CALIFORNIA COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

Annual Report of Activities
to the
Coordinating Committee
June 9, 2009

REVIEW OF PROJECTS COMPLETED IN 2008

REDWOOD CREEK JUVENILE SALMONID ABUNDANCE PROJECTS.

Investigators:	Dr. Walter Duffy, CACFRU
	Michael Sparkman, CDFG
Completed:	April 2008
Upper RC Funding:	California Department of Fish and Game ($48,355)
Lower RC Funding:	California Department of Fish and Game ($54,425)

Upper Redwood Creek Final Report Abstract: Juvenile anadromous salmonid trapping was conducted for the eighth consecutive year in upper Redwood Creek, Humboldt County, California during the spring/summer emigration period (March – August). The purpose of the study is to describe juvenile salmonid out-migration and estimate smolt population abundances for wild 0+ Chinook salmon, 1+ coho salmon, 1+ steelhead trout, and 2+ steelhead trout using mark/recapture methods. The long term goal is to monitor the status and trends of out-migrating juvenile salmonid smolts in upper Redwood Creek in relation to watershed conditions and restoration activities in the basin; and to provide data needed for Viable Salmonid Population (VSP) Analysis. The trap operated 127 day/nights out of 129 possible, and captured 15,823 0+ Chinook salmon, zero 1+ Chinook salmon, 68,573 0+ steelhead trout, 5,036 1+ steelhead trout, 525 2+ steelhead trout, 2 cutthroat trout, zero 0+ pink salmon, and for the first time in eight consecutive years, 6 0+ coho salmon. The total trap catch equaled 89,965 individuals. Catches in YR 2007 were markedly less than the average of the previous seven years, and the greatest reduction (84%) occurred for 0+ Chinook salmon. Average weekly trapping efficiency was 24% for 0+ Chinook salmon, 15% for 1+ steelhead trout, and 15% for 2+ steelhead trout. Trapping efficiency of 0+ Chinook salmon was inversely related to stream discharge and stream gage height. The total 0+ Chinook salmon population estimate with 95% confidence intervals in YR 2007 equaled 68,283 (59,378 - 77,189), and was 2.6 times greater than emigration in YR 2006 and 76% less than emigration for the previous seven year average. The large decrease in YR 2007 most likely reflected a large decrease in the number of adult spawners upstream of the trap site since no streambed mobilization from flood flows occurred after reproduction. The population estimate for 1+ steelhead trout equaled 34,431 (29,697 - 39,165), and was 1.3 times higher than emigration in YR 2006 and 11% less than emigration for the previous seven year average. 2+ steelhead trout population emigration equaled 2,861 (2,196 - 3,525) and was 1.5 times greater than emigration in YR 2006 and 47% less than emigration for the previous seven year average. 0+ Chinook salmon, 1+ steelhead trout, and 2+ steelhead trout showed a negative trend over eight study years, however, significance was only detected with 1+ steelhead trout and 2+ steelhead trout. With respect to successful watershed restoration, we expect: 1) stream

temperatures to decrease in the summer, 2) the size of 0+ Chinook salmon migrants to not be limited by smolt population abundance, 3) a change in the age class structure of steelhead migrants to favor older, larger smolts, and 4) an increase in smolt population abundances.

The final report is available at
www.humboldt.edu/~cuca/documents/reports/UpperRCSalmon2007.pdf

Lower Redwood Creek Final Report Abstract: Juvenile anadromous salmonid trapping was conducted for the fourth consecutive year in lower Redwood Creek, Humboldt County, California during the spring/summer emigration period (April – August). The purpose of the study was to describe juvenile salmonid out-migration and estimate smolt population abundances for wild 0+ Chinook salmon, 0+ coho salmon, 1+ coho salmon, 1+ steelhead trout, 2+ steelhead trout, and cutthroat trout using mark/recapture methods. The long term goal is to monitor the 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 needed for Viable Salmonid Population (VSP) Analysis.

The trap operated 136 out of 137 days/nights possible, and captured 43,233 0+ Chinook salmon, zero 1+ Chinook salmon,42,827 0+ steelhead trout, 6,679 1+ steelhead trout, 1,198 2+ steelhead trout, 44 cutthroat trout, zero 0+ pink salmon, 293 0+ coho salmon, and 34 1+ coho salmon to total 94,308 juvenile salmonids. Trap catches of most juvenile salmonids in YR 2007 were greater than previous study years, due in part to increased trapping efficiencies after moving the trap 75 m downstream to a more favorable location in YRS 2006 and 2007. Average weekly trapping efficiency in YR 2007 was 30% for 0+ Chinook salmon, 14% for 1+ steelhead trout, 10% for 2+ steelhead trout, 34% for cutthroat trout, 23% for 0+ coho salmon, and 10% for 1+ coho salmon. The total 0+ Chinook salmon population estimate with 95% confidence intervals in YR 2007 equaled 141,059 (130,068 – 152,049), and was 45% less than the previous three year average. The observed decrease over years could be due to: 1) high bedload mobilizing flows during egg incubation in spawning redds (YRS 2004 - 2007), 2) large decrease in adult spawners upstream of the trap site, or 3) a combination of the two factors. Population estimates with 95% confidence intervals in YR 2007 equaled 37,683 (33,591 – 41,774) for 1+ steelhead trout; 12,067 (9,416 – 15,798) for 2+ steelhead trout; 1,057 (793 – 1,320) for 0+ coho salmon, 102 (53 – 150) for 1+ coho salmon, and 85 (58 – 113) for age-1 and older cutthroat trout. The population abundance of 0+ Chinook salmon, 1+ steelhead trout, 2+ steelhead trout, and 1+ coho salmon showed a (preliminary) non-significant negative trend over four study years. Monthly peaks in population emigration in YR 2007 occurred in June for 0+ Chinook salmon, 1+ steelhead trout, 2+ steelhead trout and 0+ coho salmon, May for 1+ coho salmon, and July for cutthroat trout. In general, the pattern in population abundances by week for a given species at age closely reflected trap catches by week.

The final report is available at
www.humboldt.edu/~cuca/documents/reports/LowerRCSalmon2007FinalReport.pdf

VALIDATION MONITORING: TESTING PROTOCOLS IN PRAIRIE CREEK.

Investigators: Dr. Walter Duffy, CACFRU
Katrina Wright, MS Student
Katherine McLaughlin, MS Student
Brian Poxon, MS Student
Completed: May 2008
Funding: California Department of Fish and Game ($211,167)

This research assessed protocols for validation monitoring of watershed restoration. Assessment included evaluating the sensitivity of protocols to natural variation. Sampling was conducted in Prairie Creek, tributary to Redwood Creek, Humboldt County and included the following objectives:

1. Estimate the population size of juvenile coho salmon, cutthroat trout and steelhead in upper Prairie Creek was estimated during late summer 2005, 2006, and 2007.
2. Measure the condition of juvenile coho salmon and steelhead captured during juvenile population monitoring each year.
3. Estimate the number of salmon and steelhead migrating from Prairie Creek toward the ocean during 2005, 2006, and 2007.
4. Estimating the number of adult salmon and steelhead returning to Prairie Creek to spawn during 2005, 2006 and 2007.

Juvenile Population Size – The population size of juvenile coho salmon, cutthroat trout and steelhead in upper Prairie Creek was estimated during August 2005, 2006, and 2007. A two step procedure was used, consisting of habitat typing followed by electrofishing of a systematic random sample of each habitat type. Number of juvenile coho salmon estimated to occupy upper Prairie Creek during these years ranged from 3,218-6,046 (Figure 1).

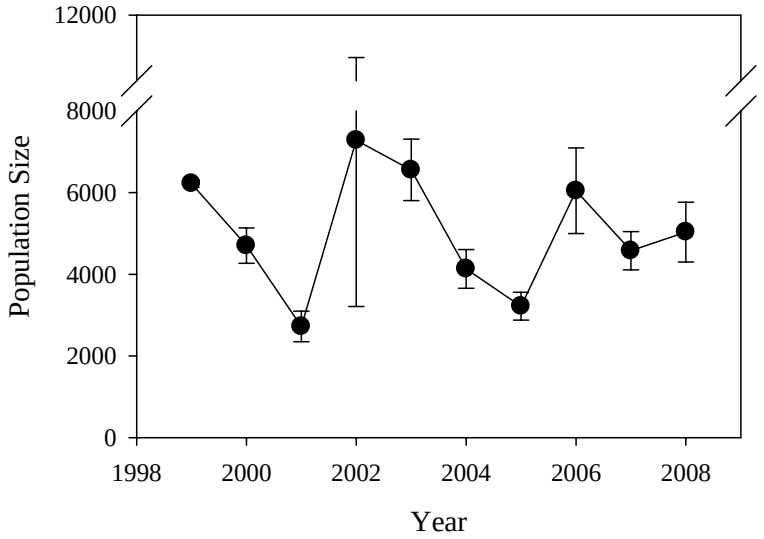


Figure 1. Abundance (+ 95% C.I.) of juvenile coho salmon in Prairie Creek, California, during August 1999-2008.

Juvenile Condition – Graduate student Katherine McLaughlin developed standard weight equations for juvenile steelhead using the regression line percentile and empirical methods. The equation developed using the empirical method better represented juvenile steelhead lengths and weights and was free of length bias. Standard weight was used to estimate average relative weights for juvenile steelhead trout populations in northern California streams. Population averages of relative weight, estimated by the empirical equation, were then modeled against turbidity, temperature, and juvenile steelhead trout density to determine if these variables had meaningful relationships with condition. Average relative weight measured in the fall was positively related to degree day accumulation during late winter and early spring. Turbidity and biomass metrics were not found to be significantly related to juvenile steelhead condition. Further research is needed to determine if relative weight accurately represents the effects of physiological, population and environmental variables on juvenile steelhead condition.

