Prattville Intake Modification and Potential Impacts to Lake Almanor Fishery Study

Interim Report

June 21, 2004

2105 LG Meeting

Study Objectives

The objectives of this study are to access the impacts to Lake Almanor's cold water fishery resulting from the selective cold water withdrawal from the lake. Lake Almanor is a complex ecosystem with many parameters affecting the fishery. Using existing documentation, this study identifies and evaluates the following potential thermal curtain induced impacts:

- Impacts to lake salmonid habitat resulting from changes to lake temperatures and dissolved oxygen concentrations.
- Impacts to the burrowing mayfly (*Hexagenia limbata*) habitat.
- Impacts on wakasagi (pond smelt) entrainment.
- Impacts predicted at or resulting from the installation or operation of TCD's at other Northern California reservoirs.
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Salmonid Habitat

Lake salmonid habitat must have sufficient dissolved oxygen (DO) and cold enough water temperatures for fish survival and growth.

The existing summertime anoxic hypolimnion and warm epilimnion limit the available habitat to the transition between the two layers, the thermocline.

The existing summertime conditions currently stress the salmonid populations.

Although the reservoir model predicts no major changes to lake DO concentrations and temperature (Jones and Stokes, 2004), those which are predicted reduce the available salmonid habitat.

Thermal curtain induced reductions during times in which the existing conditions severely limit available habitat constitute a substantial portion of that currently available.

During times in which the existing conditions are not limiting, the presence of the thermal curtain will have little impact on salmonid habitat.

The thermal curtain will reduce the DO concentrations in the Butt Valley powerhouse outflow to the extent that mitigating measures will have to be implemented.

Other Reservoirs with TCD's in Northern California

Several other Northern California reservoirs use selective withdrawal to control outflow temperatures.

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None of the reviewed literature predicted adverse impacts to the reservoirs in which the TCD's were retrofitted.

One study subsequent to the installation of the TCD in Shasta Lake (Brett et al, 1998) reports cumulative impacts of hypolimnetic releases on the cold water pool and the potential for the operation of the TCD to significantly alter the limnology of the lake.

The physical, geographical, and operational differences in these reservoirs prohibit the extrapolation of study results to Lake Almanor. The methodologies used to assess impacts of TCD's may be applied to Lake Almanor to further understand the impacts of the thermal curtain.

