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Expert Panel on Resident Fish:

The purpose of this document is to provide an outline for a presentation by ODFW staff to the expert panel on redband, rainbow and bull trout which will provide input for the secretarial determination of whether to remove the four hydroelectric dams on the Klamath River. The expert panel will evaluate if the continued operation of the four main stem hydro electric facilities is in the best interest of the people of the United States and if fisheries will benefit.

ODFW has compared a scenario of continuing to operate the Klamath Hydroelectric Project status quo with no reintroduction of anadromous fish versus removal of the four Klamath Hydroelectric dams, implementation of the KBRA and reintroduction and volitional re-colonization of anadromous fish. ODFW has extensive information on trout populations in the Klamath basin and will present information on how removal of the Klamath River dams and implementation of the Klamath Basin Restoration Agreement will effect the population of redband, rainbow, and bull trout. For redband trout ODFW answered the general questions for the expert panel and gave a brief summary of current status of the population and status of redband trout with KBRA implemented with dam removal. An outline was developed covering the major points affecting the health of rainbow and bull trout populations in the Upper Klamath Basin:

Rainbow trout in Klamath River
1) Fish Passage
2) Entrainment and JC Boyle screen effectiveness
3) Length-Weight Analyses
4) Macroinvertebrate Biomass and Fish Diet
5) Forage Fish Abundance
6) Klamath River Rainbow Trout Age Structure
7) Angler Use and catch rates
8) Population Estimates and Standing Crop
9) Habitat
10) Genetics
11) Water quality and disease
12) Non Native fish and amphibians
13) Economics

Bull trout
1) Bull Trout Status
2) Habitat
3) Genetics
4) Water Quality and disease
5) Non-native Fish
6) Economics

Status Klamath Rainbow/Rainbow Trout
Dams in Scenario

Klamath River Rainbow Trout
Peaking Reach Klamath River

Population Status Current Conditions

The establishment of impoundments and operations associated with hydroelectric production and irrigation has modified the environment of native rainbow trout in the Upper Klamath River. These modifications include fragmentation of habitats, obstruction of upstream and downstream passage, alteration of stream flows and water quality, and increased competition from introduced species associated with habitat changes. Dam operators generally do not spill at J.C. Boyle until Klamath River discharge exceeds 3,000 cfs. Over the past 25 years, the Klamath River exceeded this threshold a median of 4.5 days per year (range, 0-61 days), and 12 of these years did not exceed 3000 cfs (ODFW 2006) .During the years when J.C. Boyle Dam does not spill, juvenile trout recruitment from Spencer Creek to the Klamath River Bypass Reach may be reduced or completely prevented. Recruitment to the Bypass Reach is further reduced by fish entrainment in the powerhouse diversion canal. In 2005, 18% (2/11) of radio-tagged juvenile trout that passed downstream over J.C. Boyle Dam were entrained in the powerhouse canal (ODFW 2006). One of these ended up as a shed tag in the tailrace of the J.C Boyle Powerhouse. One radio-tagged adult rainbow trout, 287 mm fork length, was entrained in the power canal, diverted past the Bypass Reach, and ended up residing in the Peaking Reach (PacifiCorp 2004).

The intake for the powerhouse canal is screened to prevent fish entrainment, but based on the above observations and annual salvage efforts by PacifiCorp; the screen has not effectively excluded fish. PacifiCorp crews drain the 2-mile canal for maintenance at least once per year and, using electrofishers, attempt to salvage rainbow trout and sucker species from the canal. These fish are counted and transferred to the Peaking Reach of the Klamath River (ODFW 2006).

In the 48-mile section of river between Copco Dam to Link River Dam, the Klamath River has been altered ecologically, hydrologically, and geomorphically by dam construction and operation. These alterations have also affected rainbow trout life history and abundance. Spencer Creek is the only known spawning area and source of juvenile recruitment in the upper Klamath River basin upstream of J.C. Boyle Dam and Spencer Creek spawners had diverse life histories. In 1959, the year after J.C. Boyle Dam was completed, adult rainbow trout migrated from what are now known as the Peaking Reach and Bypass Reach of the Klamath River in large numbers to spawn in Spencer Creek and then returned to these reaches after spawning (Hanel and Gerlach 1964). Currently, the Peaking Reach life history appears to be gone and the Bypass Reach life history has been reduced to less than 2% of historical abundance and is composed of significantly smaller trout (ODFW 2006).

There appears to be multiple factors leading to the decline in abundance and size of adult rainbow trout migrating upstream over J.C. Boyle Dam. First, the dam is managed solely for hydroelectric power production. During base flow conditions, at least 80% of the Klamath River discharge is stored in the reservoir and then diverted through the powerhouse diversion canal. Therefore, for most of the year, the Bypass Reach experiences less than 20% of the natural flow regime, this reduces habitat volume and carrying capacity in this Reach. Second, dam operators generally only spill water when Klamath River discharge exceeds 3,000 cfs, which does not occur every year and frequently occurs for only a short period in spring. Short, unpredictable, and infrequent periods of spill at J.C. Boyle Dam appear to reduce recruitment of juvenile migrants from Spencer Creek to the Bypass Reach. A substantial proportion of juvenile trout dispersing downstream are also entrained in the powerhouse canal, which contributes to the reduction in juvenile recruitment to the Bypass Reach (ODFW 2006). Third, construction of the dam and powerhouse canal maintenance road along the Bypass Reach has improved angler access to this reach and may have increased angler harvest from this section of the river (Gerlach and Hanel 1964). Finally, construction of the dam and fish ladder has substantially narrowed passage opportunity for fish migrating upstream. While the fish ladder appears to be passable for sub-adult and adult rainbow trout, it appears to have excluded other species and created a passage bottle-neck that may increase the predation of rainbow trout attempting to enter ladder (ODFW 2006).

Adult rainbow trout from the bypass reach are now more strongly associated, during the spawning period, with known spawning areas in the lower Bypass Reach and possibly locations in the peaking reach. Adult trout from the upper Peaking Reach downstream to near Copco Reservoir are strongly associated with Shovel Creek during the spawning period and the upper Peaking Reach contributes some fish to the spawning population in the lower Bypass Reach (ODFW 2006).

1) Fish Passage

Below is a list of findings from research and ALJ court case in 2006 in regards to fish passage in the Klamath River.

a) The current fish screen and ladder at JC Boyle Dam do not meet current state and federal fish passage criteria and impairs upstream migration (McKenna 2006)

b) Fish ladder does not meet criteria for
   i) Jump height
   ii) Gradient

c) We compared our estimated of monthly trout passage at JC Boyle Dam in 1988,1989,1990 and 1991 with those reported in 1959 (Hanel and Gerlach 1964; Table 3). The number passed in 1991 was the lowest estimated during the four year span of this project, and was less than 2% of that reported one year after the construction of JC Boyle Dam (Hemmingsen *et al.* 1992 page 6, 3rd ¶).

d) Recent radio telemetry studies of adult rainbow trout in the Bypass Reach and Peaking Reach of the Klamath River add further evidence that adult life history connectivity above and below J.C. Boyle Dam has been reduced. (ODFW 2006 page 12, last ¶).

e) In 1988 Beak Consultants conducted a study in which 453 rainbow trout were tagged downstream of the J.C. Boyle dam (44 in the J.C. Boyle bypass reach and 409 in the Salt Caves reach). None of the fish tagged in the Salt Caves reach were captured in the trap at J.C. Boyle and only a very small percentage were captured in the J.C. Boyle bypass reach (City of Klamath Falls 1990 page 21, 7th ¶).

f) Spencer Creek is a highly productive spawning and rearing habitat for rainbow/redband trout. The stock of rainbow/redband trout in the bypass and peaking reaches below JC Boyle Dam is denied the use of Spencer Creek and other suitable habitat upstream of the J.C. Boyle Dam (Judge McKenna 2006).

g) The Project's limitation on riverine migration may have reduced the genetic diversity of the remaining stocks within the Project reaches (Judge McKenna 2006).

h) Resident trout are a migratory species. Because Spencer Creek, located upriver of the J.C. Boyle facility, is a primary spawning and early rearing area for resident trout within the Project area, it is important that adult spawners from the river below the dam and juvenile trout from Spencer Creek both are able to successfully migrate upstream and downstream past J.C. Boyle Dam (McKenna 2006).

i) Adults that do approach the JC Boyle ladder do not pass or have difficulty passing. Only 1 of 131 spawning sized trout passed J. C. Boyle Dam in 2003-04 studies. The one trout passed during spill event which occurs every other year for an average of four days (ODFW 2006 and PacifiCorp 2004).

j) Prior to the construction of the dams, rainbow trout within the Project area belonged to a single, large, intermixing population throughout the Klamath River Basin (McKenna 2006).

k) Migration is one of several defining life history characteristic of trout. Their ability to migrate is one of several evolutionary advantages contributing to survival of trout in the Klamath River for millions of years through dramatic environmental changes (McKenna 2006).

l) If movement or migration had survival advantages during the evolution of native trout in a particular drainage, the trout will have such movement or migration programmed into their life history (Behnke 1992 page 48, 1st ¶).

m) The Project restricts migration of resident fish within the main stem and into and out of tributaries. Iron Gate, Copco I, and Copco II Dams do not have fishways and currently block all upstream fish passage. Thus, the stocks above Iron Gate are isolated from counterparts in the lower basin. Further, the stocks between each of Iron Gate, Copco I, and Copco II Dams are similarly isolated (McKenna 2006).

2) Entrainment and JC Boyle screen effectiveness

The hydroelectric complex has impacts on productivity and abundance of rainbow trout populations. The bullets below highlight many of these impacts. Much of this information comes from the findings in the ALJ hearing in 2006 and research conducted by ODFW in 1988-1992 and 2003-2005. The bullets below refer the ineffectiveness of the screen at JC Boyle Dam and the fish bypass system.

a) The Licensee acknowledges in their license application that tens of thousands of resident fish are likely entrained annually at each of the unscreened developments on the mainstem Klamath River. (PacifiCorp 2004c page 112, second full ¶).

b) The Licensee estimates that about 40 % of fish passing through each powerhouse are killed (PacifiCorp 2004c page 113, second ¶).

c) In 2004, there was no movement of radio-tagged juvenile trout from Spencer Creek below J.C. Boyle Dam (ODFW 2006 page 18, 2nd ¶).

d) Differences in juvenile dispersal between 2004 and 2005 appeared to be related to the dramatic differences in Klamath River discharge and operation of J.C. Boyle Dam. In 2005, mean daily discharge was above 3,000 cfs for most of May and peaked at 4,500 cfs. These high flows caused dam operators to open the spillway for two weeks in May and a week June, increasing discharge in the Bypass Reach from 150 cfs to almost 2,000 cfs. Over 70% (8/11) of the downstream passage of juvenile trout over the dam occurred when the dam spillway was open (Figure 7). In 2004, peak discharge on the Klamath River only reached 2,000 cfs and the spillway was not opened during the study period. These results suggest that inter-annual variability in discharge and dam operation affect juvenile fish passage over J.C. Boyle Dam and recruitment to the Bypass Reach of the Klamath River (ODFW 2006 page 19, 1st ¶).

e) Downstream migration of rainbow/rainbow trout is also adversely impacted because of the Project dams. This is due to the hydraulics at the Project dams and mortality related to unscreened flow resulting in fish passage through Project dam turbines (McKenna 2006).

f) It is estimated that "several tens of thousands of resident fish" are annually entrained at "each of the Projects" facilities (McKenna 2006).

g) Mortality from entrainment can occur at each Project facility, thus fish surviving through one powerhouse could be exposed to potential cumulative mortality (McKenna 2006).

h) Once entrained, the fish face a high risk of mortality. For juvenile fish, the risk is between 10-30% (McKenna 2006).

i) Entrainment mortality removes fish that would otherwise add to the population base downstream of the dam (McKenna 2006).

j) In one fish salvage effort in May 2005 a total of 750 rainbow trout up to 14” were salvaged in the bypass canal. Not all fish are salvaged only those that can be captured by electrofishing (ODFW 2006)

k) The J.C. Boyle facility uses Francis turbines, at an operational head of 440 feet. A 1987 report prepared by the Electric Power Research Institute (EPRI) concluded that fish mortality from entrainment at hydroelectric projects using Francis turbines averaged 24 percent. The EPRI report found that entrainment mortality at hydroelectric projects using Francis turbines with operational head greater than 335 feet ranged from 33-48%. In light of the large percentage of river flow that is diverted into the J.C. Boyle power canal, the operation of Francis turbines, and the high operational head of 440 feet, fish mortality from entrainment at the J.C. Boyle project is likely in the higher end of the mortality ranged as described in the Electric Power Research Institute report (McKenna 2006).

l) PacifiCorp recognizes that entrainment at the J.C. Boyle Dam is a “problem that needs to be addressed (McKenna 2006)

m) Salvage records show the entrainment of over 690 trout into the J.C. Boyle reach during salvage operations between 1995 and 2002. During that same period of time, it appears that only 2 suckers were entrained. In 2003, J.C. Boyle fish salvage totaled 86 trout and 17 suckers (McKenna 2006)

n) Canal salvage data provides a snapshot of the number of fish entrained at the time that salvage operations are performed, and thus such data represents only a small fraction of the total number of fish actually entrained each year (Judge McKenna 2006).

o) Fish are killed by suddenly lowered pressure from their accustomed depth pressure. Such changes can and do cause embolism and swim bladder rupture (Bell 1991 p. 5, Item #5).

p) The downstream screw trap in the Klamath River below J.C. Boyle Dam and located immediately below the fish bypass pipe only captured 53 unmarked juvenile rainbow trout, 48 marked juvenile rainbow trout from Spencer Creek, and 43 adult trout. (Buchanan *et al*. 1991 page 2 under Findings in FY 1991, 2nd ¶).

