California Cooperative Fish & Wildlife Research Unit

Collection of an oyster sample from a longline oyster aquaculture plot, Humboldt Bay. Photo credit: Hannah Coe.

2019 Coordinating Meeting

March 5, 2019
Humboldt State University

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California Cooperative Fish & Wildlife Research Unit
2019 Coordinating Meeting
March 5
Humboldt State University, HGH 217

AGENDA

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

Additions to the Agenda

Approval of 2017 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

Graduate Student Presentations

Completed Projects Review

Current Research Projects Review

New Research Projects

Cooperator Reports and Research Needs 11:00

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
2017 Coordinating Committee Meeting Minutes
Tuesday, May 9, 2017

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.

In attendance:

Philip Bairrington, CDFW, Arcata

Bruce Bingham, USFWS, Arcata

Rich Boone, HSU, CNRS

Leslie Farrar, CA Cooperative Fish & Wildlife Research Unit

Micaela Szykman Gunther, HSU, Wildlife Department

Mark Henderson, CA Cooperative Fish & Wildlife Research Unit

Nicholas Hetrick, USFWS, Arcata

Andrew Kinziger, HSU, Fisheries Department

John Organ, Chief, USGS Cooperative Research Units Program

Larry Rabin, USFWS, Sacramento

Nick Som, USFWS, Arcata

Kevin Whalen, USGS Western Region Cooperative Research Units Program

Peggy Wilzbach, CA Cooperative Fish & Wildlife Research Unit

Rick Zechman, HSU, CNRS

Kevin Whalen served as chair and opened the meeting. Introductions were made including special guest, John Organ, Chief of USGS Cooperative Research Units Program. The agenda was approved. Minutes of the 2016 meeting were reviewed and approved with no additions or changes.

UNIT PROGRAM REVIEW

Mark Henderson has completed his first year with the Unit and has been productive preparing proposals, writing papers from his post-doc, taking on graduate students and is currently finishing up teaching his first course this spring assessing salmon populations. Peggy Wilzbach is preparing for retirement within this calendar year. The Fisheries Department is in the planning stages to take over Peggy's teaching responsibilities.

CNRS has a new dean, Rich Boone. Kevin Whalen is the new supervisor for the Western Units, Cooperative Research Units Program and John Organ joins us today as the Chief for the Cooperative Research Units Program.

Last summer Peggy Wilzbach and Mark Henderson traveled to Sacramento for a meeting with CDFW staff. Earlier this year we participated in a conference call in which some new CDFW staff were introduced who were expected to attend today's meeting: Wildlife Branch Chief T.O. Smith and Steve Torres, program manager of Wildlife Investigations. Our CDFW liaison from Sacramento, Russ Bellmer, did not participate today. The Unit is waiting for a new contract with CDFW, which expired in March. The Unit is making progress on expanding geographic coverage of research throughout the state and in increasing the number of wildlife research programs

The Unit was successful in obtaining three new FRGP grants for the last funding cycle. The contracts have not yet been awarded but expect them to be finalized sometime this summer.

The Unit has a storage facility that houses non-functional equipment located at the Coast Guard Station. The Unit no longer has a need for this facility and seeks resolution to its disposal sometime this year.

Program direction, university service, technical assistance, accomplishments, facilities and equipment were briefly outlined as supplied by the Annual Report.

Review of current, completed projects and review of new projects

Peggy Wilzbach reviewed completed and current projects as supplied by the Annual Report.

Peggy Wilzbach introduced eight new research projects to be approved:

New project review:

1. Comparative habitat use of estuarine habitats
2. Giant Kangaroo Rat monitoring
3. Characterizing the foraging ecology of marbled murrelets
4. Linking predation mortality to predator density and survival in the Sacramento-San Joaquin Delta
5. Basal hollow roost selection by Townsend's Big Eared Bat
6. Linking genetic dietary analyses and population viability approaches to develop a scientific basis for marbled murrelet recovery in California
7. Associations between deep-sea coral and sponge assemblages and demersal fishes in the the Southern California Bight

8. Winter distribution of juvenile Central Valley Chinook Salmon: Implications for growth and survival

All projects were approved.

COOPERATOR REPORTS

Report from Rich Boone, HSU-CNRS

- The Dean's office initiated a strategic planning process within the College of Natural Resources and Sciences (CNRS) in December 2016. The Dean felt it was critical to decide where the college was going. An environmental scan was conducted as part of the process. From this, a new vision and value statement will shape the College for the next 3 – 5 years. The Dean welcomes faculty feedback on anything that is relevant to CNRS as the planning document will shape the future and allocation of resources. Currently the plan doesn't identify research priorities and feels that priorities should come from the departments.

- The Dean is a firm believer that undergraduate research improves student graduation rates, and improves time to degree. He is not in favor of promoting the graduation initiative of the California State University System (CSU) at the expense of our quality programs. In a recent NSF ranking of schools according to the number of future PhD's generated from the bachelor's programs of origin, HSU was ranked #3 in the country for regional comprehensive universities per capita, and #1 within the CSU. Students apply to HSU for the quality of the program.

- Rick Zechman added that public open forums to include outside stakeholders in the strategic planning process will be scheduled.

Report from Micaela Szykman Gunther, HSU – Wildlife Department

- For the Wildlife Department, the future research direction is in natural resources management conservation. Our students want real management implications and increased opportunities have occurred as a direct result of these conversations at the Coop annual meetings.

Report from Andrew Kinziger, HSU-Fisheries Department

- This summer the Department is supporting two graduate students and two REU (Research Experience for Undergraduates) funded by NSF to work on the endangered Tidewater Goby eDNA projects surveying 200 sites throughout California. The program rroulou'sik (pronunciation is approximately "doo-loot-seek", Wiyot for "rising up") is for those students interested in research experiences in the science and management of natural resources on tribal lands and in collaboration with tribal partners.

- Fisheries is undergoing personnel changes as several faculty have already or are nearing retirement. The department is waiting to receive approval to initiate new faculty hires, especially in marine fish ecology. Overall student enrollments are increasing.

Report from Philip Bairrington, CDFW – Arcata

- Would like to have a regular meeting to identify needs/interests with the faculty at HSU which could be combined with fisheries branch meetings in Sacramento.

- Some highlights mentioned included approval of the Mad River Hatchery Monitoring Plan. The plan will provide more monitoring on the Mad River. The statewide workgroup on drones continues to meet, and coastal monitoring plan continues to document status of at-risk salmonid populations on a statewide scale using standardizing methods, with data centralized in a statewide database.

- Cannot provide a report from the Sacramento office today.

Report from Bruce Bingham, USFWS, Arcata

- Last year organized an open house to identify needs/interests with the HSU Wildlife Department. This could happen again even in slim budget times. Interested in having a mid-year meeting to build relationships to augment this annual meeting.

- Focus in future will be on recovery instead of delisting vs. listing.

Report from Nicholas Hetrick, USFWS, Arcata

- Klamath Dam removal has been the priority for the past six or seven years. Four dams are scheduled for removal in 2020, making this the largest dam removal project worldwide. Research opportunities are being facilitated by a non-profit, Klamath Renewal Corporation, with permitting in process. USFWS focus is on preserving the administrative record. There is potential to team with HSU on some of this work.

- Some other projects highlighted were Pacific Lamprey conservation initiative, with over 300 partners. The Pacific Marine Estuarine Partnership has projects from the state of Washington throughout California.

- The Klamath and Trinity rivers are where most funding comes from but would like to expand to a broader area with funding driven by issues.

Report from Larry Rabin, USFWS, Sacramento

- Department of Interior is experiencing many changes and there is waiting for political appointees to be put into place. Paul Souza, a strong science advocate, replaced Ren Lohoefener as Regional Director of the USFWS Pacific Southwest Region. USFWS does not have a dedicated research arm, and instead relies upon USGS and other research partners to help meet its information needs. A major role of USFWS Science Applications Program is to foster and strengthen partnerships between the Service and the larger scientific community to expand capacity to acquire and communicate scientific research to inform management decisions. Has already had conversations with the Coop Unit and the Yreka office to this end.

- Landscape Conservation Cooperatives (LCC's) build body of science to support decision-making by land managers and conservation practitioners in conservation land management priorities to expand research locally and more broadly across the state.

- USFWS is continuing its efforts to create a conservation workforce that looks more like the demographics of the American public; USFWS has made some progress but is interested in working with the CRUs to develop a pilot program that has a diversity component.

- Budget is either flat or some minor increases for 2017. October 1st budget is more uncertain but could mean 11.7% reduction for DOI. All indications are that this 11.7% reduction won't be spread equally across DOI bureaus and programs. This could mean greater reductions for some FWS programs. Likely as budgets get smaller it will be important to work together with partners to pull together resources to start new research projects and implement them.