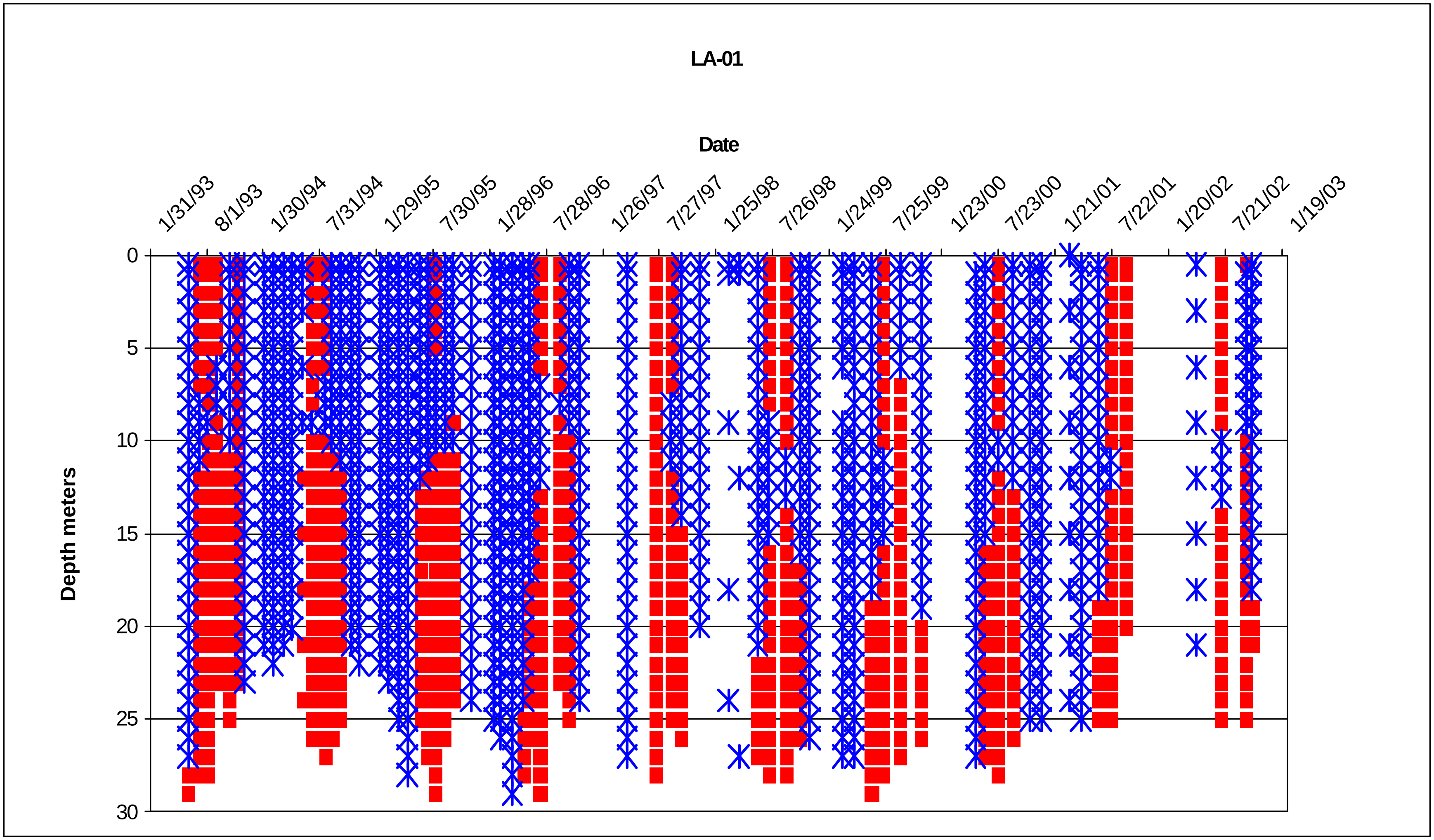

Figure 4. Salmonid Habitat in Lake Almanor from 1993 through 2002 (DWR Data). The blue area (line cross marks) salmonid habitat had temperature less than or equal to 20^0 C and DO concentrations greater than or equal to 6.5 mg/l. The red area (block square marks) represents water column measurements in which temperature either exceeded 20^0 C or DO concentrations were less than 6.5mg/l.

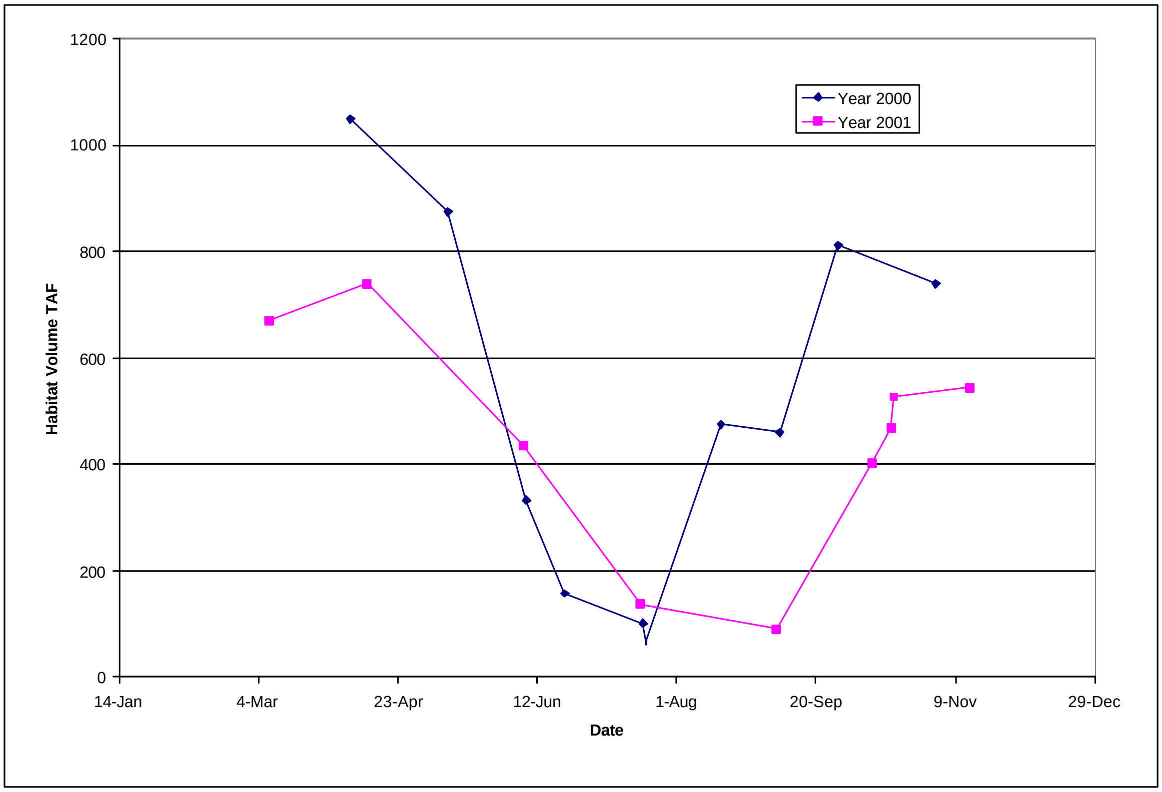

Figure 5. Habitat Volume determined by suitability index values for Lake Almanor in years 2000 and 2001 (Jones and Stokes, 2004) in thousand acre feet (TAF).

Predicted Changes in Dissolved Oxygen and Temperature due to Prattville Intake Thermal Curtain

Increase in surface water temperatures 0 – 0.5^{0}C.
Increase the depth of the thermocline 0 - 10 feet.
Lower the dissolved oxygen in the intake water.

The annual cycle of lake stratification will remain unaffected in onset and duration (Russ Brown, 2004).

All changes predicted to lake temperatures and dissolved oxygen are overshadowed by (except the lowered dissolved oxygen content of the intake water) the annually occurring meteorologically induced variations

