

Elwha Science Conference Abstracts

**Note: Number in parenthesis is the ordered poster number or the concurrent session in which an oral presentation will be given. Abstracts that apply to both an oral presentation and a poster are indicated.*

NEARSHORE SEDIMENT DYNAMICS AND BENTHIC INVERTEBRATE COMMUNITIES IN ELWHA AND DUNGENESS DRIFT CELLS

[oral session 3A]

Helle Andersen, David Parks, and Jeff Cordell; Coastal Watershed Institute, Port Angeles, WA (HA), Department of Natural Resources, Port Angeles, WA (DP), University of Washington, Seattle, WA (JC).

Hydrodynamic and sediment processes are important drivers of nearshore processes of the Salish Sea, including the invertebrate communities that form the basis of the complex food web that supports numerous species of salmon, forage fish, and birds deemed critical to Pacific Northwest ecosystems. Disruptions of sediment processes, a significant limiting factor of the region, can change substrate size, significantly impacting invertebrate communities and the larger marine ecosystem. Two studies are currently being conducted in the marine nearshore that characterize the seasonal changes in beach particle size distribution and topographic profiles. The purposes of the studies are to estimate changes in beach sediment storage in Elwha and Dungeness drift cells and the effects the sediment changes and dynamics have on the benthic invertebrate communities. These data will provide important information on how sediment and sediment dynamics define habitat functions for the benthic community and also establish a present-day baseline of the nearshore benthic invertebrate communities. The results will be available to compare to changes in community structures that may occur after the dam removal and the expected influx of sediment to the marine nearshore. The presentation will provide a short summary of the current status and preliminary results of the benthic invertebrate project, future sampling efforts, and data analyses.

INFLUENCE OF DAMS ON FLOODPLAIN DYNAMICS AND GRAIN SIZE DISTRIBUTIONS IN THE ELWHA RIVER, AND EXPECTED RESPONSES TO DAM REMOVAL

[oral session 3B]

Tim Beechie, Kris Kloehn, Sarah Morley, Holly Coe, and Jeff Duda; NOAA Fisheries, Northwest Fisheries Science Center, Seattle, WA (TB, KK, SM, HC), USGS Western Fisheries Science Center, Seattle, WA (JD).

The historical record of floodplain dynamics and the longitudinal pattern of grain size distributions in the Elwha River provide a baseline against which to measure key physical responses to dam removal. Based on historical aerial photography we found that the

percentage of floodplain surfaces >75 years old increased through time in reaches below the dams, was relatively stable in the Quinault reference reach, and fluctuated considerably in the upper Elwha reach (above both dams). Increasing age of the floodplain indicates decreased channel dynamics and channel narrowing downstream of the dams, and recent bankfull channel widths below the dams are approximately half that in the upper Elwha and Quinault reference reaches. The stable floodplain age structure in the Quinault reach reflects a long-term stability in channel migration rate, whereas fluctuations in the upper Elwha reach were primarily a result of a large landslide and dam-break flood in ~1968. Bed particle sizes in the main channel and side channels were much coarser immediately downstream of the dams than in reference reaches. However, particle sizes decreased rapidly with increasing distance from the dams, and particle sizes were within the natural range only 5 to 10 km downstream of the dams. Removal of the two Elwha dams will initially release fine sediment stored in the reservoirs, and in subsequent decades gravel bed load supply will increase and gradually return to natural levels. The release of fine sediments will initially create bi-modal grain size distributions in reaches downstream of the dams, and will likely result in considerable pool filling for a few years. Eventual recovery of natural sediment supply will likely widen channels to near reference reach widths, significantly increase lateral channel migration and erosion of floodplain surfaces, and gradually shift floodplain age distributions towards younger age classes.

ELWHA RIVER RESTORATION: ADAPTIVE SEDIMENT MANAGEMENT AND MONITORING PROGRAM

[oral session 1B; poster 16]

Jennifer Bountry, Tim Randle, Gary Smillie, Brian Cluer; Sedimentation and River Hydraulics Group, Technical Service Center, Bureau of Reclamation, Denver, CO (JB and TR), Water Operations Branch, National Park Service, Fort Collins, CO(GS), NOAA Fisheries, Santa Cruz, CA (BC).

The U.S. Department of the Interior is removing Elwha and Glines Canyon Dams on the Elwha River near Port Angeles, Washington to restore anadromous fish and the natural ecosystem. Elwha Dam, completed in 1913, forms Lake Aldwell. Glines Canyon Dam, completed in 1927, forms Lake Mills. These dams will be removed in controlled increments over a two to three-year period, beginning in September 2011. Reservoir sedimentation is estimated at approximately 24 million yd³. The sediment release impact period associated with dam removal is projected to last 3 to 5 years.

The sediment effects of dam removal were predicted based on a 1994 Lake Mills Drawdown Experiment, numerical modeling, and physical laboratory modeling. These predictions informed the design of mitigation measures for water quality and flood protection, including water treatment plants, new wells, a new surface water intake, raising the height of existing levees, and the construction of new levees.

During the first portions of dam removal it is expected that only fined grained sediments (silt and clay size range) will be released from the reservoir. Fine grained material will primarily be transported as suspended sediment and will cause spikes in turbidity concentration downstream. As the lakes are drawn down and the reservoirs become smaller and smaller, turbidity concentrations are expected to become larger with each increment of dam removal. Once dam removal is complete, turbidity levels downstream of the reservoirs are predicted to return to background levels relatively quickly. Coarse grained materials (sand size and larger) in the deltas of each reservoir are predicted to behave differently. No coarse grain sediment is predicted to leave the reservoirs until well into to the dam removal project. Delta sediments are predicted to advance downstream by eroding and redepositing in the remaining lake beds following dam removal increments. Only after the delta propagation downstream reaches the dam and attains a height equal to the remaining dam structure can coarse material be released from the reservoirs. Once introduced to the river downstream, the coarse sediments will primarily travel as bedload and may take a year or more to reach the sea depending on hydrology following dam removal.

These two dams are the largest yet removed in the world. Although the predictions from field tests, numerical modeling, and physical modeling converge, there is still uncertainty in river sedimentation and water quality. An adaptive management plan for sediment was developed to reduce uncertainty of the predicted results and ensure that the planned mitigations are adequate. In addition, reservoir drawdown will be halted during approximately 5 ½ months each year to minimize sediment impacts to adult fish entering the river as well as emigrating smolts.

The adaptive management plan relies on real-time and near real-time monitoring to verify if actual results agree with predictions within a certain tolerance. If necessary, additional actions would be taken to ensure that sediment impacts remain within tolerance. System-wide impacts would be addressed by slowing or temporarily halting dam removal until impacts are reduced within tolerance.

Monitoring will initially focus on the sediment erosion within the two reservoirs and on turbidity downstream from the two dams. Measures will be taken to ensure that the reservoir deltas are not incised by a single erosion channel along a reservoir margin. If necessary, delta erosion channels will be modified to erode and redistribute the delta sediments within each reservoir at the pace of dam removal. This will help ensure that sediments left in the reservoir after dam removal will be in a stable condition. Because of extensive vegetation growth, large wood deposits, and the delta channel being trapped along the right margin of Lake Mills, a center pilot channel was constructed in September 2010 to ensure two erodible banks. Monitoring of downstream riverbed aggradation will begin once sand and gravel-sized sediment eroded from the reservoirs are released into the downstream river channel.

A RIVERSCAPE PERSPECTIVE OF FISH AND HABITAT THROUGHOUT 45 MILES OF THE ELWHA RIVER PRIOR TO DAM REMOVAL

[oral session 1A]

Samuel J. Brenkman, Jeffrey J. Duda, Christian E. Torgersen, Ethan Welty, George R. Pess, Roger Peters and Michael L. McHenry; Olympic National Park, Port Angeles, WA (SB), U.S. Geological Survey Western Fisheries Research Center, Seattle, WA (JD), Forest and Rangeland Ecosystem Science Center, Cascadia Field Station, US Geological Survey and University of Washington, Seattle, WA (CT and EW), Northwest Fisheries Science Center, NOAA Fisheries, Seattle, WA (GP), U.S. Fish & Wildlife Service, Lacey, WA (RP), Fisheries Department, Lower Elwha Tribe, Port Angeles, WA (MH).

The removal of dams on the Elwha River provides a unique opportunity to restore 10 anadromous fish populations in a wilderness river. A key to understanding watershed recolonization is the collection of spatially continuous information on fish and aquatic habitats. In 2007 and 2008, 20 biologists conducted concurrent snorkel and habitat surveys throughout the Elwha to provide baseline information before dam removal. The riverscape approach characterized spatial extent, community structure, abundances, and densities of Pacific salmonids from the headwaters to the sea. Species richness was highest below the dams where anadromous salmonids still have access. Each year, the percent composition of salmonids over 65 rkm was nearly identical for rainbow trout (89%; 88%), Chinook salmon (8%; 9%), and bull trout (3% each year). In 2007, 7,312 trout, 687 Chinook, 215 bull trout, and 26 pink salmon were observed. Spatial patterns of abundance for trout ($r = 0.76$) and bull trout ($r = 0.70$) were consistent in 2007 and 2008. There were clear differences in major habitat features along the river profile. Longitudinal patterns of river fish in the Elwha were markedly different when compared to results from riverscape surveys in the nearby and undammed Quinault River. The riverscape approach in the Elwha provided a spatially comprehensive view of what fish and corresponding habitats were like before dam removal. The riverscape surveys highlighted species-specific biological hotspots and revealed high numbers of rainbow trout that may contribute to steelhead restoration. After dam removal, riverscape surveys can be used to identify the spatial extent of salmonid recolonizers and assess the proportion of, and habitat use by, hatchery (marked) and wild fish. In light of many upcoming dam removal projects in the western U.S., riverscape surveys that focus on collecting spatially continuous biological data will provide landscape context for understanding changes expected in fish communities.

THE MORPHODYNAMICS OF SEDIMENT MOVEMENT THROUGH A RESERVOIR DURING DAM REMOVAL

[oral session 1B; poster 15]

Chris Bromley, Colin Thorne, Gordon Grant, Timothy Randle; University of Nottingham, Nottingham, UK (CB, CT), Scottish Environment Protection Agency, Stirling, Scotland (CB), USFS

PNW Research Station, Corvallis, OR (GG), USBR Sedimentation and River Hydraulics Group, Denver, CO (TR).

The imminent removal of the Glines Canyon and Elwha dams from the Elwha River, WA, provided the inspiration for a series of physical modeling experiments whose objective was to further our understanding of the morphodynamics of sediment movement through the Glines Canyon Dam reservoir (Lake Mills) during dam removal. Each experiment involved hydraulically growing the delta and removing the dam (dropping local baselevel) in equal-sized increments, allowing the delta to erode and prograde to a static, or near-static, equilibrium between each increment. The size of the increments varied between experiments, as did the starting position of the delta surface channel. Results show that the volume of eroded delta sediment increased as the initial position of the incising channel moved from the left and right delta margins towards the center of the delta. This occurred because the evolution of the central channels was less affected by interaction with the asymmetrical reservoir basin boundary in the delta area and, as a result, was able to develop a more sinuous planform that eroded laterally into the delta terraces to a greater extent than the marginal channels. The volume of eroded delta sediment also increased with the magnitude of drop in baselevel, since a larger amount of potential energy was introduced to the delta surface at one time, thus more easily overcoming the resistance to erosion imparted by the armor layer. While the larger volumes of delta erosion associated with the central channel experiments reduced the size and height of the delta terraces, they also resulted in greater volumes of sediment being transported out of the model reservoir.

USING ARCHAEOLOGY AT THE TSE-WHIT-ZEN SITE (PORT ANGELES) TO EXAMINE ANIMAL & HUMAN RESPONSE TO EARTHQUAKES AND OTHER ENVIRONMENTAL CHANGES

[poster 6]

Virginia L. Butler, Kathryn A. Wojcik, Kristine M. Bovy, Sarah C. Campbell, Michael A. Etnier, Sarah L. Sterling; Portland State University, Portland, OR (VLB), Portland State University, Portland, OR (KAW), University of Rhode Island (KMB), Western Washington University, Bellingham, WA (SCC), Western Washington University, Bellingham, WA (MAE), Portland State University, Portland, OR (SLS).