- <u>Report from Kevin Whalen, USGS</u>

- Commended the Coop Unit for richness of work and expressed appreciation for the support represented at the meeting. The efforts made by USFWS in meeting with and engaging the wildlife faculty is totally unique and gratifying to see within the Coop Unit Program.

- Discussed the impending retirement of Peggy Wilzbach within context of other retirements within the national cooperative research units program. About 30 vacancies in 26 Units currently, which is a historically high number and affects the core program. Program managers attempt to avoid bringing multiple person units down to a single person. Units need to be supported by the state and university for additional staffing. Discussion about possibilities to add a third member to the Unit. Some of the discussion takes place at the national level for staffing, etc.

<u>Report from John Organ, USGS</u>

- The level of interaction and participation from the regional and field offices of USFWS including having affiliate faculty associated with the Unit, is unprecedented. Headquarters will be using the California Unit as a model in this regard for other units.

- Budget for 2017 was good, but it is uncertain for 2018. The message to Bureaus is to expect major cuts in programs. Program is flat funded which means a record number of vacancies. The Cooperative Research Program has an advantage with the breadth of portfolio in the ecosystems area, which is supported by the close relationships with state fish and wildlife agencies. Initiatives are underway to work on the 2018/2019 budget effort, which mean that HSU and the State of California need to be part of it. The strategy from a national perspective is strength in expertise and decision science; strategic decision making and adaptive management.

- Addressing URM, the Unit Program can help implement that with graduate and undergraduate mentorship. Currently there is a collaborative effort in the northeast wildlife refuge science for recruitment at the graduate level. Need collective,

collaborative effort for URM. An example of a successful program is the Duke Conservation Scholars Initiative that five units in the nation are participating in. Funds are dwindling, however the National Fish and Wildlife Foundation has become more involved and under discussion currently is a mechanism to extend this program to other Units as resources would allow.

- Recently signed is a MOU with the National Conservation Training Center and USFWS to offer graduate distance learning framework for Coop Unit students to be taught by Coop Research Unit scientists on a voluntary basis at no cost from USFWS other than tuition from home university.

2018 ANNUAL COORDINATING MEETING

A date for next year's meeting was not set.

CLOSING

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

EXECUTIVE SESSION HELD FOLLOWING MEETING

REVIEW OF PROJECTS COMPLETED IN 2017 - 2018

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) in Humboldt County, Northern California was established as a long-term life-cycle monitoring (LCM) station for Chinook and Coho Salmon and Steelhead trout. A primary objective of long-term studies is to encompass as much environmental and biological variability as possible. 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.

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

Downstream salmonid migrants in Redwood Creek.

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.

Low abundances over the 13-year period of monitoring indicated that 1+ Chinook Salmon are relatively rare in RC. 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 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.

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.

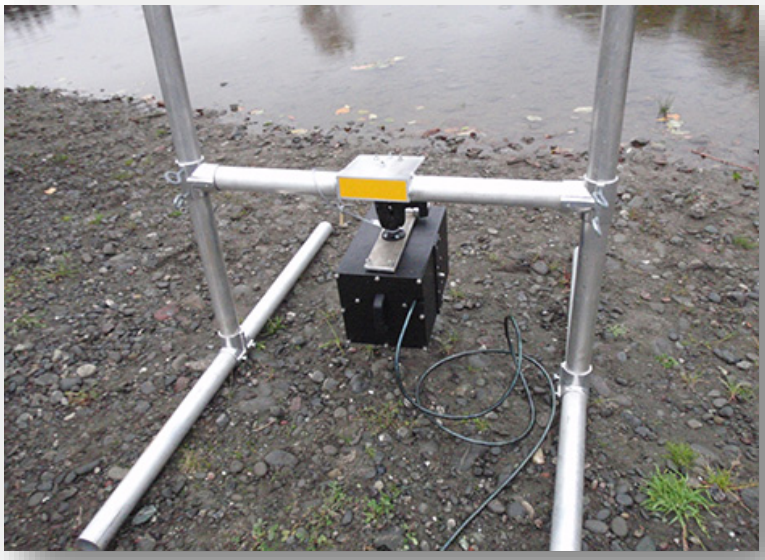
Wilzbach, M.A., M.D. Sparkman, N. Van Vleet, B. Sheppard, and M. Settelmayer. 2017. Overwinter survival and smolt abundances of Coho Salmon in Prairie Creek, California: 2014-2016. Final Report to the California Department of Fish and Wildlife Fisheries Restoration Grants Program, Project No. P1210321,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

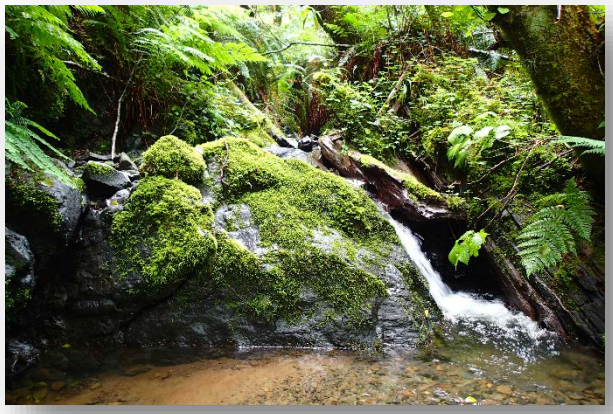
We deployed dual frequency identification SONAR (DIDSON) in Orick, CA to estimate a minimum escapement of 2,186 (+/- 329) adult salmonids entering Redwood Creek to spawn between 15 November 2015 and 29 March 2016. Estimates were based on a census of all available video when conditions allowed use of 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, CA 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, Arcata, CA.

EXPORT OF INVERTEBRATE DRIFT FROM HEADWATER STREAMS

Investigators:	Dr. Margaret Wilzbach, CACFWRU
	Jon Hollis, MS Student
Duration:	January 2015 – June 2018
Funding:	Green Diamond Resources Company ($54,000)

An understanding of ecological linkages between fishless headwater systems and downstream habitats is needed to enhance management practices for aquatic conservation. 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 contribute to biological production in downstream reaches is needed to enhance riparian management practices.



Fishless headwater stream

In this study, Jon Hollis quantified and described the export of invertebrate drift from fishless headwater streams to assess the potential importance of this export to downstream populations of Coastal Cutthroat Trout (*Oncorhynchus clarki clarki*) in the lower Klamath River in northern California. From from fishless streams throughout the year. Trout diet samples demonstrated tremendous variability in invertebrate biomass among individuals within seasons. However, average biomass per diet sample differed strongly among sampling occasions, and was greatest in April. Terrestrial taxa dominated the biomass of trout diets in June and October. Both drift and diet samples were taxonomically rich, but exhibited little similarity to each other. Jon estimated drift exports from fishless headwaters could support a maximum of 37 g dry mass stream-1 year-1 of trout, theoretically accounting for one-tenth to one-quarter of the annual production of over-yearling trout in the study streams.
Jon successfully completed and defended his master's thesis in December 2018.

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.

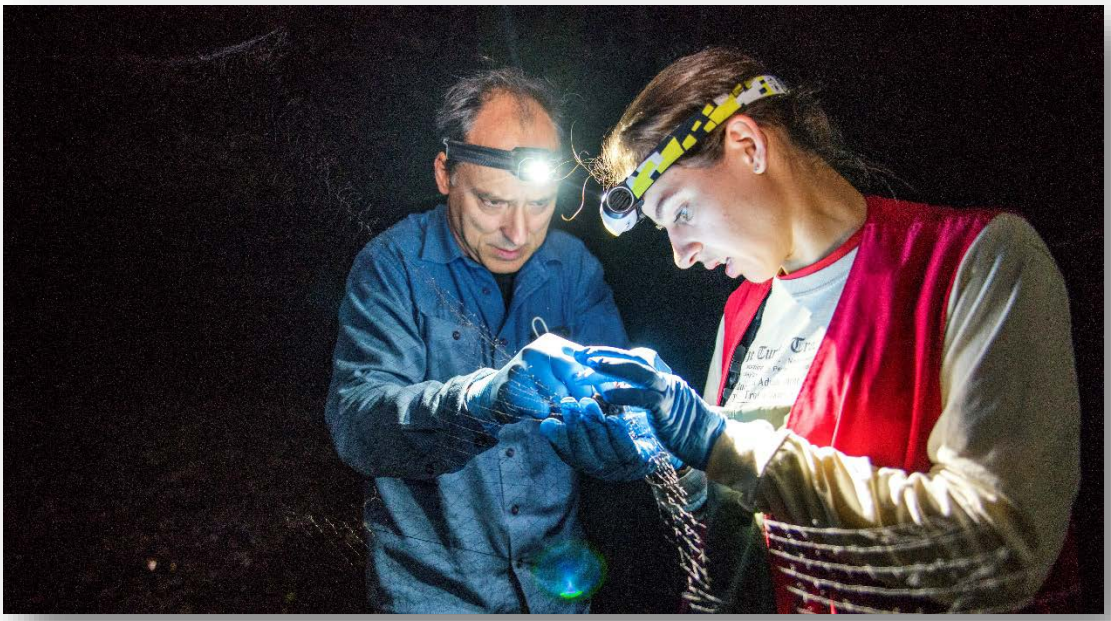
Hollis, J. and M.A. Wilzbach. Export of invertebrate drift from fishless headwater streams in the lower Klamath River Basin, California, and its use by trout. Poster presentation, Coast Redwood Forest Symposium, Fortuna, CA. September 13, 2016.