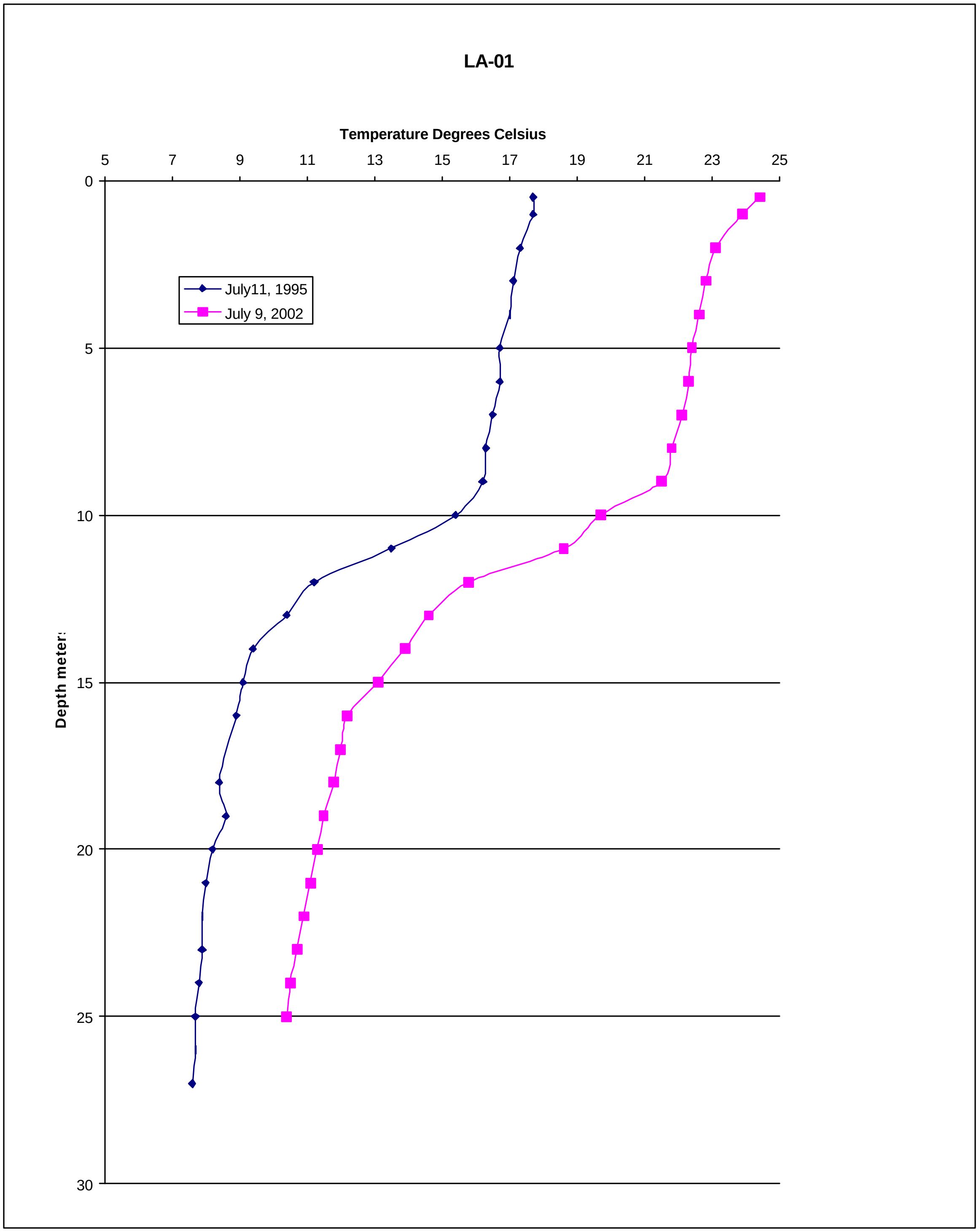

Figure 6. Water column temperatures at sampling station LA1 in Lake Almanor for July 11,1995 and July 9, 2002 (CA Department of Water Resources Data). Note the variation in temperature between the two years. The proposed thermal curtain is predicted to increase the surface mixed layer temperature only $0.5^{0}C$; a small fraction of the naturally occurring variation.

