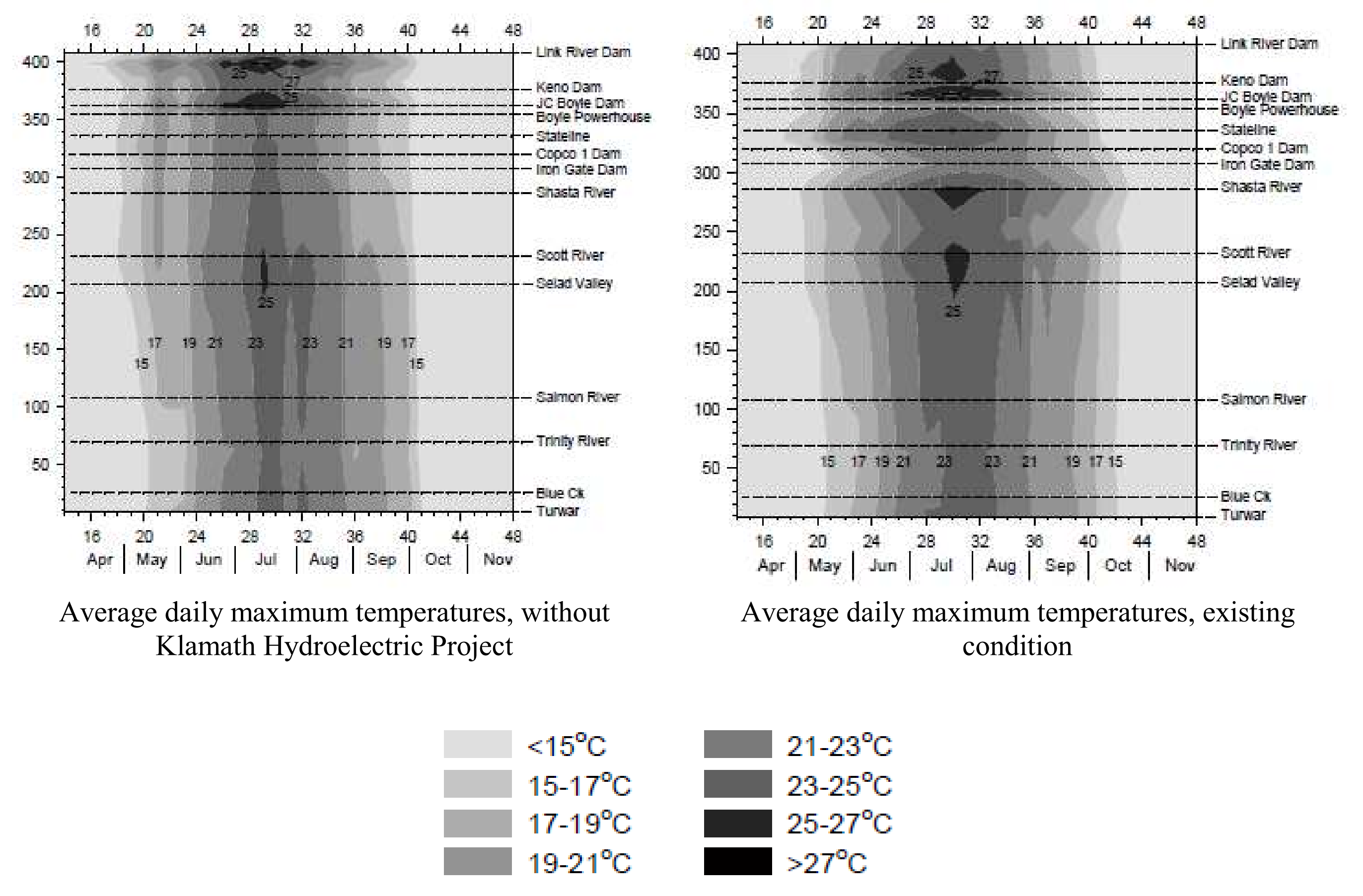

Average daily maximum temperatures, without Klamath Hydroelectric Project

Average daily maximum temperatures, existing condition

Figure 2.13: Simulated Klamath River temperatures, by week, 2000-2004.
Source: Dunsmoor and Huntington 2006

The temperature modeling indicates human impacts are responsible for the elevated temperatures that are above biological temperature thresholds for rearing juvenile salmonids and reproductive success of adult salmonids. Under current conditions, the seasonal increase in temperatures during the winter and spring months is delayed in comparison to estimated natural temperatures. Similarly, the seasonal decline in temperatures during the fall months is also delayed in comparison to estimated natural temperatures. Dunsmoor and Huntington (2006) evaluated the effects of the delay in the seasonal fall temperature decline on salmonids due to the Klamath Hydropower Project. They evaluated Pacificorp's model output data for the years 2000-2004. Their analysis of temperature alteration during the fall months indicates impaired spawning conditions resulting from the presence of the Klamath Hydropower Project, and is summarized in Table 2.10, below.

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Table 2.10: Summary of fall temperature effects resulting from human alteration at Iron Gate Dam.

| | Pacificorp Model, 2000-2004 (Dunsmoor and Huntington, 2006) | | Klamath TMDL Model, 2000 | |
|---|---|---|---|---|
| **Time Period** | **Existing Condition** | **Without Project Condition** | **Existing Condition, MWMT (C)** | **Natural Conditions, MWMT (C)** |
| Sept. 10-23 | Stressful or worse 90% of days | Stressful 9% of days | 19.2 | 18.7 |
| Sept. 24 – Oct. 7 | Suboptimal or worse 100% of days | Suboptimal 37 % of days | 18.1 | 15.5 |
| Oct. 8 – Oct. 21 | Suboptimal 70% of days | Suboptimal 1% of days | 16.1 | 11.4 |
| Oct. 22 – Nov. 4 | Optimal 100% of days | Optimal 100% of days | 12.9 | 8.2 |

Bartholow et al. (2005) concluded that in comparison to the expected temperatures resulting from a natural flow regime, the Klamath River dams create temperature conditions more favorable to migrating juveniles in the spring and less favorable to adults migrating and spawning in the fall. They suggested that the increased temperatures occurring later in the spring may increase growth rates. However, juvenile fish migrating down the Klamath River in the spring suffer high mortality rates due to C. Shasta, which is more virulent at temperatures that typically occur that time of year (see section 2.4.4.4 and Appendix A). Bartholow et al. (2005) further speculated that the changes in seasonal temperature patterns may have affected the timing of the Chinook salmon run since the dams were constructed.

The growth of juvenile salmonids is partially dependent on temperature (USEPA 2003). The optimal temperature range for juvenile salmonids is 10-15 $^{o}$C, with a lower limit of 4 $^{o}$C (USEPA 2003). The ability of salmonids to survive the ocean phase of their life cycle is partially dependent on their size upon entering the ocean. Thus, the delay in warming that occurs in the late winter may reduce the growth rates of salmonids rearing in the Klamath River, and may ultimately reduce the survival rate of salmonids in the ocean.

USEPA (2001) reviewed multiple literature sources and concluded that optimal protection of salmonids from fertilization through initial fry development requires that temperatures be maintained below 9-10°C, and that daily maximum temperatures should not exceed 13.5-14.5°C. Under current conditions, these temperatures are not reached until late October or November. However, the current Chinook spawning season begins in mid-September and peaks in late October (see Appendix 5 for more details).

In summary, the temperature alterations presented in Figure 2.12 result in adverse effects to salmonids. The comparison of estimated natural and current temperatures for the year 2000 at the location downstream of Iron Gate Dam clearly shows that the water quality objective for temperature is regularly exceeded. This conclusion is based on the observation that current temperatures are regularly more than 5$^{o}$F above the estimated natural temperatures, and the fact that there is no capacity to assimilate increased heat loads during the hottest critical periods without adversely affecting the beneficial uses.

### 2.5.2.2 Tributaries to the Klamath River

Tributaries are important habitat for Klamath River salmonids. Tributaries provide the majority of available rearing habitat for juvenile salmonids (NRC, 2004). In addition, many tributary mouth pools provide a refuge from higher mainstem temperatures for chinook salmon and steelhead (*Ibid*). Temperature data from the mouths of Klamath tributaries indicate that the seasonal maximum temperatures of the majority of the tributaries are not supportive of beneficial uses. The MWMT values at most of these sites are well above the non-core (low density rearing habitat) juvenile rearing threshold for salmonids suggested by USEPA (2003), as illustrated in Figure 2.14.

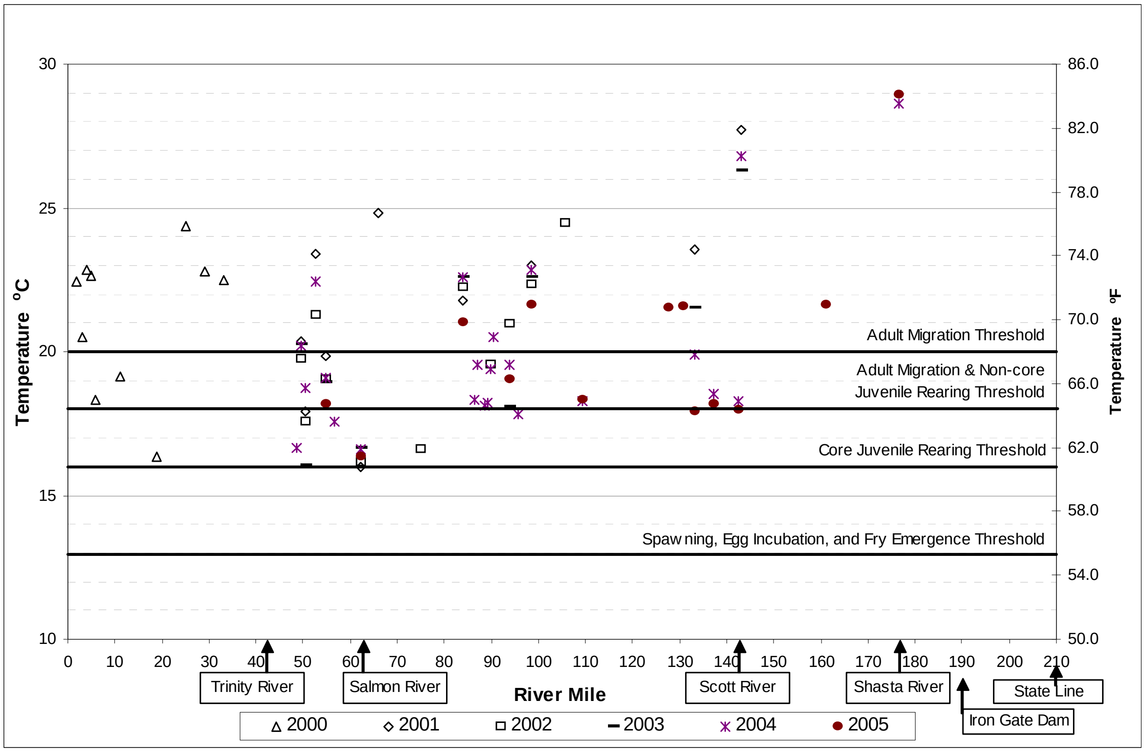

Figure 2.14: Klamath River tributary mouth MWMTs stream temperatures 2000-2005
Note: MWMTs typically occur in late July.

Of the twenty-two tributaries monitored in 2004 (the year with the most tributaries monitored), eighteen had MWMT values in excess of the adult migration and non-core juvenile rearing thresholds for salmonids suggested by USEPA (2003). These data clearly demonstrate that these tributaries have no capacity to assimilate increased heat loads during the hottest critical periods without adversely affecting beneficial uses.

The Shasta, Scott, and Salmon Rivers, three of the largest Klamath River tributaries, have been listed on the 303(d) list for temperature impairment separately. TMDL analyses developed for these tributaries have confirmed the temperature impairments, as well as the human contribution to elevated temperatures in these basins.

Although the temperatures are high relative to the temperature requirements of salmonids (USEPA 2003), the high temperatures do not exceed the water quality objective for temperature unless they are elevated due to human activities, such as riparian vegetation removal and altered channel morphology. However, it is well documented that the erosion associated with the 1997 flood in the Klamath River basin resulted in widespread stream channel alteration, loss of riparian vegetation, and shade reductions (further discussed in Section 2.5.8) and that a significant amount of the erosion was caused or exacerbated by human activities (De La Fuente and Elder 1998). Similarly, it is well known that historic mining, road building, and silvicultural practices have resulted in riparian disturbances and consequent reductions of stream shade in many tributaries (Elder et al. 2002; KNF 1999; KNF 2002). Therefore, Regional Water Board staff conclude that enough information exists to confirm impairment and justify TMDL development and implementation.

#### 2.5.2.3 Reservoirs

The available Iron Gate and Copco Reservoir temperature and DO profile data indicate that during summer stratified conditions, temperatures are only suitable for cold water species, including salmonids, rearing at depths where the DO concentrations are near lethal levels. Redband/rainbow trout are currently present in both Copco and Iron Gate Reservoir (PacifiCorp 2004b, p.4-53 - 4-55, 4-58). A representative example of typical summer conditions is illustrated in the vertical profiles of DO concentration and temperature that are presented in Figure 2.15 for Iron Gate Reservoir.

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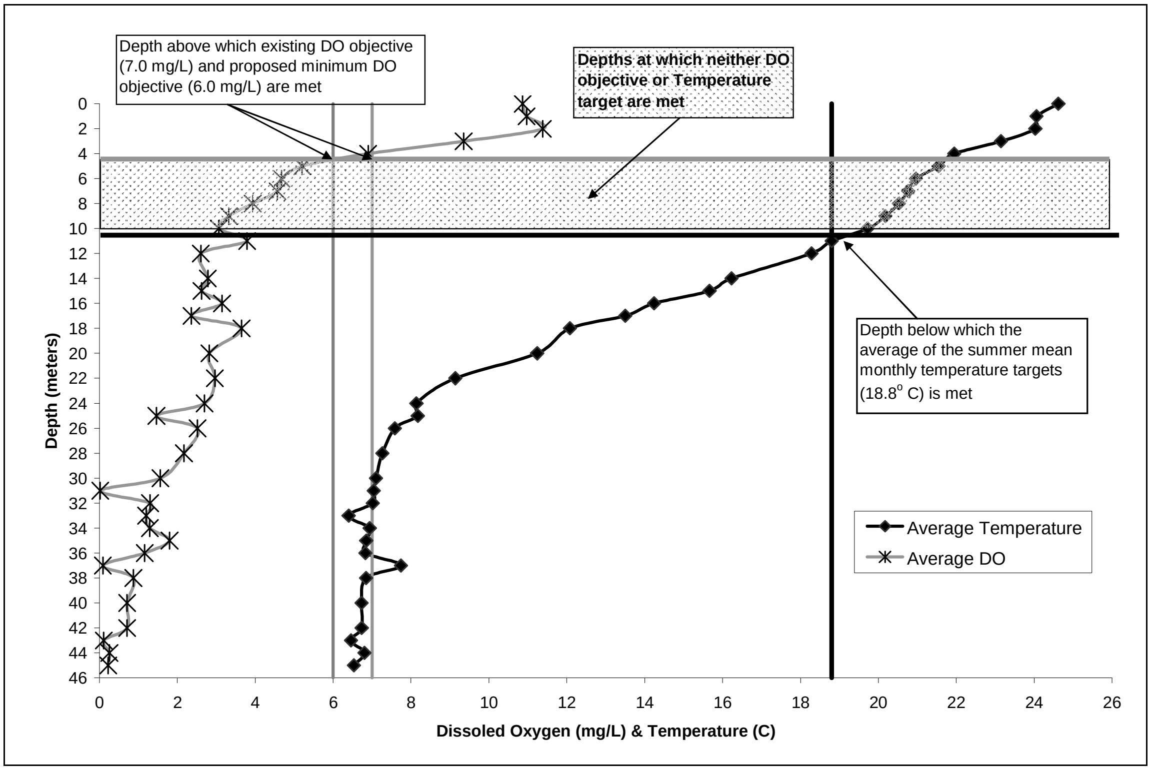


Figure 2.15: Dissolved oxygen and temperature depth profiles in Iron Gate Reservoir – average for July and August 2000 – 2005

The same pattern exists for Copco and for other years. The reservoirs become thermally stratified in the summer months. The stratification of the reservoirs prevents mixing of the low temperature/low DO waters with the high temperature/high DO waters, and thus there are no depths in the reservoirs at which the most sensitive beneficial uses are supported. Given that the stratification and the absence of suitable habitat is due to the presence of the reservoirs, Regional Water Board staff have concluded that the reservoirs contribute to exceedances of the temperature and DO water quality objectives.

### *2.5.3 Nutrients and Indicators of Nutrient-Related Impairment*

Except in extreme cases, nutrients alone do not impair beneficial uses. Rather, they cause indirect impacts through their biostimulatory effect on algal growth, low DO, and extreme pH conditions among others that can impair uses. The water quality objectives with distinct numeric limits include DO and pH. The California Nutrient Numeric Endpoints (CA NNE) framework (Tetra Tech 2006) indentifies indicators for biostimulatory effects that can impair beneficial uses, including benthic algal biomass, planktonic chlorophyll-a concentrations, and diurnal DO and pH fluctuations. Other indicators included here are toxic blue-green algae (*Microcystis*) concentrations, and un-ionized ammonia.

