OREGON STATE UNIVERSITY
DEPARTMENT OF FISHERIES & WILDLIFE

Douglas F. Markle, 104 Nash Hall, Corvallis, Oregon 97331-3803 U.S.A
douglas.markle@orst.edu , voice: (541) 737-1970, fax (541) 737-3590

MEMO

TO: S. Lewis, USFWS Klamath Falls DATE: 5 July, 2001
FROM: D. F. Markle, Professor of Fisheries
SUBJECT: Review of Klamath Project Biological Opinion

Attached is a review of the April 5, 2001 Biological Opinion and Conference Report on the Klamath Project. We are impressed with the quantity and quality of work that has gone into this document and are aware of the difficult nature of this decision. We hope our comments are useful and our criticisms constructive. They represent our professional opinions and not the opinion or position of Oregon State University.

cc.
D. Hohler, D. Lassuy, Oregon Chapter, AFS
R. Larson, USFWS Klamath Falls
T. Dutson, E. Fritzell, K. Rykbost, D. Edge, Oregon State University
M. Beuttner, US Bureau of Reclamation
R. Smith, Oregon Dept. Fish & Wildlife
L. Dunsmoor, Klamath Tribes
R. Shively, USGS
S. Gregory, IMST
G. Walden, U. S. House of Representatives

Review
of
Biological Opinion and Conference Report for the Continued Operation of the Bureau of Reclamation's Klamath Project as it Effects Endangered Lost River Sucker (*Deltistes luxatus*), Endangered Shortnose Sucker(*Chasmistes brevirostris*), Threatened Bald Eagle (*Haliaeetus leucocephalus*), and Proposed Critical Habitat for the Suckers
(dated April 5, 2001)
by

Douglas F. Markle, David Simon, Michael S. Cooperman, and Mark Terwilliger
Dept. of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331-3803
5 July 2001

On March 6, 2001 we reviewed a February 5, 2001 draft of the Biological Opinion (BO) on the Klamath Project. In our review of the draft BO, we were critical of writing, data presentation, analysis and conclusions. The Final BO, dated April 5 2001, was responsive to peer review and new information. It is thorough, well-documented, and professional.

The Final BO documents loss of numerous spawning groups of suckers in the 20th century and continued problems with fish kills and entrainment, both of which limit current population growth. We disagree with some interpretations of data, but the conclusion regarding jeopardy of suckers, based on the USBR Biological Assessment (BA), appears to be a robust conclusion. That is, given any reasonable interpretation of data in the BO, it is reasonable to conclude that a minimum Upper Klamath Lake elevation of 4136.8 ft, as allowed for in the BA, would have a negative impact.

If a minimum elevation of 4136.8 ft creates jeopardy, an important question becomes, "Why was a minimum elevation of 4140 ft chosen rather than 4139 ft as in the 1992 BO, or some other level?" In this review, we explore the answer to this question. Minor comments are included as an appendix.

Most of the scientific data were collected in the last 10 years and, to the best of our knowledge, meet accepted standards. Lake elevation is a seasonally monotonous variable that creates analytical problems such that many relevant analyses in the BO have a statistical sample size of one observation per year. Consequently, although analyses are well-reasoned, they tend to be univariate and sample sizes are relatively small. The current science is such that reasonable people could differ, within some narrow limits, in a determination of a reasonable and prudent minimum lake elevation. The Service's decision appears to have been influenced by four key factors: a benefit of the doubt instruction, failure to implement previous requirements, a perception of greater imperilment of the species since 1992, and a greater emphasis on water quality issues since 1992.

The most influential factor, p. 124 (page numbers are those for Section III, part 2), states, " Congress instructed the Service to provide the "benefit of the doubt" to the species of concern when formulating its biological opinion (H.R. Conf. Rep. No. 697, *supr*a, at 12)." When there is uncertainty, as in any complex ecosystem such as Upper Klamath Lake, this instruction suggests that the Service must always select upper confidence bands. The BO appears to have done so.