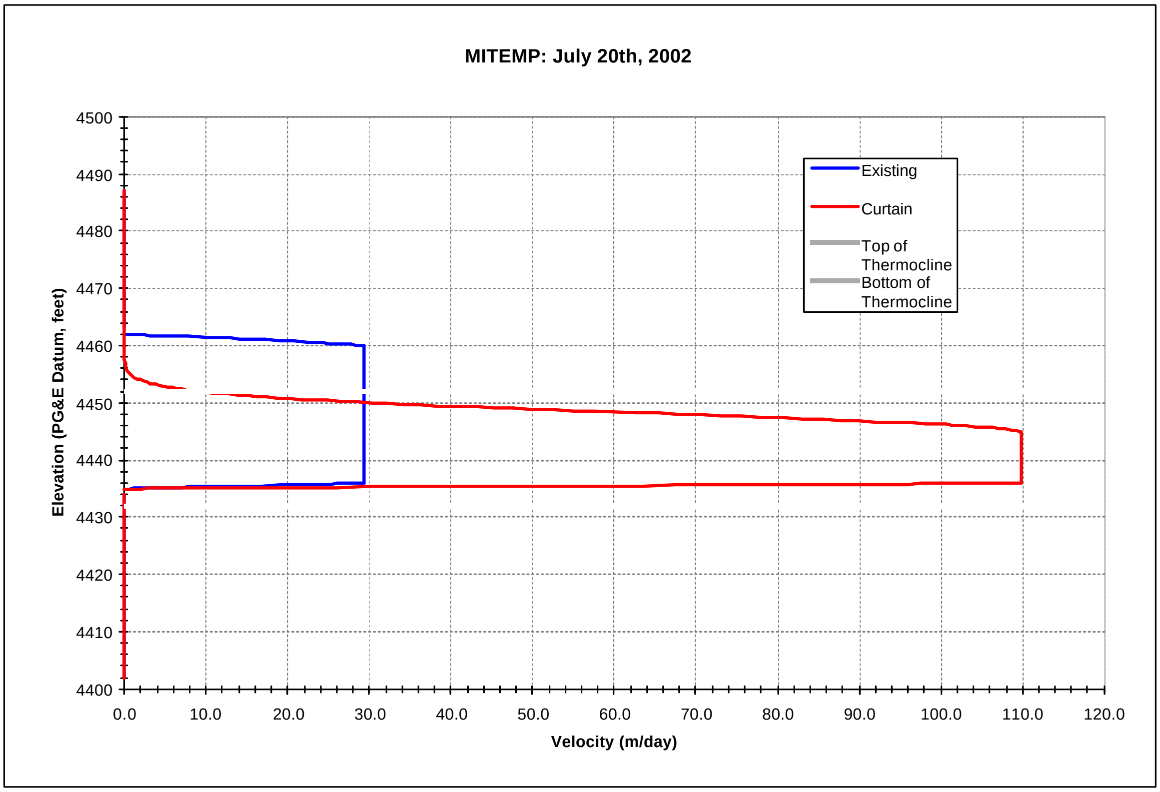

Figure 7. Simulated Prattville intake water column velocities and elevations for July 20, 2002 (PG&E, 2004). The blue line represents the existing Prattville Intake configuration and the red line represents the withdrawal zone velocities simulated with the thermal curtain installed. The Estimated thermocline (defined as 0.5 degree or greater change in temperature per meter depth) is also delineated. Note that the withdrawal from the warm, surface mixed layer is practically eliminated with the thermal curtain installed.

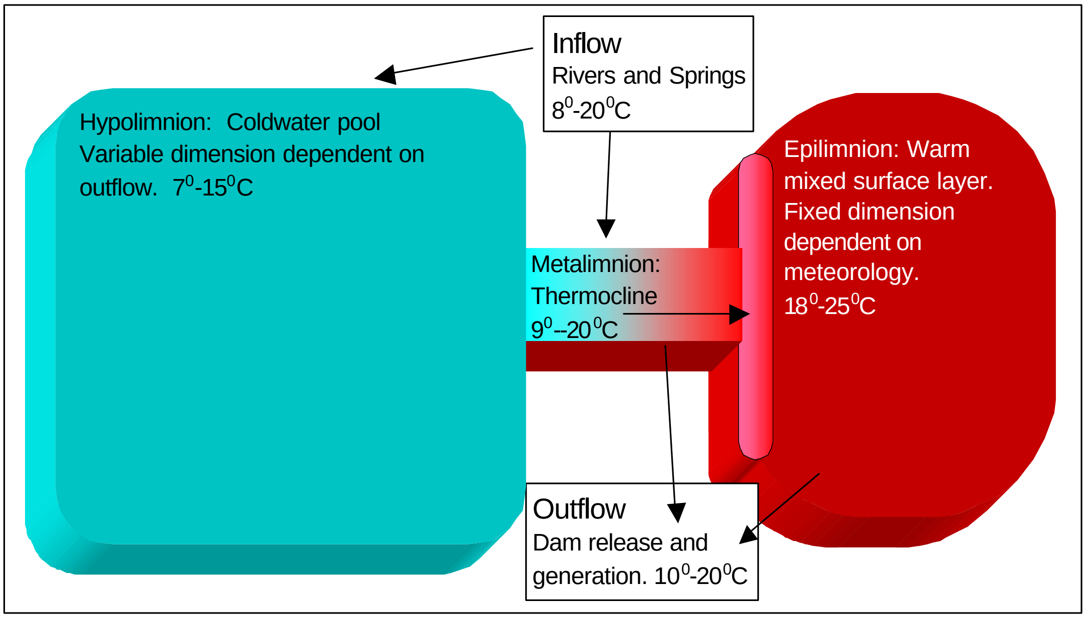

Figure 8. Schematic diagram of Lake Almanor stratification under existing conditions. The metalimnion water is mixed into the surface layer due to the portion of Prattville Intake outflow originating in the epilimnion.

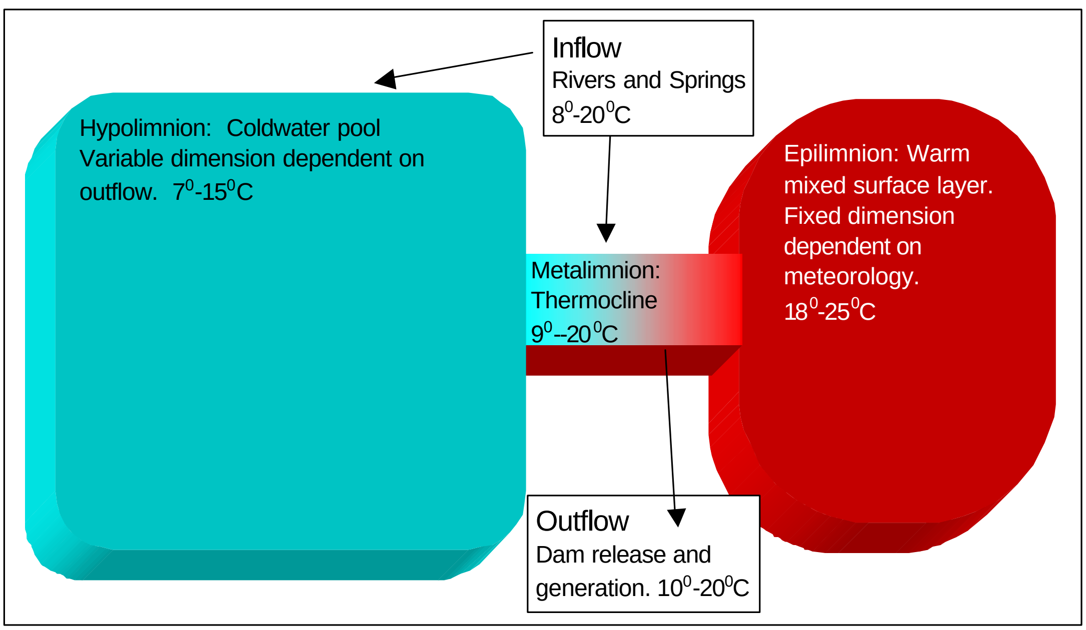

Figure 9. Schematic diagram of Lake Almanor stratification with thermal curtain. The metalimnion water is not mixed into the surface layer due to the elimination of the portion of Prattville Intake outflow originating in the epilimnion.