#### 2.5.3.1 Nutrient Concentrations

The primary driver for the nutrient conceptual model is the increased loading of nutrients to the Klamath River ecosystem. High levels of nutrient loading and elevated water column concentrations do not alone result in biostimulatory conditions, but excess nutrients are an essential precondition to this finding. Therefore the first step in evaluating impairment due to biostimulatory conditions is to determine whether existing nutrient loading and water column concentrations exceed natural baseline conditions. If it is determined that nutrient levels above natural baseline concentrations are present in the system, then the CA NNE secondary endpoints are evaluated to determine whether they have exceeded the Beneficial Use Risk Category Level III boundary for impaired waters. It is when both natural baseline nutrient levels and CA NNE Level III indicator boundaries have been exceeded that a finding of impairment due to biostimulatory conditions can be supported.

Several sources within the Klamath and Lost River watersheds contribute nutrient loads. Some of the key sources include irrigated agriculture return flows, internal nutrient cycling from nutrient enriched sediments (especially within UKL), nutrients released as a result of wetland conversion, sediments from external sources derived from land disturbance activities, and to a much lesser extent, point sources. The analysis of Klamath River nutrients involves a comparison of estimated natural baseline water column concentrations of several nutrient species to existing conditions concentrations. Natural baseline conditions are estimated based on TMDL model simulations (described in Chapter 3). These estimates are not interpreted literally but only as approximations of conditions that may have existed under natural conditions. The natural baseline conditions modeling scenario provides an estimate of nutrient loads and concentrations generated from a landscape with minimal anthropogenic disturbance. The existing conditions values come from the mean concentration of composite grab samples taken during the summer (June 1 to September 30) at twelve stations by various organizations from 1996 to 2007. Each station has at least three samples for each summer season over five years. Several stations have a much greater sampling density. The assumption for this analysis is that the annual and daily variability converges to an average over the course of a large number of samples that represent typical conditions during the summer growing season.

The purpose of the comparison is to evaluate whether nutrients have been increased by human related activities above the levels that could cause a nuisance, or adversely affect the ability of water to support specified beneficial uses. This approach does not allow for a complete mass balance comparison for the river since winter flows and concentrations have not been monitored. Rather, the information serves to provide a relative comparison of the mean summer concentrations of total nitrogen and total phosphorus to which aquatic life respond under current and natural baseline conditions (Figures 2.16 and 2.17). The left side of Figures 2.16 and 2.17 present existing conditions from stateline to the estuary, while the right side of the figure presents concentrations under natural baseline conditions. At most stations the existing summer mean concentrations for both total phosphorous and total nitrogen exceed the natural baseline conditions. Frequently the existing summer mean concentrations are more than double the natural background summer mean concentrations and can be up to five times higher than concentrations under the natural conditions baseline scenario. It is important to note that the summer mean for natural baseline conditions is based on two years of model runs versus 12 for existing (current) and that this may underestimate variability in natural conditions. These results suggest that human activities have increased nutrient loads to the Klamath River.

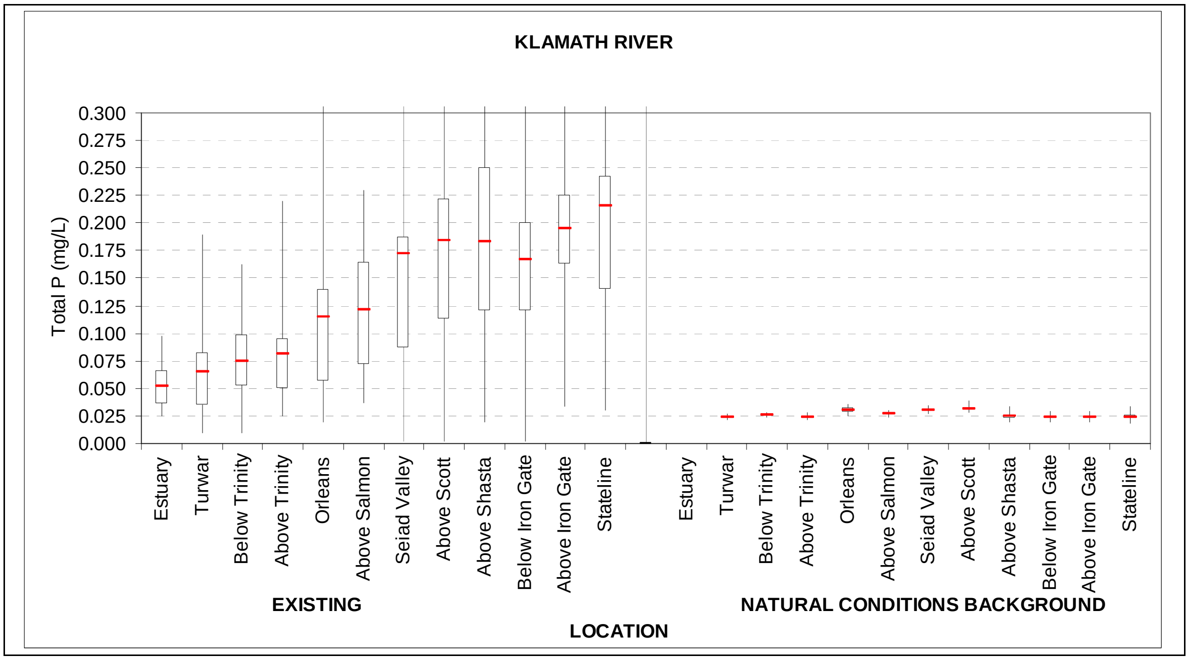


Figure 2.16: Comparison of total phosphorous concentrations for existing conditions (consolidated monitoring data 1996-2007) with estimated (TMDL model) natural baseline conditions at Klamath River monitoring stations in California.

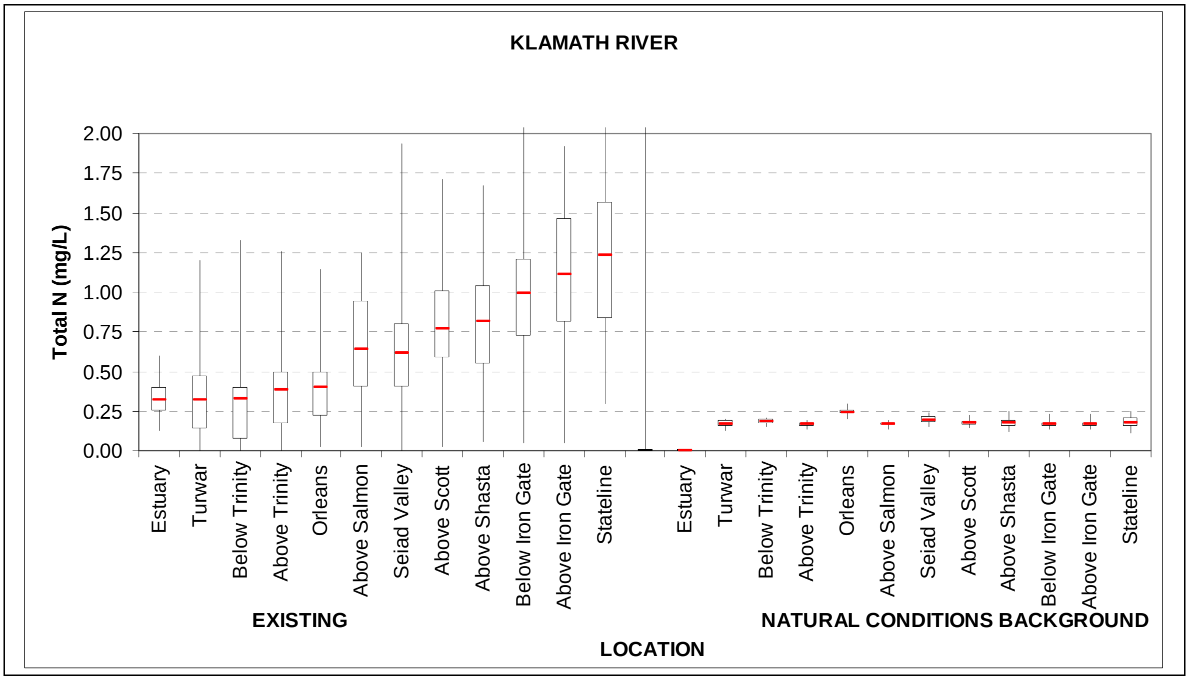


Figure 2.17: Comparison of total nitrogen concentrations for existing conditions (consolidated monitoring data 1996-2007) with estimated (TMDL model) natural baseline conditions at Klamath River monitoring stations in California.

### 2.5.3.2 Benthic Algal Biomass

Figure 2.18 presents the results of composited benthic algae biomass monitoring samples collected during summer months in 2003, 2004, 2006, and 2007.

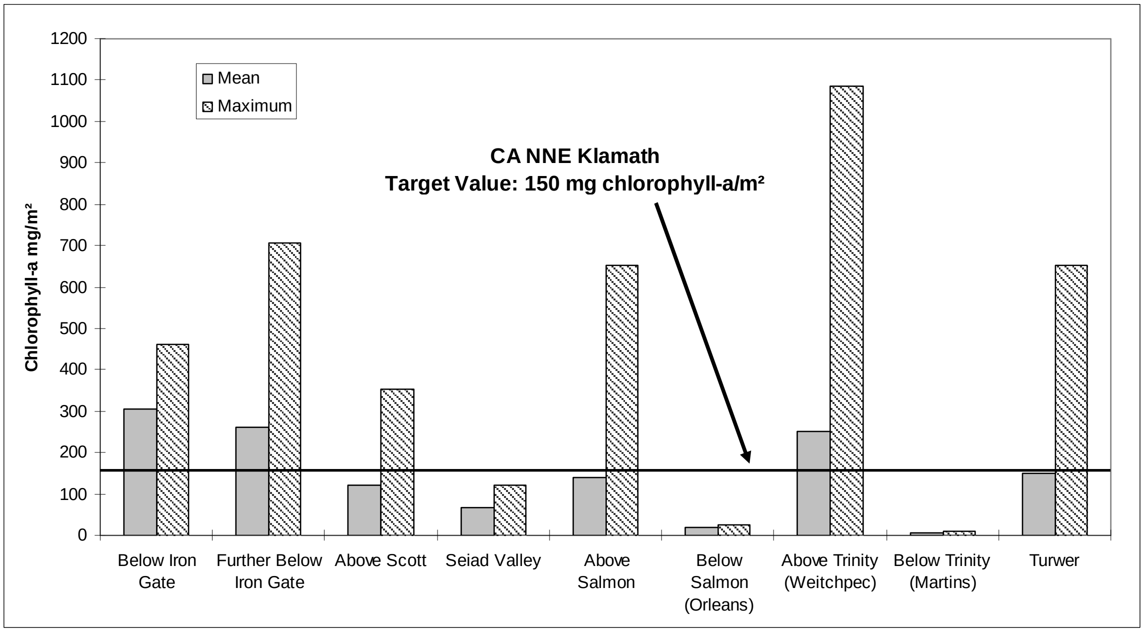


Figure 2.18: Consolidated benthic algal biomass monitoring results (summer mean and maximum) for 2003-2007 with CA NNE/TMDL numeric target.

There are a total of fifty samples for nine stations. The spatial and temporal sampling density is not ideal, but does indicate that during the summer months Klamath River benthic algae biomass in California exceed the CA NNE and TMDL numeric target of 150 mg chl-a/$m^2$ at several stations.

As demonstrated in the following sections, these benthic algae conditions have a direct impact on water quality via algal photosynthesis and respiration. In addition, the benthic algal biomass densities also provide habitat for polychaetes that serve as a host and source for the fish parasite *C. shasta.* In summary, existing benthic algal biomass conditions strongly suggest impairment.

### 2.5.3.3 Diurnal DO and pH

For several stations along the Klamath River the diurnal photosynthesis and respiration cycle is strongly influenced by dense colonies of benthic algal biomass which result in extreme diurnal cycles for DO and pH. The water quality conditions of frequent and chronic low DO and high pH illustrated in Figures 2.19 through 2.21 create chronic stressful conditions for fish populations.

