United States Department of the Interior

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September **23, 1997**

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Mr. Gwynne,

In 1986 the United States Environmental Protection Agency (EPA) published "Quality Criteria for Water 1986" which established criteria recommendations for many water quality parameters and pollutants. Phase I (water quality) of the Klamath River basin flow-related scoping study will be preformed using the EPA, 1986 water quality criteria that specifically apply to the most sensitive anadromous fish species (i.e. salmonids) (Campbell 1995). These water quality criteria are presented in Table 1. Each state also has water quality criteria and/or standards developed for waters within their domains. The California North Coast Regional Water Quality Control Board's (CNCRWQCB) current development of Total Maximum Daily Load (TMDL) allocations for 18 water bodies on the North Coast of California represents this type of effort (Campbell 1995). Included in the CNCRWQCB's TMDL development for these 18 water bodies are four contiguous sections of the mainstem Klamath River in California (Table 2). In comparison, the EPA's 1986 criteria for salmonids appear more comprehensive than the CNCRWQCB's proposed TMDL allocations for the mainstem Klamath River. However, the CNCRWQCB uses the term 'nutrients' which may include many of the specific parameters (e.g. ammonia, orthophosphorus, and heavy metals) given in the EPA 1986 criteria. Water temperature and nutrient levels are certainly applicable water quality criteria for the Klamath River. However, the U.S. Fish and Wildlife Service (Service) is very concerned that the CNCRWQCB's proposed TMDL allocations do not include dissolved oxygen (DO_2) concentrations as a standard measurement of water quality.

Service concerns are based on several factors including the current status of coho and steelhead populations on the Klamath River, past and current land use practices in the Klamath basin and their effects on water quality, annual fish and temperature monitoring data, documented fish kills, and current water quality monitoring data which indicate that acute and chronic values for temperature and DO,, as specified by the EPA 1986 criteria for salmonids, **are** observed in the mainstem Klamath River particularly during some summer periods.

Table 1. U.S. Environmental Protection Agency, 1986 Criteria for Selected Water Quality Parameters in the Klamath basin, Oregon (USEPA **1986)**.

Parameter	Acute Value	Chronic Value	Other Value
Temperature	20°C (1 day)	15°C (7 days)	
Dissolved Oxygen	5 mg/l	7 mg/l	
PH			<6.5 & >9.0
Alkalinity (CaC03)	Weakly buffered		Θ 75 mg/l
Total Ammonia	0.91 mg/l @ pH 9 6.80 mg/l @ pH 8 23.00 mg/l @ pH 7	0.13 mg/l @ pH 9 1.00 mg/l @ pH 8 1.49 mg/l @ pH 7	
Orthophosphorus	1 mg/l	50 ug/l	
Cadmium	1.80 ug/l 3.90 ug/l 8.60 ug/l	0.66 ug/l 1.10 ug/l 2.00 ug/l	@ 50 mg/l CaC03 @l00 mg/l CaC03 @200 mg/l CaC03
Copper	9.20 ug/l 18.00 ug/l 34.00 ug/l	6.50 ug/l 12.00 ug/l 21.00 ug/l	@ 50 mg/l CaC03 @l00 mg/l CaC03 @200 mg/l CaC03
Iron			1 mg/l
Lead	34.00 ug/l 82.00 ug/l 200.00 ug/l	1.30 ug/l 3.20 ug/l 7.70 ug/l	@ 50 mg/l **CaC03** @l00 rag/l CaC03 @Z00 mg/l CaC03
Manganese			50 ug/l
Mercury	2.40 ug/l	0.12 ug/l	
Selenium	260.00 ug/l	35.00 ug/l	
Zinc	180.00 ug/l 320.00 ug/l 570.00 ug/l	47.00 ug/l 47.00 ug/l 47.00 ug/l	@ 50 mg/l CaC03 @l00 mg/l CaC03 @200 mg/l CaC03

On May 6, 1997, the National Marine Fisheries Service (NMFS) listed coho salmon of the Southern Oregon/Northern California Coast Evolutionary Significant Unit (ESU) (encompassing populations of the Klamath **River basin) as a threatened** species under the Endangered Species act (ESA) of 1973 (62 Federal **Register (FR) No.** 87, 24588-24609). **On** August 11, 1997, the **NMFS, while acknowledging** that 'these fish **are** in serious trouble", deferred for six months a listing decision on steelhead stocks of the Klamath Mountains Province ESU. **A common** life history strategy of both coho salmon and steelhead, which is not shared by the majority of Klamath basin juvenile chinook salmon, is that emigration (downstream migration to the ocean) does not occur until fish are at least one year of age. This extended freshwater

Table 2. U.S. Environmental Protection Agency/North Coast Regional Water Quality Control Board schedule for the development of Total Maximum Daily Load allocations covered by the Consent Decree*.