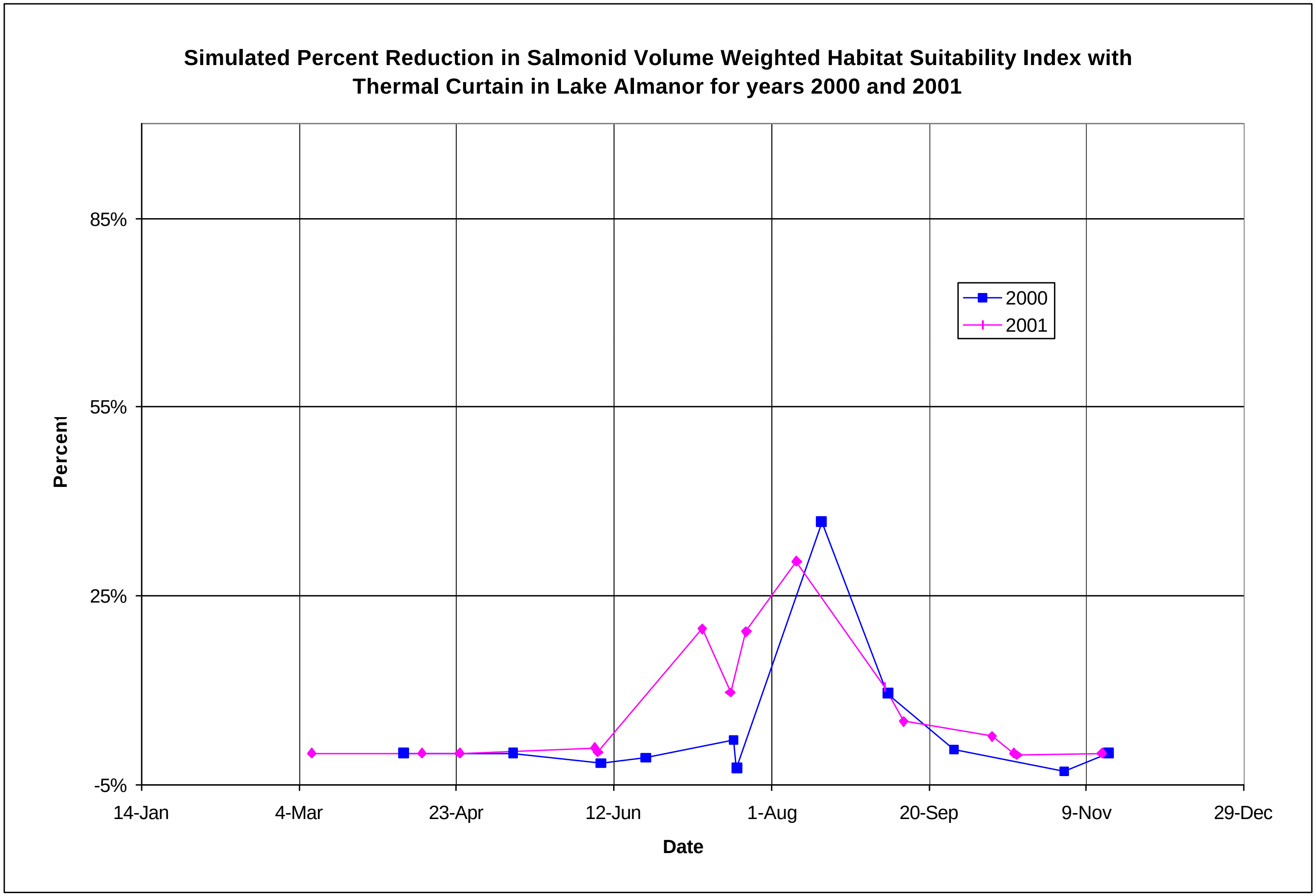

Figure 10. Percent reduction in salmonid habitat suitability resulting from a simulated thermal curtain in the years 2000 and 2001 (Jones and Stokes, 2004).

Mayfly Habitat *(Hexagenia limbat)a*

The “Hex Hatch” in Lake Almanor occurs from mid-June to the end of July (ALA, 2003, Jensen, 2003).

Fishermen have expressed concern about potential adverse effects of thermal curtain induced conditions on the mayflies (ALA, 2003).

Hexagenia limbata, burrowing mayflies, inhabit muddy areas of the bottom, tunneling into the soft substrate (Lyman, 1943). Minimum dissolved oxygen concentrations of 1.0 mg/l limit the depth at which the mayflies can inhabit (Edmunds, 1976). This depth in Lake Almanor correlates to the bottom of the thermocline. The combination of high temperatures (> 25^0C) and reduced DO can cause extensive mortality in mayfly nymph populations (Britt, 1955).

Simulated thermal curtain conditions for Lake Almanor indicate an increase in epilimnion temperatures of about 0.5^0C and a lowering of the thermocline 0-10 feet (Jones and Stokes, 2004). The seasonal timing of the onset and degradation of the lake stratification is unlikely to change due to thermal curtain conditions (Russ Brown, 2004).

Considering that the 0.5^0C increase in temperature is predicted to occur in the well oxygenated epilimnion and that a 0.5^0C change is well within the range of naturally occurring fluctuations, no adverse effects are likely to occur to the Hexagenia populations from this increase in temperature.

Because the Hexagenia habitat is limited by the depth of the bottom of the thermocline, lowering of the thermocline depth will likely increase the available habitat. Assuming that there is no substantial difference in bottom substrate, the increased depth of oxygenated water will allow the mayflies to inhabit deeper areas. In the absence of other limiting factors, the abundance of Hexagenia could actually increase with thermal curtain conditions.