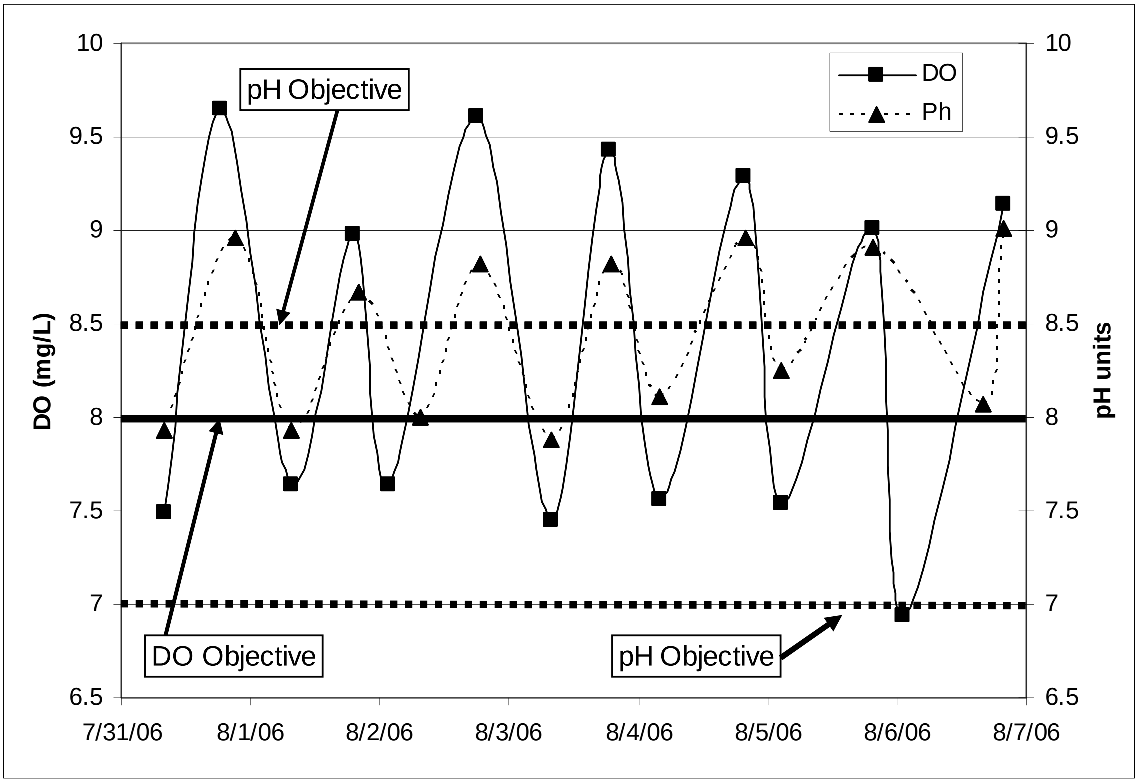


Figure 2.19: Example diurnal DO and pH cycle below Iron Gate Dam, summer 2006

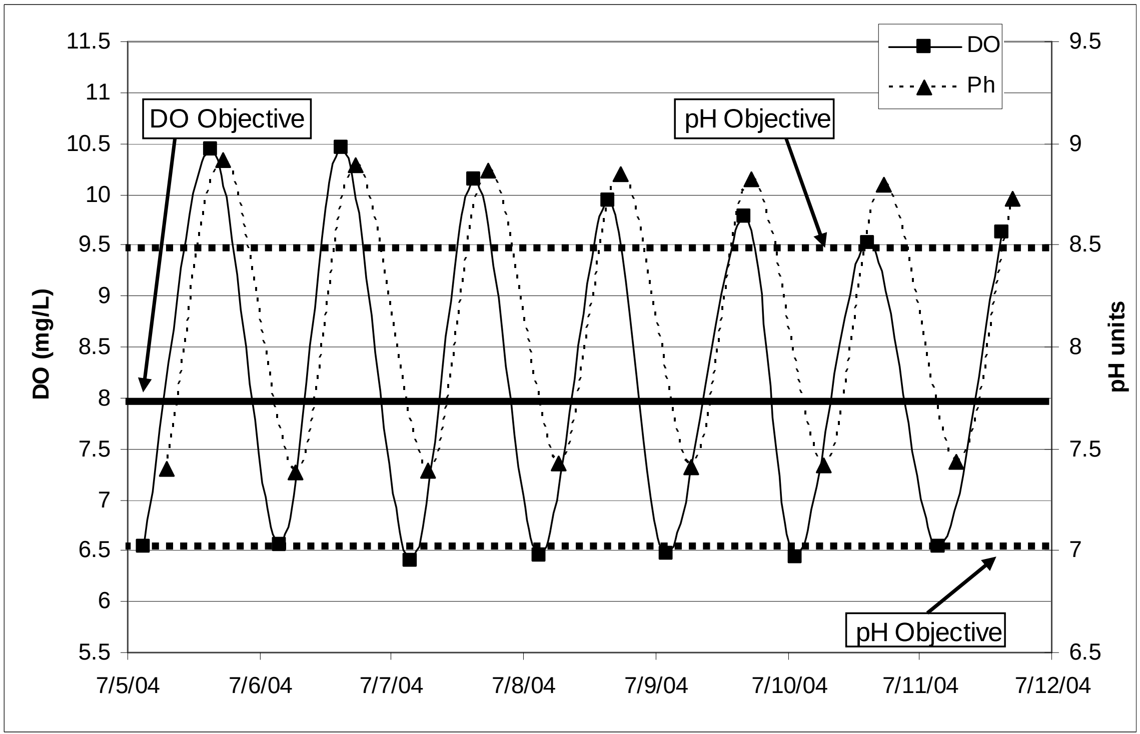


Figure 2.20: Example diurnal DO and pH cycle above the Shasta River, summer 2004

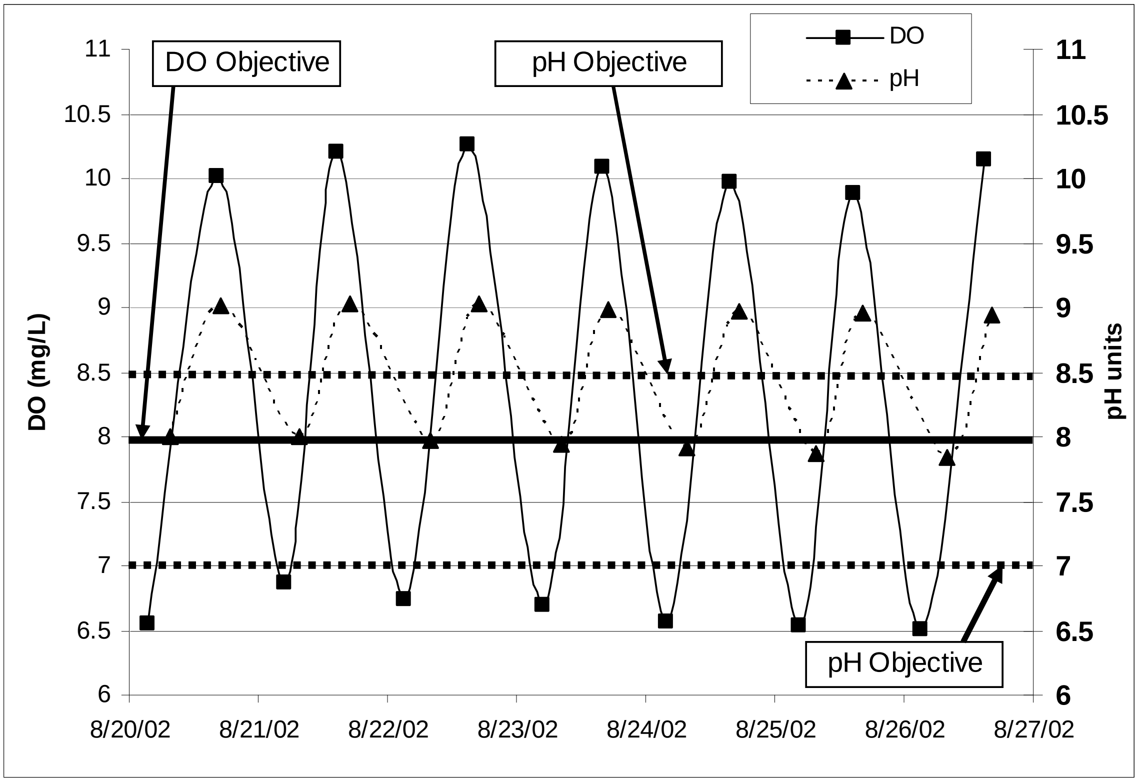
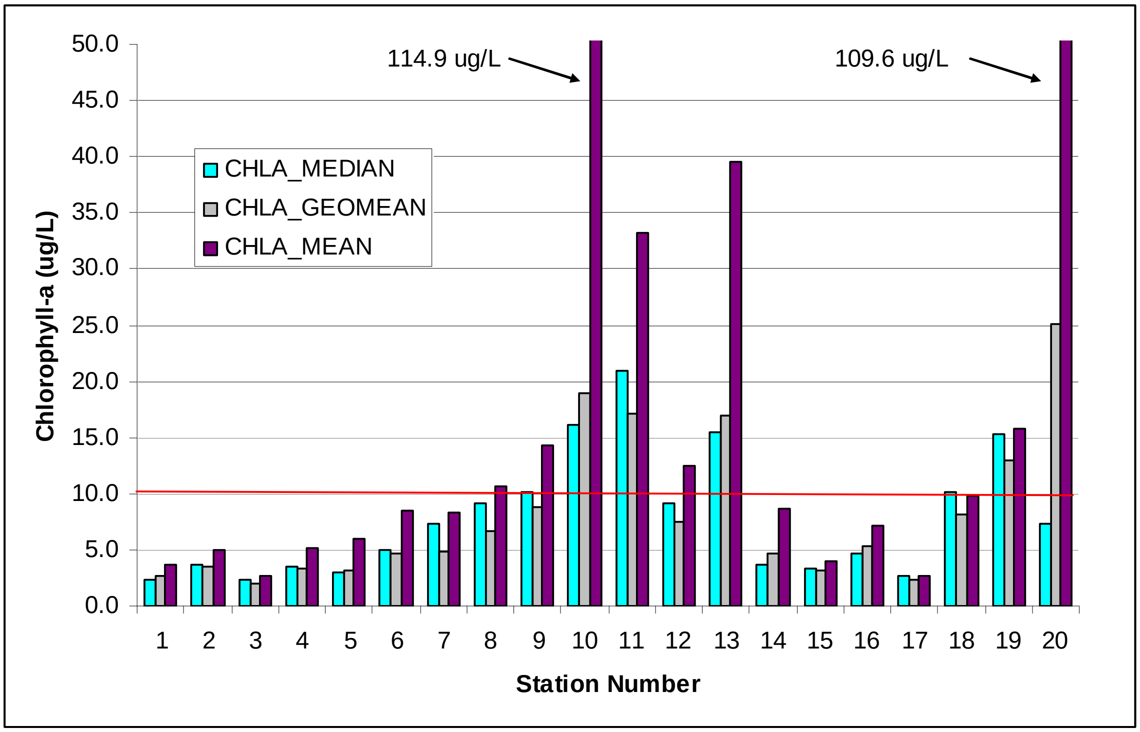


Figure 2.21: Example diurnal DO and pH cycle at Seiad Valley, summer 2002

While the three plots present monitoring data from single stations, the observed pattern is consistent with summer months for other years when diurnal data has been collected and for other stations along the Klamath River. Both the existing DO objective (>8 mg/L) and pH objective (not greater than 8.5 and not less than 7.0) for the Klamath River downstream of Iron Gate Dam are exceeded on a regular basis. The extreme magnitude and regular frequency of these excursions indicate impairment from biostimulatory substances (i.e., nutrients).

### 2.5.3.4 Chlorophyll-a – Reservoirs

Figure 2.22 compares various measures of central tendency (mean, geometric mean, and median) of the chlorophyll-a data from samples collected during the summer period (May – September) of 2005, 2006, and 2007 by the Yurok Environmental Program, Karuk Tribe of California Natural Resources Department, and PacifiCorp at twenty stations along the Klamath River.



Station List:

1 - Lower Estuary (n=11)
2 - Turwar (n=19)
3 - Below Weitchpec (n=17)
4 - Weitchpec (n=19)
5 - Orleans (n=19)
6 - Seiad Valley (n=26)
7 - Walker Bridge (n=13)
8 - I-5 (n=16)
9 - Below Iron Gate Dam (n=61)
10 - Iron Gate Res. Lower (n=49)
11- Iron Gate Res. Upper (12)
12 - Copco Res. outflow (n=37)
13 - Copco Res. Lower (n=49)
14 - Copco Res. Upper (n=11)
15 - Above Shovel Creek (n=40)
16 - Below JC Boyle Dam (n=9)
17 - JC Boyle Res.(n=3)
18 - Above JC Boyle Res.(n=17
19 - Keno Dam (n=20)
20 - Link Mouth (n=7)

Figure 2.22: Comparison of central tendencies of summer (May – September) chlorophyll-a measurements for 2005, 2006, and 2007 at twenty monitoring stations along the Klamath River. Data from Yurok Tribe Environmental Program, Karuk Tribe of California Natural Resources Department, Regional Water Board, and PacifiCorp.

It is important to note that the data presented are from samples collected by different entities using similar but not identical protocols and the number and timing of samples vary from station to station. Presentation of the mean, geometric mean, and median values of a data set provides a useful way to assess the spread of the data. A close similarity between median and mean values is an indication that the data set is normally distributed. The geometric mean[9] is a useful measure of central tendencies when the data is log normally distributed. All three measures of central tendencies for each station are illustrated in Figure 2.22 allowing a station by station comparison of the three measures. Figure 2.23 presents the same data in box and whisker diagrams. The shoulders of the

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[9] To calculate a geometric mean of the distribution values (i.e., chlorophyll-a concentrations) the following steps are taken: 1) log transform the data; 2) calculate the mean of the logged values; and 3) then antilog (raise to 10th power) the mean.

box and whisker diagram represent the 75th and 25th percentile of the distribution of measurements; the median (50th percentile) is the solid line across the box.

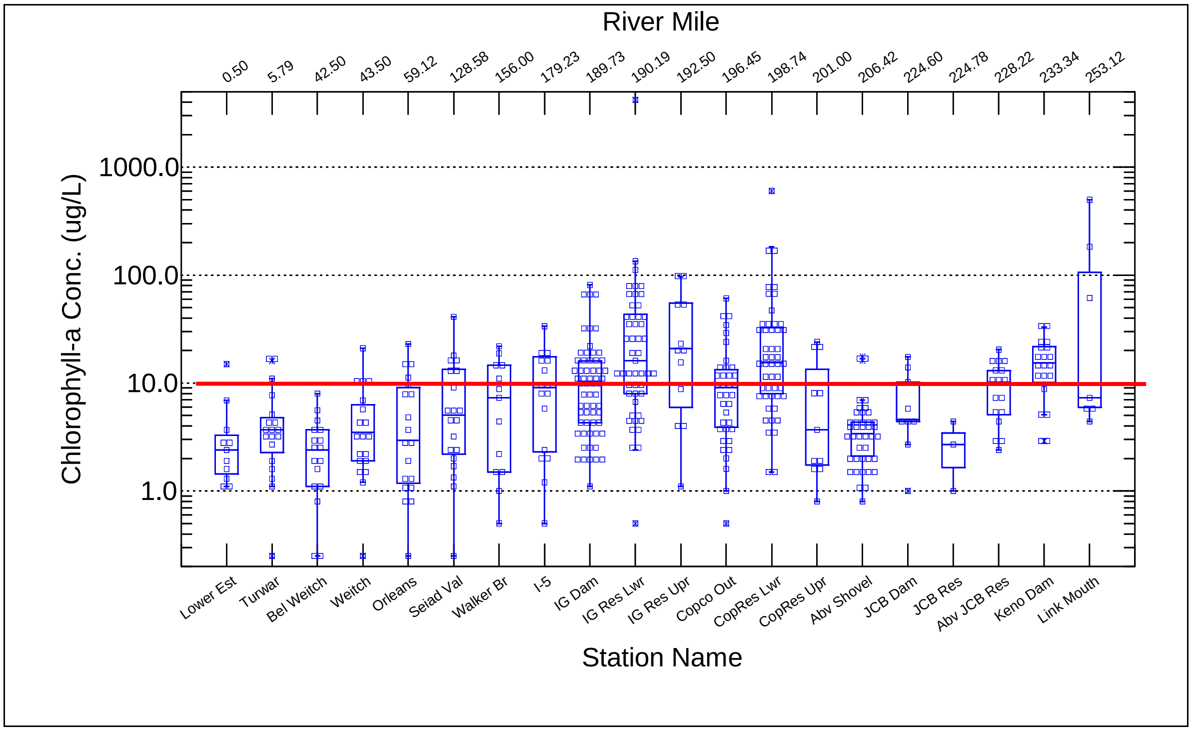

Figure 2.23: Longitudinal analysis of summer (May through September) chlorophyll-a concentrations from 2005 – 2007 along the Klamath River.
Data from Yurok Tribe Environmental Program, Karuk Tribe of California Natural Resources Department, Regional Water Board, and PacifiCorp

Each of the central tendency measures of chlorophyll-a for the Klamath River reservoir stations in California (Copco and Iron Gate) exceed the numeric target of 10 µg/L. There are also high concentrations of chlorophyll-a at Link Mouth, and at Keno Dam and above JC Boyle Reservoir. The high concentrations at these three stations are due in large part to residual algal biomass from Upper Klamath Lake. At most stations the median and the geometric mean are relatively similar, and the mean is higher than both the median and geometric mean. At the California reservoir stations (stations 10-14) however, the mean is significantly higher than either the median or the geometric mean. The very high means can be attributed to the nuisance algae bloom events during the late summer months.

The longitudinal analysis illustrated in Figures 2.22 and 2.23 demonstrates the effect of quiescent waters and the susceptibility of reservoirs on the Klamath River to nuisance algal blooms. Within Upper Klamath Lake and within the reservoirs summer mean and median chlorophyll-a concentrations are substantially higher than at the stations located in the free-flowing sections of the river. Chlorophyll-a concentrations rapidly attenuate downstream of Upper Klamath Lake and the reservoirs.

Nuisance algal blooms within Iron Gate and Copco Reservoirs are well documented in the regular blue-green algae monitoring program reports by the Karuk Tribe of California Natural Resources Department and PacifiCorp. As illustrated in Figure 2.24 the summer (May – September) mean concentrations of chlorophyll-a at all of the reporting stations for the reservoirs are at or above the summer mean numeric target of 10 µg/L. The summer mean concentrations at three of the four stations are more than double the target and the maximum concentrations are generally an order of magnitude higher.

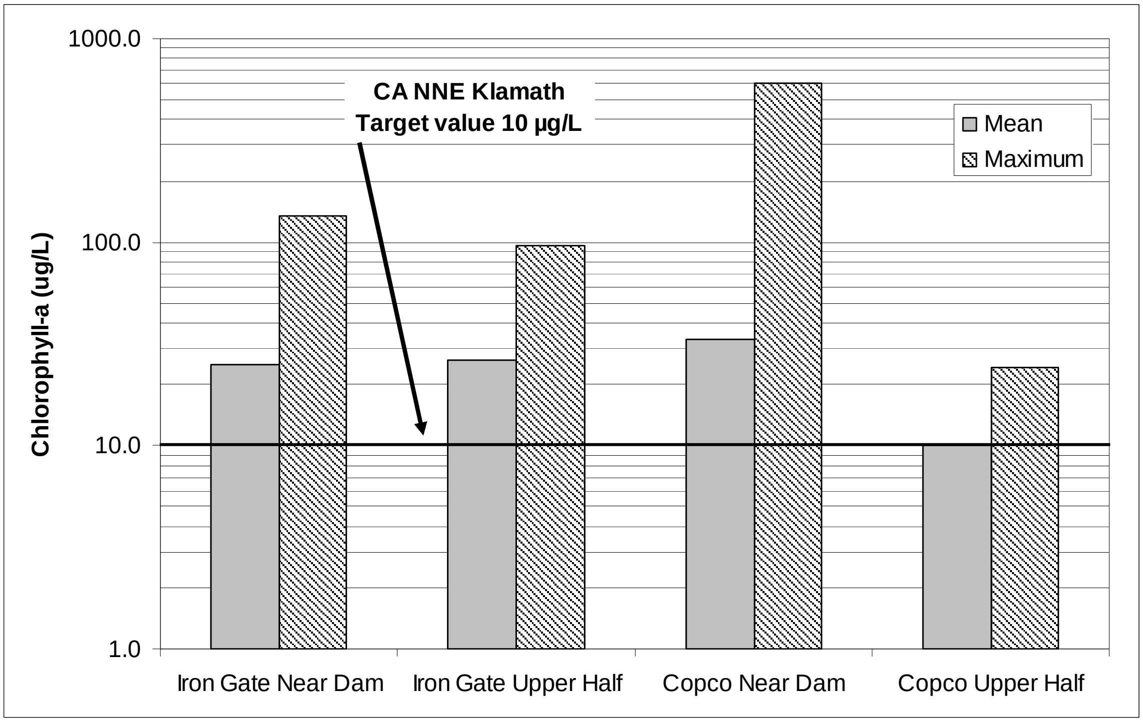

Figure 2.24: Summer (May – September) mean and maximum concentrations of chlorophyll-a (2000 – 2007) at four stations within the Iron Gate and Copco Reservoirs.

Figure 2.25 presents Regional Water Board staffs' seasonal analysis of PacifiCorp 2007 and 2008 data. The data shows an increase in total phytoplankton biovolume below Iron Gate Dam (Station KRBI) compared with above Copco Reservoir (Station KRAC). Normality tests performed on stations above and below the reservoirs showed non-normal distribution. Normality notwithstanding, the Figure 2.25 time series graphs show a distinct seasonal (June -September) increase in total algal biomass (biovolume) below the reservoirs in 2007 and 2008. Two nonparametric tests of the June - September 2007-2008 data show that the distribution of total algal biovolume is significantly greater below the reservoirs than above (Kolmogorov-Smirnov Two-Sample Test [p=0.034] and Kruskal-Wallis Mann-Whitney U Test [p=0.08]).

