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Reference # 65

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Review of Russian River Water Quality Objectives for Protection of Salmonid Species Listed Under the Federal Endangered Species Act

August 18, 2000

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by

Staff to the Regional Water Quality Control Board
North Coast Region
5550 Skylane Boulevard, Suite A
Santa Rosa, CA 95403

Robert Klamt, Contract Manager
Peter Otis, Project Leader
Gail Seymour, Environmental Specialist
Fred Blatt, Environmental Specialist

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BACKGROUND

Under the Federal Endangered Species Act of 1973 (ESA), the National Marine Fisheries Service (NMFS) listed steelhead trout (*Oncorhynchus mykiss*) in August, 1997, coho salmon (*Oncorhynchus kisutch*) in October, 1996, and chinook salmon (*Oncorhynchus tshawytsch*) in September, 1999, as threatened species within the Russian River watershed (referred to in this report as the "Species"). The ESA prohibits certain activities that directly or indirectly affect survival of threatened species.

The California Regional Water Quality Control Board, North Coast Region (Regional Water Board) has adopted in its *Water Quality Control Plan for the North Coast Region* (Basin Plan) water quality objectives for the protection of beneficial uses of water. Also contained in the Basin Plan are implementation mechanisms by which the objectives can be met. For the Russian River watershed, a discharger prohibition limiting waste discharges to the period of October 1 through May 14 and at 1% of the receiving water flow, and effluent and receiving water limitations are adopted into waste discharge requirements and federal NPDES permits (Permits) to ensure that water quality objectives are met. As such, the water quality objectives are critical elements of water quality protection.

The Regional Water Board has conducted a review of its existing water quality objectives under contract with the Sonoma County Water Agency (SCWA) for comparison to the water quality requirements of the listed species. This analysis helps determine to what degree the current water quality objectives support the water quality requirements of these species. Where additional protection of the listed anadromous species appears warranted, staff proposes recommendations for amending the Basin Plan to add protection. It is proposed that the additional protection be added to the Basin Plan as a section which specifically addresses listed anadromous species and specifies water quality goals for increased protection. The exact format of the Basin Plan amendment is not known at this point, but conceptually, it will contain new water quality objectives, goals where objectives are not appropriate, and an implementation plan. The implementation plan process will include factors not discussed in this document (such as economics) that may affect the numeric objectives themselves or the manner in which they are expressed and the actions expected to attain them. Numerous comments were received in a previous draft of this report that pertain to implementation. Those documents and suggestions will be incorporated into the Basin Plan amendment process.

As part of the process of modifying water quality objectives, the Regional Water Quality Control Board will consider factors specified in Water Code Section 13241 and propose a program of implementation or mechanisms for achieving the objectives consistent with Section 13242. This may lead to adjustment of the objectives and/or goals recommended herein. For example, if a goal or objective is found not to be reasonably achievable due to natural or other uncontrollable factors, implementation mechanisms would reflect that. Explanation of those factors and resulting proposed implementation will be discussed in the documents proposing a Basin Plan amendment. Those documents also will address questions of geographic specificity.

This report outlines the approach taken for review of the water quality objectives, some comparison of existing and proposed objectives to existing water quality data, and proposed recommendations. Individual reviews of the pollutants/characteristics and attendant water quality objectives are presented as separate chapters within this report.

A January, 2000 draft was reviewed by other agencies with jurisdiction and interest in the Species:

- NCRWQCB management – clarity, adequacy and approach
- State Water Board legal, water rights and water quality staff – approach and consistency with statewide policy and standards
- USEPA staff – approach and consistency with federal Clean Water Act provisions

- National Marine Fisheries Service – adequacy in protecting Species under FESA
- California Department of Fish and Game – adequacy in protecting Species
- Sonoma County Water Agency – approach, adequacy in protecting the Species, and regulatory implications

REVIEW APPROACH

We reviewed eight pollutants/chemicals or water quality characteristics:

Dissolved Oxygen	Sediment (settleable material, sediment deposition, turbidity, suspended sediment)
Hydrogen Ion (pH)	Aluminum
Temperature	Barium
Oil and Grease	Nutrients

The review included three narrative objectives and five numeric objectives. Our thrust was to determine if a current objective was protective of aquatic life, especially the Species, and if not, what might be a more reasonable objective. For each pollutant/characteristic, we performed literature reviews, relying heavily on USEPA "criteria documents" where available and current. Other scientific literature supplemented that information, and for some pollutants/characteristics formed the majority of the basis for a proposed change to the water quality objective.

We then assessed implementation of the objective through the permit process and compliance with the objective under the existing regulatory framework. That work is still in progress and is reported on only partially in this report for specific objectives. While we believe the concept of including objectives in permits as effluent and receiving water limitations is sound, we recognize implementation must be evaluated. The Basin Plan amendment process will more fully address implementation mechanisms.

As a logical extension of the literature review and compliance assessment, proposed recommendations suggest three basic alternatives or combinations:

1. No change – the water quality objective and its implementation are adequate
2. Change the objective – the water quality objective is not adequate to ensure "no take" and a recommendation for a revised objective or target is proposed
3. Change the regulatory framework – though the objective is adequate, the implementation is not, and a recommendation for modifying the framework is proposed

Notable exceptions to the above approach are for toxicity and the "priority pollutants" that were promulgated by USEPA in the California Toxics Rule. Clean Water Act provisions require the State to include the criteria adopted in the CTR within Permits. Our review would have been redundant, and implementation within Permits is required. A Basin Plan amendent will need to be adopted to align it with the CTR. Of these metals, for example, cadmium, copper, mercury and selenium pose particular problems for salmonids and will need to be regulated at stricter levels than those currently in place. As the result of formal ESA Section 7 consultation with NMFS on the CTR, within four years ambient water quality criteria for mercury, selenium and cadmium will be developed that are expected to be more protective of salmonids. However, NMFS believes the alternative criteria proposed in the biological opinion are the minimum needed to adequately protect listed salmonids and recommends that they should be immediately incorporated into the Russian River water quality objectives. Another exception was for color, tastes and odors, floating material, bacteria, and radioactivity.

Life History Requirements (LHR)
Staff conducted extensive literature reviews and interviews to research the water quality life history requirements of the Species in the Russian River system. Staff investigated the most pertinent requirements, including: temperature, dissolved oxygen, pH, sediment, suspended material, settleable material, turbidity, toxicity, pesticides, and chemical constituents. When possible, requirements were summarized by four life stages, specifically: adult migration, embryo incubation/fry emergence (hatching), freshwater rearing, and seaward migration. After determining the LHR of the Species, staff compared those requirements to the existing water quality objectives listed in the Basin Plan. Where the objectives appeared to support the survival of the Species, no changes were recommended. Where it appeared objectives needed refinement to provide protection of the Species (i.e., realigned with the LHR), staff provided recommendations for amending objectives. Beneficial use designations were also reviewed and recommendations presented where warranted.

Comparison to Existing Data
This element of the project has reached an interim milestone, and will be expanded with new data and to some extent through scenario analysis with a refined Russian River water quality model. Current data are sparse for tributaries for most of the pollutants/characteristics reviewed, with the exception of temperature. Mainstem water quality data go back into the early 1970s, but more recent information is sparse as well. Stepped-up data collection efforts in the future will fill some of the data gaps and provide for a more thorough analysis in the Basin Plan amendment process.

At this point, the analysis is cursory and primarily for the key mainstem Russian River stations, except for temperature which includes tributaries. We have recently organized a Russian River interagency temperature monitoring workgroup which will facilitate collaboration in the collection and sharing of temperature data in the tributaries of the Russian River watershed. It is the objective of the Board to continue to collect data and synthesize data collected by the Board and others to provide a more accurate picture of the site-specific effects of various activities in the Russian River watershed, their affect on water quality, and the corresponding affect on protected salmonid populations. The interim report is appended to this report. Summary statements of implementing mechanisms are provided for each pollutant/characteristic in the individual chapters of this report.

OBJECTIVES SUMMARY

Water quality standards are comprised of the designated beneficial uses of water and water quality objectives to protect those beneficial uses along with an antidegradation statement. The Basin Plan identifies and describes the beneficial uses of water for the Russian River. Those of most concern for protecting the Species are summarized in Table 1.

Table 1. Summary of Beneficial Water Uses of Concern for the Russian River

Beneficial Water Use	Description
Cold Freshwater Habitat (COLD)	Use of water that supports water ecosystems including, but not limited to, preservation or enhancement of aquatic habitat, vegetation, fish, or wildlife, including invertebrates.
Migration of Aquatic Organisms (MIGR)	Uses of water that support habitat necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.
Spawning, Reproduction, and/or Early Development (SPAWN)	Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.
Estuarine Habitat (EST)	Uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitat, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds).
Rare, Threatened, or Endangered Species (RARE) *	Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened or endangered.

* The Russian River is currently not designated RARE, but it is staff's recommendation to add this designation.

The Basin Plan also lists the water quality objectives that apply to the Russian River. The objectives are narrative and numeric values, summarized in Table 2a along with any discharge prohibitions applicable to the Russian River.

Table 2a. Summary of existing Water Quality Objectives and Prohibitions for the Russian River

Water Quality Objective	Description
NARRATIVE OBJECTIVES	
Color	Waters shall be free of coloration that causes nuisance or adversely affects beneficial uses.
Taste and Odors	Water shall not contain taste- or odor-producing substances in concentrations that impart undesirable tastes or odors to fish flesh or other edible products of aquatic origin, or that cause nuisance or adversely affect beneficial uses.
Floating Material	Waters shall not contain floating material, including solids, liquids, foams, and scum, in concentrations that causes nuisance or adversely affects beneficial uses.
Suspended Material	Waters shall not contain suspended material in concentrations that causes nuisance or adversely affects beneficial uses.
Settleable Material	Waters shall not contain substances that result in deposition of material that causes nuisance or adversely affects beneficial uses.
Oil and Grease	Water shall not contain oils, greases, waxes, or other materials in concentrations that result in a visible film or coating on the surface of

Water Quality Objective	Description
	the water or on objects in the water, that cause nuisance, or that otherwise adversely affect beneficial uses.
Biostimulatory Substance	Water shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growth causes nuisance or adversely affect beneficial uses.
Sediment	The suspended sediment load and suspended sediment discharge rate of surface water shall not be altered in such a manner as to causes a nuisance or adversely affect beneficial uses.
Temperature	The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Water Board that such alteration in temperature does not adversely affect beneficial uses. At no time or place shall the temperature of COLD water be increased by more than 5°F above natural receiving water temperature.
Toxicity	All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.
Pesticides	No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses. There shall be no bioaccumulation of pesticide concentrations found in bottom sediments or aquatic life.
Chemical Constituents	Waters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the limits specified in California Code of Regulations, Title 22, Chapter 15, Division 4, Article 4, Section 64435 and Section 64444.5.
NUMERIC OBJECTIVES	
Turbidity	Turbidity shall not be increased more than 20 percent above naturally occurring background levels.
Dissolved Oxygen	Dissolved oxygen concentrations shall not conform to those limits listed in Table 3-1 of the Basin Plan (Water Quality Objectives). For waters not listed in Table 3-1, and where dissolved oxygen objectives are not prescribed, the dissolved oxygen concentrations shall not be reduced below the following minimum levels at any time. Waters designated WARM, MAR, or SAL.. 5.0 mg/L Waters designated COLD......................6.0 mg/L Waters designated SPWN......................7.0 mg/L Waters designated SPWN during critical Spawning and egg incubation periods......9.0 mg/L At a minimum, waters will contain 7.0 mg/L at all times. Ninety percent of the samples collected in any year must contain at least 7.5 mg/L. Fifty percent of the monthly means in any calendar year shall contain at least 10.0 mg/L.
pH	The pH shall conform to those limits listed in Table 3-1 of the Basin Plan (Water Quality Objectives). For waters not listed in Table 3-1, and where pH objectives are not prescribed, the pH shall not be depressed below 6.5 nor raised above 8.5. Changes in normal ambient pH levels shall not exceed 0.2 units in waters with designated marine (MAR) or saline (SAL) beneficial uses nor 0.5 units within the range specified above in fresh waters with

Water Quality Objective	Description
	designated COLD or WARM beneficial uses. The pH of waters will always fall within the range of 6.5 to 8.5.
2,4-D PGBE ester	No sample shall exceed 40 parts per billion acid equivalent. No series of samples averaged over a 24-hour period shall exceed 2 parts per billion acid equivalent.
PROHIBITIONS	
The discharge of soil, silt, bark, slash, sawdust, or other organic and earthen material from any logging, construction, or associated activity of whatever nature into any stream or watercourse in the basin in quantities deleterious to fish, wildlife, or other beneficial uses is prohibited.	
The placing or disposal of soil, silt, bark, slash, sawdust, or other organic and earthen material from any logging, construction, or associated activity of whatever nature at locations where such material could pass into any stream or watercourse in the basin in quantities deleterious to fish, wildlife, or other beneficial uses is prohibited.	
There shall be no discharge of 2,4,5-T or 2,4,5-TP to waters of the State within the North Coast Region.	
"...point source waste discharges... are prohibited in the following locations in the Region: ... 4. The Russian River and its tributaries during the period of May 15 through September 30 and during all other periods when the waste discharge flow is greater than one percent of the receiving stream's flow as set forth in NPDES permits. ..."	

Table 2b is a comparison of Basin Plan objectives to recent USEPA criteria.

Table 2b. Basin Plan water quality objectives versus USEPA criteria summary.

Chemical or Pollutant	USEPA NTR [1] Current Criteria (µg/L)	USEPA CTR Proposed [2] (8/5/97) (µg/L)	USEPA National Recommended [3](12/10/98) (µg/L)	REGION I Basin Plan [4] (µg/L)	COMMENTS
Aluminum	N/A	N/A Non-priority	750 CMC [5] 87 CCC	1,000	In pH 6.5-9.0; expressed as total recoverable metal and in water w/hardness of 100 mg/L as CaCO3; EPA non-priority pollutant
Arsenic	360 CMC 190 CCC	340 CMC 150CCC	340 CMC 150 CCC	50	Expressed as dissolved metal and as total arsenic
Barium	None	N/A Non-priority	N/A	1,000	Experimental data=insoluble barium concentration in freshwater would have to exceed 50K µg/L before toxicity to aquatic life would occur. EPA non-priority pollutant
Cadmium	3.7 CMC 1.0 CCC	4.3 CMC 2.2 CCC	4.3 CMC 2.2 CCC	10	Expressed as dissolved metal; in hardness of 100 mg/L as CaCO3
Chromium (III)	N/A	570 CMC 74 CCC	570 CMC 74 CCC	50	Expressed as dissolved metal; in hardness of 100 mg/L as CaCO3; Not specific to valence state
Chromium (VI)	15 CMC 10 CCC	16 CMC 11 CCC	16 CMC 11 CCC		Expressed as dissolved metal; in hardness of 100 mg/L as CaCO3 Not specific to valence state
Copper	17 CMC 11 CCC	13 CMC 9 CCC	13 CMC 9 CCC	Not listed	Expressed as dissolved metal; in hardness of 100 mg/L as CaCO3
Lead	e(1.273[ln(hardness)]-4.705) CMC e(1.273[ln(hardness)]-1.460) CCC	N/A	65 CMC 2.5 CCC	50	Expressed as dissolved metal; in hardness of 100 mg/L as CaCO3; EPA currently working on Nat'l recommended criteria. Expected to change significantly
Mercury	2.4 CMC 0.012 CCC	1.4 CMC 0.77 CCC	1.4 CMC 0.77 CCC	2	Expressed as dissolved metal; methylmercury
Selenium	260 CMC 35 CCC	CMC N/A 5 CCC	CMC N/A 5 CCC	10	EPA is recalculating CMC based on "additive" selenium. The CCC is expressed as total recoverable metal and in hardness of 100 mg/L as CaCO3
Silver	e(1.72[ln(hardness)]-6.52)	CMC N/A CCC N/A	3.4 CMC CCC N/A	50	Expressed as dissolved metal; in hardness of 100 mg/L as CaCO3 EPA has not determined National recommended CCC criteria for silver
Sediment	N/A	N/A	N/A	Amounts deleterious	Narrative objectives prohibiting deposition, nuisance, or adverse effect on beneficial uses

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ıemical or ·llutant	USEPA NTR [1] Current Criteria (µg/L)	USEPA CTR Proposed [2] (8/5/97) (µg/L)	USEPA National Recommended [3](12/10/98) (µg/L)	REGION I Basin Plan [4] (µg/L)	COMMENTS
ıidity	N/A	N/A	N/A	<20% increase	Increase compared to "natural backgournd levels"
perature	N/A	N/A	N/A	<5° increase	Increase compared to "natural receiving water temperature" and not to increase unless it "does not adversely affect beneficial uses."
ients	N/A	N/A	N/A	No toxicity and no biostimulatio n	Narrative objectives prohibit toxicity to aquatic life and promotion of aquatic growths that "cause nuisance or adversely affect beneficial uses.
nd ɜe	N/A	N/A	N/A	Amounts deleterious	Narrative objective that prohibits visible film or coating "that cause nuisance, or that otherwise adversely affect beneficial uses.
	N/A	N/A	N/A	6.5 – 8.5	Minimum of 6.5 units and maximum of 8.5 units; no discharge shall change pH more than 0.5 units within that range

. Environmental Protection Agency. 1986. Quality Criteria for Water 1986. Office of Water, EPA 440/5-86-001.

. Environmental Protection Agency. 1997. Water Quality Standards: Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Proposed Rule. Federal Register, Vol. 62, No. 150: August 5, 1997.

. Environmental Protection Agency. 1998. National Recommended Water Quality Criteria; Notice; Republication. Federal Register, Vol. 63, No. 237: December 10, 1998.

chemical constituents, the objectives are for beneficial use MUN, domestic and municipal drinking water supply. For other beneficial uses, the narrative ective prohibits toxic chemicals in toxic amounts. For other beneficial uses, the objectives are narrative. NCRWQCB. 1994. Water Quality Control Plan for the th Coast Region. North Coast Regional Water Quality Control Board, Santa Rosa, CA

. = Continuous Criteria Concentration; CMC = Continuous Maximum Concentration

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General Life History of the Species

The life cycles of anadromous salmonids are complex and remarkable. While each of the three Species have slightly different strategies, timing, and spatial distributions within a river system, they all follow the same general pattern. After maturing in the ocean for anywhere from 1-4 years, the fish begin entering the Russian River system in fall for spawning. As flow and water quality conditions allow, fish migrate to their natal spawning grounds and build nests or redds in the river gravel for spawning. After spawning, chinook and coho salmon die while steelhead are capable of migrating back to the ocean and returning another year to spawn again. After 1-3 months of incubation in the gravel, fry hatch, emerge, and seek the safety of protected, slow moving water as they feed and avoid predation. The young coho and steelhead rear in fresh water for 1-4 years before migrating back to the ocean to start the cycle over again. Young chinook on the other hand rear in freshwater for several months before returning to the ocean.

