Posters

#004

Klamath River Nutrient Loading and Retention Dynamics in Free-Flowing Reaches, 2005-2008

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Previous analyses evaluated nitrogen loading and retention dynamics for free-flowing Klamath River reaches below Iron Gate Dam using intermittent nitrogen data collected between 1996 and 2004. These analyses showed that the river reaches between Iron Gate Dam and Orleans typically showed positive nitrogen retention (assimilation/ denitrification) and that the river reaches below Orleans were more variable, showing both periods of positive and negative retention (release) of nitrogen.

Consistent nutrient data collection efforts by the Karuk and Yurok Tribes (and additional data from PacifiCorp, USGS, and USBR) allowed for detailed multi-year and seasonal nutrient budget and retention dynamics to be evaluated for 2005-2008. In contrast to the previous iteration, dynamics were evaluated not only for total nitrogen (TN), but also for total phosphorus a well as dissolved forms of both nitrogen (i.e., total inorganic nitrogen [TIN], composed of nitrate and ammonia) and phosphorus (soluble reactive phosphorus [SRP]). Free-flowing reaches evaluated included Keno Dam to above Copco (includes the small J.C. Boyle impoundment) and four reaches below Iron Gate Dam: Iron Gate to Seiad, Seiad to Orleans, Orleans to Weitchpec, and Weitchpec to Turwar. Inflow, outflow, tributary, and ungaged accretion loads were calculated for each reach and then retention was determined via mass-balance calculations. Results were summarized for the periods June 1 – October 20 (monitoring season) and July 1 – September 30 (period of maximum periphyton productivity). Methodological improvements included the use of flow- and season-based multiple regression models to estimate nutrient concentration time-series and assess prediction uncertainty.

Provisional results indicate overall positive TIN and TN retention for middle and upper reaches (Iron Gate to Seiad, and Seiad to Orleans, and Orleans to Weitchpec), and negative for the most downstream reach (Weitchpec to Turwar). In the Keno to Copco reach, TN retention was positive and TIN was not evaluated. Retention was generally positive for TP and SRP in all reaches evaluated. Retention rates for TN were overall higher than for TP on both an absolute (i.e. kg/day/mi) and relative (percent) basis. Similarly, retention rates for TIN were higher than for TN, and SRP higher than for TP. Retention rates for all four parameters were higher in the July-Septembers period than the June-October periods.

Nutrient loading and retention rates from the current study will be compared with 1996-2004 estimates, as well as to impounded reservoir reaches.

#007

Sevenmile Creek Fish Passage

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The purpose of the project was to provide for fish passage around an agricultural diversion structure on Sevenmile Creek, located in the Upper Klamath Basin of southern Oregon. The diversion seasonally blocked up and downstream movement of fish. To provide fish passage, a natural roughened channel was constructed adjacent to the existing channel. Access to existing irrigation ditches on both banks was maintained as part of the project.

The superstructure of the diversion structure itself was removed but sheet pile on the banks and an instream support bar remained to support the banks and bed and prevent migration of the downstream head cut. A rock weir was constructed in the channel immediately upstream of the existing diversion structure to maintain water elevations for continued irrigation. A second rock weir was constructed across the main channel just above where the roughened channel returns to guide migrating fish to the roughened channel and provide additional grade control.

The project facilitates movement of redband trout (*Oncorhynchus mykiss newberrii*) and brown trout (*Salmo trutta*) during irrigation season. It also allows for upstream and downstream movement of the endangered Lost River (*Deltistes luxatus*) and shortnose suckers (*Chasmistes brevirostris*), as well as adult steelhead (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*), should they colonize Sevenmile Creek.

According to fish passage criteria established by Oregon Department of Fish & Wildlife, no jumps or steps are allowed in structures designed for passage of suckers. A pool and chute fishway, or denil ladder, was a potential option, however the landowner would not support any fish passage design that required a concrete or steel structure in the creek. Therefore, a roughened by-pass channel was designed, because it had the highest likelihood of success, the highest aesthetic appeal, and can accommodate the inherent variability of flows.

Fish passage criteria that needed to be met included minimum depth (1 foot), maximum flow velocity (4 feet-per-second), and maximum bed slope (4 percent). The roughened channel and upstream diversion weir were designed to meet passage criteria between the 10 and 90 percent exceedance flows.

The project was constructed in the early fall of 2008. Depth and velocity measurements taken in the roughened channel immediately following construction confirmed that fish passage design criteria were being met.

#008

Upper Klamath Basin Wetlands: An Assessment

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Wetlands are important habitats because of the many goods and services they provide. In the upper Klamath River Basin in southern Oregon and northern California, wetlands are especially critical to migrating birds, and provide habitat for thousands of ducks, geese, swans, and wading and shorebirds each year. Approximately 1 million waterfowl, perhaps as much as 80 percent in the Pacific Flyway, use the basin annually. Additionally 20-30 thousand shorebirds use upper basin wetlands, primarily during their spring and fall migrations. The wetlands also provide habitat for early life stages of endangered Lost River and shortnose suckers and other native fishes, and a wide variety of other native wildlife. Additionally the wetlands likely provide valuable water quality functions and sequester carbon in the form of peat.

Unfortunately these wetlands have been extensively impacted by agriculture and other development, and wetlands losses have been estimated to be as high as 65 to 90 percent. Because it is unclear exactly what wetlands remain, we undertook an assessment based on data developed by the National Wetland Inventory.

We found that approximately 380,000 acres (1,500 km^2) of wetlands of all types were present in the upper Klamath Basin above river mile 225 as of 1982, the time of the inventory. Palustrine wetlands (primarily marshes locally called “swamps”) accounted nearly 90 percent of the total or 337,000 acres (1,300 km^2). Lacustrine wetlands found along lake shores (littoral habitats) accounted for 10 percent of the total or 40,200 acres (160 km^2), and riverine wetlands (and some associated deepwater habitats) accounted for 1 percent or 5,500 acres (20 km^2).

The majority of the wetlands were located in the Lost River subbasin (36 percent of total), followed by Williamson, Sprague, and Upper Klamath Lake subbasins. Wetland losses are unknown, but are likely less than previously thought. Diking and draining and other activities have altered most of the wetlands; however, approximately 150,000 acres (600 km^2) are being managed for wetland values especially for migratory birds, but also for water

quality, recreation, and others. Climate change, exotic species, and competition for water pose threats to wetlands; however, on-going efforts to restore wetlands should lessen adverse effects.

#009

A Survey of Vernal-pool Plant Communities in South-central, Oregon with Emphasis on Searching for Two Imperiled Grasses, Slender Orcutt Grass (*Orcuttia tenuis*) and Green's *Tuctoria (Tuctoria greenei*)

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Vernal pools are seasonal wetlands that harbor a high diversity of plants and invertebrates. They are rich in species diversity and have a high rate of endemism. Because vernal pools are being rapidly lost as a result of agriculture and urbanization, many of the vernal pool species are now federally protected under the Endangered Species Act (ESA). Greene's tuctoria (*Tuctoria greenei*) and slender Orcutt grass (*Orcuttia tenuis*) are small, tufted, annual grasses (family Poaceae) that are primarily found in vernal pools. Both species were listed under the ESA in 1997, and are currently found only in northern California, primarily in the Central Valley region. Recent discoveries of these grasses in Modoc County in Northern California has expanded their range close to the Oregon border, initiating interest in searching for these species in south-central Oregon (Klamath and Lake counties), and in documenting the vernal pool flora. This study was conducted on Bureau of Land Management (BLM) land near Gerber Reservoir known as the "Gerber Block" and in the southwestern part of Fremont National Forest. To aid in locating potential areas to search for vernal pools, GIS-generated maps were developed by U.S. Geological Survey quadrangle, showing an overlay of soil types associated with wetlands (usually identified as poorly drained) and the presence of wetlands as identified by the National Wetlands Inventory. Potential sites were identified and checked for the presence of vernal pools. Plant species were investigated with a focus on searching for *Orcuttia tenuis* and *Tuctoria greenei*. Thirty-four plant species associated with vernal pools were identified and species composition was fairly consistent from site to site and were similar to those in Modoc County where *Orcuttia tenuis* and *Tuctoria greenei* occur. However, these grasses were not observed during this survey. Because this was a preliminary survey, and was done in a dry year, there is a need for continuing plant survey investigations to further understand vernal pool environments and determine if these plants are present in Oregon.

#012

Phosphorus and Nitrogen Legacy in a Restoration Wetland, Upper Klamath Lake, Oregon

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The effects of sediment, ground-water, and surface-water processes on the timing, quantity, and mechanisms of N and P fluxes were investigated in the Wood River Wetland 5–7 years after agricultural practices ceased and seasonal and permanent wetland hydrologies were restored. Nutrient concentrations in standing water largely reflected ground water in winter, the largest annual water source in the closed-basin wetland. High concentrations of total P (22 mg L^{-1}) and total N (30 mg L^{-1}) accumulated in summer when water temperature, air temperature, and evapotranspiration were highest. High positive benthic fluxes of soluble reactive P and ammonium (NH_4^+-N) were measured in two sections of the study area in June and August, averaging 46 and 24 mg m^{-2} d^{-1}, respectively. Nonetheless, a wetland mass balance simultaneously indicated a net loss of P and N by assimilation, denitrification (1.1–10.1 mg N m^{-2} h^{-1}), or solute repartitioning. High nutrient concentrations pose a risk for water quality management. Shifts in the timing and magnitude of water inflows and outflows may improve biogeochemical

function and water quality by optimizing seed germination and aquatic plant distribution, which would be especially important if the Wood River Wetland was reconnected with hyper-eutrophic Agency Lake.

#013

Use of Dual Frequency Identification Sonar (DIDSON) to Estimate Low Abundance Salmonid Escapement in California Watersheds

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Steelhead (*Oncorhynchus mykiss*) and coho salmon (*O. kisutch*) are listed as Threatened or Endangered under the Endangered Species Act throughout most of California. Monitoring these fish presents difficult challenges since their abundances are so low that often a complete census of these populations is needed. Dual frequency identification sonar (DIDSON) is a promising new technology that could potentially be used to monitor adult salmonids runs in California streams and rivers under highly variable environmental conditions. We tested the feasibility of using DIDSON to estimate steelhead escapement in two systems with low abundance in central California: the San Lorenzo River and Scott Creek in Santa Cruz County. DIDSON uses sonar to produce high-quality images in turbid water, which allows for detection and enumeration of fish, as well as estimation of fish size and swimming direction. Each deployment yielded insight into equipment durability, the importance of site selection, data management techniques, and how fish behavior affects data processing. These deployments lead to much improvement in operational techniques. Our 2006 experiment in the San Lorenzo River lasted 8 days and was focused on equipment durability. The DIDSON counts from this site yielded 41 upstream migrants compared to 46 passed at an upstream fish trap. There were some differences in operation time between the two methods which may account for the discrepancy. The Scott Creek (2008) deployment will also span the entire steelhead run season and data validation will be possible using results from a weir located 200 m downstream.