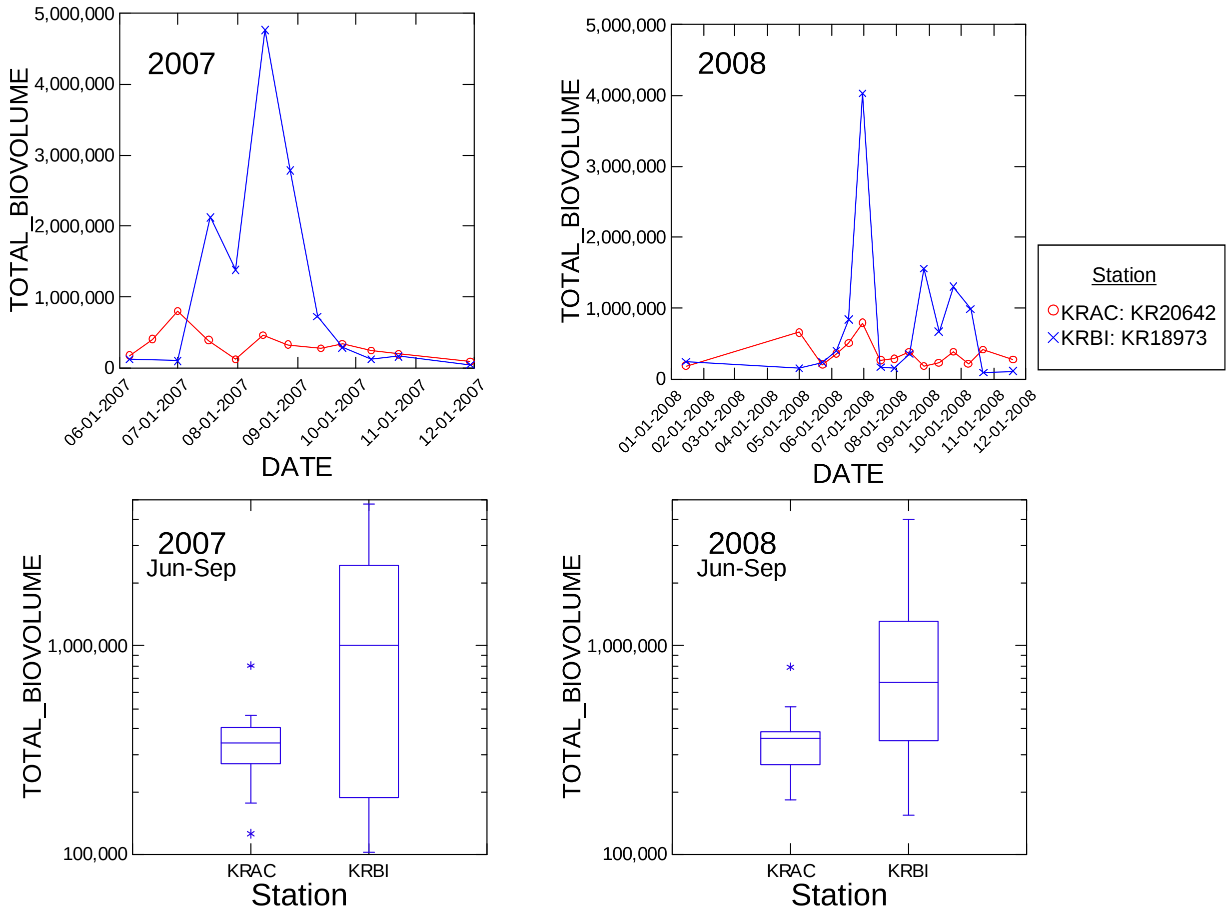

Figure 2.25. Comparison of above Copco Reservoir (Station KRAC; KR20642) and below Iron Gate Dam (Station KRBI; KR18973) biovolume for the summer 2007 and 2008. Data collected by PacifiCorp (http://www.pacificorp.com/es/hydro/hl/kr.html#).

The high concentrations of chlorophyll-a in the reservoirs have water quality impacts downstream. Suspended algae (and their breakdown products) entrained in water released from Iron Gate Reservoir may become available as a food source for polychaetes in the river reaches below the dam. In addition, these algal biomass can be deposited in the river bottom sediments, enhancing habitat conditions for polychaetes which contribute to higher levels of *C. shasta* parasite spores, and therefore contribute to higher rates of infection (Bartholomew et al. 2007; Bartholomew and Bjork 2007). The available data is insufficient to determine how the reservoirs alter the amount and form of particulate organic matter. Therefore, the net effect of fine particulate organic matter exported from the reservoirs on polychaete populations in the river downstream is unclear.

As discussed in more detail in Section 2.5.4, the reservoirs do impact the river below Iron Gate by serving as a source of blue-green algae to downstream water that can continue to grow in backwater and slower sections within the river reaches below the dams (Kann and Corum 2009, Kann and Asarian 2005). The export of algal biomass (including blue-green algae) has been documented by monitoring data showing that both *Microcystis* and microcystin are substantially higher within and below the reservoirs than they are directly upstream. For example, see Raymond (2009; *Phytoplankton Species and Abundance Observed During 2008 in the vicinity of the Klamath Hydroelectric Project* (Report prepared for CH2MHILL and PacifiCorp) which clearly illustrates (Figures 13 and 15) an increase of both *Microcystis* and microcystin toxin within the reservoirs and downstream.

**In summary, the available chlorophyll-a and biovolume data suggest that** the Iron Gate/Copco Reservoir complex significantly increases the quantity of algal biomass supplied to the river below Iron Gate Dam **and are a net sources of live algae to the river during the algae growing season.** Included in this algal biomass is blue-green algae **that** potentially serves as an in**n**oculant contributing to **nuisance conditions** in downstream backwater habitats. **However, the available data is insufficient to determine the net downstream effect of the reservoirs as a source of dead and decaying particulate organic matter.**

### *2.5.4 Blue-Green Algae and Microcystin Toxin*

An important aspect of the nuisance algae conditions within Copco and Iron Gate Reservoirs is the periodic dominance of toxic blue-green algal species during the summer season. There are many forms of blue-green algae, both toxic and non-toxic. This discussion focuses primarily on *Microcystis aeruginosa* since it has become the dominant species of concern on the Klamath River in California. The frequent documented occurrence of seasonally high concentrations of *Microcystis aeruginosa* and microcystin in reaches of the Klamath River within California in each of the last several years has resulted in the documented impairment of beneficial uses including Native American Culture (CUL), Subsistence Fishing (FISH), Water Contact Recreation (REC-1), Non-Contact Water Recreation (REC-2), Municipal & Domestic Supply (MUN), Shellfish Harvesting (SHELL), Aquaculture (AQUA), Agricultural Supply (AGR), and Commercial and Sport Fishing (COMM), as discussed below. Ongoing research may also demonstrate a direct effect on the health of aquatic organisms from exposure to high levels of microcystin which would lead to the addition of other beneficial uses to this list (de Figueiredo et al. 2004).

Routine public health monitoring of blue-green algae in the Klamath River basin began in 2005. Every year since 2004 *Microcystis aeruginosa* counts and microcystin concentrations on the Klamath River have exceeded the Blue Green Algae Work Group action levels for harmful algal blooms. Table 2.11 summarizes the blue-green algal monitoring data for the years 2006, 2007, and 2008 with respect to the Blue Green Algae Work Group action levels. Data presented in the table is summarized by reach: *Reach 1*) Oregon to Iron Gate Dam; *Reach 2*) Iron Gate Dam to Scott River; *Reach 3*) Scott River to Trinity River; and *Reach 4*) Trinity River to Estuary. The blue-green algae listing criteria are most frequently exceeded in Reach 1, which is primarily composed of sample sites within Copco and Iron Gate Reservoirs. Late summer conditions are typically characterized by dense blue-green algae blooms that form thick viscous scums in parts of the reservoirs. The bloom conditions at times span much of the open water areas within the reservoirs. The reservoirs have been posted with public health advisory signs as a result of these summer blooms in 2006, 2007, and 2008.

Table 2.11: Summary of blue-green algae and microcystin monitoring data for 2006, 2007, and 2008

| Reach Name | Reach # | Year | # of monitoring samples that exceed thresholds and targets | | |
|---|---|---|---|---|---|
| | | | MSAE Cells ≥ 40,000 ml/L | microcystin ≥ 8 ug/L | Tissue ≥ 26 ng/g |
| Oregon to Iron Gate Dam | 1 | 2006 | 27 | 29 | * |
| Iron Gate Dam to Scott River | 2 | 2006 | 1 | 1 | * |
| Scott River to Trinity River | 3 | 2006 | 2 | 0 | * |
| Trinity River to Estuary | 4 | 2006 | 0 | 0 | * |
| | | | | | |
| Oregon to Iron Gate Dam | 1 | 2007 | 47 | 35 | 41 |
| Iron Gate Dam to Scott River | 2 | 2007 | 2 | 0 | 1 |
| Scott River to Trinity River | 3 | 2007 | 4 | 0 | 4 |
| Trinity River to Estuary | 4 | 2007 | 2 | 0 | * |
| | | | | | |
| Oregon to Iron Gate Dam ** | 1 | 2008 | ** | 14 | 0 *** |
| Iron Gate Dam to Scott River | 2 | 2008 | 4 | 2 | * |
| Scott River to Trinity River | 3 | 2008 | 9 | 4 | * |
| Trinity River to Estuary | 4 | 2008 | 1 | 1 | * |

* Data not collected during this period

** Not all data from monitoring programs available at time of report publication.

*** Tissue samples taken prior to bloom to determine baseline conditions, samples were not taken during bloom.

Data sources: Yurok Environmental Monitoring Program Blue-Green Algae Annual Reports: 2006, 2007, and 2008; Karuk Tribe of California Natural Resources Department Blue Green Algae Monitoring Annual Reports: 2006, 2007, and 2008; and PacifiCorp Blue-Green Algae Monitoring Program annual Reports: 2006, 2007, and 2008.

Table 2.11 also shows high concentrations of *Microcystis aeruginosa* downstream of the Iron Gate Dam in reaches 2, 3, and 4. Some reaches of the Klamath River mainstem were posted with public health advisory signs during the summers of 2008 and 2009. Algae related sampling protocols in the Klamath River have evolved since routine sampling began in 2004. Before 2008 most samples on the Klamath River mainstem were taken from the river at higher velocity areas near the channel mid-point. Until 2008 few samples had been taken in near shore backwater areas where scums have been frequently reported and photographed. Data collected in 2008 showed frequent exceedance of both 8 µg/L microcystin and 40,000 cells/ml *Microcystis aeruginosa* in various river-edge habitats between Iron Gate Dam and Seiad Valley (Figure 6: Kann and Corum 2009). The revised September 2008 Blue Green Algae Work Group report recommends that monitoring for public health should include samples of the Reasonable Maximum Exposure (RME) conditions in areas in which people and animals are most likely to contact water (State Water Board 2008).

### *2.5.5 Dissolved Oxygen*

This section evaluates observed DO conditions relative to the existing and proposed Basin Plan water quality objectives for DO.

The US Fish and Wildlife Service (USFWS), in cooperation with the Karuk and Yurok Tribes, monitored DO conditions with datasondes at several stations along the Klamath River from 2001 to 2006. For the purposes of this assessment measured DO concentrations from the three most recent years (2004 – 2006) are evaluated in comparison to the existing and proposed DO objective. USFWS conducted an in-depth quality control review of the DO data (Ward and Armstrong 2006). Final data- sonde results have been summarized by station by evaluating the percent of total measurements during the summer season that fall below the current Basin Plan DO Objective of 8.0 mg/L. The datasondes recorded water quality conditions at 30-minute increments, for a total of forty-eight daily measurements.

In 2005 greater than ten percent of the DO measurements were less than 8.0 mg/L at six of the nine stations along the Klamath River (Table 2.12 and Figure 2.26). For the period 2004, 2005, and 2006 several of the Klamath mainstem stations (below Iron Gate, above Shasta River, above Scott River, and at Seiad Valley) had conditions where more than 40% of the measurements are less than the current Basin Plan objective indicating serious dissolved oxygen impairment for large sections of the river.

Table 2.12: Percent of DO measurements below Basin Plan water quality objective of 8.0 mg/L for 2004 – 2006 at nine stations along the Klamath River

| | **2004** | | **2005** | | **2006** | |
|---|---|---|---|---|---|---|
| **% Measurements below 8 mg/L** | **n** | **%** | **n** | **%** | **n** | **%** |
| At Iron Gate | 2706 | 64 | 4498 | 45 | 5391 | 61 |
| Above Shasta River | 5478 | 50 | 5533 | 49 | - | - |
| Above Scott River | 2966 | 58 | 4457 | 47 | - | - |
| At Seiad Valley | 3381 | 57 | 4713 | 45 | 5526 | 40 |
| At Orleans | 4057 | 37 | 4533 | 23 | 5349 | 15 |
| Above Trinity | - | - | 5535 | 5 | 5739 | 3 |
| At Weitchpec | 4142 | 48 | 5400 | 7 | 5332 | 6 |
| Below Weitchpec | 5500 | 16 | 3529 | 11 | 5293 | 4 |
| At/above Turwar | 5066 | 30 | 5543 | 6 | - | - |

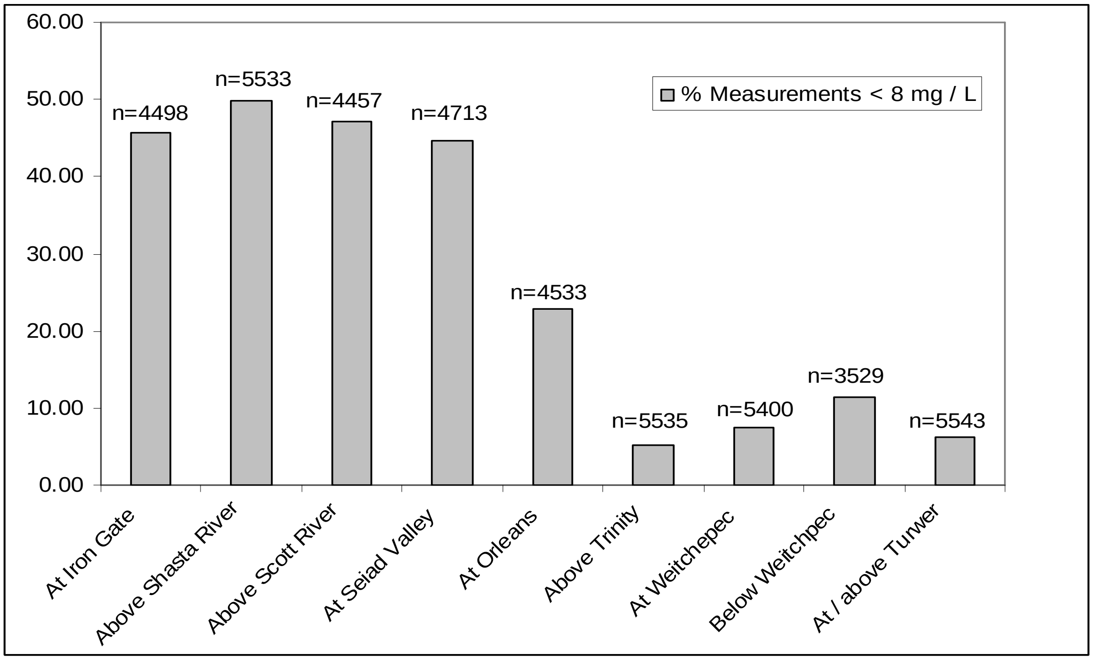

Figure 2.26: Percent of DO measurements below the Basin Plan water quality objective of 8.0 mg/L for 2005 at nine stations along the Klamath River

The analysis presented below addresses the revised DO objective being proposed (see Section 2.2.1.2. and Appendix 1). The revised objective requires that in those waterbodies identified as COLD but unable to meet the salmonid life cycle requirements (instantaneous minimum of 7.0 mg/L upstream of Iron Gate dam and 8.0 mg/L downstream of the dam, with half the monthly mean DO values for the year 10 mg/L or greater) due to natural conditions, a minimum 85% DO saturation limit throughout the mainstem, 90% DO saturation limit from October through April upstream of the Hoopa-California boundary and 80% DO saturation during August in the Middle and Upper Estuary be applied. These percent DO saturation criteria are to be calculated based on natural water temperatures.

In order to compare the USFWS measured DO data to the proposed DO objective assumptions related to temperature and barometric pressure were made. Percent DO saturation was calculated based on measured water temperatures and using a seasonal average barometric pressure. These assumptions make for a very conservative estimate of the percent of measurements below the proposed objective of 85% DO saturation at natural water temperatures. For simplicity, the analysis looks only at the 85% criteria. Estimates of natural water temperatures have not been predicted for the years 2004-2006 using the TMDL model. The results of the analysis are presented in Table 2.13 and Figure 2.27. In 2004, six of the nine stations had more than 10% of the DO measurements below 85% DO saturation.