3) **Length-Weight Analyses**

The hydroelectric reach of the river has detrimental impacts on size and condition of rainbow trout. Size and condition of rainbow trout is important in survival, fecundity and overall productivity of the population. The bullets below highlight the findings of research studies conducted on the Klamath River hydro effected reaches. Size of fish is also a factor in the economic value of a fishery.

a) Rainbow trout in the peaking reach do not typically exceed 16 inches (Addley 2005, ODFW 2003 and City of Klamath Falls 1989).

b) The Keno reach had the widest variance in size of rainbow trout and the largest rainbow trout when compared to the peaking and bypass reaches. The bypass reach was the only site where young of the year rainbow trout were captured. Average relative weights (Wr) for all rainbow trout (>200mm) captured by all gear types were 109, 114, and 117 in the peaking, bypass, and Keno reaches, respectively. The Keno reach relative weight for rainbow trout captured by all gear types was very highly significantly different ($p=3.35x10^{-9}$) than the peaking reach and significantly different (p=0.01) than the bypass reach. The bypass reach was very highly significantly different (p=0.0006) than the peaking reach. (ODFW 2003 page 10, 1st ¶). Rainbow trout greater than 300 mm captured by hook and line in the peaking reach exhibited very poor condition (Wr=99). The trend of poor condition continued into the fall as 22 rainbow trout, greater than 276mm, captured by hook and line in late September and late October had an average relative weight of 98 (ODFW 2003 bottom page 10 and top page 11).

c) In addition to the decline in abundance of upstream migrants following the construction of J. C. Boyle Dam, it appears that there was also a significant decline in fish size. The average length of rainbow trout captured from the ladder during March through May decreased from 30 cm in 1961 to 18 cm in 1990 (ODFW 2006 page 11, 5th ¶).

d) Keno reach rainbow trout attain larger size that peaking reach rainbow trout (ODFW 2003 and PacifiCorp 2004).

e) Absence of suitable spawning habitat within the Salt Caves reach (Peaking Reach) is further supported by the length frequency distribution of the trout population within the reach. Fish sampling conducted in 1984 and 1985 indicated there are few fish in the size range of the 0+ and 1+ age classes. If reproduction was occurring within the reach, these age classes should be relatively abundant. Recruitment of the new fish to the Salt Caves reach appears to be through downstream movement of larger trout that have reared for one or more years in the JC Boyle diversion reach (City of Klamath Falls 1989 page 4, 2nd ¶).

f) With the exception of one age 4 fish, all of the trout captured in the upper Boyle (bypass) reach were in the age 0, 1, and 2 categories. Trout in the lower Boyle (bypass) reach ranged in age from 0 to 3 with the majority in the age 1 and categories. With the exception of one age 0 fish, all of the trout collected in the upper Salt Caves (upper peaking) reach were in the age 2 to 4 categories. The general absence of age 0 and 1 fish from the Salt Caves (peaking) reach was consistent with previous length frequency distribution data from that reach (City of Klamath Falls 1990 page II-4, 1st ¶).

4) Macroinvertebrate Biomass and Fish Diet

The hydroelectric reach of the Klamath River reduces the diversity, abundance, drift and survival of macroinvertebrates. Compared to other areas such as the Keno reach, ODFW and other studies observe very few salmonid fry or other fish species in the margins of the peaking reach, likely because they have been flushed downstream by extreme daily flow fluctuations (City of Klamath Falls 1986, 1990 and ODFW 2003). In addition, macroinvertebrate densities are also lower in the peaking reach than they were immediately downstream of J. C. Boyle Dam, which has a stable 100 cfs of flow, indicating power peaking operations are impacting insect production.

Aquatic macroinvertebrates and small species of fish such as fathead minnow and chub are important food sources for rainbow trout in the Klamath River. Biomass of forage fish and aquatic invertebrates are abundant in Keno reach where flow fluctuations are less common than the JC Boyle peaking reach (PacifiCorp 2004). Forage fish populations such as fat head minnow, tui chub and blue chub utilize lower velocity shoreline areas as their preferred habitat (Page and Burr 1991). Abundance of these fish is greater in the Keno reach where they have a more stable shoreline environment (PacifiCorp 2004) than the peaking reach, despite the Oregon portion of the peaking reach having a lower average gradient (35' per mile in peaking vs. 50' per mile in Keno ODFW 1997). Macroinvertebrate densities for the Keno reach showed a mean of 11,849.9 to 21,366.7 macroinvertebrates per square meter in two different reaches (PacifiCorp 2004c) During the same time period, total average macroinvertebrate abundance in the Peaking reach ranged from 3,636.2 to 6,560.9 per square meter. Macroinvertebrates in the Keno reach were 3.2 to 5.8 times more abundant than the peaking reach.

Addley *et al.* (2005) used a bioenergetics forage model to evaluate trout growth over a range of flow, food and water temperature conditions. Higher P values (a P value is the proportion of the maximum food consumption required for trout to achieve the empirically-measured annual growth observed in each of the 3 reaches of the Klamath River, peaking, bypass and Keno) in the Keno reach suggest rainbow trout are acquiring more food than the bypass and peaking reaches. Addley *et al.* (2005) predicts growth of rainbow trout at the end of age four would be greater in the peaking reach if the project were not in place.

Addley *et al.* (2005) also compared forage availability for macroinvertebrate food sources for trout in the three reaches. Drift densities of macroinvertebrates in the Keno reach were higher than in the peaking reach and the bypass reach during late June- early July and early September. Size of drift organisms was greater in the Keno reach than peaking reach in June-July. Number of macroinvertebrates captured in drift at Keno was higher than both peaking reaches and the bypass reach. The loss of vulnerable prey species (insects and forage fish) along the shoreline from the flushing flows of peaking has resulted in native rainbow trout rearing in project affected reaches (bypass and peaking reaches) being shorter, thinner and younger than the upstream Keno Reach fish, despite Keno fish being exposed to stressful water temperatures than the project-affected reaches (ODFW 2003). ODFW research from 1988-91 (Buchanan *et al.*. 1991 and Hemmingsen *et al.* 1992) and the FERC Final Environmental Impact Statement (FERC 1990) for the proposed Salt Caves Project also noted low adult trout densities in the upper end of the peaking reach.

FERC (1990) reported that trout in the upper peaking reach, where peaking impacts would be most visible, had relatively low growth rates and that large trout were under represented in the age structure. The FERC EIS cited five years of investigation compiled by the City of Klamath Falls. The FERC EIS concluded that flow fluctuations below the JC Boyle powerhouse caused chronic stress on trout and stranding of eggs, fry, and juveniles. Stress occurred from daily flow fluctuations and related changes in water temperature and water quality. These flow fluctuations caused trout to continue to seek new feeding and resting habitat while water temperature changed metabolism and feeding rates. Environmental studies conducted for the Salt Caves Hydro proposal documented that large flow fluctuations associated with the J.C. Boyle Powerhouse can cause high mortality to small fish such as young trout through stranding (City of Klamath Falls 1990 and FERC 1990). Common habitat types in the JC Boyle peaking reach are shallow rapids, riffles, and runs. Channels with an abundance of shallow habitat were more likely to have larger areas exposed during down ramping where fish could become separated from the main river flow due to declines in river stage (City of Klamath Falls 1990).

In summary Addley *et al.* (2005) found that food was the most important factor in fish size and growth in the Klamath River. Data from Addley's studies and many others show that food supply is negatively affected by hydroelectric operations. Below is a list of major findings from research conducted on the Klamath River regarding food availability and macroinvertebrate abundance.

a) Food availability is more important than water temperature as a factor in trout growth in the J.C. Boyle peaking reach for the Existing Conditions, Without Project and Steady Flow scenarios (Addley 2005 page xix, 2nd ¶, 1st sentence of text).

b) Macroinvertebrate densities had the highest densities in the Keno reach and lowest densities were found in the bypass and peaking reaches (Addley 2005 page xvi, 2nd ¶, 5th sentence of text, PacifiCorp 2004c, FERC 1990, City of Klamath Falls 1990).

c) The reason for consistently higher drift density in the Keno reach is uncertain, but may partially be due to more stable flows (i.e. no peaking) and/or more productive (eutrophic) water quality from organic matter moving in a downstream direction from Upper Klamath Lake and Keno reservoir (Addley 2005 page 33, 3rd ¶, 2nd sentence of text).

d) Pre-J.C. Boyle Dam macroinvertebrate abundance taken in 1953 was highest in the peaking reach at Frain ranch and at the Highway 66 bridge now covered by Topsy Reservoir. Productivity in bottom fauna for the free flowing section of Klamath River below Keno was characteristic of a clean, fertile stream, and higher than the two grams per square foot considered rich for fish food production. The station at Highway 66 bridge at Topsy (J.C. Boyle) Reservoir, prior to Boyle Dam, showed 6.7 grams per square foot in August. The Frain Ranch station, RM 214, showed 5 grams per square foot in July (Toman 1983 page 9, bottom 2nd ¶).

e) In the stable flow immediately below JC Boyle Dam macroinvertebrate abundance was much higher than the bypass reach and peaking reach (FERC 1990 and City of Klamath Falls 1990).

f) Keno reach has higher macroinvertebrate biomass than peaking or bypass. (PacifiCorp 2004c and Addley *et al.* 2005).

g) Peaking Operations reduce production of sessile organisms by 10-25% (McKenna 2006).

h) Drift rates in Keno reach are five to six times higher than peaking (Addley *et al.* 2005).

i) Fluctuations in the peaking reach are undoubtedly a contributing factor to the lower macroinvertebrate drift rates (McKenna 2006).

j) PacifiCorp's peaking operations cause high mortality to fish and other aquatic organisms through stranding. The distribution of benthic organisms in the river channel is limited during the summer by water level fluctuations caused by the J.C. Boyle peaking operation. Benthic invertebrates were found only at locations in the riverbed that remained wet during the low flow period of the daily flow cycle. Apparently the areas of the riverbed exposed during low flow conditions dry out sufficiently to eliminate the benthic fauna. The effects of water level fluctuations on benthic production are greater in the J.C. Boyle power plant to RM 214.3 reach than in the reach from RM 214.3 and the Salt Caves powerhouse site due to the relatively greater changes in wetted perimeter that occur upstream of RM 214.3 with changes in flow (City of Klamath Falls 1986 page 3.1-65, 1st ¶).

5) Forage Fish Abundance

The Hydroelectric reach of the Klamath River including the bypass and peaking reaches have shown to reduce and eliminate some species of native and non native forage fish species. Sampling has shown stranding, mortality, and complete absence of fish species that rely on low velocity habitat near the margins of the river. This lack of forage fish will reduce the amount of food available for rainbow trout in the river. Below is a bulleted list of major findings from research conducted on the Klamath River along with matters of facts as determined by the Honorable Judge McKenna in the Administrative Law Judge hearing in 2006.

a) The high P values in the Keno reach indicate these fish are acquiring more food than trout in the other reaches. The increasing P values in years three and four in the Keno reach may indicate that as these fish get larger they are switching to a more abundant and/or higher energy prey sources than invertebrates drift (e.g. forage fish) (Addley 2005 page 34, 2nd ¶, 1st and 2nd sentence of text).

b) Forage fish will provide a higher energy source than invertebrate drift for mature fish and allow for increased growth rates (McKenna 2006).

c) The Project-caused impacts to forage fish in the peaking reach help explain the lower growth rates and absence of larger and older fish in the peaking reach, as compared to the Keno reach (McKenna 2006).

d) Forage fish (blue chub, tui chub, fat head minnow, marbled sculpin, rainbow trout fry) are more abundant in the Keno reach than the peaking reach (Pacificorp 2004 and ODFW unpublished sampling).

e) Nongame species of fathead minnow were extremely abundant in the Keno reach, while other species such as blue chub, tui chub, sculpin species and smallscale suckers were also observed (ODFW 2003 page 4, 2nd ¶).

f) Limited diet studies show that Keno reach rainbow trout had forage fish in their stomach whereas peaking reach and bypass reach rainbow trout were not found with forage fish in their stomach (ODFW unpublished).

6) Klamath River Rainbow Trout Age Structure

The conditions in the peaking and bypass reaches impact the overall survival of rainbow trout. The conditions in the peaking and bypass reach do not allow for a long lived fish despite the better water quality due to the 220-280 cfs of spring flow coming into the Bypass reach compared to the Keno Reach. The additional flow from springs in the bypass reach, flow from Spencer Creek and the additional small spring streams in the peaking reach along with lower gradient should produce larger trout. Below are the major findings of research conducted in the Klamath River.

a) Rainbow trout in the Keno reach live longer (Borgerson 2006 and PacifiCorp 2005).

b) For most of their life rainbow trout in the Keno reach grow faster (Borgerson 2006).

c) Age structure of rainbow trout is healthier and more diverse in Keno reach (ODFW 2003, PacifiCorp 2004, Borgerson 1992 and 2006, Beyer 1985).

d) Repeat spawning is much higher in Keno Reach rainbow trout (Spencer Creek 66%, Borgerson 1992) compared to Peaking Reach rainbow trout (Shovel Creek 8%, Beyer 1984).

7) Angler Use and catch rates

Conditions in the peaking and bypass reach reduce angling opportunity. Angler effort in these two reaches are well below potential due to difficulty in catching fish during high flows for most of the day in the peaking reach and small fish in the bypass reach.

a) More people fish the Keno reach than the peaking or bypass reach (Toman 1982 and OSP 2006).

b) Angling success in the peaking reach was better before construction of JC Boyle Dam (Denman expert testimony 2006).

c) The high flows during the day reduce angler use and catch rate (ODFW 2003).

