)

Once abundant and widely distributed, salmonid abundances in the Central Valley are greatly reduced from their levels in the 19th century in response to numerous limiting factors, including habitat loss, hydroelectric dams, hatcheries, and harvest. To provide the best chance of recovery for these ESA listed populations, it is necessary to identify the mortality mechanisms that are restricting salmonid population growth. Recent studies have shown high rates of mortality for salmonid smolts migrating to sea through the San Joaquin-Sacramento delta. While the exact causes of mortality are uncertain, they likely include many contributing variables including water quality, flows, water temperature, food availability, and water diversions. As little evidence exists of mass fish kill events, predation is presumed to be the proximate cause for much of this mortality.

Abundance data for fish predators is in the Delta is lacking, and has been identified as a primary research need in the Delta. The limited abundance data currently available for predators in the Delta cover relatively few locations and periods during the year, and fishery independent population estimates are unavailable. Both native (e.g., Pikeminnow (*Ptychocheilus grandis*)) and non-native species (e.g., Largemouth Bass (*Micropterus salmoides*), Striped Bass (*Morone saxatilis*)) of predator fishes inhabit the South Delta and feed on migrating smolts. Significant annual and seasonal variation in the presence or absence of individual predators is

Surveying predator densities in the Sacramento-San Joaquin delta with DIDSON acoustic cameras.

likely. Predators are likely to exhibit positive selectivity for salmonid species because salmonids are calorie-rich, likely naïve to invasive predators, and have no physical defense anatomical structures; therefore they are easily eaten and handled. Our ability to make qualitative inferences about the scale and effects of fish predation on the salmonid population are greatly hindered by this lack of information. Through a combination of paired electrofishing sampling and results from acoustic surveys conducted using Dual-frequency identification sonar (DIDSON), this study will quantify the abundance of potential predatory fish throughout the Sacramento-San Joaquin delta.

Specific objectives are to:

1) Quantify the relative abundances of piscivorous fish species in spatially balanced randomly selected sites throughout the Sacramento-San Joaquin delta using a DIDSON acoustic camera.
2) Use an open source hydrodynamic and water quality model for the San Francisco Bay Delta estuary (SCHISM) to relate predator abundance to physical habitat features.

Bat research in Humboldt Redwoods.

BASAL HOLLOW ROOST SELECTION BY TOWNSEND'S BIG EARED BAT

Investigators:	Dr. Joseph Szewczak, HSU Wildlife Department
	Dr. Margaret Wilzbach, CACFWRU
	Amon Armstrong, MS student
Duration:	March 2017 – December, 2019
Funding:	CDFW ($44,000)

This project addresses a lack of information about roosting habitat for Townsend's big-eared bat (*Corynorhinus townsendii*, COTO) and other bat species identified as Species of Greatest Conservation Need (SGCN) in the California Department of Fish & Wildlife (CDFW) 2015 State Wildlife Action Plan (SWAP). The purpose of this study is to determine the extent of use of basal hollows by COTO and other bat species and to provide land managers with specific criteria to identify and protect COTO roosting habitat. Graduate student Amon Armstrong will conduct field work as part of his MS thesis.

Objectives include:

1. Determine the range of tree species, basal hollow dimensions and configurations that COTO and other bats use as roosts in North Coast timberlands by evaluating 100-300 basal hollows and determining which bat species are utilizing them.

2. Determine if the structure of the surrounding vegetation (e.g. canopy cover, stand type and age), independent of the characteristics of the hollows themselves, affects the use of the trees by bats.
3. Using spatial analysis of tree roost locations, determine how landscape-scale variables such as proximity to water, slope position and range of ambient temperature, affect roost selection. These data will serve as baseline information that can be used to model the effects of drought and climate change on roost site availability in the future.
4. Characterize basal hollows used as roosts during the maternity season and the area surrounding those roosts.
5. Test efficacy of using eDNA collected from basal hollows as a non-invasive and efficient method for determining use by COTO and other bat species, by comparing eDNA results with those obtained from guano. Guano and soil samples will be sent to the Northern Arizona University's bat ecology and genetics "species from feces" Lab (NAU lab) to be analyzed for individual bat species.