Table 2.13: Percent of calculated percent DO saturation estimates below the proposed Basin Plan water quality objective of 85% saturation for 2004 – 2006 at nine stations along the Klamath River

| **% Measurements below 85% saturation at median of pressure range** | **2004** | | **2005** | | **2006** | |
|---|---|---|---|---|---|---|
| | **n** | **%** | **n** | **%** | **n** | **%** |
| At Iron Gate | 2706 | 10 | 4498 | 6 | 5391 | 18 |
| Above Shasta River | 5478 | 25 | 5533 | 24 | - | - |
| Above Scott River | 2966 | 35 | 4457 | 20 | - | - |
| At Seiad Valley | 3381 | 14 | 4713 | 11 | 5526 | 0 |
| At Orleans | 4057 | 6 | 4533 | 0 | 5349 | 0 |
| Above Trinity | - | - | 5535 | 0 | 5739 | 0 |
| At Weitchpec | 4142 | 19 | 5400 | 0 | 5332 | 0 |
| Below Weitchpec | 5500 | 0.1 | 3529 | 0 | 5293 | 0 |
| At/above Turwar | 5066 | 12 | 5543 | 0 | - | - |

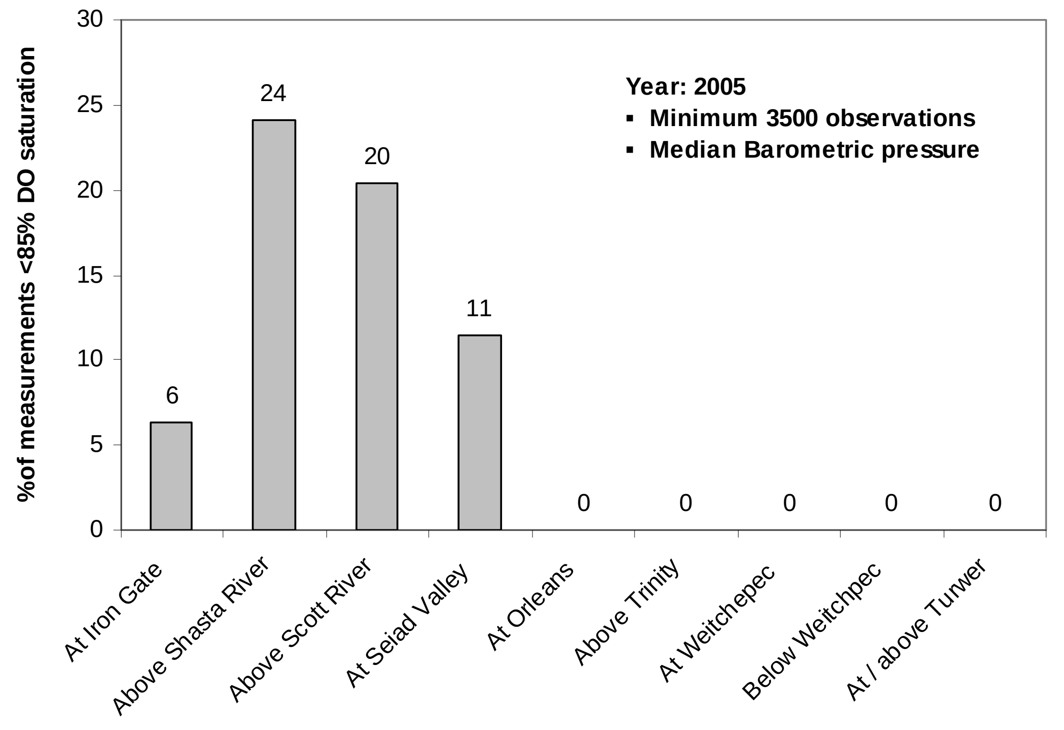

Figure 2.27: Calculated percent DO saturation at nine stations on the Klamath River for 2005 based on data sonde measurements made by U.S. Fish and Wildlife Service, Yurok Tribal Environmental Program, and Karuk Tribe Department of Natural Resources

### *2.5.6 pH*

This assessment includes an evaluation of pH conditions along the Klamath River independent of the diurnal variation driven by photosynthesis that was addressed in Section 2.5.3.3. The data for this analysis also comes from the USFWS, Karuk and Yurok Tribes datasonde measurements. The same years (2004 – 2006) used in the DO analysis were also selected for the pH assessment. The Basin Plan water quality objective for pH is a maximum of 8.5 and a minimum of 7.0.

Five of the stations have more than 20% noncompliant measurements. The highest rate of noncompliant measurements is 48% recorded at Orleans in 2006 (Table 2.14). In the three year sample all nine stations exceeded a noncompliant measurement rate of greater than 10 percent at least once. The rate of noncompliance for the minimum pH of 7.0 is less than 0.05% at all stations. Therefore a sampling station summary table and plot have not been prepared for minimum pH.

Table 2.14: Percent of pH measurements above 8.5 for 2004 – 2006 at nine stations along the Klamath River.

| **Percent of Measurements above 8.5** | **2004** | | **2005** | | **2006** | |
|---|---|---|---|---|---|---|
| | **n** | **%** | **n** | **%** | **n** | **%** |
| At Iron Gate | 5192 | 32 | 4680 | 3 | 5486 | 30 |
| Above Shasta River | 5762 | 37 | 5847 | 40 | - | - |
| Above Scott River | 3834 | 28 | 3821 | 19 | - | - |
| At Seiad Valley | 3808 | 1 | 5838 | 1 | 5576 | 32 |
| At Orleans | 4844 | 0 | 5608 | 0 | 5442 | 48 |
| Above Trinity | - | - | 5826 | 23 | 5746 | 18 |
| At Weitchpec | 4449 | 33 | 5765 | 29 | 5823 | 27 |
| Below Weitchpec | 5823 | 1 | 5469 | 23 | 5125 | 42 |
| At/above Turwar | 4712 | 16 | 5835 | 23 | - | - |

For 2005 (Figure 2.28) at six of the nine Klamath River stations the Basin Plan objective of 8.5 is exceeded in more than 15% of the samples taken.

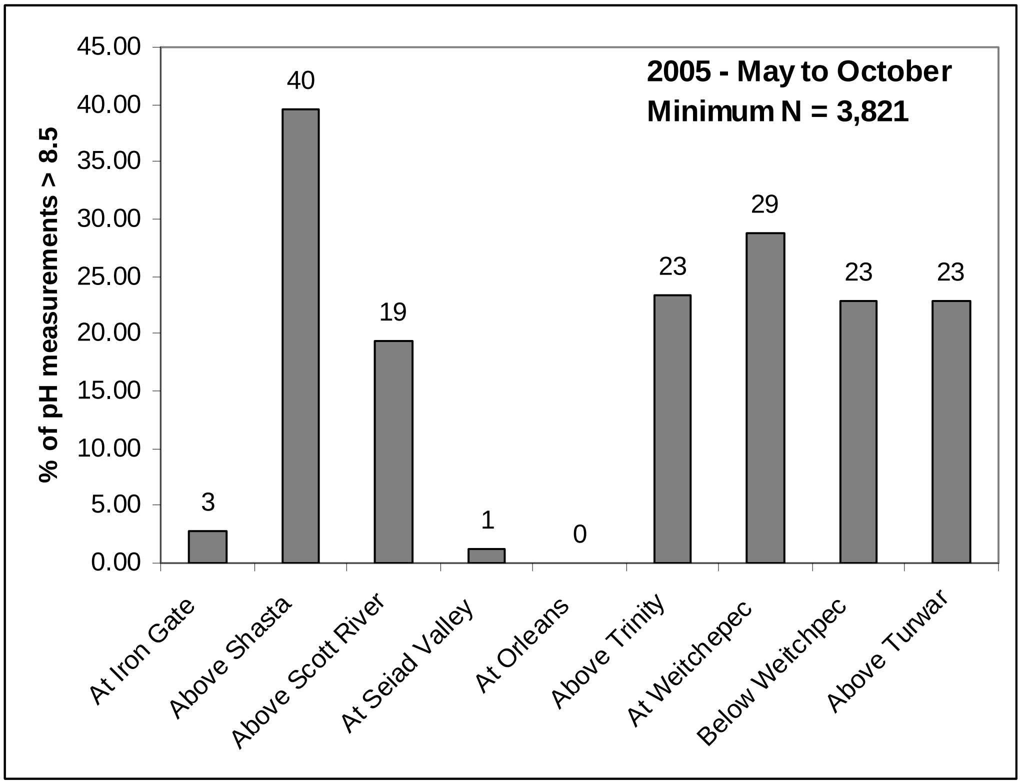

Figure 2.28: Percent of 2005 pH measurements in the Klamath River that exceed 8.5

### *2.5.7 Ammonia Toxicity*

Regional Water Board staff evaluated all the data within our compiled Klamath River datasets in which all 3 parameters (pH, NH3, and temperature) were collected at the same time. Based upon the evaluation, there were no documented times in which acute or chronic aquatic life criteria for ammonia toxicity was exceeded.

To take this one step further, staff evaluated all the available pH and temperature data to determine what the concentration of ammonia would need to be in order for toxicity (acute or chronic) to be present. The results of that effort showed that acute toxicity probably does not occur on the Klamath River in California. However, the results showed that there are probably times when the chronic criteria are exceeded, but only for short durations of perhaps a few hours in a day a few days in a year. EPA guidance suggests that chronic criteria for the protection of aquatic life should be addressed over an averaging period of 4 days. Regional Water Board staff concludes that based on the available data, acute ammonia toxicity has not occurred in the times/years when data is available, and excursions of the chronic ammonia criterion probably only occur for short durations on a few days in a year and, if so, do not constitute an impairment of beneficial uses.

### *2.5.8 Sediment*

The New Years Day flood of 1997 provided an example of some of the ways in which increased sediment loads affect stream temperatures in the Klamath River basin. A report by Klamath National Forest personnel (De La Fuente and Elder 1998) documenting the flood impacts within the Klamath National Forest reported 446 miles (20%) of channels that were significantly altered (i.e. with significant scouring, excessive sediment deposition, or riparian vegetation removal) by the flooding and associated sediment pulses of the 1997 flood. The report stated that “there appeared to be a considerable reduction in size, volume, and depth of pools in Elk, Indian, Beaver, Grider, Tompkins, South Fork Salmon, and Walker Creeks, and there is a larger proportion of fine sediment in the substrate. Alluvial reaches were made shallower and wider due to the sedimentation”. The report found that approximately 30% to 60% of riparian vegetation was lost in the alluvial reaches of the most affected tributaries. These effects of increased sediment loads were observed in Elk, Indian, Ukonom, Independence, Grider, Oneil, Portuguese, Beaver, Horse, and Walker Creeks, as well as numerous other streams throughout the Klamath basin after the flood of 1997 (Figure 2.29) (De La Fuente and Elder 1998; Kier Associates 1999). The conclusions of the Klamath National Forest assessment are consistent with Regional Water Board staff observations.

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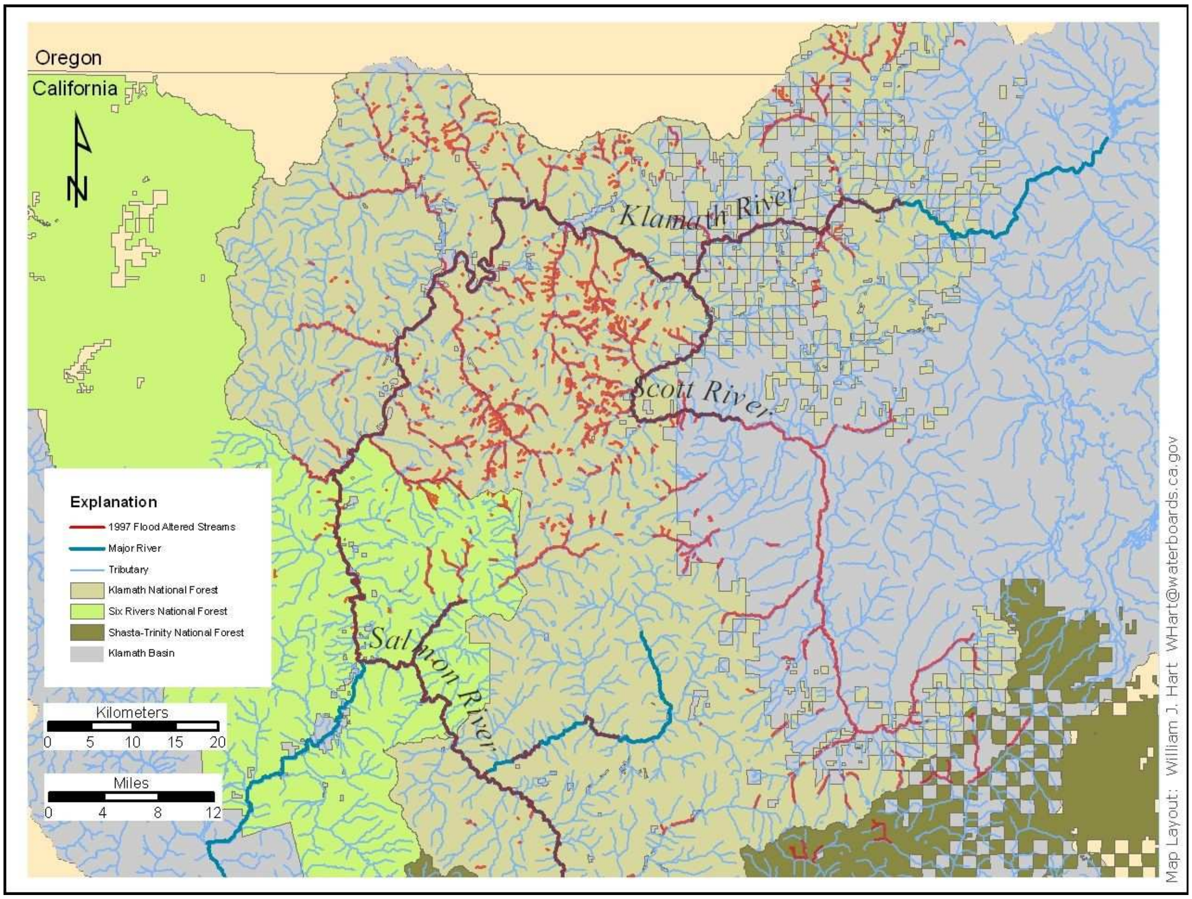

Figure 2.29: Mapped extent of stream channels substantially altered by sediment loads associated with the 1997 flood.
Source: De la Fuente and Elder 1998

The substantial changes in stream shade and channel dimensions that occurred as a result of the 1997 storm are believed to have significantly affected Klamath River tributary temperatures where they occurred. Unfortunately, little pre- and post-flood temperature comparisons are available to evaluate the changes in temperatures that resulted from the flood effects. However, a pre- and post-flood data set exists for one tributary, Elk Creek. De la Fuente and Elder presented a comparison of Elk Creek temperature data before and after the flood. The data showed that in the summer after the flood, the peak temperature was the highest of seven years of record, and was 3.8$^{o}$F higher than the average from 1990-1995. Likewise, the diurnal variation increased to12.5$^{o}$F, 4.9$^{o}$F higher than the 1990-1995 average. Furthermore, comparison of average air temperatures for the seven years show that 1997 was warmer (74.6 $^{o}$F) than all years except 1994 (76.0 $^{o}$F). The recorded low flow for 1994 was 16.1 cfs, whereas 1997 had the highest low flow of all the years measured (49.3 cfs). Despite higher air temperatures and lower flows in 1994, the instantaneous maximum temperature, 7-day maximum average, 31-day maximum average, and 31-day average diurnal variation were all lower compared to 1997 temperature data, as they were in all other years between 1990 and 1995 (no data are available for 1996). The fact that the season following the major changes in morphology and effective shade associated with the

1997 flood had higher temperatures, expressed in a variety of metrics, than the six years monitored prior to the flood, including a year with higher air temperatures and a fraction of the flow, strongly suggest that the temperature increase was a result of the effects of the flood.

The Final *Staff Report for the 2008 Integrated Report for the Clean Water Act Section 305(b) Surface Water Quality Assessment and the 303(d) List of Impaired Waters* (Regional Water Board 2009) was adopted by the Regional Water Board on June 3, 2009 and includes listings for sediment in 11 tributaries to the Klamath River in the area downstream of Iron Gate Dam to the confluence of the Trinity River. The portion of the Klamath River watershed from the Trinity River to the mouth of the Klamath is currently on the 2006 303(d) List for sedimentation/siltation impairment.

## 2.6 Evidence of Beneficial Use Impairment

Section 2.5 demonstrates that temperature, DO, biostimulatory substances, and related water quality objectives are not met at many locations at some times of the year in the Klamath River in California. Exceedance of these water quality objectives contributes to the impairment of a number of existing beneficial uses in the Klamath River. Evidence of impairment of the COLD, RARE, MIGR, SPWN, CUL, FISH, REC-1, REC-2, and MUN beneficial uses is presented in this section. This evidence of beneficial use impairment compels the need to develop TMDLs to address the temperature, DO, and nutrient water quality problems in the Klamath River.

### *2.6.1 Evidence of Impairment to Cold Freshwater Habitat (COLD), Rare, Threatened, or Endangered Species (RARE), Migration of Aquatic Organisms (MIGR), and Spawning, Reproduction, and/or Early Development (SPWN)*

The COLD, RARE, MIGR, and SPWN beneficial uses are currently not fully supported in the Klamath River in California, as demonstrated by the decline of salmonid populations, adult and juvenile fish kills caused by disease outbreaks, migration barriers for adult and juvenile salmonids, and degradation of spawning habitat.

#### 2.6.1.1 Salmonid Population Decline

Although historically there were large runs of salmonids in the Klamath River basin, current data indicate that populations have declined sharply since the early 1900's. Utilizing information from Snyder (1931), the NRC estimated that the annual total catch in the Klamath River during the period from 1916-1927 were probably 120,000 to 250,000 fish, and thus the number of potential spawners and total population numbers was considerably higher (NRC 2004, p.267, 268). In 2007, fall and spring Chinook population estimates were 132,167 and 12,628 respectively (CDFG 2008). No current estimate of steelhead and coho populations has been made, however, it is presumed that populations have declined dramatically from historic numbers (Brown and Moyle 1991, p.8; Brown et al. 1994; Busby et al. 1994 as cited by NRC 2004, p.274; CDFG 2002, p.1; NRC 2004, p.273). More detailed information on the decline of salmonid populations in the Klamath River basin can be found in Appendix 5, and brief summaries are presented below.