Hollis, J. 2018. Export of Invertebrate drift from fishless headwater streams. MS Thesis. College of Natural Resources and Sciences, Humboldt State University, Arcata, CA.

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)

This project aimed to quantify the current distribution of Townsend's big-eared bat in California by conducting a comprehensive roost assessment through a repeat of the previous statewide survey and a geographic expansion of that effort. This project constituted a



Joe Szewczak in the field with student.

comprehensive assessment of this species of concern using similar methods as were used for the first statewide survey project more than two decades earlier and thus generated a comparable data set, save for colony count data, which were not collected. The project also expanded coverage to newly documented and potential habitat locations. This assessment provided information to the California Endangered Species Act Status Review and will provide baseline data and recommendations to support CDFW and others to implement effective management actions that lead to conservation of the species.

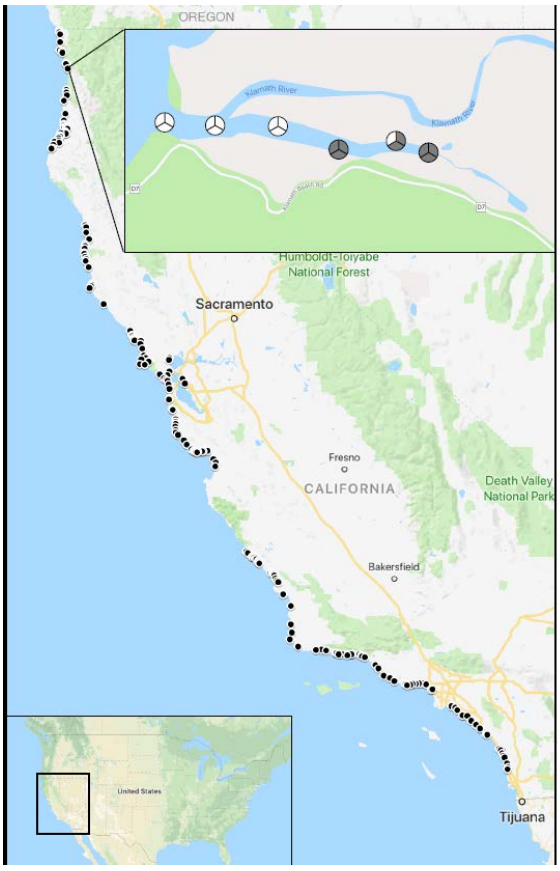
Specific project objectives include:
1. gather all existing data on the distribution, abundance and site characteristics of the bat;
2. conduct re-surveys of historic sites for current occupancy; and
3. conduct surveys in a selection of habitat occupancy and abundance.

Our surveys, along with other data known to exist on the species, indicated Townsend's big-eared bat remains distributed across much of California. Because the species is able to use a

wide variety of structures for roosting, it seems to be able to exist in suitable anthropogenic sites where naturally occurring structures are minimal in abundance or highly disturbed. Suitable anthropogenic habitat, whether mines or buildings, or even bridges in some cases where the bridge superstructure forms an appropriate cavern analog, appear to provide important resources for the species. Numerous other variables, however, play a role in the viability of a roost site, particularly for maternity roosts, such as distance to foraging habitat. Such evaluations are beyond the scope of this study, but must be considered in management approaches.

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)



Rangewide monitoring of fish species is critical for determining status and trends in distribution; however, implementations of large-scale distribution surveys have generally been constrained by time and cost. This study used environmental DNA (eDNA) to monitor the presence or absence of two endangered Tidewater Goby species, the northern Tidewater Goby (*Eucyclogobius newberryi*) and the southern Tidewater Goby (*Eucyclogobius kristinae*), across their combined geographic range that encompasses the entire California coast (1,350 km). A total of 197 estuary sites were surveyed in coastal California from Del Norte to San Diego counties between May and September 2016. Among the 197 sites, a total of 430 water samples were collected (one to six per site), filtered, and tested for the presence/absence of northern and southern Tidewater Goby, using species-specific quantitative PCR assays. Northern Tidewater Goby were detected at 81 out of 175 sites and southern Tidewater Goby were detected at 4 out of 22 sites, resulting in a combined naïve

Map of the 209 survey sites (black dots) for Tidewater Goby that encompassed the entire geographic range of the species and 1350km of California coastline. Top inset map depicts the Klamath River site to illustrate water-sampling locations at a site and the hierarchical nature of sampling, consistent with the multi-scale occupancy analysis used in this study. Each pie wedge represents a qPCR replicate with a gray wedge indicating Tidewater Goby qPCR detection and a white wedge Tidewater Goby qPCR non-detection. Map was created with Google maps.

occupancy of 0.43. In contrast, application of a multi-scale occupancy model that accounted for imperfect detection estimated site occupancy at 0.55 (95% CRI 0.46–0.64), indicating that Tidewater Goby were present but not detected at 23 additional sites.

This study illustrates that eDNA methods represent a reliable and efficient tool for aquatic species monitoring, but highlight the importance of accounting for imperfect detection by use of occupancy models in eDNA surveys. The Tidewater Goby eDNA distributional snapshot represents a baseline for evaluation of future trends in site occupancy that will inform conservation and management of this endangered species.

Notes:

(1) Completed project, including final report.
(2) Completed MS Thesis – Michael Sutter.
(3) Accepted for publication in Conservation Genetics:
Sutter, M., and A.P. Kinziger. In Press. Rangewide Tidewater Goby occupancy survey using environmental DNA. Conservation Genetics.

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 habitat 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 and Lokern Monitoring Project offer important demographic information on core populations, less monitoring is occurring at the periphery. Due to the historical drought and concerns over long-term permanent changes in climate within GKR habitat, there was a critical need to understand population dynamics within all GKR colonies across their range. GKRs are a burrowing species native to grasslands of the southwestern San Joaquin Valley. The combined behaviors of burrowing and grass clipping on top of their burrow mounds means that detecting GKR occurrence is possible through aerial surveys and review of aerial or satellite imagery. Objectives of this project were to:

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.

Giant Kangaroo Rat. photo by Alyssa Semerdjian

We conducted a systematic review of recent aerial and satellite imagery to document GKR colonies across their historical range. In total, we surveyed 17,357 km^2 for signs of GKR activity. Giant kangaroo rat burrowing activity was detected in 6% of the cells, or a little over 1,000 km^2. In 2016 and 2017, we also flew manned aerial surveys over the southern portion of their range, detecting 955km^2 of recent GKR burrowing activity. We trapped for GKR throughout their historical range; this project supported trapping efforts in 2016 and 2017, but we combined these trapping results with previous efforts from 2010-2015. In total over those years, we trapped at 436 sites across five counties, capturing a total of 1,581 individual giant kangaroo rats at 289 of the sites. In 2016 and 2017, we trapped at 106 sites, with giant kangaroo rats captured at 70 of them.

While the most recent 5-year review for GKR recognized populations in the Kettleman Hills area of southwestern Kings/ northwestern Kern county; and additional populations in the Cuyama Valley of southeastern San Luis Obispo County, our results suggest that these populations are more robust and extensive than previously thought, and deserve additional attention for recovery efforts.

We developed non-invasive sign surveys to detect GKR occupancy without live trapping, which were approximately 85% accurate at distinguishing active GKR sites from inactive ones. Our monitoring models suggested maintaining ongoing surveys at 150 sites, divided equally between the Ciervo-Panoche (northern), Carrizo (southern), and other areas within their range. This design would produce robust and reliable estimates to fulfill monitoring criteria set out in the Recovery Plan. By continuing the on-the-ground surveys with continued review of aerial imagery and manned survey flights, we can maintain an understanding of range-wide population dynamics for an endangered vertebrate.
These results will be prepared as two scientific publications led by Semerdjian, with a third planned manuscript led by Bean synthesizing these results with multiple sets of habitat suitability models constructed to guide habitat conservation efforts.