Smolt Production – The number of coho salmon smolts migrating from Prairie Creek during April – June of 2005, 2006, and 2007 ranged from 390 – 1,058 (Figure 2). Number of Chinook salmon smolts migrating during the same period ranged from 598 – 1,567, while number of steelhead smolts migrating ranged from 27 - 216.

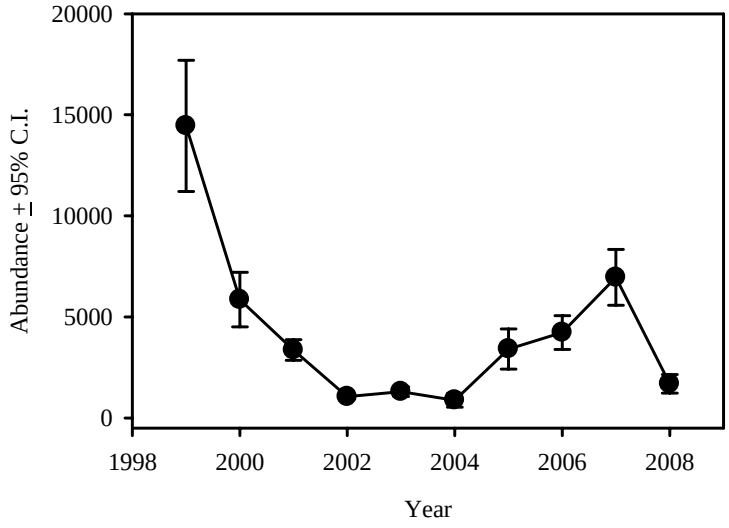


Figure 2. Abundance (+ 95% C.I.) of coho salmon smolts migrating from Prairie Creek, California, during April through June of 1999-2008.

Adult Escapement – Two graduate students, Katrina Wright and Brian Poxon, were involved in estimating escapement of adult Chinook and coho salmon to Prairie Creek, California. They compared traditional stream survey escapement estimation methods with modern mark-recapture using a resistance-board weir as a sampling platform to tag fish. Methods for estimating escapement included area-under-the-curve (AUC), redd count expansion, Chapman-Petersen live mark-carcass recapture, and Jolly-Seber carcass mark-recapture. The AUC method appeared to provide the most reliable data. Chinook salmon AUC escapement estimates for the three year period ranged from 20 to 51 (Figure 3). Coho salmon AUC escapement estimates were higher, ranging from 110 to 321 during the same period. To improve accuracy of the AUC method, residence time on spawning grounds was estimated at 12 and 17 days for Chinook and coho salmon, respectively.

Trends in species, sex, and size of fish captured at the weir were analyzed over time. Sex and body size were found to be significant in relation to entry-timing, but not for both species or over both years. Upstream movement appears to be positively correlated with increases in stream discharge.

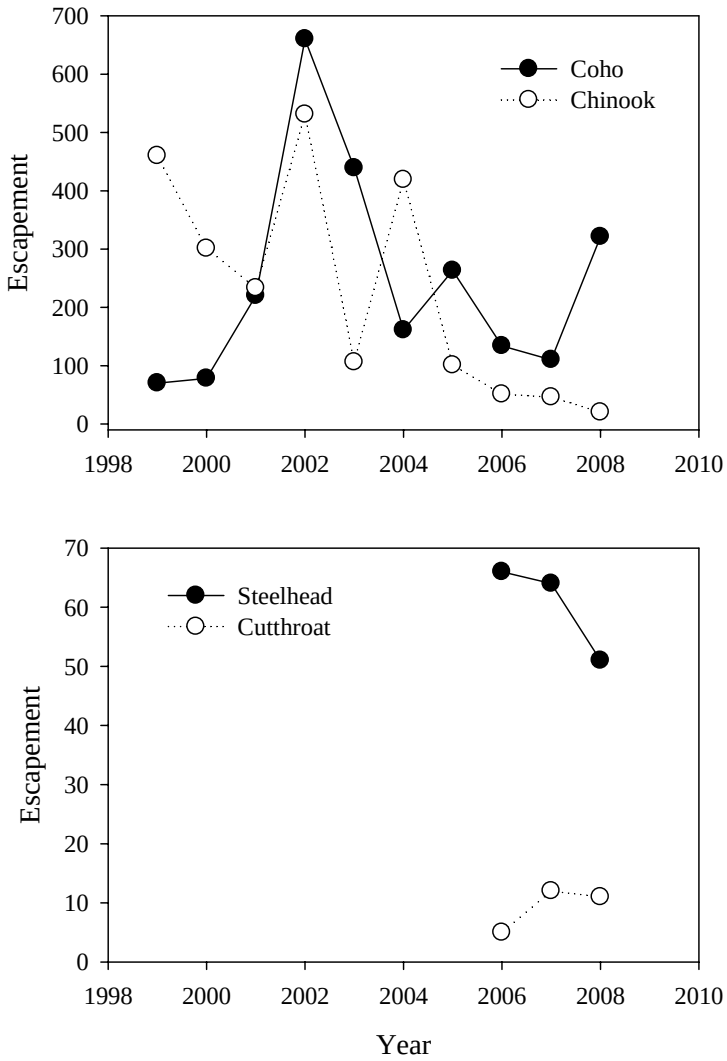


Figure 3. Estimated escapement of adult coho salmon, Chinook salmon, steelhead and cutthroat trout to Prairie Creek, California, during November - April of 1999-2008.

The final project report is available at
http://www.humboldt.edu/~cuca/documents/reports/Validation-FinalReport.pdf

McLaughlin, K. D. 2009. Development of a standard weight equation for juvenile steelhead trout and effects of temperature, turbidity, and steelhead trout biomass on relative weight. M. S. Thesis, Humboldt State Univ., Arcata, CA. 63 pp.

The student thesis is available at
http://www.humboldt.edu/~cuca/documents/theses/mclaughlinthesis.pdf

PRAIRIE CREEK SALMONID POPULATION MONITORING AUGMENTATION.

Investigators: Dr. Walter Duffy, CACFRU
Completed: April 2008
Funding: Pacific States Marine Fisheries Commission ($14,886)

An augmentation of funding for the Validation Monitoring: Testing Protocols in Prairie Creek project was provided to install a resistance board weir in early November and operate it through mid-April. The species, gender, and size (FL) of all fish intercepted at the weir were recorded and 23 mm PIT tags were applied to all adult salmonids. Remote antennae were installed and a back pack antenna was also used to determine the distribution and selection of spawning habitat by adult salmonids. An underwater video system was operated in the weir box to determine the efficiency of this technology in estimating escapement in California streams.

MANAYUNKIA SPECIOSA: LIFE HISTORY, REARING, AND ASSOCIATED DEVELOPMENT OF *CERATOMYXA SHASTA*.

Investigators: Dr. Gary Hendrickson, HSU Fisheries Biology
Dr. Kenneth Cummins, HSU Fisheries Biology
Dr. Peggy Wilzbach, CACFRU
Marlene Meaders, MS Student
Completed: June 2008
Funding: US Fish and Wildlife Service ($55,000)

Final Report Abstract: *Ceratomyxa shasta* is a serious pathogen of anadromous salmonids in the Klamath River Basin. It has a complicated life history using salmonids as the vertebrate host and the freshwater polychaete *Manayunkia speciosa* as the invertebrate (definitive) host. The objectives of this study were to: (1) rear *Manayunkia speciosa* in the laboratory so that its life history could be described, (2) examine uninfected and infected polychaetes histologically so that histopathology of infection could be described, and (3) describe the sequential development of *C. shasta* in the polychaete. This final report is broken into three parts which correspond both to these objectives and to three papers submitted or to be submitted to peer-reviewed journals. Part 1 includes rearing and life history of the polychaete. Part 2 includes internal anatomy and histology of the polychaete. Part 3 includes sequential development of *C. shasta* in *M. speciosa* with notes on the histopathology. The final report is available at http://www.humboldt.edu/~cuca/documents/reports/FinalReport-FWSAgreement.pdf

Meaders, M. D. 2008. Histological observations on the development of *Ceratomyxa shasta actinosporeans* in the polychaete host, *Manayunkia speciosa*. M. S. Thesis, Humboldt State Univ., Arcata, CA. 79 pp.

The student thesis is available at
http://dscholar.humboldt.edu:8080/dspace/handle/2148/435

GROWTH AND MOVEMENT OF RESIDENT RAINBOW TROUT TRANSPLANTED BELOW BARRIERS TO ANADROMY.