Timing of Life History Events for Species in the Russian River

The timing of life history events for the Species in the Russian River are summarized in Tables 3a, b, and c. It should be noted that the timing of the events presented in those tables is somewhat general in nature as environmental conditions ultimately determine when a species will begin, conduct, and complete life cycle events. The three tables present three different timing scenarios of life history stages (LHS) for Russian River coho salmon, steelhead trout and chinook salmon. Our review of and proposal for objectives was based on Table 3a, which was derived from a number of sources and discussions with local professionals, agency and private. Upon receiving comments from reviewers of this draft, we have concluded that further analysis is required to determine which of these tables, or possibly a combination of, most accurately reflects the timing of the Species. That analysis will be presented in the Basin Plan amendment documents.

Coho Salmon

Adult coho can enter the Russian River as early as mid-October with migration lasting through mid-February. The migration peak usually occurs in mid-November through mid-January. Spawning can occur anytime after fish have reached natal spawning grounds and environmental conditions permit, but generally occurs December through February. Coho salmon remain in the stream and die after spawning. The initiation of embryo incubation coincides with spawning and lasts through mid-April. Young coho rear in freshwater for one to two years before migrating back to sea to begin the process again. The seaward migration of juveniles begins in February and extends through mid-June, with the peak occurring in April.

Steelhead Trout

Adult steelhead begin migrating into the Russian River in mid-November and can continue through mid-May with the peak typically occurring in mid-December through mid-March. Spawning can occur anytime after fish have reached natal spawning grounds and environmental conditions permit but typically occurs January through March. As a repeat spawner, adult steelhead begin migrating back the sea after spawning. Incubation of embryos coincides with spawning and can last through mid-June. Young steelhead rear in freshwater for at least one year and up to four years before migrating back to sea to begin the process again. The seaward migration of juveniles begins in January and extends through mid-June, with the peak occurring in April.

Chinook Salmon

Adult chinook migrate the earliest of Russian River anadromous salmonids. They can begin entering the river as early as mid-September, as environmental conditions allow, with migration lasting through mid-December. The migration peak typically occurs in October. Spawning can occur anytime after fish have reached natal spawning grounds and environmental conditions permit.

This is typically occurs October through January. As with coho salmon, chinook salmon remain in the stream and die after spawning. Incubation of embryos coincides with spawning but persists through March. Young chinook rear in freshwater for several months, usually February through mid-June, and then migrate back to the ocean. They may spend a significant portion of time in the estuary.

INDIVIDUAL POLLUTANT REPORTS

The reviews of water quality objectives follow as individual chapters to this report.

References Cited

Jones and Stokes Associates, Inc. 1985. Fisheries study of the increased use of the existing Russian River projects – alternative for the Sonoma County Water Agency Water Supply and Transmission System Project, Figure 2-2.

Steiner Environmental Consulting, 1996. A history of the salmonid decline in the Russian River, Potter Valley, California, 12 + 71 pgs.

Trinity and Associates, Inc. 1994. Status of steelhead populations in California in regards to the Endangered Species Act: background report prepared for the Association of Water Agencies – Russian River. Arcata, CA, 3 + 99 pgs.

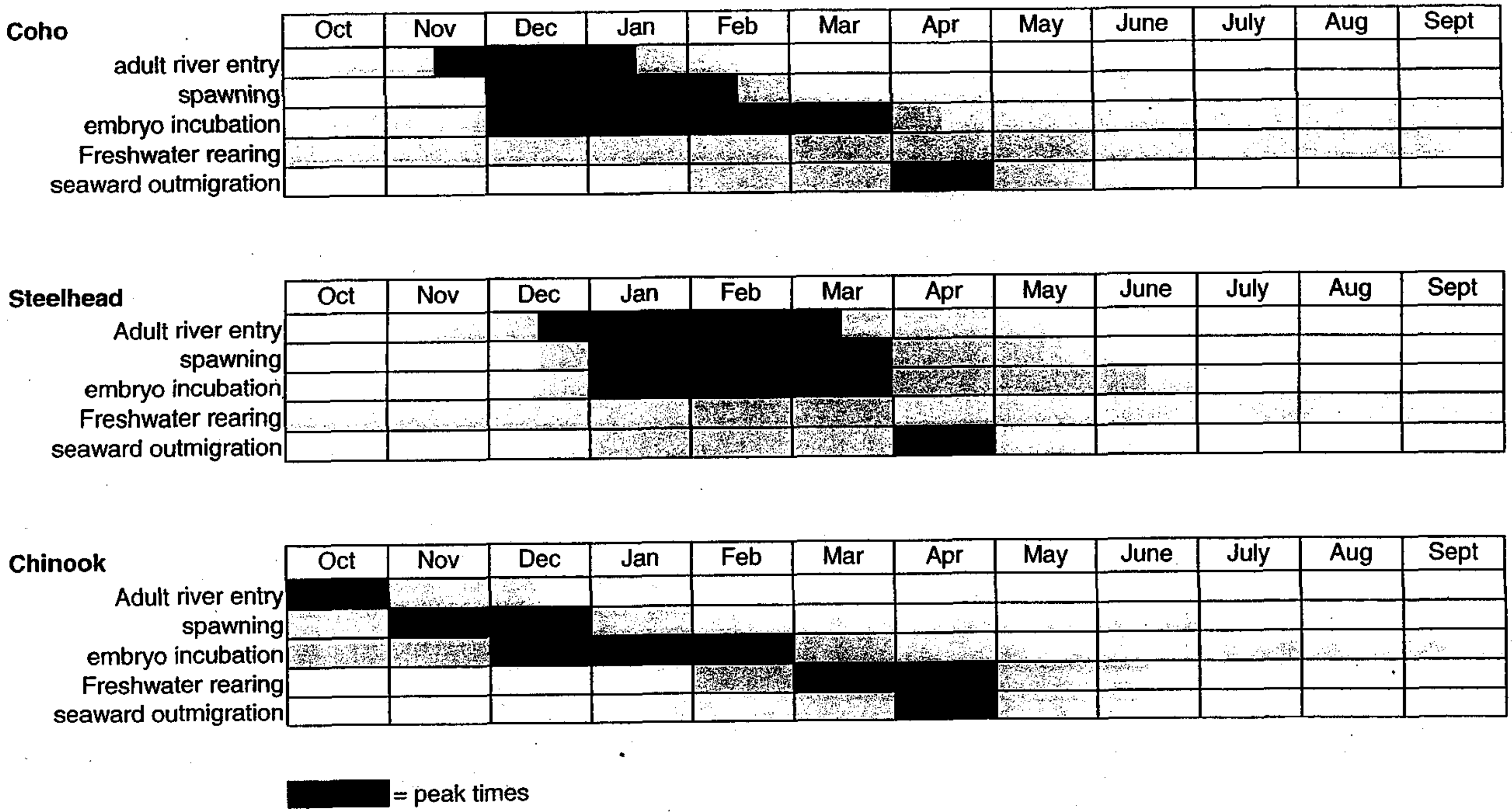
U. S. Environmental Protection Agency. 1986. Quality criteria for water 1986. Office of Water, EPA 440/5-86-001.

U. S. Environmental Protection Agency. 1997. Water quality standards: establishment of numeric criteria for priority toxic pollutants for the State of California, proposed rule. Federal Register, Vol. 62, No. 150: August 5, 1997.

U. S. Environmental Protection Agency. 1998. National recommended water quality criteria; notice; republication. Federal Register, Vol. 63, No. 237: December 10, 1998.

North Coast Regional Water Quality Control Board. 1996. Water quality Control Plan for the North Coast Region. Santa Rosa, CA

Table 3a Timing of life history stages for Russian River coho salmon, steelhead trout, and chinook salmon. Multiple sources were used for this table, including agency and private professionals.



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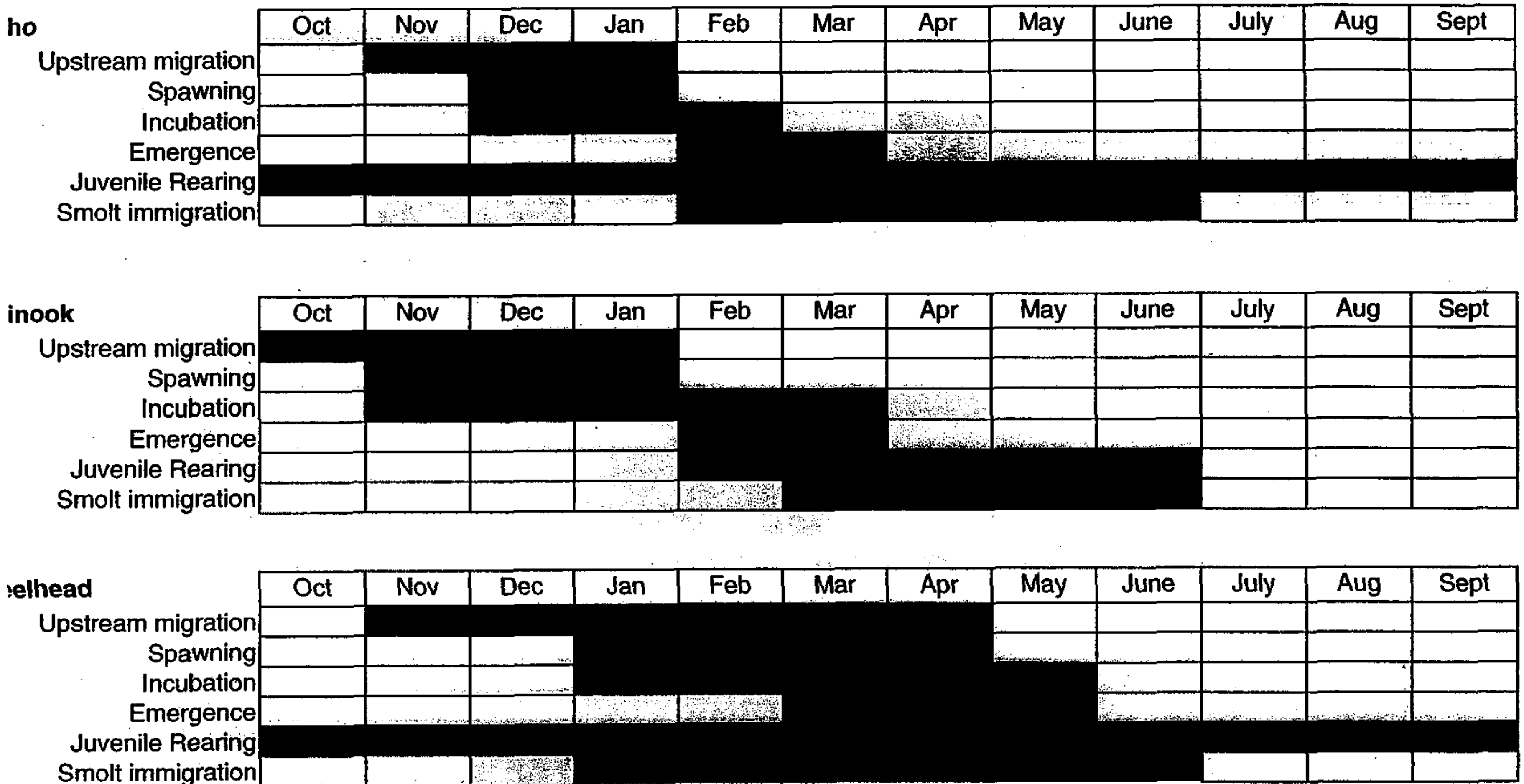
ble 3b
ning of life history stages in the Russian River for chinook, coho, and steelhead (from Trinity Associates Inc. 1994; Steiner Environmental nsulting, 1996)



DISSOLVED OXYGEN

Background

Adequate concentrations of dissolved oxygen (DO) are critical for the survival of fish, invertebrates, and other aquatic life. Salmonids are very sensitive to reduced DO concentrations. Reduced levels of DO impact growth and development of different life stages of salmon, including eggs, alevins, and fry, as well as the swimming, feeding, and reproductive ability of juveniles and adults. Such impacts can affect fitness and survival by altering embryo incubation periods and thus the timing of life cycles, decreasing the size of fry, increasing the likelihood of predation, and decreasing feeding ability. While most natural waters have adequate DO levels for the normal function of aquatic life, impacts from large amounts of organic debris, nutrients from sewage or agricultural runoff, sedimentation of spawning redds, and elevated temperature can reduce DO concentrations or the availability of DO.

The different life stages of salmonids vary in their sensitivity to changes in DO and the levels required for survival. Migrating adults need adequate levels of DO to sustain upstream swimming. Embryos and alevins need high levels of DO to develop and survive, and juveniles need adequate DO to grow, feed, avoid predation, and survive to successfully reach the ocean.

Life History Requirements (LHR)

Literature reviews were conducted to determine dissolved oxygen requirements for steelhead trout (*Oncorhynchus mykiss*), coho salmon (*Oncorhynchus kisutch*), and chinook salmon (*Oncorhynchus tshawytscha*). When possible, requirements are summarized by four life stages of the species: upstream migrating adults, spawn/incubation, freshwater rearing, and seaward migration. In general, there were some references specific to the DO requirements of the individual Species but most of the information covered salmonids as a general group of fish. Therefore, the following information applies to salmonids in general, with specific species references as appropriate.

Adult Migration – mid-October to mid-May for three Species combined

The upstream migration by adult salmonids is typically a stressful endeavor. Sustained swimming over long distances requires high expenditures of energy and therefore requires adequate levels of dissolved oxygen. Davis et al. (1963) reported that maximum sustainable swimming speeds of juvenile and adult coho salmon were reduced when DO dropped below saturation at temperatures between 50-68 °F. Further, swimming performance dropped sharply when DO was decreased to 6.5-7.0 mg/L at all temperatures studied. Migrating adults exhibited an avoidance response when DO was below 4.5 mg/L and resumed migration when DO was at 5.0 mg/L (Hallock et al. 1970). McMahon (1983) recommends DO levels > 6.3 mg/L for successful upstream migration of anadromous salmonids.

EPA (1986) presents the following table for salmonid life stages other than embryonic and larval:

Level of effect	Water Column mg/L
No Production Impairment	8
Slight Production Impairment	6
Moderate Production Impairment	5
Severe Production Impairment	4
Limit to Avoid Acute Mortality	3

Summary: For migrating adult salmonids, surface water DO should not be depressed below 7.0 mg/L or 80% saturation, whichever is greater. A DO level of 7.0 mg/L builds in some margin of safety for migrating fish.

ıble 3c
ɜasonal Pattern of Life History Events of Major Anadromous Fish Species in the Russian River (from Jones and Stokes Associates, Inc. 1985)

oho	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Upstream migration		■ (late)	■	■	■ (early)							
Spawning		■ (late)	■	■	■	■ (early)						
Downstream migration				■	■	■	■	■ (early)				

teelhead	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Upstream migration		■	■	■	■	■	■					
Spawning			■	■	■	■	■					
Downstream migration						■	■	■	■	Adults		
Downstream migration			■	■	■	■	■	■	■	Young		

hinook	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Upstream migration	■	■	■ (early)								■ (late)	■
Spawning		■ (late)	■	■	■	■ (early)						
Downstream migration					■ (late)	■	■	■	■			

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Embryo Incubation and Fry Emergence – December to mid-June for all three Species combined

While spawning is closely tied to incubation in time, the requirements for each are different. Spawning requirements apply to adults while incubation refers to the eggs. The water quality requirements for spawning salmonids mimic those discussed above for migration, and as such, the following information addresses the DO requirements for incubating embryos and early larval stages.

Embryonic and larval stages are especially susceptible to low DO levels as their ability to extract oxygen is not fully developed and their relative immobility prevents them from migrating to more favorable conditions. The DO requirements for successful incubation of embryos and emergence of fry is tied to intragravel DO levels. Intragravel DO is typically a function of many chemical, physical, and hydrological variables, including: the DO of the overlying stream water, temperature, substrate size and porosity, biochemical oxygen demand of the intragravel water and substrate, the gradient and velocity of the stream, channel configuration, depth of water, etc.

Embryos can survive when DO is below saturation (and above a critical level), but development typically deviates from normal. Embryos were found to be smaller than normal and hatching either delayed or premature when DO was below saturation throughout development (Doudoroff and Warren 1965). Silver et al. (1963) found newly hatched steelhead and chinook alevins were smaller and weaker when embryos were incubated at low or intermediate DO levels as compared to embryos incubated at high DO levels. Reduced DO levels lengthened the incubation period of coho embryos and also produced smaller alevins than normal (Shumway et al. 1964). Field studies have shown that survival of steelhead (Cobel 1961) and coho embryos (Phillips and Campbell 1961) is correlated to intragravel DO. Phillips and Campbell (1961) concluded that intragravel DO must average 8 mg/L for embryos and alevins to survive well. Embryo survival drops significantly at ≤ 6.5 mg/L and concentrations < 3.0 mg/L are lethal (Coble 1961; Shumway et al. 1964; Davis 1975). For successful reproduction of anadromous species, Bjornn and Reiser (1991) recommend DO near saturation and temporary reductions should not drop below 5.0 mg/L. McMahon (1983) recommends DO levels be ≥ 8.0 mg/L for high survival and emergence of fry.

EPA (1986) presents the following table for salmonid embryo and larval stages:

Level of effect	Water Column mg/L	Intragravel mg/L
No Production Impairment	11	8
Slight Production Impairment	9	6
Moderate Production Impairment	8	5
Severe Production Impairment	7	4
Limit to Avoid Acute Mortality	6	3

The EPA assumption of a 3 mg/L loss in DO from the surface waters to the intragravel is a minimum and highly sedimented gravels may experience DO losses of more than 6 mg/L. In an alluvial system like the Russian River, there is a high degree of connection between the water column and intragravel flow that is important to incubating embryos. Depressed levels of intragravel DO are more likely in a system where that connection is not as complete or in areas with heavy sedimentation, however, the 3 mg/L or greater difference between the water column and the intragravel water will be assumed until site specific data are collected to demonstrate higher intragravel levels. EPA (1986) further reports that for embryonic, larval and early life stages, any averaging period that might be used should not exceed 7 days. This short time is needed to adequately protect these sensitive life stages. If any averaging period is used it should be a moving average rather than a calendar-week or calendar-month average.