Waterbody	Listed Pollutants	TMDL Completion Date	Lead Agency
Klamath River (Oregon Border to Iron Gate Dam)	Nutrients Temperature	12/31/2004	CNCRWQCB
Klamath River (Iron Gate Dam to Scott River)	Nutrients Temperature	12/31/2004	CNCRWQCB
Klamath River (Scott River to Trinity River)	Nutrients Temperature	12/31/2004	CNCRWQCB
Klamath River (Trinity River to the Ocean)	Nutrients Temperature	12/31/2004	CNCRWQCB

'The schedule reflects the commitments made by U.S. EPA in settlement of a lawsuit (Pacific Coast Federation of Fishermen's Assn's V. Marcus) and the requirements of the Consent Decree in that action to address TMDL development on 18 water bodies on the North Coast of California. In addition, the schedule is based on the North Coast regional water Quality Control board's approved TMDL schedule of 1995. This schedule does not reflect the complete adopted 303(d) list for the North Coast region. For those rivers not part of the consent decree the TMDL completion schedule remains the same as was approved by the North Coast Regional Board in 1995.

rearing period necessitates that water quality be adequate enough to support life through the summer period.

Land use over the past 135 years has changed in the Klamath basin. Mining and logging were the first two major land use changes that affected streams and rivers throughout the Klamath basin (Klamath River Basin Fisheries Task Force 1991). Irrigated agriculture and livestock grazing followed but the major development of irrigation and hydropower in the Klamath basin occurred over 50 years ago. Indirect effects, such as nutrient loading, cause changes in the physical environment that, in turn, can adversely affect Salmonid life stages. On the mainstem Klamath River, the most obvious result is the luxuriant growth of aquatic plants and algae in the river channel. The growth of aquatic plants and algae fosters sediment accumulation that decreases spawning and rearing habitat. The growth and respiration cycles of aquatic plants affect DO2 concentrations, especially during the summer months. The relationship between solubility of oxygen in water and temperature is inversely proportional and is applicable to the water quality issue here because increasing temperature and lower DO* concentrations typically occur during the summer months. These naturally occurring events interact synergistically and can have much greater impact than either temperature or DO, concentrations alone (Campbell 1995).

Since 1988, the Service's Coastal California Fish and Wildlife Office (CCFWO) has annually monitored the springtime emigrations of juvenile salmonids (chinook, steelhead, and coho salmon) on the Klamath and Trinity rivers. The sampling locations (Figure 1), near the terminus of each basin proper (above the