8) Population Estimates and Standing Crop

The peaking effects on the Klamath River reduce the overall abundance and biomass of rainbow trout in the river. The loss of spawning habitat and the large loss due to entrainment and lack of fish passage has reduced the population to the lowest end of predicted abundance and biomass

a) FERC (1990) stated the Salt Caves peaking reach had growth rate and density similar to high gradient Sierra Nevada streams.

b) Abundance estimates for the Klamath River peaking reach was low compared to other streams and rivers of similar productivity (City of Klamath Falls 1986 and 1989, FERC 1990).

c) Standing crop estimates were considered well below potential These results strongly suggest that the existing standing crop in the Salt Caves reach is substantially below carrying capacity for adult fish (page 5, last ¶) The standing crop estimate for the Salt Caves Reach falls at the low end of the range of reported standing crop values (page 5, 1st ¶). For additional spawning habitat to result in an increased standing crop of adults, there must be adequate habitat for rearing of fry and juveniles. Fry and juvenile habitat is presently limited in the Salt Caves reach by the large daily fluctuations that result from the summer power peaking operations of the JC Boyle Project. The high water velocities associated with daily high flows could also be expected to wash many fry out of the reach (page 9, 1st ¶) Under existing conditions spawning habitat in the upper Klamath River is only about 54 percent of the amount needed to provide habitat for each spawning pair (page 21, 3rd ¶)(City of Klamath Falls 1989).

d) Density of rainbow trout has been reduced fifty fold from 5000 fish to less than 100 fish at the JC Boyle fish ladder (Hanel and Gerlach 1964, Hemmingsen 1992, and ODFW 2006).

9) Habitat

The hydroelectric operations have impacts on many facets of fish habitat. Most importantly is the lack of spawning substrate and the continuation of coarsening of the substrate in the Klamath River. Peaking flows completely eliminate the slow margin habitat essential for rainbow trout survival and strand both non-game fish and rainbow trout. Below is a summary of findings from studies conducted on the Klamath River and ALJ facts.

a) Riparian
   i) The riparian area vegetation in the Klamath River suffers from a lack of sediment deposition. This has allowed reed canary grass to proliferate in this reach of the Klamath River.

b) Flows
   i) Peaking is the most widely documented source of fish stranding (Judge McKenna 2006). Any young of the year rainbow trout which move downstream into the Salt Caves (peaking) reach are subjected to large flow fluctuations caused by the power peaking operation of the Boyle project. Such fluctuations can cause high mortalities to young trout through stranding. Also recruitment of young of the year trout to the Boyle (bypass) reach may not be adequate to saturate the rearing habitat for young fish. Thus, density dependent downstream movement of juvenile trout into the Salt Caves (peaking) reach may be minimal, particularly in years of poor spawning success (City of Klamath Falls 1990 page II-10, 3rd ¶) .

   ii) The reduction or elimination of access for biota to lateral floodplain habitats may diminish the resilience, productivity and biodiversity of river ecosystems (Power *et al.* 1996 p.887, 2nd column, 1st ¶). If flood pulses can be delivered with more natural frequencies, the timing of flow releases can be managed to benefit, rather than harm, biodiversity. Managers can also time flow releases to favor native species and disfavor alien invaders (p. 893, 2nd ¶).

   iii) Peaking fluctuations can result in severe cumulative impacts to fish populations (McKenna 2006).

   iv) PacifiCorp's peaking operations cause high mortality to fish and other aquatic organisms through stranding (McKenna 2006).

   v) Flow fluctuations from peaking operations increase energetic demands on salmonids, decreasing energy available for overall health, growth, and reproduction (Judge McKenna 2006).

   vi) The current ramping rate of nine inches per hour, ramping rate violations, flow reductions and emergency spill have been shown to kill large numbers of fish and invertebrates (Tinniswood 2006 and Dunsmoor 2006)

   vii) BLM high flows, as compared to current conditions, will mobilize and transport sediment more frequently within the Project (McKenna 2006).

   viii) Seasonal high flows, in combination with the BLM's proposed gravel augmentation program, will likely create a more dynamic channel with a wider range of sediment deposits. This sediment will be deposited higher on the channel margin which will serve as an ecological benefit. With the construction of dams and their operation, changes have occurred to the riparian community of the bypass reach. Specifically, reed canary grass has encroached into the channel in places that have been exposed by Project-diverted flows (McKenna 2006).

ix) In the J.C. Boyle bypass reach, the average annual flow released from the J.C. Boyle Dam has been reduced by eighty-one ("81") percent—from approximately 1,560 cfs to 296 cfs—with the 100 cfs minimum flow occurring eighty-nine ("89") percent of the time (McKenna 2006).

x) On July 5, 2006, a severe stranding along 225 feet of the peaking reach was documented near Frain Ranch. "[A]bout 5,000 fish, more crayfish, and an order of magnitude more aquatic insects perished in a single peaking cycle. No rainbow trout mortalities were documented, however few trout fry exist in the peaking reach. (Dunsmoor 2006).

xi) The severe loss of fish and other aquatic life on July 2006 is directly attributable to PacifiCorp's peaking operations (Dunsmoor 2006).

xii) Flushing of juvenile salmonids downstream is likely in the peaking reach. *Salt Caves Project EIS concludes that flows of 1500 cfs in the peaking reach "lead to fry and fingerling trout being flushed downstream"*. (McKenna 2006).

xiii) Few fry have been captured in the Oregon section of the peaking reach; the section of the peaking reach with the highest ramp rates (McKenna 2006).

xiv) PacifiCorp's mark-recapture studies did not mark or recapture any fry in the Oregon peaking reach; the area of peaking reach where peaking effects would be most pronounced (McKenna 2006).

xv) Hydropeaking decreases habitat stability and can change the quantity and quality of available habitat over short time intervals (Pert and Erman 1994).

c) Spawning

i) The only known current spawning areas between Copco Dam and Klamath Lake for rainbow trout are Shovel Creek and Spencer Creek. There was a rainbow trout egg take at Spencer Creek from 1947 to 1955 (Table 25 on page 58 shows a range of 250,000 to 2,094,000 eggs were collected each year). Some gravel has been identified in the Frain Ranch area, but extent of use by trout is unknown. There is likely some spawning in the main river in patches of gravel, but the extent is unknown (Toman 1983 page 10, 1st ¶).

ii) Rainbow trout spawned in the Peaking reach prior to construction of JC Boyle Dam (Denman Expert Testimony 2006).

iii) Trout presently do not spawn in the peaking reach (McKenna 2006).

iv) Before the J.C. Boyle dam was built, rainbow trout would use the Frain Ranch area of the J.C. Boyle peaking reach to spawn (McKenna 2006).

v) There are locations in the peaking reach with suitable spawning gravel, but these areas . . . were exposed during lower flows (McKenna 2006).

vi) Low flows contribute to the lack of spawning in the peaking reach (McKenna 2006).

vii) Low gradient spawning habitat will become accessible in the Klamath River, which is now inundated by Topsy Reservoir , above and below Spencer Creek with the removal of JC Boyle Dam.

viii) J.C. Boyle Dam has captured an average of 6,124 tons/year of channel bedload and thus blocked its transport into the bypass and peaking reaches (McKenna 2006).

ix) Channel bedload is the totality of cobble, gravel, and other sediment that form the channel bed. Bedload mobilization is the natural geomorphic process whereby flow moves gravel for deposit on alluvial features and cleanses gravel of sediment. Diversion has reduced the capacity of flow to mobilize the bedload by an estimated eighty-three ("83") percent to ninety-six ("96") percent in the bypass reach (McKenna 2006).

x) The bed material in the J.C. Boyle bypass and peaking reaches has coarsened due to the J.C. Boyle Dam limiting the sediment supply. In addition, the sediment that is delivered to the channel or was in the channel at the time of Project construction is transported downstream during Project spill events in the bypass reach and during peaking flows in the peaking reach (McKenna 2006).

xi) Trout spawning gravel in the bypass reach is embedded with fine silt. In July 2006, the spawning gravel in the bypass reach below the emergency spillway was fifty ("50") percent embedded with silt and sand. (McKenna 2006).

xii) The only observed trout spawning activities, including the presence of redds, currently occur in the main stem bypass reach just downstream of the existing J.C. Boyle emergency canal spillway (McKenna 2006).

xiii) Erosion from PacifiCorp's use of the emergency spillway has significantly increased the rate of fine and coarse sediment delivery to the area below the emergency spillway. Since J.C. Boyle Dam operations began in 1958, approximately 69,000 cubic yards of hillside sediment has been delivered to the stream from the erosional washout. The location of the redds, near the erosional feature, is relatively unstable for two reasons. First the spillway can be used at any time and its use probably destroys or buries redds and spawning gravel patches. Second, the slope of the channel in this location is very steep, making this location inherently unstable during flood flows in the bypass channel. (McKenna 2006).

xiv) An annual flushing flow can clean and redeposit gravel to provide quality spawning habitat. To be effective, flushing flows need adequate duration and frequency to mobilize and redistribute fine sediments in the spawning beds. (McKenna 2006).

xv) Substrate in the J.C. Boyle diversion reach is predominately large boulders with some large cobble interspersed. Gravel is in short supply and is restricted primarily to small pockets behind large boulders. Recruitment of gravel to this area as well as the remainder of the study reach is very limited due to the presence of the J.C. Boyle dam and the small number of tributary streams. BEAK conducted a spawning gravel reconnaissance survey of the J.C. Boyle diversion reach in September 1984 and found a few pockets of gravel that were considered suitable for rainbow trout spawning. The gravel was located about midway through the reach, just downstream from an area of severe bank erosions. Apparently material washed into the river had been sorted by the current with some gravel ranging from 0.5 to 3 inches in diameter being deposited in slower water behind boulders. The largest potential spawning areas for rainbow trout were located near RM 214. These areas contained approximately 280 yards of substrate which was rated marginal for trout spawning due to embeddedness and the presence of large cobble interspersed with the gravel. In addition, much of the gravel at this location was exposed during low flow conditions. Since peaking operations often begin in mid-May, trout embryos would still be in the gravel when daily desiccation begins. Much of the available gravel would not be suitable for incubation of trout embryos during most years. Although several small gravel bars and pockets of gravel were found, none were deemed suitable for trout spawning due to their susceptibility to desiccation during low flow conditions (City of Klamath Falls 1986 page 3.1-13, 1st ¶).

xvi) Successful spawning for trout from the Boyle (bypass) and Salt Caves (peaking) reaches has been documented to occur in Spencer Creek and to a limited extent in the midsection of the Boyle (bypass) reach. Spawning also occurs in Shovel Creek in the California section of the Salt Caves (peaking) reach but no recruitment from this area has been documented. Therefore, recruitment of trout to the Salt Caves (peaking) reach comes from trout spawned in upstream areas. (City of Klamath Falls 1990 page II-10, 3rd ¶).

10) Genetics and Residualism

Studies have shown that no effect will occur to redband or rainbow trout from steelhead recolonizing former habitat and spawning with resident rainbow trout. These fish species are closely related and steelhead were present in the Upper Klamath Basin prior to Copco Dam construction in 1917. It is likely that Spencer Creek and other tributary rainbow trout and redband trout above Upper Klamath Lake will adopt anadromy if the dams are removed.

a) No affect of mixing populations of *Oncorhynchus mykiss*. Steelhead, rainbow and rainbow trout are all closely related in the Klamath Basin (Pearse in press 2010)

b) ODFW released adult steelhead as late as the 1970's above Copco Dam and steelhead were found Spencer Creek, Shovel Creek, Hoover Creek, Long Prairie Creek and other unnamed tributaries (Stout 1974).

c) CDFG stocked steelhead juveniles above Copco Reservoir in the 1980's. Juvenile steelhead stocked in Copco Reservoir (31,000 to 100,312 yearly in 1978 to 1980) possibly contributed to the Upper Klamath River Area creel and/or the Shovel Creek spawning run (Beyer 1984 p. iii-iv).

d) Historically, anadromous steelhead trout extended up to and used tributaries of Upper Klamath Lake (Fortune 1966, Hamilton *et al.* 2005). The close similarities between anadromous steelhead trout and resident rainbow/redband trout suggest these species historically co-existed. The distribution and resistance of rainbow/redband trout in Upper Klamath Lake to *C. shasta* lends additional support that the two species co-existed and intermingled prior to the construction of Copco I Dam in 1917 (Buchanan *et al.* 1988 and 1989).

e) There are no scientific studies of the Klamath basin demonstrating that reintroduction of anadromous steelhead trout would detrimentally affect the genetic makeup of the resident trout fishery. The potential for residualization is largely dependent on environmental conditions in the river and ocean. There are many examples from nearby river systems in the Pacific Northwest that show wild anadromous steelhead trout and resident rainbow/rainbow trout can co-exist and maintain abundant populations without adverse consequences. The Deschutes River in Oregon, the Yakima River in Washington, and the river systems in Idaho are examples (McKenna 2006)

f) Significant numbers of hatchery steelhead smolts residualize and become resident (page 5 under Observations in powerpoint presentation) Resident rainbow males are often observed with spawning steelhead females (page 5 under observations in powerpoint presentation Substantial spatial and temporal overlap in spawning distribution of resident and anadromous forms (page 5 under observations in powerpoint presentation).There is considerable linkage between resident and anadromous life history forms with both producing crossover offspring (page 46 under maternal origin conclusions) (Carmichael 2005).