Over the last decade, anthropological research on the impact of catastrophic environmental events has evolved from a relatively simplistic approach that assumed natural hazards such as earthquakes and volcanoes are disasters, to a more complex understanding of the social factors that affect cultural response such as food getting, settlement pattern, population density, sociopolitical complexity, technology, and experience with the event. Archaeology offers a unique opportunity to explore societal response to past environmental changes, through study of fine-scale changes in animal bone records, compared against independent records of environmental changes. The Tse-whit-zen archaeological site in Port Angeles provides an excellent test case to illustrate these values. The site was excavated with fine geo-stratigraphic

control, faunal preservation is outstanding, multiple houses were documented that show human occupation for varying times over the past 2000 years, and regional seismic records show that the environment experienced sizeable earthquakes and more subtle changes (such as climate change associated with the Medieval Climate Anomaly, and Ediz Hook development). Our research team is in the beginning phases of a pilot project to study the fauna (fish, birds, mammals, shellfish) from this important site to better understand the dynamic linkages between the environment and humans/animals. Besides the scientific value in studying the degree of resilience of people and animals in coping with drastic and more subtle environmental changes, our project hopes to contribute to long-term goals of the Lower Elwha Klallam Tribe in developing a museum and cultural center that honors the past and takes to the future the records and stories from this exceptional archaeological site.

ELWHA RIVER SEDIMENTS: PHOSPHORUS CHARACTERIZATION AND DYNAMICS UNDER DIVERSE ENVIRONMENTAL CONDITIONS

[poster 19]

Emily Cavaliere and Peter Homann; Department of Environmental Sciences, Huxley College of the Environment, Western Washington University, Bellingham, Washington (EC and PH).

Two large dams on the Elwha River, Olympic Peninsula, Washington, are scheduled for removal in 2011. Sediments that have accumulated in reservoirs behind these dams will be exposed to new physical and chemical conditions that will affect P distribution and availability in the oligotrophic river system. Coarse sediments from a reservoir delta and fine sediments from a reservoir bottom were analyzed for physical and chemical characteristics relevant to P availability. The fine sediments had 20 to 200% greater concentrations of C, N, amorphous Fe, Fe-bound P, Ca-bound P and organic P. Both sediment types had relatively low P concentrations compared with published values for eutrophic systems. Both fine and coarse sediments immobilized large quantities of added P, but fine sediments maintained dissolved P concentrations at half the level of coarse sediments. A 300 h incubation of sediments under diverse environmental conditions indicated released P was not affected by short-term exposure to oxygen. For coarse sediments, P release was greater in freshwater than saltwater throughout the incubation, for fine sediments this occurred only initially. Results of sediment characterizations are important in understanding potential post-dam conditions. Release of P from eroded and resuspended sediments will likely be of sufficient magnitude to increase downriver P concentrations and stimulate primary production of the periphyton. Ca-bound P in non-eroded dewatered sediments will likely be sufficient to meet the P demand of vascular vegetation that establishes in the new riparian zone.

POTENTIAL VEGETATION DEVELOPMENT IN TWO DRAINED RESERVOIRS AFTER DAM REMOVAL ON THE ELWHA RIVER: IMPLICATIONS FOR REVEGETATION

[oral session 3C, poster 19]

Joshua Chenoweth, Steve Acker, Kern Ewing, Rebecca Brown, Pat Shafroth; Olympic National Park, Port Angeles, WA (JC), Olympic National Park, Port Angeles, WA (SA), University of Washington, Seattle, WA (KE), Eastern Washington University, Cheney, WA (RB), USGS Fort Collins Science Center, Fort Collins, CO (PS).

The removal of Glines Canyon and Elwha dams will expose over 300 hectares of land. The disturbance caused by 100 years of inundation and sedimentation is severe. The reservoirs have accumulated more than 19 million m³ of fine and coarse-textured sediments. Dam removal will expose valley slopes covered in fine sediments, newly deposited terraces of coarse sediments, and developing floodplains. On most of these surfaces we anticipate the rate of recovery to be slow due to the size of the disturbed landscape and the lack of developed soil, seed banks, or other biological legacies. The density and diversity of seed rain should be high within 50 meters of the forest edge but is expected to diminish with distance. Species that regenerate successfully on valley slopes will need to be capable of establishing on fine sediments 0.3-1.5 meters deep, such as graminoids. On newly formed coarse terraces 6 to 18 meter deep, regeneration likely will be limited by sparse seed rain and low water availability. In the future floodplain, hydrochorous seed dispersal, water availability, and the deposition of vegetative fragments of willow and cottonwood from upstream should facilitate natural regeneration. At sites expected to regenerate slowly, a variety of revegetation prescriptions can accelerate native plant establishment. For example, native grasses will be seeded on fine sediments. During dam removal, *in situ* growth trials will determine which native woody species will succeed on fine-textured sediments. Species with fleshy fruits will be planted to attract birds, enhancing zoochorous seed rain. Large woody debris abundant along the dewatered shorelines will be re-distributed to create safe sites for seedlings. Dense plantings of fast-growing, early seral woody species will be planted to create the foundation for future forest development (facilitation patches). This project provides an opportunity to test revegetation methods derived from our understanding of plant succession.

LONGITUDINAL AND TEMPORAL VARIATION IN PLANT SPECIES RICHNESS ALONG THE ELWHA RIVER: EFFECTS OF DAMS AND RECENT FLOODING

[poster 28]

Aaron Clausen, Rebecca L. Brown, Patrick B. Shafroth; Eastern Washington University, Department of Biology, Cheney, WA (AC, RLB), U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO (PBS).

Riparian vegetation is heavily impacted by damming and, despite its ecological value and contribution to biodiversity, continues to be threatened. Plant diversity is dependent on seed transport, sediment supply, and particular flow and disturbance regimes. Because they interrupt or alter these processes, one might expect dams and floods to affect diversity. In 2005 we observed reduced vascular plant diversity below 64 m high Glines Canyon Dam and 33

m high Elwha Dam along the Elwha River, Olympic National Park, Washington; however, extreme flood events have since altered the system. To test whether the observed reduction in diversity persists, we studied the effects of these two dams again in 2010. In 2005, 61 100m² plots were established across a range of geomorphic landforms along 15 transects, located in river reaches upstream of, between, and downstream of the dams. Within each plot we noted each vascular plant species at various scales and recorded their percent cover, along with ground cover, sediment size, elevation, soil depth, and landform. These plots were resampled in 2010. Average species richness was compared among reaches and time periods. We observed 38% fewer native species downstream compared to upstream of both dams in 2005 ($P < 0.001$), and 26% fewer in 2010 ($P < 0.025$). In the intervening years there was an increase in exotic species richness of 220% downstream of both dams ($P < 0.01$) and 300% upstream ($P < 0.01$). These results suggest that dams may negatively affect native species diversity in the downstream reach. Further, this study shows that the pattern of decreased diversity we observed downstream from dams in 2005 persists, despite large flood events in the intervening years. Understanding pre-dam removal vegetation patterns over multiple years will provide baseline data to assess the effects of dam removal on riparian vegetation.

ARCHEOLOGICAL RESEARCH IN THE ELWHA VALLEY: HOW RIVER RESTORATION HAS CONTRIBUTED TO UNDERSTANDING NATIVE AMERICAN USE OF THE ELWHA WATERSHED.

[oral session 2C]

Dave Conca and Kim Kwarsick; Olympic National Park, Port Angeles, WA (DC, KK).

Olympic National Park Cultural Resource staff, with assistance from contractors and the Lower Elwha Klallam Tribe, has been working on archeological projects associated with removal of the Glines Canyon and Lower Elwha Dams since the mid-1990s. These studies, including inventory, test excavations, construction monitoring and analysis have added substantive knowledge regarding pre-contact and historic period use of the Elwha Valley. Data categories include archeological site distribution, lithic technological organization, and raw material procurement. Because these investigations were focused on a single watershed, these data provide an opportunity to discuss how Native American groups like the Lower Elwha Klallam Tribe have used the entire Elwha River Valley corridor throughout the Holocene. Additionally, these data are also used as a template for understanding pre-contact land use within other watersheds in the Olympic Mountains. Future archeological work associated with dam removal and restoration efforts will be discussed as it relates to these and other research domains.

UPDATE ON THE ELWHA RIVER MUSSEL (*MARGARITIFERA FALCATA*) POPULATIONS

[poster 24]

David Cowles, Patrick Crain, Molly Hallock, Layla Cole, and Larry Ward; Walla Walla University Department of Biology, College Place, WA (DC), Olympic National Park, Port Angeles, WA (PC),

Washington Department of Fish and Wildlife, Olympia, WA (MH), The Nature Conservancy, Lansing, MI (LC), Lower Elwha Klallam Tribe Fisheries, Port Angeles, WA (LW).

The Elwha River was surveyed in 2008 for the presence of freshwater mussels, which are potentially the largest invertebrates in the river. Several small remnant populations of the western pearlshell, *Margaritifera falcata*, an environmentally sensitive species which has a life cycle closely tied to Chinook salmon, were found in the lower river where some salmon still migrate, and many more were found in a side stream near the fish rearing ponds. At the time, the large majority of the mussels in the side stream were in imminent danger of destruction due to ongoing construction related to dam removal. In fall 2008 9765 of the side stream mussels were moved to several small tributaries of the lower river by a team from the Lower Elwha Klallam Tribe, Olympic National Park, Washington Department of Fish and Wildlife, Jamestown S'Klallam Tribe, USGS, USFWS, Western Washington University, Oregon State University, Peninsula College, and Walla Walla University. The small remaining mussel populations in the river are vulnerable to scour and sedimentation once dam removal starts. In 2010, as many individuals as could be located (121 individuals) from the largest and likely oldest of these populations just below Elwha Dam were removed from the river and transplanted to one of the tributaries the earlier population had been moved to. Some mussels remain both in the main channel of the river and in the side stream near the fish rearing ponds. Both these and the transplanted populations will be monitored over the next several years as the river system reverts to its free-flowing state.

VALUING ECOSYSTEM SERVICE BENEFITS FROM RESTORATION ALONG THE ELWHA RIVER

[poster 1]

Colleen Donovan, Anthony Dvarskas, Peter Edwards, David Chapman, Megan Lawson; NOAA Assessment and Restoration Division, Sandy Hook, NJ (AD), NOAA Office of Habitat Conservation, Silver Spring, MD (PE), Stratus Consulting, Boulder, CO (CD, DC, ML).

NOAA's Office of Habitat Conservation (NMFS) and Assessment and Restoration Division (NOS) have embarked on a pilot project to identify and value ecosystem services associated with the Elwha River Dam removal and floodplain habitat restoration. This study will explore the linkages between ecological functioning and societal values for ecosystem services. NOAA, in collaboration with project partners, is in the process of refining appropriate scenarios for describing current ecological functions and expected changes to those functions based on the proposed restoration activities. A choice experiment approach will be used to estimate consumer surplus associated with changes in key ecosystem services and environmental quality as a result of the restoration effort. The survey instrument is being developed and will integrate ecological and economic information into the design. The selection of appropriate ecosystem service attributes including, among others, wetland area, salmon production, and recreational opportunities, is currently underway.

This poster will highlight the survey design elements being developed to elucidate public preferences for ecosystem services associated with the restored river and floodplain. The poster will focus on the attribute selection and policy scenario development steps, including linkages between ecological production function changes and ecosystem services endpoints. The study is expected to provide answers for relevant policy questions such as the effect on the public's welfare from dam removal and floodplain restoration, as well as the effect on potential resource users' welfare from the changes in ecological function and cultural and recreational opportunities, including the importance of tribal activities.

CHANNEL EVOLUTION ON THE DAMMED ELWHA RIVER, 1939 TO 2010

[oral session 3B, poster 17]

Amy E. Draut, Joshua B. Logan, and Mark C. Mastin; USGS Pacific Coastal and Marine Science Center, Santa Cruz, CA (AED, JBL), USGS Washington Water Science Center, Tacoma, WA (MCM).

Like many rivers in the western U.S., the Elwha River, Washington, has changed substantially over the past century in response to natural and human forcing. In preparation for studying the effects of dam removal, we present a comprehensive field and aerial photographic analysis of dam influence on this anabranching, gravel-bed river. Over the past century with the dams in place, loss of the upstream sediment supply has caused spatial variations in the sedimentary and geomorphic character of the lower Elwha River channel. Bed sediment is armored and better sorted than on the naturally evolving bed upstream of the dams. On time scales of flood seasons, the channel immediately below Elwha Dam is fairly stable, but progresses toward greater mobility downstream such that the lowermost portion of the river responded to a recent 40-year flood with bank erosion and bed-elevation changes on a scale approaching that of the natural channel above the dams. In general, channel mobility in the lowest 4 km of the Elwha River has not decreased substantially with time. Enough fine sediment remains in the floodplain that—given sufficient flood forcing—the channel position, sinuosity, and braiding index change substantially. The processes by which this river accesses new fine sediment below the dams (rapid migration into noncohesive banks and avulsion of new channels) allow it to compensate for loss of upstream sediment supply more readily than would a dammed river with cohesive banks or a more limited supply of alluvium. Dam removal will provide a valuable opportunity to evaluate channel response to the future restoration of natural upstream sediment supply.

RESULTS OF ARCHEOLOGICAL INVESTIGATIONS RELATED TO THE ELWHA RIVER RESTORATION

[poster 5]

Matthew Dubeau and Davina Miller; Olympic National Park, Port Angeles, WA (MD, DM).