#014

The Salmon Monitoring Advisor: A Hierarchical Web Site to Help Design and Implement Salmon Monitoring Programs

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Salmon managers, scientists, and non-governmental organizations face substantial challenges designing cost-effective monitoring programs to assess both status and time trends in abundance, productivity, spatial structure, and diversity of salmon populations. We are currently developing a web-accessible knowledge base called the "Salmon Monitoring Advisor" to help such people choose designs that (1) reliably estimate changes in salmon indicators, and (2) estimate the relative contribution of climate-driven mechanisms to those observed changes (compared to changes caused by other factors). This web site provides a systematic, structured framework to help users develop clear goals and objectives, as well as design and implement salmon monitoring programs that are reliable, informative, and cost-effective. The site is accessible in a hierarchical manner to reflect diverse audiences, including (1) scientists who design monitoring programs and/or analyze the resulting data, (2) technical staff who implement monitoring designs in the field, (3) people involved in providing funding for monitoring programs, and (4) managers and decision makers in government agencies or in local or regional salmon conservation organizations. This web site is named "Salmon Monitoring Advisor" because it provides advice and guidelines to help users work through the essential steps involved in designing monitoring programs to meet stated objectives, and provides pros and cons of different designs, rather than being prescriptive about which design best meets a particular monitoring objective. The web site uses seven sequential steps to guide monitoring design and implementation and provides extensive explanations and real-world examples for each step.

#015

Post-restoration Water Quality Monitoring at the Williamson River Delta, Upper Klamath Lake, OR

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The Williamson River Delta (the Delta) in southern Oregon was historically a fully functional freshwater marsh ecosystem that provided a substantial nutrient sink for the Williamson River before flowing into Upper Klamath Lake. Beginning in the 1940s, the delta wetlands were drained and converted for agriculture, and the wetlands became hydrologically disconnected from the lake and river. The Nature Conservancy began the large-scale restoration of the Delta in 2007 and has re-flooded approximately 5,500 acres. One of the fundamental goals of the restoration is to help improve water quality in Upper Klamath Lake (a large, shallow hyper-eutrophic lake) by increasing nutrient sequestration in the wetlands, thereby reducing nutrient loads to the lake. Water quality monitoring on the Delta began in 2007 and is currently focused on quantitatively and qualitatively describing the effects of the restoration on nutrient, chlorophyll *a*, and water chemistry dynamics within and surrounding the Delta. Preliminary results indicate that an initial pulse of phosphorus was released into the water column immediately after re-flooding and that concentrations have subsequently declined in the two years following the restoration. Seasonal trends in dissolved oxygen, pH, and chlorophyll-*a* reflect influences on water chemistry from both wetland processes and inflowing lake and river water. These trends provide important information for evaluating water quality in terms of potential endangered sucker habitat. Initial findings from water quality monitoring on the Delta provide a baseline for assessing how restoration of the Williamson River Delta will affect surface water quality in the longer term, and ultimately help to determine whether restoring wetlands is a practical strategy for improving water quality in Upper Klamath Lake.

#021

Modeling Larval Sucker Transport through the Williamson River Delta, Upper Klamath Lake, Oregon

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Deltaic marshes at the mouth of the Williamson River at Upper Klamath Lake and Agency Lake probably once served as important nursery habitats for larvae of the endangered Lost River sucker *Deltistes luxatus* and shortnose sucker *Chasmistes brevirostris*, due to their location downstream of known productive spawning grounds. Beginning in the 1940s, levees were built around the Delta and the wetlands were drained and developed for agricultural uses, and the Williamson River flowed directly into Upper Klamath Lake with no access to its floodplain or deltaic wetlands. Modeling has suggested that without access to the Delta, passively drifting larvae can be transported from the mouth of the Williamson River to the outlet of Upper Klamath Lake in as little as 8 to 10 days. The Nature Conservancy and partners recently breached and lowered over 22 miles of levees and reconnected 5,500 acres of historic floodplain and deltaic wetlands to the adjacent Upper Klamath and Agency Lakes and along 3.5 miles of the lower Williamson River. Prior to and soon after the levee breaches, there was interest in understanding the likely affect of reconnecting the Delta on the travel time of larval suckers that enter the system from upstream spawning areas. The USGS developed a calibrated hydrodynamic and heat model for the Upper Klamath and Agency Lake system based on continuous measurements of velocity and temperature. This model was expanded to include the newly inundated portions of the Williamson River Delta. A series of numerical experiments were designed to determine the expected changes in travel time and the drift pathways of larval suckers entering the Delta from the Williamson River. Based on preliminary model runs, it is expected that restoration of the Delta will increase the travel time of sucker larvae from spawning sites in the Williamson River to Upper Klamath Lake and ultimately to the outlet of the lake at the Link River Dam for a given set of meteorological and hydrological conditions. Travel time is also strongly affected by the management of the lake in terms of lake elevation and outflow. To validate the results of numerical experiments we sampled larval sucker density in the Williamson River and Upper Klamath Lake prior to restoration and within and surrounding the Delta after restoration in 2008 and 2009. Samples were collected during the larval sucker migration period at strategically selected locations along modeled flow paths. Here we present the preliminary results of a comparison between sampled and modeled larval sucker densities.

#026

Sprague River Basin Geomorphology Datasets

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The Sprague River basin encompasses about 1,610 square miles (4,170 square kilometers) of south central Oregon and is a principle tributary (via the Williamson River) of upper Klamath Lake. The lower reaches of the North Fork and South Fork Sprague River, the Sycan River, and the 86 miles (139 kilometers) of the mainstem Sprague River meander through broad alluvial valleys historically supporting agricultural crops and livestock grazing. National and regional interest in restoring Klamath Basin ecosystem conditions and processes has motivated several restoration strategies and projects in the Sprague River basin to improve aquatic, riparian, and upland habitat conditions, particularly for endangered fish species. This study, jointly conducted by the U.S. Geological Survey and University of Oregon and in cooperation with the U.S. Fish and Wildlife Service Klamath Basin Ecosystem Restoration Office and the Hatfield Restoration Program, documents historical and current channel and floodplain processes and conditions to assist management and regulatory agencies in evaluating restoration proposals and designing effective restoration and monitoring strategies for the Sprague River and its principle tributaries. The

study involves multiple analyses, including assessments of historical channel change, riparian and floodplain vegetation, and surficial geology. To support these analyses, digital floodplain and channel maps were prepared to depict channel and floodplain conditions at different times. The geospatial database of current and historic channel and floodplain conditions will also enable evaluation of long-term trends pertaining to aquatic and riparian habitat conditions.

#028

Klamath River Thermal Refugia as Critical Habitat for Threatened Juvenile Salmonids.

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Late summer and early fall water temperatures on the Klamath River can reach levels that are physiologically stressful to endangered and threatened salmonids. At the limits of their thermal tolerance, salmonids may behaviorally thermoregulate by moving to localized patches of colder water, or thermal refugia. The presence of these refugia may be key to salmonid survival, especially during periods of elevated mainstem temperatures when refugia may be the only usable habitat available, yet their dynamics and importance are not thoroughly understood. While fish obtain thermal benefits by using refugia, trade-offs may include lower food availability and increased risk of disease, and the interplay between these factors influences how much time a fish chooses to spend in the mainstem river versus the refugia. My research focuses on defining the mechanisms driving salmonid thermal refugia use at both landscape and local scales, and the implications refugia use has for salmonid growth and survival. Previous studies have not explored the potential importance of diurnal temperature variations in determining juvenile salmonid survival. The energetic costs of surviving at daily maximum temperatures may make these temperatures critical for determining overall salmonid survival. Knowledge of individual salmonid behavior surrounding refugia is key to understanding how factors such as diurnal temperature variations and heterogeneous food availability impact salmonid growth and survival. To address these issues, I will conduct radio tracking studies to measure fine-scale spatiotemporal use of thermal refugia by individual juvenile salmonids. I will correlate these data with a high-resolution stream temperature model currently being developed by NMFS, which tracks Klamath mainstem diurnal temperature fluctuations. Finally, the results of my fieldwork will be integrated into a temperature and food driven bioenergetics model, which will allow me to gain a mechanistic understanding of the relative importance and long-term consequences of the factors affecting salmonid use of thermal refugia.

#029

An Assessment of Using Wild-caught Larval and Juvenile Lost River and Shortnose Suckers for Supplementation Purposes

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Low adult survival and inadequate recruitment threaten Lost River suckers (*Deltistes luxatus*) and shortnose suckers (*Chasmistes brevirostris*) with extinction. In an effort to determine the feasibility of using wild-caught age 0 suckers for supplementation purposes, we collected larval and juvenile suckers from Upper Klamath Lake (UKL) and adjacent habitats in 2006 and 2007 and reared them.

Substantial numbers of larvae were collected using light traps and small dipnets in conjunction with bright underwater lights at night in Lake Euwauna near the outlet of the Link River in 2006. Additionally, numerous larvae were collected in the Williamson River approximately 1 mile upstream of UKL using dipnets during daylight collection and using dipnets and bright underwater lights during night collection in 2006 and 2007. Larval survival

from collection to arrival at the rearing facility was above 95%. While pathogen and water quality problems were encountered raising sucker larvae and juveniles in the rearing facility, sucker larvae were successfully reared to sub-adult size in 2 years in small ponds with thermally-heated water, demonstrating that it is feasible to artificially rear wild-caught larvae provided that good water quality, nutritious foods, and adequate pathogen-control protocols are provided.

Juvenile suckers were collected in a screw trap in the Link River during late summer 2006, using fyke nets in the Caladonia Marsh when it was flooded during 2007, and using nets and electroshockers during fall 2007 canal salvage operations. Juvenile survival from collection to arrival at the rearing facility was 99%; however, juveniles generally were in poor condition due to high pathogen loads and subsequent survival at the rearing facility was poor even though pathogens control measures were employed.

While collecting juvenile suckers should be more cost effective for providing fish for supplementation activities than collecting larval suckers, poor survival of juveniles at the rearing facility, indicated that it was more effective to collect larval suckers and rear them for supplementation needs. While wild larvae collection appeared to be a potentially effective supplementation technique at 2006 and 2007 sucker population levels, it will become ineffective if adult sucker populations decline substantially from 2006/2007 levels and will be unavailable as a tool for future biologists attempting emergency or "last ditch" recovery efforts.

#030

Potential Areas of Inundation and Stage-Volume and Stage-Area Relations for Diked and Drained Wetlands Adjacent to Upper Klamath and Agency Lakes in the Lower Wood River Valley, Oregon

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Former shoreline wetlands that have been cut off by dikes along the northern margins of Upper Klamath and Agency Lakes near the inlet of the Wood River might in the future be reconnected to the lakes by breaching the dikes. Issues of interest associated with restoring wetlands in this way include the area that will be inundated, the volume of water that may be stored, the change in wetland habitat, and the variation in these characteristics as surface-water stage is changed. A recent study conducted by the U.S. Geological Survey in cooperation with the Bureau of Land Management developed GIS maps of inundation and tables for water volume and area for various surface-water stages for wetland parcels extending to the approximate former northern margins of Upper Klamath and Agency Lakes. The analyses utilized detailed land-surface elevation derived from Light Detection and Ranging (LiDAR) data recently collected in the Lower Wood River Valley. Products from this analysis can assist water managers in assessing the effect of breaching dikes, and understanding changes to water storage and ecological habitat with changing surface-water stage in an area with water shortages and endangered or threatened species.