The second point, failure to implement actions of previous RPA's (reasonable and prudent alternatives), is mentioned several times. On p.126 "Reclamation has not complied with installation of a screen facility requirement on the A-Canal, as directed by an amendment to an RPA in the 1992 BO, and has at this time committed to no additional screening at any of its facilities. The fact that adequate screening has not been provided anywhere within the Klamath Project after nearly a century of operation is considered by the Service to be a major factor imperiling and retarding the recovery of the two endangered suckers." On p. 153 " Many of the actions identified in the RPA have been identified in previous jeopardy BOs for the Klamath Project as part of the RPA, but were not implemented. …. Under the authority of the Klamath Basin Water Supply Enhancement Act of 2000 (P.L. 106-498), Reclamation can undertake studies to reduce Project water demand and augment supply. Screening and fish passage are economically and technically feasible since they have been widely implemented by other Federal water development projects in the West, including most other Reclamation projects."

It is not clear if implementation of these actions would have changed the decision in this BO. Presumably, if screening had been done and could have been linked to increased recruitment and over-winter survival of juveniles, the Service might have concluded that a lower lake elevation was reasonable and prudent. However, the third and fourth caveats, below, suggest in the short term at least, that this is not true. The most influential upper band of uncertainty seems to have been based on fish kills and water quality, not recruitment.

The third influential factor, p. 156, states, "However, the RPAs have not been fully implemented and evidence now indicates that the two endangered sucker species are more imperiled than when previous opinions were issued." The conclusion (increased imperilment) is not well documented. We reach a different conclusion using maximum estimates based on 1987-89 larval production and minimum recent estimates. Using the larval production data from the Williamson in 1987-89 (p.12), assuming a 50:50 sex ratio, an average fecundity of 135,000 eggs/female, and a 90% mortality rate since fertilization, the population size of both species ranged from 2080 (1987) to 10,820 (1989). The population in the late 1980's was presumed dominated by older fish so the midpoint fecundity used above is a conservative estimate. The patterns of freshwater fish mortality suggest that 95% mortality is not reached until the juvenile stage (Houde, 1994. ICES J. Mar. Sci. 51:91-97) but high in-river mortality was also documented in the late 1980's so the mortality estimate may also be conservative. Assuming only half of the population estimated in 1996 and 1997 (p.41) were Sprague/Williamson fish and using the <u>lower</u> 95% confidence estimates given in the BO, the combined Sprague/Williamson populations in 1996 were 43,500 and in 1997 were 28,500. Using the Perkins adjustment for 1996 SNS, the 1996 estimate was 23,000, still 2- 10 times higher than 1987-89.

The point of the above is not to suggest that these numbers are absolutely correct, but to show that, even on an order of magnitude scale and using recent minimum estimates, there is no evidence to say that the species are less abundant than they were in the late 1980's. However, one difference in sucker populations between the two time periods is the age structure; older fish no longer dominate the population. The BO may therefore be implying that a small population of older fish is less imperiled than a larger population of younger fish. A further implication is that small populations of older fish experiencing the drought years through 1994 were less imperiled than somewhat larger populations of younger fish experiencing recent wetter years. It is difficult to agree with this scenario. If there were any differences in imperilment between the two time periods, the greater would seem to have been in the past. With forecasts of potential year classes in the 1990's, we think that the species status is equal to or better than when the 1992 BO was issued.