From the restoration of natural phenomena in the Elwha River Valley an opportunity has arisen to investigate the valley's cultural history through archeology. In 2009 Northwest Archaeological Associates surveyed 209 acres of land along the Elwha River that will likely be impacted by removal of the Elwha and Glines Canyon dams. During the course of these investigations, three previously documented archeological sites were re-evaluated and seven new sites were recorded. These sites reflect historic use of the Elwha River Valley associated with dam construction and operation, as well as prehistoric use of the Valley by Native Americans. Six of these sites are recommended eligible for the National Register of Historic Places.

Historic sites associated with dam construction, which contain a variety of domestic and industrial materials, can provide insight into daily life in construction worker camps in the early twentieth century, as well as the technological constraints of industrial construction during this period.

Prehistoric sites in the interior Olympic Peninsula are primarily composed of the byproducts of stone tool manufacture, called lithic debitage. Formed tools, such as projectile points, knives and scrapers, are typically much less common. The sites recorded during the course of this study exhibit a high degree of variability in terms of overall site area, artifact density, artifact type, and stone tool material type.

Prior to this project, discovery of sites in river valleys had been fleeting due to poor ground visibility and high soil deposition. Focused subsurface survey of the Elwha watershed has enhanced our ability to locate archeological sites in relation to dynamic river valley landforms.

CARBON AND NITROGEN STABLE ISOTOPES IN ELWHA RIVER AQUATIC FOOD WEBS PRIOR TO DAM REMOVAL

[poster 20]

Jeffrey J. Duda, Sarah A. Morley, Holly J. Coe, Michael L. McHenry, Schuyler Dunphy; USGS Western Fisheries Science Center, Seattle, WA (JD); NOAA Fisheries, Northwest Fisheries Science Center, Seattle, WA (SM, HC); Lower Elwha Klallam Tribe (MM); University of Washington (SD)

We measured carbon and nitrogen stable isotopes ratios in Elwha River aquatic food webs to document the effects of two dams prior to their removal. Stable isotope methods are commonly used in freshwater and terrestrial ecosystems to document the movement and magnitude of marine-derived nutrients derived from spawning salmon and their carcasses. Our approach was two-fold. We conducted an assessment of stable isotope ratios in tissues of primary producers, benthic macroinvertebrates, and fish from areas above, between, and below the dams. We also conducted a field experiment by measuring stable isotopes in these

same trophic groups before, during, and after the addition of salmon carcasses in side channels between the two dams and downstream of the lower dam. In the mensurative study, we found that in sites where salmon still have access, $\delta^{15}\text{N}$ was significantly higher in fish, stoneflies, black flies, periphyton, and macroalgae. Fish and stoneflies were also enriched in $\delta^{13}\text{C}$, but these values were more variable than for $\delta^{15}\text{N}$. For some taxa, there were also differences among areas between and above the dams – sections of the river that lack salmon – suggesting that other factors may be structuring longitudinal profiles of isotope ratios in the Elwha River aquatic food webs. In the carcass addition study, we observed elevated $\delta^{15}\text{N}$ values in treatment reaches for multiple species, with the timing, magnitude, and persistence of this signal varying by trophic position. Periphyton $\delta^{15}\text{N}$ was significantly elevated 1 and 2 months post carcass placement, algae-grazing mayflies from 1-3 months post placement, predatory stoneflies 2-3 months post placement, and juvenile *Oncorhynchus mykiss* 3 months post. The biggest increase in $\delta^{15}\text{N}$ was observed for periphyton with values twice as high as for reference reaches, while *O. mykiss* $\delta^{15}\text{N}$ increased 30%. The removal of these dams and the return of salmon populations to their former spawning grounds could alter the stable isotope values that we documented. Additional studies following salmon recolonization will facilitate a more mechanistic understanding of how marine nutrients affect freshwater productivity, and do so in the context of monitoring a major watershed restoration effort.

THERMAL REGIMES AND THE DISTRIBUTION AND ABUNDANCE OF NATIVE BULL TROUT AND NONNATIVE BROOK TROUT PRIOR TO DAM REMOVAL IN THE ELWHA RIVER ECOSYSTEM

[poster 21]

Jason Dunham, Steven Clark, David Hockman-Wert, Nathan Chelgren, Sam Brenkman, Michael Heck, and Robert Hoffman; USGS Forest and Rangeland Ecosystem Science Center, Corvallis, OR (JD, SC, DH-W, NC, MH, RH), Olympic National Park, Port Angeles, WA (SB).

In anticipation of the Elwha River dam removals, we have been monitoring presence and abundance of fishes with a focus on native bull trout (a threatened species) and nonnative brook trout. How do these species influence each other? How will they respond to changes in the river's floodplain and colonization by salmon after more than a century of isolation? What habitats are most important for these species? To set the stage for addressing these questions and provide a baseline for evaluation of ecosystem responses to dam removal, we have completed an extensive survey of fish and habitat conditions in the river and its associated floodplain and tributaries. Study sites within the system include locations below both dams, between the dams, and upstream of dams. Fish sampling has involved a combination of electrofishing and daytime snorkeling. Fish surveys in 2009 and 2010 covered 59 sites sampled with repeat surveys to estimate probabilities of detection, presence, and abundance. We have also modeled relationships between these estimates and habitat conditions and potential for biotic interactions among species. In addition to fish, we analyzed water temperatures to evaluate their sensitivity to atmospheric versus hydrological influences. Our results suggest that temperatures in larger mainstream and fluvial floodplain channels are less sensitive to

atmospheric influences, whereas tributaries are highly sensitive. In contrast to these habitat types parafluvial floodplain channels show high variability in their sensitivity. We suspect that subsurface influences often dominate the thermal regime of these habitats (e.g., hyporheic or groundwater fluxes). The relationship between floodplain habitats and thermal sensitivity, and influence of temperature on fish has helped us understand bull trout and nonnative brook trout in the system and set the stage for future evaluations of how the river, its thermal regime, and its fish fauna may respond to changes related to dam removal.

METHODS USED TO ASSESS EFFECTS OF ELWHA DAM REMOVALS ON SHALLOW, SUBTIDAL BENTHIC COMMUNITIES.

[poster 8]

Nancy Elder, Steve Rubin, Ian Miller, Reg Reisenbichler, and Jeff Duda; USGS Marrowstone Marine Station, Nordland, WA (NE), USGS Western Fisheries Research Center, Seattle, WA (SR, RR, JD), Washington Sea Grant, Port Angeles, WA (IM).

The impending removal of the Elwha River dams will affect marine habitats when sediments that have accumulated behind the dams for over 95 years are transported to the Strait of Juan de Fuca. To monitor changes in Elwha nearshore communities, a survey method was needed to quantify benthic macroalgae, macroinvertebrates, and fish, as well as substrate composition and seafloor relief. We adapted survey protocols developed by the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) for monitoring ecosystems associated with rocky reef habitats. Data were collected by scuba divers on 30 meter-long transects. Organisms were counted in swaths of fixed width to estimate the density of conspicuous, solitary and mobile invertebrates as well as specific macroalgae and fish. Data on presence or absence at uniformly spaced points were collected to estimate percent cover of encrusting or colonial species as well as sea floor attributes such sediment grain size. Surveys were initiated in 2008 at sites near the Elwha River mouth and at more distant reference sites expected to be minimally affected by dam removal.

EVALUATING IMPLICATIONS OF REMOVAL OF THE ELWHA DAMS ON FISH ASSOCIATED WITH INTERTIDAL AND SHALLOW SUBTIDAL HABITATS IN THE STRAIT OF JUAN DE FUCA

[oral session 3A]

Kurt L. Fresh, Anna N. Kagley, Josh Chamberlin, Larry Ward, Doug Morrill, Nichole Sather, and Kinsey Frick; NOAA Fisheries, NWFSC, Seattle, WA (KLF, AK, JC, KF), Lower Elwha Klallam Tribe, Port Angeles, WA (LW, NS), PNNL, Sequim, WA (NS).

Removal of two dams on the Elwha River, Washington will help restore natural sediment processes to the coastal environment near the river mouth. The goal of our research investigation is to evaluate responses of fish associated in shallow subtidal and intertidal

habitats because these areas function as spawning and rearing habitat for many fish species, including ecologically important forage fish and federally protected species of Pacific salmon. Since 2006, our data collection efforts have focused on species composition and size distribution of the intertidal/subtidal fish community in the Eastern and Central Strait of Juan de Fuca. Potential reference sites and impacted sites (where sediment changes are expected to occur) were sampled on a monthly basis from April to September using a beach seine and collections will continue following dam removal. We found over 45 species of fish, mostly juvenile stages, using this portion of the Strait of Juan de Fuca. Species composition can be segregated into two primary groups- species occurring in the water column and species associated with the benthos. The water column species tended to be very abundant and included both migrants (e.g., juvenile salmon) and residents (e.g., surf smelt). Although the same species tended to be present each year, they often exhibited dramatic interannual variability in abundance, suggesting the importance of using multiple years of data to evaluate changes in the nearshore fish community. Impact and reference areas exhibited some significant differences and we found strong seasonality in the fish assemblage structure. Our results suggest the useful indicators of changes in the nearshore fish community following dam removal include: 1) numbers of species, 2) species diversity, 3) composition and sizes of benthic species, 4) abundance by life history stage of surf smelt, and 5) presence of migratory species such as juvenile salmon.

DISPERSAL OF FINE SEDIMENT FROM THE ELWHA RIVER – THE POTENTIAL EFFECTS OF DAM REMOVAL ON COASTAL TURBIDITY AND SEDIMENTATION.

[oral session 2B, poster 12]

Guy Gelfenbaum, Jonathan Warrick, and Andrew Stevens; USGS Pacific Coastal and Marine Science Center, Santa Cruz, CA.

Dam removal on the Elwha River will increase suspended-sediment concentrations and turbidity of river outflow to the coastal waters of the Strait of Juan de Fuca. Here we combine observations of the currents, waves, and the buoyant river plume of the Elwha River with numerical modeling of the region's hydrodynamics to evaluate the extent and implications of the restoration of sediment discharge to the coastal waters. Currents offshore of the river mouth are adequately strong to influence the direction of the buoyant river plume – and thus the initial dispersal direction of fine sediment – from the Elwha River. Currents are also strongly influenced by the coastal headland of the delta; during both flooding and ebbing currents ~1 km scale eddies develop on the downstream side of the delta headland. These regular eddies strongly influence the initial outflow direction of the river discharge, which is toward the east much more frequently than toward the west. The sediment discharged toward the east of the river mouth will likely stay in suspension or move frequently, however, owing to the strong currents east of the river mouth. The fine sediment discharged toward the west, in contrast, should be more likely to deposit and accumulate on the seafloor, owing to the relatively weak currents between the river mouth and Freshwater Bay. These predictions will

be evaluated and tested with observations of sediment transport and seafloor change during and following the dam removal.

GEOMORPHIC PROCESSES AND POTENTIAL RESTORATION ACTIONS IN THE ELWHA RIVER ESTUARY AND NEARSHORE

[poster 14]

Eliza Ghitis, Tim Abbe, Dave Shreffler, Mike McHenry, Doug Morrill; Cardno ENTRIX, Seattle, WA (EG, TA), Shreffler Environmental, Sequim, WA (DS), Lower Elwha Klallam Tribe, Port Angeles, WA (MM, DM).

The last century has brought about dramatic loss of critical habitat in the Elwha River estuary and nearshore due to the construction of the Elwha and Glines Canyon dams, straightening of the river channel and placement of levees in the floodplain. These modifications resulted in beach erosion, coarsening river and shore substrates, decreased off-channel habitat, and simplification of tidal networks. Changes in the estuary were analyzed in the context of anticipated geomorphic response to dam removal and potential restoration opportunities. Beach profile surveys from 1996 to 2010 reveal that while overall trends are toward erosion, the foreshore position is very dynamic. Within cycles of accretion and erosion, large portions of river sediment discharge moved through the nearshore and into the Strait of Juan de Fuca, with a net loss of 51,000 cubic yards of material. The review of lower river channel dynamics was based on historical aerial photographs since 1939, 2009 LiDAR data, and previous channel migration studies. Overall lateral channel movement since 1939 was in the order of tens to hundreds of meters. Between 1939 and 2009 average channel width in the lower river decreased by 55 percent and outlet width was reduced by 65 percent due to levees and roads in the floodplain. Multiple historical river outlets to the shore were limited to a single outlet and the number of active side channels decreased. Restoration concepts were developed to address the cumulative effects of human alterations, to minimize short-term negative impacts during the initial geomorphic response period to dam removal and to make optimal use of the newly available upstream sediment and wood supply to the estuary and nearshore. The suite of options included activation of additional distributary river outlets to the delta, forested buffers for floodplain levees, engineered log jams, beach nourishment and structural driftwood enhancement.