### Fall Chinook Salmon

Fall Chinook numbers in the Klamath River basin have dramatically declined during the past century (Hardy et al. 2006, p.7). The Klamath River fall Chinook run once totaled as many as 500,000 fish annually (Moyle 2002, p.258). Fall Chinook numbers in the Shasta River basin alone historically numbered 20,000-80,000 fish per year (Regional Water Board 2006, p.1-25). Basin-wide fall Chinook population estimates for the period from 1978-2007 ranged from a high of 239,559 fish in 1987 to fewer than 35,000 fish in 1991 (CDFG 2008).

### Spring Chinook Salmon

A population of more than 100,000 spring-run Chinook was once present in the basin, although this estimate is probably low because spring-run fish were the main run of Chinook in the Klamath mainstem in the 1800's (Moyle 2002, p.259). Historic run size estimates in each of the Sprague River, Williamson River, Shasta River, and Scott River alone were at least 5,000 fish (CDFG 1990 as cited by Moyle 2002, p.259). Population estimates for spring Chinook during the period from 1980-2006 ranged from a high of 69,004 fish in 1988 to fewer than 1,945 in 1983 (CDFG 2006).

### Steelhead Trout

Hardy et al (2006, p.6) report that historical run sizes for steelhead trout in the Klamath River basin were estimated at "400,000 fish in 1960 (USFWS 1960 as cited by Leidy and Leidy 1984), 250,000 in 1967 (Coots 1967), 241,000 in 1972 (Coots 1972) and 135,000 in 1977 (Boydston 1977)." More recent run sizes are summarized below.

### Spring/Summer Steelhead Trout

Annual counts of spring/summer steelhead in holding areas throughout the Klamath River basin ranged from 500 to 3,000 fish (Roeloffs 1983, as cited by Hopelain 1998, p.1). In the 1990's it was estimated that there were 1000-1500 spring/summer steelhead adults divided among eight populations in the basin (Barnhart 1994; Moyle et al. 1995; Moyle 2002 as cited by NRC 2004, p.274). NMFS considers spring/summer steelhead stocks depressed and in danger of extinction (Busby et al. 1994 as cited by NRC 2004, p.274).

### Fall Steelhead Trout

The fall steelhead represent the largest of the three steelhead runs, and were estimated to include 55,000-75,000 spawning adults and 150,000-225,000 half-pounders during the period from 1980-1982 (D.P. Lee, CDFG, pers. comm. as cited by Hopelain 1998, p.1).

### Winter Steelhead Trout

Run size estimates for Klamath River winter steelhead were 170,000 in the 1960s, 129,000 in the 1970s, and 100,000 in the 1980s (Busby et al. 1994 as cited by NRC 2004, p.273). Current population estimates for winter steelhead have not been conducted, although Hopelain (1998, p.1) estimated a run-size of about 5,000 to 25,000 during 1980-1982. It is presumed that winter steelhead abundance is still declining although estimates, both past and present, are not very reliable (NRC 2004, p.273).

Coho Salmon

It is clear from the information available that coho salmon populations statewide have undergone a dramatic decline from historic levels (Brown and Moyle 1991, p.8; Brown et al. 1994; CDFG 2002, p.1). Maximum estimates for coho spawners in California during the 1940's range from 200,000-500,000 fish (Sagar and Glova 1988 as cited by Moyle 2002, p.250). Brown et al. (1994) state that California coho populations are probably less than 6% of what they were in the 1940s, and there has been at least a 70% decline since the 1960s. In 1994, Brown et al. estimated the coho salmon population in California to be 30,000 fish, with natural spawners comprising 43% of the total population or 13,240 fish.

The Southern Oregon/Northern California Coast Evolutionary Significant Unit (SONCC ESU), which encompasses Klamath River stocks, has been listed as threatened by the State of California and the Federal government. Coho salmon occupy only 61% of the SONCC ESU streams previously identified as historical coho salmon streams (CDFG 2002, p.2).

Historical spawning escapement estimates for the Klamath River basin approximate 15,400-20,000 coho, with 8,000 of these fish originating in the Trinity River (USFWS 1979, App. as cited by Brown et al. 1994). In 1965, CDFG estimated 15,400 coho spawners per year in the basin (CDFG 1965, p.369). In 1994, Brown et al. estimated a total abundance of 18,125 coho in the Klamath River, including 1,860 native and naturalized fish. Current population estimates for coho in the Klamath River basin have not been conducted, although adult coho return numbers to the Iron Gate Hatchery, Trinity River Hatchery, and Shasta River Fish Counting Facility during the last 42 years averaged 5949 fish (Hampton 2004, p.1; Hampton 2005a, p.1; Hampton 2005b; KRIS 2006; Marshall 2005; and Rushton 2005).

#### 2.6.1.2 Juvenile and Adult Fish Kills

Poor water quality conditions in the Klamath River have resulted in both adult and juvenile fish kills reflecting an impairment of the COLD and RARE beneficial uses. Figure 2.30 identifies the mainstem Klamath River reaches in California where adult and juvenile fish kills have been documented.

It is believed that juvenile fish kills are very common in the Klamath River from Iron Gate Dam to the mouth of the river but often go undetected. Direct observation of juvenile fish kills is not common due to the small size of the juvenile fish within the large river system and the generally small number of outmigrant traps that operate in the river (Klamath Fish Health Assessment Team [KFHAT] 2005, p.5, 6).

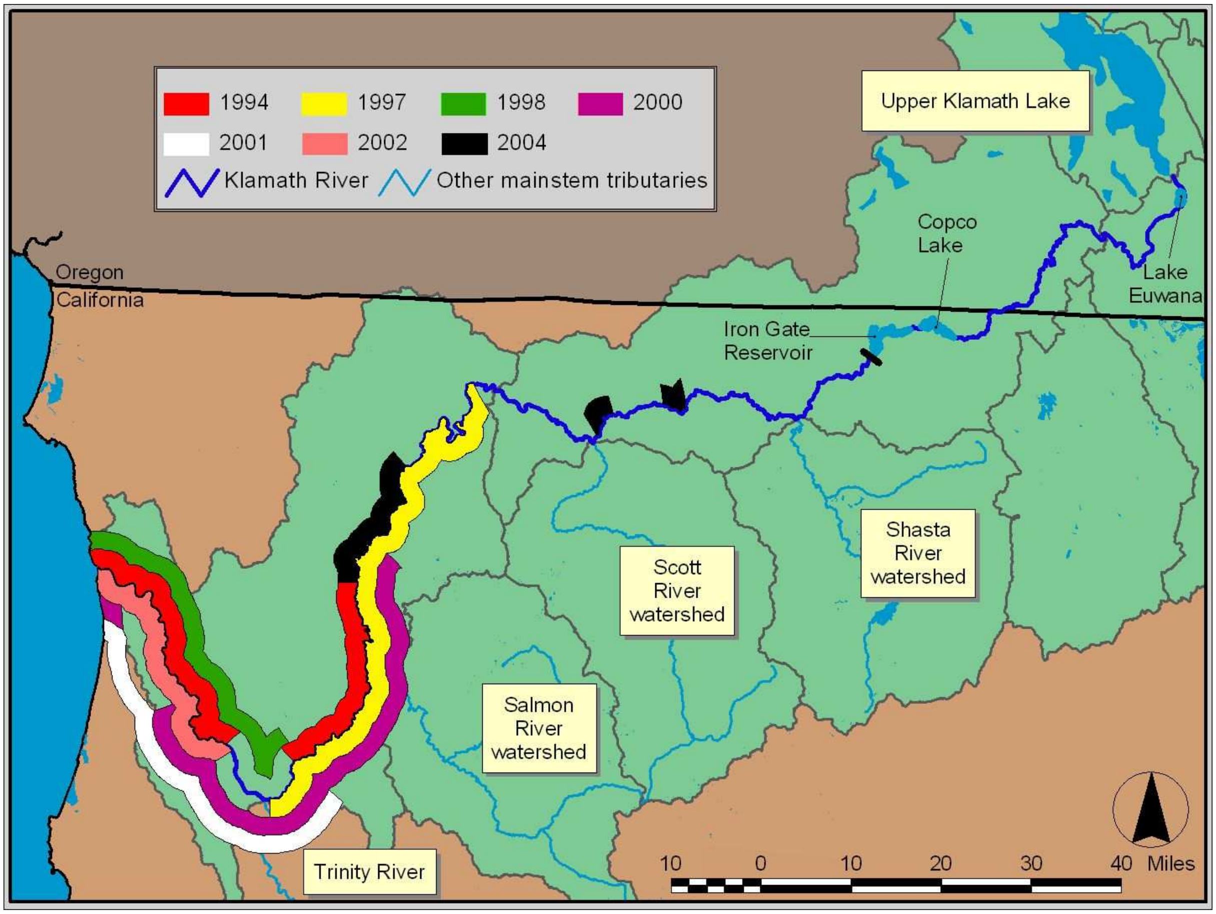

Figure 2.30: Fish kill years and locations in the Klamath River in California

Juvenile fish kills in the Klamath River in California have been documented for the years 1994, 1997, 1998, 2000, 2001, and 2004 (Table 2.15). Estimates of the number of dead fish range from 269-300,000 juvenile salmonids and non-salmonids. Disease was the ultimate cause of death in all juvenile fish kills documented. The effects of disease were exacerbated by poor water quality conditions, including low DO, high water temperature, extreme pH fluctuations, and low flow. Temperatures documented during these fish kills were as high as 25 $^{o}$C, well above the lethal threshold for juvenile salmonids. Additionally, DO levels as low as 3.1 mg/L were recorded during these fish kills, which is well below the current Basin Plan objective of 8 mg/L.

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Table 2.15: Juvenile fish kill locations and causes in the Klamath River in California

| Year | River Location | Fish | Cause of Death | Exacerbating Factors | | | | Citations |
|---|---|---|---|---|---|---|---|---|
| | | | | D.O. | Temp | $NH_3$ | Flow | |
| 1994 | middle/ lower | ~300 Chinook | None stated | | X | | | Foott (2005) USFWS (1997) |
| 1997 | Middle | non-salmonids<br>salmonids | Disease | X | X | X | X | Hannum (1997)<br>Hendrickson (1997)<br>USFWS (1997) |
| 1998 | Various | ~240,000 Chinook | Disease | X | X | | X | Williamson and Foott (1998) |
| 2000 | middle/ lower | 10,000-300,000 Chinook & steelhead | Disease | X | X | | | CDFG (2000, p.1, 10, 11), Deas (2000), Foott (2000), USFWS (2003a) |
| 2001 | | 269 Chinook[1] | Disease | | | | | Foott et al. (2002) |
| 2004 | upper/ middle | >250,000 Chinook | Disease | | X | | | Engbring (2004)<br>KFHAT (2005)<br>Klamt and Carter (2004) |

[1] It is likely that the peak of the disease epizootic and associated mortalities of juvenile Chinook likely occurred prior to when KFHAT conducted their reconnaissance surveys, and thus the actual number of dead fish was much higher (KFHAT 2005).

Documentation of adult fish kills in the Klamath River in California is available for 1997 and 2002 (Table 2.16). The 1997 fish kill was determined to be caused by Columnaris and other diseases and was exacerbated by maximum water temperatures around 26°C, low DO levels of 3.1 mg/L, and low flows (Hannum 1997; Hendrickson 1997).

Table 2.16: Adult fish kill locations and Causes in the Klamath River in California

| Year | River Location | Fish | Cause of Death | Exacerbating Factors | | | | | Citations |
|---|---|---|---|---|---|---|---|---|---|
| | | | | D.O. | Temp | $NH_3$ | Flow | Sediment | |
| 1997 | middle | >50/day non-salmonids | Disease | X | X | X | X | | Hannum (1997)<br>Hendrickson (1997)<br>USFWS (1997) |
| 2002 | lower | >34,000 (including >33,500 salmonids) | Disease | | X | | X | X | USFWS (2003a)<br>USFWS (2003b)<br>CDFG (2004) |

In mid to late September 2002 at least 34,000 fish died in the lower 36 miles of the Klamath River, although actual losses may have been more than double this number (CDFG 2004, p.III). Approximately 98.4% (33,527) of the fish killed were anadromous salmonids, representing 19.2% of the total 169,297 Klamath-Trinity run for 2002 (USFWS 2003b p.ii).

Multiple compounding factors likely contributed to the 2002 fish kill, including an early large run of fall Chinook, low river discharge which did not provide suitable attraction flows to trigger upstream migration, and warm water temperatures which were optimal for disease proliferation (CDFG 2004, p.III, 33, 124; USFWS 2003a, p.ii). Additionally, fish passage through the lower Klamath River may have been impeded by the shallow depth of the water flowing over some riffles, which were created by sediment deposition during high discharge events in the winters of 1997 and 1998 (CDFG 2004, p.III; USFWS 2003a, p.37). The majority of the dead fish examined were infected with the fish diseases *Ichthyophthiriasis* (Ich) and Columnaris, which was identified as the principal cause of death (CDFG 2004, p.III; USFWS 2003a, p.ii). Maximum daily water temperatures recorded at Turwar (RM 7) during September ranged from 18-23°C (CDFG 2004, p.70). Seven-day running averages of the weekly maximum temperature (MWMT) during this period ranged from 19-22.5°C (CDFG 2004, p.70), which exceeds the USEPA (2003) MWMT threshold values of 16°C (adult migration/core juvenile rearing), 18°C (adult migration/non-core juvenile rearing), and 20°C (adult migration). Although these high water temperatures are not unusual for the Klamath River, they are ideal for disease proliferation and thus contributed to a disease epizootic (the equivalent of an epidemic in humans) (CDFG 2004, p.III, 124; USFWS 2003a, p.ii).

#### 2.6.1.3 Adult and Juvenile Salmonid Migration Barriers and Spawning and Rearing Habitat Degradation

Unless otherwise specified, the following information is from CDFG 2004 (p.III, 83), Hardy et al 2006 (p.10, 15, 20), and USFWS 2003a (p.ii, 36).

Poor water quality conditions are contributing to the impairment of migration (MIGR) of aquatic organisms, particularly salmonids. Section 2.4.4.1 summarized findings by Strange (2007) that adult fall Chinook salmon migration is dependent on stream temperature. As shown in Section 2.5.2, Klamath River mainstem and tributary water temperatures during the period of fall Chinook migration are often over the temperatures noted by Strange (2007) that inhibit upstream migration. Thus elevated water temperatures contribute to the impairment of MIGR.

Alterations in flow in the Klamath River basin have contributed to the degradation of salmonid spawning and rearing habitat (SPWN). Principal factors affecting anadromous fish production in the Klamath River from Iron Gate Dam to Weitchpec include impaired flow in some tributaries (particularly the Shasta and Scott Rivers), impaired flows in the mainstem, and alterations to the timing and magnitude of mainstem flows. One of the primary limiting factors for anadromous fish production in the Klamath River from Weitchpec to the mouth is the cumulative effect of impaired flow and alterations in the seasonal hydrograph. These impacts have contributed to the degradation of available spawning gravel from sedimentation (Hardy et al 2006, p.20).

Cumulative impacts resulting in sediment delivery to many tributaries of the Klamath River in California have contributed to the formation and persistence of large delta fans at many tributary confluences, impeding adult and juvenile migration (MIGR). In low flow years, this accumulation of sediment can inhibit or block access to these tributaries, thereby restricting access to habitat and thermal refugia for migrating adult and juvenile salmonids. Salmonids that are unable to enter the tributaries are forced to seek space in the limited areas of thermal refugia in the mainstem Klamath River. Overcrowding of salmonids in mainstem thermal refugia areas, combined with the high water temperatures can exacerbate disease proliferation.

As mentioned in the previous section, there is evidence that conditions inhibiting adult migration may have contributed to the 2002 adult fish kill in the Klamath River. USFWS reported that in 2002 Klamath River flows were too low to trigger upstream migration, causing adults to congregate in the lower river. After the fish kill was underway the U.S. Bureau of Reclamation increased flows, and salmonids responded by migrating out of the lower river. CDFG hypothesized that fish passage may have been impeded by shallow water depth over certain riffles.

> CDFG…reported that in 1997 and 1998 high discharge events occurred in northern California that could have altered the channel of the Klamath River. They suggested that the input of high sediment loads during high discharge events could have resulted in the filling of pools and increased the elevation of riffles in the lower Klamath River. Furthermore, they speculated that discharges that may have been sufficient for fish passage in low discharge years prior to 1997 were inadequate for passage in September 2002 (CDFG 2003b, as cited by USFWS 2003a, p.37).

Additionally,

> USFWS biologists working on the lower Klamath River [in September of 2002] observed low-flow conditions, making it more difficult to traverse shallow riffles in a jet boat than in previous years (Shaw 2002, personal communication). They observed that water depth at Pecwan and Ah Pah riffles appeared shallow enough to be an impediment to adult fish passage. Yurok biologists also observed that fish passage over some riffles was confined to multiple small channels, in which their jet boat with a six-inch draft, would occasionally touch bottom (Belchik 2003, personal communication). A former NMFS fisheries biologist (Gilroy 2003, personal communication) with experience working on the Klamath river suggested when flows are low, fish passage over certain riffles is confined to smaller channels, representing the main thalweg and much of the riffle is too shallow to pass fish. The DFG Fisheries Biologist, who has participated in angler surveys on the Klamath River since 1985, described water levels during September 2002 in the fish-kill area as the lowest she has observed in over 20 years of experience (Borok 2003, personal communication). These anecdotal observations raised concern that shallow water depth over certain riffles might have impaired the ability of salmon and steelhead to migrate upstream (CDFG 2004, p. 87).