Even if the Service agreed with this position, it is not clear that the final decision would be different. The Final BO uses new information to show that two aspects of the 1992 opinion (Table I-2) required revision. The first was that the 4 in 10 year compromised (lower) elevation of 4137 ft would jeopardize suckers. The BO clearly demonstrates that this elevation creates jeopardy. Left unanswered is whether compromised elevations of any elevation or frequency create jeopardy. The second is that the un-compromised minimum elevation of 4139 ft would jeopardize suckers. The BO does not show that this elevation is a threat; but given certain climate outcomes, it says it might be a threat. On p. 106, "The Service acknowledges that meeting prescribed lake elevations does not ensure year-class success or prevent sucker die-offs. Other factors including weather, *AFA* bloom dynamics, disease outbreaks, and poor water quality can all lead to year-class failure and sucker die-offs independent of lake level. However, both Reclamation and the Service recognize that high lake elevations can enhance the probability of year-class survival and reduce the frequency and magnitude of major sucker die-offs, and is the only short-term way to offset some of the threat to sucker populations in UKL." In other words, "Since winds cannot be managed, summer and early fall lake levels in UKL need to be managed near the higher pre-project levels to reduce risk of catastrophic fish kills" (p.86).

Figure 4-10 (below) from Welch and Burke, 2001 underpins this conclusion. The data for thermal stratification/water column stability (RTRM) are based on 3 of 7 monitoring sites in the northern end of the lake where adults are most commonly found and water depths are deepest. The wind speeds are means of maximum daily 4-hour running mean wind speeds (presumably, means of maximum daily sustained wind calculated from 4-hour running means). The plot of two-month means excludes confidence intervals and the analysis is not multivariate as implied in the BO.

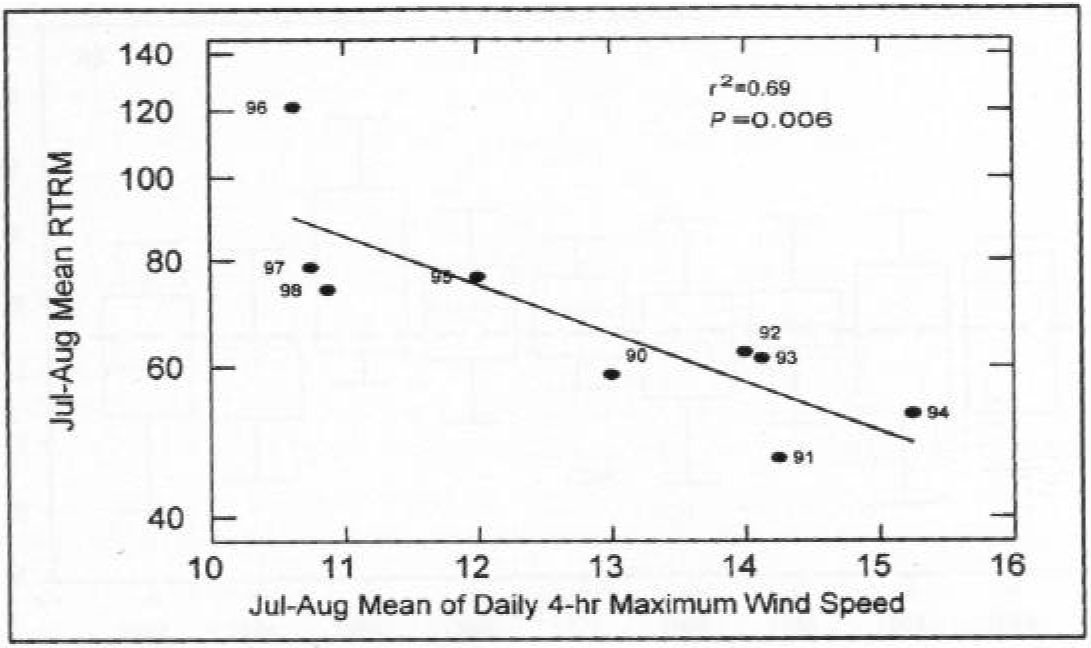

Figure 4-10. July-August mean of the maximum daily 4-hour running mean wind speed in mi/hr at Klamath Falls Airport related to July-August mean water column stability (as RTRM) at northern sampling sites (ER, SB, MN) in Upper Klamath Lake.

