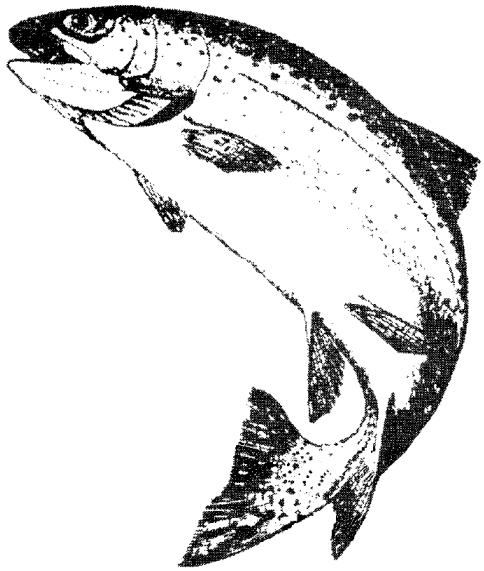
SUMMARY OF
THE THIRTEENTH

PACIFIC COAST STEELHEAD MANAGEMENT MEETING



March 13-15, 2012
Fort Worden - Port Townsend, WA

Sponsored by:

Pacific States Marine Fisheries Commission

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U.S. Fish and Wildlife Service

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Pacific Coast Steelhead Management Workshop

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I. Summary

The Pacific States Marine Fisheries Commission (PSMFC), with support from the U.S. Fish and Wildlife Service Sport Fish Restoration Program, sponsored the 13th workshop on steelhead (*Oncorhynchus mykiss*) management. The workshop, held at Fort Worden, Oregon was attended by over 100 Pacific Coast fisheries managers, researchers and other interested parties from the states of Alaska, California, Washington, Idaho, Oregon and Province of British Columbia.

Topics for the workshop included:

- steelhead stock status
- life history
- data, monitoring and management
- Invited papers on a variety of topics
- poster session

The workshop was structured as a series of individual presentations by topic area or contributed paper session, followed by a panel discussion and questions from the audience. The meeting allowed steelhead managers and researchers to discuss common problems and to share insights into possible solutions on a coast-wide basis.

The contributed papers session covered Puget Sound steelhead abundance, hatchery/wild fish interaction, synergistic impacts of climate change, Influence of resident trout on steelhead production, nomenclature for steelhead and differential productivity for coho-based on other species escapement.

Abstracts from all the sessions were prepared by the speakers and are included in this summary. The PowerPoint presentations given by the speakers can be viewed at the PSMFC website: http://www.psmfc.org/steelhead/past-2012.html

Members of the Workshop Steering Committee were:

Roger Harding, State of Alaska, **Chair**
Carol Coyle, State of Alaska
Bob Leland, State of Washington
James Dixon, State of Washington
Dan Rawding, State of Washington
Jonathan Nelson, State of California
Alan Byrne, State of Idaho
Stephen Phillips, Pacific States Marine Fisheries Commission
Shivonne Nesbit, State of Oregon
Nick Gayeski, Wild Fish Conservancy
Sue Pollard, Province of British Columbia
Mark Beere, Province of British Columbia

ABSTRACTS

II. Session One: Steelhead Stock Status Review

Session Chair: Shivonne Nesbit, ODFW

A. California – Jonathan Nelson, California Department of Fish and Game

California has six Distinct Population Segments (DPS) of steelhead as determined by the National Marine Fisheries Service (NMFS). One was determined to not warrant listing (Klamath Mountains Province), four were listed as threatened (Northern California, Central Valley California, Central California Coast, and South-Central California Coast) and one as endangered (Southern California). The two northern DPSs include summer, winter, and half-pounder runs of steelhead, while the remaining DPSs include only winter steelhead. Based on the limited data available it appears that California's steelhead populations range from stable to declining.

Monitoring efforts in California have been inadequate to properly assess population abundance and trends; and conclusions about stock status are tenuous. Only a few streams are currently monitored for adult returns. Monitoring plans have been developed to assess both California Coastal and Central Valley steelhead populations. These plans include spatially and temporally balanced sampling protocol that allow development of statistically defensible population estimates. These plans incorporate an adaptive management strategy, develop a standardized database structure, and implement standardized reporting techniques.

Implementation of recovery actions for steelhead populations in California is critical. The California Department of Fish and Game (CDFG) Steelhead Restoration and Management Plan for California (1996) is currently being updated and revised. NMFS continues to develop Federal Recovery Plans for steelhead by DPS. Their final draft Southern California DPS plan was published in January 2012. The remaining DPS plans are currently in versions of co-manager or public draft review.

Data gathered from the Steelhead Fishing Report-Restoration Card program (http://www.dfg.ca.gov/fish/Fishing/Monitoring/SHRC/index.asp) shows that steelhead anglers continue to release the majority of their hatchery steelhead. Wild steelhead harvest is no longer allowed in any river in California. CDFG is proposing statewide angling regulations to increase harvest of steelhead for all streams open to angling. The goal is to protect wild stocks by reducing negative impacts from straying, spawning, and competition with hatchery stocks.

Lack of water flowing down streams and access above barriers remains the primary limiting factors for California steelhead. Statewide threats include habitat blockages and degradation, urbanization, poor land use practices, dewatering due to irrigation and diversion, invasive species, and drought. Implementation of monitoring programs and identified recovery actions are paramount to the restoration and effective management of steelhead populations in California.

B. Oregon - Kevin Goodson, Oregon Department of Fish and Wildlife

Six distinct population segments (DPSs) of steelhead have been defined in Oregon by NOAA Fisheries. Four of the DPSs are listed as threatened under the Endangered Species Act. Recovery plans are either completed, near completion or under development for all four listed DPSs in Oregon. These plans have defined the current status of steelhead in these areas. The Mid-Columbia DPS appears to have had an increase in abundance the last few years. In the Deschutes and John Day populations of the Mid-Columbia DPS the high incidence of hatchery steelhead from Snake River hatcheries continues to be concerning. In the Lower Columbia River and Upper Willamette DPSs winter steelhead returns have rebounded somewhat from recent lows. The Oregon Coast DPS does not appear to be showing a declining trend. In the Klamath Mountains Province, the removal of Gold Ray Dam on the Rogue River has discontinued the long running dataset for summer and winter steelhead.

C. Idaho - Alan Byrne, Idaho Department of Fish and Game

The decline of the abundance of Snake River steelhead led to their listing as threatened in October 1997, pursuant to the federal Endangered Species Act. Development of the Federal Columbia River Power System (FCRPS), particularly the four dams and reservoirs on the Lower Snake River, is considered to be the primary factor in the decline of Snake River steelhead. About 60% of the historical steelhead habitat in Idaho is still available, primarily in the Salmon and Clearwater river drainages. About 30% of Idaho's existing steelhead habitat is included within designated wilderness or wild and scenic river corridors. There is a mix of natural and hatchery steelhead production strategies in Idaho, ranging from wild refugia to large-scale hatchery programs to provide harvest opportunities. Areas managed for wild steelhead include the Lochsa and the Selway river drainages of the Clearwater River, the Middle Fork and South Fork drainages of the Salmon River, Rapid River, tributaries of the Salmon River downstream of the MF Salmon River, and tributaries of the Clearwater River downstream of the SF Clearwater.

Since the 1960s, the composition of the steelhead run entering Idaho has changed. The proportion of hatchery origin steelhead has steadily increased due to declining returns of natural fish and development of hatcheries. During 1960's, the Snake River steelhead run was essentially 100% wild. From 1975-79, the steelhead run at Lower Granite Dam averaged 59% naturally-produced fish and from 1985-89, the run averaged 24% naturally-produced fish. From 1990-99, the run averaged 13% naturally-produced steelhead. The run has averaged 14% naturally produced fish in the recent 10 years (2001-02 to 2010-11) . The wild component has been 22% of the total return the past two years (44,800 and 33,100 fish, respectively). This is the first time since the wild run has exceed 20% of the total since the 1988-1989 return.

Returns of hatchery origin steelhead at Lower Granite Dam have exceeded the mitigation goal for the past 10 years. The recent 10 year average hatchery return is

169,400. The hatchery return was 163,450 in 2010-11 and was 133,170 as of December 31, 2011 for the 2011-12 return.

IDFG has initiated an expanded sampling program at Lower Granite Dam. A representative sample from the entire run is taken to determine origin (hatchery clipped, hatchery unclipped, wild), age, six, and length. Genetic samples are taken from wild fish and using Genetic Stock Identification we can now parse the wild return into reporting groups. IDFG and other Snake River basin managers have initiated genetic sampling of hatchery broodstock so Parental Based Tagging (PBT) techniques may be used to identify fish at any life-stage. This method provides a 100% mark rate and allows identification of a fish to its parents (and hence hatchery and age). IDFG is embracing this technology for harvest management and stock identification purposes. All hatchery releases are also PIT-tagged to allow managers to make in-season estimates of the abundance of hatchery stocks using detections at Bonneville, McNary, and Lower Granite dams.

D. Washington - Anne Marshall and Bob Leland, Washington Department of Fish and Wildlife

Washington State steelhead are classified into seven Distinct Population Segments (DPSs) by the federal National Oceanic and Atmospheric Administration (NOAA). Some DPSs are limited to Washington. However, most include bordering states such as Oregon and Idaho as well as British Columbia, Canada.

The Olympic Peninsula and Southwest Washington DPSs are considered *Not Warranted* for listing under the Endangered Species Act (ESA) by NOAA.

The Lower and Middle Columbia River DPSs and Snake River Basin DPS are listed as *Threatened*. The Upper Columbia River ESU was down-listed from *Endangered* status to *Threatened* by NOAA in June 2009.

In May 2007, steelhead stocks in the Puget Sound DPS were listed as *Threatened* under ESA.

Recent total run size data of wild steelhead shows a slight increase for Puget Sound winter-run stocks, and rebounding winter-runs in the Olympic Peninsula and Southwest Washington DPS populations. Lower Columbia winter and summer stocks continue to be chronically under-escaped.

Wild summer steelhead stocks in the Yakima River of the Middle Columbia River DPS, and the Methow/Okanogan and Wenatchee rivers in the Upper Columbia River DPS show an increasing trend. Their numbers mirror the trend in the passage of wild steelhead over Bonneville and Priest Rapids dams on the Columbia River and over Ice Harbor Dam on the Snake River.

The Washington Fish & Wildlife Commission has set policy direction twice for the development of Wild Steelhead Management Zones (WSMZ) and Hatchery Reform for steelhead. The Statewide Steelhead Management Plan:

(http://wdfw.wa.gov/conservation/fisheries/steelhead/management_plan.html)

and the Hatchery and Fishery Reform Policy:

(http://wdfw.wa.gov/commission/policies/c3619.html) provide this direction.