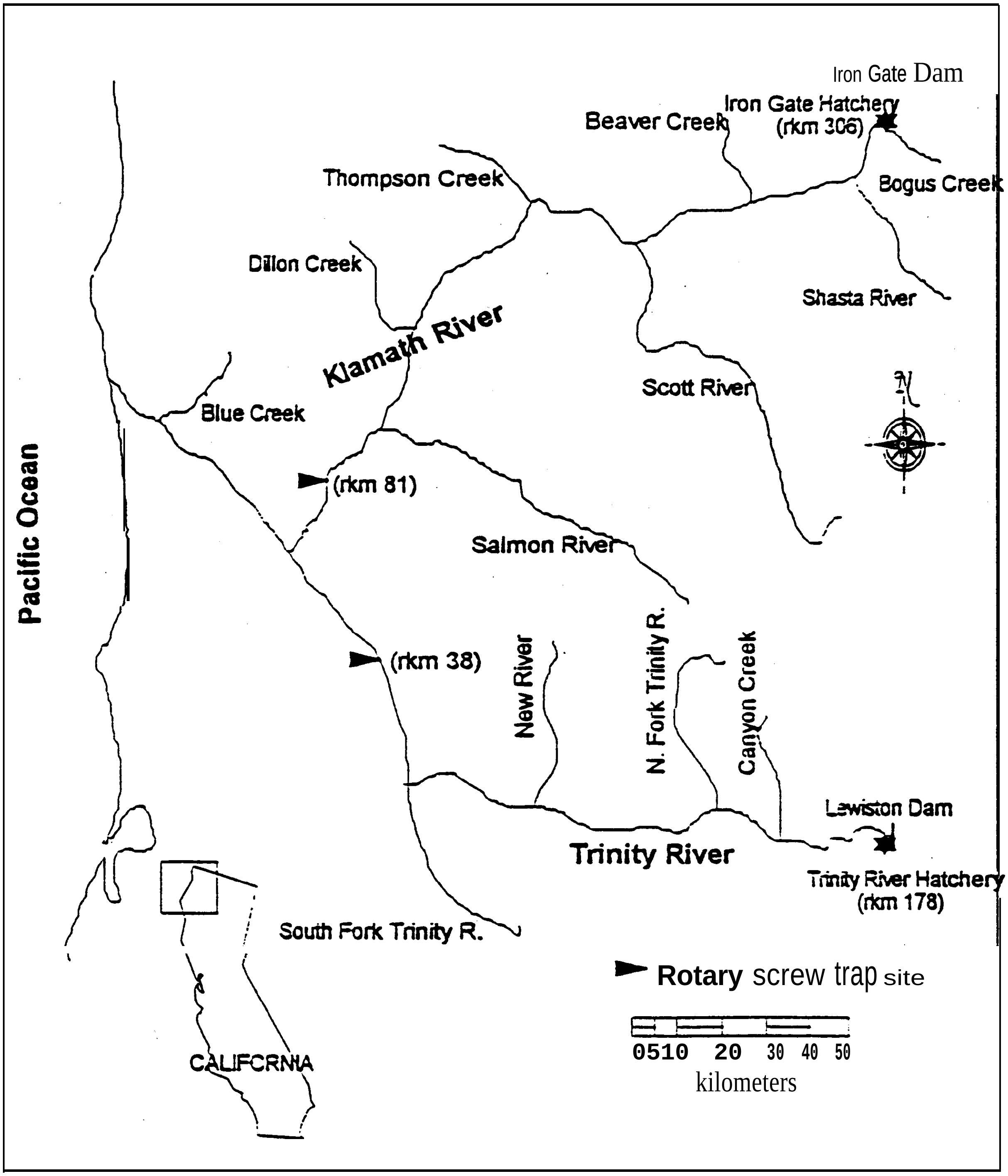

Figure 1. **USFWS juvenile Salmonid monitoring locations on the Klamath and Trinity rivers, 1989-1997.**

Klamath-Trinity confluence), allow for **assessment** of the majority of **each basin's** respective fish production. Information collected include estimates of annual abundance, natural (or wild) and hatchery composition, peak emigration timing, size, health, and age class of emigrating salmonids. Other species captured (sturgeon, lamprey, suckers, sculpin, dace, shad, etc.,) are enumerated and measured to length. Fish health is **assessed** with the cooperation *of* the Service's California-Nevada Fish Health Center (CNFHC) and Humboldt State Univereity. River flow information is provided by the U.S. Geological Survey gauging stations and hourly water temperature data is recorded at the trap sites using Ryan Tempmentor units.

The concurrent monitoring of fish populations, river flow, and water temperature on the Klamath and Trinity rivers has been a crucial asset of the juvenile Salmonid monitoring program. The concurrent monitoring allows us to compare and contrast fish population abundances, migration timing, species compositions, and fish health between the two *river* systems. We also evaluate basin specific factors such as escapement, hatchery operations, river flow, and water temperature as possible influencing factors. **As** might be expected, there are similarities and differences observed each year with respect to fish populations of the two river systems and the factors possibly influencing them.

Of great concern to this office and of relevance to the intent of this letter, has been the consistently poorer health condition and higher mortality rates of fish captured on the Klamath River compared to fish captured at the Trinity River. Since monitoring with rotary traps began in 1989, field crews have consistently noted that during the late spring and summer period, captured **Klamath** River fish appeared less vigorous and had greater rates or intensities of various external parasites, fungus, lesions, or other externally apparent afflictions than did fish captured at the Trinity *river* trap. In addition to the observations of relatively poor health, there has been a consistently higher mortality rate of fish captured at the Klamath River trap than captured at the Trinity River trap. The catch and mortality data presented in Table 3 below are specific to juvenile chinook salmon **as** this is the most abundant species

Table 3. Total juvenile chinook captured during the months of May, June and July with associated mortality and percent mortality, at the Klamath and Trinity river rotary traps from 1992 to 1996.