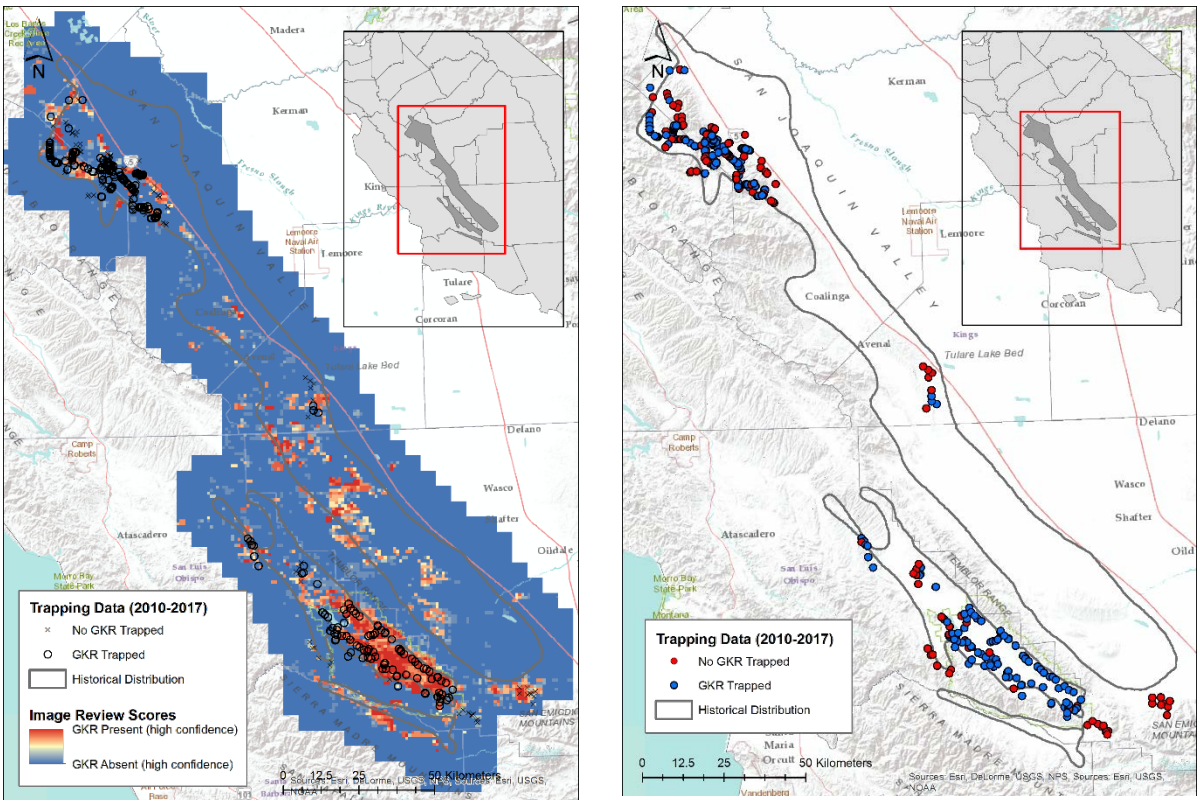


Figure 1. Results of range-wide aerial and satellite imagery review estimating occurrence of giant kangaroo rat burrowing activity (left) and results of live-trapping efforts from 2010-2017 (right). Areas of GKR activity in the central and very southern parts of their range represent more extensive populations than previously known.

RWO 90: 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 a number of factors including the loss of their old-growth nesting habitat, nest predation, and changes in marine prey resources. While extensive nesting habitat management and predator control programs have been implemented by the state and federal agencies responsible for murrelet conservation, it is increasingly recognized that changes in marine foraging conditions may interact with declines in nesting habitat to cause sustained low murrelet recruitment in California. Ensuring that adequate prey resources exist near nesting habitat and, more broadly, integrating forest and marine ecosystem management will be essential for maintaining viable populations of marbled murrelets in redwood ecosystems.

Fecal samples were obtained during two capture periods, one in September 2016 and another in August 2017. Each capture episode lasted two nights. Not every captured bird provided adequate fecal material. In total, we acquired 5 samples from 2016 and 14 from 2017. Sequencing has been completed on the fecal samples from 2016 but analyses are still to be conducted on 2017 samples and both years still await verification from voucher samples (voucher prey specimens were collected in June 2018 off the central California coast).

Preliminary results from the first sequencing resulted in identification of the following species: Pacific sandlance (*Ammodytes hexapterus*), Pacific sea nettle (*Chrysaora fuscescens*), Pacific herring (*Clupea pallasii*), Northern anchovy (*Engraulis mordax*), surf smelt (*Hypomesus pretiosus*), sole or flounder (*Lepidopsetta* sp or *Platichthys* sp, Family: *Pleuronectidae*), market squid (*Doryteuthis opalescens*), and Pacific sardine (*Sardinops sagax caeruleus*). Each fecal sample contained an average of 2.8 species of prey.

The effort to capture murrelets was typical of captures described elsewhere in that considerable effort was required by the research team to acquire birds. However all birds were captured safely. We expect that prey species lists will be completed in by September 2018.

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)

Predation is presumed to be the proximate cause for much of mortality of salmonid smolts migrating to sea through the San Joaquin-Sacramento delta. Abundance data for fish predators is in the Delta is lacking, and has been identified as a primary research need in the Delta. 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) Model predator habitat selection using compiled environmental data for the San Francisco Bay Delta estuary to relate predator densities and locations to habitat types.

Preliminary Results:

Processing and analysis DIDSON footage has been completed, resulting in estimates of predator densities throughout the south delta. Development of species differentiating models allowed for the discrimination of predator from non-predator fishes with up to 98% accuracy. Habitat selection modeling suggested that predators may be selecting habitats with diverse habitat structure including bathymetric complexity and cover. This data has allowed researchers to elucidate to relationships between predators, prey, and the environment during a critical phase in the salmonid life cycle and will continue to advise and inspire future research efforts.

REVIEW OF CURRENT RESEARCH PROJECTS

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

Investigators:	Dr. Mark Henderson, CACFWRU
	Dr. Nicholas Som, USFWS
	Chris Manhard and Eve Robinson
Duration:	October 2014 – September 30, 2019
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.

The first set of funds aimed to support development on the S3 model focused on aspects necessary to complete a Coho Salmon version of the model, and there are several significant developments to convey regarding this portion of the project. Three peer-review documents associated with this task were completed, and they include:

1) A journal manuscript outlining development of a new Coho Salmon growth model:

Manhard, C. V., Som, N. A., Perry, R. W., Plumb, J. M. 2018. A laboratory-calibrated model of Coho Salmon growth with utility for ecological analyses. Canadian Journal of Fisheries and Aquatic Sciences 75(5): 682-690. doi: 10.1139/cjfas-2016-0506.

2) A FWS technical report detailing the data, analysis, and resulting modeling tools to estimate environmental conditions in tributaries of the Klamath River to drive the S3 Coho model:

Manhard, C. V., N. A. Som, E. C. Jones, and R. W. Perry. 2018. Estimation of stream conditions in tributaries of the Klamath River, Northern California. U.S. Fish and Wildlife Service. Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR 2018-32, Arcata, California.

3) A FWS technical report detailing the data, analysis, and resulting modeling tools to simulate productivity, survival, and migration pattern sub-models to drive the S3 Coho model:

Manhard, C. V., N. A. Som, R. W. Perry, J. R. Faukner, and T. Soto. 2018. Estimating freshwater productivity, overwinter survival, and migration patterns of Klamath River Coho Salmon. U.S. Fish and Wildlife Service. Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR 2018-33, Arcata, California.

The original post-doc hired was very productive, as evidence by the above documents, but returned to the East Coast with his wife after only a single year of work. The remaining funds were paired with additional funding to create another two-year post-doc position, and a candidate was selected this fall to fill that position. Eve Robinson began work in January 2019, and we will report on her progress on two separate tasks during the 2020 CACFWRU review meeting. The first tasks relates to prior funding, and includes a survey and assessment of methods to predict habitat amounts for sections of population model domains.

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

Investigator:	Andrew Kinziger, HSU Fisheries Department
	Mark Henderson, CACFWRU
	Chad Martel, MS Student
Duration:	January 2015 to June 30 2019
Funding:	USFWS ($93,664.71)

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). 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.

Tidewater Goby.

We surveyed Tidewater Goby at 196 locations across coastal California, from Del Norte to San Diego counties, in 2016 and 2017 using environmental DNA in water samples. The site occupancy data from the two survey years was analyzed using occupancy modeling approaches to determine extinction and colonization probabilities. Also, we tested covariates that influence extinction and colonization rates. Over the one-year duration of this study, we found that patterns of extinction and colonization varied by Tidewater Goby recovery unit, three units exhibited no change in site occupancy, two units a decline in site occupancy, and one unit exhibited an increase in site occupancy. Colonization probability increased with the number of occupied neighbors and decreased with distance. Extinction probabilities were not significantly impacted by any of the covariates we examined (e.g., estuary size, temperature, salinity, dissolved oxygen). Our analysis also indicate that biased estimates of extinction and colonization would result unless imperfect detection is accounted for. This study illustrates the power of using environmental DNA for enabling rangewide evaluation of a species distribution and metapopulation dynamics. Expansion of our approach over multiple study years 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.
This project was extended and funding was added.