Investigators:	Dr. Peggy Wilzbach, CACFRU
	Mark Ashenfelter, MS Student
Completed:	June 2008
Funding:	California Department of Fish and Game ($64,088)

Project Summary: Research was conducted to determine if resident rainbow trout (*O. mykiss*) isolated above an upstream barrier to anadromous migration would exhibit migratory behavior when relocated to a stream reach below the barrier. Age 1+ trout above a 5 m high waterfall in Freshwater Creek, California were captured during 2005 - 2006 and individually marked with passive integrated transponder tags. Analysis of otolith microchemistry indicated that above-barrier trout had resident rather than anadromous parents, and genetic analysis indicated that the trout showed some degree of introgression with cutthroat trout. At each of three sampling events, half of the tagged individuals (n = 22 and 43 trout in 2005 and 2006, respectively) were released below the waterfall, approximately 10 km from tidewater, and an equal number of tagged individuals were released above the barrier. Tagged individuals in above- and below-barrier reaches were subsequently relocated and/or recaptured to track their movement. Most transplanted individuals displayed little movement or moved in an upstream direction only, while four individuals were last detected in the tidally influenced lower river. Five tagged, above-barrier individuals were found in below-barrier reaches, presumably washing over the falls. Of seven tagged trout captured in downstream migrant traps, two had smolted and one was a pre-smolt. The smoltification of at least some transplanted individuals, coupled with above-barrier 'leakage' of fish downstream, demonstrates the potential for resident trout to exhibit migratory behavior and to enter breeding populations of steelhead. The final report is available at www.humboldt.edu/~cuca/documents/reports/TransTroutFinalReport.pdf

EFFECTS OF CONSERVATION PROGRAMS ON AMPHIBIAN COMMUNITIES IN SEASONAL WETLANDS OF THE PRAIRIE POTHOLE REGION'S GLACIATED PLAINS. (RWO 78)

Investigators:	Dr. T. Luke George, HSU Wildlife
	Dr. Walter Duffy, CACFRU
	Caleb Balas, MS Student
Completed:	June 2008
Funding:	USGS, Northern Prairie Wildlife Research Center ($102,666)

Balas, C. J. Thesis Abstract: Recently, the United States Department of Agriculture's Natural Resource Conservation Service and Farm Service Agency have been required by the Office of Management and Budget to quantify the effects of the conservation programs they administer. For example, they are currently examining the influence of the Conservation Reserve Program and the Wetlands Reserve Program on various ecological services including biodiversity, carbon sequestration, sediment reduction, and water quality improvement. In response to these reporting requirements and the conservation community's concern for amphibian declines in the Great Plains of North America, I conducted this study to assess the effect of land-use change on amphibian species richness and occupancy of seasonal wetlands in the Prairie Pothole Region's

Glaciated Plain. In the summers of 2005 and 2006, I used three survey techniques (automated call surveys, trapping with aquatic funnel traps, and visual encounter surveys) to detect eight amphibian species at 40 seasonal wetlands. I partitioned my study by land-use (farmed, restored, and natural) and spatially distributed my three study sites to capture natural ecological gradients of the Glaciated Plains. I found amphibian species richness to vary by study site location and wetland land-use. Similarly, I found that probability of occupancy of amphibian species varied by study site location and (or) wetland land-use. In general, I found that farmed wetlands negatively impacted amphibians in seasonal wetlands. More specifically, farmed wetlands that had been tile drained were of less value to amphibians than farmed wetlands drained with open ditches. My study indicates that restored and natural seasonal wetlands provide comparable habitat for most amphibian species inhabiting seasonal wetlands. My results suggest that the restoration efforts of federally funded conservation programs have largely been successful in providing suitable habitat for most amphibian species utilizing seasonal wetlands. Hence, the Conservation Reserve Program and the Wetlands Reserve Program are important in the conservation of amphibians in the Prairie Pothole Region's Glaciated Plain.

Balas, C. J. 2008. The effects of conservation programs on amphibians of the Prairie Pothole Region's glaciated plain. M. S. Thesis, Humboldt State Univ., Arcata, CA. 153 pp.

The student thesis is available at
http://www.humboldt.edu/~cuca/documents/theses/balasthesis.pdf

EVALUATION AND MONITORING OF BURROW-NESTING SEABIRDS AT CASTLE ROCK NATIONAL WILDLIFE REFUGE. (RWO 74)

Investigators:	Dr. Richard T. Golightly, HSU Wildlife Richard Young, MS Student
Completed:	July 2008
Funding:	USGS – SSP Appropriated Funds ($46,875)

This study was to investigate seabird use of Castle Rock located in the Pacific Ocean offshore of Del Norte County, California. Recently, the populations of Aleutian Canada Geese and Double-crested Cormorants have increased dramatically. It is suspected that the geese and cormorants are having detrimental effects on the six species of crevice/burrow nesting seabirds known to nest on Castle Rock. The status of these seabirds has never been well understood due to the presence of many surface nesting birds, frail soils, the difficulty in monitoring the concealed nest sites, and the logistical challenges of working on an island.

Study objectives:

1. Estimate the current nesting population and examine productivity of burrow-nesting seabirds on Castle Rock;
2. Assess techniques for long-term monitoring of soil depth, vegetation, and burrows;
3. Examine possible impacts of Aleutian Canada Geese and Double-crested Cormorants on seabird burrows;
4. Provide recommendations for monitoring burrowing seabirds on Castle Rock.

We evaluated the seabird use of Castle Rock, located in Del Norte County, California using a non-invasive mechanism to establish long and short term monitoring of the seabirds on Castle Rock. The non-invasive mechanism we identified and successfully installed was a remotely operated video camera system that allows researchers to observe seabirds on Castle Rock without disturbance. We also established a long-term, forward looking monitoring program for seabirds on Castle Rock and have made information about seabirds and their specific activities on Castle Rock available to the public. The final report is available at www.humboldt.edu/~cuca/documents/reports/2009CastleRockFinalReport.pdf. The report references several presentations associated with the project.

To view live video of seabirds on Castle Rock, please visit this web page.
http://www.humboldt.edu/~rtg1/research/castle_rock.html

RESPONSE OF STEELHEAD POPULATIONS TO FIRE DISTURBANCE IN THE KINGS RANGE NATIONAL CONSERVATION AREA. (RWO 75 AND NOAA AGREEMENTS)

Investigators:	Dr. Walter Duffy, CACFRU
	Philip Colombano, MS Student
Completed:	December 2008
Funding:	US Bureau of Land Management ($30,189)
	NOAA Fisheries ($31,624)
	NOAA Fisheries ($8,376)

The original RWO was established with BLM. Funding was enhanced through two agreements with NOAA Fisheries. This research assessed steelhead populations, other aquatic biota, aquatic habitat, and water quality in streams along the west slope of the King Range following a wildfire in 2003. Data collected included estimates of steelhead population size, steelhead growth, aquatic invertebrate composition, large woody debris distribution and volume, habitat type and distribution and water quality. The experimental design included three streams. One treatment stream from near the fire origin (Big Flat Creek), one near the fires perimeter (Kinsey Creek) and one outside the burned area that served as a control (Spanish Creek).

Objectives were to determine:

1. If fire affected steelhead population size and growth.
2. If fire affected large woody debris recruitment to these streams.
3. If fire altered stream habitat volume.
4. If fire altered the water quality and aquatic invertebrate composition in these streams.

Habitats and large wood were surveyed in July 2003, 2004, 2005 and 2006. Fish sampling was completed in September and October of the same years.

Preliminary analyses suggest that fire had little effect on steelhead population size or density (Table 1, Figure 4). Composition of habitat did, however, appear to respond to fire as did recruitment of LWD (Table 2, Figure 5).

Table 1. Estimated size of juvenile steelhead populations in three streams in the Kings Range Wilderness Area, California.

Year	Spanish Cr. (Control)	Kinsey Cr. (Burned)	Big Flat Cr. (Burned Hot)
2004	3223	1099	3436
2005	1349	473	6109
2006	2646	1932	12157

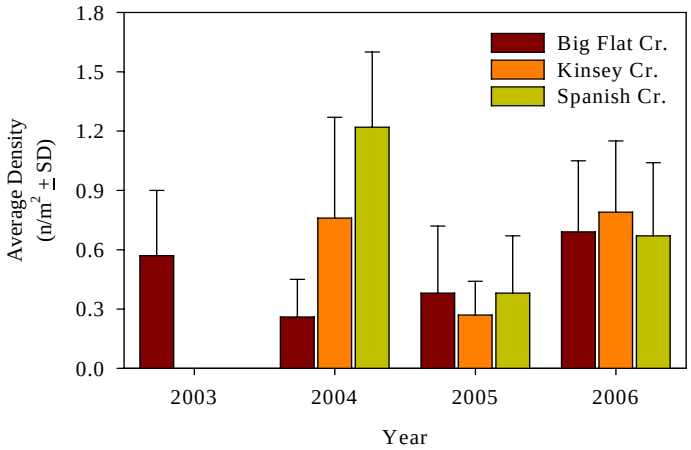


Figure 4. Average density of steelhead in three streams within the King Range Wilderness Area, Humboldt County, California.

Table 1. Proportion of four habitats in three streams within the King Range Wilderness Area, Humboldt County, California. Habitat types are C = cascade, N = run, P = pool and R = riffle.

	Big Flat Cr.				Kinsey Cr.				Spanish Cr.			
Year	C	N	P	R	C	N	P	R	C	N	P	R
2003	29.6	28.8	12.2	29.4								
2004	20.3	9.6	8.0	62.0	18.4	20.3	13.8	47.5	10.1	8.0	3.0	79.0
2005	16.4	11.0	6.9	65.8	24.1	24.4	7.0	44.6	16.9	13.4	1.2	68.6
2006	15.5	10.9	13.7	59.8	5.6	20.4	11.9	62.1	5.5	12.0	1.7	80.8

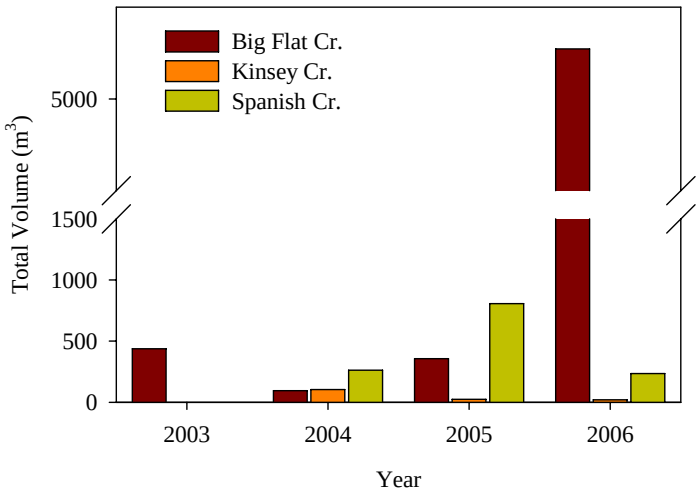


Figure 5. Volume of large woody debris (LWD) in three streams within the King Range Wilderness Area, Humboldt County, California.