Summary: Surface water DO should not be depressed below 11.0 mg/L in order to maintain an intragravel DO level of 8.0 mg/L during incubation and early larval stages (December to mid-June). If the natural surface water temperature makes 11.0 mg/L prohibitive, DO should not be depressed below 100 percent saturation.

Freshwater Rearing – Continuously for all 12 months of the year for all three Species combined

Salmonids are strong active swimmers requiring highly oxygenated waters (Spence 1996) and this is true during the rearing period when feeding, growing, and avoiding predation are dominant. DO must be above a critical level for rearing salmonids to survive and occupy streams. A typically critical period for low DO conditions, especially in small streams, is during the summer when flows are low and temperatures are elevated. As water temperatures increase the amount of oxygen that can dissolve in the water decreases. Any large amounts of organic debris, which require oxygen for breakdown, can be especially detrimental during this period. Also detrimental can be the release of hypolimnetic water from deep, productive reservoirs that have marginally low oxygen levels.

Davis (1975) reported no impairment to rearing salmonids if the DO averaged 8.0 mg/L, with deprivation beginning at 6.0 mg/L. Davis (1963) and Dahlberg et al. (1968) found that the maximum swimming speed of coho and chinook decreased when DO dropped below saturation (8-9 mg/L at 68 °F), and below 6.0 mg/L swimming speed was significantly reduced. Growth rate and food conversion efficiency of coho fry is optimum at DO above 5.0 mg/L (McMahon 1983) with growth and food conversion decreasing rapidly when DO drops to below 4.5 mg/L (Herrmann et al. 1962; Brett and Blackburn 1981).

EPA (1986) presents the following table for salmonid life stages other than embryonic and larval:

Level of effect	Water Column mg/L
No Production Impairment	8
Slight Production Impairment	6
Moderate Production Impairment	5
Severe Production Impairment	4
Limit to Avoid Acute Mortality	3

Summary: For salmonid rearing, surface water DO should not be depressed below 7.0 mg/L or 80% saturation, whichever is greater. A DO level of 7.0 mg/L builds in some margin of safety for rearing juveniles.

Seaward Migration – January to mid-June for all three Species combined

Smoltification is a physiologically demanding period for salmonids, making this stage particularly sensitive to environmental stress factors (McMahon 1983). There is little information specific to DO requirement for salmonids' seaward migration, however this stressful event probably requires DO levels near saturation (Spence 1996) or that required by rearing juveniles (McMahon 1983).

Summary: For salmonid seaward migration, surface water DO should not be depressed below 7.0 mg/L or 80% saturation, whichever is greater.

Permitting and Monitoring
The majority of NPDES (11 of 18) issued by the Regional Board within the Russian River watershed contain requirements for monitoring dissolved oxygen in the effluent and/or the receiving water. Monitoring results are submitted to and reviewed by Regional Water Quality Control Board staff for compliance with permit conditions. Violations of permit requirements, such as receiving water oxygen limits, are followed up and investigated by Regional Board staff.

Analysis of LHR versus Water Quality Objective

Dissolved Oxygen Objective
The DO objective contained in the *Water Quality Control Plan for the North Coast Region* (Basin Plan) is as follows:

> Dissolved oxygen concentrations shall conform to those limits listed in Table 3-1. For waters not listed in Table 3-1 and where dissolved oxygen objectives are not prescribed, the dissolved oxygen concentrations shall not be reduced below the following minimum levels at any time.
>
> Waters designated WARM, MAR, or SAL .... 5.0 mg/L
> Waters designated COLD .... 6.0 mg/L
> Waters designated SPWN .... 7.0 mg/L
> Waters designated SPWN during critical spawning
> and egg incubation periods .... 9.0 mg/L

Table 3-1 of the Basin Plan lists the following dissolved oxygen objective for the Russian River Hydrologic Unit (HU) and Laguna de Santa Rosa:

	Dissolved Oxygen (mg/L)		
	Min	90% Lower Limit [3]	50% Lower Limit [2]
Russian River HU			
(upstream) [8]	7.0	7.5	10.0
(downstream) [9]	7.0	7.5	10.0
Laguna de Santa Rosa	7.0	7.5	10.0

[2] 50% upper and lower limits represent the 50 percentile values of the monthly means for a calendar year. 50% or more of the monthly means must be less than or equal to an upper limit and greater than or equal to a lower limit.

[3] 90% upper and lower limits represent the 90 percentile values for a calendar year. 90% or more of the values must be less than or equal to an upper limit and greater than or equal to a lower limit.

[8] Russian River (upstream) refers to the mainstem river upstream of its confluence with Laguna de Santa Rosa.

[9] Russian River (downstream) refers to the mainstem river downstream of its confluence with Laguna de Santa Rosa.

Because the Russian River HU and Laguna de Santa Rosa are specifically listed in Table 3-1 of the Basin Plan, the values in Table 3-1 apply within the Russian River watershed.

There are essentially three parts to the DO objective listed in Table 3-1 of the Basin Plan. The most straight forward portion is the minimum value criterion. The objective states that at no time shall the DO of surface waters be less than 7.0 mg/L. This is a minimum criterion and all values at all times shall be above this value. The second part of the objective is the 90% lower limit. This is defined as 90% of the surface water DO values collected during a calendar year must be > 7.5 mg/L (10% of the values during a calendar year could be ≤ 7.5 mg/L). The final part of the objective is the 50% lower limit. This is defined to mean that 50% of the monthly means for surface water DO of a calendar year must be > 10.0 mg/L (50% of the monthly means during a calendar year could be ≤ 10.0 mg/L).

<u>Dissolved Oxygen Life History Requirements</u>

Summarizing the DO requirements of the Species, migrating adults, rearing freshwater juveniles, and migrating smolts require DO levels of ≥ 7.0 mg/L. For no impairment to embryos and early larval stages and larval stages, EPA (1986) states that intragravel DO should be ≥ 8.0 mg/L, which corresponds to 11.0 mg/L in the overlying surface water (assuming a 3 mg/L loss in DO from the surface waters to the intragravel water). Excessive fine sedimentation of gravels could result in greater losses between surface water and the intragravel. An intragravel DO of 6.0 mg/L would result in slight impairment to embryos and early larval stages and larval stages, 5.0 mg/L moderate impairment, 4.0 mg/L severe impairment, and 3.0 mg/L acute mortality (EPA 1986).

<u>Comparison of LHR and DO Objective</u>

a. Migrating Adults, Freshwater Juveniles, and Migrating Smolts
For migrating adults, rearing freshwater juveniles, and migrating smolts, a DO objective specifying a minimum of 7.0 mg/L in surface waters appears to provide adequate protection.

b. Embryo Incubation

i. minimum 7.0 mg/L
An objective specifying a minimum DO of 7.0 mg/L in surface waters will not ensure adequate protection of incubating embryos and early larval stages. Embryos encountering 7.0 mg/L would experience some impairment, however, it is likely that the intragravel DO would be would be less than the 7.0 mg/L observed in the overlying surface water. An intragravel DO of 5.0 mg/L would result in moderate impairment, 4.0 mg/L severe impairment, and 3.0 mg/L acute mortality.

ii. 90% lower limit
The 90% lower limit objective of 7.5 mg/L (90% of the values over the calendar year must be > 7.5 mg/L) will not ensure adequate protection for incubating embryos. While an intragravel DO of 7.5 mg/L may provide protection, intragravel DO concentrations are likely to be less than 7.5 mg/L when the surface water DO is 7.5 mg/L. Further, 10% of the time the DO could be less than 7.5 mg/L (and above 7.0 mg/L per the minimum value objective) again resulting in potentially unacceptable levels of impairment.

iii. 50% lower limit
The 50% lower limit objective prescribing that 50% of the monthly means for DO must be > 10 mg/L does not ensure that incubating embryos and early larval stages will be protected.

Because this objective is based on monthly means, there could be a month averaging as little as 7.0 mg/L which would not ensure protection of incubating embryos and early larval stages. Whether the 50% lower limit is protective depends on the specific DO values and their distribution throughout any given month.

In summary:

1. current Russian River DO objectives appear adequate in protecting adult migrants, freshwater juveniles, and migrating smolts
2. the Russian River objectives appear inadequate in protecting embryonic and larval stages of anadromous salmonids because they cannot guarantee adequate DO levels during these life stages. The 50% lower limit objectives relies on monthly averages and thus lacks the temporal specificity to assure protection. The 90% lower limit may allow DO levels to be too low during at least 10% of the time to assure protection.
3. the general Basin Plan DO objective (which does not apply to the Russian River HU) specifying a minimum of 9.0 mg/L in waters designated SPWN during critical spawning and egg incubation periods would likely provide a level of protection classified as slight production impairment. If there is excessive fine sedimentation of spawning redds, the assumed reduction of 3.0 mg/L from surface waters to the intragravel could be greater resulting in moderate or severe impairment. A minimum surface water value of 11.0 mg/L or 10 mg/L would likely provide full protection during the critical spawning and egg incubation periods.

Discussion of Alternatives

Several possible alternatives incorporating the above considerations are presented and discussed below, including maintaining the current narrative objective.

<u>Alternative 1:</u> Maintain the current DO objective contained in Table 3-1 of the Basin Plan.

That portion of the current DO objective specifying a 7.0 mg/L minimum is likely to protect migrating adults, freshwater juveniles, and migrating smolts. However, neither the minimum value or the 90% and 50% lower limits will ensure adequate DO levels for protection of incubating embryos and early larval stages and larval stages.

<u>Alternative 2:</u> Strengthen the current dissolved oxygen objective by specifying a level during the critical egg incubation periods throughout the Region.

Add a DO objective to the current general DO objective and Table 3-1 objectives that includes a minimum DO criterion of 10.0 mg/L during critical egg incubation and early larval stage periods in streams designated SPWN for salmonids. When natural conditions, such as temperature, make 10.0 mg/L unattainable, DO should be at saturation and efforts to reduce temperatures should be pursued.

The advantage to this approach is that it specifies a minimum numeric objective designed to meet the requirements of incubating embryos and early larval stages for all spawning salmonids in the Region.

<u>Alternative 2a</u>: Same as Alternative 2, but applies to surface waters designated RARE for an anadromous salmonid species.

Add a DO goal to current general DO objective and Table 3-1 objectives that includes a minimum DO criteria of 10.0 mg/L during critical egg incubation and early larval stage periods in streams designated SPWN for salmonids and RARE for an anadromous salmonid species. When natural conditions, such as temperature, make 10.0 mg/L unattainable, DO should be at saturation.

The advantage to this approach is that it specifies a minimum numeric objective designed to meet the requirements of incubating embryos and early larval stages for all anadromous salmonids species listed as threatened or endangered throughout the Region. A disadvantage is that areas with anadromous salmonid species without the RARE designation will not be afforded this level of protection.

Alternative 2b: Same as Alternative 2 but only applies to the Russian River Hydrologic Unit and the Laguna de Santa Rosa and tributaries from its confluence with Santa Rosa Creek downstream.

Add a DO objective to the current DO objective in Table 3-1 for the Russian River HU and Laguna de Santa Rosa, downstream of its confluence with Santa Rosa Creek, that includes a minimum DO criterion of 10.0 mg/L during critical egg incubation and early larval stage periods in streams. When natural conditions, such as temperature, make 10.0 mg/L unattainable, DO should be at saturation.

The advantage to this approach is that it specifies a minimum numeric objective designed to meet the requirements of incubating embryos and early larval stages for all salmonid species in the Russian River HU and Laguna de Santa Rosa. A disadvantage is that other areas of the Region with spawning salmonids or anadromous salmonid species with the RARE designation would not be afforded this level of protection.

Staff Recommendations

1. Designate the Russian River HU, including its tributaries as RARE, recognizing the FESA listing and afford maximum protection of the Species.
2. Propose Alternative 2a to provide protection to embryos and early larval stages during the critical incubation period.

Justification

1. The Species are being studied intensively and current information has shown the Species to be as wide-spread in distribution and use in the watershed as previously thought. In lower gradient streams, salmonids migrate but only minimally use them for spawning or rearing. The higher gradient reaches are primary areas for salmonid spawning and rearing. Water quality, regardless of the gradient level, must be maintained at equivalent levels to ensure protection of the downstream use. Designating the entire watershed as RARE would ensure protection.
2. The current objective is not protective of salmonid embryos and early larval stages during incubation. Adding an objective for protection of those sensitive life stages would be protective. Applying the objective to the areas designated RARE would at first afford protection to the entire watershed while new data are being collected, and later afford the opportunity to de-designate areas if the non-use by that beneficial use is adequately documented.

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HYDROGEN ION CONCENTRATION (pH)

Background
The natural pH of surface waters can be altered to be too high or low for survival of aquatic organisms, however most impacts generally tend to lower the pH. The natural pH of surface waters can be acidic due to geologic or biological conditions, but acidic conditions are more frequently a function of anthropogenic activities (Spence 1996).

Direct impacts to fish from low pH waters are typically expressed as respiratory problems such as mucous clogging, increased ventilation, hypoxia, etc. and an increased likelihood of disease. Besides direct impacts to organisms, pH can influence the toxicity of dissolved materials such as cyanide, ammonia, and metallic salts (Bell 1986) resulting in synergistic and direct effects on biological systems. The pH threshold for adverse impacts is water quality dependent as well as species-dependent.

Life History Requirements (LHR)
The permissible range of pH for fish can depend on factors such as temperature, dissolved oxygen, prior acclimation, and concentrations of various mineral content (McKee et. al. 1963). Literature reviews conclude no species-specific requirements for pH. Generally however, fish are adversely affected by pH levels below 5.6 (Spence 1996) and waters with healthy fish fauna typically have pH values that fall between 6.7 and 8.3 (Bell 1986).

Permitting and Monitoring
All NPDES permits issued by the Regional Board within the Russian River watershed contain requirements for monitoring pH in the effluent and/or the receiving water. Monitoring results are submitted to and reviewed by Regional Water Quality Control Board staff for compliance with permit conditions. Violations of permit requirements, such as receiving water pH limits, are followed up and investigated by Regional Board staff.

Analysis of LHR versus Water Quality Objective

pH Objective

The Russian River pH objective contained in the *Water Quality Control Plan for the North Coast Region* is as follows:

> "The pH shall conform to those limits listed in Table 3-1. For waters not listed in Table 3-1 and where pH objectives are not prescribed, the pH shall not be depressed below 6.5 nor raised above 8.5.
>
> Changes in normal ambient pH levels shall not exceed 0.2 units in waters with designated marine (MAR) or saline (SAL) beneficial uses nor 0.5 units within the range specified above in fresh waters with designated COLD or WARM beneficial uses."

Table 3-1 of the *Water Quality Control Plan for the North Coast Region*, lists a maximum allowable pH value of 8.5 and minimum value of 6.5 for the Russian River watershed.

Staff Recommendation
The current Basin Plan water quality objective for pH is protective of the Species. No action is recommended at this time.

Justification
The pH water quality objective of between 6.5 and 8.5 supports the LHR for salmonid species within the Russian River. Further, the permitting process administered by the Regional Board appears sufficient in assuring pH levels will remain within the range required by Russian River salmonid species.

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TEMPERATURE

Background

Temperature is one of the most important factors in determining the success of salmonids and other aquatic life. Most aquatic organisms, including salmon and steelhead, are poikilotherms, meaning their temperature and metabolism are determined by the ambient temperature of water. Temperature therefore influences growth and feeding rates, metabolism, development of embryos and alevins, timing of life history events such as upstream migration, spawning, freshwater rearing, and seaward migration, and the availability of food. Temperature can also have a significant influence on the amount of oxygen dissolved in water. As the temperature of water increases, the amount of oxygen that can dissolve in water decreases.

Much of the information reported in the literature characterizes temperature requirements with terms such as "preferred" or "optimum" or "tolerable". Preferred is simply that which a particular species and/or life stage prefers, while the optimum temperature typically refers to that temperature at which an organism can best perform a specific activity. For example, there are reported optimum temperatures and/or ranges for migration, spawning, growth, swimming, etc. Tolerable temperature ranges refer to that range at which an organism can survive. Many studies have been conducted to determine what temperatures salmonids can tolerate. There are two basic ways to determine tolerance levels: 1) slow heating of fish to determine the critical thermal maximum (CTM), and 2) abrupt transfer of fish to hotter water to determine the incipient lethal temperature (ILT). In general, upper lethal temperatures determined by the CTM method tend to be higher than those determined by the ILT method. Some researchers do not use the above terms but simply report the temperature ranges for which the various life stages survive.

Such information is useful in determining temperature requirements, but generally does not consider adaptations to regional or local temperature regimes. Case in point is the Russian River watershed. This watershed is located near the southern (warm) end of the geographic range where many west coast anadromous salmonid species exist. There is little literature specific to the temperature requirements of Russian River salmonid species. Most of the research and experimentation regarding salmonid requirements is derived from fish stocks and experimentation in Washington, Canada, and Alaska. These areas have a cooler climate, different geology, a different type of vegetative climax community, different summer flow regimes, etc. than the Russian River watershed. It is likely that fish stocks have adapted to the regional temperature regimes they typically experience. Similarly, Russian River salmonids have probably adapted to their regional temperature regime, which is warmer than that experienced by their northern cousins. Therefore, some caution should be used when applying temperature requirements derived from studies utilizing fish stocks from a cooler environment to Russian River salmonids species. Because of this, some of the best information on Russian River salmonid habitat requirements may come from local fisheries experts, data, and observations. The California Department of Fish and Game and the Sonoma County Water Agency (SCWA) have collected a substantial amount of temperature data from many of the Russian River tributaries.

One of the more difficult components to quantify is the effect food availability has on temperature tolerances for rearing salmonids. This is particularly true for steelhead. Steelhead can survive higher summer temperatures if plentiful food is available to support a higher metabolic rate. If the stream supports a good level of primary and secondary production, then a numeric temperature objective specific to the Russian River may be higher than research based in colder climates would indicate, If however, insufficient habitat and food production exists, higher temperatures could be detrimental.

It is likely that summertime temperatures of the Russian River and it's tributaries have been altered upward during the past 50 years. Land use activities, water withdrawals and changes in flow, dam construction and water releases, point source discharges, and natural factors have contributed to the change. As a result, to maintain a cold water fishery in the Russian River and its tributaries and protect the listed salmonid species, there is likely little room for further increases in temperature.