g) Sudden increases in strontium/calcium ratios indicative of ocean entry were observed in eight of nineteen otoliths (page 3, abstract, 3rd sentence) Eight of the samples showed no sign of ocean entry and three of the samples were not distinctly anadromous or resident fish. Our sample included examples of anadromous fish with both anadromous and non anadromous mothers and non-anadromous fish with anadromous and non-anadromous mothers (page 3, abstract, 5th and 6th sentences) Limited scale analysis in 1993 by California Department of Fish and Game (CDFG) indicated that of 12 scale sets examined, only 3 could be interpreted as possessing any ocean growth patterns (Jong 1994 in Chesney 2003 page 5, 1st ¶, last sentence)

h) Most available information on the genetics of anadromous and resident *O. mykiss* indicates that these two life history forms are more closely related to one another than they are to either life history form from separate drainages (Brannon *et al*. 2004, Narum *et al.* 2004, Docker and Heath 2003, Busby *et al*. 1997)

i) One study, comparing sympatrically occurring populations of steelhead and resident rainbow trout in five rivers in British Columbia, found that only one river system had genetically divergent steelhead and resident rainbow trout populations (Docker and Heath 2003 page 2, 3rd ¶, 2nd sentence).

j) McCusker *et al.* (2000) analyzed DNA of 69 steelhead and 99 rainbow trout populations from both coastal and interior regions of the Pacific Northwest, including the Columbia, Snake, and Fraser rivers, Coastal British Columbia, and Alaska. In their samples that included 28 winter runs, five summer runs, and 24 fall runs of steelhead, they found no significant genetic differences within a stream between run types or anadromy versus residency. McCukser *et al.* (2000) concluded, "populations in close geographical proximity are more closely related to one another than are populations of the same life history type." (page 2, 3rd ¶, last sentence).

k) Genetic profiling, and Sr/Ca analysis of otoliths from steelhead spawners and recruits has demonstrated that at least 20% of anadromous adults, and often more, result from matings that include at least one resident parent (see Blouin 2003 for Hood River, OR; Seamons *et al.* (2004) for Snow Creek, WA; Moran 2005 for Little Sheep Creek, OR; Carmichael *et al*. 2005 for upper Grande Ronde River, OR; Donohoe *et al.* 2004 for Sacramento and Klamath rivers, CA; and Marshall *et al.* 2005 for Cedar River, WA page 4, 3rd ¶, 1st sentence).

11) Water quality and disease

Current Conditions

a) Water temperature

i) Due to thermal loading water temperature can exceed 30° Celsius in the summer at Topsy Reservoir. This water temperature is stressful and can be toxic to rainbow trout. The fish ladder at JC Boyle Dam receives 80 cfs of water from the surface of Topsy (JC Boyle) Reservoir.

ii) Summer time water temperatures in the Hydro affected reach will continue to be stressful to aquatic resources. Currently, the operation of the hydro electric facilities and specifically the forebay associated with the hydro electric facilities allow for increased water temperatures through an increase in residency time as water travels through the forebay. Increases in water temperature associated with hydro electric facility management currently promotes algal growth. Algal growth and subsequent dissolved oxygen crashes associated with the decomposition of algae contributes to poor water quality. The increased residency time as water travels through the reservoir and warming of the water improves habitat for warm water fish. Predation in the forebay is believed to be high due to the continued presence of introduced fish.

b) pH

i) Topsy Reservoir increases the pH to levels toxic to rainbow trout.

c) Dissolved oxygen

i) Dissolved oxygen levels are much reduced in the evening and during time of algal die off and occasionally reach levels approaching 0 ppm.

ii) In 2003 a fish die off of suckers and rainbow trout occurred in the Upper End of Topsy Reservoir due to a stressful water temperatures, low dissolved oxygen, and secondary infections. Warmwater fish (largemouth bass, brown bullhead, goldfish, tui chub) also succumbed during this poor water quality (Tinniswood 2006).

iii) Dissolved oxygen is adequate for trout production in the free flowing sections of Klamath River but can drop to zero above Keno Dam and less than 1 ppm in Boyle Reservoir

d) Ammonia

i) Ammonia levels can reach toxic levels to fish above Keno Dam and in Topsy Reservoir

e) Disease

i) *Columnaris* and *furunculosis* outbreaks can be common when poor water quality exists in Topsy Reservoir.

12) Non Native fish and amphibians

a) Topsy Reservoir will allow populations of largemouth bass, yellow perch, bluegill, brown bullhead, pumpkinseed sunfish, white and black crappie, goldfish, Sacramento perch, fat head minnow, bullfrogs, and the potential for other invasive species to proliferate and expand their distribution. These species compete and predate on rainbow trout and other native fish species.

13) Economics

a) No positive economic impact from leaving the hydroelectric dams in place. Environmental cost, environmental impacts and cost of mitigation exceed the power generated from the hydroelectric project

Trout Fishery Status Current Conditions

Under current hydro peaking operations, angling conditions in the J.C. Boyle peaking reach of the Klamath River are highly variable in the Oregon portion of the peaking reach. Angling conditions are not consistent throughout the day due to daily peaking operations where flows fluctuate daily from 320 to 1,800 (1 turbine) or 3,000 cfs (2 turbines). Currently angling is more effective and catch rates appear to be greatest during the low flow cycle of the peaking reach. This is likely due to easier wading access, improved water clarity, lower water temperatures, and low flows which concentrate fish in smaller pools. Little success is experienced by anglers when flows exceed 1800 cfs during power peaking operations. While low flow and concentrations of fish in small pools may seem like a desirable scenario for angling, daily peaking fluctuations have serious consequences for both angler success and long term fish health. During summer months in the Oregon portion of the river there is a very limited amount time, perhaps 2-4 hours daily, when the river is low enough to be fishable during daylight hours (Figure 1). Consequently, the remainder of the year (approximately 9 months) the low flow “fishable” cycle only occurs after dark. These are not the conditions necessary to maintain a consistent high quality trout fishery.

Extensive surveys by ODFW in 2003 and 2004 observed limited use by anglers in the Oregon section of the J.C. Boyle peaking reach. All angler use was observed during low flow periods during PacifiCorp maintenance (hydro turbines not in operation-no peaking occurring) or during times when flow is low between peaking cycles. In general angler use of the area was extremely limited because peaking flows were too high for successful angling during the majority of daylight hours from early morning to late evening. Low flow conditions which are very helpful to anglers however, are very stressful for native trout. Trout rearing in project affected reaches (bypass and peaking reaches) are shorter, thinner and younger than upstream Keno Reach fish, despite Keno fish being exposed to warmer water temperatures and lower stream flows when compared to the peaking reach.

Results of angling in the peaking reach during low flows indicate rainbow trout are very aggressive and easily caught, suggesting hunger. Relative weight of trout also declined from summer to fall in the peaking reach when trout should be putting on weight in preparation for winter (ODFW 2003). The Bioenergetics study conducted by Addley suggests food is limiting trout growth in the peaking reach.

Most rainbow trout in the peaking reach are slightly larger than the bypass reach but much smaller than the Keno Reach. Most fish caught are in the 10-12 inch range. The high catch rate during low flows is hard to understand considering the low abundance of fish but these fish appear to be very aggressive likely due to lack of food in this reach which might create competition especially at low flow. The largest fish documented by ODFW captured by hook and line or electrofishing is 16 inches in this reach. Alternatively, the Keno reach produces several 16 inch rainbow trout per trip.

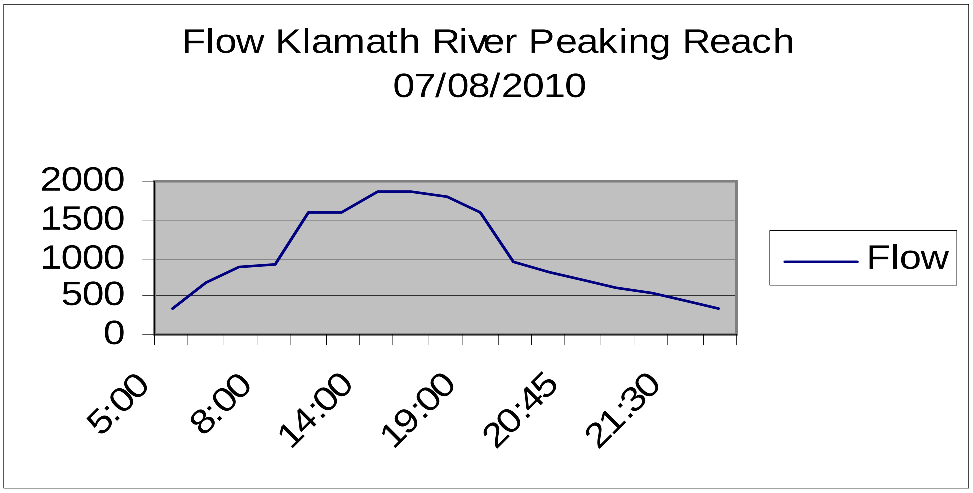

Figure 1. Flow fluctuation in Klamath River Peaking Reach July 8, 2010.

Klamath River Rainbow Trout
Hydro Bypass Reach Klamath River

Population Status Current Conditions

ODFW performed a stock status review of Klamath redband trout populations in 2005. The Klamath River population passed most criteria with the exception of productivity (ODFW 2005). Fish passage over JC Boyle Dam in 1959 was 5,529 rainbow trout with an average length of 300 mm and in 1999 70 rainbow trout passed the ladder with an average of 180 mm. The lack of fish passage and screening reduces productivity.

Rainbow trout in the bypass reach are smaller but more abundant than both the Keno and Peaking Reaches. The condition of these fish is better than peaking reach but not the Keno Reach. There is limited spawning in pockets of gravel below the emergency spillway. Spawning in this area is subject to spill events over JC Boyle Dam and unpredictable emergency spill which can destroy redds and kill young of the year trout. Rainbow trout in the bypass reach do not attain large size and are not long lived.

Trout Fishery Status Current Conditions

Angler effort is low in the bypass reach of the Klamath River. Rainbow trout size is small in the bypassed reach. Stream flows are low in the bypassed reach. Approximately 100 cfs is released into the channel directly below the JC Boyle dam. (Fish ladder =80 cfs, Juvenile bypass=20cfs). Approximately ½ mile downstream of J.C. Boyle dam an additional 220 from spring flow is added to the river. The bypass flow at times of the year when there is no spill past the dam is approximately 320 cfs. Due to the spring influence and cold ground water temperatures are much colder then the water entering the reservoir. The cold nutrient poor water produces small rainbow trout. The fish in the bypassed reach are significantly smaller in length when compared to fish from the Keno or Peaking reaches. Adult rainbow trout rarely reach 14 inches in total length. Angler caught fish range in size from 6-8 inches. Despite relatively stable flows in the bypassed reach, the small average fish size as well as the steep terrain and difficult bank access combines to make an area that is not popular with anglers. Extensive surveys by ODFW in 2003 and 2004 and Oregon State Police in 2006 confirmed limited angler use in the bypass reach during those years.

Due to hydro-facility operations and needs to make quick adjustments anglers in the bypassed reach are warned by PacifiCorp that river flow may increase dramatically without warning.

No anglers have been observed during times of spill.

Klamath River Rainbow Trout
Keno Reach Klamath River

Population Status Current Conditions

ODFW has used the popularity of the fishery, length frequency analyses, relative weight (condition factor), spawning surveys and radio telemetry to determine the current population status of rainbow trout in the Keno Reach. In 2003 sampling by ODFW (2003) showed a diverse age structure, large size, and excellent condition factor of rainbow trout in the Keno Reach. ODFW performs a one time annual spawning survey in Spencer Creek, the known spawning tributary for Keno reach rainbow trout (ODFW 2006) Redd counts in the four mile index reach typically exceeds 100 redds. Radio telemetry has shown Keno reach radio tagged fish to make migrations throughout the Keno reach downstream to just above Spencer Creek, into Spencer Creek for spawning and migrations above Keno Dam into Keno Reservoir.

Productivity of rainbow trout is still reduced in the Keno reach due to the lack of fish passage and ineffective screens at JC Boyle Dam. Hemmingsen *et al.* 1997 determined that rainbow trout using the J C Boyle fish ladder in the fall were rearing in the Keno Reach through the winter and were found on a spawning migration in Spencer Creek the following spring. Additionally, water quality and drastic flow reduction in the Keno Reach on occasion can reduce survival. Buchanan *et al.* 1991 found at minimum 1813 adult rainbow trout making an upstream spawning migration in Spencer Creek and 25,618 juveniles less than 150 mm and 4218 fry making a downstream migration.

Rearing and spawning habitat in Spencer Creek has continued to improve since the Buchanan sampling in the early 1990's. Riparian area fencing, grazing management, road improvement and abandonment, large wood additions and culvert barrier removal have improved habitat conditions for rainbow trout in Spencer Creek.

Trout Fishery Status Current Conditions

The current recreational trout fishery below Keno Dam is one of the best in Oregon. Rainbow trout 16-18 inches are common and experienced anglers typically catch fish exceeding 20 inches in length. This section of river is one the most popular trout fisheries in Klamath County and has at least four flyfishing guides work the river in the spring. Current impacts in this reach from the hydroelectric project include drastic reductions in flow for project maintenance activities. This reduction in flow can have impacts on productivity in this reach by mortality of sessile organisms in the varial zone habitat that is desiccated. Due to the more stable flow regime in the Keno reach and the larger trout the angling pressure in the Keno reach by anglers is much higher than the rest of the Oregon section of the Klamath River.