DEVELOPMENT OF A RESEARCH PLAN FOR QUANTIFYING THE ABUNDANCE OF THE INVERTEBRATE HOST OF SALMONID PARASITES IN THE LOWER KLAMATH RIVER. (RWO 77)

Investigators:	Dr. Peggy Wilzbach, CACFRU
	Dr. Kenneth Cummins, HSU Fisheries Biology
	Sarah Willson, Technician
	David Malakauskas, Technician
Completed:	December 2008
Funding:	US Fish and Wildlife Service ($91,916)

Objectives of this project were to develop a research plan for quantifying the abundance and distribution of the freshwater polychaete *Manayunkia speciosa*, which is the intermediate host of myxosporean parasites that are infecting juvenile salmon in the lower Klamath River. We presented a draft report to the USFWS describing our recommendations for a polychaete monitoring program that was founded upon preliminary field sampling of its occurrence and habitat associations, as well as upon information obtained from culture of the animal in the laboratory. Field sampling occurred at varying dates from fall 2005 through fall 2006, with additional live samples collected for laboratory studies through summer 2007. We found that polychaete exhibits a patchy distribution within the river; that prevalence and density were higher below Iron Gate Dam than in the lower river; and suggested that high polychaete densities below Iron Gate Dam likely reflect high quality planktonic food resources from the reservoir as these are released over the dam. Fine sediments at the base of beds of vascular plants and mats of filamentous algae represented the primary habitat of the polychaete. We developed the ability to culture the polychaete within the lab, and described culture conditions and information about life cycle details of the polychaete through laboratory rearing in a manuscript that is presently undergoing review. The final report is available at http://www.humboldt.edu/~cuca/documents/reports/RWO77FinalReport.pdf

REVIEW OF CURRENT RESEARCH PROJECTS

ASSESSING THE EFFECTS OF USDA CONSERVATION PRACTICES ON WETLAND ECOSYSTEM SERVICES IN CALIFORNIA'S CENTRAL VALLEY. (RWO 80)

Investigators:	Dr. Walter Duffy, CACFRU Dr. Sharon Kahara, HSU, Wildlife Rosemary Records, HSU-SPF Kimberly McFarland, MS Student Luke Groff, MS Student
Duration:	September 2006 to June 2010
Funding:	USDA, Natural Resources Conservation Service ($597,332)

California's Central Valley (CCV) encompasses an area of 55,100 km2, extending a distance of almost 7,000 km from Red Bluff in the north to around Bakersfield in the south. The CCV was historically an ecosystem consisting of grassland, prairie, and oak-grass savanna habitats. Interspersed within these primary habitats were riparian woodland, freshwater marsh, and vernal pool wetlands. These wetlands were integral in supporting the diverse flora and fauna of the historic CCV.

Most, if not all, these habitats in the CCV have been altered by human activity. Area of wetland habitats in the CCV prior to 1900 has been estimated to be 1.6-2.0 million ha. In the 1980's, wetland area in the CCV had been reduced to 153,000 ha. Human activities leading to wetland loss in the CCV are many and varied, but agricultural development and urbanization are chief among them.

The U. S. Department of Agriculture, Natural Resource Conservation Service (NRCS) administers a variety of programs intended to assist farmers and ranchers in addressing natural resource concerns on private lands. Among these programs is the Wetland Reserve Program (WRP), created as part of the 1990 Farm Bill. The WRP program focuses on restoring degraded wetlands or those that have been converted to agricultural production. In California, NRCS has focused their WRP activities on restoring a variety of wetlands, including seasonal wetlands, semi-permanent marshes, vernal pools, riparian and tidally-influenced wetlands.

This research project will assess the effects of conservation practices on wetland ecosystem services in the CCV. This CEAP-Wetlands assessment will produce estimates of wetland ecosystem services, quantify the effects of agriculture on wetlands, with and without implementation of USDA conservation practices, and develop predictive wetland functional condition indicator models.

Objectives of the research are to:

1. Organize and conduct a regional workshop for the purpose of identifying ecosystem functions and services most important in CCV wetlands.
2. Evaluate ecosystem services provided by USDA-NRCS restoration of palustrine emergent wetlands in the CCV.
3. Evaluate ecosystem services provided by USDA-NRCS restoration of different types of wetlands.

Progress:
In 2007, we completed objective #1 and selected Dr. Sharon Kahara as a post-doctoral scientist to lead the project. Dr. Kahara arrived in August and quickly became involved in all aspects of the project.

In 2008, we initiated field sampling of biological diversity, flood storage capacity and carbon, nitrogen and phosphorus storage in wetlands. We completed field data collection on 45 randomly selected wetlands in the Central Valley and six wetlands in the upper Klamath Basin. Most of these were Wetland Reserve Program wetlands, but a limited number were on National Wildlife Refuge lands. Field data collected included:

1. Biological diversity, occurrence and abundance of the following:
    a. Amphibians
    b. Shorebirds
    c. Native bees
    d. Plants
2. Carbon, nitrogen and phosphorus storage
    a. In soils
    b. In plants
3. Flood storage capacity

In 2009, an additional 44 wetlands were randomly selected for sampling and are being visited to gather field data for these three ecosystem services. In addition, we began investigating use of Wetland Reserve Program riparian wetlands by shortnose suckers in the Upper Klamath River.

CONSERVATION GENETICS OF THE FEDERALLY ENDANGERED TIDEWATER GOBY (*EUCYCLOBIUS NEWBERRYI*) IN NORTHERN CALIFORNIA. (RWO 79)

Investigators:	Dr. Andrew Kinziger, HSU, Fisheries Biology
	William T. McCraney, MS Student
Duration:	September 2006 to December 2010
Funding:	US Fish & Wildlife Service ($126,299)

The tidewater goby (Eucyclogobius newberryi) is a federally endangered fish species that inhabits brackish/freshwater lagoons and estuaries in California. Tidewater goby habitats are geographic isolated from one another by long stretches of unsuitable habitat and/or physical barriers such as sand bars. An understanding of how the fragmented distribution of tidewater goby influences population

structure is critical for proper management. The objective of this project is to use microsatellite data to evaluate migration rates, genetic structure and levels of genetic diversity among northern California populations of tidewater goby.

McCraney Thesis Abstract: The objective of this study was to determine whether a species that is adapted for living in naturally fragmented habitats can maintain genetic variation in an artificially fragmented context. Here, I evaluate the population structure and genetic diversity of the endangered tidewater goby (Eucyclogobius newberryi), a small fish that is restricted to discrete coastal lagoons and estuaries in California, USA. I use five naturally fragmented coastal populations from a 300 km spatial scale as a standard to assess migration and drift in eight artificially fragmented bay populations from a 30 km spatial scale. Using nine microsatellite loci in 621 individuals, and a 522 base fragment of mitochondrial DNA control region from 103 individuals, I found striking differences in the relative influences of migration and drift on the genetic variation at these two scales. Overall, the artificially fragmented bay populations exhibited a consistent pattern of higher genetic differentiation combined with significantly lower genetic diversity relative to the naturally fragmented coast populations. Consistent with a recent history of drift in extreme isolation, I found no mitochondrial DNA sequence variation, no relationship between genetic differentiation and geographic distance, widespread fixation of polymorphic microsatellite loci, and a strong correlation between habitat area and allelic richness in the artificially fragmented bay populations. In contrast, the naturally fragmented coast populations exhibited considerable mitochondrial DNA variation, a strong pattern of genetic isolation-by-distance, substantial microsatellite diversity, and no relationship between habitat area and allelic richness, consistent with demographic stability and periodic migration between neighboring populations. I conclude that artificial fragmentation has restricted gene flow and caused rampant genetic drift in the bay populations, and that this species' suitability to living in naturally fragmented environments is not sufficient to prevent genetic degradation in an artificially fragmented situation.

McCraney, W. T. 2009. Rampant drift in the endangered tidewater goby (*Eucyclogobius newberryi*): comparing genetic variation of naturally and artificially fragmented populations. M. S. Thesis, Humboldt State Univ., Arcata, CA. 79 pp.

The student thesis is available at
http://dscholar.humboldt.edu:8080/dspace/handle/2148/486

POPULATION STRUCTURE OF STEELHEAD IN THE KLAMATH RIVER BASIN, AND CONSEQUENCES OF THE HALF-POUNDER LIFE HISTORY.