The conclusions can be examined using the BO's empirical data and analyses as well as a multivariate analysis. The empirical data support statements in the BO, such as "Further, modeling indicated that in UKL, stability is more dependent on wind speed than depth, thus finding a significant relationship between lake levels and DO is confounded by the dominant effects of wind" (p. 82). For example, the RTRM, surface-bottom DO difference, and wind speeds were essentially identical in 1992 and 1993, as were their water column minima and mean DO's (their Figure 4-13), yet the difference in elevation between the two years (ca. 2.5 ft) is close to the maximum range for the decade. One year (1992) had the lowest median lake elevation of the decade and 1993 had the third highest for the July-August period. Welch and Burke and the BO conclude that the common feature to explain the pattern is wind speed. Using the average July-August wind speed from Welch and Burke's report, ca. 12.7 mph, an RTRM of about 70 is predicted. Six of the nine years analyzed were in the RTRM range of ca. 60-80 and included the lowest lake elevation and water column DO (1992) and two of the three fish kill years (1995 & 1997). During the two years of strong wind and lower RTRM (1991 and 1994), lake elevations were the second (1994) and third (1991) lowest but minimum water column DO (Welch and Burke Fig 4-11) ranged from second lowest (1994, which produced a poor year class) to highest (1991, which produced a good year class). During the year of highest RTRM and weakest winds (1996), July-August lake elevation and minimum water column DO were about average for the period (ca. 4140.8 ft and 5.3 mg/L) and there was a fish kill.

The BO's sought-for insurance against low wind speeds seems sound but the empirical data suggest uncertainty regarding the size of the benefit. Even in an "expected" RTRM range of 60-80, and July-August lake elevations greater than 4141 ft, the data show that a fish kill happened in 2 of 6 years (1995 & 1997). As expected in the worse case "weak wind scenario", a July-August elevation of 4140.8 ft was also associated with a fish kill (1996). The benefits of strong winds are also suspect given the different DO responses in 1991 and 1994. In part, the problem is the low slope and variance in the RTRM – wind speed relationship and the univariate analysis. A relatively large change in wind speed has a small impact on RTRM, even smaller when the statistical outlier year (1996) is excluded (Fig. 4-10). The BO recognizes other factors, primarily AFA bloom dynamics and disease, as confounding this relationship, but as cited above (p.195), considers lake levels as insurance against these unmanageable factors.

A Principal Components Analysis (PCA) provides partial support for the conclusion that lake elevation mitigates low wind speeds. We used RTRM and DO minima for the three northern sampling sites, July/August lake elevations, and wind speeds (all data approximated from Welch and Burke's figures), and USBR June 1 lake elevations:

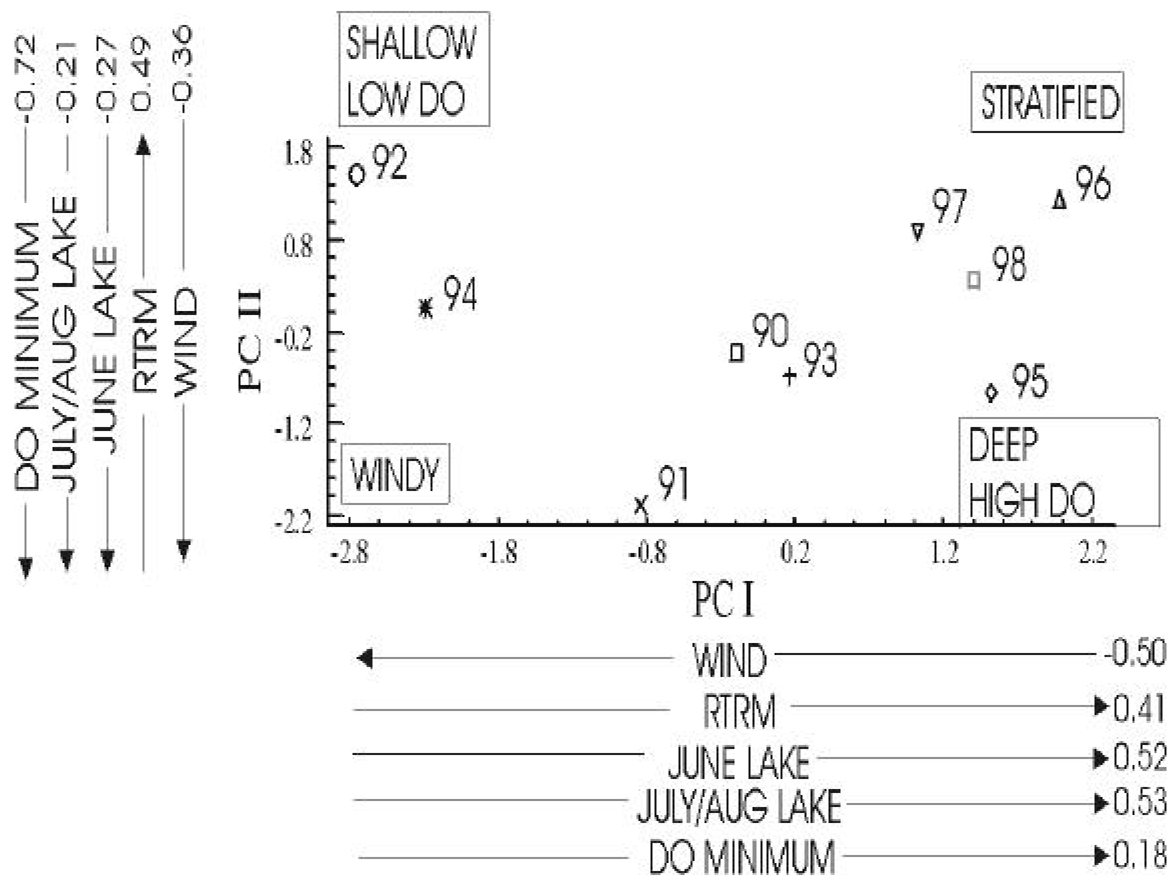

Figure 1. Principal Component Analysis of wind, RTRM, June 1 lake elevation, median July-August lake elevation, and minimum water column DO in Upper Klamath Lake for 1990-1998. RTRM and DO based on three northern sample sites. Coefficients for each variable shown in diagram below each PC. The two axes explain 84% of the variation in the data. Boxes characterize dominant influences in four quadrants.

This analysis suffers from many problems, such as seasonal lumping of observations, absence of important environmental variables such as temperature, and autocorrelated observations, but uses the primary environmental variables from Welch and Burke's analysis. It is also instructive as a first-order multivariate description. For example:

- Fish-kill years (1995, 1996, 1997) group together.
- Years of very low or no juvenile production (1992, 1994) group together.
- Years with detectable juvenile production and no fish kills (1990, 1991, 1993, 1998) group together (partly overlapping with fish-kill years) and two of those years had high juvenile production indices (1991 & 1993).

Reducing these observations to September 1 lake elevations, we see:

- in fish-kill years, 1995-1996-1997, a range from 4139.63-4140.70
- in years with detectable juvenile production and no fish-kills (1990, 1991, 1993, 1998), a range from 4138.96-4140.69
- in years with little juvenile production and no fish kills (1992, 1994) a range from 4137.70 & 4137.47.
- Only the 1992 and 1994 elevations are significantly lower (all comparisons suffer from low sample sizes).

As expected from Welch and Burke's bivariate analysis, wind and RTRM are negatively associated on both axes. However, their expected relationships with DO minima are more complex. Lower wind speeds are associated with lower minimum DO only on the second axis and higher RTRM are associated with lower minimum DO only on the first axis. The coefficients for minimum DO were the same sign as lake elevation on both axes suggesting that lake elevation does have a relationship to this measure of water quality. The wind-RTRM relationship is orthogonal to the depth-DO relationship, thus fish kills might have been avoided in the low water years (1991, 1992, 1994) by the windier conditions. Higher lake elevations have apparently compensated for low wind conditions only in 1998, *i.e.*, about 25% of the time.