Upper Klamath Lake and Tributaries

Redband Trout Status with Dams In

Redband trout in the Klamath Basin are listed as a state sensitive species under the category vulnerable. The ODFW stock status review (ODFW 2005) determined that the overall population of redband trout in Upper Klamath Basin is At Risk. Populations were rated by six categories (Existence, distribution, abundance, productivity, independence and hybridization). Eighty percent of the redband trout populations passed three or more criteria. Most populations failed productivity due to degraded habitat conditions, presence of brook trout or brown trout or limited expression of a migratory life history. The Cascade Complex has the most potential for an increase in productivity. Lack of appropriate fish screening and fish passage are the primary limiting factors of this population. The levee and water storage at Barnes and Agency Ranch reduces fish passage and summer refuge habitat. The Sprague River population failed the productivity criterion due to poor habitat conditions, lack of screening, poor water quality, and lack of appropriate flows.

One of the biggest limiting factors in the Upper Klamath basin is screening and fish passage. Below is a list of the major problems:

Fish Passage

a) Irrigation diversions continue to delay or exclude adult fish passage in the Sprague, Wood, Williamson, Sycan Rivers, as well as all tributary streams of Upper Klamath Lake eliminating the expression of the adfluvial life history. Adfluvial fish are larger, more fecund, and increase the over all productivity of the redband trout population

b) Irrigation diversions currently allow fish to be diverted from streams and into agricultural fields. The production of redband trout from tributary spawning streams is currently reduced by the losses at the unscreened diversions.

c) Many redband populations are isolated due to inadequate passage at irrigation diversions as well as extremely low stream flows. Healthy trout populations need to migrate and have the ability to exchange genes within a watershed. Current practices reduce productivity of redband populations by limiting ability of the fish to exchange genes. Genetic diversity is a buffer against catastrophic changes within the aquatic environment.

d) Obstructed passage reduces productivity but not allowing redband trout to utilize all available habitat within the stream system.

Redband Trout Fishery with Dams In

Angler Use and catch rates

The current fishery in most of the Upper Klamath Basin is managed for trophy trout under natural reproduction. Most of these fisheries are technical and have low catch rates. However, due to the size of rainbow trout they are popular destination type fisheries for one of the largest redband trout in the United States.

a) Angler catch rates for Upper Klamath Lake redband trout are low and estimated at 0.11 fish/hour (ODFW, 2009 Provisional summary, Klamath Lake Statistical Creel Survey). Angler catch rates for resident redband trout in the Wood, Williamson, Sprague, and Sycan Rivers are considered fair. Adfluvial redband trout populations are considered depressed with lower catch rates associated with the migratory fish.

b) Angler use in Upper Klamath Lake is high in the spring, low in the early summer months and high in the late summer. Anglers are attracted to the Lake for the opportunity to catch large wild redband trout. Angler use in the tributary streams is fair in the spring and early summer and declines to low use in the summer and fall.

c) Klamath Lake redband trout fishery is restricted to one fish per day with a minimum of 8 inches in length. Tributary streams including Wood, Williamson, Sprague, and Sycan have season as well as gear restricts to conserve the redband trout resource.

Bull Trout Population Status Current Conditions with Dams In

Bull trout are currently listed as "Threatened" under the Endangered Species Act. Angling for bull trout is currently closed in the Klamath basin. The current distribution of Bull trout in the Klamath basin consists of seven fragmented populations residing in a total of 34.1 km (21miles) of the Klamath basin (ODFW 1997). All populations of bull trout are considered to have moderate to a high risk of extinction under current conditions. The ODFW stock status (ODFW 2005) determined the population to be AT Risk. Most populations failed the abundance, distribution and productivity criterion. The biggest limiting factor for bull trout populations was the occurrence of brook trout. Other limiting factors include poor water quality, unscreened irrigation diversions, water withdrawals and fragmentation of the populations. Physical barriers on Sun Creek, Deming and Threemile prevent connection to other larger stream or river systems.

Habitat

a) Buchanan *et al.* 1997 identified channelization, water withdrawals, and removal of stream side vegetation as factors limiting bull trout in the Klamath Basin.

b) Bull trout evolved with anadromous fish. Nutrients from decaying salmon carcasses allow for increased primary production and improved juvenile bull trout survival.

c) The lack of anadromous fish fry production has reduced the productivity of the bull trout population by reducing the food source of the piscivorous bull trout juveniles (Buchanan *et al.* 1997). Prior to the extirpation of anadromous fish from the Klamath basin large bull trout were present in the Wood River. A 330mm specimen was collected from Fort creek in 1876 and is currently in the Smithsonian museum collection (Buchanan *et al.* 1997).

d) Bull trout are considered late Pleistocene fish meaning that they have evolved in cold waters of the last ice age. Improvements in riparian communities through the implementation of the KBRA will reduce water temperatures and give the native bull trout a competitive advantage over less cold water tolerant fish species.

e) Bull trout are known to make long migrations and traverse very step gradient streams. Improvements to fish passage at irrigation diversions will allow for bull trout to colonize new habitats and to exchange genes with bull trout in neighboring streams.

f) Screening of irrigation diversions will allow for increased survival of fry and juvenile fish.

Genetics

a) Bull trout populations are currently fragmented with little to no connectivity between populations. The isolation of these populations and the lack of genetic exchange between populations have created stocks with little heterozygosity. The lack of genetic diversity does not allow the species to cope with environmental and climatic changes.

Water Quality and disease

a) Summertime high water temperatures currently exceed the temperature preferences of bull trout in most streams in the Klamath basin. Insufficient riparian vegetation allows the streams to warm quickly.
b) No die offs of bull trout have been identified as a result of disease in the Upper Klamath basin.

Non Native Fish

a) Introduced fish species are currently posing a risk to the long term survival of bull trout in the Klamath basin. The presence of brook trout and brown trout threaten bull trout populations through hybridization as well as competition for food and space.

Angler Use and catch rates

a) Bull trout angling is closed in the Klamath.

Status Klamath Rainbow/Redband Trout
Dams Out and KBRA Implemented Scenario:

Klamath River Rainbow Trout

Rainbow Trout Status with Dam Removal and KBRA

ODFW expects the conditions in the Klamath River to return to near historical conditions with dam removal. Historically, rainbow trout rearing in the Oregon portion of the Klamath River downstream of the J.C. Boyle Dam site migrated upstream to spawn in Spencer Creek (Fortune 1966). In a corollary movement, trout rearing above J.C. Boyle Dam in the Keno Reach of the Klamath River moved downstream to spawn in Spencer Creek (ODFW 2006). Past studies show that adult rainbow trout rearing below the dam site moved upstream with two peaks in migration, one in the spring and one in the fall (Hanel and Gerlach 1964). Both spring and fall spawning migrations were associated with increases in river flow. Spawning of rainbow trout in the mainstem Klamath River was historically likely limited to lower gradient sections such as Frain Ranch and potentially low gradient areas currently inundated under Copco 1 and J.C. Boyle reservoirs. Long time Klamath River angler Don Denman has confirmed that pre-J.C. Boyle development, rainbow trout actively spawned in the Frain Ranch reach of the Klamath River. Stream habitat in the Frain Ranch section of the Klamath River historically had suitable spawning gravel but has been severely degraded due to hydropower operations and is currently unsuited for trout spawning.

Klamath River rainbow trout evolved to this migratory life history likely because the opportunity to successfully spawn in mainstem Klamath River was historically limited. As a result, these trout migrated to and spawned in the relatively more protected and stable habitat in Spencer Creek. Recruitment of juvenile rainbow trout to the mainstem Klamath River historically came from adult spawners in Spencer Creek. Migration of juvenile rainbow trout from Spencer Creek downstream to the mainstem Klamath River generally occurs following a year of residence in the creek. Prior to the construction of JC Boyle Dam productivity in Spencer Creek (the primary spawning habitat) was so high that an egg taking station for rainbow trout was operated from 1913-1956 that collected up to 3 million eggs annually (Toman 1983).

Rainbow Trout Fishery with Klamath River Dams Removed and KBRA

Prior to the J.C. Boyle project, daily stream flow was relatively stable and did not dramatically fluctuate like current power peaking operations. As stream flow receded and the river bank became more accessible following spring runoff, fishing in the project area was a popular activity for local area anglers (Denman 2006). Angling conditions were relatively predictable and consistent from day to day. Abundant large trout were available to catch (Fortune *et al.* 1966).

A more successful combination for both anglers and fish would be to return to the natural hydrograph with relatively stable flows during and between days. Such an operation would allow anglers, fish and aquatic invertebrates to adjust to stream habitat changes as flows recede during summer and fall months following high winter/spring flows.

Removal of the four hydroelectric dams on the Klamath River and with KBRA implemented the fishery in the Klamath River will become a destination for trophy rainbow trout. The river has all the characteristics of developing trophy status for rainbow trout once the dams are removed. The productive water from Upper Klamath Lake mixing with the 220-280 cfs of springs in the bypass reach has the potential to grow large trout with a high density. Water temperature data shows that the reach below the springs in the bypass reach will be cooler in the summer and warmer in the winter allowing for continued growth of rainbow trout. ODFW expects the river to produce a trout fishery that is better than the Keno reach fishery due to improved water quality. The Keno reach fishery is one of the best trout fisheries in Oregon. Due to the improved water quality and continued productivity the diversity and abundance of certain invertebrates will increase. The increase in invertebrate production will provide more food for trout. The river below the springs will produce prolific hatches of insects including the famous salmon fly (*Pteronarcys californica*) and golden stoneflies (*Calineuria californica and Hesperoperla pacifica*) hatches. These hatches do not occur above the springs in the Keno reach likely due to high pH and warm water temperatures in the summer. The peaking reach of the Klamath River will also be a larger river with the addition of Spencer Creek flow, bypass spring flows, small springs and other intermittent tributaries. Furthermore the peaking reach has a lower overall gradient than the Keno Reach making the peaking reach have more potential for increased overall productivity.

The lack of flow fluctuations in the peaking reach will increase macroinvertebrate habitat and abundance. The more natural hydrograph will also allow for the increased production of forage fish such as marbled sculpin, smallscale sucker larvae, tui chub, blue chub, rainbow trout fry, chinook fry, steelhead fry, coho fry and non native fat head minnows. Forage fish rely on the slow habitat types typically found on the margins of the river. The margins of the river are desiccated every day from flow fluctuations from 320 cfs to 1800 cfs. This increase in food supply will result in larger more abundant rainbow trout.

Following dam removal ODFW expects the population of rainbow trout in the Klamath River below JC Boyle Dam to have comparable abundance to trout in the Deschutes or Crooked rivers in Oregon, but will have larger average size due to an abundance of prey species and their piscivorous nature. The Crooked River showed peak densities of 8,000 redband trout over 200 mm per mile (Stuart *et al.* 2007).

1) Fish Passage

a) Unobstructed fish passage will occur with the removal of dams.

b) Access from the Klamath River below JC Boyle to Spencer Creek which is a highly productive spawning and rearing habitat for rainbow trout.

c) Access to the large thermal refuge area below the springs below JC Boyle Dam. This might be the reason for the historic and current fall migration. Rainbow trout would migrate to the colder water in the summer and then recolonize more productive water when water temperatures cooled.

d) Resident trout are a migratory species. Because Spencer Creek, located upriver of the J.C. Boyle facility, is a primary spawning and early rearing area for resident trout within the Project area, it is important that adult spawners from the river below the dam and juvenile trout from Spencer Creek both are able to successfully migrate upstream and downstream past J.C. Boyle Dam (McKenna 2006)

e) Return of the rainbow trout to a single, large, intermixing population throughout the Klamath River Basin. Migration is one of several defining life history characteristic of trout (McKenna 2006)

f) Their ability to migrate is one of several evolutionary advantages contributing to survival of trout in the Klamath River for millions of years through dramatic environmental changes (McKenna 2006).

g) The Project restricts migration of resident fish within the main stem and into and out of tributaries. Dams do not have fishways and currently block all upstream fish passage. Thus, the stocks above Iron Gate are isolated from counterparts in the lower basin. Further, the stocks between each of Iron Gate, Copco I, and Copco II Dams are similarly isolated (McKenna 2006).

2) Entrainment of salmonids and JC Boyle screen effectiveness

a) No loss of salmonids in the project reach by entrainment into project facilities.

3) Length-Weight Analyses

a) Increase fish size and weight to trophy size in the Klamath River below former dam site.