MOVEMENT AND HABITAT SELECTION PATTERNS OF BLACK BEARS IN THE ELWHA VALLEY PRIOR TO DAM REMOVAL AND ECOSYSTEM RESTORATION IN THE ELWHA VALLEY, WASHINGTON

[poster 26]

Patricia Happe, Kim Sager-Fradkin, Kurt Jenkins. Olympic National Park, Port Angeles, WA (PH), USGS Forest and Rangeland Ecosystem Science Center, Port Angeles, WA (KJ, KS), Lower Elwha Klallam Tribe, Port Angeles, WA (KS).

Removal of two hydroelectric dams and restoration of anadromous fishes in Washington's Elwha River Ecosystem provides a unique opportunity to improve understanding the role of anadromous fish runs in influencing black bear movement and habitat selection patterns. Dam removal is expected to restore 7 species of native salmonids, potentially providing a rich and predictable food resource for black bears during autumn prior to denning. We captured and equipped 18 black bears with transmitter collars that has GPS units and gathered detailed information on yearly movement patterns of bears from 2002-2006. In addition, we used hair snares and DNA analysis to estimate minimum number and sex of bears using riparian areas during the spring and fall, from 2006-2008. We will discuss seasonal habitat selection and altitudinal movements and discuss potential changes in black bear use of the valley following fish restoration.

RIPARIAN MAMMAL AND AMPHIBIAN COMMUNITIES PRIOR TO DAM REMOVAL AND ECOSYSTEM RESTORATION IN THE ELWHA VALLEY, WASHINGTON

[oral session 2A]

Kurt Jenkins, Nathan Chelgren, Michael Adams, Patricia Happe, Kimberly Sager-Fradkin, Steven Perakis; USGS Forest and Rangeland Ecosystem Science Center, Port Angeles, WA (KJ, KS-F), USGS Forest and Rangeland Ecosystem Science Center, Corvallis, OR (NC, MA, SP), Olympic National Park, Port Angeles, WA (PH), Lower Elwha Klallam Tribe, Port Angeles, WA (KS-F).

Removal of two hydroelectric dams and restoration of anadromous fishes in Washington's Elwha River Ecosystem provides a unique opportunity to improve understanding of habitat and trophic effects associated with dam removal on riparian faunal communities in the Pacific Northwest. Dam removal beginning this week is expected to alter channel dynamics and habitat characteristics in the riparian zone, and restoration of salmon that have been missing from the upper river for 100 years is expected to alter nutrient dynamics in riverine and riparian ecosystems. We developed a multi-species monitoring program to document current and future patterns in species occupancy, community composition, and species richness of mammal and amphibian communities in the Elwha River riparian zone. We examined patterns in species occupancy and community richness across unregulated (above dams) and regulated (below dams) river segments that also lack (above dams) or support (below dams) anadromous fishes. Species richness was derived from Bayesian multi-scale occupancy models. We will discuss present patterns in the distributions of individual species and species richness and discuss potential changes in species distributions following river restoration.

AN OVERVIEW OF ELWHA RIVER HYDROLOGY AND ITS ROLE IN ECOSYSTEM RESTORATION

[oral session 1B]

Christopher P. Konrad; U.S. Geological Survey, Tacoma, Washington.

The hydrology of the Elwha River has been investigated for over a century. While the motivation for hydrologic investigations has evolved over time from basic characterization of streamflow regime to prediction of river responses to dam removal, the cumulative result is a rather complete understanding of streamflow and its role in transporting sediment out to the Strait of Juan de Fuca. Annual runoff from the basin averages about 2 m. The river has a bimodal hydrologic regime, with storm flow and floods in late autumn and winter in response to large Pacific storms and sustained high flows as the snowpack melts during spring and summer. Most of the runoff from the basin is generated above Glines Canyon where about 70 percent of the basin area produced about 85 percent of streamflow. Historically, operations of the dams have had little effect on the magnitude of floods, which generally are about 16 percent larger and as much as 45 percent larger at McDonald bridge gage than above Lake Mills. Upstream of Lake Mills, the annual sediment load of the river is about 330,000 Mg/yr with over 90 percent of the load delivered by flows greater than 85 cms, which occur only 10 percent of the time. Only about 15 percent of the sediment load from the upper river passes through Lake Mills – all of which is fine-grained material in suspension. The river has ample capacity to transport the sediment deposited in the reservoirs provided it can continue to access these deposits once the dams have been removed from the channel. Channel incision and progressive migration of the channel will isolate some of the reservoir sediments leaving terraces. The river will routinely transport and deposit more sediment in the channel restoring a fluvial process fundamental to the structure and dynamics of the river ecosystem.

MANUFACTURING A NEW HYDROSCAPE ERA: SEMANTICS OF RESTORATION IN THE ELWHA WATERS

[oral session 2C]

Enrique Lanz Oca, Graduate Center, City University of New York (C.U.N.Y.), New York.

Dams have made America. Through dams, private and public agencies have manufactured new landscapes and ideologies of nature. In the 1840s, Lowell, Massachusetts became the first place in the country with a concentration of industry when its first hydropower system was installed. But it was Hoover Dam, built in the 1930s, that signaled the beginning of a massive physical transformation of the river landscape. F.D. Roosevelt envisioned it as a modern and nationalist symbol with which America could control nature, overcome its enemies, and propel the economy out of a depression. When the Glen Canyon Dam was built, 30 years later, however, public opinion had changed about dams. And nowadays, dams are removed in a similar public spirit in which they were once built. The Elwha Project in Washington State is the largest dam removal in history, and its removal may spur other demolitions such as the Condit,

Klamath, or Snake River dams. Although many dams will remain, I demonstrate the dam removals are part of a new radical transformation of the American energy landscape. Based on interviews, primary and secondary sources, and direct observation, this paper examines how this new waterscape is being constructed and imagined. If the Federal Government represented Hoover as a tool of domination and nationalism, the Elwha Project is posited as an ecological restoration. Although the concept of restoration is not appropriate, the Government perpetuates it, I argue, to convince Americans that if we built the colossal Hoover during an economic depression, we, as a nation, are still capable of such largess.

IMAGING SONAR BASED ESCAPEMENT ESTIMATION FOR SMALL SALMON POPULATIONS: THE ELWHA RIVER AS A CASE STUDY.

[poster 22]

Martin Liermann, Keith Denton and Dan Rawding; Northwest Fisheries Science Center / NOAA Seattle, WA (ML, KD), Washington Department of Fish and Wildlife Region 5, Vancouver, WA (DR).

Stock specific escapement estimates are an essential part of salmon and steelhead management in the Pacific Northwest. Popular visual escapement methods such as Area-Under-the-Curve (AUC), peak count expansion, and redd counts are widely implemented but are believed to often have high measurement error. Here we investigate the feasibility of imaging sonar-based escapement estimates for small salmon and steelhead populations in Washington State. While imaging sonar has been used for escapement estimation for large high value populations in Alaska and British Columbia for over a decade, it is not immediately obvious that this technology will be cost effective for small populations. However, with a steady improvement in the necessary technology and decrease in costs relative to other approaches, we believe that this escapement estimation approach may provide an attractive alternative for some small populations. We use the Elwha River as a case study along with characteristics of several representative Washington Rivers to investigate this hypothesis. Factors we consider include, 1) errors introduced through species identification in rivers with overlapping run timing for multiple species, 2) the availability of sites with good acoustic characteristics, access, security, and power options, 3) the estimated error in sonar based escapement estimates relative to the current visual approaches, and 4) the estimated cost of a sonar based approach relative to the alternatives. While the cost of buying and operating sonar for escapement estimation still limits its applicability in smaller systems, for cases where traditional methods fail (e.g. high turbidity during spawning) or the stock is of particular importance (e.g. index or ESA listed stocks) sonar may provide an attractive alternative.

MONITORING OF SUSPENDED-SEDIMENT LOAD IN THE LOWER ELWHA RIVER, WASHINGTON, USA, DURING THE FIRST TWO YEARS OF DAM REMOVAL

[oral session 1B]

Christopher S. Magirl, Christopher A. Curran, Christiana R. Czuba, and Mathieu D. Marineau: U.S. Geological Survey, Washington Water Science Center, 934 Broadway, Suite 300, Tacoma, WA 98402, United States (CM, CC, CC, MM).

An understanding of the movement and redistribution of sediment during and after the removal of two large dams on the Elwha River, Washington, will be needed to explain how the restoration project affected the biological and physical processes of the river system. The U.S. Geological Survey (USGS) and collaborating partners have installed a suite of sediment-monitoring instruments at a new USGS gaging station (#12046260, Elwha River at Diversion near Port Angeles, Washington) located at the water-diversion weir downstream of Elwha Dam. Turbidity will be monitored continuously using two instruments designed to provide measurements under both low- and high-turbidity conditions. A laser in-situ scattering and transmissometry instrument will measure both the mean suspended-sediment grain size and the total suspended-sediment concentration. Finally, a side-scanning hydroacoustic instrument will quantify both acoustic backscatter and acoustic attenuation. Correlations between suspended-sediment concentrations from discrete physical measurements and turbidity, acoustic backscatter, and acoustic attenuation data will be developed to produce a continuous record of suspended-sediment load carried by the lower Elwha River during the dam-removal process through 2013. Although knowledge of suspended-sediment concentrations and transport will be of considerable value during the early stages of the dam-removal project, this sediment-monitoring strategy will not involve quantifying bedload transport. In addition, the strategy will not quantify background sediment load in the Elwha River upstream of the removal project or sediment load in the river between the dams. Ideally, these additional datasets would be collected to determine a complete sediment budget for the duration of the dam-removal project.

USE OF A FLOATING WEIR TO ASSESS SALMONIDS IN THE ELWHA RIVER PRIOR TO DAM REMOVAL

[oral session 1A]

Kent Mayer, Mara Zimmerman, Sam Brenkman, Jeff Duda, Mike McHenry, George Pess, Roger Peters; Washington Department of Fish and Wildlife [WDFW], Port Angeles, WA (KM), WDFW, Olympia, WA (MZ), Olympic National Park, Port Angeles WA (SB), USGS Western Fisheries Science Center, Seattle, WA (JD), Lower Elwha Klallam Tribe, Port Angeles, WA (MM), NOAA Fisheries, Seattle, WA (GP), U.S. Fish and Wildlife Service, Lacey, WA (RP).

Removal of the Elwha and Glines Canyon Dams on the Elwha River is scheduled to begin in the fall of 2011. Most salmonid species in the Elwha River are ESA-listed (Chinook, steelhead, bull trout), at critically low levels (pink, chum), or extirpated (sockeye). Enumeration of anadromous salmon, trout, and char is needed to assess fish response to dam removal and the floating

provides data to adaptively manage the recovery of salmonid populations in the Elwha. The main goal of the Elwha weir project is to evaluate trends in abundance and diversity of Chinook salmon *Oncorhynchus tshawytscha* and steelhead trout *O. mykiss* in the Elwha before, during and after dam removal. In 2010, we installed and operated the first resistance board floating weir in the Elwha River. Biological information was collected from all salmon, trout, and char captured at the weir, which was fished between September 9 and October 9, 2010, at river kilometer 5.9 (river mile 3.7). Over this 30-day period, Chinook salmon, pink salmon *O. gorbuscha*, steelhead, sockeye salmon *O. nerka*, bull trout *Salvelinus confluentus*, coho salmon *O. kisutch*, chum salmon *O. keta*, and coastal cutthroat trout *O. clarki clarki* were captured. All eight species were captured within the first two weeks of weir operation. The majority (70.0%) of the female Chinook salmon captured were 5 years of age, whereas the majority (78.3%) of males were 2, 3, and 4 years of age at spawning. Scale data indicated that most (98.3%) of the spawning Chinook salmon migrated to the ocean as sub-yearlings. Mean fork length of male Chinook salmon was longer than females in the same age class. A combination of weir and SONAR technology should result in abundance estimates for winter steelhead. The weir was operated in April-May 2011 and began the 2011 summer/fall trapping season in August.