A public process has been established to develop recommendations for:

- Hatchery program modification
- Recommendations of wild populations for WSMZ inclusion
- Continuation of sustainable fishing opportunities where appropriate

For Puget Sound steelhead (ESA-listed as threatened), the federally-sponsored Technical Recovery Team (TRT) has identified 32 historical demographically independent populations within three major population groups. Documentation of these results can be reviewed at: http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Puget-Sound/PS-stlhd.cfm. Population designations serve as the template for recovering a sustainable DPS. The TRT is determining viability criteria and targets, and draft recommendations will be available in mid-2012.

E. British Columbia - Sue Pollard, BC Ministry of Environment, Lands and Parks

British Columbia has ~7,000 km of coastline, most of which is accessible to steelhead. Over 430 steelhead stocks are estimated to reside throughout the province, and can be characterized as one of three ecotypes based on adult freshwater entry date and migratory distance. In terms of numbers of stocks, the coastal winter-run ecotype dominates (300+) but these stocks tend to be limited in size due to relatively small stream size (mostly less than 300 km2 watersheds) and low productivity. The coastal summer-run ecotype also tends to be limited in terms of stock size with a couple of exceptions but this is the rarest of the ecotypes, with likely less than 40 stocks coastwide and some possible local extinctions. The interior summer-run ecotype is found in the mid- and upper tributaries of large watersheds including the Fraser, Skeena, and Nass; productivity varies with latitude. Status is not uniformly distributed across the province but highly variable depending on ecotype and geography to a large part, and associated vulnerabilities to freshwater and marine limiting factors including interception, marine conditions and changing freshwater hydrology cycles. At a very broad level, conservation status tends to improve northward; this pattern is similar to what has been reported previously and thought to reflect relative ocean marine survival rates, all other things being equal. However, there has been a recent improvement in ocean survival reported particularly for southern areas such as the some Georgia Basin streams, and this is evident in a number of coastal summer and winter run steelhead stocks on Vancouver Island and southern mainland areas. Unfortunately, this trend has

not translated to improved numbers for some notable systems including the Keogh River or interior summer run Fraser stocks which continue to report record low abundance; in such cases, additional factors such as poor freshwater productivity and near shore ocean survival are thought to be at play. Ongoing tension related to by-catch of Skeena summer-run steelhead in commercial fisheries continues to dominate management in the north. No immediate conservation concerns are evident here for aggregate steelhead numbers here but concerns for small, early run components which overlap most with commercial species persist (i.e. sockeye). These early-run components also happen to be the most valuable to the sport fishery.

In terms of recreational use, overall, annual angler effort has dropped significantly in the past two decades (from >100,000 to ~50,000 angler days); however the distribution of effort is not uniform across the landscape. Although the Chilliwack River singlehandedly continues to support more effort than any other watershed in BC (~40,000 days in 2011), angler effort has significantly declined for Vancouver Island streams (e.g. Cowichan River) that traditionally attracted large numbers of resident and non-resident anglers. In contrast, the northern region, and specifically the summer-run stocks of the Skeena watershed, is becoming an increasingly desirable destination for steelhead fishing, and angler days from this region (>40,000 in 2011) are now almost on par with the southern mainland region where the Chilliwack River is found. Total catch for wild fish is higher here than for any other region.

In terms of hatchery use in steelhead management, both the numbers of streams and the numbers of juveniles stocked have been reduced by more than three quarters of what was stocked two decades ago. For the most part, hatchery programs simply have not performed in terms of enhancing numbers of accessible adults for angling even though almost all broodstock is of wild, native origin. This failure has become most apparent in recent years where ocean survival rates have dropped considerably; in many cases, hatchery-augmented systems have performed more poorly than non-augmented neighbouring systems. An experimental, short-term captive breeding program was initiated in the late 1990s for three Vancouver streams in an attempt to boost natural production; it failed in demonstrating any sustained increase in adult returns and has since been terminated. About a dozen stocks are still augmented by hatchery programs but only three are considered successful by any measure including the Chilliwack, Stamp/Somass and Kitimat rivers. Even here, concerns with ecotype interbreeding and recent declines in angler catch for Stamp/Somass and Kitimat, respectively, suggest that these programs may be impacting natural production. Province-wide, regulations include catch and release only for all wild fish, and additional restrictions regarding gear and seasonal closures are being considered in the face of increasing angler efficiency and reduced resources for stock assessment.

F. Alaska - Brian Marston, Alaska Department of Fish and Game

Steelhead Oncorhynchus mykiss are found in streams and rivers from Cape Muzon in Southeast (SE) Alaska to the Aleutian Peninsula of Southcentral (SC) Alaska at Port Moeller. A total of 4,202 km of known steelhead waters are documented within 353 drainages. Many streams in the state have not been surveyed for steelhead presence or absence. The vast majority of runs are small containing fewer than 1,000 adults, while the largest known population, in the Situk River, averages 7- 9,000 adult kelts. Kodiak Island and the Kenai Peninsula also have significant runs. Significant sport fisheries occur in ~ 20 drainages. Yearly adult fish stock assessments are limited to 9 selected streams surveyed with snorkel counts, and 6 other selected streams surveyed with weirs. These yearly assessments are done in selected streams in all the largest sport fishery areas, and are distributed throughout the known range of steelhead in Alaska. Streams assessed in SE Alaska were at, or slightly below long term median counts in 2011, while those in SC Alaska were mixed. Length attributes measured on the Situk River, were greater than 30% of the steelhead in Alaska are caught, have not decreased and have fluctuated with overall abundance. Sport fisheries are conservatively managed with yearly harvest limits of 2 fish and minimum size limits, or as catch and release only waters. Several drainages in SE Alaska and in Southcentral have recently been added to catch and release only regulations. No hatcheries currently produce steelhead in the state. Sustaining quality wild steelhead fisheries, limiting habitat degradation, and repairing damaged habitats remain the primary objectives of steelhead management in Alaska. Management policy and regulation is focused by preemptive management planning to avoid impacts to steelhead habitats and maintain the current abundance, age, and size attributes of wild steelhead populations. Sport fishery catch of steelhead in 2011 declined from recent highs in 2008. Reported incidental harvests from commercial salmon fisheries, and subsistence harvest reports for steelhead suggest that these harvests in Alaska are low. Current abundance assessments of steelhead in selected streams of Alaska appear to be within normal variation; SE streams are at or near average after recent high counts, while SC streams are near average or peak abundance. Current conservative regulations provide for sustainability of steelhead stocks while allowing for a vibrant sport fishery.

III. Session Two - Life History Updates - Session Chair: Alan Byrne, IDFG

Response of a steelhead population and stream habitat to wildfire in a central California chaparral watershed - David Boughton, NOAA

Wildfire is a prevalent feature of watersheds in large portions of the geographic range of steelhead, but effects of wildfire on steelhead populations have commonly proven heterogeneous and context-dependent. Here I report on the effects of a large wildfire—the 2008 Indians/Basin Complex Fire in the California chaparral—on a steelhead population that inhabits the burned area. We examine hypotheses about the relative roles of habitat diversity and life-history diversity on the response of the steelhead population to the wildfire, estimated by changes in juveniles densities at sites throughout the stream network. The major impact of the fire was not direct impacts on

riparian vegetation (which were quite minor), but indirect impacts via pulses of fine sediment into channels the following winter. The negative response of the steelhead population was large but spatially heterogeneous, with rapid recovery of juvenile densities within two seasons. This study illustrates the importance of spatial structure and habitat diversity for the rapid recovery of steelhead populations following intense wildfires.

Contribution of resident O. mykiss to anadromous populations. Implications for VSP analysis - Rich Carmichael, ODFW

During the process of listing Interior Columbia River Basin steelhead as threatened under the ESA, there was considerable confusion regarding inclusion of resident O. mykiss as part of the listed species. Eventually resident rainbows were omitted from the final listing. There remains considerable uncertainty and debate whether resident rainbow should be considered in abundance and productivity viability assessments for steelhead, and if so how best to quantify the viability affects. We completed two studies to further our understanding of O. mykiss life history diversity and anadromous resident relationships in Northeast Oregon.

In one study, we conducted controlled reciprocal cross breeding experiments with known natural-origin resident rainbow (Rb) and hatchery-origin steelhead (StS) to determine the relative rate of production of migrant smolt offspring. Juveniles were reared at Irrigon Hatchery under the typical accelerated growth one-year smolt production program. Juveniles were acclimated and released into a tributary of the Wallowa River at Wallowa Hatchery in Enterprise, Oregon. The proportion of offspring that demonstrated smolt type migratory behavior was determined based on observations of PIT tagged smolts that passed Lower Granite Dam, the first dam in route to the ocean 295 km from Wallowa Hatchery. All breeding groups produced migrating offspring. The RbxRb crosses produced the fewest migrating offspring and the RbxStS and StSxRb were intermediate between RbxRb and StSxStS. The RbxRb cross produced smolts at 0.16 the rate of the StSxStS crosses. We observed a maternal influence with higher proportional smolt production from the anadromous females. The RbxRb crosses produced the highest proportion of precocious males.

In a second study, we analyzed strontium-calcium ratios from core areas and freshwater growth regions in otoliths to assess maternal origin of naturally produced O. mykiss parr, smolts, anadromous adults and resident rainbow from NE Oregon streams. A small proportion of fish at all life stages originated from resident mothers and a high proportion of the resident rainbows originated from anadromous mothers. There appears to be considerable linkage between resident and anadromous life history forms in NE Oregon streams with both producing crossover offspring. The microchemistry technique had significant limitations due to high freshwater strontium in some locations and the length of resident time and distance travelled in freshwater by anadromous mothers, thus affecting nutrient concentrations in the eggs and data quality.

There are important strategic elements of conservation and recovery that apply when considering implications of the resident-anadromous relationship. Steelhead have been listed due to depressed productivity and altered diversity resulting from man induced environmental habitat alterations. In some cases, this reduced productivity has likely resulted in favored expression of the resident life history strategy. Strategic guidance for recovery actions places highest priority on maintaining and restoring normative natural watershed processes across the entire life cycle. Thus, the conservation strategies emphasize restoring natural balances in life history expression and anadromous-resident production relationships. Achieving recovery of steelhead and restoring natural balance may result in reduced abundance and expression of resident O. mykiss.

Consideration of resident O. mykiss in viability assessments of steelhead is very complex. Quantifying the influence of resident rainbows on steelhead viability requires at minimum, understanding of spawner abundance and fecundity of both life history types, degree of interbreeding, production flow between life history types and breeding groups as well as life stage specific survival and full life cycle productivity.

Due to the complex nature of the interactions, we would expect highly variable relationships between populations that reside in different geographic areas and in divergent habitat types. Considerably more quantitative assessment is needed to improve our understanding of these complex relationships and to quantify the benefits related to steelhead viability.