4) Macroinvertebrate Biomass and Fish Diet

a) Increase in macroinvertebrate abundance, diversity and drift

5) Forage Fish Abundance

a) Increase in forage fish abundance and diversity

6) Klamath River Rainbow Trout Age Structure

a) Rainbow trout will live longer

b) Rainbow trout in the Klamath River will grow faster

c) Age structure will be more diverse

d) Repeat spawning rate will be higher

e) Fecundity will be higher

7) Angler Use and catch rates

a) Angler use will increase

b) Angler use will be able to occur at all seasons of the year at all daylight hours

c) Catch rate will improve compared to peaking flows

8) Population Estimates and Standing Crop

a) The population size and biomass will increase

9) Habitat

a) Additional habitat.

i) ODFW has calculated that the removal of JC Boyle Dam will increase year long rearing habitat for rainbow trout by four miles.

ii) Interim conditions will improve spawning substrate below JC Boyle Dam

iii) The addition of gravel will provide diversity of habitat for aquatic life.

iv) Water quality in the Klamath River is improved as riparian vegetation starts to re-establish along the historic forebay affected area. It is anticipated that the re-establishment of riparian vegetation will commence quickly due to the sediments rich in organic material. Riparian plants will re-establish within the first two years while woody trees and shrubs will take from 5 to 10 years. Shade form the re-established habitat is expected in approximately 10 to 12 years. Improved riparian habitat, improved rearing conditions, increased access to the Spencer creek in the project area, and associated improvements to water quality will greatly improve redband trout survival, production and ultimately provide more fish for recreational uses including harvest.

b) Riparian

i) Removal of JC Boyle dam will result in increased substrate movement and an improved riparian corridor which will improve cover, shade, and food supply for rainbow trout

c) Flows

i) No fish stranding

ii) No loss of fish due to peaking

iii) No more drastic flow fluctuations from peaking operations increase energetic demands on salmonids, decreasing energy available for overall health, growth, and reproduction

iv) No ramping rate

v) High flows will mobilize and transport sediment more frequently within the Project.

vi) Seasonal high flows, in combination with the BLM's proposed gravel augmentation program, will likely create a more dynamic channel with a wider range of sediment deposits. This sediment will be deposited higher on the channel margin which will serve as an ecological benefit.

vii) Reed canary grass removal. Higher flows in the bypass reach

viii) Increased flows due to KBRA measures will improve productivity of the redband trout population.

ix) No more flushing of fry and juveniles downstream

d) Spawning

i) Rainbow trout will spawn successfully in the Klamath River below JC Boyle Dam at the Frain Ranch.

ii) Low gradient spawning habitat will become accessible in the Klamath River above and below Spencer Creek with the removal of JC Boyle Dam

iii) An average of 6,124 tons/year of channel bedload will transport into the bypass and peaking reaches

iv) The bed material in the J.C. Boyle bypass and peaking reaches will diversify with smaller particle size.

v) Embeddedness of the spawning gravel will be reduced.

vi) An annual flushing flow will clean and redeposit gravel to provide quality spawning habitat. To be effective, flushing flows need adequate duration and frequency to mobilize and redistribute fine sediments in the spawning beds.

10) Genetics

a) No affect of mixing populations of fish. Steelhead, redband and rainbow trout are all closely related in the Klamath Basin

b) Historically, anadromous steelhead trout extended up to and used tributaries of Upper Klamath Lake. The close similarities between anadromous steelhead trout and resident rainbow/redband trout suggest these species historically co-existed. The distribution and resistance of rainbow/redband trout in Upper Klamath Lake to *C. Shasta* lends additional support that the two species co-existed and intermingled prior to the construction of Copco I Dam in 1917 (McKenna 2006)

c) There are no scientific studies of the Klamath basin demonstrating that reintroduction of anadromous steelhead trout would detrimentally affect the genetic makeup of the resident trout fishery. The potential for residualization is largely dependent on environmental conditions in the river and ocean. There are many examples from nearby river systems in the Pacific Northwest that show wild anadromous steelhead trout and resident rainbow/redband trout can co-exist and maintain abundant populations without adverse consequences. The Deschutes River in Oregon, the Yakima River in Washington, and the river systems in Idaho are examples (McKenna 2006)

11) Water quality and disease

a) Water temperature

i) Removal of JC Boyle Reservoir will decrease water temperatures in the summer

ii) With the absence of the dams it is anticipated that there will be higher spring water temperatures and cooler fall water temperatures. The restoration of the Klamath River to a more natural temperature regime will produce more redband trout at a larger size. Rainbow trout have evolved in warm climates as compared to the coastal rainbows. Rainbow trout have been documented to survive in temperatures up to 29 degrees C (Keno reach of the Klamath River). Optimum growth for rainbow trout is approximately 20° degree C. The thermal regime that will occur once dam removal is completed will allow for rainbow growth and survival year round. Currently rainbow trout living in the Keno stretch of the Klamath River encounter water temperatures up to 29 degree C. These fish are larger then fish reared in the hydro effected reach.

b) pH
   i) Removal of JC Boyle Reservoir will decrease the high ph that is experienced in the summer

c) Dissolved oxygen
   i) Removal of JC Boyle Dam will improve dissolved oxygen to levels that are appropriate for the survival of redband trout

   ii) Removal of JC Boyle Dam will reduce the frequency of fish die offs that occur due to drastic reductions of dissolved oxygen due to warm water temperatures and vegetation decomposition

d) Ammonia
   i) Toxic ammonia levels will be reduced

e) Disease

   i) For the most part, the pathogens existing in the lower basin historically and currently exist in the upper basin of the Klamath River above Iron Gate Dam (McKenna 2006)

   ii) Like *IHN*, there is a lack of information concerning the presence of *R. salmoniranrum* in the upper basin. Nevertheless, because of its low levels, *R. salmoniranrum* does not appear to pose a significant risk of disease in the salmonid population in the Klamath River system, and consequently the bacteria will not pose a significant threat to fish in the upper basin. (McKenna 2006)

   iii) Similarly, parasitic *Trematode Metacercaria* present in juvenile and adult Chinook salmon do not appear to present a significant health threat to resident fish in the upper Klamath. (McKenna 2006).

   iv) *F. columnaris* and *Ich* are ubiquitous in freshwater systems, and both are present throughout the Klamath River system above and below Iron Gate Dam. (McKenna 2006).

   v) *C. shasta* has been detected in the lower Williamson River, a tributary of Upper Klamath Lake, and in areas below Iron Gate Dam in nearly equal levels(McKenna 2006) .

   vi) Spencer Creek rainbow trout juveniles were moved to the Lower Klamath River below Iron Gate Dam and exposed to C. shasta. Spencer Creek rainbow trout were found to be resistant to infection (McKenna 2006) .

   vii) Within the Klamath River system, steelhead trout are resistant to *C. shasta*, a disease causing pathogen that adversely affects juvenile Chinook salmon (McKenna 2006) .

viii) Since a majority of the pathogens currently found in the lower basin also exist in the upper basin of the Klamath River system, a logical conclusion is that migration of anadromous fish would not be a significant factor contributing to disease on resident fish. Implementation of the KBRA will improve water quality in the Sprague River, Upper Klamath Lake, Lake Ewauna and Keno Reservoir. Redband trout will be able to spend more time in highly productive habitat increasing productivity. Typically redband trout need to move to thermal refuge areas in early June to avoid poor water quality (McKenna 2006).

12) Non Native fish and amphibians

a) Removal of JC Boyle Dam will eliminate or curtail populations of largemouth bass, bluegill, brown bullhead, pumpkinseed sunfish, white and black crappie, goldfish, Sacramento perch, bullfrogs, and the potential for other invasive species to proliferate and expand their distribution. These species compete and predate on redband trout and other native fish species.

13) Economics

a) Removal of JC Boyle Dam will result in a high quality fishery with abundant large rainbow trout resulting in increased tourism and resulting expenditures related to fishing in the local community.

Upper Klamath Lake and Tributaries

Redband Trout Status with KBRA

Redband trout in Upper Klamath Lake and tributaries is comprised of 10 populations that vary in life history, genetic, disease resistance, and status (ODFW 2005). Redband trout are currently widely distributed throughout the basin. With the implementation of the KBRA will aid in improving connectivity of the Cascade Complex streams. Connectivity and productivity will be improved through the re-connection of the streams to Upper Klamath Lake, through the improvements in riparian vegetation and instream habitat and through the potential for additional stream flow. Productivity of the Upper Sprague River streams will be improved through the reduction or elimination of non native brook and brown trout. The implementation of the KBRA will remove the Upper Klamath Basin Redband Trout species management unit from an "at risk" status under the 2005 ODFW stock status review to population that can further tolerate perturbations from natural events like fire and climate change.

Fish Passage

a) Un-obstructed adult fish passage in the Sprague, Wood, Williamson, Sycan Rivers, as well as all tributary streams of Upper Klamath Lake

b) All irrigation diversions have fish protection screens which do not allow for juvenile fish to be diverted from the stream course.

c) Spring areas and associated restored riparian areas downstream provide additional refugia for trout during summertime high temperatures and provide additional protection from future increases in climate change

d) Allows for genetic exchange between the meta populations of the Upper Klamath basin. Redband trout from Klamath River will have un-obstructed access to spawning areas in the tributary streams of the Wood, Williamson, Sycan and Sprague Rivers.

e) The ability to migrate is one of several evolutionary advantages contributing to survival of trout in the Klamath Basin for millions of years through dramatic environmental changes. Improved fish passage provides for the diversity in life histories that contributes to the long term survival of Klamath Basin trout.

Redband Trout Fishery with KBRA

Angler Use and catch rates

a) Angler catch rates will increase from larger population of redband trout

b) Angler use above Upper Klamath Lake and tributaries will increase due to improvements in the number of the Klamath redband trout (trophy size trout).

c) Tribal and non tribal fishers will have additional angling opportunities in the Williamson, Sprague, and Wood Rivers for resident trout due to increases in population size and increased opportunities for harvest. Currently all tributary streams have protective angling regulations (gear restrictions, season restrictions) to conserve redband trout resource.

Bull Trout Status with KBRA

a) Buchanan *et al.* 1997 identified channelization, water withdrawals, and removal of stream side vegetation as factors limiting bull trout in the Klamath Basin. Through the implementation of the KBRA stream habitat will be improved by restoring stream sinuosity through the removal of dikes.

b) Flows will be improved through the addition of 30,000 acre feet of water. Riparian areas will be restored through improved riparian management practices.

c) Bull trout are considered late Pleistocene fish meaning that they have evolved in cold waters of the last ice age. Improvements in riparian communities through the implementation of the KBRA will reduce water temperatures and give the native bull trout a competitive advantage over less cold water tolerant fish species.

d) Bull trout populations are currently fragmented with little to no connectivity between populations. The isolation of these populations and the lack of genetic exchange between populations have created stocks with little heterozygosity. The lack of genetic diversity does not allow the species to cope with environmental and climatic changes. The reconnection of these populations through flow augmentation as well as allowing more cold water habitat through improved riparian management will benefit bull trout populations.

e) Introduced fish species are currently posing a risk to the long term survival of bull trout in the Klamath basin. The presence of brook trout and brown trout threaten bull trout populations through hybridization as well as competition for food and space. Dollars associated with the KBRA will allow the State Agency to implement chemical treatment projects to restore a native fish assemblage to the bull trout streams.

f) Bull trout evolved with anadromous fish. Nutrients from decaying salmon carcasses allow for increased primary production and improved juvenile bull trout survival. Through the implementation of the KBRA anadromous fish will return to the Upper Klamath basin and enhance the streams through the addition of decaying carcasses as well as eggs and fry (Buchanan *et al.* 1997)

g) Bull trout are known to make long migrations and traverse very step gradient streams. Improvements to fish passage at irrigation diversions will allow for bull trout to colonize new habitats and to exchange genes with bull trout in neighboring streams.

h) Screening of irrigation diversions will allow for increased survival of fry and juvenile fish.

Angler Use and catch rates

Increases in bull trout populations through KBRA actions will allow for future recreational fisheries. Currently bull trout angling is closed in the Klamath

ODFW Answers to Expert Panel Questions
Rainbow/Redband Trout with Dam Removal and KBRA implemented

ODFW provides the following answers to the general and specific questions submitted to the expert panel to analyze in this review process.

1. Geomorphology: The two alternatives will result in very different geomorphic dynamics of the Klamath River down stream of Keno Dam. We recognize that the dams are associated with bed starvation of gravels and removal of dams may mobilize sediments over the short-term and over decades. How will alternatives affect geomorphology in the short-term (1-2 years) and over the 50 year period of interest? Included in this question are the potential effects of KBRA restoration activities on geomorphology of tributaries throughout the Klamath Basin and subsequent effects on harvestable populations of fish. What are the expected short-term effects of dam removal on the fish abundance and how long will it take these populations to return to baseline levels?

   a. Current Conditions

      1. Reduced productivity of rainbow trout population (ODFW 2005)

      2. Lack of movement of spawning gravel and sediment

      3. Increased habitat and food supply for polychaetes which are the intermediate host for *C. shasta*.

   b. KBRA implemented

      1. Ten years of funding of $150,000 for gravel augmentation in Klamath River below JC Boyle Dam until the year 2020.

      2. Rainbow trout populations below JC Boyle Dam will rebound quickly due to productivity of Spencer Creek. Likely in 3-5 years. Redband trout in Spencer Creek have been documented to spawn at age 1 (90 mm). Large fish up to 12 inches will be produced in the Klamath River hydro reach 3 years after removal. From past studies Spencer Creek has the current potential to seed the lower Klamath River to Shovel Creek (Buchanan 1988-1991)

      3. Other tributaries such as Shovel Creek, Fall Creek and Jenny Creek and the Keno Reach of the Klamath River will allow for quick recovery of trout population

2. Water quality: The panels will be provided with information on numerous water quality issues from throughout the basin including dissolved oxygen, pH, ammonia, blue green algae, microsystin toxin, phosphorus loading, and Total Maximum Daily Loads (TMDL).

Water quality in the Klamath Basin presents a multiplicity of challenges to restoration of fish populations. The Stakeholders and Water Quality Subgroup will provide some insight concerning the likely trends in water quality during the 50 year period of interest. Under these water quality scenarios, how will the two alternatives differ in reaching the goal of harvestable fish populations?

a. Current Conditions

1. Water quality in the Hydro effected reach will continue to be stressful to lethal for aquatic resources. Currently, the operation of the hydro electric facilities and specifically the forebay associated with the hydro electric facilities allow for increased water temperatures through an increase in residency time as water travels through the forebay. Current forebay water management results in algal growth, increases in ammonia as the algae decomposes and subsequent decline in D.O. The constant filling and lowering of the forebay does not allow for riparian vegetation to establish on the reservoir margins which decreases the value as native fish habitat. The increase in water temperature favors introduced fish predators such as largemouth bass. Predation in the forebay is believed to be significant due to the continued presence of introduced fish.