Life History Requirements (LHR)
Literature reviews were conducted to determine temperature requirements for the various life stages of steelhead trout (*Oncorhynchus mykiss*), coho salmon (*Oncorhynchus kisutch*), and chinook salmon (*Oncorhynchus tshawytscha*). When possible, species specific requirements were summarized by four life stages: migrating adults, embryo incubation and fry emergence, freshwater rearing, and seaward migration. Some of the references reviewed covered salmonids as a general class of fish, while others were species specific.

Temperature Criteria For Freshwater Fish: Protocol and Procedures (EPA 1977)

This EPA document discusses development of criteria for maximum weekly average temperatures (MWAT) and short-term or daily temperature exposure criteria.

Maximum Weekly Average Temperatures

MWAT is essentially the upper temperature that an organism can withstand over the long term and maintain healthy populations. MWAT is defined in EPA (1977) as "... the mathematical mean of multiple, equally spaced, daily temperatures over a 7-day consecutive period." MWATs are typically developed for the growth phase of fish life, as growth appears to be the most sensitive function and it integrates many physiological functions. To calculate the MWAT the following equation is used:

$$\text{MWAT for growth} = \text{optimum temperature} + \frac{\text{ultimate upper incipient lethal temperature} - \text{optimum temperature}}{3}$$

This equation uses the physiological optimum temperature, in this case for growth, and the ultimate upper incipient lethal temperature. The latter temperature is the "breaking point" between the highest temperature to which a fish can be acclimated and the lowest of the extreme upper temperatures that will kill the warm-acclimated fish.

EPA (1977, 1986) calculates a growth MWAT of 64 °F for juvenile coho salmon. This value could vary slightly depending on the optimum and ultimate upper incipient lethal temperatures used in the calculation. The EPA (1977) document does not report an MWAT for chinook or steelhead, although there is a reported MWAT of 66 °F for rainbow trout.

Short-Term Maximum Temperature

It is recognized that fish can withstand short-term exposure to temperatures higher than those required day in and day out without significant adverse effects. The short-term maximum temperature represents this temperature and is calculated using the following formula:

$$\text{Temperature } (^{\circ}C) = \frac{\text{log time (min)} - a}{b}$$

For the daily maximum the equation would use 1440 minutes. The constants "a" and "b" are intercept and slope, respectively, derived from each acclimation temperature for each species. The result of this calculation is the temperature at with there is 50% survival. A safety factor of 2 °C is subtracted to calculate the temperature at which 100% survive.

For juvenile coho salmon, when the acclimation temperature is 20 °C, a = 20.4022 and b = -0.6713 and the short-term maximum temperature is calculated to be 23.7 °C or 74.7 °F. EPA (1977) does not calculate a short-term maximum temperature for chinook or steelhead, although there is a reported short-term maximum temperature value of 75 °F for rainbow trout. Using data in EPA (1977) juvenile chinook would have a daily maximum temperature of approximately 74 °F.

A. Adult Migration – mid-October to mid-May for all three Species combined

Salmon and trout respond to temperatures during their upstream migration (Bjornn and Reiser 1991). Delays in migration have been observed for temperatures that were too cold and too warm. Most salmonids have evolved with the temperature regime they historically used for migration and spawning, and deviations from the normal pattern can affect survival (Spence 1996).

Upstream migration of adult salmonids in the Russian River occurs during a stream temperature transition period. Migration begins when the warmer summer period is waning, the cooler temperatures of fall are being felt, and river temperatures are generally falling. Chinook enter the Russian River system first, beginning as early as mid-September and continuing through mid-December. Coho can begin entering the Russian River in mid-October and continue through mid-February. Steelhead begin migrating in mid-November and continue through mid-March.

Salmonids - general

Most salmonids typically migrate at temperatures less than 57 °F (Spence 1996) with migration being blocked or delayed at temperatures above 70 °F (Bell 1986).

Coho

Adult coho prefer to migrate between 45 and 60 °F (Reiser & Bjornn 1979; Bell 1986). Migration is reported to begin at < 50 °F (Allen 1959) and delayed at 70 °F (Bell 1986). EPA and NMFS (1971) report the upper incipient lethal temperature to be 70 °F.

Steelhead

Upstream migration is limited when the temperature is > 70 °F (Lantz 1971 cited by ODEQ 1995).

Chinook

The normal temperature range for migration is between 51 and 67 °F (Bell 1986; Bjornn and Reiser 1991). ODEQ (1995) reported a preferred range of 36-67 °F and migration blocked at 70 °F (EPA and NMFS 1971).

Summary:

From the literature, temperatures greater than 70 °F block migration. Chinook appear able to tolerate slightly higher stream temperatures during migration than coho (51-67 °F versus 45-60 °F). There are little data for the requirements of steelhead. Temperatures up to the 60-65 °F range are likely to allow upstream migration of the three Species.

B. Spawning – October to mid-May for all three Species combined

The timing of salmonid spawning has likely evolved in response to water temperatures before, during and after spawning. The various native fish stocks each appear to have chosen a unique time and temperature for spawning to maximize spawning success (Spence 1996). Intuitively, the temperatures required for spawning should be close to those required for embryo incubation as these two events occur so close in time.

Spawning typically begins after flows have increased from winter rains and stream temperatures have decreased. Coho can begin spawning as soon as they reach natal spawning grounds, typically December through February. Steelhead spawning can begin in mid-December and continue through mid-May, with the peak in January through March. Chinook spawning typically occurs from October through January.

Spence (1996) reports that salmonid spawning has been observed at 33-57 °F but most spawn between 37 and 57 °F. The following summarizes preferred spawning temperatures reported by Bell (1986):

	preferred spawning temperature
coho	40 - 49 °F
steelhead	39 - 49 °F
chinook	42 - 57 °F

Coho

Hassler (1987) reports that coho spawn between 42 and 53 °F. Some report coho surviving spawning at 36-57 °F (Murray and McPhail 1988) and 34-57 °F (Murray et al. 1990). ODEQ (1995) reports that coho prefer temperatures of 40-49 °F for spawning and EPA (1977, 1986) reports a maximum weekly average of 50 °F.

Chinook

Wilson et al. (1987) reports a tolerable temperature range of 41-57 °F for chinook spawning while Murray and McPhail (1988) report a survival range of 36-57 °F. Spawning has been observed at 50-63 °F (Shepherd et al. 1986). ODEQ (1995) reported that chinook prefer 42-55 °F and that spawning is inhibited at 60 °F. EPA and NMFS (1971) recommend 45-55 °F for spawning.

Summary:

The reported preferred range for coho spawning is 40-57 °F, for steelhead 39-49 °F, and chinook 36-57 °F. Chinook spawning may be inhibited at 60 °F. A temperature range of 40-57 °F should protect Species spawning.

C. Embryo Incubation and Fry Emergence – December to mid-June for all three Species combined

It is critical that embryo and fry emergence stages have the proper environmental conditions, including temperature, as these life stages are essentially immobile and unlike juveniles and adults they cannot migrate to areas where conditions are acceptable. Water temperature during incubation affects the rate of embryo development, intragravel dissolved oxygen, and survival. Generally, the warmer the water the faster the development time (within an acceptable range after which survival is affected), the shorter the incubation period, and the sooner emergence occurs. Incubation temperatures can also effect the size of hatching alevins (Bjornn and Reiser 1991). Because spawning and embryo incubation are so closely linked in time, they have similar temperature requirements.

Embryo incubation begins anytime after spawning has commenced. For coho, incubation generally begins in December and can last through mid-April, with the peak December through March. For steelhead, incubation can begin in mid-December and last until mid-June with the peak January through March. The incubation period for chinook is generally October through March.

Coho

Bell (1986), Hassler (1987), and ODEQ (1995) report a preferred temperature range of 40-56 °F for coho embryo incubation. Ranges for which survival of embryos are reported include 35-57 °F (Murray and McPhail 1988) and 34-57 °F (Murray and Beacham 1990). EPA (1977, 1986) recommends a short-term maximum temperature of 55 °F for incubation. Fifty percent (50%) mortality was reported when the temperature was >56 °F (Spence 1996).

Steelhead

Bell (1986) reports a preferred temperature of 50 °F.

Chinook

Bell (1986) and Bjornn and Reiser (1991) recommend a temperature range of 41-58 °F for chinook. Murray and McPhail (1988) report a survivable range of 35-57 °F, while Wilson et al. (1987) reports a tolerance range of 32-61 °F. Highest survival occurs at 53-57.5 °F (CDWR 1988) and ODEQ (1995) specifies a preferred range of 40-55 °F.

Summary:

The reported range for successful incubation of coho embryos is 34-56 °F . The reported preferred temperature for steelhead is 50 °F. For chinook the reported range is 32-57 °F. Temperatures below 56 °F and above 34 °F should protect incubating embryos of the Species.

D. Freshwater Rearing – Continuously throughout the 12 months of the year for all three Species combined

As a coldwater fish, salmonids have defined temperature requirements during rearing. Temperature affects metabolism, behavior, and survival of fish as well as other aquatic organisms which may be food sources. Temperatures in salmonid streams vary daily, seasonally, annually, and spatially within a river system. Humans can alter temperature patterns by modifying riparian vegetation, altering flow regimes by removing water or releasing water from reservoirs, and allowing discharges.

In the Russian River system, young coho and steelhead generally rear in the freshwater environment anywhere between one and four years before migrating to the ocean. Young chinook have a different strategy. After hatching, they reside in the freshwater environment for several months before migrating to the estuary and ultimately the ocean. The chinook freshwater rearing period is generally February through May.

As mentioned previously, many studies have been conducted to determine what temperatures salmonids can tolerate with two basic approaches to determine tolerance levels: slow heating of fish to determine the critical thermal maximum (CTM) and abrupt transfer of fish to hotter water to determine the incipient lethal temperature (ILT). The upper ILT for anadromous salmonids ranges from 73 to 84 °F depending on species and acclimation temperatures. Although some salmonids can survive high temperatures, conditions are generally life-threatening when temperatures exceed 73 to 77 °F (Bjornn and Reiser 1991), and they avoid such temperatures by migrating to cooler areas if they can. Anecdotal evidence indicates that deep pools were (historically) the summer rearing habitat and not cool water surface flow in the mainstem. In small streams with little shade and flows less than 1 m^3/s, daily summer temperatures can fluctuate as much as 59 °F (Meehan 1970; Bjornn 1978). Yet, salmonids can survive temperatures approaching the upper lethal temperature if the exposure is for only a short period of time before returning to the optimum range (Bjornn and Reiser 1991).

species	preferred range	reference
coho	54 - 57 °F	Brett 1952
steelhead	50 - 55 °F	Bell 1986
chinook	54 - 57 °F	Brett 1952

species	lethal temp.	reference	technique
coho	79 °F	Brett 1952	ILT(*)
	84 °F	Becker and Genoway 1979	CTM(**)
steelhead	75 °F	Bell 1986	
chinook	79 °F	Brett 1952	ILT(*)

(*) incipient lethal temperature
(**) critical thermal maximum

Coho

Hassler (1987) reported an upper thermal limit of 78 °F and a preferred range of 50-58 °F for coho. ODEQ (1995) reported a preferred range of 54-59 °F. CDWR (1988) reported that this range inhibits parr to smolt conversion. The MWAT for juvenile coho salmon is calculated to be 64 °F and the short-term daily maximum temperature is calculated to be 75 °F (EPA 1977, 1986).

Steelhead

Bell (1986) reports an optimum range of 45-58 °F. ODEQ (1995) reported that steelhead were found between 55 and 66 °F and avoided waters > 71 °F. No MWAT or short-term maximum temperature was reported in EPA (1977). However, for rainbow trout, the calculated MWAT is 66 °F and the short-term daily maximum is 75 °F.

Chinook

A preferred range of 45-58 °F and upper lethal level of 77 °F is reported by Bell (1986). ODEQ (1995) reported that positive growth occurred for temperatures between 40-66 °F and that the maximum temperature should not be above 72 °F. Armour (1991) reported maximum production between 50-60 °F. Chinook can tolerate between 36-61 °F as reported by Wilson et al. (1987). The upper lethal long-term exposure is reported to be 78.5 °F by CDWR (1988). Using data in EPA (1977) juvenile chinook would have calculated daily maximum temperature of approximately 74 °F.

Summary:

The upper lethal temperature for young coho and chinook is reported to be around 77-79 °F and around 75 °F for steelhead. The temperature ranges for which coho have been observed or survived is 50-58 °F, for steelhead 50-66 °F, and 54-61 °F for chinook. The MWAT for coho is calculated to be 64 °F and the daily maximum temperature is 75 °F. The daily maximum for chinook is calculated to be 74 °F. A maximum 7-day average stream temperature of 64 °F and a daily maximum temperature of 75 °F will likely protect all three Species.

E. Seaward Migration – January to mid-June for all three Species combined

The timing of seaward migration appears to be tied to the photoperiod but streamflow, temperature, and growth may play a role (Bjornn and Reiser 1991). Spring is usually the time of year when seaward migration occurs as streams still have adequate flow from winter rains or snowmelt to move fish to higher order streams for transport to the ocean.

After spending at least one season rearing in freshwater, and sometimes longer, juvenile coho and steelhead migrate to the ocean environment. This migration generally occurs from February through mid-June with the peak in April. Young chinook spend only a couple months in freshwater before migrating to the ocean between March and mid-June.

Specific temperature requirements of salmonids migrating to the ocean are not well documented (Spence 1996). Bell (1986) reports a preferred range of 42-62 °F for coho seaward migrants. The downstream migration of chinook is prevented at temperatures > 70 °F (CDWR 1988).

Summary:

Coho have a preferred temperature range of 42-62 °F. Temperatures in the range of 42-62 °F should provide protection for the downstream migration. Chinook downstream migration appears to be prevented at temperatures greater than 70°F (CDWR 1988). Optimal temperature ranges for steelhead are not well documented.

Literature review summaries are presented in the following tables.

Table 1. Summary of literature review for temperature requirements of coho salmon.

Life Stage	
adult migration	prefer: 45-60°F (Reiser & Bjornn 1979, Bell 1986) migration delayed @ 70°F (Bell 1986) migration begins at <50°F (Allen 1959) upper incipient lethal: 70°F (EPA & NMFS 1971)
spawning	prefer: 40-49°F (Bell 1986) prefer: 42-53°F (Hassler 1987) prefer: 40-49°F (ODEQ 1995) survive: 36-57°F (Murray & McPhail 1988) survive: 34-57°F (Murray et al. 1990) maximum weekly average: 50°F (EPA 1977, 1986)
embryo incubation/ fry emergence	prefer: 40-56°F (ODEQ 1995, Bell 1986, Hassler 1987) survive: 35-57°F (Murray & McPhail 1988) survive: 34-57°F (Murray & Beacham 1990) short-term maximum: 55°F (EPA 1977, 1986) 50% mortality at >56°F (Spence 1996)
juvenile rearing	prefer: 54-57°F, incipient lethal: 79°F (Brett 1952) prefer: 50-58°F, upper thermal limit: 78°F (Hassler 1987) 54-59°F inhibited parr to smolt (CDWR 1988) prefer: 54-59°F (ODEQ 1995) MWAT: 64 °F, daily maximum: 75 °F (EPA 1977, 1986)
seaward migration	prefer: 45-62°F (Bell 1986) Smolt: 48°-59°F (Rich 2000, pers comm)

Table 2. Summary of literature review for temperature requirements of chinook salmon.

Life Stage	
adult migration	normal range: 51-67°F (Bell 1986, Bjornn & Reiser 1991)
	blocked at 70°F (EPA & NMFS 1971)
	prefer: 36-67°F, blocked at 70°F (ODEQ 1995)
spawning	prefer: 42-57°F (Bell 1986)
	observed: 50-63°F (Shepherd et.al. 1986)
	survive: 36-57°F (Murray & McPhail 1988)
	recommend: 45-55°F (EPA & NMFS 1971)
	tolerance: 41-57°F (Wilson et.al. 1987)
	prefer: 42-55°F; inhibited @ 60°F (ODEQ 1995)
embryo incubation/ fry emergence	recommend: 41-58°F (Bell 1986, Bjornn & Reiser 1991)
	survive: 35-57°F (Murray & McPhail 1988)
	tolerance: 32-61°F (Wilson et.al. 1987)
	highest survival: 53-57.5 °F (CDWR 1988)
	prefer: 40-55°F (ODEQ 1995)
juvenile rearing	prefer: 54-57°F, incipient lethal: 79°F (Brett 1952)
	prefer: 45-58 °F; upper lethal: 77°F (Bell 1986)
	50-60°F max. production (Armour 1991)
	upper lethal for long-term exposure: 78.5 °F (CDWR 1988)
	tolerance: 36-61°F (Wilson et.al. 1987)
	positive growth: 40-66°F, upper maximum: 72°F (ODEQ 1995)
	daily maximum: 74°F (EPA 1977, 1986)
seaward migration	45°- 55.9° F (Rich 2000, pers comm)
	prevented @ > 70°F (CDWR 1988)

Table 3. Summary of literature review for temperature requirements of steelhead trout.

Life Stage	
adult migration	movement limited @ >70°F (Lantz 1971 cited by ODEQ 1995)
spawning	prefer: 39-49°F (Bell 1986)
embryo incubation/ fry emergence	prefer: 50°F (Bell 1986)
juvenile rearing	prefer: 50-55°F, optimum: 45-58°F, upper lethal: 75°F (Bell 1986) found at 55-66°F; avoid >71°F (ODEQ 1995)
seaward migration	Smolt: 44.5° - 52.3° F (Rich 2000, pers comm)

Analysis of LHR versus Water Quality Objective

Temperature Objective

The temperature objective contained in the *Water Quality Control Plan for the North Coast Region* (Basin Plan) is:

> "The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Water Board that such alterations in temperature does not adversely affect beneficial uses.
>
> At no time or place shall the temperature of any COLD water be increased by more than 5°F above natural receiving water temperature.
>
> At no time or place shall the temperature of WARM intrastate waters be increased more than 5°F above natural receiving water temperature."

The current designated beneficial uses which protect the listed anadromous Species within the Russian River watershed are: Cold Freshwater Habitat (COLD), Migration of Aquatic Organisms (MIGR), and Spawning, Reproduction, and/or Early Development (SPWN). The RARE (Rare, Threatened, or Endangered Species) beneficial use is currently not designated, however, given the recent listing of the Species as Threatened under the Federal Endangered Species Act (ESA), it is recommended that the RARE designation be added to the Russian River.