Effect of differing age structure in steelhead populations within an MPG on productivity estimates used in VSP analysis - Timothy Copeland, Alan Byrne and Brett J. Bowersox, Idaho Department of Fish and Game

Steelhead trout have the most variable suite of life histories of all genus Oncorhynchus, which greatly complicates assessment and management. A significant aspect of this diversity and an important factor affecting population productivity is the number of years spent in freshwater versus time in saltwater before reproducing. Steelhead populations in the Snake River basin inhabit a wide range of environments and express a complex age structure but historically there was little information at the population level to inform management. Consequently, a generic age structure was assumed to develop management goals. Using a simple life-cycle model, we examine recent data on the aggregate age structure and selected populations to understand the implications of varying age structure on inherent productivity. Size-selective smolt survival and increased fecundity with additional years of ocean residence are necessary to generate the observed aggregate age structure. Even given these assumptions, populations with older age structure have lower productivity in terms of adult-to-adult replacement than populations with a quicker life cycle. Impacts on returning adults for older populations are potentially important sources of lost productivity. Given the elevation and geological gradients in the Snake River, productivity may vary on a scale smaller than the current population delineations. We demonstrate that population-specific age data need to be incorporated into the criteria for management of Snake River steelhead.

Iteroparity in SE Alaska steams: Importance of repeat spawning to sustained production - David Love, ADFG

Research from the continental US and British Columbia, Canada indicates that steelhead (Oncorhynchus mykiss) iteroparity is more common in ocean-maturing life histories, among females, at higher latitudes and in shorter, coastal streams. During 2003-2009, Alaska Department of Fish and Game Sportfish Division conducted a multi-year study of steelhead production on Sitkoh Creek on Chichigof Island, in Southeast Alaska. For all 7 years of the study, > 98% of all adult and smolt steelhead passed through a bipod-and-picket weir were tagged with 134.2 kHz Passive Integrative Transponder (PIT) tags, measured, sexed and systematically sampled for scales. Tagging mortality of smolts appeared to be low (< 15%) and tag retention was high (94%) for all years. Estimated ages, obtained by triplicate reads of digitally imaged scales from systematically sampled smolts and adults, appeared to have good precision. All fish observed appeared to be ocean-maturing life history with only a small percentage (2.3%) present in the stream prior to the weir being installed in April. Counts of all adults and smolt passed through the weir were considered essentially censuses as supported by Petersen mark-recapture estimates. Repeat spawning adults were accurately identified > 88% of the time based on scale sampling of recaptured PIT-tagged fish. Low but variable freshwater smolt production, higher smolt-adult survivals, high repeat spawning rates (average 41% for al 7 years), high kelt survival rates (73%), possible straying of about 12%, sex ratios skewed towards females (67%), and abundant resident rainbow populations were observed at Sitkoh Creek during 2003-2009. The short coastal streams at the higher latitudes of Southeast Alaska, including Sitkoh Creek, seemed to favor ocean-maturing steelhead populations with sex ratios skewed towards females that survived well. Female steelhead from these streams grew slower, became larger and more fecund, repeat spawned more frequently, and may have had a higher lifetime reproductive success. The typically colder, oligotrophic freshwater habitats of Southeast Alaska also appeared to produce slower-growing, older but larger smolts that survived better in the marine environment. Overall production of steelhead in small Southeast Alaska streams such as Sitkoh Creek appears to be characterized by variable smolt freshwater production but good smolt-to-adult marine survivals, iteroparity favoring high repeat-spawning rates and straying, and possible contribution by abundant resident rainbows. These characteristics may allow steelhead populations like those in Sitkoh Creek to be more resilient to perturbations caused by changes in the highly dynamic and variable freshwater habitats and variations in the marine environment

Natural stray rates - What's a stray and how can we measure it? Insights from Steelhead populations in the Copper River and Prince of Wales Island –
Jeff Olsen, USFWS

Adult salmon and steelhead that do not return home to their natal stream to spawn are called "strays". In general, strays are emigrants (or immigrants) that contribute to population connectivity and play an important role in the ecology and evolution of salmon and steelhead. As such, there is much interest in identifying and measuring

strays and the rate of straying among populations. However, how straying is defined and measured depends upon the context in which it is evaluated. Two paradigms exist (Waples and Gaggiotti 2006; Lowe and Allendorf 2010). Under the ecological/demographic paradigm the questions relate to population growth, viability, harvest potential etc. and the interest is in measuring dispersal as the total number of immigrants or immigrant fraction (m). Under the evolutionary/genetic paradigm the questions relate to reproductive isolation, population evolution, fitness, etc. and the interest is in measuring gene flow as the effective number of migrants (Nem). Multiple methods can be employed to assess the ecological as well as evolutionary impacts of straying. In the case of *Oncorhynchus mykiss* in the Copper River, Alaska, genetic data showed that sympatric steelhead and resident rainbow trout are not reproductively isolated (are part of a single gene pool) but that geographically distinct but proximate spawning groups are reproductively isolated regardless of migratory type. In addition, the data provided evidence that fine-scale dispersal is biased in favor of resident rainbow trout. This study suggests the two migratory types may play different roles demographically and in the colonization and maintenance of inter- and intra-population genetic diversity.

How do we incorporate all this variation in a steelhead VSP analysis. Some insights using 'what-if?' modeling - Tom Cooney, NOAA

No abstract submitted

IV. Session Three -Hatchery Issues - Chair: James Dixon, WDFW

Ecologic and demographic costs of releasing non-migratory juvenile hatchery summer steelhead - Charlie Snow, WDFW

Juvenile hatchery summer steelhead Oncorhynchus mykiss from the 2002, 2003, and 2004 broods at Wells Hatchery were tagged with Passive Integrated Transponder (PIT) tags prior to release and were allowed to migrate volitionally (VM) or were forced out of rearing ponds after volitional migration had ceased (NM). We monitored releases of these three broods to quantify the number of PIT tagged fish in each release category in order to estimate the relative contribution rates of VM and NM releases to the stream resident (SR) population of juvenile hatchery summer steelhead in the Twisp River, Washington. We utilized recreational angling equipment to recapture PIT tagged fish after the typical emigration period had ended in each year of release. Overall, we estimated that 82% of SR hatchery juvenile summer steelhead originated from releases of NM fish. Within each year of release, a significantly greater proportion of SR fish originated from releases of NM juveniles than from VM juveniles. Further, we compared the relative contribution of each release type to the anadromous adult population by assessing survival from release to adult return (SAR) at Bonneville and Wells dams, Washington. The mean SAR to Bonneville Dam was 1.31% for VM fish and 0.51% for NM fish. Mean SAR to Wells Dam was 1.05% for VM fish and 0.22% for NM fish. Within each brood examined, SAR was significantly greater for VM fish. As an index of release strategy effect on the SR population of juvenile hatchery steelhead, VM fish

released into the Twisp River, Washington, produced 0.12 SR fish per each adult returned, while NM fish produced 2.07 SR fish per adult return. These results suggest that volitional release can successfully segregate hatchery steelhead populations to reduce stream residence of juvenile hatchery steelhead at little cost to adult returns.

Lower Snake River Compensation Plan Steelhead Program - A retrospective and program adaptive management - Mark Schuck and Joe Bumgarner, WDFW

In the 1970's, four dams were constructed on the lower Snake River in SE Washington. A federal hatchery program (Lower Snake River Compensation Plan – LSRCP) was established in SE Washington, NE Oregon, and Idaho to compensate for losses caused by the dams to spring/summer Chinook, fall Chinook and summer steelhead within the Snake River basin. Prior to completion of the LSRCP facilities, summer steelhead fisheries within the Snake River Basin were being or had been closed. Harvest numbers indicated a rapid decline of summer steelhead in the Snake River Basin through the 1960s. The WDFW LSRCP facilities (Lyons Ferry and Tucannon Hatcheries) were built, and one out-of-basin stock (Lyons Ferry – derived primarily from Wells Stock) and one in-basin composite stock (Wallowa) were produced for release into various locations around SE Washington. LSRCP steelhead programs quickly rebuilt fisheries in SE Washington and other areas of Idaho and NE Oregon. Program performance of Washington's hatchery stocks (smolt-to-adult survivals and adult returns to the project area) has been exceptional, but also has led to conflict with ESA recovery strategies and Washington State's wild fish management goals. Due to these concerns, numerous changes to the hatchery program have occurred, including: altered release locations of hatchery fish to reduce hatchery/wild fish interactions, reduced smolt releases into rivers, removal of excess hatchery adult returns at weirs and development of new integrated fish stocks. All current releases are tagged with both CWT and PIT tags for estimating adult returns, and to monitor fishery contributions and straying. Examples of program modifications to address ESA concerns, and of problems that remain a concern are presented, including: elimination of large surpluses of hatchery steelhead on the Grande Ronde river after passing through extensive fisheries; the degree of straying/wandering of steelhead from the program to locations within the Snake River; moving release locations downstream (Walla Walla), installing barriers to prevent hatchery fish from reaching main spawning areas (Touchet), and testing of new hatchery broodstocks in the Touchet and Tucannon rivers. Possible future changes to the program currently being discussed include: 1) the consolidation of the Lyons Ferry and Wallowa stock programs to free up rearing space at Lyons Ferry for spring Chinook, 2) implementation of the Touchet River endemic stock program, and 3) re-assess adult contributions and straying rates from the various programs that might lead to changes in release locations or overall mitigation production. WDFW has also implemented adult trapping programs in other small tributaries to the Snake River to monitor straying of hatchery steelhead, and established a steelhead reference stream (Asotin Creek) to monitor wild population's status and trend. Washington remains committed to retaining the benefits of the LSRCP for its residents while modifying it hatchery programs to protect ESA listed natural populations.

Is interbreeding of wild and hatchery winter steelhead prevented by divergent life history? - Todd Seamons, WDFW

I will be presenting the results from our recently published paper in which we evaluated the segregation strategy, one of two recommended strategies proposed to avoid negative genetic effects of artificially propagated individuals on wild populations. We tested the efficacy of the strategy of segregation by divergent life history in a steelhead trout, Oncorhynchus mykiss, system at Forks Creek, a tributary to the Willapa River in southwest Washington State. The hatchery broodstock were the ubiquitous Chambers Creek winter steelhead, selected to spawn months earlier than indigenous wild populations. Using genetic data, we identified proportions of annual collections of natural origin smolts and adults with hatchery and wild ancestry. The proportion of wild ancestry smolts and adults declined by 10–20% over the three generations since the hatchery program began. Up to 80% of the naturally produced steelhead in any given year were hatchery/wild hybrids. Regression model selection analysis showed that the proportion of hatchery ancestry smolts was lower in years when stream discharge during hatchery spawn timing (Dec. - Feb.) was high, suggesting a negative effect of flow on reproductive success of early-spawning hatchery fish. Furthermore, proportions of hybrid smolts and adults were higher in years when the number of naturally spawning hatchery-produced adults was higher. Divergent life history failed to prevent interbreeding when physical isolation was ineffective, an inadequacy that is likely to prevail in many other situations. The paper is available free in open access at Evolutionary Applications, http://onlinelibrary.wiley.com/doi/10.1111/j.1752-4571.2012.00247.x/full

Effectiveness of alternative broodstock, rearing and release practices - Methow River Summer Steelhead - Bill Gale, Mathew Cooper and Chris Pasley - USFWS

In an effort to contribute to the recovery of Threatened upper Columbia River summer steelhead, Winthrop NFH is developing a locally adapted Methow River summer steelhead program. This program spawns and rears the progeny of within basin origin wild and hatchery brood stock using a two year production cycle that seeks to partially mimic the predominate age at smolting seen in naturally reared steelhead. The later collection date required for using within basin brood combined with the cold temperatures seen in the Methow river basin precludes the ability to produce smolts under a standard one year rearing program. The focus of this presentation is to compare the characteristics and performance of both one and two-year smolt rearing programs. This research is a component of a broader collaborative project to investigate the genetic, physiological, behavioral and environmental mechanisms that determine the various life history fates of steelhead.