RESULTS OF 12 YEARS OF HABITAT RESTORATION IN THE LOWER ELWHA RIVER AND PREPARATION FOR DAM REMOVAL

[oral session 3B]

Mike McHenry and Tim Abbe; Lower Elwha Klallam Tribe, Port Angeles, WA (MM), Cardno ENTRIX, Seattle, WA (TA),

Over the last century the lower 3 miles of the Elwha River have been impacted by deforestation, channelization, dike construction and construction of the Elwha and Glines Canyon dams that interrupted the supply of wood and sediment to the lower river. In the 1990s the lower Elwha River was characterized by a single large meandering channel with little or no in-stream structure, a very coarse cobble substrate and few perennial side channels. Beginning in 1999, the Lower Elwha Klallam Tribe began to place engineered logjams (ELJs) into the river to create pools with complex cover to provide refugia for both juvenile and adult salmonids. The ELJ restoration strategy expanded as the ELJ structures demonstrated their ability to partition shear stress and locally decrease the bed material grain size to sizes more conducive to spawning, an effect particularly of interest when we were uncertain about when the dams would be removed. As of 2011 a total of 44 ELJs have been constructed in the river between River Mile 1 and 3. The ELJ placements have induced some very positive changes in the river that include: 1) creation and maintenance of pools, 2) an increase in shaded complex cover, 3) reduced bed material grain size, 4) retention of sediment within bars and islands created by the structures, 5) an increase of invertebrates where ELJs have been placed, 6) retention of more organic material, 7) increases in local water elevations that have improved floodplain and side channel connectivity, 8) transformation from a single thread to an anabranching channel, and 9) triggering of natural wood recruitment by deflection of river flow and creation of new channels.

ENGAGING BIRDS IN ELWHA VEGETATION RESTORATION

[oral session 2A]

John McLaughlin; Huxley College, Western Washington University, Bellingham, WA.

Establishing native vegetation in the two drained reservoirs represents both opportunities and challenges to Elwha restoration. Draining the two reservoirs will expose nearly 800 acres of accumulated sediment, which may provide area to restore native forest, substrate for exotic plant invasion, or unstable terraces of eroding sediment. Terrestrial animals often are considered beneficiaries of vegetation restoration, but some may act as agents of restoration. This presentation focuses on one of the most important restoration roles of terrestrial animals: dispersal of native seeds by birds. Birds are potentially important to Elwha forest restoration due to their flight and foraging behaviors. Birds are known to disperse seeds of 23 (59%) of 39 native woody plants common in the Elwha's early seral communities.

Although many bird species are active in floodplain habitats, American Robins appear to be the most important potential seed disperser for restoration. Robins fly frequently between seed sources in established forests and open habitats, while most other birds remain within a particular habitat type.

My objective was to evaluate several hypotheses for bird-dispersed seed distributions. Causal factors in these hypotheses included: proximity to existing forest, distance from river channels, floodplain vegetation characteristics, and large woody debris (LWD) characteristics. I measured avian scat deposition along randomly located transects in the Geyser Valley Floodplain and in the Lake Mills reservoir delta. I fit linear and nonlinear models to scat data, and evaluated model fit using Akaike's Information Criterion. Most bird-dispersed seeds were found on or adjacent to LWD, particularly large logs and debris piles. I found little empirical support for other hypotheses. These results suggest birds can increase the anticipated slow rate of natural vegetation establishment in reservoir beds. Revegetation programs can leverage birds as restoration agents by locating or retaining LWD where fruit-bearing plants are desired.

COMMUNICATING SCIENCE: BRIDGING THE GAP

[poster 4]

John R. McMillan, National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, WA

Photography provides a means of distilling the otherwise complex results of contemporary ecological science into images that capture the essence and value of river restoration. While quantitative science is certainly the most robust way to assess pre- and post-river restoration conditions, it is also difficult for non-scientific audiences to quickly visually assess and grasp the

meaning of complex tables and figures. River restoration projects are ideal candidates for photographic documentation because they offer the opportunity to record pre- and post-restoration river characteristics and salmon abundance and diversity. Here photography was used as part of the pre- and post-dam removal monitoring on the Elwha River dam removal project. The photography focuses on documenting the small populations of spawning adult salmon that have survived in the lower five miles of river, waiting for two high dams to be removed and subsequent access to an additional 75 miles of available habitat. Despite a truncated distribution, reduced abundance and diversity, the fish have remained resilient in a consistently tenuous situation. During the fall of 2009 the salmon returned in relative abundance to the section of the lower Elwha River known as the Hunt Channel. For a brief period of time the Elwha was --- being filled with spawning salmon and brimming with underwater life --- as it was for thousands of years prior to the dams. Combining these types of images with data provides a means of integrating the beauty of ecology into the science of restoration.

REMOVAL OF ELWHA AND GLINES DAMS – REVISITING BENEFITS

Philip Meyer, Meyer Resources, Inc., Davis CA

[oral session 2C]

The Elwha Project Human Effects Team (1995) identified benefits from removal of Elwha and Glines dams - 507,000 added visitor trips per year to Clallam County- up to 2,000 jobs during construction phases of the project – another 446 long term jobs for county workers.

Updating to July, 2011 dollars, annual economic benefits associated with dam removal are:

- Annual net business benefits associated with commercial and sport fishing: \$5.1 million.
- Annual business revenue from recreation and tourism: \$42.2 million.
- Annual business profits associated with recreation and tourism: \$5.7 million.

Loomis identified that Washington residents associated an additional \$94 million in annual “satisfaction” benefits, above monies paid or received, with removal of the Elwha dams. In 2011 dollars, this increases to \$139 million. The Elwha Human Effects Team concluded:

Crediting even miniscule proportions (one half of one percent or more) of the non-market benefits from removing both dams reported by Loomis (1995) yields a positive benefit-cost ratio under all (dam removal) discounting scenarios.

The Lower Elwha Klallam Tribe, suffering from high rates of unemployment will benefit substantially from return of the salmon. But tribal values transcend the statistics presented above. The Elwha is a salmon Treaty river – and stands at the center of tribal life ways.

Our Creator gave us the fish to live on...and we cherished it, and we respected it, we used every bit of it... I may not see the abundance of fish come back in my lifetime, but I would like to see it come back for my grandchildren, my great-grandchildren, and the rest of my people, the following generations to come. It was a gift from our Creator, it was our culture and heritage (Beatrice Charles, Lower Elwha Klallam Elder).

SEED RAIN AND REVEGETATION OF EXPOSED SUBSTRATES FOLLOWING DAM REMOVAL ON THE ELWHA RIVER

[oral session 3C]

James Michel, James Helfield, David Hooper; Western Washington University, Bellingham, WA (JM, JH, DH).

Scheduled to begin in 2011, the removal of two dams on the Elwha River, Washington, will be one of the largest dam removal and river restoration projects undertaken in the United States. One challenge associated with this project is to understand how exposure and downstream deposition of sediments presently detained behind the dams will influence patterns of revegetation and invasive species colonization following dam removal. We conducted two greenhouse experiments assessing the potential effects of reservoir sediments on germination success and growth of (1) propagules dispersed naturally via seed rain, and (2) seeds of selected native and invasive species. Observed summer seed rain density was relatively low (<125 seeds m⁻²). This suggests slow recolonization in the initial years following dam removal, although these results may have been influenced by sampling methods and timing. In the selected species experiment, four out of five tested species exhibited reduced germination and growth on fine reservoir sediments, while the invasive forb *Cirsium arvense* was unaffected. Though reduced compared to more typical alluvial sediments, germination and growth of the natives *Artemisia suksdorfii* and *Rubus parviflorus* were comparable to that of *C. arvense* on reservoir sediments. These native species may be useful for revegetating exposed sediments. However, depending on such factors as source population sizes, seed production and dispersal rates, growth rates, water availability and competition during establishment, control of *C. arvense* and other exotics in the years following dam removal may be necessary to prevent a relative increase in invasive species populations on the new post-dam substrates.

THE ELWHA DELTA: SHRINKING OR GROWING?

[oral session 3B]

Ian Miller, Jon Warrick, Andrew Stevens, and Guy Gelfenbaum; UC Santa Cruz, Santa Cruz, CA and WA Sea Grant, Port Angeles, WA (IM), USGS Pacific Coastal and Marine Science Center, Santa Cruz, CA (JW), USGS Pacific Coastal and Marine Science Center, Menlo Park, CA (AS and GG).

Chronic erosion on the sub-aerial shoreline fringing the Elwha River delta on the Strait of Juan de Fuca in Washington State is well documented. Mean beach erosion rates of 0.6 m/yr (measured between 1939-2006) are frequently attributed to the emplacement of two dams on the Elwha River in 1913 and 1925. The impending removal of the two dams, slated to begin in September 2011, could provide an additional 28,000 to 80,000 m³/yr of coarse sediment to the coastal zone. Here we present the results of an analysis of annually-collected topography and bathymetry data set. Data were collected on the beach and in the near-coastal zone with an RTK-DGPS system, mounted either on a backpack or on a jet-ski. Digital elevation models were constructed and annual differences calculated. Results suggest that the Elwha River typically delivers more sediment to the coastal zone than is transported away from the river mouth, and that sediment is retained in the river mouth bar and accretion is primarily sub-tidal. Rates of volumetric change in the Elwha River mouth region range from -21000 ± 24000 m³/yr to 30000 ± 24000 m³/yr, with the total change between September 2007 and May 2011 estimated to be 54000 ± 12000 m³. Our results, which point to accretion in the river mouth area even as adjacent beaches and sub-tidal areas erode, suggest that a simple model of coastal response to dam removal (i.e. remove the dams and the sub-aerial shoreline responds) may need to be revised. This large dam-removal provides an exceptional natural laboratory in which to test models of coastal response to new additions of sediment.

COARSE SEDIMENT MOVEMENT ON THE MIXED GRAINS SIZE BEACH OF THE ELWHA DELTA

[poster 11]

Ian Miller, Russell Means, and Jon Warrick; UC Santa Cruz, Santa Cruz, CA and WA Sea Grant, Port Angeles, WA (IM), Peninsula College (RM), USGS Pacific Coastal and Marine Science Center, Santa Cruz, CA (JW)

The removal of two dams on the Elwha River is expected to deliver between 153,000 and 1.1 million m³ of coarse sediment (sand, gravel and cobble) to the lower river and coastal zone within a few years. Predicting the transport of this material is of importance to understanding how the removal of the impoundments may influence beach and delta morphology. This investigation utilized a novel application of Radio Frequency Identifier (RFID) technology to track coarse sediment on the mixed grain size beach of the Elwha delta over weeks to months. Clasts implanted with radio frequency identifier (RFID) tags were released at an elevation of 1.9 m (MLLW) in August of 2009 at three sites on the Elwha delta and surveyed approximately monthly for >3 months. The distance travelled of tagged sediment over the study period varied from >500 m to < 1 m. Clast movements are paired with sediment characteristics across samples to evaluate the role of breaking wave angle in beach sediment transport.

ELWHA AQUATIC FOODWEB RESEARCH: BASELINE, EXPERIMENTAL, AND FUTURE DATASETS

[oral session 2A]

Sarah Morley, Jeffrey Duda, Holly Coe, Michael McHenry, Kristopher Kloehn, Brian Beckman, Schuyler Dunphy, and George Pess; NOAA Northwest Fisheries Science Center, Seattle, WA (SM, HC, BB, GP), USGS Western Fisheries Research Center, Seattle, WA (JD), Lower Elwha Klallam Tribe, Port Angeles, WA (MM), University of Victoria (KK), University of Washington (SD).

Primary and secondary producers are vital to the structure and function of aquatic ecosystems, are sensitive to changes associated with river impoundment, and have rapid response and recovery timelines well suited to capturing ecological response to dam removal. Over the last decade we have conducted a series of related studies examining how the Elwha dams have affected primary and secondary producers, how these patterns may change following dam removal, and what such changes will mean to fish. From 2004-2006, we collected data on water chemistry, stable isotope ratios, and periphyton and benthic invertebrate assemblages from 52 study sites distributed across the river basin. Water chemistry analyses confirmed earlier reports that the river is oligotrophic, while $\delta^{15}\text{N}$ was significantly higher in fish, stoneflies, black flies, and algae where salmon still have access. We found that periphyton biomass was consistently higher in regulated than unregulated sections and that benthic invertebrate composition at sites above both dams was distinct from sites between and below. From 2006-2008 we conducted a nutrient limitation and salmon carcass addition experiment to better understand how future re-colonization by salmon will affect river productivity. We found that nitrogen and phosphorus co-limit aquatic primary productivity during most times of the year. Following carcass placement, periphyton growth rates and $\delta^{15}\text{N}$ values of juvenile salmon were significantly elevated in treatment reaches relative to reference reaches. In 2010, we began incorporating data on invertebrate drift and juvenile salmonid diet into our overall monitoring plan to better track short and long-term foodweb responses to dam removal. The extended timeline predicted for Elwha River recovery and the complexities of forecasting ecological response highlights the need for more long-term assessments of dam removal and river restoration practices in general.

THE ELWHA NEARSHORE: AN OVERVIEW

[poster 9]

Tara Morrow, Clinton Stipek, Anne Shaffer, Chris Byrnes, Barbara Blackie, and Dwight Barry; Huxley College of the Environment on the Peninsulas, Port Angeles, WA, (TM), University of Washington, Seattle WA (CS), Coastal Watershed Institute, Port Angeles, WA (AS), Washington Department of Fish and Wildlife, Port Angeles, WA (CB), Huxley College of the Environment on the Peninsulas, Port Angeles, WA (BB, DB).