The immediate concern is whether the current narrative temperature objective is adequate in protecting the Species. USEPA has advised the State Water Resources Control Board that the current narrative temperature objective for the North Coast Region may be too general to be protective of salmonids. Federal guidance directs protection for the most sensitive species in a particular water body by season. It appears that the current temperature objective could be improved to provide increased protection of the Species. The objective states that the natural temperature of receiving waters shall not be altered unless it can be demonstrated that such an alteration will not adversely affect beneficial uses. The original intent and the common practice has been to consider background or upstream as "natural". However, there is a concern whether what is "natural" or background today can protect the Species as there have been incremental modifications in the watershed which have likely modified background conditions. It is likely that watershed modifications over the past 50 years have gradually altered "natural" to what we observe today and that the objective is protecting the current "natural" temperature level not the historical one. Under this scenario there is a danger that one day we will be protecting a temperature regime that may not support the Species. Therefore, better protection would be provided by specifying numeric temperature values, whether as objectives or goals, which support actual life stages of the Species.

There are several considerations in specifying numeric temperature criteria.

1. What should the numeric temperature objective or objectives be? The three species have slightly different temperature requirements but they are very similar both across species and across critical life cycle stages. Logically, one could choose the temperature requirement for each life stage that is protective for all three species. This approach can be simplified by the fact that the life stages of spawning, egg incubation, and fry emergence have similar temperature requirements as do the life stages of adult migration, freshwater rearing, and seaward migration.

   In 1995, the Oregon Department of Environmental Quality (DEQ) concluded an extensive analysis of their temperature standard. The final report, *1992-1994 Water Quality Standards Review* (ODEQ 1995), contains an extensive literature review, temperature standard alternatives, a technical analysis and evaluation, a policy analysis, and recommendations. Their analysis seems to be thorough and well thought out. The report recommends a 7-day average of <u>maximum</u> daily stream temperature (note: the EPA MWAT uses a 7-day average of <u>average</u> daily stream temperatures) to be less than 64 °F for salmonid streams except during the occurrence of salmonid spawning, egg incubation, and fry emergence at which times the maximum stream temperature shall not exceed 55 °F, also measured as a 7-day average of <u>maximum</u> stream temperatures.

   Adult Migration, Freshwater Rearing, and Seaward Migration

   It appears that a MWAT of 64 °F and an short-term daily maximum of 75 °F would protect the Species during adult migration, freshwater rearing and seaward migration. While migration is reported to be blocked at 70 °F and the allowable maximum would be 75 °F, the MWAT would preclude stream temperatures from being above 70 °F for significant portions of the day. A MWAT of 64 °F and a short-term daily maximum of 75 °F is consistent with temperature requirements found in the literature and the ODEQ report.

   Spawning, Embryo Incubation, and Fry Emergence

   An MWAT of 56 °F during spawning, egg incubation, and fry emergence should protect the Species during these critical periods. This value is consistent with literature findings and the ODEQ report. The North Coast Regional Board Basin Plan temperature threshold for upper reaches of the Trinity River during pre-spawning and spawning is 56 °F.

2. How should the stream temperature objective to be measured? There are several options: a daily maximum temperature value, an average daily maximum temperature, a 7-day moving average of the average daily stream temperatures (i.e. MWAT), a 7-day moving average of the maximum daily stream temperatures, a combination of an average measurement and an absolute maximum, or some other measure of stream temperature. As discussed above, a MWAT is specifically calculated as a 7-day moving average of the average daily stream temperatures. Averaging temperatures over 7-day periods provides an indicator of more prolonged conditions and a daily maximum provides an instantaneous measure of protection. A MWAT with a short-term daily maximum is appropriate and together should provide protection.

3. Where at any given sampling point should temperature be measured? During periods of higher flow, such as late fall, winter and early spring, stream temperature is most likely vertically homogenous in a stream and temperature can be measured nearly anywhere in flowing water. However, during summer months when stream flows are low, some reaches may become thermally stratified. During such periods, temperature may be measured at the stream bottom rather than the surface as fish are capable of moving to these cooler areas or thermal refugia.

4. When in time should the temperature thresholds that vary with life stages be applied? There are basically three choices, apply them to specific calendar dates (e.g. 56 °F applies October 1 - April 30), apply them based on the activity actually occurring (e.g. 56 °F applies during spawning, egg incubation, and fry emergence) or a combination of the two (e.g. 56 °F applies October 1 - April 30 or if spawning, embryo incubation, or fry emergence is occurring). The latter option appears appropriate as it provides definitive application dates, yet protects the activity if it occurs outside the normal time periods. It may not be possible or feasible to determine when activities are occurring.

5. Where within the watershed should the numeric temperature thresholds be applied and monitored? Options include applying new objectives across the entire watershed, to portions of the mainstem and all tributaries, to only some tributaries, to specific reaches within tributaries, only to reaches where the Species are present or were historically present, or a combination of historical presence and historical/present conditions, or where attainment of the objectives are possible.

   It has been documented that the main stem Russian River temperature and flow regimes have been significantly altered from historic conditions. Prior to the beginning of Eel River diversion flows in 1908, the Russian River did not have extensive summertime flows as it does today. The main channel dried to a trickle with deep pools, sloughs, and backwater areas providing fish habitat and thermal refugia. This is in stark contrast to the river today which generally maintains a summer-long flow around 200 cfs as a result of Eel River diversions and water releases from Lake Mendocino and Lake Sonoma. For the most part, the thermal refugia supplied by deep pools and sloughs have been eliminated by the continual summer flows. It is reported that summer temperatures between Hopland and Cloverdale cause salmonid stress, and high temperatures below Cloverdale prevent juvenile salmonids from using the river (SEC 1996). Portions of the main stem Russian River cannot support a cold water fishery during the summer months and newly proposed temperature objectives for the non-spawning period (summer) probably should not be applied to the entire main stem of the Russian River. There is a question of whether newly proposed temperature objectives to protect the Species can be met in many tributaries during the summer as flow, temperature, and habitat of many tributaries may have been altered over the past 90 years. Several options as to where to apply new objectives are discussed in the alternatives.

6. Other considerations include allowing variances due to excessively high air temperatures and/or low stream flow (drought) conditions. Oregon DEQ allows variances under both conditions. Specifically, if the stream flow falls below the lowest 7-day flow level that recurs on the average once every 10 years (7Q10 level), an exceedance of the temperature objective is not considered a violation. Likewise, if stream temperatures exceed the objective while the air temperature is higher than the 90 percentile level over the historical record for the warmest 7-day period of the year, it will not be considered a violation. Finally, if anthropogenic sources prevent achievement of temperature objectives, should this trigger development of temperature management plans aimed at reducing stream temperature with measures such as increasing stream shading, reducing summer withdrawals, increasing cold water releases from reservoirs, etc?

Permitting and Monitoring

The majority of NPDES permits (10 of 18) issued by the Regional Board within the Russian River watershed contain requirements for monitoring temperature in the effluent and/or the receiving water; two of those dischargers have maximum temperature limits in their permits. Monitoring results are submitted to and reviewed by Regional Water Quality Control Board staff for compliance with permit conditions. Violations of permit requirements, such as receiving water temperature limits, are followed up and investigated by Regional Board staff.

Discussion of Alternatives

Several possible alternatives incorporating some of the above considerations are presented and discussed below, including maintaining the current narrative objective.

Alternative 1: Maintain the current temperature objective.

The current temperature objective states that the natural receiving water temperature shall not be altered unless it can be demonstrated to the satisfaction of the Regional Water Board that such an alteration in temperature does not adversely affect beneficial uses. Additionally, at no time shall the temperature of any COLD water be increased by more than 5 °F above natural receiving water temperature.

This objective is not fully protective, since it is not designed to specifically protect the critical life stages of the listed anadromous salmonid Species in the Russian River watershed. Further, as discussed above, there is some question as to what constitutes "natural" and whether protecting the temperature regime observed today will protect the Species now or in the future.

Alternative 2: Strengthen the current temperature objective by applying specific numeric criteria as goals and times of application throughout the Region based on the occurrence of specific life stage activities.

In addition to the current temperature objective, the following goal or objective would be added to all streams designated COLD:

> The natural receiving water temperatures shall not exceed 64 °F, measured as a 7-day average of daily average stream temperatures (MWAT). Additionally, the maximum daily temperature shall not exceed 75 °F. Exceptions to this objective are that from November 1 through April 30 or when anadromous salmonid species are engaged in

> spawning, embryo incubation, or fry emergence, the maximum stream temperature shall not exceed 56 °F, measured as a 7-day average of daily average stream temperatures (MWAT). If there are insufficient data to establish a 7-day average of daily average temperatures, 64 °F or 56 °F shall be applied as an instantaneous maximum. Additionally, at no time shall the temperature be increased by more than 5 °F above natural receiving water temperatures. If anthropogenic sources prevent achievement of the 64 °F MWAT and 75 °F daily maximum temperature objectives, efforts should be made to develop temperature management plans aimed at reducing stream temperatures.

The advantage to this approach is that it specifies numeric objectives designed to meet critical life stages of the Species while those life stages are occurring and provides this protection to all coldwater species. A disadvantage is that the 64 °F summer time requirement may not be attainable under current conditions within portions of the Region. Data analysis by Regional Board staff indicates that for years 1997, 1998, & 1999, over 90% of the Russian River tributaries exceeded the 64 °F summer time requirement.

Alternative 2a: Same as Alternative 2, but applies to surface waters designated RARE for an anadromous salmonid species.

In addition to the current temperature objective, the following goal or objective would be added to all streams designated RARE for an anadromous salmonid species (the COLD designation would logically apply):

> The natural receiving water temperatures shall not exceed 64 °F, measured as a 7-day average of daily average stream temperatures (MWAT). Additionally, the maximum daily temperature shall not exceed 75 °F. Exceptions to this objective are that from November 1 through April 30 or when anadromous salmonid species are engaged in spawning, embryo incubation, or fry emergence, the maximum stream temperature shall not exceed 56 °F, measured as a 7-day average of daily average stream temperatures (MWAT). If there are insufficient data to establish a 7-day average of average temperatures, 64 °F or 56 °F shall be applied as an instantaneous maximum. Additionally, at no time shall the temperature be increased by more than 5 °F above natural receiving water temperatures. If anthropogenic sources prevent achievement of the 64 °F MWAT and 75 °F daily maximum temperature objectives, efforts should be made to develop temperature management plans aimed at reducing stream temperatures.

This alternative applies only to streams designated RARE for an anadromous salmonid species. The advantage to this approach specifies numeric objectives designed to meet critical life stages of listed anadromous salmonid species and affords this protection to all listed anadromous salmonid species. A disadvantage is that it is not fully protective of all salmonid fish, since areas with coldwater species without the RARE designated will not be afforded this level of protection. There may be areas within the Region where the summer time temperature requirement of 64 °F may not be attained under current conditions.

Alternative 2b: Same as Alternative 2 but only applies to streams in the Russian River Hydrologic Unit, excluding the Laguna de Santa Rosa upstream of its confluence with Santa Rosa Creek.

In addition to the current temperature objective, the following goal or objective would be added to streams on the Russian River Hydrologic Unit, excluding the Laguna de Santa Rosa upstream of its confluence with Santa Rosa Creek:

> The natural receiving water temperatures shall not exceed 64 °F, measured as a 7-day average of daily average stream temperatures (MWAT). Additionally, the maximum daily temperature shall not exceed 75 °F. Exceptions to this objective are that from November 1 through April 30 or when anadromous salmonid species are engaged in spawning, embryo incubation, or fry emergence, the maximum stream temperature shall not exceed 56 °F, measured as a 7-day average of daily average stream temperatures (MWAT). If there are insufficient data to establish a 7-day average of average temperatures, 64 °F or 56 °F shall be applied as an instantaneous maximum. Additionally, at no time shall the temperature be increased by more than 5 °F above natural receiving water temperatures. If anthropogenic sources prevent achievement of the 64 °F MWAT and 75 °F daily maximum temperature objectives, efforts should be made to develop temperature management plans aimed at reducing stream temperatures.

The Laguna de Santa Rosa upstream of its confluence with Santa Rosa Creek is exempt as this stream reach does not appear to support the Species. However, tributaries to the Laguna do support the Species. The advantage to this approach is that it specifies numeric objectives designed to meet critical life stages of the Species while those life stages are occurring for nearly all of the Russian River watershed. A disadvantage is that is not fully protective regionally, since only Russian River watershed Species would be afforded this level of protection. There may be areas within the Russian River watershed where the summer time temperature requirement of 64 °F may not be attained under current conditions.

Alternative 2c: Same as Alternative 2, but only applies to streams in the Russian River Hydrologic Unit, excluding the main stem Russian River below Cloverdale and Laguna de Santa Rosa upstream of its confluence with Santa Rosa Creek from the 64 °F temperature requirement. The approach taken in this alternative (2c) would be adequate if it included protection for migrating salmonids (both smolts and adults) in the Russian River below Hopland.

In addition to the current temperature objective, the following goal or objective would apply to streams in the Russian River Hydrologic Unit, excluding the main stem Russian River below Cloverdale and the Laguna de Santa Rosa mainstem upstream of its confluence with Santa Rosa Creek from the 64 °F temperature requirement:

> The natural receiving water temperatures shall not exceed 64 °F, measured as a 7-day average of daily average stream temperatures (MWAT). Additionally, the maximum daily temperature shall not exceed 75 °F. Exceptions to this objective are that from November 1 through April 30 or when anadromous salmonid species are engaged in spawning, embryo incubation, or fry emergence, the maximum stream temperature

shall not exceed 56 °F, measured as a 7-day average of daily average stream temperatures (MWAT). If there are insufficient data to establish a 7-day average of daily average temperatures, 64 °F or 56 °F shall be applied as an instantaneous maximum. Additionally, at no time shall the temperature be increased by more than 5 °F above natural receiving water temperatures. If anthropogenic sources prevent achievement of the 64 °F MWAT and 75 °F daily maximum temperature objectives, efforts should be made to develop a temperature management plan. Planning should be aimed at reducing stream temperatures and framing water quality objectives in consideration of the timing of the Species' life history events.

The main stem Russian River below Cloverdale and the mainstem Laguna de Santa Rosa upstream of its confluence with Santa Rosa Creek would be exempt from the 64 °F temperature requirement as these reaches generally have stream temperatures greater than 64 °F between June 1 and September 30. A disadvantage is that it is not fully protective, since only a portion of the main stem Russian River would be afforded this level of protection. Even when exempting the above mentioned reaches, there may be areas within the Russian River watershed where the summer time temperature requirement of 64 °F may not be attained under current conditions.

Alternative 2d: Retain the current temperature objective except during periods of spawning, egg incubation, and fry emergence where numeric temperature objectives would apply to protect these critical life stages.

In addition to the current temperature objective, the following goal or objective would be added:

From November 1 through April 30 or when anadromous salmonid species are engaged in spawning, egg incubation, or fry emergence, the stream temperature shall not exceed 56 °F, measured as a 7-day average of daily average stream temperatures (MWAT). If there are insufficient data to establish a 7-day average of average stream temperatures, the numeric criterion shall be applied as an instantaneous maximum.

This alternative protects the critical life stages of spawning, egg incubation, and fry emergence, but affords little protection to juvenile salmonids from high summer temperatures. It is not fully protective.

Staff Recommendations

1. While Alternative 2 is preferred, staff is not prepared to recommend a specific alternative within Alternative 2 at this time. Careful consideration of the timing and occurrence of life history events should frame any changes to the Region's water quality objectives. Where water temperature objectives are not achievable, management plans to reduce thermal loading should be developed.
2. Additionally, staff recommends adoption of the RARE beneficial uses designation for the Russian River per the recommendation for dissolved oxygen.
3. Staff further recommends adding the MIGR beneficial use designation to the mainstem Laguna de Santa Rosa. The Laguna is used as a migration corridor for fish migrating to and from Santa Rosa Creek and, potentially, other tributaries further upstream.

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USEPA, Region IX, Correspondence to SWRCB, Edward C. Anton, Acting Executive Director, re Review of the Water Quality Control Plan for the North Coast Region, May 2, 2000

OIL AND GREASE

Background
Oils and greases generally are not a part of the natural environment. Oils and greases of petroleum origin are commonly man-made and introduced as a pollutant and toxicant in natural aquatic systems. Oils of animal or vegetable origin are generally chemically non-toxic to aquatic life; however, floating sheens of such oils result in some of the deleterious effects described below. Oily substances of any kind may be harmful to fresh-water fish in the following manners (McKee et. al. 1971):

- Free oil and emulsions may coat the epithelial surfaces of the fish, adhering to the gills and interfering with respiration.
- Free oil and emulsions may coat and destroy algae and other plankton, thereby removing an important part of the food web.
- Settleable oily substances may coat the bottom, destroy benthic organisms, and interfere with spawning areas.
- Soluble and emulsified material, ingested by fish, taint the flavor of the flesh.
- Organic materials may deoxygenate the waters sufficiently to kill fish.
- Heavy coatings of free oil on the surface may interfere with the natural processes of reaeration and photosynthesis.
- Water-soluble components of oil and grease may exert a direct toxic action on fish or fish food organisms. Such toxicity may be acute or chronic.

Concentrations of oil and grease can also have negative impacts on aquatic systems, including salmonids (see Table 2). The sub-lethal effects of petroleum products have been reported at concentrations between 10 and 100 ug/L (parts per billion). Mironov (1967) reported that oil at a concentration of 10 ug/l produced deformed and inactive flatfish larvae.

Life History Requirements (LHR)
Many differences in the toxic properties of oil make it difficult to establish numerical criteria which would be applicable to all types of oil. Because of this, the U.S. Environmental Protection Agency (EPA) criteria for oil and grease for aquatic life states (U.S. EPA 1986) :

1. The upper allowable limit of an individual petrochemical in the water column should not exceed a factor of 0.01 of the lowest continuous flow 96-hr. LC50 to several resident freshwater or marine species, each having demonstrated a high susceptibility to oils and petrochemicals. **Note:** It is impossible to establish meaningful 96-hr. LC50 values for oil and grease without specifying the individual product(s) involved (LC50, lethal concentration is a point estimate of the toxicant concentration that would be lethal to 50% of the test organisms during a specific period).
2. Levels of oils or petrochemicals in the sediment which cause deleterious effects to the biota should not be allowed.
3. Surface waters shall be virtually free from floating nonpetroleum oils of vegetable or animal origin, as well as petroleum-derived oils.