Year	Klamath River Trap			Trinity River Trap		
	Total Chinook	Chinook Mortality	Percent Mortality	Total Chinook	Chinook Mortality	Percent **Mortality**
1992	5097	102	2.00	43960	176	0.40
1993	8933	72	0.81	5086	36	0.71
1994	55659	1745	3.14	56106	184	0.33
1995	13486	1325	9.83	2353	93	3.95
1996	25973	2004	7.72	13156	163	1.24
Total	109148	5248	4.81	120661	652	0.54

captured. The counts of mortality include those fish that expired while entrained and those that *were* moribund before capture (floated into the trap). Although data presented in Table 3 are specific to juvenile chinook, the differentially higher rates of mortality between the two capture sites are consistent with nearly all fish species typically captured. The higher mortality rate of captured fish at the Klamath River trap is even more alarming considering that the holding time within the traps live box is much less than at the Trinity River trap. Since 1994, during summer (June-August) months, the Klamath River trap has been checked two to four times a day (within a **24** hour period). Prior to 1994 at the Klamath River trap and for all sample years at the Trinity River trap, sampling of the trap catch occurred **just once** in a 24 hour period. It was believed that by decreasing holding time we would reduce the stress levels of the entrained fish and thus lower the mortality rate. It is difficult to say how much higher the mortality **rate** of captured fish at the Klamath River trap would have been without these additional efforts.

In an attempt to determine the causative factors involved with the higher differential mortality rates and apparent poorer health of Klamath River trap captured fish we examined several possible factors. Mortality of trap captured fish may result from many stress-related causes such as the capture itself, and high debris loads and/or high fish densities within the trap's livebox (reduced water quality). *However,* these factors are similar for both traps throughout most of the trapping season and yet mortality rates are always higher for the Klamath River captured fish. The likely causative factor is a reduced health condition of fish on the Klamath River prior to capture at the trap. Health and physiology monitoring of chinook and steelhead smolts in the Trinity and Klamath rivers by the CNFHC has found that Klamath/Trinity basin salmonids are typically exposed to or infected with several disease pathogens during their juvenile life stage. Healthy fish are better able to cope with these infections or avoid infection entirely. However, stressful environmental conditions (e.g., poor water quality, crowding in **raceways,** release from hatchery into the river, etc.,) must usually occur before high intensity of infections are observed (USFWS 1994). Compromised health condition due to disease infection and/or other stress factors (e.g., smolting, high water temperatures) undoubtably increases the probability of mortality prior to and/or following capture.

We first evaluated water temperatures **as a** probable contributing factor to the higher mortality rates of Klamath River fish. However, it **was** fairly apparent that the annual seasonal temperature profiles of the two rivers, as measured at the respective monitoring locations, were very similar (Figure 2). During summer months the mean daily water temperatures at both river locations typically exceeds the EPA's seven-day Chronic Value of **15°C.** The apparent disparity (e.g., high mortality on the Klamath River **and** not on the Trinity River despite similar water temperatures) indicated that water temperature alone was not going to explain the differentially higher mortality rates of Klamath River fish.

Fish mortalities have not been limited to the juvenile salmonid monitoring operations. Significant fish kills have occurred on the Klamath River in the past few years as well. In late June of 1994, Service biologist began observing large numbers of dead and dying juvenile chinook in the Klamath River. Observations were made over a 30 mile section of the river between Presido Bar (river mile (rm) 81) and Bluff Creek (rm 49). Surveys were not conducted upstream of Presido Bar. At this same time, Service biologists and technicians from the Yurok Tribe reported seeing from a few to several hundred dead juvenile chinook on some gravel bars. These observations were made over a 35 mile section of the lower Klamath River from Cappell Creek to the Klamath River estuary.