Wells steelhead stock (of mixed Methow and Okanogan origin) were reared using a standard one year rearing program (S1) and the progeny of local Methow river stock were reared using a two year rearing program (S2). Ration was adjusted (increased for S1, constrained for S2) to rear S1 and S2 fish of a similar size at release. A subset (≈15K/group) of each rearing program was PIT tagged and downstream detections

monitored using the PTAGIS website. Post release survival was examined using Cormack Jolly Seber mark –recapture models for open populations. Residual steelhead from both rearing programs were collected in the fall following release using a variety of techniques and examined for size, age at release, and gender. Preliminary results from the 2010 and 2011 release groups are presented here.

Final mean FL at release of S2 fish was significantly larger than S1 fish (t-test, $p<0.05$) though the length frequencies show a considerable amount of overlap. Mark recapture modeling revealed significant difference in apparent survival to downstream interrogation sites with S1 fish surviving at a lower rate than S2 fish between release and Rocky Reach Dam, survival was similar between the groups in lower reaches (e.g. Rocky Reach to McNary Dam).

The estimate for apparent survival between release and Rocky Reach is a combination of mortality and residualism suggesting that there may be a difference in the rate of S1 and S2 residualism. The length frequency for S1 fish suggests the presence of two putative residual life history types, smaller parr and larger maturing male residuals. Conversely the S2 program appears to be largely limited to only maturing male residuals. Residual sampling in the fall supports this contention with S2 residuals largely absent compared to S1's and exhibiting significantly greater size and a sex ratio with a greater bias towards males than S1 residuals.

Variation in the effectiveness of alternative broodstock, rearing and release practices among three supplemented steelhead populations - Hood Canal, WA
Barry Berejikian, NOAA

The Hood Canal Steelhead Project is a replicated before-after-control-impact experiment testing the effects of hatchery supplementation on natural population abundance, productivity and diversity. The project incorporates two fairly unique practices, hydraulic embryo sampling and age-2 smolt rearing and release, to minimize hatchery-induced selection on the three supplemented populations (Dewatto, Duckabush, South Fork Skokomish Rivers). Hydraulic embryo sampling obviates the need for artificial spawning and associated selection by removing eggs from natural redds in each river. Embryo collection goals have consistently been met in two of the three rivers (Dewatto and South Fork Skokomish), and have fallen short each year in the Duckabush River, largely as a result of high spring flows, which make hydraulic removal difficult. Survival of natural-origin embryos has consistently averaged above 90% from collection at the eyed stage to emergence, indicating little damage caused by the hydraulic sampling method. Control of feed rations and growth rates to produce age-2 smolts has resulted in a more natural age-at-smoltification than is common for steelhead hatcheries, which nearly all release fish steelhead at age-1. Size-at-release targets have been consistently met. However, hatchery-raised steelhead from the South Fork Skokomish River have experienced higher male maturation rates (approximately 40% of males mature) and greater size variation than the other two populations (maturation rates typically less than 5%). Three years of acoustic telemetry-based early marine survival estimates indicated that steelhead smolts from

one hatchery (Dewatto and Duckabush populations) survived at rates (freshwater: 88.9%, early marine: 27.4%) similar to the two natural-origin smolts (freshwater: 88.9-97.7%, early marine: 5.7-14.7%), while smolts from the other hatchery (Skokomish population) exhibited much lower freshwater survival (43.1-60.2%) and early marine survival (1.9-7.4%). Between-hatchery differences in rearing density and vessel geometry likely affected survival and behavior after release and contributed to greater variation between hatcheries than between wild populations. The effectiveness of 'progressive' hatchery techniques should be expected to vary among populations and hatcheries, especially during initial development.

Strategies to maximize the efficiency of using parental based tagging as a tool to meet management and research objectives - Carl Stiefel, IDFG

Parentage-based tagging (PBT) is a new mass tagging methodology that can be used to address a host of management and research objectives that would be difficult or impossible to do with traditional tagging techniques due to cost or logistical constraints. PBT involves the annual genotyping of all hatchery broodstock, creating a parental genotype database. This parental genotype database can then be used to relate the progeny (juvenile or returning adults) to its parents with a high rate of assignment (approximately 98%). This high level of resolution has tremendous promise to meet a variety of management and research objectives because all fish are essentially tagged. However, depending on the number of release groups and their size, as well as the infrastructure for a particular hatchery facility (rearing container size and quantity), tracking 100% of the progeny to a group of interest (i.e. release or experimental group) can be problematic. We found that by slightly redistributing existing release plans, and focusing on multiple groups of intact progeny, as a whole we were able to track a large proportion (>80%) of progeny to nearly all release groups. In doing so, our PBT tagging rate (>80%) for each release group was substantially higher than our current coded wire tag program (approximately 20%). This increase will allow us to better evaluate harvest and straying for each of these groups. Additionally, these strategies used to maximize the PBT tagging rate at release sites could be employed at a finer scale, such as multiple experimental groups within a release group.

V. Contributed Posters - Session Chair: Carol Coyle, Alaska Department of Fish and Game

ESA coverage of steelhead harvest in Puget Sound salmon and steelhead fisheries - Amilee Wilson, NOAA

The Puget Sound Steelhead Distinct Population Segment (DPS) was listed as "threatened" under the Endangered Species Act (ESA) on May 11, 2007. NMFS issued protective regulations for Puget Sound steelhead on September 25, 2008. Under the 4(d) Rule in 2008 and 2010, the Washington Department of Fish and Wildlife (WDFW) and Puget Sound Indian Tribes (PSIT) through the Northwest Indian Fisheries Commission (NWIFC) submitted a joint resource management plan (JRMP) for steelhead harvest in Puget Sound. In 2010 and 2011 under ESA Section 7, co-

managers worked with NOAA Fisheries to obtain authorization for steelhead harvest under the Puget Sound Chinook Harvest Biological Opinion. All Puget Sound steelhead fisheries are restrictive and incidental mortality is minimal. Steelhead mortality occurs mainly in terminal recreational fisheries using mark-release regulations to target hatchery fish, or incidentally in state and tribal commercial net fisheries targeting more abundant species of salmon. Limited tribal steelhead harvest, reported through fish tickets, also occurs for ceremonial and subsistence purposes. Recreational catch is reported through the WDFW catch record card system; retention of Puget Sound wild steelhead in recreational fisheries is prohibited. Harvest is currently approved at no more than 4.2 percent for ESA-listed winter steelhead in the Skagit, Snohomish, Green, Puyallup and Nisqually rivers. This harvest rate is comparable with rates previously approved for steelhead in the Columbia River basin. For other Puget Sound basins where data are limited, steelhead fisheries must remain within the harvest limits observed during the time period reflective of the 2000/2001 through 2006/2007 steelhead seasons.

Genetic estimation of stock abundance and run-timing of Interior Columbia River steelhead passing Bonneville Dam - Jon Hess, CRITFC

The Columbia River Basin supports ESA listed stocks of wild steelhead as well as hatchery supplemented populations. Accurate estimates of hatchery and wild stock abundance are critical for population viability assessment and are particularly useful information for steelhead fisheries managers when combined with stock run-timing trends. In this study, we used a set of 188 single nucleotide polymorphism (SNP) genetic markers and determined that genetic stock identification (GSI) analysis could accurately distinguish 17 reporting groups (stocks) of steelhead within the Columbia River Basin. Further, we genotyped unknown stock-of-origin wild and hatchery adult summer-run steelhead sampled at Bonneville Dam during each of three years between 2009 to 2011 (n=2468, 1760, and 1394 respectively) and performed GSI on these mixtures to obtain estimates of run-timing and abundance for each stock. Stock abundance was calculated by first pooling mixture samples into 10 biweekly strata (mean n = 88, range 6 - 288 per strata) representing >98% of the total summer-run from April to October, and then multiplying GSI-estimated stock proportions for each stratum with the total abundance of steelhead tallied at the Bonneville Dam fish counting window. Aside from improving spatial resolution of GSI applications, SNP markers also provide an efficient way to perform large-scale parentage based tagging (PBT) analyses, which are used to identify an individual's parents. A large-scale PBT baseline has been completed for all 2008-2011 Snake River steelhead hatchery broodstock, and we demonstrate the utility of this PBT baseline by using it to assign 4-year-old spawn age steelhead from the 2011 Bonneville Dam mixture back to their hatchery parents. The benefit of these two genetic tools, PBT and GSI, is maximized when the tools are applied in concert. This is because PBT provides highly accurate hatchery-level assignments and age information for Snake River hatchery steelhead, and GSI provides stock-level information for wild steelhead as well as for hatchery fish that were not assigned with PBT.

Comparison of wild and hatchery estimates of stock abundance showed large differences in relative stock proportions (e.g. middle Columbia R. versus Upper Salmon R. had highest abundance for wild and hatchery steelhead, respectively) and showed hatchery stocks with the severest declines across years. Run-timing distributions of wild and hatchery stocks could be divided into three categories: early (Skamania summer-run), intermediate (most reporting groups), and late (SF/Upper Clearwater R. and SF Salmon R.). PBT analyses were able to assign 208 steelhead to six Snake River source hatcheries, and the majority (75%) was found to originate from Dworshak Hatchery. This study demonstrates great potential for the application of two genetic tools, GSI and PBT, in the management of Columbia River steelhead fisheries evidenced by high accuracy of stock-/parent- assignments and the ability to estimate hatchery and wild components of stock abundance, and to characterize stocks by life-history traits (e.g. ocean-age, length, and run-timing).