\ paucity of data exists for the effects of oil and grease on fresh water salmonids of concern in the Russian River watershed. The following able details the results of studies completed on other species.

:able 1. Summary of Toxic Responses of Finfish (from Moore, et al. 1973)

:ommon Name	Scientific Name	Experiment Type	Substance and Reported Amount	Estimated Hydrocarbons in Solution	Duration	Response	Reference	Remarks
ıtlantic almon	Salmo salar	Laboratory	Corexit 8666 1-10,000 mg/L complete emulsion		7-14 days	4 day LD50 >10,000 mg/L	Sprague & Carson (1970)	Authors point out probability of sublethal-long-term effects of oil dispersant at lower conc.
"	"	"	1-10,000 mg/L complete emulsion) BP1100 B BP1100 Gulf agent 1009 Naphtha gas Dispersant 88 Dispersol SD BP1002 XZIT x-1-11	2-200 ppm	7-14 days	4 day LD50 1-100 mg/L		Authors believe Corexit is microbially degraded; the by-products of this process, either from Corexit or waste from microbes are toxic after 7 days building in test tank
"	"	"	1-10,000 mg/L temporary emulsion Bunker C	0-1 pm	7-14 days	4 day LD50 >10,000 mg/L 7 day LD50 ~2000 mg/L		
"	"	"	Bunker C & Corexit 8666		7-14 days	4 day LD50 7 day LD50 =100-1000 mg/L		
lounder vinter)	Pseudo-pleuronectes americanus	"	Bunker C & Corexit 866		7-14 days	4 day LD50 >10,000 mg/L 7 day LD50 ~1000 mg/L		

freshwater fish	Mugli saliens Sargo annularis Creilabrus tenca	"	"oil" .25 ml/l		"many days" "several days"	no effect	Mironov (1970)	Emulsion more toxic than film
Plaice	Rhombus maeoticus	"	"oil" $10^{-4} - 10^{-5}$ ml/l		2 days	Lethal toxicity to eggs	"	
Shad	Alosa sapidissima	"	Gasoline #2 Diesel fuel Bunker C			LD50 24 48 96 Gas 91 91 – #2 204 167- C -2, 417, 1,952	Tagatz (196_)	Loss of toxicity by evaporation
Mullet	Mugil cephalus Micropogon undulatus	"	#2 Diesel oil .01 – 10% emulsified	.002-2 ppm		LD50 (48 hrs.) ~420 ppm (acute) LD50 (Chronic) 42 ppm	Texas Instruments (1971)	Safe at 4.2 ppm

Permitting and Monitoring

Some NPDES permits (5 of 18) issued by the Regional Board within the Russian River watershed contain the Basin Plan oil and grease objective. Violations of permit requirements, such as oil and grease discharge limits, are followed up and investigated by Regional Board staff.

Analysis of LHR versus Water Quality Objective

Oil and Grease Objective

The oil and grease objective contained in the *Water Quality Control Plan for the North Coast Region* (Basin Plan) is as follows:

> Waters shall not contain oils, greases, waxes, or other materials in concentrations that result in a visible film or coating on the surface of the water or on objects in the water, that cause nuisance, or that otherwise adversely affect beneficial uses.

This objective appears to be appropriate when considering the major difficulties encountered in setting criteria for oil and grease. The difficulty arises because oil and grease is not comprised of definitive chemical categories, but thousands of organic compounds with varying physical, chemical, and toxicological properties. These compounds may be volatile or nonvolatile, soluble or insoluble, persistent or easily degraded.

Discussion

Field and laboratory evidence has demonstrated both acute lethal toxicity and long-term sub-lethal toxicity of oils to aquatic organisms. Several studies following oil spills have documented the immediate death of a wide variety of aquatic organisms, including the *Tampico Maru* wreck of 1957 in Baja, California, (Diaz-Piferrer 1962, as cited in EPA 1986), and the No.2 fuel oil spill in West Falmouth, Massachusetts, in 1969 (Hampson and Sanders, 1969, as cited in EPA 1986).

The long-term sub-lethal effects of oil pollution refer to interference with cellular and physiological processes such as feeding and reproduction and do not lead to immediate death of the fish (see Table 2). Investigations conducted over several years into the effects of the 1989 *Exxon Valdez* oil spill in Prince William Sound, Alaska, (Willette 1996) suggest that chronic damage occurred to populations of salmonids.

The results of a study performed following the *Valdez* spill in 1989 through 1993 (Bue, et. al 1998) indicate significantly elevated embryo mortality in populations of pink salmon inhabiting streams previously contaminated by oil.

The impacts on migration, growth, and survival of juvenile pink salmon were studied beginning in 1989 following the *Valdez* spill (Willette 1996). Exposure to hydrocarbons appeared to reduce the growth rate by 0.76 to 0.94% body weight/day. The observed reduction in growth rate was associated with a significantly greater frequency of cytochrome P-4501A enzyme induction. The greater frequency of cytochrome P-4501A induction in moderately oiled areas than in non-oiled and lightly oiled areas in 1989 indicates that fish in oil-contaminated habitats expended energy to metabolize and depurate hydrocarbons, leaving less energy available for somatic growth. The reduction in growth rate is attributed to oil contamination in 1989 which is presumed to have caused a 1.7 to 2.2% reduction in survival to the adult stage among fish reared in the oiled areas. The adult pink salmon return to Prince William Sound in 1990 was thus lower than if the *Valdez* spill had not occurred.

Another *Valdez* study (Geiger et. al. 1996) estimated that approximately 28% (1.9 million) of the potential wild-stock pink salmon failed to return to the southwestern part of Prince William Sound the year following the oil spill. This was primarily due to a lack of growth in the critical near-shore life stage when they entered seawater in spring 1989 during the height of the spill.

Due to direct poisoning of pink salmon in the embryonic stage in 1989, a reduction of 60,000 adult pink salmon in 1991 and 70,000 in 1993 was observed. In both 1991 and 1992 this was 6% or less of the potential wild-stock production in the southwestern part of the Sound and less than 2% of the potential wild production in the entire sound.

Staff Recommendation

No change to the current objective. The current Basin Plan water quality objective does not allow the presence of oil and grease constituents in water, and appears to provide adequate protection. Staff effort to develop a numeric objective would be complex considering the myriad of chemicals comprising "oil and grease", and it would be difficult to enforce given the cost of monitoring alone. The California Toxics Rule promulgation will address the major toxic components of the broad oil and grease category.

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SEDIMENT, SETTLEABLE MATERIAL, TURBIDITY, AND SUSPENDED MATERIAL

Background

This section will address four Basin Plan objectives related to sediment: settleable material, sediment, turbidity, and suspended material. These four constituents are being grouped together because they are closely linked in their impacts on aquatic habitats, their sources within a watershed, their natural time of occurrence at elevated levels, and in how they have been addressed in the development of total maximum daily loads (TMDLs) for sediment impaired streams.

In general, excessive sedimentation contributes to the reduction and loss of habitat necessary to support cold water fish. Increased erosion can cause coarse and fine sediment to enter the stream, filling in deep pools and silting in potential spawning gravels to the detriment of salmonids. Impacts are generally to the habitat required by the Species rather than the direct physical health of the organisms.

North Coast watersheds, such as the Russian River, typically have a geology that is prone to storm-induced erosion events. As such, settleable material, sediment, turbidity, and suspended material are all part of the natural aquatic environment. These parameters are naturally elevated for periods of time during the high runoff, rainy season, and aquatic organisms have developed life history strategies around the natural timing, duration, and levels of these constituents. There is of course natural inter-annual variation in both the timing, duration, and levels of these constituents. However, land use activities can accelerate the natural process and alter the timing, duration, and amount of these constituents to levels significantly outside their natural range. This can overwhelm a stream channel's naturally ability to efficiently move the delivered sediment while still providing salmonid habitat.

The majority of what is being proposed here to address sediment related impacts is taken from previously developed North Coast TMDLs for sediment-impaired coastal streams. In development of these TMDLs, Regional Board and Environmental Protection Agency (EPA) staff have proposed to use numeric instream targets which are believed to integrate cumulative effects over annual timeframes instead of indicators which measure instantaneous conditions (e.g. turbidity). These numeric targets (goals for instream indicators) serve to address the settleable material, sediment, turbidity, and suspended material water quality objectives. The numeric targets focus on the impacts to the habitat necessary for successful migration, spawning, reproduction, and early development of salmonids caused by the delivery of coarse and find sediment to stream systems.

The approach of using instream numeric targets as surrogates for attaining the settleable material, sediment, turbidity, and suspended material objectives is the approach we propose to use for protecting the Species from sediment related impacts in the Russian River watershed. Because the Russian River is listed as impaired due to sedimentation, this approach will serve us now in beginning to protect the Species from sediment related impacts and in the future when the sediment TMDL is ultimately developed for the Russian River. When the Russian River sediment TMDL is developed, the other necessary TMDL components, namely a detailed problems statement, a source analysis, a linkage analysis, the load allocation(s), and an implementation plan, will be developed, as will a re-evaluation of the proposed numeric targets. Information on hydrology, stream type, watershed condition, and the association of aquatic life to the physical measures will also be analyzed and incorporated into the process of developing an implementation plan. In the mean time, the numeric targets we are proposing can be the basis for monitoring sediment related impacts and reducing sediment inputs to the Russian River and its tributaries. The need to continually collect data that can be used in further research and analysis is paramount to this effort.

While the general approach outlined above will likely be effective in monitoring long-term trends in the system, and will be valuable in identifying problems and establishing overall objectives for the watershed, the TMDL process will address the tasks of assessing and addressing potential short-term or chronic, site-specific conditions.

Life History Requirements (LHR)
In general, sedimentation impacts the *habitat* of the Species rather than their direct physical health. Laboratory experiments designed to assess the impact of various levels of a specific pollutant can provide reliable results regarding acute or chronic effects of a given pollutant. However, no such direct experiment can determine how much sediment can enter a stream before altering the habitat in such a way as to significantly reduce the Species sustained reproductive success. Because of this and the fact that we propose to use numeric instream targets to achieve the settleable material, sediment, turbidity, and suspended material water quality objectives, and more importantly, the proper physical habitat conditions, staff did not conduct literature reviews to determine the sediment requirements of the Species. Instead, we focus discussion on the general problem excessive sediment produces for instream salmonid habitat and how numeric instream targets can address the problems.

We recognize that chronically high levels of suspended solids and turbidity also can directly affect fish populations. The severity of the effects on fish depends on the level and duration of exposure. We will consider in the development of implementations for achieving new objectives the methodologies contained in the following documents: Newcombe and Jensen (1996) for quantitative assessment of risk and impact to fish that could be applied to site-specific activities, such as temporary dam installation or removal, instream work, or removal of vegetation that results in increased erosion; Lloyd, et al. (1987) who proposed turbidity standards for salmonid habitats in Alaska to protect against loss of primary productivity, and Barrett, et al. (1992), Bisson and Bilby (1982), and Sigler, et al. (1984) who have reported on long term effects of turbidity and suspended solids.

Water Quality Objectives
The water quality objectives for settleable material, sediment, turbidity, and suspended material contained in the *Water Quality Control Plan for the North Coast Region* are as follows:

Settleable Material:
"Waters shall not contain substances in concentrations that result in deposition of material that causes nuisance or adversely affect beneficial uses."

Sediment:
"The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses."

Turbidity:
"Turbidity shall not be increased more than 20 percent above natural occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof."

Suspended Material:

"Waters shall not contain suspended material in concentrations that causes nuisance or adversely affect beneficial uses."

These objectives, with turbidity being a possible exception, are not specific enough to protect salmonid habitats from the cumulative effect of sediment related impacts. They also, to some degree, allow for degradation up to the point at which there begins to be a nuisance or adverse affect on beneficial uses and the Species. By the time adverse impacts are realized, it may be very difficult to mitigate the impacts and recover the Species to acceptable levels. For these reasons, we are proposing to use the approach used in developing TMDLs for sediment-impaired coastal streams, namely the use of instream indicators which address sediment related impacts to the quality and quantity of instream habitat necessary for successful migration, spawning, reproduction, and rearing of anadromous salmonids. While it may be appropriate to consider changing the turbidity objective, we are hesitant at this time to propose an actual numeric limit based on our literature review. If new data are available as we develop the Basin Plan amdendment documentation, we will reconsider proposing a different turbidity objective.

General Problem Statement

Streams in the Russian River watershed have experienced a reduction in the quality and quantity of instream habitat which is capable of supporting the cold water fishery due to sediment related impacts. Three important factors in describing the issue of sedimentation are: sediment production, sediment delivery, and sediment transport. Sediment trapping caused by large reservoirs and in-channel gravel extraction from past mining practices have caused channel incision in some portions of the river. The incision and channelization results in nearly vertical banks and erosion of these unstable banks. Other areas of the River are aggrading due to too much sediment from land use activities, river incision, and erosion of vertical banks. These geomorphic changes also effect tributaries as they adjust to changes in the mainstem Russian River. The Sonoma County Aggregate Resources Management Plan imposes restrictions on extraction to ensure that incision, or channel degradation, does not occur. A determination should be made regarding current in-channel mining in Sonoma and Mendocino Counties and its effects on channel incision.

For gravel-bed streams, such as the Russian River and its tributaries, the presence of channel structure plays a crucial role in the efficient storage, sorting, and transport of sediment through the river system. Channel structure includes boulders, armored stream banks, large woody debris, and other structural elements. For streams in the Pacific Northwest, including northern California, large woody debris has been identified as a particularly important structural element. Thus, sediment delivery and instream channel structure are integral companions in the problems (and solutions) related to sedimentation and the reduction in the quality and quantity of instream habitat.

1. Instream Problem Statements

A. Fine Sediment in Spawning Gravels

This statement relates to the SPAWN beneficial use and the potential for settleable material to impact spawning substrate or redds. Spawning gravels of the Russian River watershed are impacted and likely to suffer additional impacts by the delivery of fine sediment to the stream which fills the interstices of the framework particles: 1) cementing them in place and reducing their viability as spawning substrate, 2) reducing the oxygen available to fish embryos, 3) reducing gravel permeability and intragravel water velocities which directly affect the delivery of nutrients to and waste material from the interior of the redd (salmon nest), and 4) impairing the ability of fry (young salmon) to emerge as free-swimming fish.

Gravel requirements of salmonids differ with life stage and therefore, a single statistic cannot fully or accurately represent gravel size relevant to the functions of redd construction, embryo incubation, and fry emergence (Kondolf 2000). The timing of sediment transport in the channel is critical to spawning success. Knowledge of natural sediment transport and life history requirements during any point in time is necessary to plan oversight of anthropogenic sources of sediment. As updated and state-of-the-art assessment approaches are developed, we will move closer towards a comprehensive understanding of sediment dynamics relating to the various life history stages of the Species.

B. Channel Aggradation/Degradation
This statement relates to the SPAWN and COLD beneficial uses and the potential for sediment and settleable material to impact spawning substrate and habitat. Stream channels in the Russian River watershed are impacted by the delivery of fine and coarse sediment to the stream which causes aggradation, the burial of large woody debris and other structural elements, difficulties in adult migration past large depositions in low flows, a loss of the stream's ability to effectively sort gravel, and a potential reduction in the dominant particle sizes. Likewise, channel down-cutting impacts habitat and streambed gravel structure.

C. Lack of suitable pools for Rearing Habitat
This statement relates to the SPAWN and COLD beneficial uses and the potential for sediment and settleable material to impact rearing habitat. Pools in the Russian River watershed potentially suitable as rearing habitat are impacted by the delivery of fine and coarse sediment to the stream which: 1) reduces the volume of available rearing habitat by filling in pools and burying pool-forming structural elements such as large woody debris, 2) reduces pool depth and therefore the cool water refuge associated with temperature stratification, 3) reduces the availability of fish cover as a result of decreased depths and the burial of large woody debris and other structural elements, and 4) causes loss of surface flow as pools are filled in resulting in less available habitat and protection from predators. Due to its size, geology, and hydrology, the variability in the Russian River watershed may make some numeric instream targets difficult to implement, particularly for pool depth. Site-specific conditions may affect whether a pool of depth greater than one meter provides better fish habitat, for instance.

D. Stream Channel Instability
This statement relates to the COLD and EST beneficial uses and the potential for sediment to impact stream channel stability and habitat niches. Increased sediment delivery to the Russian River watershed impacts stream channel stability by causing: 1) aggradation, stream channel widening, greater flood potential, and greater stream bank erosion, and 2) the burial of channel structural elements such as large woody debris with consequent sediment transport changes.

E. Physical Barriers to Migration
This statement relates to the MIGR beneficial use and the potential for barriers to prevent the migration of salmonids. (Natural barriers, such as bedrock falls, are not addressed here since they were not created by land management activities and hence are not controllable.) The migration of anadromous fish in the Russian River watershed from the ocean, within the watershed, and back to the ocean is impacted by the presence of migration barriers. These include, but are not limited to, shallow or dewatered stream segments due to aggradation (rising stream bed elevation from excessive sediment inputs) or degradation (loss of streambed elevation from excessive sediment withdrawal or sediment barriers) which may be in combination with water diversions, summer impoundments

lacking functional fish ladders, plugged or hanging culverts, poorly constructed stream crossings, and water conveyance structures which prohibit passage by being too long, having high winter velocities, or shallow summer depths. Site-specific conditions are important here as well, restricting passage of small fish to and among rearing habitats during low summer flows and high water temperatures.

2. Upslope Problem Statements

A. *Improperly Designed or Maintained Roads*
This statement relates to the COLD and SPAWN beneficial uses and the potential for sediment and settleable matter to impact stream channel stability and habitat niches. Improperly designed and maintained roads can cause: 1) increased surface erosion and fine sediment production and delivery, 2) an increased potential for stream diversions (stream channel capture), rill and gully erosion, and road related catastrophic failures, including landslides and crossing failures with significant increases in coarse and fine sediment production and delivery, as well as cumulative impacts well downstream and downslope from the road, and, 3) increased stream discharge above the natural flow regime by altering flow patterns with culverts and ditches which ultimately may increase velocity and erosion.

B. *Sediment from Unstable Areas*
This statement relates to the COLD beneficial use and the potential for sediment and settleable matter to impact stream channel stability and habitat niches. Unstable areas created from construction activities, agricultural operations in streamside areas, and timber harvest operations on unstable slopes (e.g., inner gorges, headwall swales, active or potentially active landslides, or steep slopes) in the Russian River watershed can cause an increase in the delivery of fine and coarse sediment.