2. The operation of the hydro electric facility and associated forebay inundates the mouth of the major trout spawning tributary, Spencer creek. It is believed that the flooding of the mouth of Spencer Creek makes it more difficult for redband/rainbow trout to locate the spawning tributary. Habitat that would be available to rearing juvenile trout is lost due to the existence of the forebay.

b. KBRA implemented:

1. Upstream of Link River it is anticipated that improvements to riparian vegetation will provide improved spawning and rearing conditions for redband trout. The re-establishment of riparian vegetation along the Sprague, Wood, and Williamson River will help lower phosphorus levels in the Rivers and Upper Klamath Lake. Reduced phosphorus levels will help alleviate algae blooms and associated anoxic conditions created after algae crashes and decomposition.

2. The addition of 30,000 acre feet of water will benefit redband trout through additional summer time habitat through the increase in flow. Additionally, the increase in flow will help buffer against the warming effects of the sun and provide more cool water which will further improve summer time river and lake conditions for trout. Increases in summer habitat through cooler water temperatures will equate to more redband trout for both tribal harvest as well as recreational fishery uses.

3. Restoration of the Barnes and Agency Ranches back into wetland habitat will sequester phosphorus, provide additional redband trout rearing habitat, and additional water storage through the wetland complex which will provide more late season flows. Improvements associated with the wetland restoration of these two Ranches will provide additional opportunities for both tribal as well as non tribal fishers for red band trout harvest and recreation.

3. <u>Water temperature:</u> If reviewers consider the broad distribution of salmonids, salmonids in the Klamath River Basin are at the southern limit of their range. Furthermore, the removal of dams is predicted to alter the seasonal pattern of water temperatures with higher spring and summer temperatures and cooler fall water temperatures. What are the likely effects of the water temperature regimes under the two alternatives on rearing, spawning, and use of thermal refugia by native salmonids that might be manifest in harvestable fish?

   a. Current Conditions:

      1. The hydro electric facility operation diverts the river into a penstock which travels approximately 4.1 miles down hill in order to create hydraulic head. Flow in the bypass reach at that point consists of approximately 100 cfs of river water provided by the fish ladder and dam leakage and 220 cfs of ground water. The ground water temperature is approximately 50 degree F. The bypass reach creates a temperature challenge for redband trout as they migrate upstream to spawn. These fish encounter temperatures in the bypass reach that can have a 20 degree difference between the Klamath River water temperatures.

      2. Current conditions on tributary streams above Upper Klamath Lake are less then optimal. The lack of functioning riparian areas contributes to high summer time water temperatures with large diurnal fluctuations.

      3. High water temperatures in Upper Klamath Lake currently put all fish under stress. *Columnaris* and the causative agent that causes *Furunculosis* is more pathogenic at higher water temperatures and has been identified as the causative agent in recent fish die offs.

      4. *Ceratomyxa shasta* is more virulent at warm water temperatures. Klamath Redband trout are resistant to *C. shasta* but not immune. Increased water temperatures increase the probability that redband trout will become infected with *C. shasta.*

   b. KBRA implemented:

      1. Upstream of Link River it is anticipated that improvements to riparian vegetation will provide reductions in summertime high water temperatures. The re-establishment of riparian vegetation along the Sprague, Wood, and Williamson River will help lower summer time water temperatures in the

Rivers and Upper Klamath Lake. Reduced water temperatures will help alleviate fish stress and fish die offs from *Columnaris, Furunculosis* and *C. shasta*.

2. The addition of 30,000 acre feet of water will improve summertime stream flows and will help buffer against the warming effects of the sun and provide more cool water which will further improve summer time river and lake conditions for trout. Increases in summer habitat through cooler water temperatures will equate to more redband trout for both tribal harvest as well as recreational fishery uses.

4. <u>Habitat and restoration (KBRA):</u> Habitat is essential to productive fish populations and the stakeholders have recognized this critical linkage in the crafting of the Klamath Basin Restoration Agreement. The review panel will receive information on the use of Ecosystem Diagnosis and Treatment (EDT) method for tributaries above Upper Klamath Lake and the 2-D model of mesohabitats in the project reach to estimate aquatic habitat under the two alternatives. In addition, the panel will be provided a description of KBRA effects on habitat in the Klamath River Basin. The two proposed alternatives will result in different paths and timelines for habitat management. What are the likely effects of the two alternative habitat management paths on the recovery of ESA-listed fish or in the level of harvest of fish populations?

   a. Current Conditions

      1. Current habitat efforts on going in the Klamath basin are not necessarily driven by what is limiting either fish or watershed conditions. Habitat projects currently being implemented are a function of a willing landowner and compromises driven by the landowner's wishes with and eye towards a more effective compromises including fish, wildlife or watershed functions.

      2. Screening and passage will not occur under current scenario

   b. KBRA Implemented

      1. Habitat and restoration under KBRA will be driven by the limiting factors identified under the EDT analysis. A triage approach will be implemented to address the factors that will benefit aquatic resources and watershed functions in the timeliest manner. For example, fish passage and fish protection screening will allow all habitats that are currently available to be used for fish production. Juvenile fish protection screening will ensure that the production from the habitat is not lost from the system. The increase in production should be accrued almost immediately. Both ESA listed fish as well as redband / rainbow trout will benefit from restoration actions under the KBRA.

2. Implementation of the KBRA will significantly improve habitat for redband trout in the Cascade mountain tributaries, Wood River watershed, Sprague River watershed and Williamson River watershed

3. Habitat improvements in the Sprague River will address one of the biggest limiting factors for adfluvial redband trout in the Klamath Basin which is juvenile rearing habitat.

4. Improving habitat in the Sprague River has the most potential for improved density and production of redband trout and improves the fishery in the trophy trout waters of the Williamson River and Upper Klamath Lake.

5. Williamson River under KBRA (8 million dollars dedicated to restoration) Below is an outline on the focus of habitat restoration in the Williamson River.

    1. Improved riparian area corridor management (fencing and management agreements)

    2. Levee set back or removal

    3. Physical habitat improvement including wood and gravel additions

    4. Lower Williamson Delta vegetation management

    5. Fish screening

6. Sprague River KBRA (63 million dollars dedicated to restoration)

    1. Massive levee system removal or set back

    2. Complete channel reconstruction

    3. Volunteer retirement of 30,000 acre feet of water

    4. Water leasing instream

    5. Riparian corridor management with fencing and agreements

    6. Fish passage

    7. Fish screening

    8. Spring reconnection

9. Improve dry land range

7. Wood River under KBRA (13 million dedicated to restoration)

    1. Screening

    2. Riparian area management (riparian fencing)

    3. Fish passage

8. Barnes, Agency, BLM wetland dyke removal with resulting restoration of Sevenmile and Fourmile Creeks

    1. An additional 10,000 acres of wetted habitat along with associated wetlands.

    2. Improves fish passage into Fourmile and Sevenmile Creeks

5. <u>Climate change:</u> We recognize a high level of uncertainty is associated with climate change during the 50 year period we are studying for the Secretarial Determination. The review panel will receive information on predicted hydrology and temperature for several climate change scenarios that have been downscaled for the Klamath River Basin. To what extent might potential changes in habitat, the hydrograph, and thermal refugia mitigate the effects of climate change under the two alternatives? What are the likely effects of climate change on the harvest levels of fish under the two alternatives.

    a. Current conditions

        1. Under current conditions and continued climate change over the next 50 years it is estimated that temperatures will rise. The increase in temperature will adversely effect stream temperatures and impair the ability of cold water fish species to survive in the lower reaches of the Williamson, Sprague Rivers and tributaries. Spring dominated systems like the Wood River, Fort Creek, Crooked Creek and Spring Creek will be less impacted by the increase in temperature but if snowpack dwindles these large springs could see a reduction in stream flow.

    b. KBRA implemented:

        1. The increase in air temperature will be buffered by the shade provided by improved riparian habitat and the stream narrowing process that occurs with more diversity of vegetation types. Climate change will impact productivity through insect production as well as changing the summertime high water temperatures of larger bodies of water (Klamath and Agency Lakes).

Klamath Lake has a large spring influenced section (Pelican bay, Recreation Creek, Crystal creek) which will continue to allow cold water fish to survive and prosper during summertime high water temperatures

2. ODFW believes that because of the large amount of spring fed streams and rivers in the Klamath Basin will buffer the negative affects of climate change and will not have a dramatic affect on water temperature and water quantity in many streams (Table 1). With improved riparian conditions and increases in flow from water acquisition and leasing ODFW believes that water temperature and flows could increase despite climate change.

River System	Section	Groundwater Flow (CFS)
Lower Williamson River and Tributaries	RM 16.5-22.2	350
Wood River and Tributaries	Crooked Creek confluence (RM 2) to headwaters	490
Sevenmile Creek and Tributaries	Crane Creek confluence to headwaters	90
Sprague River	SF Sprague (RM 10.2) to Sprague River (RM 10.1)	202
Upper Klamath Lake	Springs in UKL including Malone, Crystal, Sucker, Barclay	350
Klamath River	Keno Dam (RM 231.5) to Power House 219	190
Klamath River and Fall Creek	Powerhouse to Iron Gate Dam	128
Total		1800

Table 1. Estimated groundwater discharge (springs) into Upper Klamath Basin River systems (USGS 2007)

6. Abundance: How will the two alternatives affect abundance of the fish population and what are the expectations for the enhancement of the fisheries? This question may have several milestones along a timeline or population trajectory. For example, inasmuch as some fish populations have been extirpated from the upper Klamath Basin for more than 90 years, when might fish be available for tribal ceremonial use within the upper Klamath Basin? Using a time trajectory, when will a sustainable fishery start and at what levels? We recommend the Panel consider abundance at different time scales ranging from seasonal, inter-annual, and to decadal trends. Economic concerns are that extreme variation in fish populations can affect economic stability of fisheries and fishing communities or slow recovery of fish populations and will delay any economic benefits.

ODFW has made an attempt to quantify a level of increased abundance with dam removal. The biggest limiting factors for rainbow trout abundance in the Klamath Basin are

1) Lack of screening
    a. According to KBRA all major diversion points will be screened on a quick time line. Funding has been appropriated to screen 100 diversions

2) Lack of fish passage in certain tributaries
    a. Most fish passage problems will be addressed with KBRA

3) Lack of juvenile rearing habitat
    a. Much of the juvenile rearing habitat occurs in the Sprague so the resulting focus of KBRA on Sprague River habitat will result in increases in juvenile production.

4) Lack of spawning gravel which results in superimposition of redds and concentration of spawners for predation.
    a. KBRA will have up to 10,000 cubic yards of spawning gravel added to most spawning tributaries.

5) Water quality and quantity in the Sprague River and tributaries, Upper Klamath/Agency Lake, Lake Ewauna and Keno Reservoir (Klamath River to Keno Dam)
    a. Improved water quality will improve survival thus improve size, fecundity and overall productivity.

ODFW has made some rough calculations on estimated abundance increases for redband and rainbow trout.

a. Abundance of rainbow trout in the project reach can be expected to increase by a factor of 5-8 times using population estimates from other similar river systems. This would be an increase of 890 trout per mile to 5-8000 trout per mile.

b. Historic numbers of rainbow trout using the JC Boyle Fish Ladder went from over 5000 to under 100. This was a fifty fold decrease.

c. Information on abundance can also be attained from historic rainbow trout egg take on Spencer Creek. Egg take on Spencer Creek from 1947-1955 (Table 2). Only took a proportion of the run.

Table 2. Redband trout Egg take at Spencer Creek hatchery from 1947 to 1955.

DATE	Number Females	number of eggs	eggs per female	Average Length
1947		1,800,000		
1948		1,500,000		
1949		250,000		
1950	315	500,000	1586	17.5

1951	493	756,000	1534	15.7
1952	695	1,000,000	1600	16
1953	785	1,193,680	1520	15.5
1954	1102	1,668,800	1514	16.8
1955	1228	2,094,000	1705	16.4

d. Egg take was also conducted on Shovel Creek. A total of 1,100 fish in 1892 and 1,776 in 1893 trapped at egg taking stations on Shovel Creek (California State Board Fish Commission 1892).Unknown what this number means.

e. ODFW has developed a quick summary of redband trout populations from the ODFW Stock Status review in 2005. ODFW has listed some of the primary streams with their respective status of their trout populations. ODFW has also estimated an increase in adfluvial redband trout spawners that could use the existing habitat if restored. The numbers developed are a estimate based on similar streams of known redband trout use. Most river and streams used by large adfluvial redband trout are stable, spring fed with water temperatures ranging from 43-60 degrees. ODFW has developed a list of the major streams that lack redband trout or their population is depressed Many of these streams that will benefit from KBRA passage, screening, increase in flow. These include:

f. Lower Sprague River Population

1. Sprague River (Mainstem)
    1. Current Conditions
        a. likely over 500 adfluvial adult spawners and unknown fluvial component
        b. Many areas of degraded habitat
        c. Water temperatures and nutrients create stressful conditions for salmonids and favor non native largemouth bass and yellow perch.
        d. Sprague River has great potential with passage, habitat, flow, gravel augmentation, and screening to improve the existing 85 miles of habitat.
    2. KBRA conditions
        a. Improvement in riparian conditions
        b. Improvement in stream habitat

c. Improvement in floodplain habitat with levee removal and setback

d. Improvement in stream flow

e. Improvement in water quality

f. Improvement in spawning habitat

g. Connection to springs will improve

h. Abundance difficult to predict due distance of habitat

2. Whiskey Creek (8 mile potential habitat)
    1. Current conditions

        a. Habitat severely degraded but has enormous potential with up to 20 cfs of spring water historically at the mouth.