Columbia River alternative gear studies: Preliminary survival estimates of steelhead caught and released in commercial purse and beach seines
Josh Holowatz, WDFW

Columbia River commercial fisheries targeting salmon incidentally catch steelhead and fishers are required to release all steelhead back into the river. During the summer and fall fisheries, gill nets are used to catch salmon. Although not empirically measured for steelhead, their release survival from these fisheries is believed to low. This is an important issue since all summer steelhead populations in the Columbia River are listed for protection under the Endangered Species Act. In 2011, the Washington Department of Fish and Wildlife (WDFW) in cooperation with local fishers evaluated a purse and beach seining program to estimate the survival of released steelhead using Passive Integrated Transponder (PIT) tags. A second group of steelhead was PIT tagged at the Bonneville (BON) Dam fish collection facility and transported downstream to an area adjacent to the fishery to serve as a control. A total of 459 fish were tagged in the BON ladder and 543 seined fish were tagged. Using contingency table analysis with a significance level of 0.05, there was no difference in recapture probabilities to BON between purse and beach seine fish and these groups were pooled for further analysis. There was no difference in the recovery probabilities of seined and control fish to BON. Using Ricker's two release method, survival of seined fish was estimate to be 97.9% with 95% CI from 95.4% to 99.8%. There was a 98.9% probability that the survival of seined fish exceeded 95%. Longer-term survival will not be evaluated until the summer of 2012 after tagged steelhead have completed their spawning migration.

A comparison of the nutritional and energetic status of kelts from the Snake River and coastal Situk River, AK using blood plasma metrics - Zachary Penney, University of Idaho

Steelhead trout iteroparity (repeat spawning) is highly variable, ranging from less than 1% in inland populations to as high as 70% in coastal populations. In general, it has been observed via scale analysis that coastal steelhead exhibit higher rates of iteroparity than inland populations. The physiological capacity for iteroparity between

inland and coastal steelhead is not well understood, but has been attributed to differences in gonadal maturation strategies, freshwater re-entry timing, migration distance, and total time spent in freshwater. We provide an assessment of physiological nutritional factors between inland and coastal steelhead kelts using measures of blood plasma. From 2009 to 2011, steelhead from the Snake River subbasin were sampled at the Lower Granite Dam juvenile bypass facility (N=1649) and multiple weir sites in tributaries of the Clearwater River (N=272). For comparison, blood plasma was collected from kelts in the Situk River (N=37), a coastal system in southeast Alaska in 2011. Plasma nutritional factors of cholesterol and triglycerides were nearly three times higher in Situk River kelts than in Snake River kelts. When detectable, values of plasma protein were similar between Situk and Snake River kelts; however, plasma protein was below detection limits in 52% of Snake River kelts and in only 32% of Situk River kelts. Our results suggest that coastal Situk River kelts have greater nutritional and energetic reserves following spawning than inland steelhead kelts from the Snake River subbasin.

Steelhead smolt survival in Oregon coastal rivers - David Noakes, OSU

We studied a means of improving upon estimates of ocean survival and identifying potential sources of mortality in lower rivers and estuaries of steelhead, Oncorhynchus mykiss, in the Oregon coastal distinct population segment (DPS). Steelhead smolt survival to the ocean is currently estimated using data from smolt traps located well upstream of the estuary. Mortality incurred in this lower river and estuary zone has previously been incorporated into survival models under the category of ocean mortality. Our data from the Nehalem and Alsea rivers in Oregon suggest: 1) wild steelhead smolts spend little time in the estuary, 2) typically only 40 - 50% of the wild steelhead smolts reaching the estuary actually enter the ocean, 3) most mortality occurs in the lower estuary, and 4) smolts tagged during the peak of the run appear to have higher survival rates. Our research provides information to strengthen life cycle models used in recovery plans by providing missing data on mortality locations and mortality rates in the riverine and estuarine portions of smolt migration. We will use radio tags to determine the fate of missing acoustically tagged smolts, and then propose the design of a monitoring plan for estimating survival of migrants to the ocean within currently accepted errors.

Diminished reproductive success of steelhead from a hatchery supplementation program (Little Sheep Creek, Imnaha Basin, Oregon) - Ewann Berntson, NWFSC

Hatchery supplementation programs are designed to enhance natural production and maintain the fitness of the target population; however, it can be difficult to evaluate the success of these programs. Key to the success of hatchery supplementation programs is a relatively high reproductive success of hatchery fish. This study investigated the relative reproductive success (RRS) of steelhead Oncorhynchus mykiss by creating pedigrees based on microsatellite loci for hatchery and natural spawning steelhead. We genotyped adult steelhead spawners as well as adult resident rainbow trout from multiple locations upstream of the weir. We then determined the parentage of progeny collected at various life history stages, including returning adults in subsequent years.

Analysis of progeny sampled at both the juvenile and adult life stages suggested that the RRS of hatchery-origin fish was 30–60% that of their natural-origin counterparts. Using generalized linear models we determined that the greatest effects on RRS were origin (natural versus hatchery), length, return date, and the number of same-sex competitors. Natural parents were less negatively affected by same-sex competitors. Differential survival of juveniles and the behavior of offspring and/or spawning adults may all contribute to diminished fitness in hatchery-reared salmon, although it could not be determined to what extent these effects were of a persistent, heritable nature as distinct from an environmental effect associated with hatchery rearing and release strategies.

Restoring anadromy: Identifying historic fish passage beyond natural obstacles in the Oregon Cascades - Sierra Lewis, OSU

Historically, fish passage research has focused on mitigation of impacts due to man-made barriers, and project success is defined as observed passage beyond these obstacles to reconnect fragmented habitats. Restoring aquatic connectivity for migratory fishes in the headwaters of rivers can be an expensive restoration proposition if the total length of stream or river to be regained is uncertain due to natural barriers. We collected telemetry data on non-marked, migratory steelhead, O. mykiss, which were transplanted above a known hydropower barrier. We documented observed behaviors such as habitat exploration, holding, spawning, and outmigration timing from June 2010 to June 2011. We also collected and analyzed foliar samples from Douglas fir trees, P. menziesii, (>100 years old) to determine 15N nutrient linkages between headwater tributaries of the main-stem river in an effort to discern the true extent of historic anadromy above both a hydropower dam as well as a natural waterfall complex in the last major tributary below the end of historic anadromy. By comparing the telemetry data with the potential historic distribution, as elucidated by marine nutrient deposition patterns throughout the headwater tributaries of this coastal river, we hope to improve the methodology used to define project success through restorative alteration of anthropogenic barriers. This poster displays the initial results which seem to be confounded with elevation and the presence of nitrogen-fixing species, such as red alder (A. rubra).

Steelhead monitoring program in California: Past, present and into the future
Jonathan Nelson, CDFG

The establishment of accurate monitoring of steelhead population abundance and distribution within the State of California is a necessary component for restoration and recovery of the species under the Federal Endangered Species Act recovery plans and State management plans. The large, variable geographic distribution and significant population declines of steelhead throughout the state warranted the creation of a consistent, comprehensive monitoring program to statistically measure population abundance and trends necessary for effective fishery management on a statewide basis. The monitoring program divides California geographically into three areas based on species composition, abundances, and habitats: the Central Valley and Northern and

Southern Coastal Areas. The monitoring plan is science based and statistically sound, with temporal and spatial variability to procure information on adult, juvenile, and smolt life history stages at the population and subpopulation levels for assessment of trends in each Distinct Population Segment (DPS). The data from monitoring sites is recorded into an evolving centralized database for archive and analysis, allowing quality control. Information gained from monitoring will be used to select restoration and recovery activities that will aid in the reestablishment of self-sustaining steelhead populations. The monitoring program was developed through a collaborative process to ensure that existing and future monitoring sites and data reporting are in compliance with the protocols presented in this plan.

VI. Session Four: Steelhead Data, Monitoring and Management: Approaches to Steelhead Monitoring and Management with Decreasing Budget - Chair: Dan Rawding, WDFW

Mark-resight estimates using PIT and Floy tags to estimate adult steelhead responses to Hemlock Dam removal in SW Washington - Charlie Cochran, WDFW

No abstract submitted

Decomposing Lower Granite Dam steelhead runs into tributary escapement estimates using instream PIT tag arrays - Chris Beasley & Jody White, QCI

No abstract submitted

Comparisons abundance estimate based on PIT Tag detection and weir operations in Snake River tributaries - Jason Vogel, NPT

No abstract submitted

Genetic based approach to steelhead population estimates above Lower Granite Dam - Matt Campbell, IDFG

Genetic stock identification (GSI) has been conducted successfully in the lower Columbia River and elsewhere throughout the Pacific Rim to estimate stock contributions in salmon and steelhead mixed fisheries. For this talk, we present the first single nucleotide polymorphism (SNP) baseline completed for ESA-listed Snake River steelhead and review the first two years of GSI results estimating abundance and diversity of adult wild steelhead stocks migrating above Lower Granite Dam. Initial results indicate that GSI methodologies using SNPs should greatly assist managers in assessing the viability of natural origin steelhead in the Snake River Basin. We also review current efforts to improve the resolution of the existing baseline and present some initial results demonstrating the potential utility of this set of SNP loci for assessing intraspecific hybridization and introgression.

Estimates of steelhead harvest rates based on PIT tag sampling in Columbia River Fisheries - Steve VanderPloeg, WDFW

Since the 1990's, the incorporation of Passive Integrated Transponder (PIT) tag and detection infrastructure has lead to the widespread use of PIT tags for monitoring salmon and steelhead in the Columbia River system at mainstem dams, in-river sites and traps, and bird nesting sites. One of the biggest remaining gaps for PIT tag monitoring in the Columbia River are mainstem fisheries. In August 2010, the Washington Department of Fish and Wildlife (WDFW) and the Pacific States Marine Fisheries Commission (PSMFC), with funding from the Bonneville Power Administration (BPA), implemented PIT tag sampling concurrent with the ongoing fisheries sampling for biological data and coded-wire-tag (CWT) recovery. The purposes of this monitoring program are to: 1) report PIT tag fish sampled to PTAGIS, 2) develop estimates of PIT tags sampled in fisheries, and 3) where possible develop estimates of harvest by PIT tag group. Preliminary results from a study to determine the detection efficiency of handheld detectors and harvest estimates from the fall 2010 Zone 6 fishery will be presented. Given the successful fall implementation, PIT tag sampling has been expanded to all mainstem commercial, treaty, and recreational fisheries.