#037

Hydrogeologic Relations in the Williamson River Sub-basin of the Upper Klamath Basin, Oregon

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The hydrogeology of the Williamson River sub-basin of the Upper Klamath Basin is controlled by deposition and erosion of volcanic and sedimentary units during the late Miocene to Pleistocene, distribution of pyroclastic deposits from the eruption of Mount Mazama, geomorphic response after the eruption and before widespread vegetation growth, and geomorphic processes acting in the landscape after vegetation became established. In general, Miocene

to Pleistocene volcanic and volcaniclastic rocks, particularly pyroclastic flows and hydroclastic deposits, are relatively low permeability. Ground water migrates along stratigraphic boundaries between these lower permeability units and lava flows. Ground water discharges to springs and seeps where erosion has cut valleys into these more permeable zones. Pyroclastic flows and pumice deposits from the eruption of Mount Mazama fill topographic lows near the Cascades and mantle the landscape throughout the basin, respectively. Streams along the eastern flank of the Cascade Range have cut steep-walled canyons through the pyroclastic flows and into underlying pumice deposits. Streams lose to the ground water in these canyons. Pyroclastic flow deposits are relatively lower permeability than pumice deposits and in the vicinity of Klamath Marsh form a confining layer over the pumice. Ground water discharge from the Cascade Range to Klamath Marsh flows through the pumice deposits. Elsewhere in the basin, pumice deposits store perched ground water in topographically lower areas in the pre-eruption landscape and locally release water to low-discharge streams. As a result, more water appears to be stored in the landscape now than prior to the eruption. Local erosion of pumice deposits in upland areas and deposition in low-lying areas prior to the time vegetation became widely established modifies pumice stratigraphy and the movement of surface and ground water. The distribution of some wetlands appears to be influenced by these relations. Infrequent high discharge during spring snowmelt continues to modify the distribution of pumice deposits in uplands areas and to modify the distribution of pumice deposits and alluvial fans building eastward from the Cascade Range. Hydrologic relations in the Williamson River basin are significantly mediated by the physical properties and distribution of pumice.

#038

Spawning Ecology and Larval Drift of Klamath Largescale, Lost River, and Shortnose Suckers in the Williamson and Sprague Rivers, Oregon

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The USGS Klamath Falls Field Station has been monitoring the spring spawning migrations of Klamath largescale, Lost River, and shortnose suckers in the Sprague River, Oregon. Information regarding the spawning ecology of these populations was collected before the removal of Chiloquin Dam to provide baseline data about their migrations, distributions, and spawning locations. Larval drift was also monitored to assess the relative contribution of the various spawning areas to larvae found emigrating from the Williamson and Sprague rivers. Spawning distributions and locations were determined by tracking radio-tagged suckers and suckers implanted with passive integrated transponder (PIT) tags. Migratory behavior was observed from March to June with fish congregating in discrete reaches of the Sprague and lower Williamson rivers. Some individuals were found to migrate more than 140 river kilometers upstream from the dam before returning to Upper Klamath Lake. Each species exhibited some level of spatial or temporal separation in their spawning behavior. Klamath largescale suckers migrated into spawning areas earliest, followed by Lost River suckers, then by shortnose suckers. Klamath largescale suckers and some Lost River suckers migrated to spawning areas high in the Sprague River drainage; whereas the majority of shortnose suckers and Lost River suckers migrated to spawning areas low in the Sprague and Williamson rivers. Spatial and temporal patterns were also observed during larval drift and generally mirrored adult migration patterns. This study is ongoing and data will be used to assess the affects of dam removal on the spawning ecology of catostomids in the Williamson and Sprague rivers.

#039

Data Collection to Better Understand Instream Processes in the Klamath River from Link River to Keno Dam, Oregon: Nutrients, Algae, Bacteria, Zooplankton, Oxygen Demand, Stable Isotopes, and Acoustic Doppler Measurements

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The 21-mile reach of the Klamath River from Link River to Keno Dam experiences poor water quality on a seasonal basis, manifested as high concentrations of algae and ammonia, elevated pH, and hypoxic to anoxic dissolved-oxygen conditions. Data from two seasons of sampling and experimental work have yielded insights into the dynamics and variation of water-quality and transport processes and have provided an improved basis for modeling. Weekly water samples, for example, quantified the timing and amount of *Aphanizomenon flos-aquae* that enters Link River from Upper Klamath Lake in summer. Hourly measurements from acoustic Doppler current profilers deployed in Lake Ewauna, just downstream of Link River, showed circulation patterns that are complex, responding to the river's bathymetry and the direction and magnitude of wind as well as inflows from Link River. Moving downstream, the imported algal biomass tended to decrease in concentration due to settling, grazing, and decomposition, whereas concentrations of ammonia tended to increase in summer.

In midsummer, the Klamath River can become hypoxic or anoxic for substantial reaches upstream of Keno Dam. Oxygen-demand experiments showed that decomposition of algal biomass consumes dissolved oxygen quickly, but a significant oxygen demand also is derived from the decomposition of dissolved organic matter. The rates of those oxygen-demanding processes are significant to the river's oxygen budget, and decomposition of dissolved organic matter exported from this reach is likely to be important downstream as well. Stable isotope studies were used to quantify the rate of dissolved oxygen production by algae, another important component of the oxygen budget. These data-collection efforts and experimental studies have resulted in a rich and diverse dataset that has greatly enhanced our understanding of instream processes in this reach of the Klamath River.

#040

Bathymetry and a Model Grid for the Upper Klamath River, from Link River Dam to Keno Dam, Oregon

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Poor summer water-quality conditions in portions of the upper Klamath River have resulted in recent efforts to study and model streamflow and water-quality dynamics. Using the two-dimensional, laterally averaged CE-QUAL-W2 model, hydrodynamics and water quality have been simulated for the 21-mile stretch of the river between Link River and Keno Dams, just below Upper Klamath Lake near Klamath Falls, Oregon. In order to effectively model the river at various depths, bathymetric surveys on the river by J.C. Headwaters, Inc. and the Bureau of Reclamation were used to develop the model grid. The bathymetric data was processed in geographic information systems (GIS) to produce the necessary grid inputs for the CE-QUAL-W2 model. Using GIS tools, the entire river reach was divided into 113 segments, each about 1010 feet long. Because of the flow component of the model, the orientation

of each segment was also derived. Each river segment represented the average volume of 10 equally spaced subsampled cross-sections between segment boundaries. These average segment cross-sections were divided into 1 foot high layers to allow simulation of vertical variation in the river channel. Producing a model grid that represented the river bathymetry was an important step in building a model that could accurately simulate hydrodynamics and water quality.

#043

A Spatial Model for Predicting Unknown Populations of Oregon Spotted Frogs in the Klamath Basin

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The Oregon Spotted Frog (*Rana pretiosa*), endemic to the Pacific Northwest, was once considered widespread in complex warm water wetlands. Over 70% of historic populations are thought to be extirpated with range-wide habitat loss exceeding 90%. We developed a spatial model to elucidate the probable historic distribution of *Rana pretiosa* toward the southern end of its geographic range using Maxent software and ESRI Geographic Information System technology. This model was generated from two sets of spatial data, a set of occurrence points and a suite of environmental variables. Occurrences include all verifiable populations within the study area. The variable suite, used to characterize habitat associated with known populations, includes landcover, soil hydricity, slope, elevation and selected climatically derived variables. The final output from this model is a predictive map that identifies areas of suitable habitat. Importantly, suitability values from this output are continuous, allowing comparisons to be made between the suitability of different areas. Coupled with the National Wetlands Inventory, we intend to use this model to identify survey-deficient areas for this species, which are anticipated to occur primarily on private lands in the Klamath Basin of Oregon and the Pit River system of California. Most previous surveys of the southern range have focused on public land. Our aim is to survey areas that the model reveals as promising during the 2010 breeding season. Any previously unrecognized populations found, particularly near the species' range limit in California, would be important to its conservation.

#044

Klamath Basin Conceptual Model – Water Quality and Aquatic System Management

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Flow and water quality conditions in the Klamath River basin vary dramatically along the approximately 250 river miles from Upper Klamath Lake (UKL) to the Estuary at the Pacific Ocean. There are a wide range of natural and anthropogenic influences affecting water quality throughout the system: inflows to the system at Link Dam originate in hypereutrophic UKL; there are four major reservoirs on the main stem Klamath River, two of which are operated as hydropower peaking facilities; diversions and return flows for agriculture, as well as municipal and industrial use, occur in the reach between Link Dam and Keno Dam; and the river receives considerable inflow from major and minor tributaries (each with unique natural and anthropogenic influences) between Iron Gate Dam and the Estuary.

Not only is the Klamath River System complex, it is also unique because water quality generally improves as water flows from headwaters towards the estuary; in most river systems water quality is highest at the source and degrades as water flows downstream. The water quality of UKL is seasonally impaired and has deteriorated at an accelerated rate over the last century due to anthropogenic activities. UKL is now hypereutrophic. A critical feature of

hypereutrophic systems is that the eutrophication processes are typically irreversible. The result is that the quality of the water flowing from UKL is a principal "driver" that dictates seasonal water quality throughout the system. Further, the dynamic nature water quality conditions is an underappreciated factor in understanding and managing water quality in downstream river reaches. The influence of these highly variable seasonally discharges of large quantities of algae, nutrients, and organic matter on downstream river reaches can be dramatic. The characteristics (hydrology, geomorphology, tributary water quality, instream processes, etc.) of the various downstream river reaches affect the fate and transport of these materials. These water quality conditions have direct implications for other processes and functions in the river, including direct aquatic ecosystem affects (elevated pH, elevated temperature, potential ammonia toxicity, depressed dissolved oxygen), as well as indirect effects (primary production, support of fish disease organisms). Consideration and understanding of multiple processes and stressors, and their interactions both locally and at the basin scale, is critical to successful management and restoration of aquatic systems in the basin.

#047

Fairy and Tadpole Shrimp of the Upper Klamath Basin: Hidden Diversity of Vernal Pools

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Vernal pools are temporarily ponded wetlands endemic to regions with wet winters and dry summers, such as California, Australia, Chile, the Middle East, Spain, and Africa. These shallow wetland depressions have seasonally perched water tables above a shallow, impervious substratum. Although surveys of vernal pools have been completed in California, little is known about those in south-central Oregon. Vernal pools constitute distinct habitat sites within semi-arid landscapes and, therefore, play an important ecological role in southern Oregon. Fairy and tadpole shrimp (Branchiopoda) have inhabited temporary freshwater pools for hundreds of millions of years. They have few defense mechanisms and therefore, occupy temporary wetlands where many predators cannot survive. Branchiopod populations inhabiting temporary waters are declining worldwide. However, because of their temporary nature, vernal pools are frequently created and destroyed over time and are difficult to survey.