        b. Large springs used for irrigation and enormous amount of groundwater pumping in area

        c. Redband trout adfluvial population likely less than 20 adults

        d. Fish passage curtailment during irrigation season

    2. KBRA conditions
        a. Opportunity to reconnect springs

        b. Chance of purchasing instream flows for fish

        c. Improvement in fish passage

        d. Potential for spawning and rearing is tremoundous due to the large amount of spring water

        e. A similar 20 cfs spring fed system of Agency Creek with gravel additions produces 200 spawning adults per mile. This system could produce 1000 adults in the 5 miles of completely restored habitat below the first major spring.

g. Upper Sprague River Population

1. Fishhole Creek (24 miles of potential habitat)
    1. Current conditions:
        a. Little to no adfluvial population
        b. Fish habitat poor with passage problems

    2. KBRA conditions
        a. Improved fish passage and screening combined with possible increase in summer flows would produce redband trout

        b. Increased population of Adfluvial adults not likely to exceed 100

2. South Fork Sprague (65 miles of potential habitat)

    1. Current Conditions:
        a. Unknown status but very low population of adfluvial redband trout
        b. Many fish passage issues
        c. Lower part of stream channelized and leveed with little riparian vegetation

    2. KBRA Conditions:
        a. Passage, habitat and flow improvements would improve the population of adfluvial and fluvial population likely to exceed 1000% percent in 65 miles of available habitat including tributaries

h. Wood River Population

1. Wood River (20 miles habitat available)
    1. Current conditions:
        a. Adfluvial population depressed. Approximately 500 spawners in mainstem
        b. 7 unscreened diversions up to 200 cfs. Three have screens in disrepair

    2. KBRA conditions:
        a. Benefits by screening large diversions of 100 and 200 cfs and small diversions

        b. Improved riparian habitiat will benefit fry and juvenile rearing which is limiting factor

c. Estimate a doubling of spawning population

2. Annie Creek (12 miles habitat available)

    1. Current conditions:
        a. 9 unscreened diversion points up to 9 cfs.
        b. No screens in system
        c. Near zero adfluvial adult redband trout abundance

    2. KBRA conditions

        a. With screening, passage and habitat improvement likely increase redband trout abundance

        b. Improving fish passage opens up 12 miles of potential redband trout habitat

        c. Likely to see Adfluvial population of 100 adults

3. Sun Creek (5 miles of available habitat)

    1. Current Conditions:
        a. No redband trout
        b. Passage is poor
        c. 3 unscreened diversion points up to 10 cfs

    2. KBRA conditions
        a. Screening and passage opens up five miles of potential redband trout habitat up to bull trout barrier

        b. Restoring Sun Creek to original stream channel will increase habitat by two miles

4. Fort Creek
    1. Current conditions
        Currently one screen near spawning grounds not screened

    2. KBRA conditions

        a. Unscreened diversions screened
        b. Spawning gravel added to creek

i. Cascade Complex Population

1. Fourmile Creek 10 miles of mainstem habitat (Fourmile Lake)

1. Current conditions
    a. Intermittent flow needs flow enhancement abundance less than 20 adults
2. KBRA conditions
    a. Possible purchase of instream flow

2. Fourmile Creek (4 miles of mainstem habitat available)
    1. Current conditions
        a. Fish passage issue on Fourmile Canal
        b. Abundance less than 20 adults

    2. KBRA conditions
        a. Likely to increase with habitat restoration and passage improvement to likely 100 adults in one mile of spawning habitat

3. Denny Creek (6.8 miles of mainstem habitat)
    1. Current Conditions
        a. Channelization and levees impairs fish passage

        b. Lack of flow

        c. Abundance less than 20 adfluvial adults

    2. KBRA conditions

        a. Restored stream channel along with Upper Klamath Lake wetland area along the creek.

        b. Redband trout spawning will likely result in near 100 adult spawner in one mile of spawning habitat

4. Cherry Creek (11 miles of habitat)
    1. Current conditions
        a. Good abundance of resident fish but adfluvial component lacking due to passage and flows

    2. KBRA conditions
        a. Improved fish passage, screening and habitat near the confluence with Fourmile Creek

5. Sevenmile Creek (19 miles of habitat)

1) Current conditions
    a. Limited redband trout use near extirpation with less than 20 adfluvial adults

    b. 8 unscreened diversion points up to 43 cfs

2) KBRA conditions

    a. With passage and breaching of levees at Agency Ranch and BLM Ranch and screening of diversion estimate 1000 spawners in existing 19 miles of potential habitat.

Abundance of redband trout is likely to increase with the reintroduction of salmon. Salmon will bring marine nutrients to areas such as the Wood River, Spring Creek and Williamson River that have low productivity due to domination of spring fed water. Redband trout will also feed on eggs, fry, invertebrates dislodged by spawning, and carcasses of Chinook salmon. Rainbow trout in Alaska rely on the return of salmon for much of their food source for the year. Steelhead juveniles, halfpounders and adults can also be found feeding behind redds on the mainstem Klamath River below Iron Gate Dam. Despite some competitive interactions between chinook and redband the overall benefit of food will be a net positive for redband trout.

7. <u>Productivity:</u> The metrics of productivity of fish populations may be measured several different ways. These methods include: 1) number of recruit spawners produced per parent spawner at low abundance, 2) juvenile outmigrants per adult spawner, or 3) redd counts per redd count of the previous generation. Each of these examples may be expressed through commonly used stock-recruitment models, such as the Beverton-Holt or Ricker curves. We recognize that conditions resulting from the proposed alternatives may not restore fish productivity to levels associated with historical pristine conditions. What are the most likely expectations for productivity over time and what is the effect of productivity on the number of harvestable fish? (role of hatcheries and productivity?)

    a. Size and age of fish will improve in the project reach due to higher survival rates due to improved water quality and improved food resources

    b. Improved fry survival with gravel additions and improved watershed health

    c. The larger the fish the higher the fecundity. Adfluvial redband trout population at Kirk Springs (Williamson River) average size 500 mm redband trout (2000 eggs per female), Spencer Creek rainbow trout average 1514-1705 eggs per female prior to dams and average size 350-450 mm. Average size of Spring Creek spawners are 540 mm (Buchanan *et al.* 1991) Average size of adfluvial redband trout at Sprague River ladder was 526 mm in 1989. Average size of redband trout captured by trammel net in Upper Klamath and Agency Lakes from 1999-2009 was 399-514 mm. In small streams resident redband trout have reduced fecundity. Kunkel (1976) found that adfluvial redband trout from Threemile Reservoir increased productivity of Threemile

Creek by twelve times and produced ten times as many eggs as stream resident adults. Resident Threemile Creek redband trout produce on average 247 eggs per female.

d. Improved water quality and additional summer and winter refuge habitat will improve the survival of redband trout which will thus produce older, larger, and more fecund adults which will increase productivity.

8. **Diversity:** Diversity refers to the variation in phenotypic characteristics such as individual size, fecundity, run timing, and life history patterns of fishes. Collective diversity of groups of subpopulations will reflect the diversity in the selective environments across the range of a fish species. The diversity enables the individuals to respond to changes resulting from subtle to catastrophic events across space and time. For populations lacking diversity the seasonal availability of adult (harvestable) fish to fisheries might result in very short and highly regulated harvest seasons. Historically, diversity of the salmonid populations may have been an important determinant of the seasonal patterns of harvest, the range in size of harvestable adults, and perhaps other characteristics of the fisheries. What will the effect of the two alternatives be on diversity of fish populations? How will the resulting diversity be manifest in the harvestable population of fish? How will potentially low baseline populations and/or introductions of hatchery fish affect diversity under the two alternatives?

   a. Redband trout in the Upper Klamath Basin have some of the most phenotypic diversity of any known population of redband trout.

   b. The KBRA will improve access to many streams that currently lack redband trout or abundance is well below potential due to passage and/or habitat issues.

   c. Diversity of redband trout will increase by allowing them to return to the Ocean. Returning to the Ocean has overall survival benefits to the species in case of stochastic events.

   d. Additional populations of redband trout will develop with improved fish passage and increases in instream flow

9. **Spatial structure**: Spatial structure of the fish populations refers to the distribution of fish in various habitats used throughout their life history. Spatial structure enables fish populations to respond to localized catastrophic events across the landscape or to long-term changes in the environment. For a fishery, spatial structure of the population may stabilize the opportunity to produce harvestable fish. Will the two alternatives result in improved spatial structure of fish populations and to what extent is that improved structure likely to result in harvestable fish?

   a. Distribution of redband trout will be increased due to improved fish passage at remaining barriers. Improved connectivity will also allow for redband trout to compete with non native fish such as brook and brown trout. Many streams in the Klamath Basin have extirpated redband trout population due to lack of fish passage in conjunction with sympatry with brook and/or brown trout.

b. Removal of the dams will allow redband trout to adopt anadromy

c. Improved water quality in the Sprague River, Upper Klamath Lake, and Lake Ewauna, and Keno Reservoir will allow juvenile and adult redband trout to stay in more productive habitat for a longer period of time which will increase fitness.

d. Removal of the levees on Barnes, Agency and BLM wetland will improve the cold water refuge area of Fourmile and Sevenmile Creek. Redband trout seek these areas when water quality conditions in the lakes become inhospitable.

e. Redband trout fry will be able to access higher quality slow velocity margin habitat

10. **Ecosystem restoration**: Numerous small dams across the U.S. have already been removed and several large dams in the West such as the Elwha Dam (105 ft) and Glines Canyon Dam (210 ft) in Washington State are scheduled for removal in the future. The goals of these dam removal projects range from restoring volitional movement of fish to restoration of entire ecosystems. One of the goals of the KBRA is to restore and maintain ecological functionality and connectivity of historic fish habitats. However, in most drainages, in addition to dams, widespread degradation of habitat and other forms of human perturbations have contributed to the decline of harvestable populations of salmonids. The signatories to the KHSA recognized that dam removal on the Klamath River is perhaps not a panacea for restoration of fisheries, and therefore also proposed the restoration activities of KBRA in an attempt to provide participation in harvest opportunities for fish species. How do the proposed alternatives address ecosystem function and connectivity sufficiently to recover the lost harvest opportunities of fish populations?

Dam removal and KBRA will improve almost all connectivity to populations by removing fish passage barriers. Some streams in the Klamath basin lack fish passage and the result have been complete loss of the redband trout population. In Fort Creek when an impassable irrigation dam was built the redband trout were lost. Brook trout were the only salmonid found above the barrier. When the barrier collapsed in 1992 redband trout were observed that year spawning in the habitat above the barrier. Today over 100 redband trout redds per year occur in the area above the barrier.

The Klamath Basin ecosystem relies on fish. Many bird and mammal species benefit from the abundance of fish species in the basin. For example during the spawning of redband trout bald eagles can be observed at every major spawning area from the headwaters of the Wood River to the Williamson River at Kirk Springs to the tiny Sunnybrook Creek. Otter and mink can also be found close to these spawning areas. The large parasitic lamprey of Upper Klamath Lake relies on the large redband trout for food. Many redband trout in Upper Klamath Lake can be observed with past lamprey wounds. The redband trout are one of the last food fish that the Klamath Tribes are allowed to harvest. Klamath tribal members can be observed almost year long fishing for redband trout in various locations. Freshwater mussels rely on redband trout and other fish early in their life cycle as they attach to the gill surface of the fish. Numerous aquatic life feed on carcasses of redband trout that die after spawning. This includes the very abundant crayfish population in the Williamson River which experiences a significant harvest by humans.

Disease

ODFW believes that there is no known disease or pathogen that will occur due to removal of the Klamath River dams and allowing for the return of Chinook salmon and steelhead. Redband trout in this basin are

i) For the most part, the pathogens existing in the lower basin historically and currently exist in the upper basin of the Klamath River above Iron Gate Dam.(McKenna 2006).

ii) Like *IHN*, there is a lack of information concerning the presence of *R. salmoniranrum* in the upper basin. Nevertheless, because of its low levels, *R. salmoniranrum* does not appear to pose a significant risk of disease in the salmonid population in the Klamath River system, and consequently the bacteria will not pose a significant threat to fish in the upper basin (McKenna 2006).

iii) Similarly, parasitic *Trematode Metacercaria* present in juvenile and adult Chinook salmon do not appear to present a significant health threat to resident fish in the upper Klamath (McKenna 2006).

iv) *F. columnaris* and *Ich* are ubiquitous in freshwater systems, and both are present throughout the Klamath River system above and below Iron Gate Dam (McKenna 2006).

v) *Ceratomyxa shasta* has been detected in the lower Williamson River, a tributary of Upper Klamath Lake, and in areas below Iron Gate Dam in nearly equal levels(McKenna 2006).

vi) Redband trout in Upper Klamath Lake and Lower Williamson River are resistant to *C.shasta*. Trout Creek redband trout in the Sprague River have an intermediate resistance to *C. shasta*. Redband trout from tributaries that access upper Klamath Lake are assumed to have a resistance to *C. shasta* but streams such as the Upper Williamson River and Deming Creek which have populations of redband trout that are not connected to the lake have high mortalities when exposed to *C. shasta* (Buchanan *et al.* 1988 and 1989).

vii) For unknown reasons *C. shasta* does not occur in large tributaries such as the Wood River, Spencer Creek or Sprague River despite adult redband trout from Upper Klamath Lake carrying and dispersing the spores. Currently the only area containing spore levels high enough to infect fish are Williamson River, Upper Klamath and Agency Lakes and Klamath River (Buchanan *et. al* 1988 and 1989).

viii) Rainbow trout from Spencer Creek have been exposed to areas of high spore loads of C. shasta in the Klamath River below Iron Gate Dam. Rainbow trout from Spencer Creek showed resistance to infection to C. shasta. (Batholomew *et al.* unpubl.).

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