Wakasagi Entrainment

Wakasagi (also referred to as freshwater smelt and pond smelt,) were introduced into Lake Almanor in 1972 as a forage fish.

Wakasagi have been very successful, out-competing and causing the extinction of Kokanee (CDFG 1987).

Entrainment of large numbers of wakasagi in the Prattville intake and subsequent passage through the Butt Valley Powerhouse supports a trophy trout fishery in Butt valley Reservoir (PG&E, 2002).

Reduction of the numbers of wakasagi entrained in the Prattville Intake could reduce the food supply for the trophy trout in Butt Valley Reservoir and increase the abundance of wakasagi in Lake Almanor.

The construction of a thermal curtain at the Prattville intake will alter the flow patterns at the intake and potentially alter the entrainment of wakasagi. .

Results of Wakasagi Entrainment Analysis

This analysis indicates there will be a substantial reduction in Wakasagi entrainment subsequent to the installation of the thermal at the Prattville Intake.

Threshold Analysis

Using the temperature threshold criteria with 22^0C and 6 mg/l DO reduced the entrainment 50% in June and September, 2000 and practically eliminated entrainment in July and August of 2000 and all of 2001. Using threshold criteria of 22^0C and 5 mg/l DO decreased entrainment in June, 2000 by 14%, and decreased entrainment 95%, 99%, and 29% in July, August, and September of 2000. For 2001 the 5 mg/l threshold decreased entrainment 86% and 88% in June and July, and 99% in August and September (Table 1, Figure12 & 13).

Suitability Index Analysis

The suitability index analysis for year 2000 indicated reductions of wakasagi entrainment with thermal curtain conditions of: 19% in June, 65% and 71% in July and August, and 30% in September. For 2001 the reductions were 79%, 93%, 72%, and 97% for June through September (Figure 12 & 13).

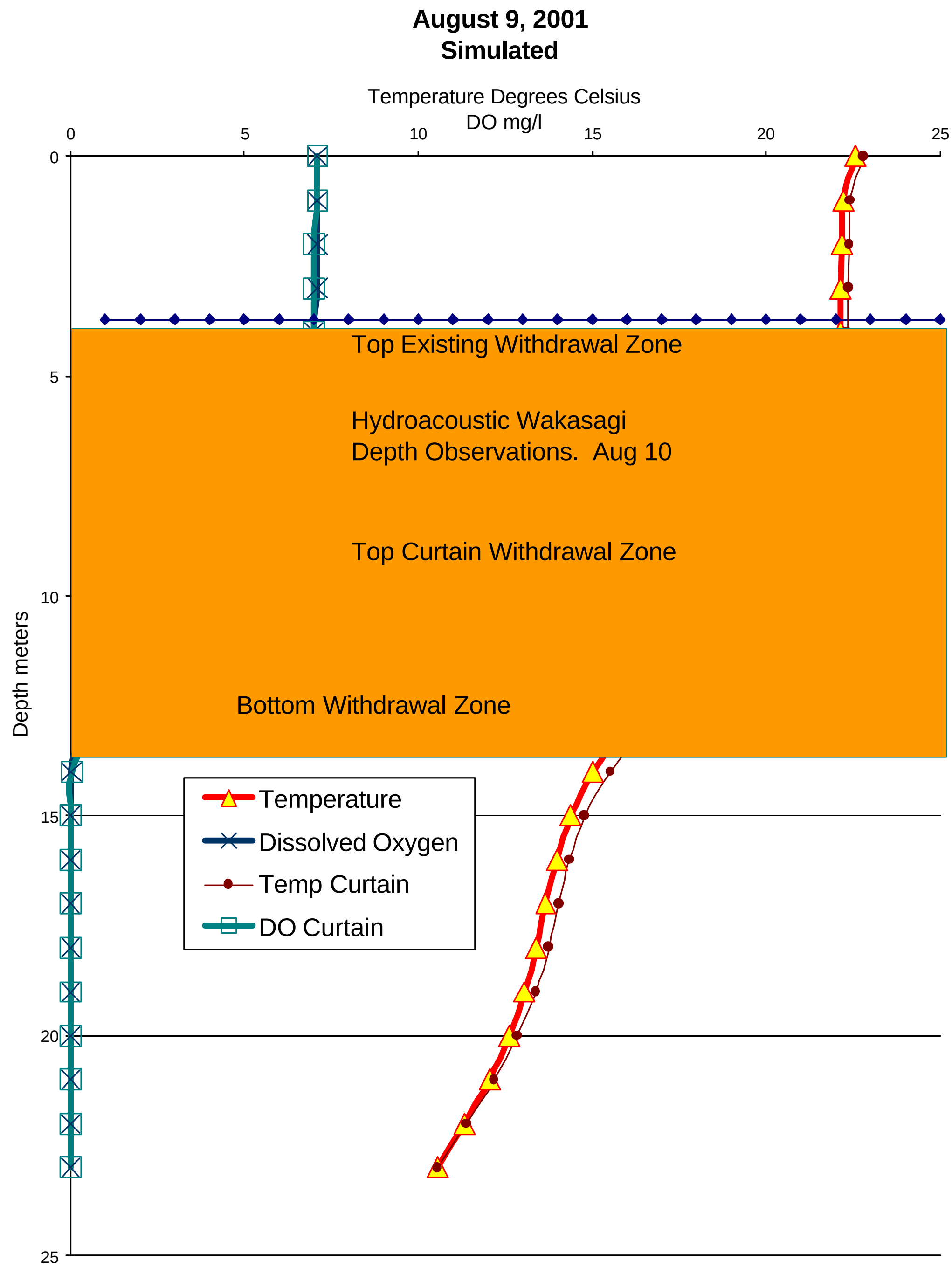

Figure 11: Lake Almanor W2 simulated temperature and dissolved oxygen for existing and curtain conditions on August 9, 2001 (Jones and Stokes, 2004). The beige shaded area represents depths at which wakasagi were hydroacoustically detected on August 10, 2001(PG&E, 2004b). The least depth of the Prattville Intake withdrawal zones under existing and curtain conditions is also depicted (Estimated from withdrawal simulations for August 17, 2002, PG&E, 2004a). The greatest depth of the withdrawal zone is the same for both existing and curtain conditions.