The Elwha nearshore encompasses approximately 12 linear shoreline miles including the Elwha drift cell which stretches from the west entrance of Freshwater Bay east to the tip of Ediz Hook. It consists of five distinct geomorphic habitat landform types of lower river and estuary,

embayed shoreline, feeder bluffs and spit. It is defined as extending from the area of tidal influence, including the riparian zone, out to 30 meters Mean Lower Low Water (MLLW) depth. The Elwha River is one of the dominant rivers on the Olympic Peninsula and has functional linkages to the Strait of Juan de Fuca including providing rearing and migration for juvenile salmon and migration and spawning habitat for forage fish. The Strait is a major conduit linking coastal regions to the inner Salish Sea. Sediment processes from feeder bluffs and the river are defining features of the Elwha nearshore. These processes are currently disrupted by the dams, shoreline armoring and diking, which significantly disrupt sediment and wood delivery to the nearshore. Although approximately 7.5 million cubic meters of coarse and fine sediment are expected to be delivered to the Elwha nearshore after dam removal, this will only partially restore the function of the nearshore. Additional restoration plans such as augmenting the Elwha bluffs to optimize sediment delivery, restoring hydrologic connectivity to the estuary, and incorporating adaptive management actions are necessary for optimal restoration of the nearshore and successful recovery of the sediment starved central Strait of Juan de Fuca and the ecosystem it supports.

FINE-GRAINED SEDIMENT DISPERSAL FROM THE ELWHA RIVER, PRESENT AND FUTURE, AND EXPECTATIONS FOR SEABED CHANGES NEAR THE MOUTH OF THE ELWHA RIVER IN THE COASTAL STRAIT OF JUAN DE FUCA

[oral session 2B]

Andrea S. Ogston, Charles A. Nittrouer, Kristen M. Lee; School of Oceanography, University of Washington, Seattle, WA 98195 (AO, CN, KL).

The 72-km Elwha River originates in the Olympic Mountain Range and dams at 8 and 22-km from its mouth are about to undergo removal. We hypothesize that prior to damming, sediment gravity flows were a dispersal mechanism for sediment and associated chemical constituents, and a dominant progradation process of the delta. Baseline observations of present sediment-transport processes were obtained under various river discharge conditions, and include seabed characterization, nearshore currents, water-column structure and suspended-sediment concentrations. The time series of sediment resuspension and transport in ~20-m water depth explored relationships between sediment delivery by the Elwha River and oceanic processes (including winds, waves, tides, and currents) operating in the Strait of Juan de Fuca. We deduce that sediment dispersal under present, restricted supply is broad and most of the fine-grained sediment likely leaves the vicinity of the delta topset. The little that does get temporarily deposited during floods is resuspended and moved away from the nearshore during storms. The active processes have winnowed the seabed creating a coarse lag layer ranging from sand to cobble size. This layer is ubiquitous over much of the subaqueous delta, although regions with some fine-grained sediment are found near the river mouth and trapped between the paleo-spits on the eastern delta topset. And thus, anthropogenic changes in the sediment supply to the nearshore have led to a new phase of delta evolution - specifically one of net erosion. This baseline research provided a framework for future coring and process studies to understand sediment budgets offshore of small

mountainous rivers. It also allows us to develop predictions for seabed changes near the mouth of the Elwha River during the dam removal period when river-supplied sediment concentrations are expected to be elevated enough to induce sediment gravity flows in the Strait of Juan de Fuca.

RECREATIONAL BENEFITS OF RIVERS RESTORED THROUGH DAM REMOVAL

[poster 2]

Thomas O'Keefe and Megan Hooker; American Whitewater, Seattle, WA (TOK), Portland, OR (MH).

Over the past five years a number of dams have been removed throughout the Pacific Northwest, reconnecting riparian ecosystems that include the Clark Fork (MT), Bear (ID), Rogue, Sandy, and Hood Rivers (OR), and Trout Creek (WA). The upcoming removal of Condit Dam on the White Salmon and the Elwha and Glines Canyon Dams on the Elwha River will restore additional river miles in the region. While the fishery and ecosystem benefits of restoring these rivers have been well documented, these projects also afford significant recreational benefits. American Whitewater has completed an overview of these projects throughout the region, which quantifies project size as a function of mean annual discharge relative to reservoir volume. Our overview also includes a photographic record of the dams and the resulting river channel following removal. Additionally, while dams throughout the Pacific Northwest and the country are coming down, many are here to stay. Full restoration through dam removal may not be an option in these cases, however there is still opportunity for restoration through modifying operating regimes. To illustrate this, we will present a conceptual model that demonstrates how recreational flows, fishery flows, and geomorphic process flows have been integrated to benefit river health. Overall, our review and related poster offers insight into the benefits of river restoration efforts throughout the region and how a comprehensive case, which includes recreation, can be built for dam removal or improved operations.

BASELINE OBSERVATIONS OF BEACH CROSS-SHORE TOPOGRAPHY AND SEDIMENT GRAIN-SIZE DISTRIBUTION IN THE ELWHA AND DUNGENESS DRIFT CELLS

[poster 10]

David Parks, Helle Andersen; Washington Department of Natural Resources, Port Angeles, WA (DP) , Coastal Watershed Institute, Port Angeles, WA (HA).

Beach cross-shore topography and sediment grain-size distribution play an important role in habitat forming processes for many species of marine fish and invertebrates. Construction of two dams on the Elwha river and shoreline armoring of coastal bluffs between the Elwha River and Ediz Hook have reduced the supply of sediment to the nearshore resulting in shoreline erosion and coarsening of beach sediments. The pending removal of the two Elwha dams will

likely restore a portion of the historic sediment supply to nearshore beaches. Evaluation of the role that future contributions of sediment from the Elwha River may play in changing beach topography and sediment size requires pre-dam removal observations of seasonal changes in beach topography and sediment grain-size distributions. Seasonal changes in beach topography and grain-size occur from seasonal changes in wind intensity and direction which in turn affect the size and direction of waves that transport sediment both across and along beaches. This study observes bi-monthly changes in cross-shore beach topographic profiles and grain-size distributions at eight respective locations in the Elwha and Dungeness drift cells between July, 2010 and July, 2011. Observation sites are distributed across a range of drift cell conditions (source, transport and sink) and include armored and un-armored beach profiles. The resulting data demonstrate the range and frequency of seasonal changes in beach profiles and grain-size distributions across the Elwha and Dungeness drift cells and will help inform a companion invertebrate study (Andersen, et al., 2011) examining the relationships between nearshore sediment dynamics and invertebrate community composition. These data may also provide useful baseline observations with which to evaluate future contributions of sediment to the nearshore from the removal of two dams on the Elwha River.

THE IMPORTANCE OF FLOODPLAIN CHANNELS IN THE ELWHA RIVER DAM REMOVAL

[oral session 3B]

George Pess, Mike McHenry, Sarah Morley, Martin Liermann, John McMillan, Keith Denton, Tim Beechie, Jeffrey Duda, Roger Peters, and Sam Brenkman; NOAA-NWFSC, Seattle, WA (GP), Lower Elwha Tribe (MM), NOAA-NWFSC, Seattle, WA (SM), NOAA-NWFSC, Seattle, WA (ML), NOAA-NWFSC, Seattle, WA (JM), NOAA-NWFSC, Seattle, WA (KD), NOAA-NWFSC, Seattle, WA (TB), USGS Western Fisheries Science Center, Seattle, WA (JD), USWFS, Lacey, WA (RP), NPS-ONP Port Angeles, WA (SB)

On September 17 of 2011, a 2.5 year deconstruction of two long-standing, high-head dams will begin on the Elwha River of the Olympic Peninsula, Washington State. Over the past decade, a variety of ecosystem related information (e.g., fish, riparian, in-stream habitat, and stream productivity) has been collected in the Elwha River basin to establish baseline conditions prior to one of the largest watershed and salmon restoration projects in North America. The design of these studies is based upon the geomorphic template of the watershed, as different channel types are expected to respond differently to the large amount of sediment that will be released as a result of dam removal. For example, we anticipate that floodplain channels will attenuate the impacts of sediment and provide biological refuges after dam removal. Over the last decade the group of scientists from several state, federal, and tribal organizations have collaborated to identify the most important questions and develop adequate study designs that can answer these questions such as how will salmon populations respond to the removal of large-scale, long-term barriers to migration and utilize these floodplain channels? How will these same populations react to the large amount of sediment that will be released in combination with the large amount of pristine habitat that will be re-connected? Our ultimate goal is to quantify the ecological "signal" following dam removal in the Elwha River basin, in order to better tell the

story of this unique watershed restoration and share critical findings with other dam removal projects.

DISTRIBUTION, DENSITY, AND POTENTIAL FUNCTIONAL LINKAGES OF LARGE WOODY DEBRIS IN THE ELWHA NEARSHORE

Samantha Rich; University of Illinois at Urbana-Champaign.

[poster 18]

Large Woody Debris (LWD) is an important part of the marine ecosystem in that it is a base component of physical processes that form critical habitats for numerous fish species such as endangered salmon and forage fish including smelt and sand lance. The Elwha drift cell, a naturally sediment rich system, has been sediment starved for close to a century as the dams, dikes and shoreline armoring along it have kept back not only sediment, but also the large wood that would have naturally made its way into the Strait of Juan de Fuca. Little is currently known about large wood in the nearshore system, including the Elwha. Given the upcoming dam removals there is a need to define baseline parameters of LWD in Elwha and comparable drift cells to establish benchmarks for what restoration might look like, and make predictions of the Elwha's future state.

This study looks at the function of the current distribution and density of LWD deposition on riparian and nearshore ecosystems in the Elwha. This study aims to examine unmodified comparable landforms as well as accessing the historical information available about the Elwha's pre-dam state. Questions I am addressing are: 1. How much nearshore habitat would a normal volume of Large Woody Debris provide, and;

2. What is the current LWD of the Elwha nearshore. Key sampling parameters include a qualitative description of LWD with an emphasis on location on the beach, general composition, configuration and size. Linkages between LWD's biological functions within the intertidal Elwha nearshore will be illustrated as well.

RIVER-DEPENDENT BIRD SURVEYS PRIOR TO ELWHA RIVER DAM REMOVALS

[poster 27]

Melanie Roed and Barbara Blackie; Huxley on the Peninsulas/Western Washington University Port Angeles, WA (MR, BB), Peninsula College, Port Angeles, WA (BB).

The upcoming removal of the Elwha dams, with consequent return of anadromous fish, is anticipated to cause changes that reverberate through trophic levels. All life stages of salmon provide a direct food source to various species of birds. The presence of spawning fish leads to changes in populations of macroinvertebrates that further impacts benthic feeders. Surveys were conducted in the 1990s to estimate pre-dam removal densities of five species of birds (harlequin ducks (*Histrionicus histrionicus*) American dippers (*Cinclus mexicanus*) common mergansers (*Mergus merganser*), belted kingfishers (*Ceryle alcyon*) and spotted sandpipers (*Actitis macularia*)) using non-intrusive, easily repeatable survey methods. In 2009 a subset of surveys were repeated to a) reestablish a pre-dam baseline estimate of relative density, b) identify any major shifts in relative densities since 1997 and c) test the assumptions that the surveys will be able to detect changes in bird use during and after dam removal. We compare the 1996-97 survey data on the Elwha and Duckabush Rivers for two of the species surveyed, harlequin ducks and American dippers. Using our current method, we detected a statistically insignificant and small decrease in harlequin duck relative abundance over the 12-year time period and a slight increase in dippers on some reaches. These data are noisy but potentially useful as a monitoring tool for post-removal comparisons, especially if correlated with parallel studies of fish, macroinvertebrates and mesocarnivores. We briefly discuss alternative potential analyses and modification of survey methods that would improve the statistical analyses of future surveys.

SCUBA SURVEYS TO ASSESS EFFECTS OF ELWHA DAM REMOVAL ON SHALLOW, SUBTIDAL BENTHIC COMMUNITIES

[oral session 3A]

Steve Rubin, Ian Miller, Nancy Elder, Reg Reisenbichler, Rusty Rodriguez, Jeff Duda, Rob Pedersen, Mike McHenry, and Matt Beirne; USGS Western Fisheries Research Center, Seattle, WA (SR, RR, RR, JD), UC Santa Cruz, Santa Cruz, CA and WA Sea Grant, Port Angeles, WA (IM), USGS Western Fisheries Research Center Marrowstone Marine Station, Nordland, WA (NE), USEPA Region 10 Environmental Cleanup Office, Seattle, WA (RP), Lower Elwha Klallam Tribe (MM, MB).