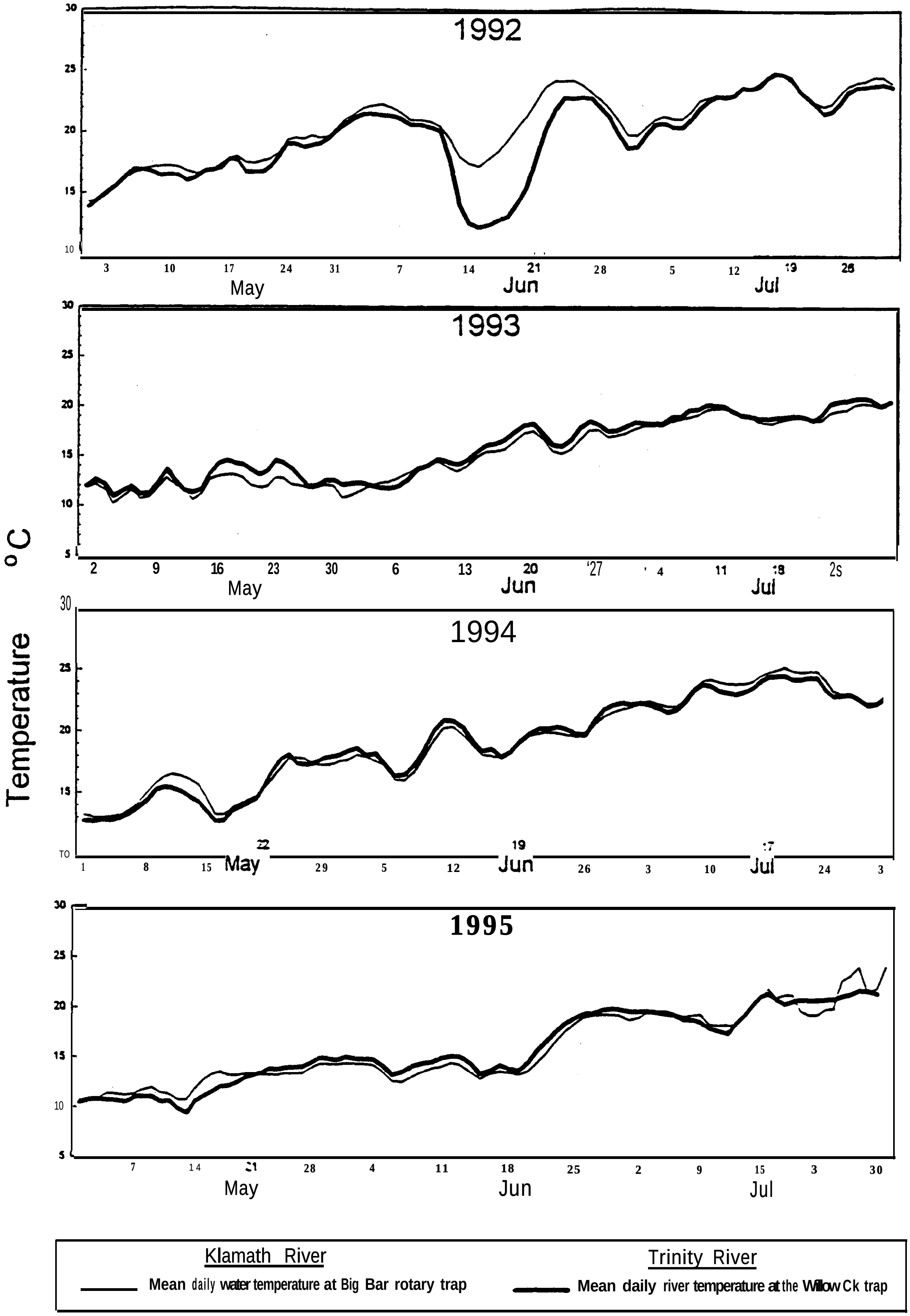

Figure 2. Mean daily water temperature during the months of Hay through July on the Klamath River (trap site = river mile 81) and Trinity River (trap site = river mile 38), for the years 1992-1995.

These same crews also received several reports from tribal fishermen regarding additional mortalities upstream of Cappell Creek. All species were effected to some degree. Observations of dead fish included small numbers of juvenile steelhead and other non-salmonid species. Observations and reports of dead fish continued for several weeks and then abruptly ended. Temperature data collected at the Big Bar trap site on the Klamath River indicated water temperatures peaked (mean daily = 25.1°C) on July 19 and decreased thereafter. Despite a similar temperature profile (mean daily water temperature recorded at the trap site on the Trinity River peaked at 24.4°C (from July 17-19)), no observations of dead or dying fish were made on the Trinity River during this period.

The most recent fish kill occurred on the Klamath River in early August 1997. Our first indications of a problem were the unusually large numbers (up to 50+/day) of dead adult Klamath smallscale suckers captured each day at the trap. Typically, live adult suckers are captured in very low numbers (few each month). Other dead and dying suckers were also observed in the river and along the shoreline. Speckled dace and sculpins (juveniles and adults) were also being captured in usually high numbers and with a high rate of mortality.

Concurrently, Service biologist conducting habitat typing work on the Klamath River reported seeing very high numbers of dead suckers and dace throughout a 75 mile section of the Klamath River from Thompson Creek (rm 123) to Aikens Creek (rm 48). Some mortality of juvenile chinook and steelhead was also observed. Personnel from the California Department of Fish and Game (CDFG) surveyed river areas from Iron Gate Dam (rm 190) downstream to Indian Creek (rm 107) for fish mortalities. Dead fish were only observed in the downstream-most area of the survey (M.Rode, CDFG, personal communication). Mel Willis, CDFG fish pathologist, examined several dead suckers and indicated that the fish may have been suffering from the bacteria Columnaris. The low level of chinook mortality observed in the river and trap, relative to the high chinook mortality observed in 1994, may be attributed to the fact that most chinook had already migrated through this area of river. Trap catches of juvenile chinook in 1997 peaked the week of June 29-July 5, and over 90% of the season catch had been made by July 19. In addition, it appears that some fish (primarily salmonids) were able to locate cool water "refugia" areas in the river. The Service's habitat typing crews observed hundreds of juvenile steelhead and chinook holding in cool water confluence pools below some tributaries. And, despite the fact that mean daily water temperatures at both trap locations (Table 4) exceeded EPA's one-day Acute Value of 20°C throughout July and August, there were no reports or direct observations of dead fish on the Trinity River.