LINKING GENETIC DIETARY ANALYSES AND POPULATION VIABILITY APPROACHES TO DEVELOP A SCIENTIFIC BASIS FOR MARBLED MURRELET RECOVERY IN CALIFORNIA

Investigators:	Dr. Richard Golightly, HSU Wildlife Department
	Dr. Margaret Wilzbach, CACFWRU
Duration:	November 2017 – November, 2019
Funding:	CDFW ($110,271)

This proposed project will conduct a population viability analysis (PVA) for marbled murrelets in California, and provide specific diet information to inform the PVA in regard to potential climate change.

We propose to use NGS methods to characterize the species-level diet of marbled murrelets in California using fecal material collected from individuals captured at sea in central California during the nestling provisioning stage (July and August). We will conduct a population viability analysis to estimate the viability of marbled murrelets under alternative management strategies in both the marine and terrestrial environments, while taking into account climate change.

Major tasks include:

1. Capture marbled murrelets off the coast of California and sample fecal material

2. Amplify and sequence prey DNA extracted from marbled murrelets feces using NGS methods and identify prey species using available reference DNA sequence data. Analyses will be conducted in Peery's Wildlife Conservation Genetics Laboratory at the University of Wisconsin-Madison.

3. Conduct a population viability analysis to assess the viability of marbled murrelets in California and evaluate alternative management strategies in terms of their potential benefits to murrelets populations. The population viability analysis model will be

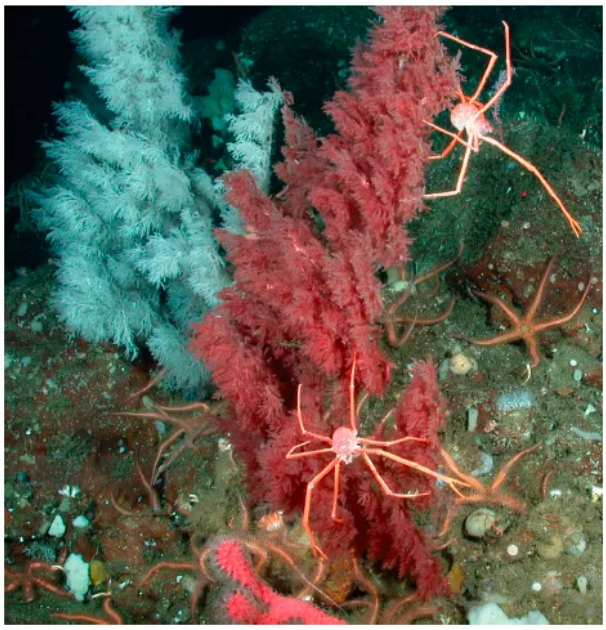
spatially-explicit in the sense that it will take into account the current distribution of murrelet nesting in California, and be temporally dynamic in the sense that it will allow for changes in the distribution of nesting habitat associated with climate change, harvesting and protection. The murrelet demographic component of the model will be structured and parameterized based on long-term demography work we have conducted in California. The distribution of nesting habitat will be derived from the literature and from aerial photo interpretation in central California. Murrelet reproduction and survival will be linked statistically to forage fish abundance, sea surface temperature, and projected changes in temperatures, refined by our improved understanding resulting from the genetic-based diet study. We will use standard Species Distribution Models informed by topography and spatial variation in temperature and precipitation, as well as carbon emission scenarios from the IPCC, to project the distribution of murrelet nesting habitat in the future. Finally, we will link murrelet breeding success to corvid nest predation and nesting habitat configuration using previously published predation rates. By manipulating nesting habitat inputs, for example, the user will be able use this model to evaluate the relative likelihood of murrelets in California going extinct under different forest management and conservation scenarios such as the acquisition of nesting habitat that would otherwise be harvested and corvid management, in the context of climate change impacts to terrestrial and marine habitats. All modeling will be implemented in program HexSim.