Thus, alterations in flow and changes in channel conditions resulting from sedimentation in the mainstem Klamath River in California have contributed to the impairment of MIGR and SPWN.

### *2.6.2 Impairment of Native American Culture (CUL) and Subsistence Fishing (FISH) Beneficial Uses*

The Water Quality Control Plan for the North Coast Region (Basin Plan) includes two Native American Cultural beneficial uses; Native American Culture (CUL) and Subsistence Fishing (FISH). The CUL beneficial use covers "uses of water that support the cultural and/or traditional rights of indigenous people such as subsistence fishing and shellfish gathering, basket weaving and jewelry material collection, navigation to traditional ceremonial locations, and ceremonial uses"; FISH encompasses "uses of water that support subsistence fishing" (Regional Water Board 2007). CUL is designated as an "Existing" use in the Ukonom, Happy Camp, Seiad Valley, Klamath Glen, and Orleans Hydrologic Subareas of the Klamath River. Due to a lack of available information at the time of the last update of the Basin Plan, no waterbodies in the North Coast have been designated as "Existing" or "Potential" use for FISH. Based on the available information, however, Regional Water Board staff consider FISH an existing use within the same Hydrologic Subareas of the Klamath River as those designated CUL.

Given the scope of the CUL and FISH uses within the Klamath River basin in California, support of these uses is closely interrelated with the uses associated with the cold freshwater salmonid fishery (i.e. COMM, COLD, RARE, MIGR, and SPWN), as well as with the water contact and drinking water uses (REC-1 and MUN). The CUL and FISH beneficial uses in the Klamath River in California is currently impaired due to the decline of salmonid populations and degraded water quality resulting in changes to or the elimination of ceremonies and ceremonial practices and risk of exposure to degraded water quality conditions during ceremonial bathing and traditional daily activities. The FISH beneficial use is currently impaired in the Klamath River basin in California due to the decline of salmonid populations and other Tribal Trust fish populations resulting in decreased use, abundance, and value of subsistence fishing locations, altered diet and associated physical and mental health issues, and increased poverty. Additionally, the presence of the toxin microcystin in fish and mussels in the Klamath River has the potential to impair both the CUL and FISH beneficial uses. It is important to note that other beneficial uses, such as COLD and MUN, are linked to the support of the CUL and FISH beneficial uses throughout the year.

#### 2.6.2.1 Decline in Salmonid and Other Fish Populations

The decline of salmon populations, as well as the decline of other Tribal Trust fish species of the Klamath River basin in California including sturgeon, eulachon (candlefish), lamprey (eel) and some species of suckers, has impaired the CUL and FISH beneficial uses. The elimination of the spring Chinook run above the Salmon River has resulted in the elimination of cultural ceremonies associated with the migration of this species through the length of the Klamath River. Declines in fish populations, especially salmonids, has also resulted in decreased use, abundance, and value of subsistence fishing locations, an altered daily diet that has been linked to health issues for Tribal Members, and increased poverty.

An elaborate ceremony, called the First Salmon Ceremony, marks the passing of the first spring Chinook salmon up the Klamath River. This migrating salmon was allowed to pass all the way up the Klamath River to its spawning ground. It was believed that the first spring Chinook migrating upstream would leave its scales at each spawning location for the rest of the salmon run to follow (Roberts 1932 as cited by Sloan 2003, p. 25). This first migrating salmon of the year was considered taboo, and if eaten would cause convulsions and death. Thus, the First Salmon Ceremony allowed this fish to pass safely upstream, thereby lifting the taboo, and allowing the Native People to fish for salmon in the river (Waterman and Kroeber 1938 as cited by Sloan 2003, p.25). The dramatic decline in the spring Chinook run has made it impossible for the Klamath River Tribes to conduct the First Salmon Ceremony. "And how do you perform the Spring Salmon Ceremony, how do you perform the First Salmon Ceremony, when the physical act of going out and harvesting that first fish won't happen?"(Leaf Hillman 2004 as cited by Norgaard 2005, p.35).

The Karuk Tribe historically depended on the abundant populations of fish found in the mainstem Klamath River for subsistence. However, as fish populations have declined the Karuk have shifted their diets to other food sources (Reed 2007a). Ron Reed (2005), traditional dipnet fisherman and cultural biologist for the Karuk Tribe, states that there is only one remaining Tribal fishery location that provides any level of subsistence fishing to the Karuk Tribe, Ishi Pishi Falls. According to Reed (2005), in 2002, about 1,500 fish were caught at Ishi Pishi falls, in 2003 approximately 1,000 fish were caught, and in 2004 only 100 fish were harvested at this location. The limited harvest of fish at Ishi Pishi Falls has meant that even ceremonial salmon consumption is limited (Ron Reed Pers. Comm. as cited by Norgaard 2005, p.4). According to Norgaard (2006), in addition to declining salmonid numbers, the fishery at Ishi Pishi Falls is negatively affected by low flows. When flows are too low the ability to perform dip net fishing is limited and fewer fish are caught (Norgaard 2006).

The importance of fishing to Tribal Members is reflected by the fact that fishing locations are a form of real property (Pierce 2002, p.7-2; Sloan 2003, p.17). They can be owned by individuals, families, or a group of individuals, and can be borrowed, leased, inherited, and bought and sold (Sloan 2003, p.17, 18). The quality, use, and value of these fishing locations has been reduced as changes including increased siltation and decreased salmonid abundance have occurred in the Klamath River and its tributaries (Sloan 2003, p.18, 28).

Historically, the Karuk Tribe had a platform fishery associated with each of their 100 Tribal village sites (Reed 2006). These fisheries were located near the tops of riffles, where eddies were created along the margins of the Klamath River. These areas of low velocity were where the salmon would hold and/or utilize this microhabitat as a migration corridor. According to Reed (2006) these 100 platform fishery locations are no longer as productive as they once were, or are gone. Tribal elders convey that the riffles near these fishing areas have been filled in and flattened out by sediment, contributing to the decline in overall fish populations (Reed 2006), as well as contributing to the loss of a culturally significant way of life.

The decline of salmonids and other Tribal Trust fish populations in the Klamath River basin has altered the diet of each of the Tribes along the river and its tributaries. Historically, traditional consumption of fish by the Karuk Tribe was estimated at 450 pounds per person per year, while in 2003 the Karuk People consumed less than 5 pounds of salmon per person per year, and in 2004 less than ½ pound per person per year was consumed (Norgaard 2005, p.13). In 2005 over 80% of Karuk households surveyed reported that they were unable to harvest adequate amounts of lamprey (eel), salmon or sturgeon to fulfill their family needs (Norgaard 2005, p.4). Furthermore, 40% of Karuk households reported that there are fish species that their family historically caught, which are no longer harvested (Norgaard 2005, p.7).

The decrease in abundance and availability of traditional foods, including salmon, trout, eel, shellfish, sturgeon and riparian plants, is responsible for many diet related illnesses among Native Americans including diabetes, obesity, heart disease, tuberculosis, hypertension, kidney troubles and strokes (Joe and Young 1993 as cited by Norgaard 2005, p.9, 39). These conditions result from the lack of nutrient content in foods consumed in place of the traditional foods such as salmon, as well as from the decrease in exercise associated with fishing and gathering food (Norgaard 2005, p.40). The estimated diabetes rate for the Karuk Tribe is 21%, nearly four times the U.S. average, and the estimated rate of heart disease for the Karuk Tribe is 39.6%, three times the U.S. average (Norgaard 2005, p.40).

In addition to altered diet and increased health issues, declines in fish populations have resulted in a documented increase in poverty rates for some Klamath River Tribes.

> The destruction of the Klamath River fishery has led to both poverty and hunger. Prior to contact with Europeans and the destruction of the fisheries, the Karuk, Hupa and Yurok tribes were the wealthiest people in what is now known as California. Today they are amongst the poorest. This dramatic reversal is directly linked to the destruction of the fisheries resource base.
>
> The devastation of the resource base, especially the fisheries, is also directly linked to the disproportionate unemployment and low socio-economic status of Karuk people today. Before the impacts of dams, mining and over fishing the Karuk people subsisted off salmon year round for tens of thousands of years. Now poverty and hunger rates for the Karuk Tribe are amongst the highest in the State and Nation. The poverty rate of the Karuk Tribe is between 80 and 85% (Norgaard 2005 Exec Summary).

### 2.6.2.2 Degraded Water Quality

Degraded water quality in the Klamath River basin in California, including the seasonal presence of blue-green algae and algal toxins in the Klamath River and reservoirs (see Section 2.5.4), has impaired the CUL and FISH beneficial use. Known and/or perceived health risks associated with degraded water quality have resulted in the alteration of cultural ceremonies to exclude or limit ingestion of river water. Additionally, known or perceived risk of exposure to degraded water quality conditions during ceremonial bathing and traditional cultural activities such as bathing, gathering and preparing basket materials, and collecting and using plants has resulted in an impairment of CUL.

The presence of blue-green algae and algal toxins in the Klamath River and reservoirs has impaired the cultural practice of subsistence fishing. The Karuk Tribe has only one fishing location available to them and it is flow dependent. Thus, when fish are in the river and the flow is suitable for fishing, Tribal Members must fish even if blue-green algae and algal toxins are present in the river. Susan Corum, Water Resources Coordinator for the Karuk Tribe, states: “It is really not a choice to fish. It is part of their culture which they need to maintain (Corum 2007).”

Microcystin has been identified in the waters of Klamath River, as well as in the liver of salmonids and in mussels from the river. Laboratory analyses detected a trace of microcystin in the liver of an adult steelhead, and 0.54 µg/kg in the liver of a half-pounder steelhead landed in the Klamath River at Weitchpec on October 3, 2005. Although these levels are not above the 250 µg/kg threshold which is advised by Van Buynder et al. (2001) to protect human health, the Yurok Tribe has expressed concern that the mid to late summer blooms of *Microcystis* in the Klamath River generally coincides with increased salmonid upstream migrations and subsequent usage of salmonid meat for recreational, cultural, and sport purposes. Mussels in the Klamath River have also had detectable levels of microcystin found in them. In 2007, a mussel was found in the Klamath River containing >1500 µg/kg microcystin, over the threshold to protect human health advised by Van Buynder et al. (2001). Additionally, upon review of the 2007 data, OEHHA recommended against consuming mussels from the affected sections of the Klamath River and yellow perch from Iron Gate and Copco Reservoirs due to their high concentrations of microcystin (OEHHA 2008). The presence of microcystin in salmonids and mussels of the Klamath River has resulted in an impairment of the cultural practice of subsistence fishing.

The Klamath River Tribes practice their culture through their “World Renewal” ceremonial cycle, such as the “First Salmon Ceremony” and Jump Dance, the Boat Dance, the War Dance, and the White Deerskin Dance (Reed 2007b). Other Tribal ceremonies and rituals include the Brush Dance and the Flower Dance, as wells as other rituals that require a spiritual cleansing process such as for fishing and hunting, funerals, and good luck (Reed 2007b). All of these ceremonies and rituals require Tribal members to be in close proximity to the Klamath River and they are integrally linked to the river and its health (Sloan 2003 p.18).

According to Karuk Cultural Biologist Ron Reed (2006, 2007b), the “World Renewal” ceremonial cycle is held on the Klamath River at Amerikirum (approximately 2 miles below Somes Bar), Clear Creek (Inam), Somes Bar (Katimin), and Orleans (Panamnik) starting in April and continuing through September of each year. The Medicine Man, who leads the ceremony at Clear Creek, walks 14 miles through the ridges and hills along the Klamath River and is joined halfway through his journey by children and adults of the

Tribe who follow him the rest of the way for good luck. Upon reaching the Klamath River at the end of this walk, it was historically tradition to drink water from the river to complete the ceremony. This is no longer done due to health concerns about drinking water directly from the river, though children are still known to jump in and drink the water (Reed 2006).

Ceremonial bathing in the river is an important part of most ceremonies (Curtis 1924 as cited by Sloan 2003, p.28). For example, bathing in the Klamath River and its tributaries is a requirement for participants in the Brush Ceremony (Sloan 2003, P.16). "During the Fish Dam Ceremonies at *Kepel*, young girls were selected by the Medicine Man to participate in the ceremonies. Once selected, they were sent to the river to bathe and then were dressed in full regalia which they would wear during the ceremonies. Then they were sent home to their families, and were required to fast and bathe in the river every day" (Van Stranlen 1942 as cited by Sloan 2003, p. 28). During the World Renewal Ceremonies, the Medicine Man and other participants bathe in the Klamath River for up to 10 days (Reed 2006).

Bathing is also associated with funeral services, subsistence practices, recreational swimming, courtship, and for individual hygiene (Reed 2007a). Bathing associated with funeral rituals occurs year round and includes preparation for burial, and purification after burial (Curtis 1924 as cited by Sloan 2003, p.28). The Karuk Tribe historically bathed freely in the Klamath River, however in more recent years degraded water quality conditions during the summer have forced them to take precautionary steps while bathing in the river (Reed 2007a). The Yurok Tribe has reported that detached algae have been present in the Klamath River in amounts high enough to prevent access and negatively affect the spirituality associated with bathing areas (McKernan 2006).

Willow roots, wild grape, Cottonwood, and Oregon Grape are collected by Tribal Members in the riparian zone of the Klamath River and used to make baskets (Reed 2007a). Traditional collection of these basketry materials often involved wading in the water (Sloan 2007a), and further contact occurs when the material is washed and cleaned in the water (Reed 2007a). Additionally, willow roots are peeled by mouth following cleaning with river water (Reed 2006). In addition, plants are collected for food, medicine, materials, and other cultural functions (Reed 2007a). Gathering plants or plant materials involves wading and contact with the Klamath River (Sloan 2007a; Reed 2007a). Ingestion of water can occur because plants are often cleaned in the river water and water is consumed with medicinal plants (Sloan 2007a). Given degraded water quality conditions, ingestion of water may pose a potential health risk.

Table 2.17 provides a summary of the activities that are encompassed by the CUL and FISH beneficial uses. Table 2.17 also denotes when those activities occur during the year, and the footnotes identify the amount of physical contact with the water associated with each of these activities. This table is not comprehensive, but conveys the magnitude and diversity of activities that are covered under these uses. Based on the information presented, Regional Water Board staff find that the CUL and FISH beneficial uses of the Klamath River in California are not being fully supported.

Table 2.17: Karuk, Yurok, and Quartz Valley Tribes cultural beneficial uses (CUL and FISH) of the Klamath River and tributaries[4]

| **Resource** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CUL** | | | | | | | | | | | | |
| Plants[1,3] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Fish[1] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Fishing[1,2] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Water-drinking, steaming, cooking[1,3] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Rocks[1] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Bathing[2] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Boating[1,2] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Wildlife[1] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Hunting & Trapping[1] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| River & Trail Access[1] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Training[2] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Swimming[2] | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Prayer & Meditation[1] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | |
| Fish Dam[1,2] | | | | | | | ■ | ■ | ■ | | | |
| Washing[1] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Meditation[1] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Wood Gathering[1] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Tanning Hides[1] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Roots[1,3] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Sticks, Shoots & Bark[1] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Weaving[1] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Shells[1] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| World Renewal Ceremonial Cycle[2,3] | | | | ■ | ■ | ■ | ■ | ■ | ■ | | | |
| **FISH** | | | | | | | | | | | | |
| Plants[1,3] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Fishing[1,2] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Eeling[1,2] | ■ | ■ | ■ | ■ | ■ | | | | | | | |
| Shellfish[1,2] | | | | | | ■ | ■ | ■ | | | | |
| Water-drinking, steaming, cooking[1,3] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Rocks[1] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Bathing[2] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Boating[1,2] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Wildlife[1] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| River & Trail Access[1] | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |

Sources: Bowman 2006; Norgaard 2006; Reed 2007a, Reed 2007b; Sloan 2007a, Sloan 2007b

■ Indicates time of use.

1-Wading, 2-Full submersion, 3-Ingestion of water

4-Tributaries utilized by the Tribes of the Klamath River for cultural purposes include many of those from the Scott River down to the mouth of the Klamath river. Additionally, the Quartz Valley Tribe utilized all tributaries which flow into the Scott and Shasta Rivers. Tributaries considered as having cultural beneficial uses include any tributary that provides spawning or rearing, or provides a migration pathway for Tribal Trust species.

Note: This table is not an exhaustive list of all activities covered under the CUL and FISH beneficial uses.

### *2.6.3 Impairment of Water Contact Recreation (REC-1), Non-Contact Water Recreation (REC-2), and Municipal and Domestic Supply (MUN)*

Toxigenic blue-green algae blooms and their associated toxins measured in Copco and Iron Gate Reservoirs and in select reaches of the Klamath River downstream from the reservoirs are periodically impairing the Water Contact Recreation (REC-1) and Non-Contact Water Recreation (REC-2) beneficial uses. Additionally, the toxins have the potential to impair Municipal and Domestic Supply (MUN) beneficial use in the Klamath River.