The impending removal of the Elwha River dams will affect marine habitats when sediments that have accumulated behind the dams for nearly 100 years are transported to the Strait of Juan de Fuca. Deposited and suspended sediments can have a variety of effects on marine plants and animals including burial, inhibition of propagule settlement, light reduction affecting plant growth, damage to animal gills and filter feeding structures, and alteration of interactions among species with different tolerances and responses to sediment. The initial large sediment influx from release of accumulations in the reservoirs may stress nearshore communities, but in the long run communities may benefit from reestablishment of sediment delivery from the upper watershed. Scuba surveys were initiated in 2008 to characterize nearshore biological communities prior to dam removal. Community structure in the Elwha nearshore (west Freshwater Bay to the base of Ediz Hook) was partly controlled by substrate composition and

seafloor relief. Kelp density was low in sandy areas, intermediate on gravel-cobble substrates, and highest on bedrock or boulder reefs. Taxa richness (number of kelp, invertebrate, and fish taxa) was more strongly associated with seafloor relief than with substrate. Relief was usually provided by scattered boulders perched on top of mixed sand and gravel-cobble substrate. On average, 12 (59%) more taxa occurred where boulders were present compared to areas lacking boulders but with similar base substrate. The presence of boulders allowed species adapted to rocky reefs to coexist with species that inhabit sand and gravel-cobble substrates, thereby increasing species richness. These results highlight the importance of seafloor characteristics and suggest that different habitats and associated communities may respond differently to sedimentation. Elwha nearshore communities will continue to be surveyed during and after dam removal. Measuring community responses to short and long term changes in deposited and suspended sediments offers an unprecedented opportunity to gain insight relevant to managing these important marine resources.

IMPACT OF ELWHA RIVER RESTORATION ON RIVER-DEPENDENT SPECIES: RIVER OTTERS AND AMERICAN DIPPERS (POSTER)

[poster 25]

Kim Sager-Fradkin, Peter Marra, Kurt Jenkins, and Patti Happe; Lower Elwha Klallam Tribe, Port Angeles, WA (KS-F), Smithsonian Conservation Biology Institute, Washington, DC (PM), USGS Forest and Rangeland Ecosystem Science Center, Port Angeles, WA (KJ), Olympic National Park, Port Angeles, WA (PH).

River otters (*Lontra canadensis*) and American dippers (*Cinclus mexicanus*) are both representative species of the river-obligate mammalian and avian taxa found in the Elwha River ecosystem on Washington's Olympic Peninsula. Both species are considered to be indicators of ecosystem health, yet we know very little about their populations in the Elwha. In anticipation of removal of the Elwha dams, we have commenced a study of otters and dippers designed to document distribution, seasonal movement patterns, and dietary composition of marine-derived nutrients. Specifically, we are in the process of capturing both species below, between, and above the dams for the purposes of applying radio-tracking devices and collecting biological samples for stable isotope analysis. It is widely believed that restoration of salmon to the Elwha River will substantially alter the nutrient composition of the ecosystem, and because river otters and American dippers are so closely tied to the riverine environment, we expect that both species will be important indicators of river restoration. We will present information gathered to date, and will discuss the potential implications of our work, both for salmon and river restoration as a whole.

LONG TERM FISH USE OF THE ELWHA NEARSHORE

[oral session 3A]

Anne Shaffer, Chris Byrnes, Justin Brown, Tara Morrow, and Patrick Crain; Coastal Watershed Institute, Port Angeles, WA. (AS), Washington Department of Fish and Wildlife, Port Angeles, WA. (CB), University of Washington, Seattle, WA (JB), Western Washington University, Port Angeles, WA (TM), Olympic National Park, Port Angeles, WA (PC).

The nearshore is a complex and critical component of the Elwha ecosystem. Extending from the area of tidal influence, including the riparian zone, and out to 30 meters MLLW, the Elwha nearshore drift cell comprises approximately 11 linear miles of shoreline. Variability and sediment processes, severely disrupted due to shoreline armoring, lower river alterations, and in river dams, are two signature features of the Elwha nearshore. Detailed information on each, and a clear understanding of the linkages between the two are needed. Fish use in the Elwha nearshore has been documented to be variable with season, geomorphic landform, and species. Evidence suggests that at the drift cell scale, the Elwha nearshore is functioning at a significantly lower ecological level for fish use than other comparable intact drift cells. Habitat function has also been documented to be partitioned across the estuary. To better understand interannual variation in fish use of the Elwha nearshore as well as define sediment linkages to nearshore Elwha ecological functions, we initiated a long term fish use monitoring of the Elwha west estuary and comparative area. Beginning in 2005 and continuing to present we have conducted monthly beach seining in the Elwha west estuary. In this presentation we provide an overview of results to date, including seasonal trends in species richness, diversity, and densities of the Elwha west estuary, and how these results compare to observations in the comparative area. We also provide a discussion on key features of the Elwha estuary that will need to be closely monitored before, during, and following dam removal, as well as potential adaptive management for future restoration actions.

STRUCTURE, COMPOSITION, AND DIVERSITY OF FLOODPLAIN VEGETATION ALONG THE ELWHA RIVER.

[oral session 3C]

Patrick B. Shafroth, Chanoane Hartt, Laura G. Perry, Jeffrey B. Braatne, Rebecca L. Brown, Aaron Claussen; U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO (PBS, LGP), University of Idaho, Department of Fish and Wildlife Resources, Moscow, ID (CH, JBB), Colorado State University, Department of Biology, Fort Collins, CO (LGP), Eastern Washington University, Department of Biology, Cheney, WA (RLB, AC).

Floodplain vegetation dynamics and diversity in the Pacific Northwest are linked to flows of water, and fluxes of sediment and large woody debris. Dam removal on the Elwha River will alter these system drivers, inducing changes to floodplain vegetation. To evaluate these changes, we collected baseline data between 2003 and 2010 along five cross-valley transects in each of three reaches of the Elwha: above both dams (reference), between the dams, and downstream of both dams. Along each transect, we randomly selected nested tree, shrub, and

herbaceous vegetation quadrats within different vegetation types and sampled the vegetation composition, structure, age, and diversity. From 2003-2005, we sampled 138 tree, 275 shrub, and 120 herbaceous/diversity plots. Most plots were resampled in 2010. Environmental data included transect topography, quadrat elevations, and surficial soil particle size. We encountered approximately 13 tree, 30 shrub, and 150 herbaceous species along the transects. Young bar surfaces (5-20 yrs) were dominated by *Salix* spp., *Alnus rubra*, and *Populus trichocarpa* and had the highest species richness. Young floodplains (<80 yrs) comprised much of the Elwha bottomland and were generally dominated by *A. rubra* and sometimes by *P. trichocarpa*. High floodplain surfaces and terraces (>80 yrs) were often dominated by *Acer macrophyllum* with an understory of *Acer circinatum* and *Abies grandis*. *Pseudotsuga menziesii* occurred on young and older floodplains. Substantial geomorphic change has occurred recently within the mostly-braided reference reach, resulting in a large number of young *Salix*, *Alnus*, and *Populus* patches, as well as extensive, relatively unvegetated bars. The reach between the dams is quite stable with relatively few young vegetation patches and abundant, stable floodplain surfaces. The reach below both dams shows moderate channel and floodplain dynamics, especially as the valley widens in and near the delta. We conclude with predictions and hypotheses regarding post dam removal vegetation responses.

VEGETATION OF THE ELWHA RIVER ESTUARY

[poster 30]

Patrick B. Shafroth, Tracy L. Fuentes, Cynthia Pritekel, Matthew Beirne, and Vanessa B. Beauchamp; U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO (PBS), U.S. Geological Survey, Northwest Area, Seattle, WA (TLF), ASRC Management Services under contract to the U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO (CP), Lower Elwha Klallam Tribe, Port Angeles, WA (MB), Towson University, Department of Biological Sciences, Towson, MD (VBB).

The Elwha River estuary supports one of the most diverse coastal wetland complexes yet described in the Salish Sea region, in terms of vegetation types and plant species richness. Using a combination of aerial imagery and vegetation plot sampling, we identified six primary vegetation types and 121 plant species in a 39.7 ha area. Most of the estuary is dominated by woody vegetation types, with mixed riparian forest being the most abundant (20 ha), followed by riparian shrub (6.3 ha) and willow-alder forest (3.9 ha). The shrub-emergent marsh transition vegetation type was fourth most abundant (2.2 ha), followed by dunegrass (1.75 ha) and emergent marsh (0.2 ha). We document the abundance, distribution, and floristics of these six vegetation types, including plant species richness, life form, species origin (native or introduced), and species wetland indicator status. Between 30 and 50 plant taxa occurred within each vegetation type, typically including several taxa unique to each type. Native species predominated, but approximately 37 percent of taxa were introduced. Introduced species were most common and abundant in the shrub-emergent marsh transition and dunegrass vegetation types. Plants in lower elevation plots were most likely to be categorized as obligately or

facultatively occurring in wetlands. These data will serve as a baseline to which future changes can be compared, following the impending removal of Glines Canyon and Elwha Dams upstream on the Elwha River. Dam removals may alter many of the processes, materials, and biotic interactions that influence the estuary plant communities, including hydrology, salinity, sediment and wood transport, nutrients, and plant-microbe interactions. Understanding how physical processes and environmental gradients interact with species dispersal, establishment, and survival would greatly improve our understanding of how Elwha estuary vegetation may respond to dam removals, and could be linked to physical process models to predict biological responses over time.

A GENETIC ANALYSIS COMPARING PINK SALMON IN THE ELWHA AND DUNGENESS RIVERS

[oral session 2A]

Maureen P. Small, Alice E. Fry, Jennifer Von Bargen and Sewall Young; Molecular Genetics Laboratory, Conservation Division, Washington Department of Fish and Wildlife, Olympia WA.

We assessed genotypes at 15 microsatellite loci in four collections of pink salmon from the Elwha and Dungeness rivers. Early and late run pink salmon from the Elwha River were genetically differentiated from each other and differentiated from early and late run pink salmon from the Dungeness River, suggesting that the Elwha River supports a native population of pink salmon. However, the like-timed run groups from the two rivers were more similar to each other than they were to the different-timed run group in the same river – e.g. early run pink salmon from the Elwha and Dungeness rivers were more similar to each other than early and late run pink salmon in the Elwha River. This indicates that, at least at this geographic scale (roughly 15 miles between river mouths), genetic structure in pink salmon is more influenced by run-timing than by spatial distance.

OTOLITH ANALYSIS OF CHINOOK SALMON IN THE ELWHA RIVER PRIOR TO DAM REMOVAL

[poster 23]

Karl Stenberg, Kim Larsen, Jeffrey Duda, Matt Beirne, Mike McHenry, Kurt Fresh, Anna Kagley, Josh Chamberlin and Anne Shaffer ; USGS - Western Fisheries Research Center, Seattle, WA (KS, KL, JD); ; The Lower Elwha Klallam Tribe, Fisheries, Port Angeles, WA (MB, MM); ; NOAA - Northwest Fisheries Science Center, Seattle, WA (KF, AK, JC); Coastal Watershed Institute (AS)

Puget Sound Chinook salmon have declined to precariously low levels (ESA threatened status) due to a variety of perturbations, including estuarine and coastal development. Juvenile fall Chinook salmon utilize a number of habitats as they migrate from their freshwater rearing areas to the open ocean. Estuaries are recognized as one important habitat because they provide a migratory corridor, protection from predators, and opportunity to forage, grow and

adapt to seawater. However, the importance of the Elwha River estuary and nearshore to Chinook salmon populations is relatively unknown.

We used otolith microstructure to examine the importance of the Elwha River estuary to juvenile Chinook by acquiring baseline information on habitat utilization, growth, and residence time prior to dam removal. The otolith microstructure revealed three distinct areas early in development associated with hatch, emergence and first feed, and two distinct areas associated with migration into estuarine and nearshore habitats. Growth, measured indirectly through mean increment width on the otolith, revealed an increase of 27 percent from freshwater habitat (3.20 microns) to lower estuary habitat (4.06 microns). The average size of juvenile Chinook salmon increased as they migrated successively among freshwater, estuary, and nearshore environments. The average estuarine residence time determined from Chinook captured in the nearshore habitat was 25 days. Wild-origin fish were mostly using the lower estuary habitat, whereas hatchery fish were mostly using nearshore habitat. Once in the Strait of Juan de Fuca, Elwha hatchery and wild juveniles migrated east and west. Seventy-six percent of the adult Chinook collected from the lower Elwha River in 2008 and ninety-six percent in 2009 were identified as hatchery fish (thermally marked otoliths).

THE ELWHA RIVER ESTUARY – AN OVERVIEW OF ITS MORPHOLOGY AND HYDROLOGY.

[oral session 2B]

Jonathan Warrick and Matt Beirne; USGS Pacific Coastal and Marine Science Center, Santa Cruz, CA (JW), Lower Elwha Klallam Tribe, Port Angeles, WA (MB).