Raymond W. Coopey described the vernal pool fairy shrimp of southern Oregon in the early 1940's; however, little has been done to survey them since. The purpose of this poster is to show how diverse the fauna of vernal pools is in our region. In 2009, we began to survey vernal pools in the upper Klamath Basin to document the diversity of fairy and tadpole shrimp. This effort is part of a larger assessment of the flora and fauna of vernal pools in the Klamath and Modoc Plateau ecoregions being undertaken by the Fish and Wildlife Service and Forest Service. Based on this preliminary work, we believe there are substantial numbers (likely in hundreds) of vernal pools in the upper basin. We plan to continue surveys in 2010.

#049

Age-1 Sucker Habitat Use, Distribution, and Apparent Movement in Upper Klamath Lake, Oregon

Jared Bottcher and Summer Burdick

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Contrary to other life stages, little is known regarding age-1 Lost River and shortnose sucker habitat use and the influence of poor summer water quality on their distribution, movement, and survival within Upper Klamath Lake. Although significant juvenile sucker mortality occurs at dissolved oxygen (DO) concentrations below 1 mg/L, the effect large diel DO fluctuations have on juvenile sucker distribution is still unclear. Therefore, our goal was to assess seasonal changes in the distribution and abundance of age-1 Lost River and shortnose suckers as they relate to water quality and habitat composition. We collected juvenile suckers in fyke nets between April and September in 2007 and May and September in 2008 and recorded a variety of habitat parameters at each site, including water

depth, substrate, and aquatic vegetation composition. We examined water quality from two monitoring stations, which encompass the range of conditions encountered within Upper Klamath Lake. Age-0 juvenile suckers were captured more frequently in relatively shallow water (1-3 m), whereas catches of age-1 suckers peaked in relatively deep water (4-7 m). Deep-water habitats decrease in Upper Klamath Lake as water levels recede throughout the summer. Differences in age-1 sucker catch rates among nearshore and offshore sites were minimal. Spatial-temporal patterns in catch rates of age-1 suckers suggest initial directed movement towards deep water areas along the western shore in late June and early July, followed by emigration away from these areas as DO concentrations dropped below 4 mg/L. From our results, it is unclear why age-1 suckers move to deep water habitats in late spring, but poor water quality events provide a likely explanation for their emigration from these areas in mid-summer. A distributional shift of age-1 suckers after mid-summer declines in water quality, followed by their near-disappearance in late-summer, suggests poor water quality may also affect overall survival.

#051

Effects of a Poor Water Quality Event on the Distribution of Juvenile Suckers within the Williamson River Delta, Upper Klamath Lake, Oregon

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The earth moving activities to reconnect the Williamson River Delta to Upper Klamath and Agency lakes by The Nature Conservancy in Oregon were completed in November 2008. Delta wetlands were probably used historically as rearing habitat by endangered juvenile Lost River (*Deltises luxatus*) and shortnose (*Chasmistes brevirostris*) suckers given their downstream location from known spawning areas. Prior studies determined that marsh-like habitats, such as those found in deltaic wetlands, are important rearing habitat for larval and juvenile suckers. A poor water quality event in the Williamson River Delta during late-summer 2008 produced conditions similar to those frequently observed during summer months in Upper Klamath Lake. This event provided an opportunity to examine the effects of water quality on spatial and temporal distributions of juvenile sucker catches in a smaller area. We compared water quality data to juvenile sucker catch rates in Agency Lake and within two distinct strata in the Williamson River Delta, deep water wetland and open water. We examined daily maximum pH levels and percentage of the day exceeding a suspected growth limiting stress threshold for dissolved oxygen (DO; 2 mg/L). Our results corroborated previous studies in Upper Klamath Lake that indicated low DO concentrations negatively affect catch rates of juvenile suckers to a greater extent than elevated pH. A decline in juvenile catch rates to zero in the deep water stratum was correlated with the percentage of the day exceeding the DO stress threshold. As catch rates in the deep water strata declined, juvenile sucker catch rates increased from 0.22 to 1.5 fish per net in Agency Lake and from 0.17 to 2.0 fish per net in open water where DO concentrations were rarely below 2 mg/L. As water quality recovered and DO concentrations below 2 mg/L did not occur during a 24 hour period in any strata, Agency Lake catches decreased while catches increased in open water and deep water wetland suggesting a redistribution of suckers to the delta strata. We believe this indicates that the newly reconnected Williamson River Delta provides potentially attractive habitat for juvenile suckers, but extreme water quality events may play an important role in the distribution of juvenile sucker catches.

#055

Hydrologic Monitoring and Trends in the Upper Klamath Basin Over the Last Decade

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Over the last decade hydrologic monitoring efforts in the Upper Klamath Basin (UKB) of Oregon have increased in response to the continued strain on surface water and groundwater to meet competing biological and agricultural demands. The Oregon Water Resources Department (OWRD) increased its stream gaging network from three to ten gages, and approximately 80 long–term sites were added to the OWRD and US Geological Survey (USGS) well monitoring network to track both anthropogenic and climate related stresses to the hydrologic system. The expanded monitoring effort accompanied several hydrologic studies to better understand the basin hydrology. A major result of the hydrologic investigations was to quantify groundwater/surface water interactions in the UKB (e.g., Gannett, et. al. 2007). For example, the estimated gross groundwater discharge in UKB is roughly 2600 cubic feet per second (cfs), of which 1800 cfs occurs into or above Upper Klamath Lake—approximately 70 percent of the lakes' gross annual inflow.

Data collected over the last 10 years demonstrate that dry climate conditions persist in the UKB. Recorded precipitation at Crater Lake reveals below normal precipitation in eight of the last ten years. Although near normal precipitation has occurred in the last few years, this trend has only halted not reversed the decadal decline in summer baseflows and groundwater levels at most monitoring locations above Upper Klamath Lake (UKL). The trends in stream baseflows generally follow groundwater levels observed in nearby wells. Most monitoring locations reflect hydrologic lows similar to the droughts of 1992 and 1994. USGS stream gages operated on the lower Sprague and Williamson Rivers reflect baseflows similar to those encountered during the drought of the late 1930s and early 1940s.

Below UKL, anthropogenic stresses are more prominent than climate influences on streamflow and groundwater. Streamflow below Link River Dam is entirely regulated. Groundwater monitoring shows the added pumping stresses from expanded use since 2001 have locally produced 10 to 15 feet of decline in the Klamath Valley and Tule Lake sub basin. The increased groundwater pumping has also resulted in a greater amount of seasonal fluctuation.

#058

Current-Use Pesticides in the Klamath River Basin

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Current-use pesticides and their degradates present in the Klamath River ecosystem may pose risks to aquatic organisms through direct exposure in water and sediments, and could affect human health through multiple indirect pathways. A wide variety of pesticides are applied in agriculture and forestry in the Klamath River Basin watershed. These pesticides can be transported off-site and into surface waters via rainfall-runoff, irrigation-return flows, and atmospheric drift. The result is a complex mixture of current-use pesticides and degradates in various environmental compartments (water, sediments, biota, and plants). Inhabitants of the area, particularly the tribes, are concerned with pesticide residues in their water, food, and plant materials. Mixtures of pesticides in the ecosystem may cause adverse effects on key aquatic species and hinder the reintroduction and recovery of salmonids. Possible removal of dams will allow the transport of sediments and associated pesticides into the downstream ecosystem.

The California Water Science Center has been studying the occurrence, transport, and bioavailability of current-use pesticides in aquatic ecosystems across the Nation for two decades. With our current analytical methods, nearly one

hundred pesticides and degradates can be measured in water and sediments. Since moderately-hydrophobic pesticides can bioconcentrate in organisms, methods have been developed to analyze pesticides in crab embryos and fish tissue. In ongoing studies in other locations, pesticide concentrations in water, sediments, and tissue are being measured concurrently with measurements of biological effects on fish and crabs. In addition, methods are being developed to analyze pesticides in plant tissue. This comprehensive analytical approach can be used to characterize the occurrence and fate of current-use pesticides and degradates in the Klamath River ecosystem and observe the effects of changes in the watershed.

#062

Monitoring Groundwater Fluctuations in the Upper Klamath Lake Basin

Dan Polette and Marshall Gannett

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The U.S. Geological Survey (USGS) has been mapping water-table elevations and monitoring groundwater fluctuation in the upper Klamath Lake Basin cooperatively with the Oregon Water Resources Department (OWRD) since 1999. This monitoring was born out of an interest to quantitatively characterizing the regional groundwater flow system and to develop a computer model to simulate the regional groundwater flow to help understand the resource and test management scenarios. It continues today as management questions and water-use patterns have evolved.

Monitoring began with the mapping of the hydraulic head distribution in the upper Klamath Basin which relied on water-level measurements from approximately 1,000 field-located water wells in the more populated areas of the basin and the location of springs and gaining reach streams in the less populated areas of the basin.

A subset of just over 100 of the field-located wells was then identified as key wells representing major parts of the system including: recharge areas, discharge areas, different geologic settings, and principal pumping areas. The water-levels in these wells were then monitored to track changes resulting from the effects of pumping, climate, lake-stage variation, and canal operation. The network is reviewed periodically and it's scale, location, and frequency is modified as needed in response to changes in pumping and climate patterns and to accommodate the resulting resource-management questions that arise. Currently, there are 51 USGS sites in the network, seven of which are continuous-recorder sites and the rest are measured quarterly throughout each year.

Monitoring includes the quarterly manual observation of water-levels in most of the wells and the two-hour interval electronic sensing and recording of water-levels in some of the wells where more detail is necessary and/or seasonal access is prohibitive. These data are collected using established USGS water-level measurement protocols for the methods of both manual observation including steel tapes, electric tapes, pressure gages, manometers; and also for the methods of continuous recorder observation including both float and pressure transducer sensor-based systems. This equipment is routinely calibrated to ensure the consistency and the quality of the data. These data are then processed into the USGS's National Water Information System (NWIS) for archiving and are readily available on either the project website, national NWIS website, or the USGS Groundwater Networks website. Data from 20 additional wells monitored quarterly by OWRD in the upper Lost River subbasin have also been entered into NWIS. Not all of the data collected by OWRD in the entire upper Klamath Basin are in NWIS. Intentions are to pursue including additional OWRD data into the USGS system so as complete a picture as possible of the state of the regional groundwater system in the upper Klamath Basin can be obtained from a single source.

#066

Strategic Habitat Conservation: An Integrated, Landscape-level Approach to Conservation Science in the Klamath Basin

Nicole Athearn, Paula Golightly, and Michael Cunanan

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The Klamath River Basin (Basin) spans 40,790 square kilometers and encompasses a diversity of habitats for sensitive species. This watershed supports a complex ecosystem, including many state or federally listed species which often have conflicting habitat and management needs. Several federal agencies as well as tribes, universities, the states of Oregon and California, and other groups have worked to address species conservation and human resource needs in the Basin, and have contributed strongly to our collective understanding of science in the Basin. However, the scope and Basin-wide relevance of these independent efforts could be improved through a synergistic strategy focused on interdisciplinary teamwork and Basin-wide targets. The introduction of the Klamath Basin Restoration Agreement, along with the latest predictions and challenges of climate change, reveal that large-scale habitat changes within the Basin are likely, thus an integrated and strategic approach to conservation and restoration throughout the Basin is more urgent than ever. Strategic Habitat Conservation (SHC) is an approach developed by the U.S. Fish and Wildlife Service (USFWS) and U.S. Geological Survey using principles of conservation biology and landscape ecology to organize conservation strategies on a regional scale. Landscape Conservation Cooperatives, described by USFWS in their Climate Change Strategic and Action Plans, are conservation-science partnerships between agencies, organizations, Native American tribes, and community members developed to provide and share applied science using SHC as a methodology within a geographic framework. Within the Basin, these strategies are being developed to help us address conservation challenges, many of them unknown, that may result from large-scale restoration efforts and from climate change.