Investigators:	Dr. Walter Duffy, CACFWRU
	Dr. Peggy Wilzbach, CACFWRU
	Brian Hodge, MS Student
Duration:	June 2007 to August 2009
Funding:	California Department of Fish and Game/AFRAMP ($52,972)

The Klamath River is the most productive steelhead fishery in the state of California, and one of only several rivers in the world in which steelhead exhibit the unique half-pounder life history. Half-pounders return to overwinter in freshwater less than a year after initial ocean entry, despite that fact that few fish have attained sexual maturity. Although existence of the half-pounder life history is well documented, no consensus exists as to what ecological conditions promote this life history, nor does a consensus exist as to what selective pressures favor the continued expression of this life history.

The primary objectives of this study are i) to determine the population structure of steelhead in the Klamath River Basin with respect to age, growth, size, fecundity, incidence of repeat spawning, and incidence of the half-pounder life history; and ii) to estimate fitness consequences of the half-pounder migration by comparing the relative size of fish that do and do not make the migration, while also considering the effect of size on fecundity in females.

Between fall 2007 and spring 2009, scales were collected from approximately 600 wild steelhead. Fish were captured with hook and line, and at flat-panel resistance weirs operated by the California Department of Fish and Game. Otoliths were extracted from 55 half-pounders and 10 adults. Preliminary results from scale pattern analysis and otolith strontium isotope analysis indicate that wild Klamath River steelhead exhibit a multitude of life histories. First, both anadromous and resident forms of O. mykiss occur in the Klamath River. Second, Klamath steelhead may spend up to four years in freshwater before initial ocean entry. Last, most steelhead from the middle and upper Klamath Basin exhibit the half-pounder trait, while most Trinity fish remain in the ocean for a year or more. In May-June 2009, scale-otolith pairs will be analyzed to create a reference set for scale pattern recognition.

Examination of 100 half-pounders indicated that the sex ratio is nearly 1:1, and also indicated that a small percentage of both male and female half-pounders are sexually mature. Fecundity data collected from 115 hatchery females and 10 wild females confirmed that size is positively correlated with egg production in Klamath Basin steelhead. The numerical length-fecundity relationship and length at age data will be used to estimate potential costs or benefits of an amphidromous migration into the Klamath.

SAMPLE, IDENTIFY, AND ENUMERATE MACROINVERTEBRATES OF CASPAR CREEK WATERSHED.

Investigators:	Dr. Kenneth Cummins, HSU, Fisheries Biology
	David Malakauskas, student technician
Duration:	September 2007 to September 2009
Funding:	USDA Forest Service ($40,000)

The objective of the study is to compare the present day macroinvertebrate fauna of the Caspar Creek watershed with an earlier inventory, and to provide baseline data for future assessments of the watershed under new harvest operations. Benthic macroinvertebrates were surveyed in the spring and fall of 2008. Semi-quantitative (30 second timed) samples were taken in three habitats (cobble riffles, fine sediment pools, and litter accumulations) using a D-frame 250 µm mesh dip net. Three samples were taken from each habitat type at each site. Two sites on the North Fork, two on the South Fork, and two on the mainstem of Caspar Creek were sampled. Functional feeding group (FFG) analysis was performed on each live sample in the field, and the material was then preserved in 70% ETOH for return to the lab for microscope sorting and further identification of the invertebrates.

The functional feeding group approach, developed by Cummins (1973) over 30 years ago, is based on categorization of macroinvertebrates based on their morphological and behavioral mechanisms by which they acquire one or more of six general food types. Availability of these food types, such as litter from the riparian zone or in-stream algae that is regulated by riparian shading and nutrient levels, are reflected in the relative abundances of the functional groups that utilize them. In this way, the invertebrate functional groups integrate watershed conditions through the availability of their food supply. The level of taxonomy performed in the field is that sufficient to designate to which functional group an invertebrate belongs. Because the numerical field data characterized by the relative abundances of functional groups are expressed as dimensionless ratios, they are independent of sample size over a fair range. The sample size collected in 30 seconds is normally sufficient to obtain a total count of 100 individuals or more. The field counts are not accurate for individuals less than one mm in size, but that size category is enumerated when the samples are analyzed in the lab. Ecological tables in Merritt et al. (2008) provide tables of the functional feeding group categorization of essentially every genus of North American aquatic insect. A great deal of information about the status of stream systems can be obtained in the field using the FFG approach, but it does not foreclose the ability to analyze the samples in the lab. The advantage is that the survey crew leaves the field with the data as well as with preserved samples that can be analyzed in taxonomic detail in the lab, if (and this is almost always the problem) funds are available for the very time-consuming process of microscope analysis.

In the laboratory, further identification and measurements of sizes of individuals in the samples can be made and converted to biomass using length-mass regressions. With the more refined taxonomy and inclusion of individuals smaller than 1 mm obtained in the laboratory, any of the commonly used indices of stream condition (e.g. % Ephemeroptera, Plecoptera, and Trichoptera in a sample) can be calculated.

A taxonomic list of the invertebrates of Caspar Creek has been produced based on the fall samples, all of which have been analyzed. To date, 107 taxa have been identified. This

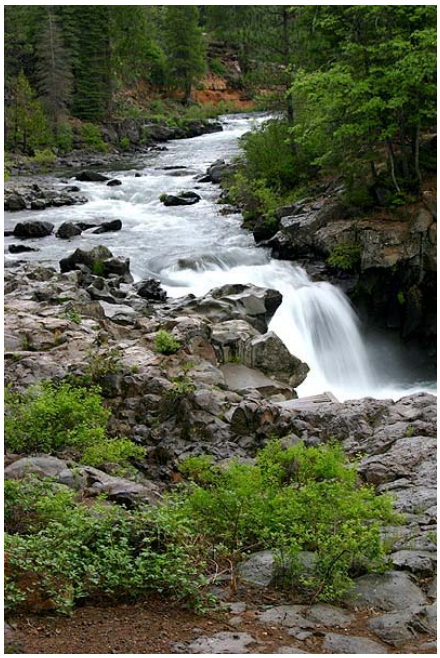
includes 92 to the generic level, 6 to the family level, 2 to the subfamily level (Chironomidae), and 7 to the level of order or higher. The Ephemeroptera, Plecoptera, Trichoptera, used to calculate the EPT Index as measure of stream health are very well represented in the invertebrate taxa of Caspar Creek: Ephemeroptera with 18 genera in 6 families, Plecoptera with 13 genera in 7 families, and Trichoptera with 18 genera in 12 families. Given the near canopy closure of the North and South Forks and the mainstem of Caspar Creek, it is not surprising that the fall invertebrate community was dominated by shredders – that is, taxa that feed on riparian leaf litter once it is conditioned in the stream

Once the spring samples have been analyzed, seasonal functional group ratios will be calculated and used as surrogates for ecosystem attributes of the Caspar Creek system (Merritt et al. 2009). In addition, standard taxonomically based indices of diversity, richness, and EPT will also be calculated. . Based on the analyses to date, Caspar Creek appears to be a healthy, diverse stream ecosystem.

THE ROLE OF BARRIERS IN THE CONSERVATION OF MCCLOUD REDBAND TROUT.

Investigators:	Dr. Peggy Wilzbach, CACFRU Roman Pittman, MS Student
Duration:	September 2007 to September 2010
Funding:	USDI Fish & Wildlife Service ($80,000)

In 1994, the U.S. Fish and Wildlife Service determined that potential threats to the McCloud River redband trout (*Oncorhynchus mykiss* spp.) and its habitat were sufficient to warrant classification as a Candidate species under the federal Endangered Species Act of 1973, as amended. This status reflected concern over threats imposed by land use activities and introductions of exotic salmonids, as well as threats to its genetic integrity from genetic introgression with stocking of hatchery strains of rainbow trout. In 1998, a multiple-signatory conservation agreement was established to ensure that steps are taken to reduce or remove threats that could cause it to be listed as threatened or endangered. Due to commitments made to protect and conserve McCloud River redband trout (MRT) through this agreement, candidate status was discontinued in 2000. Among potential strategies to achieve conservation goals is isolation management, employing the use of natural or artificial barriers to protect upstream populations from direct contact with hatchery or exotic salmonids. This approach has been adopted for other threatened species or populations, and may be particularly appropriate in river ecosystems where movement corridors are well-defined and animal passage easier to control. The success of this approach hinges on providing sufficient resources in the isolated reach to meet all life history requirements, as well as on maintenance of a sufficiently large population to promote long-term persistence. To assist in conservation efforts, this



proposal seeks to explore the feasibility of adopting an isolation management strategy for redband trout by identifying potential stream barriers and evaluating MRT population parameters in two tributaries of the upper McCloud River to determine the capacity of these streams to sustain deliberately isolated stocks. Specific objectives are: 1) to identify existing and potential barriers in Tate and Trout creeks and to establish the range of flows within which these barriers are operational; and 2) Describe and compare population structure of MRT in isolated and connected reaches of 2 creeks (Tate and Trout), and 3) Estimate minimum stream length for population viability of MRT based on density and survivorship estimates.

Selected Methods and Preliminary Results:

Age and Growth

Fish were sampled according to Hankin-Mohr (2005) methodology in Tate and Trout Creeks. Species captured in Trout Creek were limited exclusively to MRT. Tate Creek samples included 25 MRT and 7 brook trout (*Salvelinus fontinalis*). Scales were removed from each fish and utilized in growth and age analysis. Of 32 Tate Creek scale samples, nine were dropped from analysis due to poor quality (eg. excessive regeneration or physical damage) or undesired species (brook trout). Of 27 Trout Creek scale samples, eight were not considered for analysis due to excessive regeneration or physical damage. Brook trout were not observed in Trout Creek. Maximum age observed in both streams was two years of age which prevented complete growth analysis (construction of Walford plots predicting ultimate length at age was not possible with only two age classes and one growth interval). Confidence intervals for back calculated lengths at age were quite large on both streams (~ 100 mm).