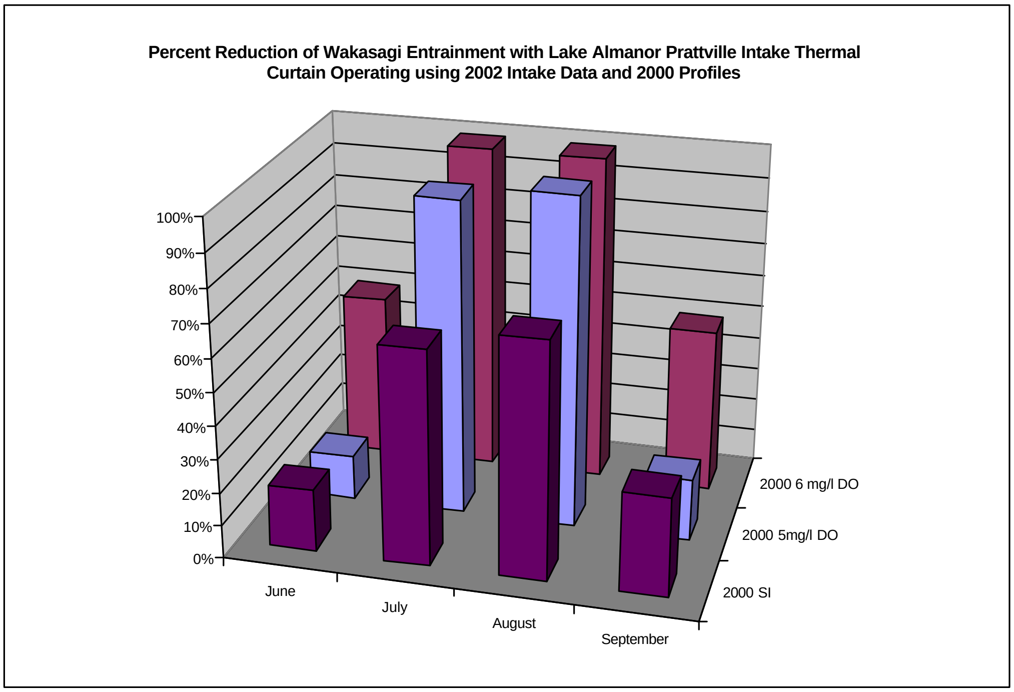

Figure 12. The percent reduction in wakasagi entrainment at the Prattville Intake due to thermal curtain conditions for year 2000 simulated (Jones and Stokes, 2004) temperature and DO profiles. .

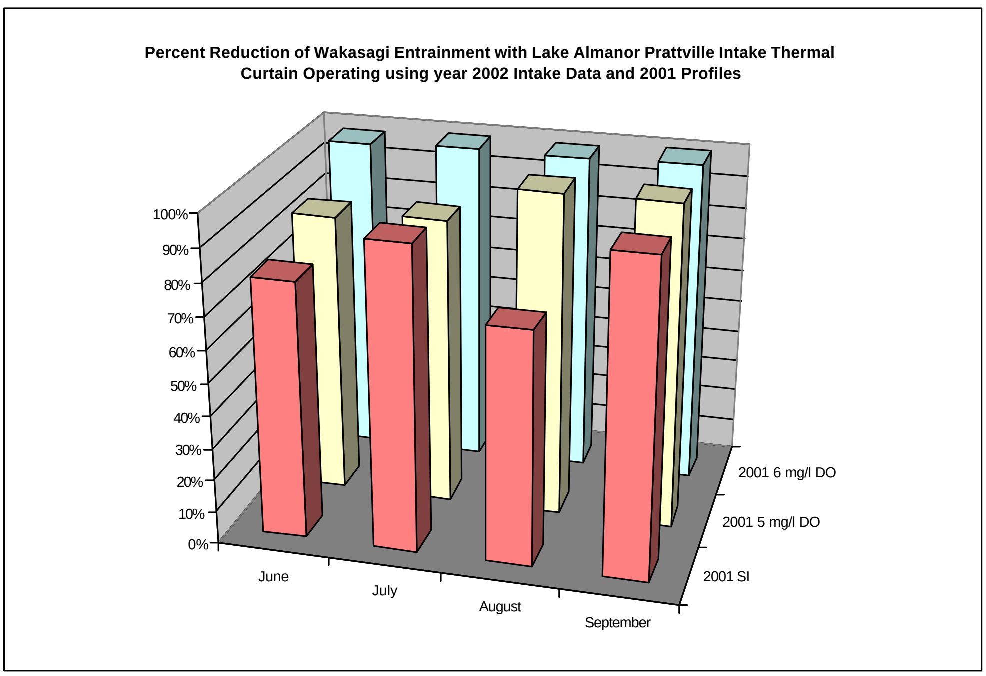

Figure 13. The percent reduction in wakasagi entrainment at the Prattville Intake due to thermal curtain conditions for year 2001 simulated (Jones and Stokes, 2004) temperature and DO profiles.