Examination of angler catch by stock composition of summer steelhead in the Deschutes River, OR 1977-2011: Why don't hatchery fish bite? –
Jason Seals, ODFW

Stock composition of sport angler caught adult summer steelhead (Oncorhynchus mykiss) on the Deschutes River, Oregon, was disproportionate to stock composition of steelhead sampled at the Sherars Falls Adult Salmon and Steelhead Trap for nearly all years from 1977 to 2011. The Oregon Department of Fish and Wildlife estimated sport angler catch of hatchery and wild summer steelhead on the lower 42 river miles of the Deschutes River, while also capturing and sampling hatchery and wild summer steelhead at the Sherars Falls Adult Salmon and Steelhead Trap at river mile 43. Angler catch estimates were generated by conducting angler interviews at the entrance to the Macks Canyon Access Road and Heritage Landing. Annual population monitoring of Deschutes steelhead at the Sherars Falls trap was used to determine stock composition. Higher numbers of wild steelhead were caught by sport anglers than hatchery steelhead, even though hatchery steelhead greatly outnumbered wild steelhead captured at the adult trap. Between 1990 and 2011, anglers averaged 4.07 hatchery and 4.41 wild steelhead caught per 100 hours while the Sherars Falls Trap caught an average of 2.78 hatchery and 0.79 wild steelhead per hour during the same sampling period as the creel. The data was very consistent over time in describing this difference. These findings indicate that wild steelhead are captured by sport anglers at higher rates than hatchery steelhead, demonstrating the need of fishery managers to consider the implications and importance of wild fish to sport anglers.

Factors influencing redd observer efficiency in the Wenatchee Basin
Chad Herring, WDFW

Steelhead *Oncorhynchus mykiss* run escapements into the upper Wenatchee Basin have been calculated based on Tumwater Dam passage data since 1999. WDFW has been conducting steelhead spawning ground surveys in the Wenatchee Basin since 2001. Mean proportion of the run escapement accounted for on the spawning grounds was only 56% for 2004 thru 2009. The low proportion of run escapement accounted for on the spawning grounds generated two possible hypotheses: 1) spawning ground surveys are not covering all spawning habitat available in the basin; and 2) our ability to find steelhead redds or observer efficiency is lower than expected. Beginning in 2010, we began a three year study to calculate observer efficiency and to evaluate what factors influence observer efficiency. We measured a variety of habitat, environmental, biological and observer specific variables to see what effect they had on observer efficiency. We used a mark-resight approach slightly modified from Thurow and McGrath (2010) to determine observer efficiency and Spearman Rank correlation to determine which factors were significantly correlated with observer efficiency. Preliminary results after analyzing two years of data suggest that the factors that explain the most variation in observer efficiency are effort, visibility, stream width, channel complexity and density of redd like features. Interestingly, while experience wasn't significantly related to correctly identifying steelhead redds it was significantly negatively correlated with falsely identifying features as steelhead redds. Also, calculations of total and net error rates of spawning ground surveys found surveyors consistently underestimated the total number of redds, except in a few occasions. These findings are similar to what Thurow and McGrath (2010) found conducting a similar study on spring Chinook *O. tshawytscha* in the Middle Fork Salmon River, Idaho. The methodology is repeatable and needs to be conducted in a variety of different habitat and environmental conditions, but does demonstrate that steelhead redd abundance can be estimated across a range of survey conditions.

Estimating steelhead redd abundance and variance based on redd observer efficiency - Andrew Murdoch, WDFW

Summer steelhead exhibit a prolonged and complex freshwater migration in route to their natal stream. Fish often overshoot their natal streams in search of cool water refugia and may experience differential survival based on overwintering location. These factors dramatically confound the use of dam counts as an index of abundance. Spawner abundance estimates based on redd counts are also confounded by the variation in the ability to correctly identify and enumerate redds (i.e., observer efficiency). Factors that may contribute to variation in observer efficiency are numerous and include environmental, habitat, and surveyor experience. Despite these challenges, spawner abundance estimates remain a critical component in understanding the status and productivity of a population. Unlike other species of anadromous salmonids, steelhead have been found to spawn in a wide range of habitats within a watershed, often precluding the use of more traditional salmon based techniques (i.e., total census of redds) due to logistical and financial constraints. We

developed a model that estimated observer efficiency and found that an index of habitat complexity, an index of visibility, reach specific surveyor experience, and density of redd like features were the most important factors explaining variation in observer efficiency. Redd abundance and variance estimates for each stream reach can be estimated using a modified area-under-curve (AUC) methodology, redd life, and observer efficiency. Application of the methodology should be possible anywhere steelhead redd surveys can be conducted, but does rely on robust estimates of redd life and observer efficiency, which may require additional financial support at least initially. An evaluation and refinement of the methodology will be conducted in the Wenatchee Basin in 2012.

Directed acyclic graphs: A tool to incorporate uncertainty in steelhead redd based escapement estimates - Danny Warren, WDFW

One of the purposes of the Columbia River Coordinated Assessments Project was to develop transparency in the documentation of data storage, analysis, and reporting for three high level indicators including natural origin spawners (NOR), spawner to spawner ratio (SSR), and smolt to adult return (SAR). In the Lower Columbia Region, the Washington Department of Fish and Wildlife (WDFW) concentrated on the development of a specific type of data analysis flow diagram called a directed acyclic graph (DAG) for various monitoring methods such as redd surveys, Area-Under-the Curve, and mark-recapture. A DAG is a graphical representation of a statistical model that facilities the understanding of the model and analysis structure. However, when developed in BUGS software the DAG provides a transparent, graphical, and statistical depiction of the model on multiple levels, which facilitates the development of point and variance estimates for the measurements and indicators. We will demonstrate the application of this approach to estimating steelhead escapements in the Mill-Abernathy-Germany (MAG) population based on census and systematic sampling designs.

Estimates of steelhead escapement from video counts - Ken Gates, USGS

Enumerating salmon and steelhead abundance is critical for the purposes of managing run strength, stock composition, and directed fisheries. Accomplishing this can be difficult especially in large river systems comprised of multiple species with overlapping run times. Several techniques such as sonar, mark-recapture experiments, or traditional weirs could be used to estimate the abundance of salmon and steelhead, but these techniques are often expensive, time consuming, can adversely impact returning fish runs, and can have a significant amount of error associated with the estimate. A successful technique recently used to estimate salmon and steelhead abundance and run timing is weirs equipped with underwater video systems. Underwater video monitoring offers several advantages such as unobstructed fish passage, accurate counts and species identification, fish enumeration during high and turbid water conditions, and long-term cost savings. Motion-detection hardware and software records images only when fish are passing through the weir, which requires considerably less staff time to review than actual live counts. The ability to replay, freeze-frame and zoom in during file review has also improved the accuracy of counts and species identification compared to traditional weirs. This technique is illustrated

using data collected from salmon and steelhead spawning migrations on the Kenai Peninsula in Southcentral Alaska.

An approach for developing biological reference points for steelhead populations in the Lower Columbia River - Bryce Glaser, WDFW

The Washington Department of Fish and Wildlife developed a Statewide Steelhead Management Plan in 2008. The next phase of the plan calls for the development of quantifiable population escapement objectives that balance ecosystem, demographic, and genetic concerns with fishing opportunities. Most Lower Columbia River steelhead populations are listed under the Endangered Species Act and historic maximum sustainable yield escapement goals for these populations were based on professional opinions from the US vs. Oregon Technical Advisory Committee or application of the Potential Parr Production model from the Boldt Case area. Challenges to develop biological reference points for Lower Columbia River steelhead include: 1) a ten-fold variation in smolt to adult return rates since the 1980's and short data series, 2) various levels of hatchery spawning and relative reproductive success, 3) few data sets with low escapement measurement error, such as census counts or precise mark-recapture estimates, 4) many data sets with large measurement error due to AUC redd counts and sparse coverage of spawning areas, and 5) derived estimates of hatchery escapement. To address these challenges, we will present a quantitative approach to develop biological reference points for steelhead.

We standardized abundance estimates into fish per square kilometer of drainage area, which allowed for the use of hierarchical modeling to avoid over-fitting data with high measurement error while borrowing strength from better monitoring programs. We analyzed data using various spawner to smolt relationships to avoid the variability in marine survival that obscures true spawner to adult recruitment patterns. We used estimates of relative reproductive success to the smolt stage to adjust hatchery spawners into wild equivalent spawners. Future work includes refinement of the watershed area approach to a spawning distribution approach using GIS derived attributes, such as gradient, that may more accurately reflect individual population biological reference points.

Integrated Status & Trend (ISTM) Project: An overview of establishing, evaluating and modifying monitoring priorities for Lower Columbia River Steelhead
Jeff Rodgers, ODFW

The purpose of the Integrated Status and Trend Monitoring (ISTM) demonstration project is to develop processes and tools for the design and implementation of integrated regional strategic action plans or roadmaps for monitoring the status and trends of aquatic habitat, watershed health, and salmon populations (including steelhead). The Lower Columbia River (LCR) has been chosen as the demonstration area for this project because it represents the challenges faced when integrating monitoring across multiple Evolutionary Significant Units (ESU) and Distinct Population Segments (DPS), and among multiple jurisdictions (e.g. the states of Oregon and

Washington, the Federal Columbia River Power System (FCRPS), and federal and tribal management through U.S. v. Oregon and the Pacific Salmon Treaty). Five objectives were identified to meet ISTM project goals including: 1) Identify and prioritize management decisions, questions, and objectives; 2) Evaluate the extent to which existing programs align with these management decisions, questions, and objectives; 3) Identify the most appropriate monitoring design to inform priority management decisions, questions, and objectives; 4) Use trade-off analysis to develop specific recommendations for monitoring based on outcomes of objectives 1-3; and 5) Recommend implementation and reporting mechanisms.

Monitoring needs identified in Oregon and Washington recovery plans and National Oceanic and Atmospheric Administration (NOAA) recovery plan monitoring guidance provided the framework to make informed decisions on where to allocate limited monitoring resources. In our Objective 1 report, we developed a prioritization tool that included factors such as population recovery priority, current natural origin abundance, the potential for fish in/out monitoring, and special cases identified in the recovery plans along with the prioritization of Viable Salmonid Population (VSP) population monitoring indicators. The tool incorporated spatially explicit information on both the priority of the monitoring data and the feasibility/relative expense of obtaining it. In our Object 2 report, we evaluate how existing monitoring programs align with the management decisions, questions, and objectives identified in the first objective. To accomplish this task, we describe criteria to evaluate the 10 indicators against the priorities identified in the first report for all 103 populations of salmon and steelhead that are addressed in the states of Washington and Oregon recovery plans for the LCR. In addition to identifying the gaps, we make recommendations to improve population specific indicators that are not meeting the monitoring goals. Using graphs, we are able to succinctly display monitoring gaps and opportunities to improve these by species, adult and juvenile life stage, population, and indicator.

VII. Session Five – Invited Papers - Chair: Nick Gayeski, Wild Fish Conservancy

Puget Sound steelhead abundance near the turn of the 20th century estimated from commercial catch record data - Nick Gayeski, Wild Fish Conservancy

We used reported commercial catch data and historical information regarding unreported catches to estimate the abundance of winter steelhead, Oncorhynchus mykiss, in Puget Sound rivers in 1895, the year in which the peak commercial catch of steelhead occurred. We employed a Bayesian analysis to address the uncertainties associated with the estimation process and report abundance estimates for four large northern Puget Sound rivers and for the remaining aggregate of rivers and streams in Puget Sound. The central 90% of the posterior distribution of total abundance ranged from 485,000 to 930,000, with a mode of 622,000. Compared with the 25-year average abundance for all of Puget Sound of 22,000 for the 1980–2004 period, our results show that current abundance is likely only 1%–4% of what it was prior to the turn of the 20th century. Loss of freshwater habitat alone can account for this reduction in abundance only if there was an extraordinary decline in productivity. Our estimates of historical

abundance should better inform the development of recovery goals for Puget Sound steelhead. The complete details were presented in the Canadian Journal of Fisheries and Aquatic Sciences, vol. 68: 498-510, March 2011.