#072

Canal Flow Monitoring and Assessment at Selected Sites in the Upper Klamath Basin

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The use of slope gages has proven to be an inadequate method for delivering accurate discharge values in many of the Klamath Basin's canal monitoring locations due to low gradients and variable backwater. Acoustic Doppler Velocity Meters (ADVMs) installed in the canals for the Bureau of Reclamation have the capability to provide reliable information on the transport and quantity of flow in the canals. The ADVMs, when calibrated, provided a surrogate for mean channel velocity. The calibrated mean channel velocity multiplied by the channel cross-sectional area can, with ongoing QA/QC, provide an adequate, continuous, real-time record of discharge.

From March 2008 until present, Reclamation and the USGS have cooperated on measuring flow volume and developing QA/QC guidelines for the seven sites listed below. The methods, initial calibrations results, and data summaries for the sites will be presented and discussed. This cooperative work will improve the long term understanding of the quantity and transport of channelized flow in the basin.

Discharge measurement sites:

1. 11509105 North Canal at Highway 97, near Midland
2. 11509340 Klamath Straits Drain near Worden
3. 11509200 ADY Canal at Highway 97, near Worden
4. 11486900 Wilson River/Lost River Diversion entrance
5. 11486400 C canal Below C-G cutoff at Henley at (KID)

6. (Station Number Not assigned) Oregon Drain at State Line Road
7. 11486900 Lost River Diversion near Henley

#076

Yurok Tribal Fisheries Program Green Sturgeon Studies

Barry McCovey Jr,

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To the Yurok Tribe, green sturgeon are considered sacred and these large fish are an extremely valuable source of food. The Yurok people have lived along the banks of the Klamath River for millennia, subsisting on the Klamath's once abundant runs of anadromous fish. Water quality and water quantity issues have led to the large scale declines Klamath River salmonids and the status of green sturgeon populations are not known. The Yurok Tribe is concerned that declines in green sturgeon numbers may be eminent, and therefore initiated a long term study intended to gather as much information on these revered fish as possible.

From 2002 to 2005 the Yurok Tribal Fisheries Program (YTFP) captured and tagged 56 adult green sturgeon in the Klamath and Trinity Rivers. In 2002 and 2003 we used radio telemetry and focused our study on in-river movements and migrations of green sturgeon. Studies conducted in 2004 and 2005 also examined in-river movements, however in these years we used acoustic telemetry which allowed us to focus our study on where green sturgeon go after emigrating from the Klamath River. Green sturgeon from all four study years were internally tagged with either radio or acoustic transmitters, or both. The acoustic transmitters used in 2004 and 2005 had a life expectancy of up to five years, so it is possible that many are still operational. Since 2002, the YTFP has deployed acoustic monitoring receivers throughout the lower Klamath, Trinity, and Salmon Rivers in order to track the movements of any returning green sturgeon tagged in the Klamath River. Numerous green sturgeon have also been tagged at various locations in California, Oregon, and Washington, and our receivers will detect any of these fish if they enter the Klamath River. In 2006, 2007, and 2008 we deployed a small receiver array in the Pacific Ocean approximately one kilometer off the mouth of the Klamath River. This array has detected numerous green sturgeon from all tagging locations. This poster summarizes some of the major results our green sturgeon study has uncovered.

#077

Yurok Tribal Fisheries Program Pacific Lamprey Studies

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The Yurok people have called northwestern California home since time immemorial. Yurok territory lies along the banks of the Klamath River and shores of the Pacific Ocean. The abundance of the river and ocean has provided a wealth of subsistence resources to the Yurok people. One of the most important and overlooked subsistence foods to the Yurok is the Pacific Lamprey. The Yurok people capture and consume lamprey in a variety of ways, however there is little scientific knowledge concerning lamprey in the Klamath River. There is no quantitative data on historical abundance or distribution specific to the Klamath River watershed, but anecdotal evidence suggests that Pacific lamprey abundance has been in decline since the late 1980's. Presently few efforts have been made to identify causative factors for this decline. In 2006 and 2007 the Yurok Tribal Fisheries Program conducted a pair of pilot studies that could help to answer some of the critical unknowns related to these revered creatures. This poster summarizes the results of these two pilot studies and illustrates some of the cultural aspects concerning the Pacific lamprey and the Yurok Tribe.

#078

Salmon River TMDL Implementation

Lyra Cressey

Salmon River Restoration Council, Sawyers Bar, CA

The Salmon River TMDL for Temperature and Implementation Plan was adopted by the NCRWQCB in 2005. We will look at steps being taken by the Salmon River Restoration Council to implement the TMDL, including riparian assessment/restoration and thermal refugia assessment/restoration.

#079

Modeling Wind on Upper Klamath Lake, Oregon

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A hydrodynamic and heat transport model developed by the USGS is being used to determine the travel times and pathways of larval Lost River (*Deltistes luxatus)* and shortnose (*Chasmistes brevirostris)* suckers throughout the newly restored Williamson River Delta in Upper Klamath Lake (UKL) through numerical experiments. Larval fish density (concentration) is computed as a function of Williamson River inflow, Link River outflow, lake elevation, and meteorological conditions. Due to the shallow depth of UKL, wind speed and direction are vital forcing factors in determining currents, and thus the spatial distribution of larval suckers within the lake. Measured data from six land-based meteorological stations exists continuously year-round, while the critical mid-lake data from two raft-deployed meteorological stations are available only during late spring and summer months. The critical period for modeling the transport of larval suckers is early spring, a time when data from the rafts is not generally available. A separate wind model is being developed to fill data gaps and create a continuous year-round record of raft data based on statistical relationships to continuous land-based meteorological data. Two model frameworks, Neural Networks and Multivariate Adaptive Regression Splines, are employed and compared with varying degrees of success. The most successful models incorporated time-lagged wind speed, wind direction, and air temperature data as input variables. A similar model is being used to recreate weekly wind conditions at UKL extending back to 2000 to produce a “library” of wind-forcing conditions. This “library” will aid in modeling environmental and reservoir management scenarios, based on the range of forcing conditions that have occurred in the past.

#082

Using Remote PIT Tag Readers to Understand Movements and Habitat Use by Coho Salmon *Oncorhynchus kisutch* in the Klamath River Corridor

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Little is known about movements and habitat utilization by juvenile coho salmon *Oncorhynchus Kisutch* in the Klamath River Corridor during their freshwater residence. The Klamath mainstem corridor consists of the mainstem river and associated habitats, as well as the lower reaches of tributary streams. Karuk Fisheries and cooperators have been involved in studies using PIT tags and other marks to understand year-round movement and habitat use by juvenile coho salmon in the Klamath River Corridor since 2006. In October 2008, remote PIT tag detection systems were constructed and deployed at two sites to provide capture points for tagged fish. A multiplexing PIT tag reader and six antennas were deployed at two locations representing different habitats. One habitat was a side-channel pool that was fed by a tributary, and the other was a mainstem backwater at the top of a side-channel.

Systems were successful at collecting data on tagged fish around the clock at both sites. Habitat use varied seasonally and by type.

#083

Assessment of Fire Impacted Klamath Tributaries (2007-2008 Fires): Observations and Management Recommendations

Will Harling and Nancy Bailey

Mid Klamath Watershed Council, Orleans, CA

During the summer of 2008, the Klamath River experienced one of the longest and largest fire seasons in recorded history. Over 210,000 acres burned in the watershed this year. This is in addition to the 2007 Elk Complex fires near Happy Camp which burned 17,684 acres. Fire intensity mapping of the 2007 and 2008 fires indicate that many of the perennial streams in the wildfire areas were burned hot enough to lose riparian vegetation and destabilize hydrologically connected slopes. These streams are important cold-water contributors to the Klamath system, and are essential to anadromous fishery survival.

Through funding from the Bella Vista Foundation, MKWC (in collaboration with the US Forest Service) assessed and identified restoration actions in several Mid Klamath Tributaries severely impacted by the 2007 and 2008 fires. Objectives were to: 1) prevent erosion and sediment delivery in sediment loaded streams, 2) revegetate riparian areas using native species, 3) treat identified barriers to fish passage, 4) monitor survival of plantings and effectiveness of erosion control structures, and 5) explore future opportunities for implementing identified riparian restoration actions following wildfires.

Tributaries addressed by this project provide either spawning (natal), non-natal, or refugial habitat for threatened Coho salmon and other salmonids. Assessments were completed on Bear Creek, Buckhorn Creek, Stanza Creek, Elk Creek, Johnson Creek, Cub Creek, Copper Creek, Burney Valley Creek, and Independence Creek. Implementation of directional felling augmented with manual placement of small woody debris to create erosion control structures occurred on a tributary to Bear Creek.

#084

Endangered Lost River and Shortnose Suckers in Lake Ewauna and use of the Link River Dam Fish Ladder, Oregon

Missy Braham and Alex Wilkens

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Passive Integrated Transponder (PIT) tags were used to investigate endangered adult Lost River sucker *Deltistes luxatus* and shortnose sucker *Chasmistes brevirostris* use of the Link River fish ladder to return to Upper Klamath Lake, Oregon. Suckers were tagged in Lake Ewauna throughout the late winter and early spring of 2008 and 2009. Trammel nets were set one hour before sunrise and retrieved after four hours of fishing. Using a stratified random sampling technique, in 2008, we found the suckers tended to use the northern end of Lake Ewauna in late March to early May. In 2009, we utilized this information to target our sampling and maximize catches. In 2008, we PIT tagged 126 suckers of which 63% were shortnose and 14% were Lost River. In 2009 we PIT tagged 519 suckers of which 72% were shortnose and 13% were Lost River. Eighteen percent of the 2009 tagged suckers were recaptured in 2009 and 11% of the 2008 tagged suckers were recaptured in 2009. This study is in collaboration with the US Geological Survey's (USGS) Klamath Falls Field Station. USGS is monitoring sucker movements through the Link River Dam fish ladder using four fixed underwater PIT tag antennas arranged throughout the ladder. In 2009, USGS detected 16 suckers using the fish ladder; 15 were from our 2008 and 2009 Lake Ewauna PIT tagging efforts. Three of the 16 suckers were later detected at other USGS monitoring sites in the upper reaches of Upper Klamath Lake. This study will provide information on the degree of connectivity between Upper Klamath Lake and Lake Ewauna

suckers, and lead to refined operational procedures for the Link River Dam fish ladder. Although Lake Ewauna is considered unsuitable for suckers, this study suggests they may be able to survive in numbers.