Salmonid populations at high elevation often exhibit slow growth and this phenomenon may have resulted in underestimation of age. Accurate back calculation of age depends on identification of periodic features on calcified structures that may vary greatly depending on individual fish or environmental conditions. Late spawning and a short growth period at high elevation may inhibit development of first year annuli. Tightly spaced outer annuli in older fish may also be obscured by scale erosion (Kruse et al. 1997). These factors may be in effect on tributaries to the Upper McCloud River as young of the year (~25-35 mm FL) were not observed until early September and scales on older fish were largely unreadable some distance from the scale margin. Annuli formation is predicated on growth response to significant changes in temperature which may not occur in systems in extreme northern latitudes, high elevation, or the tropics. The paucity of total circuli produced by fish in slow-growing populations also presumably reduces the visible width of annuli formation. Slow growth may be one of the ancestral traits that served MRT well during the ice age but render them difficult to age today. These biological factors likely combine to obscure annuli and reduce age estimates.
Studies in high elevation systems have had similar difficulties in using scales to determine age and growth (Hubert and Baxter 1987, Kozel and Hubert 1987, and Kruse et al. 1997). Large confidence intervals in back calculated length at age of MRT may be explained by underestimation of age and subsequent inclusion of multiple ages in each assumed cohort class. It is unlikely that MRT in tributaries to the Upper McCloud grow at a rapid rate then perish after two years. This hypothesis cannot be tested with scale analysis as the sole method of age and growth determination. Employment of alternative methods such as length frequency analysis may produce a viable estimation of age and growth in high elevation salmonid populations.

Barrier Assessment

Tate and Trout creeks were extensively searched for vertical falls and other barriers. Jump heights, maximum depth in jump pool, distance between maximum depth and plunge depth, and distance to resting point above the barrier were measured. Culverts were surveyed for similar features including gradient and water depth within the culvert. FishXing software (Furniss et al.) will be used to assess fish passage in culverts.

Challenges and Goals for 2009

Recapture of PIT tagged fish should clarify the effectiveness of scale analysis as a means of determining age and growth for MRT. If fish captured and aged in 2008 do not exhibit additional annuli, other methods mentioned previously will be employed for age and growth estimates. Determination of barrier effectiveness at numerous cascades and small vertical falls may not be possible as the physical structure of such barriers are not uniform and change drastically with small fluctuations in flow. Tagging of fish above and below barriers may be the most effective method of assessing movement but CDFG permit restrictions prevent tagging beyond units randomly selected for abundance estimates. However, units selected for use in the Mohr-Hankin abundance estimation methodology may reveal the influence of barriers on distribution of brook trout in Tate Creek. Brook trout were not observed in reaches above a knick point in Tate Creek 2008 surveys. The Mohr-Hankin method excludes smaller habitat from the sampling universe as it is difficult to accurately conduct multiple pass snorkeling in pools smaller than the length of the surveyor. Reconnaissance efforts of all three streams revealed MRT in extreme upper reaches that would be excluded under Mohr and Hankin and cannot be electroshocked due to permit restrictions. Abundance in these areas will be estimated by spotlight survey (Hickey and Closs 2006). A prediction model will be constructed by correlating spotlighting technique with results from snorkeling and electrofishing from each stream (Van Kirk 2009). Pools and riffles will be assessed separately. This model can then be applied to results from spotlighting alone on Edson creek and the upper reaches of Tate and Trout creeks.

REDWOOD CREEK JUVENILE SALMONID (SMOLT) ABUNDANCE PROJECTS 2008-2009

Investigators:	Dr. Walter Duffy, CACFRU
	Michael Sparkman, CDFG
Duration:	May 2008 to June 2009
Upper RC Funding:	California Department of Fish and Game/FRGP ($38,654)
Lower RC Funding:	California Department of Fish and Game/FRGP ($43,976)
Lower RC Funding:	Save the Redwoods League ($14,967)

Redwood Creek is one of the major rivers in Humboldt County, CA and supports salmon and steelhead trout that are federally listed as threatened under the Endangered Species Act. Redwood Creek is currently listed as sediment and temperature impaired (USEPA), and various restoration efforts (and plans) in the basin are on-going. These juvenile smolt abundance studies are a cooperative effort with CDFG, Redwood Creek Landowners Association (RCLA), and the private landowner where the upper trap is located. Redwood National Park (RNP) also assists via their estuary sampling.

Data is collected to determine the current population size, status, and trends of salmon (Coho, Chinook), cutthroat trout, and steelhead trout in Redwood Creek. Peer reviewed mark/recapture techniques are used to determine population estimates. The study is designed to be long term and also encourages research/monitoring of adult populations because such studies, when combined with the current smolt study, would help establish relationships between adults and juveniles.

A smolt trap (modified rotary screw trap) will be deployed in late March, and operated 24 hours a day, 7 days a week until early to mid August. The trap is checked at 0900 every day, however we check the trap at night to remove debris (leaves, sticks, etc.) from the livebox as needed (to reduce mortality to captured fish). Every fish captured is identified to species at age, observed for trap efficiency trial marks, and enumerated. Population estimates (weekly and seasonal) are determined using multiple trap efficiency trials using peer reviewed methods. Fork lengths are taken every day and weights are taken every other day for each species at age. Random samples of fish are given pit tags and released downstream of the trap site to investigate travel time and growth during downstream migration, and to investigate residence time in the estuary via Redwood National Park's sampling in the estuary. Stream temperature is recorded every half-hour using optic stowaway temperature probes.

Deliverables will include a detailed assessment and monitoring report, annual report comparing data (population estimates, size of fish, etc.) among study years, complete with tables, graphs, text, a manuscript for submission to a journal, and presentations for various agencies (NOAA, CDFG, RNP, etc).

PRAIRIE CREEK SUB-BASIN LIFE CYCLE MONITORING.

Investigators:	Dr. Walter Duffy, CACFRU
	Brian Poxon, MS Student
Duration:	June 2008 to March 2010
Funding:	California Department of Fish and Game/FRGP ($129,614)

The Prairie Creek sub-basin of Redwood Creek supports self-sustaining populations of coho salmon, Chinook salmon, steelhead and coastal cutthroat trout in addition to occasional chum salmon. It was recognized as an excellent "field laboratory" for the study of anadromous salmonids in California by the Coastal Watershed Planning and Assessment Program. Studies of fisheries in the Prairie Creek sub-basin began in the late 1940's and extend to the present. Nearly continuous estimates of adult salmon returning to Prairie Creek have been made since 1990 (Figure 1), while estimates of juvenile abundance and smolt production have been made each year since 1998.

This project will monitor a 12 km reach of Prairie Creek and a 12 KM reach of Lost Man Creek. We will monitor the abundance of salmonids at adult, juvenile and smolt life stages utilizing survey methods that include:

a) Estimate the escapement of adult coho, Chinook, steelhead and cutthroat trout returning to the Prairie Creek sub-basin in the winter of 2008/09. Adult salmonids will be captured at resistance board weirs located on Lost Man Creek and Prairie Creek operated from November to April each year. All weir captured adult salmonids will be PIT tagged, identified by species, gender, size, and condition, and released upstream. Surveyors will walk upstream of the weirs at bi-weekly intervals and identify PIT tagged fish with a backpack PIT tag antenna, and non-tagged fish by visual observation. Stationary PIT tag antennas will be utilized to record fish leaving the sample area. Adult salmonid escapement will be estimated each year using Mark recapture of tagged fish, and area under the curve methodologies.

b) Estimate the abundance of juvenile coho, steelhead, and cutthroat trout in summer 2008. The juvenile salmonid abundance estimate will utilize an electrofish calibrated dive survey methodology described by Hankin and Reeves (1988) and Duffy, W. G. (2005).
c) Estimate the production of Chinook pre-smolts, and coho, steelhead, and cutthroat trout smolts in March through June of 2009. The smolt production estimate will be accomplished using continuously operated downstream migrant traps located in Prairie Creek and Lost Man Creek. The population estimate will utilize a trap mark-recapture method described in Bjorkstedt and Duffy (2005).

A comprehensive report will analyze trends in salmonid population abundance, survival of salmonids between juvenile and smolt life stages, ocean survival of adults and efficiency of methods used to monitor salmonids in streams.

Project status: The weirs were constructed and operating in both streams when the project funding was suspended by the State of California in December 2008. The graduate student continued a drastically reduced monitoring of Prairie Creek in an effort to salvage his thesis work.

NEW RESEARCH PROJECTS REVIEW (four projects to be approved)

KLAMATH REMS, FISHERIES (RWO 82).

Investigators:	Dr. Walter Duffy, CACFWRU
	Dr. Peggy Wilzbach, CACFWRU
Duration:	September 2008 to September 2010
Funding:	U. S. Geological Survey ($4,515)

Declining populations of Pacific salmon (*Oncorhynchus* spp.) in the Klamath River have led to concerns about water quality in the river. Water temperature in the river during summer months often approaches or exceeds physiological tolerance limits of most Pacific salmon species. Reliance of these fish on cold water has been studied extensively. While temperatures at which the physiological performance of Pacific salmon is optimal is typically 14.0 - 17.0 °C, salmon are also frequently are found occupying habitats where water temperatures reach 23.0 - 24.0 °C on a daily basis. Much of the variation in tolerance to warmer water temperature in Pacific salmon is attributed to acclimation temperature.