#### 2.6.3.1 Recreational Impacts

The available data on blue-green algae and toxin concentrations in the Klamath River and reservoirs are presented in Section 2.5.4. Water contact recreation (REC-1) during swimming, diving, and other direct water contact presents a high risk of exposure to inhalation or ingestion of cyanotoxins in waters contaminated with *Microcystis aeruginosa* (or other toxigenic species). Blooms of *Microcystis* and the presence of its cyanotoxin, microcystin, have prompted health advisories by the California Department of Health Services as well as the posting of on-site warnings for the public to avoid contact or use caution during water contact recreational activities in Iron Gate and Copco Reservoirs and some reaches of the river since 2005.

The presence of elevated *Microcystis* and microcystin concentrations in Iron Gate and Copco Reservoirs during August 2005 prompted the Regional Water Board cooperating with the State Water Board, USEPA, and Karuk Tribe to issue a joint press release (State Water Board 2005) warning of the potential adverse health effects to persons recreating in waterbodies of the Klamath River system contaminated with noticeably excessive algal concentrations. The Siskiyou County Health Department also issued a health advisory warning people about elevated toxin levels in Copco Reservoir. Additionally, warning signs were posted at key recreational access facilities around Iron Gate and Copco Reservoirs by the Regional Water Board.

During mid-August 2006, large blooms of *Microcystis aeruginosa* and high concentrations of microcystin led the Regional Water Board, Karuk Tribe, State Water Board, and USEPA to issue another press release, again warning recreational water users and other area residents to use caution when near the reservoirs, or avoid water contact recreation altogether in locations with noticeable blue-green algal blooms in Copco and Iron Gate Reservoirs (State Water Board 2006). The Siskiyou County Health Department also issued a public health advisory for Iron Gate and Copco Reservoirs in 2006 (Siskiyou County Public Health Department 2006). In early September 2006 the Regional Water Board posted warning signs at prominent recreational access points in both reservoirs reiterating the cautionary advisories contained in the earlier press release. In addition to these postings at the reservoirs, the Yurok Tribe posted health advisory signs along the mainstem Klamath River within the reservation borders (Fetcho 2006).

*Microcystis* scums were present in Iron Gate and Copco Reservoir beginning in mid- to late-June 2007 at concentrations that prompted the Regional Water Board to post precautionary health advisory signs at boat launches, campgrounds, swimming areas, and other high traffic, recreational use access points along the shorelines of the reservoirs. Shortly after the posting of the two reservoirs the USEPA as lead agency, with a number of state agencies, and the Yurok and Karuk Tribes issued a joint press release on July 5, 2007 advising the public to use caution when recreating at the two reservoirs (USEPA 2007). In August 2007, Microcystis cell counts in the mainstem Klamath River exceeded the Blue Green Algae Work Group's guidelines for posting health advisories. Consequently, Regional Water Board staff posted precautionary health advisory signs at 24 locations along the mainstem Klamath River from the sport fishing access point at Iron Gate Hatchery to the Aikens Creek Campground.

#### 2.6.3.2. Health Impacts

Blooms of *Microcystis aeruginosa*, and subsequent releases of its cyanotoxin, microcystin, during the summer and early fall in the mainstem Klamath River have the potential to impair the municipal and domestic supply (MUN) beneficial use. The State Water Board's Department of Water Rights Information Management System (WRIMS 2006) shows numerous existing water rights that utilize in-river water withdrawals for sources of domestic drinking water and other uses. Nearly all of the water rights are located downstream from Iron Gate dam. The location, engineering, and timing of water withdrawals, as well as the magnitude and velocity of streamflow are factors that affect the possibility of entraining blue-green algae and their toxins in water supplies.

There have been no documented human health impacts due to drinking or recreating in Klamath River water during *Microcystis* blooms. However, the presence of the toxin during periods when water withdrawls are occurring and when people are recreating, presents the possibility that human health impacts could occur.

In August of 2007, a dog became very ill a few hours after swimming in Copco Reservoir and drinking the water during a *Microcystis* bloom (Tobler 2007). The sick dog was taken to the vet and tests showed elevated levels of several enzymes indicative of liver disease. Microcystin is a liver toxin, and is capable of producing this type of an enzymatic response.

#### 2.6.3.3. Aesthetic Impacts

Visible scums formed by the presence of *Microcystis aeruginosa* and other blue-green algae in Copco and Iron Gate Reservoirs present an aesthetic nuisance, potentially impacting the aesthetic enjoyment (REC-2) of these reservoirs. A study conducted by CH2M Hill for PacifCorp compiled interviews and survey responses of recreational water users about their experiences at locations along the Klamath River, including Copco and Iron Gate Reservoirs (PacifiCorp 2004a). Interviewees' responses showed that water condition during the summer to early fall seasons has affected the quality and enjoyment of their experiences. The survey did not link responses to a specific time period; however, nearly all of the concerns expressed by respondents pertained to the summer and early fall recreational seasons of 2001 and 2002.

Approximately 70% (n = 89), of the responses to the interview questions stated water quality either detracted a lot or a little from their aesthetic enjoyment of the Klamath River within the geographical boundaries of the survey. By far, the most common complaint related to large amounts of "algae" and odors related to "algae." The survey data show that of the 70% of water uses reporting unfavorable recreational experiences with "algae," approximately 42% (n = 37) of those negative responses directly involved Iron Gate and Copco Reservoirs. Though not stated, presumably the "algae" in question were blue-green algal species that tend to accumulate along shorelines, forming scums and surface films during blooms.

### *2.6.4 Impairment of Commercial and Sport Fishing (COMM)*

The Commercial and Sport Fishing (COMM) beneficial use is currently impaired in the Klamath River in California, as demonstrated by restrictions and closures on the sport and commercial fishing industries in the basin and beyond. Salmonid population decline has resulted in severe reductions in available Chinook salmon for both the in-river and ocean troll commercial fishing communities, and sport fishing community. Additionally, federal regulations have eliminated the right to harvest coho salmon stocks due to their dwindling numbers. Evidence documenting declining numbers of salmonids returning to spawn in the Klamath River basin is discussed in detail in section 2.6.1 and Appendix 5. The apparent disappearance of eulachon (*Thaleicthys pacificus,* also known as candlefish) spawning activity in the Klamath River (Belchik and Larson 1998) has resulted in the cessation of a historically important, commercially valuable non-salmonid fishery that was primarily utilized by Yurok Tribal members.

#### 2.6.4.1 In-River Sport Fishing Impairment

Decreased salmon populations in the Klamath River have resulted in the alteration of fishing regulations further restricting the number of in-river fish harvested recreationally and the length of the recreational salmon in-river fishing season. For the 2006 season, the California Fish and Game Commission (Commission) decreased the number of days that recreational salmon fishing could occur by 11 days in the Klamath River below the Highway 96 bridge at Weitchpec (CFGC 2006). This was done in an attempt to ensure that the quota for in-river recreational harvest would not be met before Labor Day, allowing fishing during the holiday weekend (CFGC 2006).

The documentation of microcystin toxin concentrations in fish tissue of yellow perch from Copco Reservoir above human health thresholds represents an impairment of in-river sport fishing. Table 2.18 presents data from 2005 and 2007 when salmonids were collected in the Klamath River and yellow perch were collected in the reservoirs to test for the presence of microcystin. As the table reflects, microcystin was detected in the liver of a salmonid collected at Iron Gate Hatchery at a level >250 µg/kg, which is over the threshold recommended by Van Buynder et al. (2001) to protect human health. Additionally, four of the yellow perch fish tissue samples and one of the liver samples collected in Copco Reservoir were >250 ug/kg. Yellow perch are commonly harvested from Copco and Iron Gate Reservoirs for consumption.

Table 2.18: Detection of microcystin in fish tissue and liver samples from the Klamath River and reservoirs

| Location Fish Collected | Year | # of fish tissue samples where Microcystin Detected | # of fish tissue samples with Microcystin total >250 µg/kg | # of fish liver samples where Microcystin Detected | # of fish liver samples with Microcystin total >250 µg/kg |
|---|---|---|---|---|---|
| Klamath River | 2005 | 0 of 2* | 0 | 2 of 4* | 0 |
| Iron Gate Hatchery | 2005 | 0 of 2* | 0 | 0 of 2* | 0 |
|  | 2007 | 0 of 1* | 0 | 1 of 1* | 1 |
| Iron Gate Reservoir | 2007 | 15 of 19** | 0 | 2 of 3* | 0 |
| Copco Reservoir | 2007 | 18 of 19** | 4 | 3 of 3* | 1 |

*salmonid
** yellow perch

### 2.6.4.2 Ocean Sport Fishing Impairment

During the period from 1960 through 1965 there was no closed season for ocean salmon sport fishing north of Tomales Point (CDFG 1967). The catch limit during this period remained constant at 3 salmon per day. In 1960 and 1961 the minimum size limit for salmon was 22 inches, and in 1962 one fish of any size was allowed with the remainder to be over 22 inches. From 1963 through 1965 the minimum size limit was one salmon over 20 inches and two over 22 inches.

In contrast, the currently depressed state of the fall Chinook run in the Klamath Management Zone (KMZ), and the listing of coho as threatened on both the federal (1997 listing) and California (2005 listing) Endangered Species lists, has resulted in increased restrictions on the ocean sport fishery. The 2007 ocean sport fishing season in the Klamath Management Zone (KMZ), extending from Humbug Mountain, OR to Point Arena, CA, was open from May 5 to September 4 (Pacific Fishery Management Council [PFMC] 2007). However, the Klamath Control Zone, extending 6 miles north and south of the Klamath River and 12 miles off-shore, was closed in August. The catching of coho was prohibited and the Chinook catch was limited to two fish per day (PFMC 2007). Chinook were required to be a minimum of 24 inches in total length to be legal to keep (PFMC 2007). These greater restrictions have contributed to the impairment of the sport fishery in the Klamath River basin.

### 2.6.4.3 In-River Commercial Fishery Impairment

Between 1912 and 1934 approximately 957,000 pounds of Chinook salmon, representing close to 55,000 fish, were harvested and preserved during a single fishing season in the Klamath River (Snyder 1931, p. 7, 8, 88, and 89). Daily salmonid catches by the Tribal commercial fishery commonly ranged from 7,000 to 10,000 fish per day, with a one-day high that was reportedly approximately17,000 fish. Catch totals were mostly Chinook, but coho salmon, steelhead trout, lamprey, and green sturgeon were also caught and preserved (Snyder 1931, p. 7, 8, 88, and 89). Due to precipitous declines in salmonid populations attributed to over harvesting by the in-river commercial salmon fishery, the fishery was declared illegal and closed by court order in 1934. It was subsequently reopened by another court order in 1977; however, the Bureau of Indian Affairs closed the Tribal in-river commercial fishery the following year under a “conservation moratorium." It remained closed until 1987, when it was again reopened (Pierce 1998; Yurok Perspectives 2001, p. 7.1-7.13).

In 1993 the Department of Interior modified catch limits for the Klamath River basin Tribes, allotting 50% of the available Klamath River basin salmon harvest to the Hoopa and Yurok Tribes, or an amount sufficient to support a moderate standard of living, which ever is less. Given the depressed condition of the Klamath River basin salmon stocks in 1993, the Department of Interior concluded that 50% of the salmon harvest during that year would be allocated to the Tribes because there weren't enough fish to allow them to catch enough to support a moderate standard of living (50 CFR Part 661, NOAA 1993). Of the 50% allocated to the Tribes, 80% and 20% of that allocation, referred to as Tribal shares, are allotted to the Yurok and Hoopa Tribes, respectively. Currently, the Yurok and Hoopa Tribes are the only Tribes with Federally-recognized commercial fishing rights in the Klamath River (Pierce 1998; Yurok Perspectives 2001, p. 7.1-7.13)

From 1990 through 1998 the in-river Tribal fishery was closed to commercial gillnetting due to depressed salmon runs. In recent years, harvest rates for the Tribal gillnet fishery have varied and are currently so low that it is hard to support an in-river commercial fishery. For the 2006 salmon season the Pacific Fishery Management Council (PFMC), working with the Klamath Fisheries Management Council, determined that the allowable Tribal share of the Klamath-Trinity River basin salmon harvest is 10,000 fish (PFMC 2006a). This would allocate 8,000 salmon to the Yurok Tribe and 2,000 salmon to the Hoopa Tribe from the in-river salmon fishery.

#### 2.6.4.4 Ocean Commercial Fishery Impairment

Salmon sold to fish buyers and processors within the Klamath Management Zone (KMZ) have dwindled significantly since 1976 through 1980 when an average of 143,900 Chinook and 72,100 coho salmon were delivered per season to the port of Crescent City alone (PFMC 2003, 2006b). From 1993 through the present, concerns about the plummeting coho salmon populations have led to the closure of the entire California ocean commercial troll for coho. In order to more rigorously protect all salmonid stocks within the KMZ, regulations on the ocean commercial fishery (consisting mostly of Chinook salmon) has been progressively more restrictive.

The economic impacts to the fishermen and on-shore industries that support the ocean commercial salmon industry have been, and continue to be significant. The maximum dollar values for the ex-vessel price (the price received by fishermen for fish landed at the dock) adjusted to 2005 dollar values are presented in Table 2.19 for the four major ports in the KMZ. The seasons when regulatory closures prohibited commercial ocean salmon fishing are not shown in the table, and correspond to no income for fishermen.

Table 2.19: Estimates of maximum dollars for the ex-vessel price of the commercial ocean salmon fishery for the four major ports within the KMZ from 1976-1990 and 1991-2001.

| Port | Year(s)[1] / Maximum Dollars | Year(s)[1] / Maximum Dollars |
|---|---|---|
| Brookings, OR | 1976-1980 / 7,355,000 | 1991-1995 / 126,000 |
| Crescent City, CA | 1976-1980 / 5,931,000 | 1991-1995 / 9,000 |
| Eureka, CA | 1976-1980 / 8,884,650 | 1991 / 43,640 |
| Fort Bragg, CA | 1986-1990 / 14,902,000 | 2001 / 663,000 |

Source: PFMC 2006b

[1] Multiple year's values represent the average income per year

The 2006 ocean commercial troll non-Tribal salmon fishery was severely curtailed along much of the west coast by the PFMC. The potential offspring of the 2002 Chinook stocks, the four year age class, is that cohort of fish that were predicted to have subsequently returned to the Klamath River as spawners in 2006. The loss of over 33,000 salmonids in 2002, mostly fall Chinook (USFWS 2003b p.ii), was a contributing factor to the low return and resulting fishery restrictions in 2006. In particular, within the KMZ, extending from Humbug Mountain north of Brookings, OR to Horse Mountain just south of Shelter Cove, CA, the 2006 season was closed (NOAA 2006). South of Horse Mountain to Point Arena the season was open only from September 1 through September 15, or when a Chinook salmon quota of 4,000 fish was reached. The extreme seasonal and take restrictions were deemed necessary by the PFMC to assure an adequate numbers of spawners returned to the Klamath River.

During 2007 the PFMC (2008) considered Chinook salmon stocks within the KMZ somewhat healthier than 2006 but only opened the ocean commercial Chinook season from September 10 - September 30, imposing a fleet quota of 6,000 fish. Chinook stocks south of the KMZ to Point Arena were deemed depressed to the point that the PFMC only allowed fishing during the periods from April 9-April 27 (fleet quota of 2,000 fish) and August 29-September 30 (no quota set). The ocean coho salmon fishery remained closed along the California coast for the entire fishing season.

## 2.7 Problem Statement Synthesis

Based on the analysis presented in this chapter, there is little doubt that the Klamath River is an impaired waterbody. The Klamath River TMDL problem statement has identified numerous water quality related factors that must be addressed in the TMDL allocations and the implementation plan. The following is a summary of the water quality conditions and impacts that are addressed in the TMDL.

- Temperature conditions that exceed natural levels exist throughout the Klamath River basin and contribute to: chronic stress and sometimes acute lethal conditions for cold water fish, migration barriers, proliferation of fish diseases such as Columnaris, lower reproductive success, increased juvenile and adult mortality, and lower overall fish populations.
- Nutrient concentrations in much of the Klamath River watershed are well above natural background levels and contribute to excess periphyton and suspended algae growth, which in turn contributes to poor DO and pH conditions, and also

contributes to increased abundance and exposure of fish to parasites (e.g., *C. shasta*).

- High levels of nutrients and the presence of impoundments have contributed to the development of nuisance levels of blue-green algae that have created potential health hazards for people exposed to reservoir and downstream river waters. This health hazard has negatively impacted both recreational and ceremonial use of the reservoirs and the river.
- Conditions of low DO and high pH are persistent in much of the Klamath River and contribute to multiple impacts on cold water fish including: migration barriers, decreased growth and fecundity, decreased reproductive success, increased juvenile fish mortality, increased adult mortality, and lower overall fish populations.
- Excess sediment delivery to the Klamath River and tributary streams has contributed to habitat impairment, increased levels of nutrients, and to the development of water column temperatures that exceed Basin Plan water quality objectives.
- Reduced flows contribute to increased water column temperatures, the accumulation of organic matter, and low DO conditions which have contributed to impacts on aquatic life.
- Water quality objectives for temperature, DO, pH, biostimulatory substances, and toxicity are regularly exceeded in the Klamath River basin in California.
- Seventeen of the twenty-three designated beneficial uses for the Klamath River are not supported due to existing water quality impairments and related factors.

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