Fish kill years (1995, 1996, 1997) have positive PC I scores and positive (1996 & 1997) or negative PC II scores. The primary influences on positive PC I scores are low wind speeds, high lake elevation and high RTRM. The primary influences on positive PC II scores are low DO and high RTRM. The two years of low or no juvenile production (1992 & 1994) have low PC I scores and high PC II scores and can be characterized as years with low lake elevations and low DO. Two years with higher juvenile indices (1991 & 1993) have PC I scores near zero and negative PC II scores. Those years could be characterized as having high DO and moderate lake elevations.

PCA finds patterns in complex data but can not predict. In this case, the patterns suggest September 1 lake elevations above 4138.96 and July/August maximum daily 4-hour running mean wind speeds greater than about 12 mph (Fig 4-10) can produce good recruitment and water quality. With wind speeds less than 12 mph and September 1 elevations from 4138.96-4140.69, fish kills happened 75% of the time. The BO

September 1 elevation of about 4140.75 is higher than the fish kill years and presumes it will insure against low wind speeds. The PCA shows similar magnitudes in wind and lake elevation coefficients on the first axis, but opposite signs. This suggests that, all things being equal, an increase of one foot in lake elevation compensates for a reduction of one mile per hour in wind speed. However, since RTRM also has a negative relationship with wind speed (Fig 4-10), an even larger increase in lake elevation is required to compensate for a reduction of one mile per hour in wind speed.

Based on average hourly wind speeds at Klamath Falls Airport, as reported at http://www.ocs.orst.edu/pub_ftp/climate_data/wind/klamathfalls.html, wind speeds will be below 12 mph 81.5% of the time in August. The relationship of hourly wind speeds to Welch and Burke's 4 hr maximum running mean is not obvious. However, low wind speeds would seem "insurable", but, given the nature of the system, the increase in lake elevation required to compensate for very low wind speeds may be unattainable. A more rigorous analysis of the compensatory effect of lake elevation on wind speeds is needed.

The higher lake elevations required in the BO do not relate solely to water quality and also include dilution effects, reduced sediment re-suspension, access to preferred habitats, and possible delayed effects. Recently, Simon and Markle (2001) suggested winterkill might be a problem for several species in Upper Klamath Lake, including suckers. It is possible, as the Service contends, that poor summer water quality could have delayed effects that are manifest as over-winter mortality.

In the 1992 opinion, periodic low lake levels were considered reasonable. Disturbance is a normal and necessary part of ecosystems and the 1992 opinion could be viewed as allowing too much disturbance in terms of low lake levels, while the 2001 opinion attempts to allow none. The BO suggests that lowered lake levels are no longer reasonable because of concerns for water quality, population size, age structure, and recruitment. The population size and age structure necessary for lower or compromised lake levels to again be considered reasonable or prudent is not obvious.

In summary, the final BO makes a strong case for revising the conditions of the 1992 BO. It does so based primarily on the congressional instruction to provide "benefit of the doubt", supplemented by a belief of greater imperilment of the species, failure to implement prior requirements, and an increased concern for water quality. It makes a good case that the 4 in 10 year compromised elevation of 4137 ft might create jeopardy, but it does not address whether compromised elevations or their frequency can be considered reasonable and prudent in the future. The BO also presents an argument for raising the un-compromised elevation one foot to 4140 ft. The argument is primarily based on a potential indirect benefit to insure against low wind speeds, but the amount of insurance provided by one foot of lake elevation is not described. We estimate that lake elevation compensation for the lowest wind speeds may be unattainable but suggest more rigorous analyses are necessary.