At the mouth of the Elwha River, freshwater from the river mixes with saline waters of the Strait of Juan de Fuca creating estuarine habitats across a complex of coastal ponds, channels and nearshore waters. In this presentation we will introduce the recent history and geomorphic evolution of the Elwha estuary and present hydrologic data collected by the USGS and Lower Elwha Klallam Tribe (LEKT) that reveals patterns of water mixing within this estuary. The present estuary has been established through avulsions and meandering of the river and through direct manipulation of the channel by humans. Humans have altered the estuary directly through the construction of levees that have cut off the exchange of water, sediment and biota, and also through the two Elwha River dams that have reduced sediment discharge to this estuary. Coastal erosion – which is likely related to the dams – has resulted in the reduction in the size and extent of the estuarine wetlands. The Elwha River estuary continues to change through channel movement and redistribution of sediment from waves and other coastal processes. These changes in the morphology of the river mouth alter the hydraulics of water exchange throughout this estuary. For example, the exceptional river discharge event of December 2007 resulted in 7-8 m of lateral migration in the channel at the river mouth (Draut et al., 2011), and this resulted in much greater exchange of fresh and saline water through the eastern portion of the estuary. Future changes to the estuary will be monitored with continued sampling of the water, sediment and geomorphology of the river mouth estuary by the USGS and LEKT.

THE COASTAL RIVER PLUME OF THE ELWHA

[poster 13]

Jonathan Warrick and Andrew Stevens; USGS Pacific Coastal and Marine Science Center, Santa Cruz, CA (JW,AS).

The initial sediment dispersal from the Elwha River to the coastal waters of the Strait of Juan de Fuca will be influenced by the patterns and dynamics of the river's buoyant plume. The Elwha River provides a unique opportunity to study the effects of coastal topography on a buoyant plume, because it discharges into the Strait of Juan de Fuca on the western side of its deltaic headland. Here we show that this headland induces flow separation and transient eddies in the tidally-dominated currents ($O(100 \text{ cm/s})$), consistent with other headlands in oscillatory flow. These flow conditions are observed to strongly influence the buoyant river plume, as predicted by the "small-scale" or "narrow" dynamical classification using Garvine's (1995) system. Because of the transient eddies and the location of the river mouth on the headland, flow immediately offshore of the river mouth is directed eastward twice as frequently as it is westward. This results in a buoyant plume that is much more frequently "bent over" toward the east than the west. During bent over plume conditions, the plume was attached to the eastern shoreline while having a distinct, cusped front along its westernmost boundary. The location of the front was found to be related to the magnitude and direction of local flow during the preceding $O(1 \text{ hr})$, and increases in alongshore flow resulted in deeper freshwater mixing, stronger baroclinic anomalies, and stronger hugging of the coast. During bent over plume conditions, we suggest that significant convergence of river plume water toward the frontal boundary occurred in the initial 1 km from the river mouth. These results show how coastal topography can strongly influence buoyant plume behavior, and they should assist with understanding initial coastal sediment dispersal pathways from the Elwha River during the pending dam removal project.

RESIDENT RAINBOW TROUT POPULATIONS ARE GENETICALLY DIVERGENT FROM ONE ANOTHER AND FROM DOWNSTREAM ANADROMOUS STEELHEAD IN THE ELWHA RIVER

[oral session 1A]

Gary A. Winans and John Baker; Northwest Fisheries Science Center, Seattle, WA (GAW), Salmonmetrics, Mukilteo, WA (JB).

We highlight a study of the levels and patterns of genetic variability in rainbow trout collected above the two Elwha dams using 14 microsatellite markers. Data were available from fish tissues collected by various agencies from 2004 to 2007. Significant differences were seen between small, neighboring streams of rainbow trout; and between upstream trout and the extant population of anadromous steelhead downstream. We make comparisons with other

dammed populations of rainbow trout studied in the Pacific Northwest. The contribution of resident rainbow trout to recolonization of the upper Elwha River by steelhead can be studied with these markers. Variation at major histocompatibility loci and parr mark patterns is discussed.

PREDICTING SPREAD OF INVASIVE EXOTIC PLANTS INTO DE-WATERED RESERVOIRS OF THE ELWHA RIVER

[oral session 3C]

Andrea Woodward, Christian Torgersen, Joshua Chenoweth, Katherine Beirne, and Steve Acker; USGS Forest and Rangeland Ecosystem Science Center, Seattle, WA (AW, CT), Olympic National Park (JC, KB, SA).

The potential for dispersal of exotic invasive plants into the de-watered reservoirs following removal of two dams on the Elwha River, and consequent inhibition of native vegetation restoration, is of great concern. Because the reservoirs are not currently vegetated and adjacent locations of exotic plants have been treated, we focused on predicting long-distance dispersal rather than diffusive spread away from parent plants. We considered long-distance dispersal vectors (wind, water, birds, beavers, ungulates, and users of roads and trails) in relation to seven focal invasive taxa (*Cirsium arvense*, *Cytisus scoparius*, *Geranium robertianum*, *Hypericum perforatum*, *Lathyrus sylvestris*, *Phalaris arundinacea*, and *Rubus* spp.) These taxa were selected because they have great potential to do environmental harm and sufficient sample size in the area to support analysis. Using information about the surveyed or modeled spatial distribution of invasive species, vectors, and environmental variables we determined potential source areas and species-specific environmental relationships. We then identified high-priority areas within Olympic National Park for Park staff to treat prior to dam removal, and areas outside of park boundaries that require collaboration with the community or other agencies to minimize the spread of invasive species. We also predicted areas of the dewatered reservoirs at greatest risk for establishment of invasive exotic plants following dam removal.

ADELINE SMITH: THE STORY OF A KLALLAM GIRL GROWING UP ON THE ELWHA RIVER

[oral session 2C]

Jacilee Wray, Adeline Smith; Olympic National Park, Port Angeles, WA (JW), Elwha Klallam, Port Angeles, WA (AS).

Klallam Indian territory extended along the Strait of Juan de Fuca into Hood Canal, but the largest population of Klallam lived at the mouth of the Elwha River and upriver for at least 12 miles. The Treaty of Point No Point protected the Klallam's aboriginal fishing rights, among other rights. This was the major fishing source for the Elwha Klallam before the Elwha dams were constructed.

Soon after 1860, small numbers of settlers began homesteading in the lower part of the Elwha Valley. They claimed land on the broad flood plain near the river's mouth and continued to settle upriver until the entire valley was homesteaded. The Klallam were not permitted to homestead under the General Homestead Act of 1862 because a homesteader had to be a citizen of the United States. The first Indian homestead law was enacted in 1875, allowing Klallam families to acquire legal title to land in the Elwha Valley.

One such Klallam homestead was that of Hunter John, who willed his land to his daughter's, Emily Sampson and Sally Jackson, and to his grandson Charlie Sampson. Charlie is the father of Adeline Smith who has recalled much of her life story growing up on this homestead below the Elwha Bridge with her family and traveling to the beach at Freshwater Bay, Ediz Hook, and Agate Beach with her niece Beatrice Charles in the 1920s. This presentation recounts some of Adeline's early life on the Elwha.

THE ELWHA RIVER RESTORATION PROJECT AS A SIGNATURE EXAMPLE OF WHAT ENVIRONMENTAL RESTORATION SHOULD BE.

[Friday Morning]

Robert S. Young, Program for the Study of Developed Shorelines, Western Carolina University, Cullowhee, NC

The Society for Ecological Restoration International (SERI) has a very clear definition of environmental or ecological restoration should be: 1) The project should return the ecosystem to its historical trajectory; 2) It should reestablish a characteristic assemblage of species found in the native ecosystem; and 3) It should be sustainable. Sadly, many of this nation's largest and most expensive, large-scale ecological restoration projects do not meet this definition. So-called "beach restoration" has cost the country over \$6 Billion during the last four decades, but it does not meet the SERI definition of restoration on any level. Numerous, multi-billion dollar plans exist to implement large-scale ecological restoration of the wetlands and barrier islands of southern Louisiana, but these projects are not sustainable under today's regime of rapidly rising sea level. Even, the large-scale restoration of the Florida Everglades is looking increasingly cost-ineffective in light of the likelihood of future sea level rise.

On the other hand, the Elwha River Restoration Project meets all the criteria outlined by SERI for the guidance of sensible, meaningful ecological restoration. The project will clearly return an ecosystem to its historical trajectory. The land bordering the project is well-protected, lessening the possibility of future, unexpected ecosystem impacts. And, the chances for restoration of target species seems to be excellent. Finally, once restored, the ecosystem should have excellent prospects for long-term sustainability without continued, expensive management. In light of this, it is suggested that future, federal spending on ecological

restoration should look carefully at the recommended SERI criteria and focus taxpayer dollars on projects more like the Elwha project and less like the restoration of troubled barrier islands.

LEVERAGING RIVER RESTORATION FOR GEOSCIENCE EDUCATION: THE ELWHA SCIENCE EDUCATION PROJECT

[poster 3]

Robert S. Young, Program for the Study of Developed Shorelines, Western Carolina University, Cullowhee, NC

Native Americans are poorly represented in all science, technology and engineering fields. This under-representation results from numerous cultural, economic, and historical factors. The Elwha Science Education Project (ESEP), initiated in 2007, strives to construct a culturally-integrated, geoscience education program for Native American young people through engagement of the entire tribal community. The ESEP has developed a unique approach to informal geoscience education, using the Elwha River Restoration Project as a centerpiece. Environmental restoration is an increasingly important goal for tribes. By integrating geoscience activities with community tradition and history, project stakeholders hope to show students the relevance of science to their day-to-day lives. The ESEP's strength lies in its participatory structure and unique network of partners, which include Olympic National Park; the non-profit, educational center Olympic Park Institute (OPI); a geologist providing oversight and technical expertise; and the Lower Elwha Klallam Tribe (LEKT). Lower Elwha tribal elders and educators share in all phases of the project, from planning and implementation to recruitment of students and discipline. The project works collaboratively with tribal scientists and cultural educators, along with science educators to develop curriculum and best practices for this group of students. Use of hands-on, place-based outdoor activities engage students and connect them with the science outside their back doors. Preliminary results indicate that most (75% or more) students were highly engaged approximately 90% of the time during science instruction. Recruitment of students has been particularly successful, due to a high degree of community involvement. Preliminary evaluations of the ESEP's outcomes indicate success in improving the outlook of the Tribe's youth towards the geosciences and science, in general. The project has also helped to raise the high school graduation rate for LEKT young people to record levels.

WHERE WE ARE TODAY: A QUANTITATIVE BASELINE FOR ASSESSING RESPONSE OF ELWHA RIVER CHINOOK SALMON TO DAM REMOVAL

[oral session 1A]

Mara Zimmerman, Kent Mayer, Randy Cooper, and Mike McHenry; Washington Department of Fish and Wildlife, Olympia, WA (MZ), Washington Department of Fish and Wildlife, Port

Angeles, WA (KM), Washington Department of Fish and Wildlife, Port Townsend, WA (RC), Lower Elwha Klallam Tribe, Port Angeles, WA (MM).

Removal of two hydroelectric dams on the Elwha River, slated to begin in fall 2011, will provide salmonid populations access to 130 km of pristine habitat. The Elwha Fish Restoration Plan relies heavily on hatchery supplementation to rebuild a self-sustaining wild population of Elwha Chinook salmon. The success of efforts to rebuild this population will depend on the abundance and productivity of wild and hatchery-origin Chinook salmon following dam removal. Until recently, relative contributions of wild and hatchery origin fish could not be assessed because spawner origin was not detectable. Beginning with the 2004 brood year, an origin-specific comparison of the survival and age-at-return was enabled by a hatchery program that fully marks or tags hatchery releases and a smolt trap study that estimates the number of wild Chinook out-migrants. All Elwha River Chinook salmon from the 2004 brood year and later were recognizable as one of three out-migrant types: wild sub-yearling, hatchery sub-yearling, or hatchery yearling. Chinook out-migrants during this period were predominantly (84-93%) sub-yearling hatchery fish. In order to compare survival and age-at-return among out-migrant types, Chinook spawner carcasses were collected from the Elwha River during spawner surveys, brood stock collection, and operation of a floating fish weir. For the 2004 brood year, survival-to-return of wild out-migrants was 3 times greater than sub-yearling hatchery releases and 2 times greater than yearling hatchery releases. Age-at-return also differed among out-migrant types. Wild out-migrants returned primarily as age-4 spawners (61%), whereas hatchery yearling releases returned primarily as age-3 spawners (55%). Returns of hatchery sub-yearling out-migrants were evenly distributed among age-3 and age-4 spawners. The survival-to-return and age-at-return of wild- and hatchery-origin Chinook prior to dam removal should be useful for evaluating future changes in abundance and productivity and for adaptively managing the restoration of self-sustaining wild populations in the Elwha River.