ASSOCIATIONS BETWEEN DEEP-SEA CORAL AND SPONGE ASSEMBLAGES AND DEMERSAL FISHES IN THE SOUTHERN CALIFORNIA BIGHT

Investigators:	Dr. Mark Henderson, CACFWRU
	Nissa Kriedler, MS student
Duration:	August 2017 – July 2019
Funding:	NOAA ($80,000)

A more holistic view of fish populations, habitat use, and anthropogenic effects on deep sea habitats is needed to understand and support fisheries for long-term sustainability. This project specifically addresses the deep sea monitoring and climate change research needs assessed by the Channel Islands National Marine Sanctuary (CINMS) in their efforts to protect and sustain California coastal fisheries and marine habitats. The CINMS holds several deep sea coral biological communities whose species associations have begun to be characterized. However further research is needed to characterize biological community assemblages of these deep sea coral reef habitats and environmental factors that may impact these assemblages to better manage these habitats.

Our proposed project will characterize deep sea coral and fish community assemblages both inside and outside the CINMS and examine how environmental parameters impact these assemblages via multivariate analyses using oceanographic circulation and production models. This research will further the understanding of deep sea corals and their associations with demersal fish species both inside and outside the Sanctuary, thus providing baseline data for how these communities are changing in protected and unprotected marine areas. Several predicted coral hotspots remain unprotected from fishing, particularly in areas adjacent to highly populated portions of the Southern California Bight. Our study can help prioritize areas for future protection and inform best management practices for demersal fish species with respect to their association with deep sea corals.



Christmas tree coral.

We specifically addresses the following research needs of the CINMS: (1) characterization of habitat, species, and communities in deep waters, (2) determination of changes in abundance and diversity inside vs outside reserves, (3) are specific or multiple stressors, including oceanographic and atmospheric conditions, affecting water quality, habitat status, or ecosystem health? (4) what results will climate change have throughout biological communities? (5) how will resources be affected by climate change?

WINTER DISTRIBUTION OF JUVENILE CENTRAL VALLEY CHINOOK SALMON: IMPLICATIONS FOR GROWTH AND SURVIVAL

Investigators:	Dr. Mark Henderson, CACFWRU
	Dr. Andre Buchheister, HSU Fisheries Department
	Dr. David Huff, NOAA Northwest Fisheries Science Center
	Dr. Joseph Smith, ICF
	Dr. Jason Hassrick, ICF
Duration:	June 2018 – May 2020
Funding:	NOAA / CA Sea Grant ($276,000)

This proposed project will examine the winter distribution of juvenile Central Valley Fall Run Chinook Salmon (CVFCS) and identify the primary environmental and biological drivers that influence their distribution. While data are available for marine distributions of juvenile salmonids in the California Current for summer and autumn months following ocean entry, data on winter distribution and growth dynamics of juvenile CVFCS is lacking. The winter is generally considered a critical period for these fish, when individuals that have not reached a sufficient size can starve due to decreased energy reserves and available prey resources. Despite the importance of the winter months to the salmon population, their winter distribution has rarely been studied due to a lack of an appropriate technology to track these small fish. We propose to use a new smaller version of a pop-up satellite tag (PST) to track the winter distribution of juvenile CVFCS. We will then use an ocean circulation and production model to identify the primary environmental drivers influencing their winter distribution and the potential for starvation based on individual size at the beginning of the winter season.

This project will provide empirical information on the occurrence, timing, and extent of movement of juvenile salmon within the Pacific coast environments that can be used to inform salmon assessments. These data are invaluable in understanding the environmental drivers that control the distribution of these fish, and, thus, how environmental changes may affect their distribution. Furthermore, by combining these distributional data with physical-biogeochemical models we will estimate how different migration strategies can influence potential growth and probability of starvation throughout their first ocean winter. Specific project objectives are:

1) identify the environmental and biological drivers that influence juvenile salmon movements and winter distribution

2) estimate the probability of fish starvation based on ocean conditions and fish size at the end of the summer growing season.