Service biologist collected moribund adult suckers and sculpins for assessment by Dr. Gary Hendrickson at Humboldt State University (report attached as Appendix A). Dr. Hendrickson found high levels of parasites (Lernaea sp.) and bacteria (Flexibacter columnaris and Aeromonas hydrophila) in the suckers and "nearly double the heaviest infection I have ever seen before" of eye flukes (Diplostomulum sp.) in the sculpins. Dr. Hendrickson reported that A. hydrophila bacteria is often present in surface waters with a high organic load and affects fish only when fish are somehow compromised. In summary, Dr. Hendrickson speculated that "fish in the Klamath River are being stressed, probably by poor water quality. The most likely problems are high temperatures, low flows, low DO_2 and high ammonia". Piper et al (1992) associated Columnaris disease with environmental stress conditions such as high water temperature, low oxygen concentration, crowding, and handling (Piper et al 1992).

Table 4. **Absolute minimum** and maximum water temperatures, and average minimum, mean, and **maximum** daily water temperatures by month for July and **August** 1997 at the Trinity and Klamath rivers.

Month	Temperature Criteria	Temperatures (°C) Klamath River	Temperatures (°C) Trinity River
July	Average Daily Minimum	21.3	19.6
	Average Daily Mean	22.0	21.4
	Average Daily Maximum	23.2	23.2
	Absolute Daily Minimum	17.7	16.0
	Absolute Daily Maximum	25.4	24.8
	Date of Absolute Maximum	July 28	July 28
August	Average Daily Minimum	21.9	20.4
	Average Daily Mean	22.6	21.8
	Average Daily Maximum	23.6	23.1
	Absolute Daily Minimum	21.2	18.6
	Absolute Daily Maximum	26.5	25.4
	Date of Absolute Maximum	August 8	August a

To test if problems other than water temperature were contributing to the fish mortality we initiated short-term monitoring of other water quality parameters. On August 9-10 we monitored water temperature and DO_2 concentrations and on August 18-19, we monitored water temperature, DO_2, pH, and nutrient levels. Water samples were taken approximately 2 meters(m) out from shore at two depths (0.2 and 1.4m below surface). Samples were taken every few hours over a 24 hour period at the Big Bar river access on the Klamath River and analyzed using Hach testing procedures and equipment. Results from the August 9-10 sampling indicated DO_2 concentrations were below the EPA's Chronic Value (7.0 mg/l) throughout most of the 24 hour period and were at or below EPA's Acute Value (5.0 milligrams/liter (mg/l)) from approximately midnight to 8:OOam (Table 5).

Dissolved oxygen levels of 5 mg/l or less are generally considered to be lethal or immediately threatening to the survival of most fish species (Campbell 1995, Gwynne 1993). With a water temperature of 20°C, the minimum DO_2 concentrations recommended to protect the health and physiological condition of cold- and warmwater fishes during rearing is 7.8 mg/l. At / the minimum required is 7.4mg/l (Wedemeyer et al. 1976).

By the third week of August, the number of dead fish captured at the Klamath River trap began decreasing. The trap ceased operation on August 20. The results of the water quality sampling conducted on August 18-19 indicated relatively improved temperature and DO_2 conditions (Table 6). The Service's

Table 5. Water temperature and dissolved oxygen concentration data collected over a 24 hour period from August 9-10, 1997, at the Big Bar river access, Klamath River.

Date	Time of Sample	Dissolved Oxygen (mg/l)		Water Temp. (°C)
		Shallow	Middle	
August 9	1200	7.8	7.4	25.0
	1600	6.2	6.0	26.5
	2000	5.6	5.5	24.3
August 10	2400	4.0	4.0	23.1
	0300	3.1	3.1	22.0
	0500	3.8	3.8	23.5
	0600	4.0	4.0	23.2
	0700	5.0	5.0	23.5
	0800	5.4	5.4	23.4
	0900	6.0	6.0	23.0
	1000	7.1	7.0	24.0
	1200	7.6	7.4	25.2
Sample depth: Surface = 0.18 meter, Middle = 1.37 meter				

Table 6. Water quality data collected over a 24 hour period August 18-19, 1997, at the Big Bar river access, Klamath River.