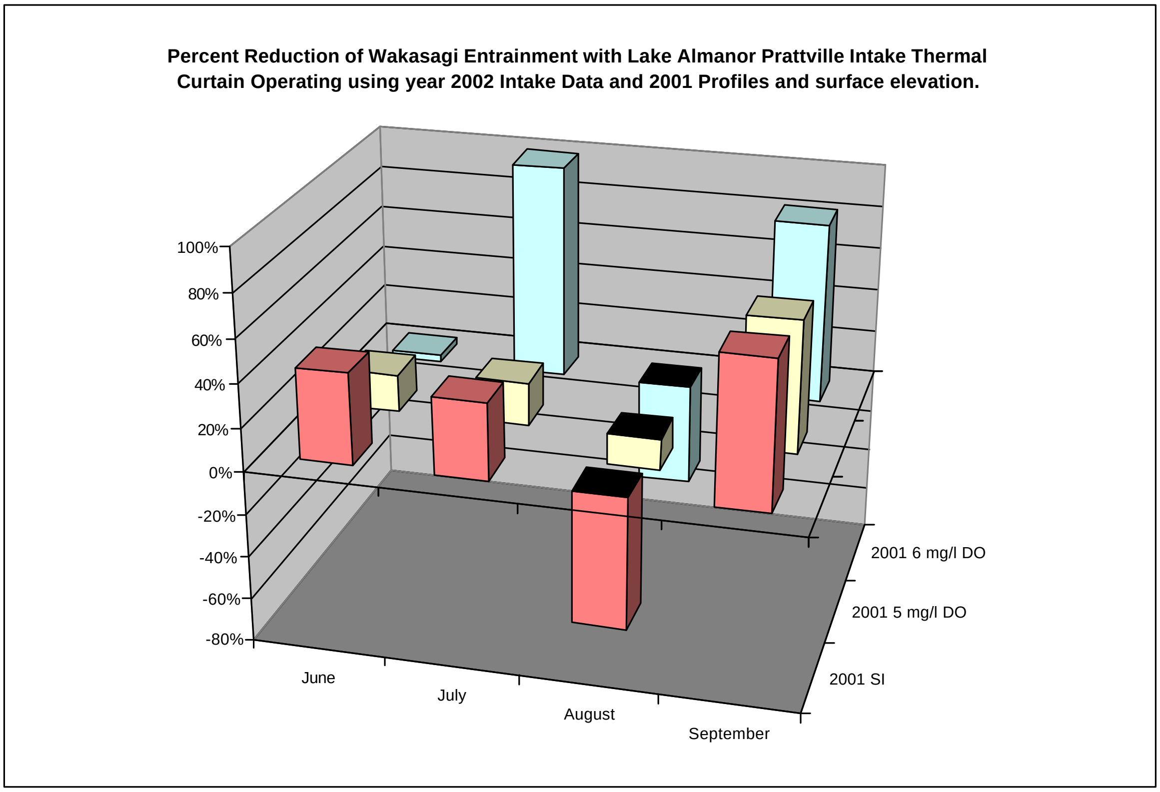

Figure 14: Thermal curtain induced percent reduction in wakasagi entrainment at the Prattville Intake for 2001 lake levels using the volume withdrawal scenario from 2002. Negative values indicate increases in entrainment.

Other Reservoirs with TCD's in Northern California

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Further Investigation

The quantitative knowledge of the salmonids utilization of the available habitat limits the ability to quantitatively assess the affect of the thermal curtain. There is a basic understanding of the seasonal behavior obtained through conversations with local fishermen and guides and the general knowledge base of habitat utilization; however, quantifiable data for the salmonid population of Lake Almanor is not available

1) A summertime telemetry study of tagged, adult salmonids can provide information on how trout use the available habitat, including springs or tributary's that can not be done through the literature.

2) Additional hydroacoustic surveys are necessary to establish accurate temperature and DO criteria for wakasagi. The only hydroacoustic survey conducted was during August, 2001.

3) Another method of determining the effects of temperature on the growth of fish is to apply bioenergetics equations to the W2 simulated output temperatures (Hanson et al, 1997). This method will give quantifiable results using established bioenergetic equations, but will be still limited to water column habitat.

4) Also, since the purpose of the addition of a TCD in Lake Almanor is to achieve reduced water temperatures and benefit the aquatic resources in the downstream river reaches, it is recommended that an evaluation be conducted for the Belden, Rock Creek, Cresta, and Poe reaches on the effects of cooler water temperatures during the summer months on the change in habitat for the fishery resources in these reaches.

Conclusions

Existing summertime temperature and DO conditions limit salmonid habitat. During warm summers, this limitation can be severe. The predicted thermal curtain induced reductions in salmonid habitat represent a substantial portion of that currently available when the existing conditions are severely limiting. Current knowledge of the utilization of salmonid habitat and the degree to which spring and riverine inflows are utilized limits the ability to accurately quantify the thermal curtain induced changes.

The "Hex Hatch" will not be adversely affected by the thermal curtain, and is predicted to be expanded with the increased thermocline depth. Without other limiting factors, the Hexagenia population could be expanded.

Wakasagi entrainment is predicted to be severely reduced and in some months eliminated with installation of the thermal curtain. Lake level will have a substantial effect on the amount of entrainment. High lake levels will cause maximum entrainment reductions and low lake levels will cause minimum entrainment reductions.

The thermal curtain will cause the Butt Valley tailrace water to have low DO concentrations.

Review of the available documentation regarding selective withdrawal to control water temperatures in other Northern California reservoirs revealed no adverse fisheries predictions or impacts. The methodologies of these investigations can be used for Lake Almanor, but the conclusions can not be directly transferred.