#086

Salmon River Spring Chinook Status (Modeling for Recovery)

Thomas Hotaling and Petey Brucker

Salmon River Restoration Council, Sawyers Bar, CA

Among the native aquatic species at risk in the Klamath basin, spring run Chinook salmon are viewed as an emblematic species, particularly by the native American tribes, requiring protection and restoration in order to adapt to climate change. The Salmon River spring-run Chinook demonstrate a stream-type life history strategy, where juveniles remain at least a year in freshwater before entering the ocean (Healey 1991), and therefore require coldwater-river conditions like those found in the coldwater system of the Salmon River. This life history requires suitable winter rearing habitats, commonly found in off-channel reaches, wetlands and estuary environments. Cooperative assessment, planning, implementation and monitoring efforts to promote the recovery of the spring-run Chinook in the Salmon River and Klamath Basin have been underway and articulated in the SRRC poster. Reconnecting historic habitats in the Klamath and its tributaries is necessary for long term persistence of these fish (Moyle 2008). Salmon River spring-run Chinook stocks demonstrate a unique life history, fundamental to the ecosystem of the Klamath basin. It is a population that 1) is substantially reproductively isolated from con-specific populations and 2) represents an important component of the evolutionary legacy of the species. The near extirpation of Spring Chinook in the Klamath River basin indicates potential future problems for other anadromous stocks that rely on freshwater habitats during the juvenile and adult life histories (Moyle 2008). Spring run Chinook are listed by the US Forest Service as a Sensitive Species in the Klamath National Forest.

Spring run Chinook are distinct from fall run Chinook in that adult spring Chinook enter fresh water in spring and early summer, before their gonads are fully developed and hold in cold water areas for 2-4 months before spawning. Because of this unique life history trait spring run Chinook spawn in the upper reaches and tributaries of their native watersheds. Spring Chinook were once found throughout the Klamath Basin. Passage of spring Chinook into their historical range was blocked below Klamath Falls in 1895 by construction of Copco 1 Dam, and on the Shasta River with the construction of Dwinell Dam (Hamilton et al. 2005, Moyle 2008). Historically, they were especially abundant in the major tributary basins of the Klamath and Trinity Rivers, such as the Salmon, Scott, Shasta, South Fork and North Fork Trinity Rivers. Due to a legacy of human impacts (i.e. dams, mining, logging, and overfishing), today, only the Salmon River and its two forks maintain a viable population (Moyle 2008).

Approximately 177 km of habitat is accessible to spring Chinook in the Salmon River (West 1991) but most of it is underutilized or unsuitable. With the imminent removal of 4 Klamath River Dams, and restoration of the upper Klamath River Basin, spring run Chinook may be restored to other parts of their historic range, in the Spraque, Wood, and Williamson Rivers. The Salmon River spring-run Chinook stock are a likely source population for reintroduction in the current PacifiCorp hydro-electric project area and above Upper Klamath Lake.

#088

Salmon River Community Restoration Program 1992-2010

Petey Brucker and Thomas Hotaling

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The Salmon River Restoration Council (SRRC) was formed in 1992 and was provided support by the Klamath Basin Fisheries Task Force between 1993 - 2006. The SRRC has served as the lead entity in the Salmon River subbasin in the effort to enlist cooperation amongst the stakeholders to create a watershed restoration program, highlighting the anadromous fisheries resources. The SRRC's efforts were spawned by a successful Poaching Prevention Program, which was embraced by the local community starting in 1992, and highlighted the protection of spring-run Chinook

and summer steelhead. The SRRC, through its educational approach, has been recognized as reducing the poaching of these species in the Salmon River by over 90%.

The SRRC initiated the Community Restoration Program (CRP) in 1993. Through the CRP, the SRRC has planned and sponsored an annual series of ecosystem awareness workshops to increase stakeholder awareness for the Salmon River conditions and needs. These workshops are often accompanied by volunteer workdays, which provide the opportunity for stakeholders to apply learned restoration techniques needed to promote salmonid species recovery. Through the CRP, the SRRC has held over 1,000 scheduled workshops and/or workdays that have involved over 100,000 hours of in-kind contribution, largely from the local community members. Since 1993, the SRRC has administered over $5,000,000 in fisheries/wateshed restoration activities in the Salmon River, with almost $ 2 million provided by the SRRC as in-kind contribution.

In 1994 the SRRC adopted its first annual Work Plan for the Community Restoration Program, which created an overview of conditions and needs for anadromous fisheries in the Salmon River and identified projects for the community to address these needs. The annually updated and adopted CRP Plan has helped to guide efforts for the community to help address factors that limit Salmon River salmonids.

In 2002 the SRRC and the US Forest Service completed the Salmon River Subbasin Restoration Strategy (Strategy), which assessed the anadromous fisheries resource conditions for the Salmon River and developed an "Action Matrix" to best address the limiting factors for the existing species. The SRRC and its partners utilize this Strategy, which incorporates the CRP Plan, and tiers to the Klamath and Six Rivers Land and Resource Management Plans, adopted by the US Forest Service in 2005. The SRRC assisted in the North Coast Regional Quality Control Board's (Board) TMDL process for water temperature in the Salmon River. This assessment was completed in 2005. The Board adopted the Strategy as the Salmon River TMDL Implementation Plan.

The SRRC and its partners have utilized the Strategy to guide prioritized watershed restoration and fisheries protection in the Salmon River. To address the multiple needs of salmonids, the SRRC has created nine Programs to help focus cooperator attention on specific areas. Each year the Program Coordinators develop annual work plans that are used to coordinate with our cooperators. The Program Areas include: Fisheries Management; Watershed Monitoring; Watershed Education; Roads Management; Fire, Fuels, and Forestry; Invasive Species Control; Riparian Habitat Assessment and Restoration; River-Clean Up; and Maintaining the Watershed Center.

#089

A Review of Assessment/Manual Improvement of Salmonid Fish Passage on Klamath River Tributaries (2006-2008)

Will Harling[1], Toz Soto[2], and **Charles Wickman**[1]

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Thermal refugia are physically and biologically complex environments. Their ultimate size (volume: vertical, lateral, and longitudinal dimensions and characteristics) is generally a function of mainstem and tributary flows and velocity distribution, geomorphology, meteorology, and temperature. These habitats are not stable. Year-to-year variability in hydrological and meteorological conditions can lead to variable channel morphologies, seasonal flow, and temperature response. Because thermal refugia are relatively small in comparison to mainstem regions, changes in flow regime can potentially impact their size. A long-term warming trend has been identified in the Klamath River. Dams and diversions have significantly reduced and degraded habitat. Salmonids disease rates have increased. Coho salmon have been listed as threatened (less than 10% historic abundance). Coho are less tolerant of higher temperatures than Chinook or steelhead. Wild Spring Chinook, once the dominant run in the Klamath with annual returns over 800,000, have been reduced to relictual populations in the Salmon River and SF Trinity. Climate change in the southern range of salmon country could further stress threatened Klamath fish populations.

<u>Objectives</u>

- Monitor tributaries in the Mid Klamath, Scott and Salmon River subbasins for blockages to juvenile and adult fish passage from May to November.
- Improve juvenile and adult salmonid fish passage to tributaries in the Middle Klamath, Salmon and Lower Scott River subbasins through manual modification of seasonal barriers (over 200 miles of anadromous habitat).
- Report findings to increase understanding of alluvial fish passage issues in the Middle Klamath, Salmon and lower Scott Rivers.
- Educate local residents on techniques for maintaining fish passage at nearby creeks through involvement in volunteer workdays.

Methods

From May-July, we focus on streams that provide natal and non-natal habitat to juvenile salmonids, in particular threatened coho salmon. From August-November the focus shifts to providing access to adult Fall Chinook, coho, and steelhead. It is critical to maintain connectivity to high quality off-channel pond habitats year-round. Examples of barriers include swimmer's dams, bedrock/boulder cascades, alluvial sills/low flow barriers, culverts/road crossings, and log jams and beaver dams. Monitoring included collaborative biological sampling with Karuk Tribe Fisheries Department, Six Rivers National Forest, and Klamath National Forest. Dive sampling occurred before and after treatments. We also tracked changes in stream gradient, velocity, and pool depth on treated sections. Redd surveys occurred during the fall and winter.

Results and Summary

- Boise Creek: 10 Fall Chinook redds in 2008…no redds since 2006 flood event.
- Sandy Bar Creek: Ongoing PIT Tag study in 2008 showed juvenile coho began moving into off-channel ponds immediately after fishway was constructed at the mouth.
- Portuguese Creek: Fall Chinook juveniles found 0.5 miles up creek after cascade at mouth was treated.
- SF Clear Creek: 1.6 added miles of coho habitat. Estimated 4,000+ juvenile coho counted above the logjam the year after it was removed.

Manual fish passage work on Klamath River tributaries is a viable, low cost method for significantly increasing access to high quality salmonid habitat at critical life history stages. Until larger fixes such as dam removal and restored in-stream flows occur, access to suitable habitat can help maintain viable populations of threatened Klamath salmon. Example of adaptive management based on recent Klamath River thermal refugia studies. Stakeholder involvement is key to the continued success of this work.

#090

Water Supply and Quality Issues Related to Groundwater-Surface Water Interaction in the Upper Lost River Sub-basin, Klamath County, Oregon

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Most groundwater discharge within the 920-square mile, Upper Lost River sub-basin east of Klamath Falls, Oregon occurs at fault related valley springs. These spring complexes are subject to reduced flow due to groundwater development, and under certain conditions, are avenues for groundwater contamination through flow reversals.

The geologic environment is complex. Northwest trending Basin and Range fault-block mountains separate four interconnected valleys. Basalt occurs throughout the sub-basin as multiple layers with some sedimentary interbeds. The basalt depositional environments range from subaerial, to some interaction with water, to submerged. Basalt is exposed mostly in the uplands and at mid-valley buttes, and it is buried in the valleys beneath lacustrine, fluvial, and volcaniclastic sediments. The sedimentary unit can contain basalt dikes, sills, and flows. This basin fill can range in thickness from a few feet to hundreds of feet. Some basalt and sedimentary units show evidence of hydrothermal alteration or secondary mineralization that followed deposition.

Groundwater occurs in both the basalt and basin fill sediments. Sufficient hydraulic connection exists between water bearing zones within the basalt units and within the basin fill units to allow lumping each as undifferentiated basalt and undifferentiated sediments. While groundwater in the basalt and the overlying basin fill is generally hydraulically interconnected, the units have very different hydraulic properties. The most productive wells obtain groundwater from basalt.

Groundwater in the basalt generally flows toward the valleys from the surrounding uplands and then flows down valley toward or parallel to the Lost River. Recharge occurs locally in both the uplands and valleys. Most discharge occurs at fault-related valley springs within or near the Lost River, most notably at Bonanza Big Springs adjacent to the Town of Bonanza. Limited groundwater discharge occurs through the basin fill and through stratigraphically controlled springs above the valley floors. Additionally, some groundwater discharge occurs at fault controlled hot springs within the sub-basin.