HABITAT SELECTION IN AN ARCTIC SEABIRD: IMPLICATIONS FOR CLIMATE CHANGE

Investigators:	Dr. Mark Colwell, HSU Wildlife Department
	Dr. Mark Henderson, CACFWRU
	Aaron Gottesman, MS Student
Duration:	September 2015 – December 2019
Funding:	USGS, Alaska Science Center (45,225)

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.

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. Additional funding added for student stipend.

Semipalmated Sandpiper (Calidris pusilla) in breeding plumage.

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.

Gottesman, A., T. Bean, D. Ruthrauff, and M. Colwell. 2017. Shorebird nest site habitat composition: implications for climate change. Oral presentation, Seventh Meeting of the Western Hemisphere Shorebird Group, Paracas, Peru, November 2017.

REDWOOD CREEK CHINOOK SALMON MONITORING AND LIFE CYCLE MODEL

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

Monitoring baseline trends in salmon productivity and survival is imperative to understanding how populations will respond to restoration efforts and environmental changes. 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. Redwood Creek contains the northernmost functionally independent population of the California coastal Chinook Evolutionary Significant Unit, which are listed as threatened under the Federal Endangered Species Act.

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 are currently being combined into a life-cycle model as part of Emily Chen's master's thesis. The primary purpose of Emily's thesis is to evaluate the effect of the Redwood Creek bar-built estuary on the recruitment of Chinook Salmon. Preliminary results suggest warm temperatures during the summer in the estuary could contribute to the poor success of estuary rearing Chinook and that estuarine restoration should target improving growth in the estuary. She is currently planning to defend her thesis in the spring of 2019.

Pit tagging in Redwood Estuary.

HUMBOLDT BAY COHO MONITORING

Investigators:	Dr. Darren Ward, HSU Fisheries Department
	Dr. Mark Henderson, CACFWRU
	Grace Ghrist, Madison Halloran, MS Students
Duration:	June 2017 – August 2020
Funding:	California Department of Fish and Wildlife/FRGP ($966,547)

For this project, we use spawning ground surveys in tributaries of Humboldt Bay to establish the regional status and trends of adult salmonid abundance and we operate a life cycle monitoring station (LCS) on 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 more than 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.

Field work at Cloney Gulch.

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. To assess connections among populations, we have expanded the juvenile tagging and detection efforts to two additional streams adjacent to Freshwater Creek. This effort allows us 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. Detections of tagged fish moving between basins in the winter of 2017-2018 showed that at least some juvenile Coho Salmon leave their natal tributary, move through Humboldt Bay, and enter a separate nearby tributary to rear for the winter before going back to sea as a smolt.
This spring, we also published one new paper based on analyses of the Freshwater Creek dataset (Cochran et al. 2019. Fisheries Ecology and Management). The paper presents an analysis comparing marine survival rates calculated using two different techniques (population abundance and PIT tag returns). Results of this analysis show that there are uncertain assumptions and potential biases inherent in both of these approaches.

LIFE CYCLE MONITORING OF COHO SALMON IN PRAIRIE CREEK

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

This project continues 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. The primary purpose of this project is to contribute to population life cycle monitoring of Coho Salmon 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 with downstream migrant smolt trap data; and 3) estimate freshwater and marine survival rates using Passive Integrated Transponder (PIT) tag detections at stationary antenna arrays and recapturing tagged fish in the migrant trap. Freshwater growth and survival of juvenile fish were estimated from capture of tagged fish in the smolt trap and antenna detections. Additionally, we hope to estimate marine (smolt-to-adult) survival of this year's Coho Salmon cohort in the future using encounter histories constructed of smolts tagged during this trapping season that are detected on antennas returning to Prairie Creek as adults. These Life Cycle Monitoring (LCM) station components are critical to analyzing long-term Coho Salmon population trends in Prairie Creek and comparing demographic rates across the region. The hope for this project is to provide fisheries managers

Tracks at Lost Man Creek.

with results to direct management decisions and give restoration groups the biological responses needed to assess treatments across the local and regional landscapes.

We are currently in the middle of our second monitoring season and will soon begin to trap emigrating smolts. For Emerson Kanawi's masters research he will collect water samples to determine if environmental DNA (e.g. feces, urine, mucous) is correlated with the number of outmigrating juvenile salmon.

COMPARATIVE HABITAT USE OF ESTUARINE HABITATS

Investigators:	Dr. Mark Henderson, CACFWRU
	Hannah Coe, MS student
Duration:	September 2016 – August 2019
Funding:	Confluence Environmental Company, NOAA ($61,655.65)

Hannah Coe in the field.

Oyster aquaculture has been a commercial presence in Humboldt Bay for nearly 60 years, but the ideal habitat for growing oysters overlaps with the 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 oyster 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. This thesis research will evaluate how invertebrate communities are affected by the presence of longline oyster aquaculture. Specific objectives are to: 1. compare macroinvertebrate assemblages between four habitat types- mudflat with longlines, eelgrass with longlines, and eelgrass without longlines. 2. understand how benthic and epibenthic communities are affected by the presence of longline oyster aquaculture in Humboldt Bay.

Preliminary results indicate little to no change to the invertebrate community in eelgrass habitats with the addition of longline oyster aquaculture. These initial results indicate the importance of structure in driving invertebrate community composition, with aquaculture lines potentially fulfilling the role of eelgrass in supporting invertebrate communities.

BASAL HOLLOW ROOST SELECTION BY TOWNSEND'S BIG EARED BAT

Investigators:	Dr. Joseph Szewczak, HSU Wildlife Department
	Dr. Mark Henderson, CACFWRU
	Amon Armstrong, MS student
Duration:	May 2017 – June 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:

- Identify bat species roosting in basal tree hollows on the north coast of California by analyzing DNA in guano collected from at least 100 hollows over 1 year
- Test the efficacy of identifying bat species from environmental DNA (eDNA) within soil samples collected beneath hollows
- Examine seasonal activity levels at roosts, using guano mass as an index
- Determine which habitat variables affect bat species' selection of basal hollow roosts at local (hollow and surrounding area) and landscape scales

Progress:

Corynorhinus townsendii flying out of basal hollow.

In 2017, HSU students, led by Amon Armstrong and CDFW staff located 140 trees with basal hollows and installed guano traps at 9 sites in Del Norte, Humboldt, and Mendocino counties. Guano traps were left in tree hollows for at least one year in order to capture the range of bat species using hollows, and to determine seasonal changes in use. The team has completed hollow measurements, and will finish collecting local and landscape variables by spring, 2019. During 2018, HSU students completed sorting and weighing monthly guano collections per hollow. An initial set of guano collected over 6 months from 10 hollows was sent to the Northern Arizona University "Species from Feces" lab to determine bat species by DNA analysis. In November, another 120 samples were sent and analysis is in progress. Thirty soil

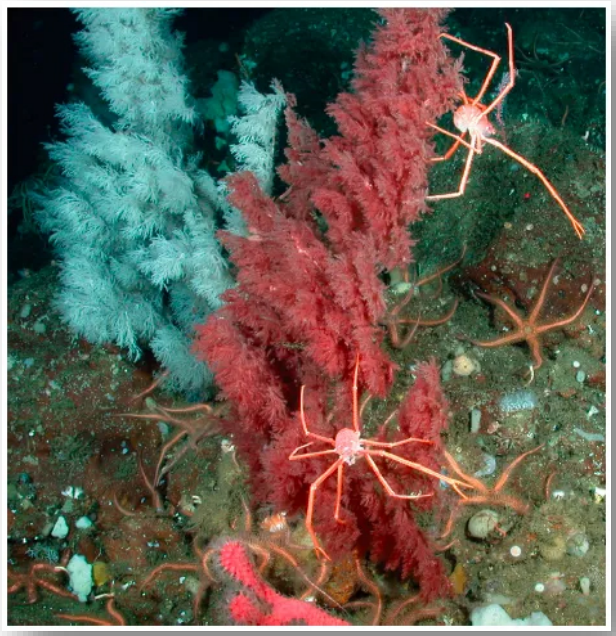
samples from inside hollows with a range of bat use were also sent to determine effectiveness of extracting species identifications (to be compared with identifications from guano).

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)

Deep Sea Coral and Sponge Species (DSCS) are some of the longest-lived marine species and their complex, three-dimensional structure provides habitat for demersal fish and other invertebrates. A recent study on benthic assemblages in Southern California revealed statistical associations between several DSCS and demersal fishes. Maps of known locations and maps that predict where these DSCS may occur are needed for the management and protection of this habitat and the fauna that use it.

Our study will create Species Distribution Models (SDMs) for DSCS in the SCB, focusing on eleven species of DSCS that have been associated with fishes, some of which are of management concern (Henderson et al., in prep). Our goals for this project are to:



Christmas tree coral.