In the Klamath River, water temperature regularly exceeds 25.0 °C during July and August. Pockets of cool water that form at tributary mouths are believed to be critical to the survival of Pacific salmon during these periods. Re-analysis of data gathered by the Yurok Tribe during 1998 confirms use of cold water patches at temperatures > 22.0 °C, but also reveals a strong temporal component in use. Furthermore, spatial distribution of refuges having high abundance (> 1000 juvenile Chinook salmon) are clumped at a few stream mouths. The periodicity in heavy use of cold water patches by Chinook salmon and their spatial clumping at limited sites suggest that habitat selection is governed by more than water temperature alone.

The objectives of this study are:

1. To determine if juvenile Chinook salmon and steelhead use cold water patches in the Klamath River preferentially over other habitats.
2. To determine if juvenile Chinook salmon and steelhead use specific cold water patches in the Klamath River for extended periods or for short periods during migration.
3. To determine the physiological benefit of cold water refuges to juvenile Chinook salmon and steelhead in the Klamath River.

QUANTIFYING THE INFLUENCE OF CLIMATE CHANGE ON ROCKY MOUNTAIN UNGULATE POPULATIONS, MIGRATION AND FEEDGROUND USE, AND HERBIVORY IMPACTS ON VEGETATION. (RWO 81).

Investigators:	Dr. Erik S. Jules, HSU, Biology
Duration:	September 2008 to September 2009
Funding:	U. S. Geological Survey ($21,391)

The purpose of the research is to reconstruct past climate in Yellowstone National Park (YNP) using tree-ring data. Tree-ring increment cores from over 250 aspen trees in YNP were collected previously. The trees date back to the early 1800s, and the widths of the rings produced each year are a good reflection of climate (e.g., moisture stress). The ring widths will be used to create the first climate reconstruction for YNP. The project is part of a larger, collaborative effort with investigators at several other institutions; the other investigators will use our reconstruction to understand the relationship of climate with ungulate populations and their migratory patterns.

Because the aspen increment cores have already been measured for the earlier project, the work to be conducted under this grant is limited to data analysis and preparation of a manuscript as itemized below.

1. Detrend ring-width series: a statistical procedure of reducing noise and omitting the influence of tree size on a growth series.
2. Create "master chronology": a statistical procedure of making one single time series of tree growth.
3. Assess the correlation of the master chronology and climate: run statistical correlations of aspen growth and climate. Climate, in this case, has been recorded using instruments in the YNP region (since 1895).
4. Reconstruct climate: use the correlation from above to reconstruct the climate "backwards" for years prior to 1895.
5. Prepare manuscript for publication.

CORIXIDS – A KEYSTONE TAXON FOR FRESHWATER INVERTEBRATES OF COPPER RIVER DELTA EQCOSYSTEMS.

Investigator:	Dr. Kenneth Cummins, HSU, Fisheries Biology
Duration:	April 2009 to September 2009
Funding:	USDA Forest Service ($10,000)

During four years of sampling for benthic freshwater invertebrates in streams, ponds, and wetlands of the Copper River Delta in the Chugach National Forest in southeast Alaska, the most ubiquitous freshwater invertebrate taxon encountered has been the Corixidae (Hemiptera, Heteroptera). These water boatmen have been encountered in every freshwater habitat examined to date. Often the corixids are the most abundant invertebrates present.

Corixids are generally categorized as piercer-herbivores with some as predators (piercers) and secondarily as facultative collector-gatherers or scrapers. Gathering collectors feed on fine particulate detritus (FPOM) which they remove from the sediments by brushing it

from surfaces or "mining" if from interstices. Scrapers feed on attached algae as periphyton on rocks in streams or epiphytes on stems and leaves of vascular aquatic plants in ponds and wetlands (Cummins and Klug 1979, Merritt and Cummins 2006, Merritt et al. 2008). It is not clear how corixids function as predators because, unlike the rest of the aquatic Hemiptera, they do not have front legs modified for grasping and the piercing beak is very much shorter than the other aquatic forms in the suborder Heteroptera. Rather, the tarsae of the front legs are paddle-like and primarily modified for swimming, although with stout setae that could be used as a "rake" in gathering up FPOM or scraping lose attached algae.

Rather little is known about the morpho-behavioral feeding strategies of corixids. This makes categorization into functional feeding groups quite provisional at this time. Direct observations of feeding by corixids of the Copper River Delta freshwater ecosystems are needed. Corixids are easy to rear in aquaria, so the observations could be readily done. Of critical interest would be observations on how they handle salmonid eggs because field observations show that they are strongly attracted to the eggs. When roe was used in minnow traps that were set to catch juvenile coho and dolly-varden, masses of corixids were often found attached the surface of the eggs when the traps were retrieved.

With regard to categorization of corixids by functional feeding group (FFG; Merritt et al. 2008), a piercer-herbivore designation will be difficult to separate from a designation of scrapers. Nymphs and adults may puncture surface vascular plant tissues and cells of macro-algae. However, personal observations of Florida species indicated that mature nymphs and adults scrape, i.e. abrade away, epiphytic algae and the surface tissues and cells of the macrophytes to which they are attached. Observational work is needed to determine how corixids feed on salmonid eggs. It is not known whether corixids feed on intact eggs by piercing or abrading the egg surfaces or if they only feed on eggs in which the chorion already has been ruptured. Insects feeding on eggs generally would be classified as predators, but herbivore –piercer and/or scraper are still the most likely overall FFG designations.

The importance of scent glands in corixids of the Delta to fish and/or waterfowl feeding remains open. Corixids are not normally an important component of fish and waterfowl diets, but they have been reported from juvenile coho and cutthroat gut contents of Delta fish and there are reports of using corixids as food for aquarium fishes. Although it is likely that the corixids of the Delta have scent glands (yet to be verified), they do not appear to inhibit fish feeding. It seems likely that the absence of corixids in the verified diets of fish from other regions may simply be a matter of availability rather than noxious scent glands. On the Delta, corixids are so abundant and seem always to be associated with the abundance of salmonid eggs, it would be expected that they would be consumed by stream fishes. The role of corixids as possible food for waterfowl remains completely unknown at this point. However, stable isotope studies are underway that may clarify this issue.

Given their widespread distribution and great abundance in all freshwater habitats across the Delta, they must serve an important and likely keystone role in the trophic food webs of streams, ponds, and wetlands on the Delta. Corixids likely serve as a major seasonal food for juvenile salmonids and waterfowl in these habitats.

The goals of this study are to investigate:

1. Specific seasonal habitats used by corixids and their relative densities in these habitats.
2. Number of species and/or subspecies that make up these corixid populations.
3. Life history patterns of the corixids – seasonal size (age) distribution, time of mating and dispersal.
4. Food habitats of corixids.
5. Importance of corixids as for waterfowl and fishes including juvenile salmonids, sticklebacks, and Eulacon.

LOWER REDWOOD CREEK JUVENILE SALMONID ABUNDANCE 09-10.

Investigator:	Dr. Walter Duffy, CACFRU
Duration:	April 2009 to April 2011
Funding:	California Department of Fish and Game/FRGP ($108,972)

The Fisheries Restoration Grant Program will continue this project funding through 2011, with 2009 being the 6th year of the study. The long-term goal of the project is to determine the status and trends of juvenile salmonid smolt population out-migrating past the lower Redwood Creek trapping site. The field surveys and time frame are described below.

Data is collected to determine the current population size, status, and trends of salmon (Coho, Chinook), cutthroat trout, and steelhead trout in Redwood Creek. Peer reviewed mark/recapture techniques are used to determine population estimates. The study is designed to be long term and also encourages research/monitoring of adult populations because such studies, when combined with the current smolt study, would help establish relationships between adults and juveniles.

A smolt trap (modified rotary screw trap) will be deployed in late March, and operated 24 hours a day, 7 days a week until early to mid August. The trap is checked at 0900 every day, however we check the trap at night to remove debris (leaves, sticks, etc.) from the livebox as needed (to reduce mortality to captured fish). Every fish captured is identified to species at age, observed for trap efficiency trial marks, and enumerated. Population estimates (weekly and seasonal) are determined using multiple trap efficiency trials using peer reviewed methods. Fork lengths are taken every day and weights are taken every other day for each species at age. Random samples of fish are given pit tags and released downstream of the trap site to investigate travel time and growth during downstream migration, and to investigate residence time in the estuary via Redwood National Park's sampling in the estuary. Stream temperature is recorded every half-hour using optic stowaway temperature probes.

Deliverables will include a detailed assessment and monitoring report, annual report comparing data (population estimates, size of fish, etc.) among study years, complete with tables, graphs, text, a manuscript for submission to a journal, and presentations for various agencies (NOAA, CDFG, RNP, etc).

ESTIMATING SALMON AND STEELHEAD ESCAPEMENT TO REDWOOD CREEK USING A DUAL FREQUENCY IDENTIFICATION SONAR (DIDSON) IMAGING SYSTEM.
(approved by the committee June 2008).

Investigators:	Dr. Walter Duffy, CACFRU
Duration:	November 2009 to December 2012
Funding:	California Department of Fish and Game/FRGP ($164,288)

The Redwood Creek watershed in Humboldt County is considered an important watershed for anadromous salmonids in northern California. It supports self-sustaining populations of coho salmon, Chinook salmon, steelhead and coastal cutthroat trout in addition to other native fishes. There are no hatcheries in the watershed, although hatchery stocks of salmon and steelhead do stray into the stream each winter. Salmon and steelhead in the Redwood Creek watershed are recognized as important for recovering populations of anadromous salmonids throughout northern California.