The interconnection between groundwater in basalt and fault-related valley springs in south Langell Valley, Bonanza, and west Poe Valley is highly efficient and problematic. When groundwater use increases, spring levels and flows decrease. Calls for regulation to maintain senior surface water rights have occurred, and new groundwater rights have been denied. Where the springs occur adjacent to or within the Lost River channel, reverse flow through the springs can contaminate local groundwater depending on the stage relationship between groundwater and surface water. In Bonanza, a seasonally impounded river pool inundates Bonanza Big Springs and periodically backflows to groundwater when adverse climate, groundwater use, and river management conditions converge. The backflow has historically caused contamination of nearby domestic wells and interference with surface water rights. Under a 2006 settlement, post 1990 groundwater rights utilizing wells connected to the springs must shut off when groundwater levels are less than 0.5 feet above the river level. The neighboring irrigation district now voluntarily manages the river pool to keep it more than 0.5 feet below the groundwater level.

#092

Two Cyanophages Capable of Lysing *Microcystis* from Klamath River

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For the last several years, Copco Reservoir has suffered from highly toxic blooms of the cyanobacterium *Microcystis aeruginosa*. With a view to examining the role of virus infection in *Microcystis* population dynamics, we have embarked on a search for cyanophages in this reservoir. We have isolated two *Microcystis*-infecting cyanophages from water samples taken from Copco Reservoir in September 2008. One virus is able to amplify in and lyse cells of *Microcystis aeruginosa* UTEX LB2386. This virus is a myophage with a double-stranded DNA genome 179 kbp in length. The entire genome has been sequenced, revealing similarities to the photosynthetic phages of marine cyanobacteria. The second virus is able to amplify in and lyse cells of an isolate of toxigenic *Microcystis* cultured from Upper Klamath Lake. The genome of this virus is dsDNA 60.5 kbp in length. Its genome has also been entirely sequenced, identifying it as a siphophage with many previously unrecognized genes. Information on the distribution of these viruses in the Klamath Basin will be presented.

#098

Variability of Water Quality Dynamics and Cyanotoxins in Upper Klamath Lake, Oregon

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Seasonal phytoplankton blooms in Upper Klamath Lake, Oregon, frequently cause extreme water-quality conditions characterized by high pH, widely fluctuating concentrations of dissolved oxygen, and high levels of un-ionized ammonia, which contribute to the overall decline in populations of endangered Lost River (*Deltistes luxatus*) and shortnose (*Chasmistes brevirostris*) suckers. In addition, preliminary work by the U.S. Geological Survey (USGS) and others has shown that cyanobacteria, primarily *Microcystis aeruginosa*, produce microcystins in the lake at concentrations that may be detrimental to the suckers. From June to October, 2009, the USGS collected weekly vertical measurements of *in situ* phycocyanin, dissolved oxygen, temperature, pH, and specific conductance at 5 sites in Upper Klamath Lake. These profile data provide a means to quantify the spatial variability of cyanobacteria throughout the lake and model the behavior of buoyant cells in the water column. The variation in temperature with depth shows that surface cell accumulation depends on the degree of thermal stratification and the depth of the upper mixed layer. Dissolved oxygen profiles show elevated concentrations produced during photosynthesis near the water surface and a high oxygen demand in bottom sediments. Where the lake becomes thermally stratified, these data also show minimum dissolved oxygen concentrations below the surface layer, indicating a sub-surface maximum in gross oxygen demand. In contrast, vertical profile data show that during peak concentrations of dissolved microcystins, the water column was mixed, overall temperature decreased, and concentrations of dissolved oxygen were generally low. Also during this time, levels of chlorophyll *a* (a surrogate measurement of phytoplankton biomass, composed mostly of *Aphanizomenon flos-aquae* in Upper Klamath Lake) were low and dissolved nutrient concentrations were high. Taken together, these observations suggest that microcystins produced by *M. aeruginosa* are released from lysed cells following the rapid decline in the *A. flos-aquae* bloom after extended periods of high productivity near the surface of thermally stratified lake water. Whether populations of *M. aeruginosa* and therefore, microcystin concentrations, increase as conditions become less favorable for the *A. flos-aquae* bloom is currently under investigation.

#103

Aging Western Pond Turtles (*Actinemys marmorata*) Using Annuli Counts: Considering Growth During the Active Season to Accurately Reflect Individual Ages

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The western pond turtle (*Actinemys marmorata*) is a freshwater turtle of the western United States that shares many life history parameters with other freshwater turtles worldwide; they are long-lived, age at maturity is later in life, and larger females can produce larger clutches. To understand life-history traits accurately, biologists need to consider the timing of their encounters with species exhibiting plasticity in traits such as annual deposition of growth rings. We surveyed two populations on western pond turtles, one on the mainstem Trinity River and one on the South Fork Trinity River over three summers using mark-recapture to estimate population parameters. We photographed most turtles encounter with two to four photos (Carapace, Plastron, Plastron Length, and Age Photo). Our mark-recapture data indicated that some animals caught late in one season would be assigned the same age as if captured early in the following season, and if captured again 30 or more days later in that same field season. We verified our aging records with close scrutiny of photos to determine when turtles started to put on growth for each season. We consistently saw no new growth in earlier captures compared to those captured after the first of July. This is consistent with the hypothesis that as turtles coming out of over-wintering hibernation must allocate resources for replacement and maintenance before allocating energy to growth. We caution biologist working with this species to consider the age of turtles by factoring in when the animal is captured and not assuming that plastron annuli represent the age of the animal for that field season when encountered early in the active season.

#108

Scott River Water Trust: A Cooperative Water Solution

Sari Sommarstrom

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The Scott River and its major tributaries support important runs of Chinook salmon, coho salmon, and steelhead trout. Low water levels in the streams may limit suitable over-summering habitat for juvenile coho and steelhead during the late summer and prevent adult Chinook and coho salmon from getting upriver to prime spawning areas in Scott Valley during the fall months. In 2007, the Scott River Water Trust began to lease water from water users as a means of improving instream flows for fish. Irrigators and stock water users are paid fair compensation for the instream use of their water in priority stream reaches during critical fish periods. Monitoring evaluates the changes in flow and habitat conditions.

Results are presented for the first three years of operation, all of which have been dry or critically dry water year types. Summer leases over the years have added from 279 to 330 acre-feet of water to several priority streams, benefiting 3.7 to 6.1 miles of instream habitat. Fall leases have provided from 280 to 481 acre-feet in the Scott River mainstem, benefiting up to 53 miles of spawning habitat. Another effort of the Water Trust is adding "instream" as a use under the California Water Code (Section 1707) to an individual water right and one of the water rights decrees, in order to develop a more efficient process with the State.

Our organization is the first water trust in California and became a nonprofit in 2009. Water trusts are a popular fish and water conservation tool in the Pacific Northwest. The Scott River Water Trust is adapting their experiences for this part of the Klamath River Basin as well as practicing our own adaptive management.
www.scottwatertrust.org

#115

Restoring Habitat Productivity in the Middle Klamath Basin: An Overview

Jennifer Silveira and Gary Curtis

U.S. Fish and Wildlife Service, Yreka, CA

The U.S. Fish and Wildlife Service's Yreka Fish and Wildlife Office has carried out a wide variety of habitat restoration work in the middle Klamath Basin, and has completed more than 200 projects since 1987. Restoration work has been supported by our Partners for Fish and Wildlife, Fisheries, and National Fish Passage Programs. Since 2005 the Yreka office has funded and participated in more than 50 projects, wholly or in part, partnering with agencies, community partners, and private landowners. This work has included projects to restore in-stream and riparian habitats, provide fish passage, create wetlands, improve upland habitats through road decommissioning, and weed control, and increase the resiliency of forested habitats to wildfire by reducing fuels.

#116

Successfully Implementing Habitat Restoration Projects in the Middle Klamath Basin

Mark Cookson, Sheri Hagwood, and **Dave Johnson**

U.S. Fish and Wildlife Service, Yreka, CA

The U.S. Fish and Wildlife Service's Yreka Fish and Wildlife Office has implemented a wide variety of habitat restoration work in the middle Klamath Basin over the past two decades. Project types include riparian plantings, livestock exclusion fencing, fish barrier removal, and fuels reduction. Projects typically address habitat limiting factors that influence species diversity, abundance and productivity. We display and discuss representative projects that demonstrate methods used for restoration, including data on the project footprint, and the benefits to the resources.

#117

Summary of USGS Collected Turbidity and Temperature Data and Sediment Sampling on the Williamson and Sprague Rivers, near Chiloquin, Oregon and on the Sprague River near Beatty, Oregon.

Mark D. Schuster and Marc A. Stewart

U.S. Geological Survey, Central Point, OR

Klamath Tribes and USGS have cooperated on an ongoing project to collect baseline data that can be used with flow to estimate sediment loads at three monitoring locations: (1) Sprague River near Beatty (USGS Station # 11497500), (2) Sprague River near Chiloquin (USGS Station # 11501000), and (3) Williamson River near Chiloquin (USGS Station # 11502500). Data collected by the USGS includes continuous turbidity and temperature data and suspended sediment samples.

#118

Modeling the Extent Restoration Wetlands around Upper Klamath Lake Release and Sequester Phosphorus

Emily Mulford and Desiree Tullos

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Each year, the Aphanizomenon algal blooms of the Upper Klamath Lake are one of the factors limiting endangered fish species from flourishing in the lake. Within the lake, phosphorus has been shown to be the limiting growth factor of the algae. Reducing phosphorus loads is viewed as a solution to reducing the blooms. The wetlands around the lake may act as both a source and a sink of phosphorus to the lake, and are important when investigating how to reduce algal blooms. The rate of phosphorus release from wetlands is influenced by both biotic and abiotic mechanisms. It has been determined that all detectable phosphorus is released only during the first 60 days after inundation, with the majority released during the first 48 hours. It is theorized that when natural hydrologic and biochemical functions are resumed, phosphorus sequestration will resume as well.

The point in time when phosphorus sequestration in restoration wetlands resumes was determined through hydrodynamic modeling. The modeling objective was to determine, once phosphorus sequestration begins, the change in phosphorus sequestration over time in the restoration wetlands. Relationships between the carrying capacity of phosphorus storage of the wetlands and the biotic and abiotic variables that may cause phosphorus sequestration were also modeled. The Autobiotic Wetland Phosphorus Model (Kadlec 1996), was used to predict

the amount of phosphorus sequestration in Agency Lake Ranch Wetland on an annual basis and the time it takes for the carrying capacity of the wetlands to be reached. The Autobiotic model is a spatially variable, dynamic model that describes the spatial distribution of both biomass and P concentrations in wetlands. From this model, we described phosphorus removal rates of Upper Klamath wetlands in three major removal processes: sorption, biomass expansion and new soil accretion.

#126

Klamath River Estuary Wetlands Restoration Prioritization

Bill Patterson

Yurok Tribe Environmental Program, Klamath, CA

The Yurok Tribe Environmental Program (YTEP) has developed wetland mitigation guidance for the Klamath River Estuary. The document titled "Klamath River Estuary Wetlands Restoration Prioritization Plan" guides wetland restoration efforts by identifying the most degraded wetlands and provides a framework for prioritizing wetland restoration based on restoration success potential. The goal of the document is to ensure wetland restoration projects not only have the best chance for success, but are addressing the highest priority aquatic resource needs of the Klamath River Estuary (KRE).