1) Create distribution maps of DSCS habitat suitability
2) Identify the environmental variables that predict DSCS distributions
3) Compare differences in predicted distributions based on two common modeling approaches
4) Compare DSCS distributions inside and outside of the Channel Islands National Marine Sanctuary

This information is needed by managers of the Channel Islands National Marine Sanctuary to better characterize the resources available in the sanctuary and for future management decisions such as where to draw MPA boundary lines. Our maps will provide this missing information and provide data on DSCS habitat suitability in the Southern California Bight. This work will extend current knowledge on DSCS that are known to be associated with commercially important rockfish, provide baseline data on sensitive deep sea habitat, and reveal areas for future surveys and protection.

NEW RESEARCH PROJECTS REVIEW

TRACKING COHO SALMON SMOLT MOVEMENT AND ABUNDANCE USING EDNA WATER SAMPLES

Investigators: Dr. Mark Henderson, CACRWRU
Emerson Kanawi, MS student
Duration: March 2018 – December 2019
Funding: Save the Redwoods League ($24,798)

eDNA water sample collection Freshwater Creek, Humboldt County, CA

The management of salmon fisheries in California is highly dependent on life-cycle monitoring and sound estimates of the number of out-migrating smolts. Traditional fisheries monitoring approaches to this issue involve the use of traps and other large infrastructure to measure fish abundance. California Department of Fish and Wildlife (CDFW) and Humboldt State University (HSU) cooperatively monitor smolt abundance and movement timing on Prairie and Freshwater through the use of juvenile traps. This infrastructure provides an opportunity to compare known, daily abundance and biomass measurements of Coho Salmon to environmental DNA (eDNA) concentrations in a field setting. In recent years, eDNA has been investigated as an effective, low-cost technique to monitor rare, elusive, and invasive species. It has been used widely in lotic systems to evaluate the presence or absence of target species. However, few investigations have assessed the possibility of using eDNA concentrations to evaluate the abundance of individuals. Studies addressing these questions have showed promising evidence that monitoring eDNA concentrations over time may provide information on the relative changes in abundance and biomass. To date, no studies have attempted to establish a relationship between the biomass of downstream migrant salmon and eDNA concentrations.
Specific objectives are to:

1. Compare and contrast two methods of enumerating out-migrating Coho Salmon, eDNA concentrations and traditional monitoring approaches (rotary screw trap and modified weir box trap).
2. Analyze and interpret the effects of changes in water quality on eDNA concentrations throughout the out-migration season.

Sampling for this project includes two seasons of out-migration, spring 2018 and spring 2019. Preliminary results for spring 2018 show a high degree of variability in measurements of eDNA

concentration both within sampling events and within sites. No significant correlations were found between eDNA concentration and trap abundance or between water-quality measurements and eDNA concentration. For spring 2019, sampling frequency and sampling protocols will be altered to attempt to more accurately capture eDNA concentrations representative of trap catches.

Final results will be compiled into a project report and submitted to HSU, CACFWRU, and Save the Redwoods League by the end of 2019.

COMPARISON OF STANDARD AND EDNA METHODS FOR ESTIMATING CHINOOK SALMON SMOLT ABUNDANCE IN THE KLAMATH RIVER

Investigators:	Dr. Andrew Kinziger, HSU Fisheries Biology Department
	Dr. Mark Henderson, CACFWRU
	Doyle Coyne, MS student
Duration:	October 2018 – April 2020
Funding:	National Fish & Wildlife Foundation ($95,418)

A critical monitoring parameter for Chinook Salmon on the mainstem Klamath River is determination of smolt (age-0) outmigration timing, weekly abundance, and overall abundance. These data are used for assessing status and trends of Chinook Salmon in the Klamath River and also provide information for disease monitoring and salmon production models. For the purposes of smolt abundance estimation, weekly counts of age-0 Chinook Salmon are determined using a rotary screw traps. The catch data is combined with estimates of trap efficiency from mark-recapture studies to estimate weekly and season abundance using time-stratified approaches. The objective of this study is to compare standard and eDNA-based estimates of weekly and season totals of Chinook Salmon at the Kinsman site, Klamath River. This project will address a foundational question in eDNA analysis: Can eDNA concentrations be used as a proxy for species abundance. If successful, this study may serve as the foundation for replacing traditional species monitoring with rotary screw traps with eDNA approaches elsewhere in the Klamath River basin and other locations similar approaches are applied. Also, if the approaches developed herein are proven effective for monitoring Chinook Salmon, they could be easily expanded for monitoring of other commercially, recreationally, and tribally important species, such as Coho Salmon, steelhead, green sturgeon, and Pacific Lamprey.

PREDICTIVE MODEL DEVELOPMENT OF C. SHASTA IN SUPPORT OF KLAMATH RIVER MANAGEMENT DECISIONS AND THE KLAMATH BASIN STREAM SALMONID SIMULATOR (S3) (RWO 91)

Investigators:	Dr. Mark Henderson, CACFWRU
	Dr. Nicholas Som, USFWS
	Eve Robinson, Research Associate
Duration:	October 2018 – September 2023
Funding:	USFWS ($118,321)

Eve Robinson began work in January 2019, and we will report on her progress on two separate tasks during the 2020 CACFWRU review meeting. The second task relates to this funding, and

includes the development of a model to predict C. Shasta waterborne spore concentrations in the Klamath River to both drive the S3 disease submodel, and independently assess various water management alternatives in the context of disease risk.

APPLYING MOLECULAR TECHNIQUES TO ASSESS THE IMPACTS OF NON-NATIVE PREDATORS ON JUVENILE CHINOOK SALMON MIGRATING THROUGH SACRAMENTO-SAN JOAQUIN DELTA

Investigators:	Dr. Mark Henderson, CACFWRU
	Dr. Andrew Kinziger, HSU Fisheries Biology Department
	Dr. Suresh Sethi, NYCFWRU
	Dr. Wes Larson, WICFWRU
	Dr. Devon Pearse, NOAA SWFSC
	Cyril Michel, University of California – Santa Cruz
	Postdoctoral Researcher
	Three HSU MS students
	UWSP MS student
Duration:	August 2019 – December 2022
Funding:	CDFW ($1,489,432)

Juvenile Chinook Salmon migrating through the Sacramento-San Joaquin Delta (the Delta) have high mortality rates and biologists assume that predation is the proximate cause of this mortality. This project will combine molecular methods with common field sampling methods to assess the impacts of piscivorous fish on juvenile Chinook Salmon migrating through the Sacramento-San Joaquin delta (the Delta). The abundances of potential salmon predators will be assessed using multiple fishery independent methods to gain an understanding of predator distributions throughout the Delta relative to environmental conditions and physical structures. We will also collect stomachs from three of the most abundant salmon predators: Striped Bass, Largemouth Bass, and White Catfish. These stomachs will be examined both visually and with a novel molecular method to quantify the number of juvenile salmon consumed by individual fish. Combining the consumption information with a laboratory study on digestion rates, bioenergetics models, and predator abundance estimates will provide a means to assess the total number of juvenile salmon consumed by the three most abundant salmon predators throughout the Delta.

LARGE WOOD RESTORATION EFFECTIVENESS FOR SALMON IN PUDDING CREEK, CA: A BEFORE-AFTER-CONTROL-IMPACT (BACI) EXPERIMENT

Investigators:	Dr. Mark Henderson, CACFWRU
	Natalie Okun, MS Student
Duration:	August 2018 – December 2020
Funding:	CDFW

It is estimated that over a billion dollars has been spent on watershed restoration since 1991, yet relatively few studies have linked habitat improvements with any effects on fish survival, growth, or abundance. To more efficiently spend the limited amount of restoration funds available, it is essential to examine the response of fish population to different types of

Winter spawning grounds on Caspar Creek, CA.

restoration efforts. For example, adding large woody debris (LWD) to rivers and streams has become the most popular approach; however, studies have rarely provided evidence that the addition of LWD has created lasting effects on availability of rearing habitat or increases in fish abundances, growth, or survival. This project will evaluate the survival and growth of endangered Central California Coast Coho Salmon (*Oncorhynchus kisutch*) and threatened Northern California steelhead (*O. mykiss*) to large wood-treatments on Pudding Creek in Fort Bragg, California. We will use a Before-After Control-Impact (BACI) complete watershed experimental design in Pudding and Caspar creeks, which includes three years of pre-treatment monitoring initiated in 2012 and three years of post-treatment monitoring initiated in 2016. The analysis of the BACI data will comprise Natalie Okun's master's thesis and will aim to provide quantitative evidence that LWD restoration can be an effective measure to increase salmonid populations as it continues to be implemented as a major method for restoring imperiled fish populations. This study is the first of its kind in California and could provide the most intensive and comprehensive restoration effectiveness monitoring in the Pacific Northwest to date.