Date	Time of Sample	Dissolved Oxygen mg/l		Water Temp. (°C)	pH	TDS (g/l)	NO3 (mg/l)	Specific Conduct. (ms/cm)
		Shallow	Middle					
8/18	1300	9.4	9.4	22.3	8.6	0.10	1.4	0.20
	1600	8.6	8.6	23.6	8.6	0.10	1.4	0.20
	2000	6.6	6.6	21.3	a.5	0.09	1.5	0.20
8/19	2400	5.3	5.3	20.7	a.4	0.08	1.6	0.19
	0300	5.0	5.0	20.1	a.5	0.08	1.8	0.19
	0500	5.4	5.5	20.3	a.5	0.08	1.7	0.18
	0600	6.0	6.0	20.8	a.4	0.08	1.6	0.18
	0700	6.4	6.4	21.1	a.4	0.09	1.7	0.18
	0800	7.0	7.0	21.4	a.3	0.09	1.8	0.18
	0900	7.3	7.3	21.7	a.2	0.08	1.8	0.17
	1000	7.4	7.4	22.1	a.5	0.09	1.9	0.17
	1200	a.9	a.9	22.1	a.5	0.09	1.6	0.18
Sample depth: Surface = 0.18 meter, Middle = 1.37 meter. NH4 (mg/l) samples negligible								

habitat typing crews also resumed their field activities the week of August 18-22. The crews surveyed the Klamath River from Clear Creek (rm 99) downstream to Ikes falls (rm 64) and reported observing very few dead fish and relatively low fish densities at refugia areas.

During both water quality sampling periods in August, DO* concentrations showed strong diel fluctuations with minimum values observed in the dark early morning hours (midnight to 6:00am). Maximum DO_2 values were observed in the early afternoon hours (10:00am to about 6:00pm). Similar diel fluctuations of DO_2 concentrations have been observed in the Klamath basin on the Shasta River (Gwynne 1993). High DO_2 levels on the Shasta River were attributed to high photosynthetic production of plant matter during the day. Conversely, strong drops in DO_2 concentrations during nighttime hours are likely the result of high biological demand due to respiration of aquatic plants and sediment loads of nutrient rich detritus in the river. Summertime high water temperatures and the growth and respiration cycles of aquatic plants are events which interact synergistically. The negative impact to water quality (and therefore to fish populations) can be much greater than either temperature or DO_2 concentration alone (Campbell 1995).

In summary, the Service agrees that water temperature and nutrients are appropriate "listed pollutants" in the CNCRWQCB's schedule for development of TMDL allocations for the mainstem Klamath River in California. The Service recognizes that water temperatures on both the Trinity and Klamath rivers at the respective trapping locations can be high enough during some summer periods to be stressful to fish populations. However, the relatively greater quantity of aquatic plant growth and nutrient rich detritus of the Klamath River, combined with warm water temperatures in the summer, have resulted in deleterious DO2 concentrations which have directly contributed to occasional fish kills on the river and led to the consistently higher rate of fish mortalities at the Klamath trap.

Therefore, the Service strongly recommends that the CNCRWQCB consider including DO_2 as a listed pollutant in the development of TMDL allocations for the mainstem Klamath River in California. And in order to have any significance, it is imperative that during summer months when high water temperatures can be expected, measurements of DO_2 concentrations include samples taken during those hours when minimum values can be expected (e.g. 3:00am). Further, water quality sampling locations should include additional sites that include several main river channel areas that are relatively of slower relative velocity. It is in these areas that aquatic plant growth, and therefore diel fluctuations of DO_2 levels, may be significant.

If you have any questions or require additional information please contact staff biologist Jim Craig of this office at (707) 822-7201.

Sincerely,

Bruce G. Halstead
Project Leader

cc: Cindy Barry, ARD, FWS, Portland, Oregon
Steve Lewis, Project Leader, FWS, XBERO, Klamath Falls, Oregon
Ron Iverson, Project Leader, FWS, KRFWO, Yreka, California
Karl Witkus, Area Manager, BOR, Klamath Project, Klamath Falls, Oregon
Rich Elliot, Regional Manager, CDFG, Region 1-HQ, Redding California
Troy Fletcher, Fishery Program Director, Yurok Tribe, Klamath, California.
Mike Orcutt, Natural Resources Director, Hoopa Tribe, Hoopa, California
Leaf Hillman, Director, Department of Natural Resources, Karuk Tribe of California, Orleans, California
Don Reck, NMFS, Eureka, California

with attachments

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Personal Communication

Rode, M. August 13, 1997. California Department of Fish and Game - Region One, Inland Fisheries Division, Shasta, California.