Initiated in 2008, YTEP began assessing the ambient condition of KRE wetlands using the California Rapid Assessment Method (CRAM). CRAM is a recently developed rapid assessment tool which offers standardized procedures for use throughout the state. CRAM assessments are designed to measure the overall condition of a wetland by systematically assessing four attributes: Buffer and Landscape Connectivity, Hydrology, Physical Structure and Biotic Structure. Standardized assessments allow for numerical comparability between sites, leading to identification of the most degraded wetlands, and information regarding anthropogenic stressors causing decline in wetland condition.

YTEP has utilized CRAM attribute data to develop "restoration potential" of each wetland complex assessed. Based on feasibility and restoration project success at the local level, restoration potential is the basis for prioritizing the wetland restoration that should take place. Based on knowledge of the local infrastructure and land use activities, the CRAM attributes Buffer and Landscape Connectivity and Hydrology are much less likely to be restored than are Physical Structure and Biotic Structure. Restoration potential is defined as the numerical difference In CRAM scores between these two groups.

#127

Trends in Temperature, Precipitation, and Snowpack in the Klamath Basin Region

Tim Mayer[1] and Seth Naman[2]

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Declining spring snowpack as a result of warmer winter temperatures has been documented in much of the western U.S. Reductions in snowpack and warmer temperatures will have important effects on streamflow and aquatic resources. Here we present the results from one of two studies of Klamath Basin hydroclimatology. In this study, we examine historic changes in winter temperature, winter precipitation, and April 1 snow water equivalent (SWE). We used monthly temperature and precipitation from 20 US Historical Climatology Network (USHCN) climate stations and Apr 1 SWE from 46 snowcourse sites in the region. Our results show that winter temperatures have warmed considerably over the period 1925-2007, especially in the last few decades. The average rate of increase since 1945 at all 20 USHCN stations is 0.2˚C/decade, a rate comparable to other studies in the Pacific Northwest. Modern temperatures are higher than during a previous positive phase of the Pacific Decadal Oscillation (PDO) from 1925 to 1944, suggesting that the increase is only partially explained by the changes in the PDO phase after 1977.

#129

Periphyton Assessment of the Lower Klamath River on the Yurok Indian Reservation

Scott Sinnott and Ken Fetcho

Yurok Tribe Environmental Program

YTEP's goal in sampling periphyton on the Lower Klamath River within the boundaries of the Yurok Indian Reservation (YIR) is to understand the extent of nutrient pollution, the prevalence of toxic cyanobacteria in the riverine environment and the potential risk both pose to the food web and human health. In the long-term, this sampling will assist in illustrating pollution variation between water years and provide a basis to judge effectiveness of short-term and long-term management and regulatory actions taken to abate pollution throughout the Klamath River Basin.

This poster presentation will focus on periphyton data gathered at three sites on the YIR: Klamath River at Turwar USGS Gage (TG), Klamath River upstream of Weitchpec (WE), and Trinity River upstream of Klamath River confluence at Weitchpec (TR) during sampling years 2006-2008. It will discuss the types of periphyton detected at each sampling location, the presence or absence of blue-green algae at each sampling location, and the trends of periphyton metrics at each site throughout each sampling season.

#130

Hydrologic Assessment of Lower Klamath River Tributaries

Micah Gibson and Ken Fetcho

Yurok Tribe

YTEP's goal in operating gaging stations in tributaries to the Lower Klamath is to obtain a continuous record of streamflow, which can be estimated by creating a relationship, or rating curve, between gage height at the gaging station and discharge measurements taken at a range of water levels. In addition, data such as suspended sediment concentration (SSC) and turbidity are also monitored during the winter months, when most sediment transport occurs in watersheds. Watersheds can be impaired by excessive sediment loads, which can lead to changes in channel morphology, habitat degradation, loss of spawning habitat, and may influence salmonid migration. The objectives for conducting this monitoring are: 1) establish baseline conditions and long-term trends, 2) provide a basis for comparing inter-annual flow regimes as they relate to fisheries studies, and 3) to monitor long-term progress of restoration projects.

This presentation will focus on Lower Turwar Creek. The Lower Turwar gaging station was installed in October of 2007 to measure height, turbidity, and temperature. YTEP also collects SSC samples before, during and after peak storm events to better understand the relationship between SSC and turbidity. YTEP has another gage on the upper portion of Turwar Creek about 1 mile upstream that has been operational since 2002 with turbidity and a high flow cableway added in 2005. In the Spring YTEP conducts macroinvertabrate sampling as another biological indicator of stream health. It will help us further understand the Turwar watershed and potentially see the result of intensive streambed restoration conducted by Yurok Tribe fisheries program that has been ongoing for almost 3 years. Even in this short period of monitoring YTEP has seen some promising results. The total drainage area of the watershed is 20,380 acres (31.84 mi^2).

#134

Shasta River juvenile coho early life history and survival study

Christopher Adams

California Department of Fish and Game, Yreka, CA

Passive integrated transponder (PIT) tags were used to gain information regarding the rearing, migration, growth, and survival of juvenile coho salmon (brood year 2007) in the Shasta River in 2008 and 2009. Newly developed and relatively inexpensive remote PIT tag detection systems were installed at key locations to monitor tagged individuals. These efforts revealed migrations to areas of cold spring inflow of the Shasta and its tributaries where coho successfully reared over the summer of 2008. Fall/winter redistribution was documented when tagged individuals were detected at locations throughout the watershed. Survival over three river reaches was estimated using a Cormack Jolly Seber model in program Mark for tagged coho emigrating from main stem Shasta rearing habitats as smolts in the spring of 2009. Detection probability of several remote detection systems was also estimated using this analytical methodology.

#135

Klamath Hydro Settlement Agreement: 2010 Water Quality Monitoring

Mike Deas[1], Rick Carlson[2], Clayton Creager[3], Susan Corum[4], Rich Fadness[5], Ken Fetcho[6], Sue Keydel[7], Steve Kirk[8], and Linda Prendergast[9]

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[8]Oregon Department of Environmental Quality, Bend, OR
[9]PacifiCorp, Portland, OR

2010 marks the second year of formal monitoring associated with the Klamath Hydro Settlement Agreement (KHSA). Initiated through Interim Measure 12 (Water Quality Monitoring) of the Agreement in Principal, PacifiCorp provides $500,000 per year to fund (1) long-term baseline water quality monitoring to support dam removal, nutrient removal, and permitting studies; and (2) blue-green algae (BGA) and BGA toxin monitoring as necessary to protect public health.

Through a cooperative monitoring program that includes the Yurok Tribe, Karuk Tribe, PacifiCorp, and the U.S. Bureau of Reclamation, water quality monitoring occurs over approximately 250 miles of river and reservoir waters from Link Dam near Klamath Falls to the Klamath River Estuary near Klamath. Annual planning and coordination meetings are organized and administered by the North Coast Regional Water Quality Control Board and Oregon Department of Environmental Quality with support from the U.S. Environmental Protection Agency. Monitoring is coordinated to ensure appropriate quality assurance protocols and standard operating procedures, with transparency a key element of the program.

The program has completed one year of sampling and intends to produce a data summary report for year 2009 baseline monitoring, which will include data presentation, lab cross comparisons among the various sampling parties, and quality assurance information pertinent to the program. Public health monitoring will be reported separately.

#140

Adequacy of Klamath River Fishery Flows under Terms of Klamath Settlement

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To evaluate risks to Trinity River fish populations, water volumes available for fishery flow releases to Klamath River under terms of the proposed Klamath Settlement (KBRA) were analyzed using criteria adopted from 1) current federal Endangered Species Act (ESA) requirements for coho salmon, and 2) recommendations for minimum flows (subsistence limits) from Hardy *et al.* (2006). Hydrologic modeling used in Klamath Settlement negotiations, specifically KLAMSIM Run32 – Refuge, was selected to simulate future conditions for Klamath River flows below the location of Iron Gate Dam. Our analysis found violations of the selected criteria were frequent and of large magnitude, especially in years with less than average precipitation. While many violations could likely be avoided though in-season management of water supplies, doing so under the water-allocation terms of KBRA appears to require trade-offs between protection of minimum regulatory and environmental flows, and provision of flows adequate to restore habitats crucial to Chinook fry rearing in mainstem reaches of Klamath River. We conclude that fishery flows resulting from adoption of KBRA are likely inadequate for protection of Trinity River stocks while complying with legal requirements under ESA and at the same time restoring non-Trinity fish populations of the Klamath River.

#142

Harvest and Quality Control of Aphanizomenon flos-aquae (Cyanobacteria) by Simplexity Health for Human Dietary Use.

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In western cultures, certain cyanobacteria have for about 30 years been an accepted source of microalgal biomass for food. Beginning in the early 1980's, Aphanizomenon flos-aquae (AFA) was adopted for similar use. The only known commercial harvesting of AFA is from Upper Klamath Lake, the largest freshwater lake in Oregon. Procedures for removal of detritus and mineral materials, and those for monitoring and reducing the amounts of certain contaminants that can produce cyanotoxins, have become a very important part of Simplexity Health's harvesting process. Meticulous quality control standards and good manufacturing practices for making nutritional supplements for human consumption are priorities for the company.

#154

Using Archaeological Fish Remains to Determine Species of Anadromous Salmon and Trout in the Upper Klamath Basin before Hydropower Development

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Fish remains from archaeological sites represent an important source of knowledge about pre-development species distribution. The archaeological record of salmonids in the Upper Klamath Basin illustrates this value particularly well, given: a) major habitat destruction occurred prior to any systematic biological surveys; b) the difficulty in distinguishing salmonid species using historic records; and c) the magnitude of the issues involved associated with restoration efforts. A pilot study of Upper Klamath archaeological fish remains using mtDNA and stable isotope analysis ($^{13}C/^{12}C$; $^{15}N/^{14}N$) was undertaken to evaluate whether these tools could identify salmonid species and migratory patterns. Seven archaeological salmonid remains from the Beatty Curve site (35KL95) (between 1600 and 120 yrs old) were analyzed. Polymerase Chain Reaction (PCR) analysis focused on short sections --one from Cytochrome B and a section from the D-Loop. Amplified sequences compared to published salmonid species sequences closely match two species: *Oncorhynchus tshawytscha* (Chinook salmon) and *O. mykiss* (steelhead/rainbow trout). Because *O. mykiss* includes both an anadromous and resident freshwater form, to establish whether the archaeological samples represent sea-run fish, we obtained ratios of stable carbon and nitrogen, which are distinctive of adult residence habitat (freshwater vs. marine). All the samples showed a strong marine signal, indicating anadromous life history. Our pilot project demonstrates that at least two species of salmonids, Chinook and steelhead trout, occupied the Upper Klamath prior to major historic habitat losses; and more generally highlights the need to incorporate study of archaeological fish remains in conservation biology and habitat restoration efforts.