EFFECTS OF TROUT STOCKING ON BLACK BASS GROWTH AND SIZE STRUCTURE IN CALIFORNIA'S LAKES AND RESERVOIRS

Investigators:	Dr. Mark Henderson, CACFWRU
	MS student
Duration:	August 2019 – December 2021
Funding:	CDFW

There is a long history of stocking both cold- and warm- water fish species into California's lakes and reservoirs for the purpose of improving recreational angling opportunities. Because of these and other stocking efforts, today California's watersheds now contain more non-native fishes than any other state. The black bass populations in California are now self-sustaining, but trout stocking efforts still continue in many parts of the state. Understanding the ecological roles these trout and black bass have in these ecosystems is crucial to the managing the fisheries of these lakes and reservoirs. In this study, we propose to examine black bass consumption of stocked trout in California's lakes and reservoirs.

Our primary research questions for this study are:

1) What black age classes consume stocked trout?
2) What percentage of the black bass diet is stocked trout?

3) Does lake/reservoir elevation affect black bass consumption of stocked trout?

Our primary methods to answer these research questions will be through fish and zooplankton surveys and stable isotope analysis. Due to the rapid digestion rate of many prey items, natural dietary variability can be misinterpreted with traditional gut content analysis. In contrast, stable isotope analyses give a time-integrated estimation of predatory diets, diminishing the need for an increased sample frequency necessary with gut content studies. We will conduct fish and invertebrate surveys in lakes and reservoirs to collect tissue samples from the potential prey items of different sizes classes of black bass. We will then conduct stable isotope analysis on these tissue sample and use mixture models to determine what percentage of the diet came from the different prey items, including stocked trout.

PRAIRIE CREEK COHO SALMON LIFE CYCLE MONITORING

Investigators:	Dr. Mark Henderson, CACFWRU
	MS Student
Duration:	June 2020 – March 2024
Funding:	California Department of Fish and Wildlife/FRGP ($1,019,167)

Coho Salmon within the Prairie Creek sub-basin are recognized by NMFS and CDFW as important for population recovery within the Redwood Creek basin and regionally. Because the watershed is in near-pristine condition, population data for the Coho Salmon residing in the creek can be used as a benchmark for setting freshwater restoration targets for populations in streams with have experienced more extensive disturbance. This project will continue the long-term monitoring of adult and smolt abundances of the Coho Salmon population in Prairie Creek. We will also use this rich long-term dataset to better understand the population dynamics and movement patterns of Coho Salmon in a pristine watershed as part of a master's thesis.

REDWOOD CREEK CHINOOK SALMON LIFE CYCLE MONITORING

Investigators:	Dr. Mark Henderson, CACFWRU
	MS Student
Duration:	June 2020 – March 2024
Funding:	California Department of Fish and Wildlife/FRGP ($1,063,644)

Monitoring of California Coastal Chinook Salmon populations is vital to understand how environmental and biological changes will impact the abundance of these threatened populations. Therefore, to ensure their sustainability, it is necessary to study how the populations respond to restoration efforts, climate change, and drought. To understand how these environmental modifications will impact coastal Chinook Salmon, a sufficient time-series of monitoring data is essential to encompass as much environmental and biological variation as possible. This project will continue a long time series of monitoring data on adult returns and smolt abundances of Chinook Salmon in Redwood Creek. By combining data on adult returns, smolt abundances, and recaptures of marked individuals, we will be able to estimate freshwater and marine survival rates for these fish. This data will be useful for advancing a current life-

cycle model that is currently under development for Redwood Creek Chinook Salmon to aid in understanding how estuarine restoration would impact recovery of the population.

UNIT PROGRAM REVIEW

PROGRAM DIRECTION

Personnel

Coop Staff – Mark has been acting as unit leader since Peggy's retirement in August of 2017. He has been working together closely with Roger Bloom, the new official CDFW liaison with the California Cooperative Unit, to develop a new vision for the Unit to assist with fisheries research needs throughout the state. Mark has also developed a new Fisheries Ecological Modeling course at HSU that he will teach in even years. Mark will teach a River Restoration Ecology course in odd years, starting in 2019.

Leslie continues to contribute to guidance of Unit and CNRS students in addition to providing administrative support to the Unit. Leslie's workload has grown more complex in recent years as we have hired 16 seasonal employees to assist with our salmon monitoring programs in Northern California and as Mark continues to bring on a flock of graduate students. Leslie also supports graduate students in Biology, Wildlife and other Fisheries students with mentorship, appointments, payroll, tuition, travel and other needs.

We are also very happy to report that HSU recently recognized Leslie's hard work, and the complexity of her position, and granted her a well-deserved reclassification of her position. Congratulations, Leslie!

We are happy to welcome Eve Robinson as a new postdoctoral researcher working in collaboration with Nick Som at the US Fish and Wildlife Service. Eve will be working on Klamath Basin modeling as part of the Stream Salmonid Simulator project. Welcome Eve!

Cooperators – The College of Natural Resources and Sciences at Humboldt State University is currently hiring a new dean. Dale Oliver is currently serving as interim Dean of the College. Dale has been a professor of Mathematics at HSU for the past 27 years. At various times during his career he has served as the Associate Dean of the College of Natural Resources and Sciences, as chair for the departments of Mathematics, Computer Science, and Oceanography, and as chair of the HSU School of Education. Dean Oliver 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 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.

Roger Bloom, Environmental Program Manager for Inland Fisheries, is the new official CDFW liaison for 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. CDFW Director Charlton Bonham has signatory authority on the Cooperative Agreement.

Research

The Unit continues to make progress in expanding the geographic coverage of our research program within the state. Chris Loomis is currently completing his master's thesis on estimating predator abundances in the southern portion of the San Francisco Delta. Nissa Kreidler is completing her master's thesis developing species distribution models for deep-sea corals in the Southern California Bight to provide managers of the Channel Islands National Marine Sanctuary with information necessary to better characterize the resources available in the sanctuary. Furthermore, Mark has submitted another proposal to use novel molecular methods to study the impacts of non-native predators on juvenile Chinook Salmon migrating through the Sacramento-San Joaquin delta. Finally, Mark and Roger Bloom have collaboratively developed a project to examine the impacts of trout stocking on black bass populations in inland lakes and reservoirs.

Unit Operations

The Unit has not received annual operating funds since the beginning of 2017. Although the Unit has continued to function, it is becoming difficult to operate efficiently and provide the graduate students with the opportunities important to a high quality education in natural resource management.

FACILITIES AND EQUIPMENT

We appreciate the outstanding facilities provided by HSU.

UNIVERSITY SERVICE AND TEACHING

Courses Taught

Salmon Population Assessment (3 units)	Henderson	Spring 2017
Limnology (3 units)	Wilzbach	Spring 2018
Fisheries Ecological Modeling (3 units)	Henderson	Spring 2018

Graduate Student Major Advisor

Wilzbach

Andrea Dockham – MS Fisheries, Humboldt State University
Peter Drobny – MS Fisheries, Humboldt State University
Jon Hollis – MS Fisheries, Humboldt State University

Henderson

Hannah Coe – MS Fisheries, Humboldt State University
Emily Chen – MS Fisheries, Humboldt State University
John Deibner-Hanson – MS Fisheries, Humboldt State University
Emerson Kanawi – MS Fisheries, Humboldt State University
Nissa Kreidler – MS Fisheries, Humboldt State University
Christopher Loomis – MS Fisheries, Humboldt State University
Natalie Okun – MS Fisheries, Humboldt State University
Nicholas Van Vleet – 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 Madison Halloran – MS Fisheries, Humboldt State University Laura Solinger – MS Fisheries, Humboldt State University Max Grezlik – MS Fisheries, Humboldt State University Max Ramos – MS Fisheries, Humboldt State University
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 Emily Chen – MS Fisheries, Humboldt State University Natalie Okun – 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 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
Henderson	HSU Klamath Connection affiliate North American Journal of Fisheries Management Best Paper Award Committee

THESES OF UNIT-SPONSORED GRADUATE STUDENTS

Hollis, J. 2018. Export of Invertebrate drift from fishless headwater streams. M.S. Thesis, Humboldt State University, Arcata, CA.

STUDENT AWARDS

Chen, Emily:

- Danielle Plum Zumbrun Memorial Scholarship 2018.
- International Women's Fishing Association Scholarship 2018.
- Undergraduate Researcher of the Year, Department of Ecology and Evolutionary Biology, UCLA 2017.

Coe, Hannah:

- Woolford-Hegy Scholarship, spring 2017.
- International Women's Fishing Association Scholarship 2017 and 2018.
- Don Stabile Alumni Post-Graduate Scholarship, 2018.
- Academic scholarship from St. Mary's College of Maryland.

Ghrist, Grace:

- Coast Graduate Research Award 2018.
- Richmond Rod and Gun Scholarship 2018.

Halloran, Madison:

- Roelofs Humboldt Fisheries Fund 2018.
- Fisheries Founding Faculty Scholarship 2018.