HUMBOLDT
STATE
UNIVERSITY

Department of Fisheries
August 21, 1997

TO: All interested parties

FROM: Dr. Gary L. Hendrickson

SUBJECT: Fish mortalities on Klamath River

I was contacted separately by several people concerning fish mortalities especially among suckers on the Klamath River. I ended up examining some fresh dead fish obtained from the USFWS's trap at Big Bar. My findings are as follows:

Catostomus rimiculus - **Klamath finescale** sucker

I examined four specimens. The two larger specimens all had pronounced external lesions primarily at the bases of the fins. Parasitic copepods commonly known as anchor worms (Lernaea sp.) or anchor worm scars were almost always associated with the lesions. In addition, there were numerous anchor worms on the gills. primarily the gill arches. Cytophaga-like bacteria (probably Fiexibacter columnariis) also occurred on the gills. Gills were clearly hyperplastic but whether this was due to Lernaea, the bacteria, or some problem in water quality could not be determined.

I examined smears from the lesions. Smears contained large numbers of short rods and a few Cytophaga-like bacteria, probably Flexibacter columnaris. I did bacterial isolations from the lesions and from the kidney of one of the suckers on Tryptic Soy Agar (TSA- note that TSA will not support growth of Cytophaga-like bacteria). Aeromcnas hvdroohifa (causative agent of **Aeromonas** hemorrhagic septicemia) was isolated from both lesion and kidney. This bacteria is often prevalent in surface waters with a high organic load and affects fish only when fish are somehow compromised. I would speculate that Lernaea punched the initial holes in the fish and the bacteria gained access through these holes. Isolation irom the kidney is noteworthy because it indicates that bacteria have become systemic (are circulating in the blood). Bacteria were identified using the API 20-E bacterial identification system so I feel confident that this is an accurate diagnosis.

Cottus **rimiculus - slender sculpin**

I examined two specimens. Both specimens had enormous numbers of eye flukes (Diplostomulum so.) in the retinas of the eye. These are the metacercarial stage of a digenetic trematode which reaches sexual maturity in a fish-eating bird probably a seagull. Fish are infected by coming into contact with a free-swimming stage (cercaria) which are produced through an asexual process in snails (most likely Lymnaea but occasionally Phvsa). One eye contained close to 1,000 parasites. I have studied eye flukes quit a bit and this is nearly double the heaviest infection I have ever seen before. One sculpin had two Lernaea as well as the eye flukes.

COMMENTS

The life cycle of Lernaea is complex and involves many larval stages separated by molts. The speed of the life cycle is directly related to water temperature (faster at higher temperatures). In addition, Lernaea tends to be seasonal (bloom in the summer, die off in the winter. Thus, you do not usually see problems with Lernaea in coldwater fishes because the fife cycle proceeds so slowly that numbers do not build up enough in the summer to kill fish before the parasites start to die back off in the fall. In rivers, Lernaea is less likely to be a problem because the infective stage is blown downstream after only a short time.

Both Lymnaea and Fhvsa are air breathing snails. The tend to bloom in our north coast rivers only when the flows are low and the temperatures are warm. Even then the probably frequent the backwaters more than the mainstream. When these snails bloom you get eye flukes.

Both Aeromonas hydrophila and Fiexibacter columnaris are bacteria which occur naturally in the environment Normally they affect fish only when the fish is somehow stressed by some other factors. Such factors are often environmental such as unusually high temperatures, low dissolved oxygen, low flows, etc. Both are rather classic “stress mediated diseases”.

Based on my experience, I would speculate (and it is only speculation) that the fish in the Klamath River are being stressed, probably by poor water quality. The most likely problems are high temperatures. low flows, low DO, and high ammonia. Fish of course try to maintain homeostasis. More stress means that more energy is require5 to maintain homeostasis. This energy is obtained by "shorting" other requirements including the immune system. Consequently, ubiquitous bugs can become a problem. Unfortunately, these water quality parameters also favor completion of certain parasite life cycles which only exaggerates the problem. I would expect the mortalities to cease when the water quality improves, presumably when it cools off (more oxygen. less ammonia) in the fall.

I hope that this has been of some help. Do not hesitate to call me if you have further questions. My number is (707) 826-4233 at work and (707) 822-8657 at home. If anybody is interested in supporting continued work on this problem, I am sure that I could come up with a graduate student.