UNIT PROGRAM REVIEW

PROGRAM DIRECTION

Personnel

Coop Staff - The Unit is pleased to have Mark on board as Assistant Unit leader. Mark has had to burn the candle at both ends. In addition to preparing proposals and working on publications, Mark both taught his first university class and became a new father this past year. Peggy is expecting to retire from her position as Unit Leader within the year, and is working on shoring up loose ends and helping to stage a successful transition for the Unit.

Leslie continues to contribute to guidance of Unit and CNRS students in addition to providing administrative support to the Unit. Leslie put in many hours working on the submission of three FRGP proposals (collectively totaling over 400 pages of text) last year while Coop Unit scientists were attending an All Hands meeting in New Mexico. Her expertise was so well accepted by the Sponsored Program Foundation that she was granted permission to complete the online submission herself. Leslie updates the Unit's websites at the university and the Cooperative Research Unit Headquarters with new projects, staff and students.

Post-doctoral researcher Chris Manhard left his position on the Klamath Basin Stream Simulator S3 Model Project to accept other employment. While we were disappointed with his early departure, we were pleased with his productivity during his time here and wish him well in his new position.

Cooperators – Richard Boone joined the university this past summer as the new Dean of the College of Natural Resources and Sciences. He joined us from the University of Alaska Fairbanks where he was a professor of Ecosystem Ecology in the Department of Biology and Wildlife and the Institute of Arctic Biology. Rich has a strong background in forest ecology, biogeochemistry, trans-national Arctic education and support for both undergraduate and graduate education. He served as the Program Director of the National Science Foundation Research Traineeship Program and Program Director of the Integrative Graduate Education and Research Traineeship Program at the National Science Foundation. Dean Boone has signatory authority on the Cooperative Agreement to establish and operate the California Coop Unit, and represents the University on the Coop Unit Executive Committee.

Kevin Whalen is the new Supervisor of the western Coop Units for the USGS Cooperative Research Units Program. Kevin has previously served as Deputy Director of the Coop Unit Program, and as supervisor of the southern units. He maintains an office in Bozeman, MT.

Russ Bellmer, acting Environmental Program Manager of Anadromous Fisheries, continues to serve as the official CDFW liaison with the California Cooperative Unit. Fisheries Branch Chief Kevin Shaffer serves as contract manager of the Coop Unit Fund, which provides annual base operating funds to the Unit. The Unit also welcomes T.O. Smith, Steve Torres, and Roger Bloom to the team of scientists representing the California Department of Fish and Wildlife in discussions with Coop Unit scientists. T.O. is the Wildlife Branch Chief, Steve is Environmental Program Manager of the Wildlife Investigations Laboratory, and Roger is Environmental

Program Manager of Inland Fisheries. CDFW Director Charlton Bonham has signatory authority on the Cooperative Agreement.

Research

On the research front, we were pleased that the three proposals we submitted to the CDFW Fisheries Restoration Grants program (FRGP) were funded for the next cycle of funding. These projects will allow us to continue our long-term tracking of salmon population status in Prairie and Redwood Creeks, and to collaboratively engage with Fisheries faculty Darren Ward in life-cycle monitoring and investigation of metapopulation dynamics of Coho Salmon in Humboldt Bay.

The Unit continues to make progress in expanding our program to address wildlife concerns and to expand the geographic coverage of our research program within the state. For example, in addition to the project to assess the status of the Townsend's big eared bat across its California range, we have received new funding to work with HSU researcher Joe Szewczak to identify roosting habitat for the bat. The USFWS has provided us with supplemental funding to work with HSU researcher Rick Golightly to characterize the diet of marbeled murrelet, and we have submitted a proposal to integrate dietary analysis with population viability assessment of marbled murrelets within California. Mark Henderson received a subaward from UC Santa Cruz to identify and quantify the relative abundances of predatory fishes preying on salmonid fishes in the Sacramento-San Joaquin Delta system, and has submitted two proposal for further fisheries work in coastal environments of central and Southern California.