Origin and run-timing of hatchery steelhead strays into the spawning grounds of two eastside tributaries of the Deschutes River, OR - Derrek Faber, ODFW

The Steelhead endemic to the eastside tributaries of the Deschutes River have garnered a high-risk rating for viability due to the likelihood of high introgression rates between Snake River hatchery steelhead and native Mid-Columbia steelhead (Carmichael et al 2005). Some level of straying and gene flow occurs naturally in wild populations, however natural levels of gene flow and straying were presumed to be at a much lower rate than what was observed during spawning surveys. In the late 1990's greater that 50% of the steelhead observed spawning in Deschutes eastside tributaries of Bakeoven and Buck Hollow creeks were determined to be of hatchery origin (ODFW, 2000); though their specific hatchery of origin was mostly unknown. Observations of fin-clips, coded wire tags, and PIT tags on steelhead at the Sherars Falls trap on the lower Deschutes suggested that many fish originated from the Snake River, but their retention and subsequent spawning in the Eastside tributaries was similarly unknown. Stray hatchery steelhead remaining to spawn with wild fish can impact the viability of the wild population thereby reducing the overall productivity. Through the Oregon Mid-Columbia Steelhead Recovery Plan, in 2010 we implemented a study to test if high introgression rates would affect productivity by excluding hatchery spawners from Bakeoven Creek, while allowing them to spawn in Buck Hollow Creek. From the first year of study, we have learned much about the origin of hatchery steelhead that remain to spawn in tributaries to the Deschutes. In general, hatchery steelhead arrive on the spawning grounds about one-month later than wild-origin steelhead. Through the use of coded-wire-tag observations, PIT tag observations, and genetic markers (parentage based tagging (PBT)), we determined the specific hatchery of origin for observed hatchery steelhead. Previously tagged strays originated from seven hatchery stocks, five hatcheries and 10 release sites. Hatchery sources included–Round Butte–Hagerman–Niagra Springs–Magic Valley and–Irrigon. One wild stray from the Snake River basin that was PIT tagged at Lower Granite Dam and barged for release downstream of Bonneville Dam was also detected. PBT analysis was completed on 110 fin-clip samples of hatchery fish collected at Bakeoven and Buck Hollow Creeks. From these samples, 37 were positively matched to hatchery of origin. The vast majority of these fish originated from Pahsimeroi hatchery (27 of 37), but also included Dworshak,–Lyons Ferry–Oxbow–and Sawtooth; which is consistent with Sherars Falls PIT tag observations. With more hatcheries' joining the PBT baseline, we expect to identify a greater percentage of hatchery fish in the coming years.

Reduced recruitment performance in natural populations of anadromous salmonids associated with hatchery-reared fish - Kevin Goodson, ODFW

We found a negative relationship between the reproductive performance in natural populations of steelhead, coho, and Chinook salmon and the proportion of hatchery fish in the spawning population. We used intrinsic productivity as estimated from fitting a variety of recruitment models to abundance data for each population as our indicator of reproductive performance. The magnitude of this negative relationship is such that we predict the recruitment performance for a population comprised entirely of hatchery fish would be 0.128 of that for a population comprised entirely of wild fish. The effect of hatchery fish was the same among all three species. Further, the impact of hatchery fish from 'wild type' hatchery broodstocks was no less adverse than hatchery fish from traditional, domesticated broodstocks. We also found no support for the hypothesis that a population's productivity was affected by the length of exposure to hatchery fish. In most cases, measures that minimize the interactions between wild and hatchery fish will be the best long-term conservation strategy for wild populations.

Physical habitat characteristics contribute to life history variation among seven Oncorhynchus mykiss populations in Hood Canal
Lance Campbell, WDFW and Barry A. Berejikian, NOAA Fisheries

Juvenile Oncorhynchus mykiss maternity was determined from otolith Sr:Ca ratios to investigate the degree of anadromy in eight highly diverse freshwater streams draining to a common fjord (Hood Canal, Washington). Laser transects measuring Sr:Ca ratios from the primordial core to the edge of individual otoliths indicated that O. mykiss 'parr' (100 to 170 mm fork length) produced by anadromous females generally dominated the parr populations in stream reaches accessible to anadromous adults. The proportions of parr produced by anadromous mothers ranged from an annual average 41.3 percent (Hamma Hamma River) to 100 percent (Dewatto River) over three years. The proportion of stream habitat available only to resident O. mykiss (i.e., upstream of barriers to anadromous migration) explained a significant portion of the variability in maternal life history below barrier falls and was included in each of the five logistic regression models with the lowest AIC scores. Transitional hydrologic profiles, low mean annual temperatures and high mean annual stream flow, common to Olympic Peninsula streams, were each associated with greater proportions of offspring from resident mothers. The upstream-most reaches below barrier falls (i.e., nearest the falls) had significantly greater proportions of resident offspring than lower reaches in the three streams that supported resident populations above the barrier falls. Only 2 out of 234 parr from the lowland, rain-driven, low-flow streams of the Kitsap Peninsula were produced by resident mothers. Thus, large-scale habitat features and the presence of resident population above natural barriers to anadromous migration appear to shape the degree of anadromy in geographically proximate O. mykiss populations. Estimating the influences of resident O. mykiss on anadromous population productivity will require additional information regarding the source of above-barrier populations, current rates of migration over the falls, contributions of resident females to anadromous offspring, and reproductive interactions between resident and anadromous forms.

Influence of changing thermal regimes on steelhead growth and life history expression - Matthew Sloat, OSU

Fueled by concerns over climate change, ecologists and resource managers are increasingly being challenged to predict the response of aquatic organisms to alterations in thermal regimes. Species such as Oncorhynchus mykiss that exhibit plastic life histories may respond in complex ways to bioenergetic changes mediated by warming stream temperatures. The adoption of resident or anadromous life history strategies in O. mykiss is thought to be a flexible response to bioenergetic performance during the first year of life, although the relative importance of factors such as absolute size, growth rate, and growth efficiency during early development is unknown. We tested the effects of water temperature on male energy allocation and life history expression in a laboratory study using a full-sibling group of O. mykiss of Clackamas River origin. Males subjected to a cool thermal regime (range: 7 – 13°C) had lower somatic growth rates than males subjected to a warm thermal regime (range: 7 – 18°C). However, despite lower growth, male maturation rates within the cool thermal regime were 25% higher and smoltification rates were 30% lower than in the warm regime. Within temperature treatments, mean growth rates of freshwater maturing males tended to be higher than mean growth rates of smolting males. However, considerable overlap in the growth trajectories of fish exhibiting alternative life histories precluded the prediction of individual life history expression using somatic growth. Our study provides some of the first empirical evidence for changes in O. mykiss life history expression as a function of water temperature and highlights some of challenges of predicting life history responses to potential impacts of climate change.

The influence of sex and migration distance on the expression of anadromy in Oncorhynchus mykiss - Haley Ohms, OSU

Steelhead and rainbow trout (Oncorhynchus mykiss) are sympatric, mate with one another, and produce offspring that may adopt either a resident or anadromous life history. A frequent observation of returning adult steelhead is that there is a greater proportion of females. This may be evidence that females and males have different evolutionary tradeoffs associated with anadromy, such that females are more likely to migrate. However, it is unclear whether the female bias observed among returning steelhead is related to sex-specific mortality in the ocean, greater iteroparity among females, or female bias among strays. To investigate female bias among steelhead and to understand how migration distance and latitude influence female bias, I obtained smolt samples from eight O. mykiss populations that have a range of migration distances from small coastal streams to the interior Columbia and ranging in latitude from Alaska to California. In one of these rivers, the South Fork John Day, I also measured sex ratios in juvenile and resident O. mykiss to assess corresponding male bias among resident rainbow trout and the sex ratio of age-0 fish. My preliminary results indicate a high degree of female bias among smolts in all populations, except for smolts in the coastal Oregon population. Female bias among smolts ranges from approximately 60 to 75% and does not differ by migration distance or latitude. In coastal Oregon the sex ratio among smolts was approximately equal. Within the South Fork

John Day smolts were approximately 76% female (95% CI: 68 to 84%), whereas mature resident fish were 42% female (95% CI: 25% to 59%) and the primary sex ratio was 43% female (95% CI: 29% to 57%). This work provides evidence of a high degree of female bias among steelhead smolts and suggests that there are possible differences in the life history tradeoffs between males and females. It also suggests that male bias among residents may be difficult to detect in populations with a large component of resident fish.

Sex reversal or selection against hatchery females does not explain differences in sex ratio between hatchery and wild steelhead, Oncorhynchus mykiss
Neil F. Thompson, OSU

Hatchery steelhead from the Hood River (first generation, created using local, wild broodstock) display a 50:50 sex ratio among returning adults, while wild fish have displayed a strong female bias (60:40) from 1991 to 2009. We used a Y-chromosome specific marker (OmyY1 locus) to test whether sex reversal or selection against hatchery females could explain the higher proportion of males in hatchery steelhead from the Hood River. Hatchery fish sampled as 1-year olds and as returning adults all exhibited the same 50:50 chromosomal (OmyY1 marker) sex ratio. Therefore, we can rule out selection against hatchery females while in captivity or after release as a cause of the lower female bias in hatchery steelhead. We found low levels of non-concordance between phenotypic sex and chromosomal sex in both juvenile and adult samples (3.4% and 2%). Both male-to-female and female-to-male reversals were observed. However, the rate of non-concordance between chromosomal and phenotypic sex that we observed is well within the published non-concordance rate for the OmyY1 marker. More importantly, we observed a similar rate of non-concordance in samples of wild and hatchery adults. Therefore, we see little evidence for sex reversal in hatchery fish. We hypothesize that the greater female bias in wild than in hatchery steelhead from the Hood River results because wild males become residents (non-anadromous) at a higher rate than hatchery males.

Update on development of a nomenclature for steelhead - Hal Michael, Retired WDFW

Recent studies and accumulated observations of steelhead and other anadromous salmonids show a significantly more diverse suite of life histories. The complexity, overlap among species, and radically different trajectories require a review of how we identify life history stages. A group has been formed to develop a unified nomenclature to better describe the fish. People interested in assisting in the project will be invited to join in.