C. *Removal of Riparian Trees and Loss of Large Woody Debris*
This statement relates to the COLD beneficial use and the potential for sediment and settleable matter to impact stream channel stability and habitat niches. The removal of vegetation from the riparian zones of the Russian River watershed can cause: 1) a loss of stream bank stability and increased stream bank erosion, 2) a loss of sediment filtering capacity and increases in sediment delivery, and 3) a reduction in the potential for large woody debris recruitment to the stream and in the stream's sediment transport dynamics.

Numeric Targets
The numeric targets developed for North Coast sediment TMDLs, and those proposed in this analysis for the Russian River Watershed, are intended to interpret the narrative water quality standards adopted in the Basin Plan. Except for the existing turbidity standard which we propose to retain, the numeric targets would not be directly enforceable. Rather, they are tools which assist in analyzing and depicting the extent of the current problem, which is how we propose to use the existing turbidity standard. The numeric targets and turbidity standard will serve as monitoring tools which will assist in evaluating whether the sediment load reductions are being attained and whether these load reductions are effective in bringing about needed improvements in aquatic habitat quality. In addition, these targets will help to develop a water quality process for sediment control at the Regional Board that can be referenced in water rights permits similar to waste discharge requirements for point sources.

Instream numeric targets, as included in this analysis, represent the optimal stream habitat conditions for salmonid reproductive success. They were chosen after reviewing the sediment–related TMDLs developed for other North Coast streams and noting numeric targets common to most TMDLs. Staff did not conduct an extensive assessment of current sediment conditions within the watershed as is done in development of a TMDL, but relied on the work of others in developing numeric targets in conjunction with sediment TMDLs for North Coast streams. The numeric targets are based on scientific literature and best professional judgment. The instream targets provide a vital set of measures of whether, in the long run, beneficial uses impacted by sedimentation are recovering. When these targets are met, the water quality objectives should also be met.

The indicators for which we are proposing instream numeric targets include percent fines <0.85 mm, percent fines <6.5 mm, width-to-depth ratio in tributary streams, percent riffles, pool depth, and barriers to migration. We are also proposing to use the current Basin Plan turbidity standard as a tool for assessing potential problems and tracking trends. We do not propose a target for pool sediment or "V*" due to the controversy and question of its applicability in this watershed. It will be considered again if data are developed that shed more light on its utility in this setting. Table 1 summarizes the proposed numeric targets.

Table 1. Instream Numeric Targets for the Russian River Watershed, based on ten-year rolling averages

Parameter (Instream Indicators)	Numeric Target
Percent fines <0.85 mm in gravels in fish-bearing[1] streams	<14%
Percent fines <6.5 mm in fish-bearing stream	<30%
% of Stream Length in Riffles[2]	<30% of stream reaches in riffles (reach gradient <2%)
Pool Depth (dependent to some degree on channel type)	low flow pool depth is >1.5 meters (>4.9 feet) for the mainstem of the Russian River; >1 meter (>3.3 feet) for third and fourth order tributaries; >0.5 meter (>1.6 feet) for first and second order tributaries.
Turbidity	Turbidity shall not be increased more than 20 percent above natural occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof.
Migrational Barriers	Zero, with improving trend.

1) Fish bearing streams: Fish present seasonally or year-round, or having fish habitat capable of supporting fish.
2) Riffle – low gradient (<2%): shallow stream channel areas with swiftly flowing turbulent water with some partially exposed substrate. Gradient<4%, substrate is usually cobble dominated. The gradient is the general slope, or rate of change in vertical elevation per unit of horizontal distance, of the water surface of a flowing stream; or the rate of change of any characteristic per unit of length

Pool depth targets for the mainstem and for tributaries to the Russian River have been separated to reflect the differences in stream sizes and related differences in desirable pool characteristics. In addition, the stream riffle target is being set only for the lower gradient parts of the Russian River watershed to reflect the fact that pool riffle structure may be substantially different in higher gradient streams. Scientific literature suggests that these indicators are the most easily linked to fish habitat conditions which support salmonids and can assist in evaluating long term impacts of upslope activities and erosion reduction efforts (Knopp, 1993, Chapman, 1988, Peterson, et.al. 1992, NMFS, 1997).

Some of the selected indicators and target values are sensitive to variations in conditions in different areas of the watershed, which are influenced by differences in geology and stream morphology. Insufficient information was available to reliably stratify the targets based on geologic settings. It may be desirable to use more dynamic indicators which set erosion reduction and habitat improvement goals as a function of the factors that determine year-to-year variations in sediment loading and stream responses. Ideally, we could include indicators which directly account for variations in precipitation and resultant runoff and flows. Use of this type of indicator would enable analysts to distinguish changes in erosion and instream effects associated with land management actions from changes attributable to differences in runoff intensity. This approach could make it easier to evaluate the effectiveness of the targets based on limited data.

Because such indicators could not be identified for this analysis, most of the numeric targets are proposed as ten-year rolling averages. This approach recognizes variability and helps ensure that conclusions concerning watershed responses to erosion control actions are not drawn prematurely. The drawback of this approach is that we must wait several years before we will be able to complete this critical evaluation of the effectiveness.

1. <u>Percent Fines <0.85 mm</u>
   Once the eggs are laid and fertilized, the spawners cover the redds with material from upstream, including clean gravels and cobbles. The interstitial spaces between the particles allow for water to flow into the interior cavity where dissolved oxygen, needed by the growing embryos, is replenished. Similarly, the interstitial spaces allow water to flow out of the interior cavity carrying away metabolic wastes. However, fine particles either delivered to the stream or mobilized by storm flow can intrude into those interstitial spaces, reducing gravel permeability which results in reduced water velocity through the gravel (McBain & Trush 1999). This blocks the flow of oxygen into the redd and the metabolic wastes out of it. The reduced permeability into and out of the redd results in a reduction in the rate of embryo survival.

   Numeric Target
   <u>The numeric target for fines ≤.85mm for the Russian River is less than or equal to 14%.</u> The target should be monitored at stream reaches around existing monumented cross sections to be selected during the design of the monitoring plan. The target is selected as the midpoint between the percentages of fines reported in unmanaged streams in the Peterson (1992) and Burns (1970) studies. The target takes into account that the 11% fines <0.85 mm which was observed in unmanaged streams in the Pacific Northwest (Peterson et al., 1992) is probably lower than would be expected in California. On the other hand, the 17% fines <0.85 mm which was seen in unmanaged California streams beginning in 1967 (Burns, 1970) is probably too high given the tremendous sediment loads which were discharged to streams as a result of the 1964 storms. In addition, Tappel and Bjorn (1983) predicted that 14% fines <0.85 mm in combination with about 30% fines <9.5mm would provide an average of 50% survival to emergence for steelhead and an average of 70% survival to emergence for chinook salmon. These appear to be acceptable rates of survival to emergence. The literature sources reviewed in setting the target generally support the 14% target level as reasonably protective.

2. <u>Percent fines <6.5 mm</u>
   After 4 to 6 weeks, the embryos are ready to emerge from the gravel as fry (young swimming fish). The presence of fine sediment in the gravel interstices can impede fry emergence. However, the size

of fine particles likely to fill the interstices of redds sufficient to block passage of fry are larger than those likely to suffocate embryos. That is, particles ranging from 0.85 mm to 9.5 mm are capable of blocking fry emergence, depending on the sizes and angularity of the framework particles, while still allowing sufficient water flow through the gravels to support embryo development. Besides a correlation between percent fines and the rate of survival to emergence, there is also a correlation between percent fines and the length of incubation; i.e., the amount of time it takes for the fry to emerge from the egg. Percent fines is also inversely related to the size of emerging fry (Chapman, 1988). Each of these factors impact the ultimate survivability of the embryos and fry.

Numeric Target

The numeric target for fines ≤6.5 mm is less than or equal to 25% for the Russian River watershed. The target should be monitored at stream reaches around existing monumented cross sections to be identified during the design of a monitoring program. The numeric target was selected based on a review of literature which evaluated the relationship between fines <6.5mm and survival to emergence rates for salmonids. Research results concerning the relationship between salmonid survival to emergence and levels of fines <6.5mm are relatively consistent. Tappel and Bjorn (1983) predicted that 30% fines <9.5mm in combination with 14% fines < 0.85mm would provide an average of 50% survival to emergence for steelhead. The same study predicted that 32% fines <9.5mm in combination with 14% fines < 0.85mm would provide an average of 70% survival to emergence for chinook salmon. Both steelhead and chinook are expected to have greater emergence success than coho salmon when redds are sedimented. McCuddin (1977) found that the ability of chinook salmon and steelhead trout to emerge from the substrate decreased sharply when sediment less than 6.4mm in diameter comprised more than 20-25% of the substrate. Kondolf (unpublished data), evaluating data from other studies, concluded that if one chooses a 50% survival to emergence rate, the data indicate that fines defined either as <3.35 or <6.5 mm should not comprise more than 30% of substrate composition. Finally, Chapman (1988) reported data from several other studies concerning fine sediment levels in unlogged Oregon watersheds which varied from 27-55%. The 30% target rate appears consistent with the research findings concerning acceptable survival to emergence rates and the levels of fines found in unlogged watersheds.

3. Percent Riffles

Juvenile coho require pools for both summer and overwintering rearing. In the summer, pools provide cool, quiet habitat where coho feed and hide from predators. During the winter, off-channel pools provide habitat in which coho and steelhead both can get out of flood flows to avoid being swept downriver and out to sea. Steelhead prefer riffles for rearing during their first summer, but make more regular summer uses of pool habitat as they grow in size. Pool volumes are reduced either when a stream's hydrologic power is reduced (e.g., by increased sediment loading) or by the reduction of pool-forming elements. The number of pool-forming elements can be reduced by modification of the channel morphology (e.g., burial), physical removal (e.g., log jam removal), reduction in supply (e.g., logging of near stream trees), or a combination of all three causes. Although vital to north coast streams, excessive riffle habitat indicates that deep water habitat is deficient as well.

Numeric Target

The target for percent riffles is no more than 30% riffles, by length for river and creek reaches less than 2% in gradient. This target is based on professional judgment and communication with staff developing TMDLs for north coast rivers with different habitat qualities. The 25-30% level is believed to be consistent with the riffle patterns found in well-functioning north coast streams.

This target only applies in the lower gradient sections of the watershed because percent riffles may exceed the target level in steeper streams which support excellent habitat. A single number for the entire Russian River may be overly restrictive. In the long run, it may prove more effective to measure pool quality and distribution based on statistical analysis of longitudinal profile data collected at monumented reaches. This monitoring method has promise in providing a more discriminating indicator of channel roughness and variability which can be adjusted (normalized) to account for and allow comparisons between streams of different sizes.

4. Pool Depth
Salmonids rely on deep, cool pools during the rearing stage for protection from predators and as refuges from high temperature water. Pool depth is partly a function of stream disturbance (and associated channel changes), geology, watershed conditions, topography, watershed size, flow, and pool-forming elements such as LWD and bedrock. Pools in larger streams tend to be deeper, on average, than pools in smaller streams (assuming other factors are equal). Flosi et al. (1998) concluded from the Department of Fish and Game's habitat typing data that better California coastal coho streams (stream order 3 or 4) have pools with depths of at least 3 feet. Better 1st and 2nd order streams have pool depths >18" (B. Coey 2000).

Numeric Target
The numeric target for low flow pool depth for salmonid rearing is >1.5 meters (>4.9 feet) for the mainstem of the Russian River, >1 meter (>3.3 feet) for third and fourth order tributaries to the Russian River, and >0.5 meters (>1.6 feet) for 1st and 2nd order tributaries. This target is based principally on the results reported by Flosi et al. (1998). While there is some evidence that chinook salmon prefer deeper pools than coho, the targets are consistent with the "species habitat needs matrix" developed by an interagency group in connection with resource management discussions with Pacific Lumber Company (NMFS, 1997). Because of the influence of summer impoundments on the mainstem, the numeric targets apply to those areas outside the influence of summer impoundments.

Ideally, the targets for pool depth should be geomorphologically based as well as fish habitat based. Some stream reaches may readily support deep pools, and therefore will have a high potential to support salmonid fishes. Other stream reaches, depending on the soil type or underlying geology and surrounding plant community, may not support deep pools. The mainstem Russian in Sonoma County may have had pools well in excess of 1.5 meters while the lower Russian may have had pools with a depth of 3 meters or more. As data are collected it should serve to adjust targets as appropriate to incorporate a more geomorphic approach.

5. Turbidity
Turbidity can be caused by phytoplankton, inorganic sediment and organic material suspended during high flows. High turbidity can adversely impact fish at nearly every life stage. Although there is usually a relationship between turbidity and sediment, generally, deposited sediments have a greater impact on fish than do suspended sediments, with spawning and incubation stages most directly affected. Particulate material associated with high turbidity can effect respiratory structures (e.g., fish gills) through physical abrasion and mechanical disruption. Sediment can cover intergravel spaces which fish use for shelter and reduce the diversity of aquatic insects and other aquatic invertebrates by reducing interstices in the substrate.

Application of the Basin Plan turbidity standard is sometimes problematic. One of the biggest problems is defining background conditions. Most watersheds are affected to some degree by recent land use activities, thus making a determination of background conditions somewhat arbitrary. The original use of the turbidity standard was as a comparison of conditions above and below a specific discharge. Background was simply determined to be the above discharge conditions. Nonpoint source impacts that emanate from diffuse watershed-wide activities make a simple upstream-downstream comparison nearly impossible. We therefore propose to use the turbidity numeric target as a tool for assessing potential problem areas and for tracking trends in degradation or improvement of sediment related conditions.

As more data are developed and presented in the literature, we will review the appropriateness of developing a different numeric objective for turbidity that relates to impacts to the Species.

Numeric Target
Turbidity shall not be increased more than 20 percent above natural occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof. The proposed numeric target for turbidity is a reiteration of the Basin Plan water quality objective for turbidity.

6. Migration Barriers The migration of adult salmon and trout upstream requires that there be no impassable barriers to their passage from the ocean to their spawning streams. Similarly, once the fry emerge from the gravel, there must be no barrier to the passage of these small fish from the spawning reaches to and among rearing habitats, particularly during the summer when flows may be low and temperatures warm. And finally, once the juveniles are ready to return to the ocean, there must be no barrier to their passage from their rearing reaches to the estuary and out to the ocean.

   Numeric Target
   The numeric target for human-caused migrational barriers is zero (0), with the goal being an improving trend. (Natural barriers, such as bedrock falls, are not addressed here since they were not created by land management activities and hence are not deemed controllable.)

Conclusion

The numeric targets are intended to interpret and apply the narrative water quality objectives. They were developed to support a goal of optimal salmonid success which is a conservative approach. A variety of instream indicators were selected because no single indicator provides a truly effective, discriminating measure of the relationship between sediment loading and instream sediment impacts. The instream numeric targets are expressed as ten-year rolling average values to account for interannual variability.

It is not intended that numeric targets for the Russian River Watershed be derived wholly from existing TMDLs in other watersheds in the North Coast region. Future monitoring and analysis will provide additional information concerning these indicators and their specificity for the Russian River watershed especially during development of a sediment TMDL for the Russian River. Cross section and thalweg measurements should prove effective in the future as indicators of channel stability and change over time. Monitoring and assessment protocols which are being developed and refined to analyze the substrate composition and quality of instream habitat conditions will give us greater resolution in fine-tuning numeric targets. These indicators and targets can be revisited and revised if necessary to provide the most discriminating set of indicators possible. The Regional Water Board will consider inclusion of indicators based on these and other new monitoring approaches as they become available in the future.

Permitting and Monitoring
With the exception of turbidity which is in most permits, none of the current Waste Discharge Requirement permits issued by the Regional Board within the Russian River watershed contain the above numeric instream targets. Likewise, there are no current requirements to monitor the proposed numeric targets.

Currently, 14 of 18 dischargers' permits contain standards and are monitored for suspended solids, eleven of 18 dischargers' permits contain standards and are monitored for settleable solids, and seventeen of 18 dischargers' permits contain standards and are monitored for turbidity. Those sources, however are not of an erosional or geologic sediment.

Analysis of LHR versus Water Quality Objective
Staff has not analyzed the Species LHR for settleable material, sediment, turbidity, or suspended material, per se. Rather, we are proposing to use numeric instream targets to improve instream salmonid habitat quality and quantity from sediment related impacts and meet associated water quality objectives.

Discussion of Alternatives

Alternative 1: Maintain the current Basin Plan water quality objectives for settleable material, sediment, turbidity, and suspended material with no other considerations for addressing sediment related impacts.

The advantage to this approach is that it uses existing objectives with little impact to staff resources and time. Disadvantages include the likelihood that the current standards are inadequate in protecting anadromous fish from cumulative sediment related impacts and that impacts up to the point of causing a nuisance or adversely affecting beneficial uses is allowed.

Alternative 2: Adopt the proposed instream numeric targets as goals for addressing sediment related impacts and meeting the settleable material, sediment, and suspended material and retain the existing Basin Plan water quality objective for turbidity.

The advantage to this approach is that the numeric targets (goals for instream indicators) focus on the impacts to the habitat necessary for successful migration, spawning, reproduction, and early development of salmonids caused by the delivery of coarse and find sediment to stream systems. Hence, when the targets are met, there should be instream habitat conditions that support sustainable populations of listed anadromous fish. Also, in meeting the numeric targets, the settleable material, sediment, turbidity, and suspended material Basin Plan objectives also should be achieved. Finally, adopting the proposed numeric targets sets a base for developing the required sediment TMDL for the Russian River. A disadvantage might include the need to train people for monitoring the proposed instream indicators.

Staff Recommendation
Staff recommends Alternative 2 with flexibility to modify the targets for local conditions as data become available.

Staff believes the translation of the narrative objectives for sediment and sedimentation are necessary to more full define objectives along life history requirements. While the proposed targets are from the literature, we recognize the opportunity to amend the targets as data are collected to define local or site-specific conditions. For that reason, we recommend that the targets be considered non-enforceable goals. Regarding implementation of controls to meet goals, the Basin Plan amendment process must consider other factors, such as economics and reasonableness.

Also, the Russian River is 303(d) listed for sediment meaning that no new discharges that contribute to the impairment are permitted without offsetting reductions in loading from another source. This means that all new permitted sources of sediment may harm beneficial uses, no matter how small the contribution to the waterway. There is some confusion regarding the application of this regulation to non-permitted and/or nonpoint source discharges.
These goals may serve as preliminary targets for the development of TMDLs, with final targets based on compliance with Water Code sections 13241 and 13242.