Unit Operations

The contract with CDFW that provided the Coop Unit with its annual operating funds from 2012-2015, with a no-cost extension to March 2017, has expired. We are hopeful that a new contract can be put in place quickly to allow us to continue our operations.

FACILITIES AND EQUIPMENT

We appreciate the outstanding facilities provided by HSU.

Years ago, the California Unit received permission to construct and build a metal storage shed on the grounds of the US Coast Guard Facility in Samoa, California. We continue to occupy the building, rent-free, for storage of boats and field gear. However, we have not maintained the building nor do we have funding to do so. It, and the remaining boats and trailers in the shed, are in considerable disrepair. The shed has broken windows, is infested with rodents and feral cats, and the automated door opener is non-functional. The building is now not only an eyesore, but a potential liability for the Unit. A solution is needed.

UNIVERSITY SERVICE AND TEACHING

Courses Taught

Ecology of Running Waters (3 units)	Wilzbach	Fall 2016

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 Jon Hollis – MS Fisheries, Humboldt State University
Henderson	Nicholas Van Vleet – MS Fisheries, Humboldt State University Hannah Coe – MS Fisheries, Humboldt State University

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

Henderson	Brendan Foster – MS Environmental Systems, Humboldt State University Grace Ghrist – MS Fisheries, Humboldt State University Laura Solinger – MS Fisheries, Humboldt State University Nicholas Macias – PhD Ecology & Evolutionary Biology, UC Santa Cruz
Som	John Deibner-Hanson – MS Fisheries, Humboldt State University Peter Drobny – MS Fisheries, Humboldt State University Nicholas Van Vleet – MS Fisheries, Humboldt State University Justin Alvarez – MS Fisheries, Humboldt State University
Wilzbach	Justin Alvarez – 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 Lara Janson – MS Environmental Science & Mgmt, Humboldt State University Michelle Krall – MS Fisheries, Humboldt State University Alexander Wick – MS Forestry, Humboldt State University

UNIVERSITY AND OTHER SERVICE

Wilzbach	Member, IACUC Member, Hatchery Staff Search Committee Member, Elk River Technical Advisory Committee Member, Prairie Creek Technical Advisory Committee Alternate Member, California Advisory Committee on Salmon and Steelhead Trout
Farrar	Updates and maintains the Unit's University and USGS web pages; member of Fisheries building evacuation team.
Henderson	HSU Klamath Connection affiliate Cal-Neva AFS annual meeting coordinating committee Introduction to "R" for biologists, workshop instructor, Stockton, CA.

THESES OF UNIT-SPONSORED GRADUATE STUDENTS

Dockham, A. 2016. Comparison of benthic invertebrate community structure and diet composition of steelhead (Oncorhynchus mykiss) in Dry Creek, California. M.S. Thesis, Humboldt State University, Arcata, CA.

Drobny, P. 2016. Influence of body size, intra- and inter-specific salmonid densities, and habitat on overwinter survival of juvenile Coho Salmon in Prairie Creek, California. M.S. Thesis, Humboldt State University, Arcata, CA.

STUDENT AWARDS

Deibner-Hanson, John: State University Grant

Drobny, Peter: Danielle Plumb Zumbrun Memorial Scholarship, Marin Rod and Gun Club, State University Grant

Gottesman, Aaron: State University Grant

Hollis, Jon: Founding Faculty Scholarship, Spring 2016

Van Vleet, Nick: Danielle Plumb Zumbrun Memorial Scholarship

PRESENTATIONS

Henderson, M.J., Huff, D.D., and Yoklavich, M. Associations between deep-sea coral and sponge assemblages and demersal fishes in the Southern California Bight. 6th International symposium on Deep-sea corals, Boston, MA. Sept 11-16, 2016.

Hollis, J. and M.A. Wilzbach. Export of invertebrate drift from fishless headwater streams in the lower Klamath River Basin, California, and its use by trout. Poster presentation, Annual Meeting, Society for Freshwater Science, Sacramento, CA. May 21-26, 2016.