<u>Appendix: minor comments</u>

Abbreviations

pH is the negative log of the $[H]^+$

Section II

p 29. Wasn't Agency Lake Ranch a purchase, rather than a lease?

p 31, #26. UKL is "for the most part a natural lake"? It is a natural lake with a manipulated hydrological cycle, but by all accounts a natural lake.

p 41. predecessor should not be capitalized.

Section III, part 2

p 2. synonymized - spelling.

p 3. para 2. C. Snyderi. No capital on snyderi and italics needed; KLS used elsewhere. If SNS in Clear Lake are "atypical" a comparison is being made, presumably to "typical" SNS from UKL. However, there are plenty of "atypical" "SNS" collected from UKL, some of which are reported as "potential" hybrids. Based on the logic that SNS from Clear Lake are characterized as "atypical", SNS from UKL could be characterized as "atypical". Better to say that SNS from Clear Lake and UKL appear morphologically different.

p 4, last para. "among", rather than "between"

p 6, para 2. There is no Markle 1993 in references.

p 8 para 1. If nighttime use of former spawning springs and lack of night observations precludes the determination that these springs are no longer used for spawning, why are lack of night observations of tagged suckers not recognized as precluding a determinatin that sucker avoid shallow water?
p 8, para 4. In 1999 sampling at mouth of Wood River, 32 SNS, 2 LRS, and 12 SNS/KLS intermediates were identifed, but later it is written that 3 KLS tagged at the Sprague Dam were captured at Wood River mouth. Is there a typo here or an ID problem with the tagged and recaptured KLS in the Sprague?

p 13, last para "*Combined with channel deepening and reduced flow velocities, first-feeding larvae may be deprived of a critical food supply as evidenced by the frequency of empty guts that has been observed.*"

This seems contradictory to previous information in the BO that suggested larvae are transported down the river and into the lake in about 1 day and there is a 3-6 day in reduced performance and starvation.

p. 20 - meaning unclear and data not shown “Spawning runs at Clear Lake…depending on ice and flow conditions” do they prefer low flows? high flows? what cfs?

p 37, last para. "*UKL (including Agency Lake), with a surface area ranging from 60,000 to 90,000 acres depending on lake levels…*"

One third of the area is dry in low water years? This does not seem plausible. Can it be documented?

p 37, last para. It is stated that the Link River dam was completed in 1919, but in Section II, pages 31 and 33 it is stated that the Link River dam was completed in 1921.

p 37, last para. "*Prior to construction of the dam, the lake level varied from about 4139.9 to 4143.1 ft., with a mean annual…"*

--"prior to" should only include the period of recorded keeping, 1904-1921

p 39, 2nd para. "become *established*"

fathead minnow, bluegill, pumpkinseed, yellow perch, brown bullhead have "become established". Largemouth bass, crappie, brown trout are present and very rare. Are sturgeon considered established?

p. 42 - numbers don't add up. " Private diversions represent the largest number, **122. Of these 132** were documented in the Lost River area and 61 are on the Klamath River from Link River Dam to Keno."

page 44 para 2. "*Only age 14 and 9 year-classes were documented for LRS and SNS respectively."* meaning of this sentence unclear

p. 44. – This statement doesn't fit with an earlier statement. "By 1995, there was an increase in the numbers of spawning adults in the Williamson and Sprague rivers due to recruitment of the strong 1991 year class (Perkins et al. 2000)." According to information on p. 5, only a few males should have recruited by 1995 - "Sexual maturity for LRS begins at about four years of age for males and 7-9 for females (Buettner and Scoppettone 1990; Perkins, Scoppettone; and Buettner, in prep.). Most SNS reach sexual maturity at 6-7 years (Buettner and Scoppettone 1990)."

p. 45 – Related to the above, the following shows the effect of full recruitment of 1991 year class. "However, for the 2000 spawning run, Cunningham and Shively (2001) found slightly higher abundance index values for LRS and SNS in the lower Williamson River than for the previous 3 years and an improved size-class distribution, indicative of possible improving population status."