VIII. Session Six Invited Papers – Part II - Chair: Hal Michael, Retired WDFW

Discussion of winter steelhead R/S and implications for management
Hal Michael, Salmonid Ecosystem Ecologist, Olympia, WA

Quantification of the relationship between spawning population and resulting production is the cornerstone of sustainable resource management. Winter steelhead present many difficulties in obtaining a complete census of spawning population, total adult return, and age at return due to complexities in life history. Reasonably complete data sets that are based on counts of entire run routinely show R/S as less than 1.0 for all first time spawners in a brood. As components of the run (escapement, age composition) are estimated/extrapolated the R/S approaches or exceeds 1.0.

Synergistic impacts of climate change: Increased temperature and flooding and the persistence of endangered steelhead in southern California –
Matthew Sloat, OSU

Characterizing natural disturbance regimes that affect the quantity and quality of critical aquatic habitat is an important first step for steelhead management and recovery planning. Perspectives from the Pacific Northwest regarding the role of disturbance regimes in maintaining a mosaic of critical aquatic habitats have improved management and conservation of anadromous salmonids. Here, we offer a complimentary case study from the southern margins of salmonid anadromy. In southern California, El Niño climate events drive large flood disturbances with a periodicity of about 5 – 8 years. In some catchments, these floods completely remove riparian trees. Immediately after flood disturbance, the loss of riparian vegetation increases stream insolation, causing stream temperatures to heat quickly and constrain the summer distribution of thermally sensitive species such as steelhead trout. In Santa Paula Creek, a tributary to the Santa Clara River, riparian vegetation recovered quickly following complete removal during the 2005 flood disturbance. In response to increased stream shading, maximum summer stream temperatures cooled by an average of 3ºC between 2 and 4 years after flood disturbance. Steelhead persisted in stream habitats where summer temperatures did not exceed 30ºC, but their probability of persistence declined precipitously at higher temperatures. Because the threshold dividing thermally suitable and unsuitable habitat was very steep, small decreases in stream temperature result in large changes in the extent of available summer rearing habitat. The 3ºC cooling of stream temperatures following recovery from flood disturbance resulted in a 43% increase in the length of stream suitable for steelhead. These results suggest that the extent of thermally suitable steelhead rearing habitat expands and contracts cyclically in response to the effects of El Niño-driven flood disturbance on riparian vegetation. Furthermore, the frequency of large floods has increased in the latter half of the 20th century as the southern California climate shifted from drier to wetter conditions. These findings suggest that shifts in large-scale climate drivers have influenced patterns of flood disturbance and recovery of riparian vegetation in the study system with cascading effects on summer stream temperatures and the distribution of thermally sensitive aquatic organisms such as O. mykiss.

Differential productivity for Coho-based on other species escapement
Leon Shaul, Harold Geiger and Roger Harding, ADFG

The coho salmon population in Ford Arm Creek in Southeast Alaska was studied as an indicator stock for fishery management during 1980−2009. A doubling of the average adult return between 1982−1991 and 1992−2009 resulted from a 48% increase in average presmolt production and a 37% increase in average presmolt-adult survival. The increase in freshwater production occurred concurrent with a quadrupling of both average pink salmon spawner abundance and average all-species carcass biomass. Relationships were explored using independent variables that included the pink salmon peak escapement survey count and total MDN loading in the common brood year, the following year, and an average for both years, with the average for both years producing the best statistical fit with coho salmon production. Average pink salmon escapement in the coho brood year and the following year explained 58% of variation in the survival-adjusted return of coho salmon. A logistic hockey stick model predicts an increase of 127% in the coho salmon return as pink salmon escapement increases from zero to an inflection point at a peak count of 79 thousand spawners, with a further 18% increase in coho production to a nominal saturation point at 116 thousand pink salmon spawners, above which further response was nil. Both reference points fall within the current pink salmon escapement goal of 48−156 thousand spawners, established using single-species yield analysis. On an area-density basis, the relationship between MDN and coho salmon production in Ford Arm Creek was consistent with the observed growth response by coho salmon fry to the addition of pink salmon carcasses reported from other research based on a controlled experiment in an artificial stream. These observations further support inter-species relationships and the response to MDN as important considerations in setting escapement goals for salmon. Evidence suggests that steelhead production may also benefit from an increase in MDN derived from higher pink salmon escapement levels.

Friend or Foe: Influence of resident trout on steelhead production in the Yakima Basin - Ian Courter, Cramer Fish Sciences

Steelhead, a name used to describe ocean-going (anadromous) rainbow trout, represent one of many life-history types within Oncorhynchus mykiss populations. Another common life-history tactic is residency, whereby individuals remain in freshwater until fully mature, often traveling only a short distance from their place of origin over the course of their life-cycle. O. mykiss juveniles do not always emulate their parent's life-history choices. This life-history plasticity is assumed to be reflective of habitat-dependent trade-offs between freshwater survival and increased reproductive output resulting from ocean maturation. We demonstrated that resident rainbow trout play a critical role within steelhead populations in the Yakima Basin, Washington through production of significant numbers of anadromous offspring that survive and return as adult steelhead. Incorporating these estimates of cross-ecotype exchange into a steelhead population dynamics model yielded more accurate predictions of adult steelhead production compared with a model that did not account for cross-ecotype exchange, particularly during years of low marine survival. These results suggest that

steelhead population viability and recovery may be dependent on existence of a robust resident trout cohort, which highlights the importance of jointly managing freshwater and anadromous life-histories as units of the same population.

Maybe it wasn't hatchery fish; environmental possibilities to steelhead decline
Wes Hoppler, Steelhead Trout Club of WA

Recently several papers have examined historical abundance of wild steelhead and other historical documents that are informative on run timing. While agreement on the specifics is not necessarily complete, general consensus is that we did in fact have significantly greater numbers of wild steelhead in the past and they were more abundant in the early portion of the season than they are today.
In the case of the West coast of the Olympic Peninsula, two basins are of particular interest because of the high level of protection they receive from inclusion in Olympic National Park. The Hoh River is a highly glacially influenced river that drains much of Mount Olympus and has approximately 65% of its basin located inside the park. The larger Queets River to the South is also glacially influenced, draining the South side of Mount Olympus and Mount Queets, and has 40% of its basin within the park boundaries.

The objectives of this study were:

1. To better understand the historical context of these rivers relative to other Olympic Peninsula rivers and what insight that might bring to determining the underlying nature of the declines.
2. To investigate various literature and studies specific to these basins to further understand the drivers of the declines.
3. To analyze available hydrologic data and attempt to see how recent hydrologic trends may be impacting wild steelhead stocks, both from productivity and run/spawn timing perspectives.
4. To perform an assessment of other steelhead runs/systems that may be able to inform us of the nature of the mechanisms of the change we see in these two basins.

What we found were unique historical circumstances that set these two drainages apart from most of the other major rivers on the western Olympic Coast. In some ways they had further to fall than all others.
We focused on land use, hydrology and sedimentation as key drivers to change. We discovered that these rivers are being subjected to escalating disturbances, many with long time constants, and that these are likely causal candidates for the changes manifested in wild steelhead stocks of these basins. We also found a regional example of wild winter-run steelhead run time shifting that does not appear to be caused by hatchery fish interaction.

The clean-water paradox: Impacts of Troy WWTP on juvenile steelhead habitat
Hal Michael, retired WDFW and Ricardo Sanchez-Murillo, University of Idaho

No abstract submitted

Western Washington winter steelhead stock structure –
Todd Kassler and Ken Warheit, WDFW

The WDFW molecular genetics laboratory has completed a microsatellite analysis on a total of 3,079 anadromous and resident *O.mykiss* samples from the Skagit River Basin. Genetic analysis was conducted on collections of adult and juvenile steelhead throughout the basin, and resident rainbow trout to determine if there was any population genetic structure. Preliminary analysis shows that the unclipped steelhead samples are not genetically differentiated from each other while samples collected at Marblemount Hatchery are significantly different. Collections of juveniles and adults from the same watersheds are also not differentiated from one another while collections of resident *O.mykiss* taken above barriers are genetically differentiated. Analysis of juvenile collected below barriers and resident *O.mykiss* above the barriers suggest no mixing has occurred and that the resident *O.mykiss* are not falling below the barrier and mixing with the anadromous juveniles.

Part 1: Management and recovery implications of wild/hatchery steelhead interactions within a large complex watershed – Skagit River, WA
Dave Pflug and Ed Connor, Seattle City Light

Interactions between non-listed hatchery steelhead and listed wild steelhead have been identified as a factor contributing to the decline of wild steelhead. The 2007 federal listing of Puget Sound steelhead prompted Skagit tribes, WDFW and Seattle City Light to complete a multi-year evaluation of possible genetic and ecological interactions between wild origin and hatchery steelhead within the Skagit watershed. The Skagit River is a large, complex watershed that supports Puget Sound's largest wild origin winter steelhead population. A segregated hatchery program has been in operation on the Skagit River for the past 40 years with smolt releases ranging from 100,000 to 600,000.

While a statistically based level has yet to be determined, there is evidence of spatially diverse introgression. We also found evidence of hatchery steelhead reproducing with each other throughout the basin. The immediate and long-term genetic impacts of hatchery/wild interbreeding are far reaching from a fish management, tribal treaty, sport fishing and steelhead recovery standpoint.

We also examined the combined effects of ocean conditions and hydrological variability on the long-term abundance and productivity of Skagit River steelhead using multiple regression and life-cycle models. Both freshwater and ocean survival of Skagit have declined substantially since 1990, and total egg-to-adult survival rates are now at the lowest levels predicted for the past 70 years. Freshwater survival of wild steelhead in

the Skagit River has declined to less than 2 percent (egg-to-smolt) from 2006 to 2010. Ocean survival rates (smolt-to-adult returns) have declined to less than 2 percent for wild Skagit steelhead in 2000, and persisted at this low level over most of the last decade. We assessed the long-term viability of Skagit steelhead populations using a life-cycle model based upon freshwater survival, ocean survival, age-class composition, and juvenile carrying capacity values. This model predicts that wild steelhead populations will decline below critical levels (i.e., quasi-extension threshold) if freshwater survival rates fall below 2% when smolt-to-adult survival are at the 2% level. Wild Skagit steelhead are very close to this critical threshold level at this time. Under these historically low survival conditions, maintaining and improving the freshwater survival and genetic fitness of wild steelhead becomes imperative. Hatchery practices that even slightly reduce survival and fitness of wild juvenile fish can have substantial impacts on steelhead productivity under current conditions. Moreover, improvements in freshwater habitat quantity and quality can make a substantial contribution towards recovery under these conditions.

Four future hatchery production scenarios are explored taking into consideration how each might affect fish management, tribal treaty rights, sport fishery and steelhead recovery. The scenarios range from no change in hatchery smolt production to reduced production levels and include an integrated hatchery program scenario.

Part 2: Management and recovery implications of wild/hatchery steelhead interactions within a large complex watershed – Skagit River, WA

Dave Pflug and Ed Connor, Seattle City Light

See abstract above

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