Hollis, J. and M.A. Wilzbach. Export of invertebrate drift from fishless headwater streams in the lower Klamath River Basin, California, and its use by trout. Poster presentation, Coast Redwood Forest Symposium, Fortuna, CA. September 13, 2016.

Wells, B.K., Snatora, J.A., Henderson, M., Warzybok, P., Jahncke, J., Bradley, R.W., Huff, D.D., Schroeder, I.D., Nelson, P., Field, J.C., and Ainley, D.G. Caught in the middle: top-down impact of seabirds on Chinook Salmon (Oncorhynchus tshawytscha) is dependent on bottom-up mechanisms. Annual meeting of the North Pacific Marine Science Organization (PICES), San Diego, CA. Nov 2-13, 2016.

Wilzbach, M.A. Fisheries and Aquatic Resources of Prairie Creek. Invited oral presentation, Prairie Creek Technical Advisory Committee, Redwood National Park, Orick, CA. April 2016.

SCIENTIFIC PUBLICATIONS

Hassrick, J.L, M.J. Henderson, D.D. Huff, W.J. Sydeman, M.C. Sabal, J.A. Hardin, A.J. Ammann, E.D. Crandall, E.P. Bjorstedt, J.C. Garza, and S.A. Hayes. 2016. Early ocean distribution of juvenile Chinook salmon in an upwelling ecosystem. Fisheries Oceanography 25 (2): 133-146. IP-000001.

Sabal, M.C., Huff, D.D., Henderson, M.J., Fiechter, J., Harding, J.A., and Hayes, S.A. 2016. Contrasting patterns in growth and survival of Central Valley fall run Chinook salmon related to hatchery and ocean conditions. Environmental Biology of Fishes 99 (12) 949-967. IP-000001.

Cummins, K.W. and M.A. Wilzbach, in press. River and streams: ecosystem dynamics and integrating paradigms. Book chapter in Encyclopedia of Ecology. Academic Press. IP-081945.

Wells, B.K., Santora, J.A., Henderson, M.J., Warzybok, P., Jahncke, J., Bradley, R.W., Huff, D.D., Schroeder, I.D., Nelson, P., Field, J.C., Ainley, D.G. in review. Environmental conditions and prey-switching by a seabird predator impacts juvenile salmon survival. Journal of Marine Science. IP-077038.

Wilzbach, M.A. and K.W. Cummins, in review. Rivers and streams: physical setting and adapted biota. Encyclopedia of Ecology, Academic Press. IP-086036.

Wilzbach, M.A. and V. Ozaki, in review. Fisheries and aquatic resources of the Prairie Creek Watershed, Redwood National and State Parks. IP-083912.

UNIT STAFF

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Mark Henderson, Assistant Unit Leader mark.henderson@humboldt.edu

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

GRADUATE STUDENTS:

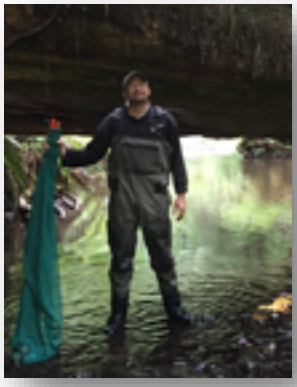
Peter Drobny, Fisheries

Andrea Dockham, Fisheries

John Deibner-Hanson, Fisheries

Jon Hollis, Fisheries

Nick Van Vleet, Fisheries



Hannah Coe, Fisheries

Student Technicians

Rose Dana
Wayne Hicks
Deven Kammerichs-Berke
Ashley Kay
Dylan Keel
Jason Long
Ethan Lukens
Lloyd Petrungaro
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Technicians

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Nicholas Easterbrook
Mia Eddington
Elizabeth Entzel
Melissa Gordon
Reed Hamilton
Steven Holt
Nicholas Judd
David Kissling
James Lucchesi
Chad Martel
Todd Newhouse
Matthew Settelmayer
Benjamin Sheppard

RESEARCH ASSOCIATES AND COOPERATORS

Nick Som, Affiliate Scientist
Christopher Manhard, Research Associate
Matt Metheny, Biologist