p. 45. "Prior to construction of the Link River Dam, upper Klamath Lake levels fluctuated between 4140 and 4143 feet (USBR 2001)." Again, this should be qualified for the period of observation, October 1904-Sept 1921. Low water years prior to the period of observation would likely have brought the lake to the reef at 4138 ft.

page 45, para 1. There may be some residual use of Crooked Creek for spawning. Hatchery personnel report observations. After Dominic Herera of the Klamath Hatchery reported seeing adult suckers in Crooked Creek in 1991, OSU conducted drift net sampling for larval fish (Markle and Simon 1993). Four larval suckers were captured indicating at least minimal sucker reproduction in Crooked Creek in 1991.

p 47 last para. *(2) only a proportion of each population occurs in the Williamson River in any given year and this proportion probably varies between species and among years*;

This appears to suggest that suckers don't spawn every year? Is there evidence?

p 49, para 4. *The westside diversion has a maximum capacity of 300 cfs;*

--earlier in the BO it is stated the westside diversion is maxed at 250 cfs.

p. 52. "At Keno (Fortune data), …103 KLS…and apparently no KLS were identified." You mean no KSS, based on totals later in the paragraph.

p. 61, last para. It is stated the mortality threshold for pH was >10. For clarity, there no deleterious effect at ph 10, so it was logically assumed to be >10.

p. 62. Lease's sample sizes for the statistically significant differences ranged from 3 to 4 fish per ammonia concentration.

p. 63. The case for poor water quality and its affects on young suckers does not appear to be strong. The recent models of Terwilliger et al (in review) cannot detect any influence of pH and un-ionized ammonia on age 0 sucker growth. The *in situ* studies by Martin (1997) showed heavy mortality only when DO levels were very depressed. In most springs there appear to be good numbers of larval suckers present, and in summers there seem to be good numbers of age 0 juvenile suckers. Length frequency distributions from the late 1990s suggest a much more diverse age structure than in the 1980s, suggesting improved recruitment during the past decade. In 1997 there was some indication that larval abundance was high early, but later larval and juvenile abundance was low. Un-ionized ammonia was also high that summer. This might be the strongest case for water quality affects on larval suckers. Water quality seems to be much more important related to adult sucker health.

p. 64, para 1. Buettner (1997) is not in references.

p. 64, para 2. Use of the word, "catastrophic", to describe fish kills seems subjective. There were undoubtedly lots of fish killed, but the population estimates given in the BO, the diverse length/age structures, and increased recruitment suggest the kills, although substantial, may not have been "catostrophic".

p. 66-68. Discussion of climate influence on fish kills. As in our earlier review, why provide an analysis with N=1 when data for N=3 are available? Do the meteorological and biological conditions you imply caused the 1996 fish kill relate in any way to the 1995 and 1997 fish kills? This information is important in light of the discussion of fish kills and water quality presented later in the report.

p 65, last para. *OSU biologists noted a substantial drop in age 0 sucker cast net catches in September and October suggesting these fish were affected by the die-off (Simon and Markle 1997).*
That was suggested but sampling in later years has demonstrated this is a seasonal phenomenon independent of adult fish kills. There is no suggestion from the OSU sampling that age 0 juveniles are affected by adult fish kills.

p 66, 2nd para. What is APS? It is not in list of abbreviations.

p 69, para 2. *Suckers are rarely observed in these areas except possibly during the spawning season*. earlier in the BO it is stated that Markle et al (2000) documented residual use of the lower Williamson river.

p 75, para 1. This 100% total is external loading only.

p.108. “The 90 observations made in two months were associated with near bottom pH ranging from 7.3-9.0, water temperatures of 9.1-20.8E C, and DO from 3.8-11.2 mg/l.” The analysis of depths includes availability, but it is not included for these water quality variables.