The pattern of land ownership within the Redwood Creek watershed presents opportunities for restoration. Ninety-six percent of the land area of the lower basin is in state and federal park ownership, and watershed restoration is being actively implemented on these lands. Although 51% of the upper basin is in private ownership, a small number of land owners control most of these lands making restoration planning simpler than in watersheds having complex ownership patterns. Watershed restoration actions have and are also being implemented in the upper watershed. An understanding how the environment influences salmon and steelhead is necessary to inform restoration actions. The environmental influences on salmon and steelhead include those operating on freshwater environments as well as on marine environments. Understanding the response of salmon and steelhead to these factors requires monitoring of at least two life stages. Due to its size and compliment of steelhead and salmon species, Redwood Creek offers opportunities for monitoring and developing techniques for monitoring. The Redwood Creek watershed, at 285 m^2, is representative of northern California watersheds, being near the median size of rivers in the SONCC coho domain. It is large enough to support a diversity of species of salmonids, with some having moderate population size. It is also large enough to present challenges in monitoring fish populations.

Our objective is to estimate escapement of adult salmon and steelhead to Redwood Creek. Escapement estimates will be made using dual frequency identification sonar (DIDSON) imaging system. Project tasks: 1) We will estimate the number of adult coho salmon, Chinook salmon, steelhead and coastal cutthroat trout migrating into Redwood Creek to spawn using a DIDSON. While operation of a DIDSON unit is straightforward, it does require care in sighting and some training. A DIDSON unit consists of the sonar (camera), a set-top control box, a data cable, control software and an associated laptop computer. The DIDSON is directly connected to the set-top box, which is linked to the laptop via an ethernet connection. Images of fish are transferred from the DIDSON to the laptop via the control software. The software displays the data as a streaming image. Image files will be saved onto a hard drive and reviewed manually later. 2) We will develop and conduct a workshop to train California Department of Fish and Game staff in using the DIDSON. This workshop will be hosted during the second year of the project. We anticipate that we will have gained enough experience in DIDSON field deployment and data analysis at that time to transfer the information to others.

UNIT PROGRAM REVIEW

UNIVERSITY SERVICE AND TEACHING

Courses Taught

Fish Bioenergetics (3 units)	Duffy	Spring 2009
Restoration Ecology of Riverine Fish (3 units)	Duffy	Fall 2007
Ecology of Running Waters (3 units)	Wilzbach	Fall 2007, Fall 2008

Graduate Student Major Advisor

Duffy	Philip Colombano – MS Fisheries, Humboldt State University
	Stephen Gough – MS Fisheries, Humboldt State University
	Brian Hodge – MS Fisheries, Humboldt State University
	Katherine McLaughlin – MS Fisheries, Humboldt State University
	Brian Poxon – MS Fisheries, Humboldt State University
	Michele Wheeler – MS Fisheries, Humboldt State University
	Katrina Wright – MS Fisheries, Humboldt State University
Wilzbach	Mark Ashenfelter – MS Fisheries, Humboldt State University
	Brian Hodge – MS Fisheries, Humboldt State University
	Barbara McCoy – MS Fisheries, Humboldt State University
	Seth Naman – MS Fisheries, Humboldt State University
	Roman Pittman – MS Fisheries, Humboldt State University

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

Duffy	Caleb Balas – MS Wildlife, Humboldt State University
	Brooke DeVault – MS Fisheries, Humboldt State University
	Luke Groff – MS Biology, Humboldt State University
	Stephanie Souza – MS Mathematics, Humboldt State University
Cummins	Michael Brady – MS Biology, Humboldt State University
	Oswaldo Hernandez – PhD Entomology, Michigan State University
	Marlene Meaders – MS Fisheries, Humboldt State University
	John Walsh – MS Biology, Humboldt State University
Wilzbach	Dawn Alvarez – MS Fisheries, Humboldt State University
	Colin Anderson – MS Fisheries, Humboldt State University
	Brooke DeVault – MS Fisheries, Humboldt State University
	Jon Goin – MS Fisheries, Humboldt State University
	Josh Fuller – MS Fisheries, Humboldt State University
	Erin Hannelly – MS Biology, Humboldt State University
	Oswaldo Hernandez – PhD Entomology, Michigan State University
	Katherine McLaughlin – MS Fisheries, Humboldt State University
	Marlene Meaders – MS Fisheries, Humboldt State University
	Susan Corum - MS Fisheries, Humboldt State University
	Heidi Vogel – MS Fisheries, Humboldt State University
	Katrina Wright – MS Fisheries, Humboldt State University

TECHNICAL ASSISTANCE

Duffy provided a written review of the Department of Defense, Naval Training Plan to Congressman Mike Thompson's office. For the Department of Fish and Game, he continues to serve as Chair of the Fishery Restoration Grants Program, Peer Review Committee and as a member of the California Advisory Committee on Salmon and Steelhead. Duffy also continues to provide technical assistance to the Karuk Tribe regarding gold mining in streams.

Wilzbach continued to provide guidance to Plum Creek Timber Company, OR, in developing an aquatic monitoring program. Provided assistance to USFS in predicting impacts of Iron Gate Dam removal on habitat for polychaetes (intermediate hosts for salmon pathogens). She provided guidance to Idaho Fish and Game on transplantation of a cutthroat trout project.

COOPERATIVE AGREEMENT

A new cooperative agreement was completed and executed by all cooperators during the past year. The agreement was updated and adds the U. S. Fish and Wildlife Service and Wildlife Management Institute as full cooperators. The name of the Unit is changed to "California Cooperative Fish and Wildlife Research Unit". We appreciate the support and continued good relations with all of our cooperators.

PROGRAM DIRECTION

Expansion of the unit to include a wildlife scientist continues to languish for lack of funding within the national CRU program. Support for the CRU program has, however, appeared to increase with the new administration. Furthermore, CRU may be willing to look at restructuring of established units.

ACCOMPLISHMENTS

Three theses were completed in 2008 (Balas, McCoy, Naman). Duffy had one paper accepted for publication and Wilzbach had three papers published and two in review in the past year.

FACILITIES AND EQUIPMENT

Unit vehicles are in a bit of flux. Units are being encouraged to surplus vehicles defined as gas-guzzlers, so we may be able to acquire a fuel efficient vehicle in the future. One unit vehicle being used by the Fisheries Biology and Wildlife Departments has been scheduled for surplus.

FINANCIAL STATUS

Review current financial information and budget projections.

CALIFORNIA UNIT BUDGET

U. S. Geological Survey	Expended FY 2008 Oct 07 to Sep 08	Income FY 2009 Oct 08 to Sep 09	Projected FY 2010 Oct 09 to Sep 10
Base Salary	245,709	258,261	266,009
Operating Expense	1,000	1,000	1,000
Vehicle Fund	5,000	5,000	5,000
Other Funds	0	2,000	0
Total	**251,709**	**266,261**	**272,009**

Humboldt State University	Expended FY 07-08 Jul 07 to Jun 08	Income FY 08-09 Jul 08 to Jun 09	Projected 09-10 Jul 09 to Jun 10
Administrative Support Coordinator	63,156	65,202	67,158
Office Space	9,683	9,974	10,273
Support Services	3,814	3,928	4,046
Storage Space	4,502	4,637	4,776
Total	**81,155**	**83,741**	**86,253**

California Department of Fish & Game	Expended FY 07-08 Jul 07 to Jun 08	Income FY 08-09 Jul 08 to Jun 09 *Pending*	Projected 09-10 Jul 09 to Jun 10
Operating Expense	7,191	8,000	11,000
Administrative Staff Support	6,714	4,000	4,000
Faculty Support	0	2,500	6,000
Projects - Student Support	5,551	34,500	15,000
Total	**19,456**	**49,000**	**36,000**

Research Work Orders & Projects	Expended Jul 07 to Jun 08	Funding (New / Incremental) Jul 08 to Jun 09	Projected Jul 09 to Jun 10
USFS Copper River Corixids		10,000	
CDFG Redwood Creek DIDSON	0		164,288
USGS Klamath REMS Fisheries	0	5,000	5,000
USGS Rocky Mountain Ungulates	0	21,391	0
CDFG Prairie Crk Basin Life Cycle	0	129,614	129,673
SRL Lower Redwood Creek	3,707	0	0
CDFG Prairie Monitoring Augmentation	14,886	0	0
FS Caspar Creek Watershed	3,707	0	0
FWS McCloud Redband Trout	13,183	0	0
CDFG Half Pounder Study	23,487	0	0
RWO 80 CCV Assessment	133,621	250,000	210,000
RWO 79 Tidewater Goby	31,253	32,869	0
CDFG Transplant Trout	30,163	0	0
FWS C. Shasta & Chinook	20,169	0	0
RWO 78 Pothole Amphibians	18,696	0	0
RWO 77 Klamath Polychaetes	11,044	0	0
CDFG Prairie Monitoring	21,230	0	0
CDFG Upper Redwood Crk Abundance	47,936	38,654	0
CDFG Lower Redwood Crk Abundance	54,047	43,976	54,486
RWO 76 Cal Fed Birds	17,871	0	0
NOAA Fire Disturbance KRNCA	1,018	0	0
NOAA Fire Response KRNCA	5,920	0	0
RWO 75 Steelhead/Fire KRNCA	180	0	0
RWO 74 Castle Rock Seabirds	5,095	0	0
Total Projects	**457,213**	**531,504**	**563,447**
Total Operating & Project Funds	**809,533**	**930,506**	**957,709**

Prepared: 6/1/2009