Hollis, Jon:

- Granite Bay Flycasters Bill Carnazzo Fellowship, March 2017.

Kreidler, Nissa:

- NOAA Nancy Foster Scholar 2017 – 2019.

PRESENTATIONS

***Graduate student in bold**

Chen, Emily, H. Henderson. Contribution of juvenile estuarine residency to Chinook Salmon recruitment in Redwood Creek, California. Cal-Neva Chapter of the American Fisheries Society 52nd Annual Meeting, San Luis Obispo, CA. Feb 28-March 2, 2018.

Chen, Emily, H. Henderson. Contribution of juvenile estuarine residency to Chinook Salmon recruitment in Redwood Creek, California. Oregon Chapter of the American Fisheries Society 54nd Annual Meeting, Eugene, OR. March 13-16, 2018.

Ghrist, Grace, D. Ward. Does Freshwater Life History Affect Marine Survival Rate of Coho Salmon? 52nd Annual Meeting, Cal_Neva Chapter of the American Fisheries Society, San Luis Obispo, California. March 1, 2018. Tied for 3rd place for poster session in addition to presentation.

Ghrist, Grace, D. Ward. Does Freshwater Life History Affect Marine Survival Rate of Coho Salmon? Salmon Restoration Federation Annual Meeting. Fortuna. 2018. American Fisheries Society Oregon Chapter, Eugene, OR. 2018.

Gottesman, Aaron, T. Bean, D. Ruthrauff, and M. Colwell. 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.

Gottesman, Aaron, T. Bean, D. Ruthrauff, and M. Colwell. Shorebird nest site habitat composition: implications for climate change. Oral presentation, COS26: "Arctic,

Alpine, Antarctic Systems:, Annual Meeting of the Ecological Society of America, Portland, OR. August 2017.

Gottesman, Aaron, T. Bean, D. Ruthrauff, and M. Colwell. Shorebird nest site habitat composition: implications for climate change. Oral presentation, Seventh Meeting of the Western Hemisphere Shorebird Group, Paracas, Peru, November 2017.

Halloran, Madison, Ward, D. Juvenile Coho Salmon Life History Variants in Humboldt Bay Tributaries. 52nd Annual Meeting, Cal_Neva Chapter of the American Fisheries Society, San Luis Obispo, California. March 1, 2018. Tied for 3rd place for poster session.

Halloran, Madison, Ward, D. Juvenile Coho Salmon Life History Variants in Humboldt Bay Tributaries. 36th Annual Salmonid Restoration Conference, Fortuna, CA. April 2018.

Henderson, M., Iglesias, I., Michel, C., Huff, D., Pike, A., Danner, E., and Hayes, S. 2017. Mortality of Central Valley Chinook salmon smolts relative to physical habitat features. 51st Annual meeting, Cal-Neva Chapter of the American Fisheries Society, Eureka, California, April 5-7, 2017.

Henderson, M.J., Huff, D.D., and Yoklavich, M. 2018. Associations between deep-sea coral and sponge assemblages and demersal fishes in the Southern California Bight. 2018 Ocean Sciences Meeting, Portland OR, 11-16 September 2018.

Henderson, M., I. Iglesias, C. Michel, D. Huff, A. Pike, E. Danner, and S. Hayes. Mortality of Central Valley Chinook salmon smolts relative to physical habitat features. 51st Annual Meeting, Cal-Neva Chapter of the American Fisheries Society, Eureka, California. April 5-7, 2017.

Henderson, M.J., I. Iglesias, C. Michel, D. Huff, E. Danner, and S. Hayes. 2018. Processes influencing outmigrating Chinook Salmon survival in the Sacramento River. 148th Annual Meeting, American Fisheries Society, Atlantic City, NJ, 19-23 August 2018.

Kreidler Nissa, A. Buchheister, A., and Henderson, M. Habitat Suitability Mapping for Southern California Bight Deep Sea Corals and Sponges. 15th Deep-Sea Biology symposium. Monterey, CA. September 9-14, 2018.

Loomis, Chris, Henderson, M. Estimating predator fish density and abundance in the Sacramento-San Joaquin Delta using DIDSON Acoustic cameras. 36th Annual Salmonid Restoration Conference. April 13, 2018.

Loomis, Chris, Henderson, M. Estimating predator fish density and abundance in the Sacramento-San Joaquin Delta using DIDSON Acoustic cameras. Bay-Delta Science Conference, Sacramento, CA. September 10-12, 2018.

Michel C., Smith, J., Demetras N., Iglesias I., Lehman B., **Loomis C.**, Henderson M., Huff D. 2018. Spatial patterns and environmental associations of piscivorous predation

throughout the south Sacramento-San Joaquin River Delta in 2017. 10th biennial Bay-Delta Science Conference, Sacramento, CA. September 10-12, 2018.

H. Eve Robinson, J. Rudi Strickler, Mark J. Henderson, Daniel K. Hartline, Petra H. Lenz. Predation strategies of larval fish capturing evasive copepod prey. 2018.

Solinger L., Bjorkstedt E., Buchheister A., Henderson M., and Field J. 2018. Developing spatially-explicit stock assessment models to explore spatial variability in recruitment of Chilipepper Rockfish (Sebastes goodei). 13th National Stock Assessment Workshop. Irvine, CA. May 22-24, 2018.

Van Vleet, Nicholas, Henderson, M. Winter Movement and Survival of Juvenile Coho Salmon in Freshwater Creek, California. 52nd Annual Meeting, Cal_Neva Chapter of the American Fisheries Society, San Luis Obispo, California. March 1, 2018.

Van Vleet, Nicholas, Henderson, M. Winter Movement and Survival of Juvenile Coho Salmon in Freshwater Creek, California. Oregon Chapter of the American Fisheries Society 54nd Annual Meeting, Eugene, OR. March 13-16, 2018.

SCIENTIFIC PUBLICATIONS

Chapin, K.J., **Chen E.K.** 2018. Reproductive strategy of a cave-living arachnid with 2018 indeterminate growth *Phrynus longipes*. Journal of Arachnology 46(2):380-383.

Iglesias I.S., Henderson M.J., Michel C.J., Ammann A.J., and Huff D.D. 2017. Chinook Salmon smolt mortality zones and the influence of environmental factors on out-migration success in the Sacramento River Basin. Final report to USFWS - Agreement Number F15PG00146. 30 pgs. 2017.

Robinson, H.E., Strickler, J.R., Henderson, M.J., Hartline, D.K., Lenz, P.H. Predation strategies of larval fish capturing evasive copepod prey. 2018. Marine Ecology Progress Series.

Wik, M., Johnson, J.E., Crill, P.M., DeStasio, J.P., Erickson, L., **Halloran, M.J.**, Fahnestock, F., Crawford, M.K., Phillips, S.C., Varner, R.K. 2018. Sediment Characteristics and Methane Ebullition in Three Subarctic Lakes. JGR Biogeosciences July 2018. https://doi.org/10.1029/2017JG004298.

UNIT STAFF

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

Leslie Farrar, Unit Administrative Support

GRADUATE STUDENTS

Emily Chen, Fisheries

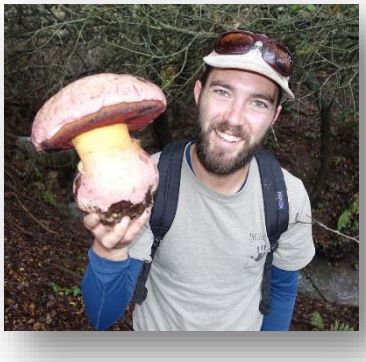
Hannah Coe, Fisheries

John Deibner-Hanson, Fisheries

Jon Hollis, Fisheries

Emerson Kanawi, Fisheries

Nissa Kreidler, Fisheries



Chris Loomis, Fisheries

Natalie Okun, Fisheries

Nick Van Vleet, Fisheries

Graduate Student Assistants

Amon Armstrong, Biology
Doyle Coyne, Fisheries
Grace Ghrist, Fisheries
Aaron Gottesman, Wildlife
Max Grezlik, Fisheries
Madison Halloran, Fisheries
Chad Martel, Fisheries
Michael Sutter, Fisheries

RESEARCH ASSOCIATES AND COOPERATORS

Nick Som, Affiliate Scientist
Eve Robinson, Research Associate
Colin Anderson, Biologist

Student Technicians

Ryan Carey
Rose Dana
John Deiber-Hanson
Ashley Kay
Trevor Kumec
Leah Lehr

Technicians

Ryan Arsenault
Madeline Cooper
Chris Diviney
Nicholas Easterbrook
Reed Hamilton
Nathan Harris
Steven Holt
Rachael Iversron
David Kissling
Trevor Kumec
Jessica Meija
Curtis Newell
Jesse Nolan
Eric Ojerholm
Billie Prosser
Melissa Reneski
Aaron Rotman
Tony Scheiff
Sydney Stewart
Chris Tevini
Jolyon Walkley