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ALUMINUM

Background

Aluminum is the third most abundant element in the earth's crust, the first two being oxygen and silicon. Widely distributed throughout rocks and soils, it is found in silicate rocks such as feldspars, in gibbsite, alunite, and in various minerals contained in clays. Weathering and erosion processes of these minerals cause the natural input of aluminum into surface waters (Faust 1981).

Anthropogenic sources include building material in the automotive industries, for power transmission, as an alloying element with magnesium, manganese, silicon, and zinc, in special paints, in packaging materials, and as a flocculating agent in the purification of water and sewage.

The complexity of aluminum in water presented challenges in developing water quality criteria for freshwater aquatic organisms because:

1. Aluminum is amphoteric, more soluble in acidic solutions and in basic solutions than in circumneutral solutions.
2. Aluminum forms soluble complexes with ions such as chloride, fluoride, nitrate, phosphate, and sulfate.
3. Aluminum can form strong complexes with fulvic and humic acids.
4. Aluminum ions can be connected by hydroxide ions to form soluble and insoluble polymers.
5. In some conditions, solutions of aluminum in water approach chemical equilibrium somewhat slowly.

USEPA's Aluminum Criteria for Protection of Aquatic Life

Aluminum criteria were developed by USEPA (1988), which address the toxicity of aluminum to freshwater organisms in waters where the pH is between 6.5 and 9.0. The data used to derive the criteria are presented below in tabular form. Data references can be found in USEPA (1988).

Acute Toxicity of Aluminum to Freshwater Aquatic Animals

Species	Method *	Chemical	Hardness (mg/L as CaC03)	pH	LC50 or EC50** Al (μg/L)	Species Mean Acute Value Al (μg/L)
Chinook Salmon (juvenile) <u>Oncorhynchus tshawytscha</u>	S, M	Sodium aluminate	28.0	7.0	>40,000	>40,000
Rainbow trout, (juvenile) <u>Salmo gairdneri</u>	S, M	Aluminum chloride	47.4	7.46	8,600	-
Rainbow trout, (juvenile) <u>Salmo gairdneri</u>	S, M	Aluminum chloride	47.4	6.59	7,400	-

Species	Method*	Chemical	Hardness (mg/L as CaC03)	pH	LC50 or EC50** (µg/L)***	Species Mean Acute Value (µg/L)***
Rainbow trout, (juvenile) Salmo gairdneri	S, M	Aluminum chloride	47.4	7.31	14,600	-
Rainbow trout, (juvenile) Salmo gairdneri	S, M	Aluminum chloride	47.4	8.17	>24,700	10,390
Brook trout (juvenile) Salvelinus fontinalis	F, M	Aluminum sulfate	-	6.5	3,600	3,600
Fathead minnow (adult), Pimephales promelas	S, U	Aluminum sulfate	-	7.6	>18,900	-
Fathead minnow (juvenile), Pimephales promelas	S, M	Aluminum chloride	47.4	7.61	>48,200	-
Fathead minnow (juvenile), Pimephales promelas	S, M	Aluminum chloride	47.4	8.05	>49,200	-
Fathead minnow (juvenile), Pimephales promelas	F, M	Aluminum sulfate	220	7.34	35,000	35,000

* S = static; F = flow-through; M = measured

** EC50 (Effect Concentration) is a point estimate of the toxicant concentration that would cause an observable adverse effect (such as death, immobilization, or serious incapacitation) in 50% of the test organisms
LC50 (Lethal Concentration) is a point estimate of the toxicant concentration that would be lethal to 50% of the test organisms during a specific period

Chronic Toxicity of Aluminum to Freshwater Aquatic Animals

Species	Test	Chemical	Hardness (mg/L as CaC03)	pH	Chronic Limits Al (µg/L)	Chronic Value Al (µg/L)
Fathead minnow, Pimephales promelas	ELS*	Aluminum sulfate	220	7.24 - 8.15	2,300 - 4,700	3,288

* ELS = early life-stage

Acute-Chronic Ratio

Species	Hardness (mg/L as CaC03)	pH	Acute Value Al (µg/L)	Chronic Value Al (µg/L)	Ratio
Fathead minnow, Pimephales promelas	220	7.24 - 8.15	35,000	3,288	10.64

Other Data on the Effects of Aluminum on Freshwater Aquatic Organisms

Species	Chemical	Hardness * (mg/L as CaC03)	pH	Duration	Effect	Concentration Al (µg/L)
Rainbow trout (fingerling) Salmo gairdneri	Aluminum chloride	46.8 28.3 28.3 56.6 56.6	8.02 8.48 8.99 6.64 6.80	32 days 7.5 days 3 days 44 days 39 days	50% dead 50% dead 50% dead 50% dead 50% dead	5,230 5,140 5,200 513 5,140
Rainbow trout (embryo) Salmo gairdneri	Aluminum chloride	-	7.0-9.0	Fertilization to hatch	No reduced fertility	5,200
Rainbow trout (embryo, larva) Salmo gairdneri	Aluminum chloride	104 (92-110)	7.4	28 days	EC50** (death & deformity)	560
Rainbow trout (juvenile) Salmo gairdneri	Aluminum sulfate	25	7.0 8.0 8.5 9.0	10 days 96 hr 42 hr 42 hr	0% dead 40% dead 100% dead 100% dead	200,000 50,000 50,000 50,000
Rainbow trout (embryo, larva) Salmo gairdneri	Aluminum sulfate	14.3	6.5 7.2	8 days	No effect No effect	1,000 1,000
Rainbow trout Salmo gairdneri	Aluminum sulfate	14.3	6.5 7.2	8 days	14.2% dead 21.6% dead	1,000 1,000
Rainbow trout Salmo gairdneri	Aluminum sulfate	-	6.5	11 days	Increased ventilation rate	75
Brook trout (eyed embryo) Salvelinus fontinalis	Aluminum sulfate	13	7.2	To 30 days post-hatch	Reduced some behaviors	242
Brook trout (37 days) Salvelinus fontinalis	Aluminum sulfate	14	7.3	30 days	Reduced some behaviors	242

Brook trout (eyed embryo) Salvelinus fontinalis	Aluminum sulfate	<1	7.8	To hatch	Did not decrease % hatch	283
Brook trout (larva) Salvelinus fontinalis	Aluminum sulfate	<1	7.8	60 days	Reduced growth & some behaviors	283
Brook trout (embryo, larva) Salvelinus fontinalis	Aluminum sulfate	12.3	6.5-6.6	60 days	48% dead 3% dead 24% reduction in weight 4 % reduction in weight	Cleveland et al. Manuscript

* The freshwater criterion for this metal is expressed as a function of hardness (mg/L) in the water column. The value given here corresponds to a hardness of 100 mg/L.

** EC50 is a point estimate of the toxicant concentration that would cause an observable adverse effect (such as death, immobilization, or serious incapacitation) in 50% of the test organisms

EPA's aquatic life criterion is, "an estimate of the highest concentration of a substance in water which does not present a significant risk to the aquatic organisms." (USEPA 1985). The following represents the current USEPA national recommended freshwater quality criteria for aluminum, a non priority pollutant, in water at pH 6.5 – 9.0. (USEPA 1998). This pH range of 6.5 to 9.0 was used as it appears to adequately protect freshwater fishes and bottom-dwelling invertebrate fish food organisms from effects of the hydrogen ion. The criterion is expressed in terms of total recoverable metal in the water column.

750 **µg/L Al** (Criteria Maximum Concentration - short-term concentration acute limit)

87 **µg/L Al** (Criteria Continuous Concentration - a four-day average concentration chronic limit).

The above criteria are unchanged from USEPA national criteria of 1988 which was based on the water quality data for aquatic life presented in this report. USEPA also recommends the above criteria in its "National Recommended Water Quality Criteria Notice" (USEPA 1998) pursuant to section 304(a) of the Clean Water Act (CWA) for freshwater aquatic life. Although these criteria are not required, they provide guidance for States under CWA section 303 (c) in developing and adopting water quality standards. These standards provide guidance in setting discharge limits in National Pollutant Discharge Elimination System (NPDES) permits. The criteria are based on the latest scientific knowledge and peer review by qualified independent experts. In general, USEPA recommends that States, "should take action to adopt new or revised water quality critera necessary to protect designated uses of their waters," within five years from the publication of USEPAs water quality criteria.

Permitting and Monitoring
Waste Discharge Requirement permits issued by the Regional Board within the Russian River do not contain aluminum limits nor requirements for monitoring the receiving waters for aluminum. However

permits do contain the narrative toxicity objective and are regulated per the statement below, excerpted from the toxicity objective:

> "The survival of aquatic life in surface waters subjected to a waste discharge, or other *controllable water quality factors*, shall not be less than that for the same water body in areas unaffected by the waste discharge..."

Analysis of LHR versus Water Quality Objective

Regional Water Board Objective

The Russian River chemical constituents objective contained in the *Water Quality Control Plan for the North Coast Region* is as follows:

> "Waters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the limits specified in California Code of Regulations, title 22, Chapter 15, Division 4, Article 4, Section 64435 (Tables 2 and 3), and section 64444.5 (Table 5), and listed in Table 3-2 of this Plan."

Table 3-2 lists maximum aluminum concentration of 1.0 mg/L (1000 µg/L) for the purposes of groundwater and surface water discharges and cleanup. This applies to waters used as domestic or municipal supply (MUN).

Maximum aluminum concentrations for designated COLD (Cold Freshwater Habitat), and RARE (Rare, Threatened, or Endangered Species), MIGR (Migration of Aquatic Organisms), and SPWN (Spawning, Reproduction, and/or Early Development) beneficial uses are not listed specifically, but are covered indirectly in the narrative objective, partially stated below:

> All waters shall be maintained free of toxic substances in concertrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.

Conclusion

The aluminum concentration water quality criterion of a maximum of 750 µg/L Al CMC and 87 µg/L Al CCC supports the LHR for salmonid species within the Russian River. The permitting process administered by the Regional Board should be adjusted in assuring aluminum concentration levels will remain within the range required by Russian River salmonid species.

Staff Recommendation

The water quality criterion of 750 µg/L Al CMC and 87 µg/L Al CCC for aluminum is protective of the Species. It is recommended that this objective be considered for adoption into the *Water Quality Control Plan for the North Coast Region* for the protection of aquatic life in the Russian River watershed.

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BARIUM

Background
Barium occurs naturally in a variety of compounds. Barium sulfate and barium carbonate are relatively insoluble. Barium acetate, barium chloride, barium hydroxide, barium nitrate, and barium sulfide are more water soluble, but it appears that barium in general is less cumulative in the body than other metallic poisons. Anthropogenic sources of barium include the oil and gas industries and the manufacture of paints, bricks, tiles, glass, rubber, and pesticides.

Life History Requirements (LHR)
Bell (1986) suggested a limit of 5.0 mg/L (5,000 µg/L) to protect fish and aquatic life from toxic effects. USEPA 1986) suggested that the soluble barium concentration in fresh water would have to exceed 50 mg/L (50,000 µg/L) before toxicity to aquatic life would be expected. "In most natural waters, there is sufficient sulfate or carbonate to precipitate the barium present in the water as a virtually insoluble, non-toxic compound. Recognizing that the physical and chemical properties of barium generally will preclude the existence of the toxic soluble form under usual fresh water conditions, a restrictive criterion for aquatic life appears unwarranted" (USEPA 1986). No specific numeric criterion was found for salmonids.

<u>Barium Objectives</u>
The Russian River chemical constituents numeric objective for designated use MUN contained in the *Water Quality Control Plan for the North Coast Region* is as follows:

> "Waters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the limits specified in California Code of Regulations, Title 22, Chapter 15, Division 4, Article 4, Section 64435 (Tables 2 and 3), and Section 64444.5 (Table 5), and listed in Table 3-2 of this Plan."

Table 3-2 lists maximum barium concentration of 1.0 mg/L (1000 µg/L) for the purposes of groundwater and surface water discharges and cleanup as human health criterion (waters used as domestic or municipal supply, MUN.

Maximum barium concentrations for designated COLD (Cold Freshwater Habitat), and RARE (Rare, Threatened, or Endangered Species), MIGR (Migration of Aquatic Organisms), and SPWN (Spawning, Reproduction, and/or Early Development) beneficial uses are not listed. However, the narrative objective for toxic pollutants is intended to protect aquatic life:

> All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life. Compliance with this objective will be determined by use of indicator organisms, analyses of species diversity, population density, growth anomalies, bioassays of appropriate duration, or other appropriate methods as specified by the Regional Water Board.
>
> The survival of aquatic life in surface waters subjected to a waste discharge, or other controllable water quality factors, shall not be less than that for the same water body in areas unaffected by the waste discharge, or when necessary for other control water that is

consistent with the requirements for "experimental water" as described in Standard Methods for the Examination of Water and Wastewater, 18th Edition (1992). As a minimum, compliance with this objective as stated in the previous sentence shall be evaluated with a 96-hour bioassay.

In addition, effluent limits based upon acute bioassays of effluents will be prescribed. Where appropriate, additional numerical receiving water objectives for specific toxicants will be established as sufficient data become available, and source control of toxic substances will be encouraged.

Permitting and Monitoring
The current Waste Discharge Requirement permits issued by the Regional Board within the Russian River do not contain effluent limitations nor requirements for monitoring the receiving waters for barium. Barium is not a likely constituent in waste from Russian River dischargers, and based on its chemical properties and the discharge restrictions (wintertime discharge only) for the Russian River watershed, the current regulatory approach is protective.

Staff Recommendation
No change.

The existing narrative objective for toxic pollutants contained in *the Water Quality Control Plan for the North Coast Region* is protective of COLD, MIGR, and SPWN beneficial uses with respect to barium.

Regional Board staff also recommend that the RARE beneficial use be designated to the Russian River watershed and that the above conditions with respect to barium apply.

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NUTRIENTS

Background
Nitrogen and phosphorus are essential growth nutrients affecting the productivity of aquatic ecosystems. While other elements affect productivity, this review focuses primarily on nitrogen and phosphorus constituents and cycles and how they affect the federally listed endangered salmonid species (Species) and other species within the Russian River watershed.

Nutrient concentrations vary throughout the watershed both in time and space as a result of the many biotic and abiotic processes operating with the ecosystem. Precipitation, geologic weathering, erosion, chemical exchange, physical adsorption and absorption, transport and retention in surface waters, and biotic uptake and release influence nutrient cycling and nutrient movement through the watershed. The chemistry of the surface waters is determined in part by the age and composition of the parent geology that contains chemical constituents that contribute nutrients such as nitrogen and phosphorus. The particular biota of an aquatic ecosystem is a primary influence in the chemical parameters that result from cycling processes such as photosynthesis, respiration, food consumption and physical retention. Aquatic organisms, from microbes to vertebrates, and their colonization within stream substrates, may significantly impact nutrient cycling.

The chemical and nutrient composition in surface waters may be greatly influenced by regional climate. Direct input of constituents by precipitation and the hydrologic regime which are both determined by climate, will cause evaporation, dilution, geologic weathering, runoff patterns, and nutrient movement.

The delivery and transport of sediment, nutrients and other materials are also influenced by the presence and conditions of the vegetative floodplain along the river. The plant communities of the floodplain filter dissolved nutrients before they enter adjacent surface waters and may account for 60% - 90% of the nitrogen and phosphorus in transport (Lowrance et al. 1984, Peterjohn and Correll 1984). The natural cycling of nutrients within a watershed may be substantially changed when the riparian structure is altered. Alteration or elimination of floodplains is one of the main anthropogenic alterations affecting nutrient cycling in lotic ecosystems (Smith et al. 1987, Junk et al. 1989, Sparks et al. 1990).

The hyporheic zone, the area of waterflow in the ground adjacent to and beneath the streambed, influences nutrient cycling, temperature modification, dissolved oxygen microbial processes, and provides refugia for many of the aquatic organisms (Pinay and Decamps 1988, Stanford and Ward 1988, Triska et al. 1990, Valett et al. 1990, Hendricks and White 1991). The hyporheic zone may cover several meters below and laterally across the area below the channel bed and 30% - 60% of the total flow may occur in this zone. Where the channel bed is porous or when there are low flow conditions, the amount of flow may exceed 60%. In desert, forest, or grassland ecosystems, most of the nutrient uptake in a stream may take place in the hyporheic zone (Duff and Triska 1990).

Nitrogen and phosphorus, though necessary for sustaining life, may also have profound deleterious effects on surface waters and aquatic life. Excessive and inappropriate application of these chemicals create the potential of movement from land to water. Soil type, climatic conditions, and tillage practices in the local area will determine the extent of nutrient transport. Highly mobile nitrate nitrogen leaches readily into groundwater, volatizes in the atmosphere, or moves from land to nearby surface waters. Phosphate, which is less mobile than nitrate, adheres to soil particles and enters surface waters through erosion processes. The effects of excessive nutrient inputs to an aquatic syustem are realized in algal growths, drastic swings in dissolved oxygen and pH, and a resultant change in the characteristics of the waterbody that cause changes in the diversity of aquatic organisms.

Nutrient pollution that causes an unbalanced aquatic ecosystem may lead to elimination of sensitive aquatic species. The resultant degradation and simplification of the system's food webs and species diversity creates an unstable ecosystem in a weakened state, rendering it vulnerable to other ecological disturbances. Sensitive species such as trout are threatened due to low dissolved oxygen (DO) and in extreme situations, possible toxicity from hydrogen sulfide and methane gases released by anaerobic micro-organisms. Blue-green or dinoflagellate algal blooms also produce endo- or exotoxins that may cause mass fish mortality. Especially susceptible to the effects of eutrophication are aquatic organisms with slow reproduction and long life spans that require long periods of stable conditions.

Eutrophication / Algae Proliferation

Inputs of nutrients into a stream or river may promote robust aquatic plant growth and large inputs can induce prolific algal blooms leading to eutrophication. The decomposition of excessive aquatic vegetation significantly increases the biochemical oxygen demand (BOD) of the water, causing a sharp decline in the amount of DO. The effects of eutrophication directly influence the ability of fish to satisfy their oxygen demands (Spence et al. 1996).

Nutrient input may change the natural background color of a water body due to excessive growth of microscopic phytoplankton. Depending on the types of the phytoplankton species, the water may vary in shades of green, blue-green, red, gray, or yellow (USDA 1991).

The diversity and abundance of benthic aquatic species may be greatly compromised by eutrophication. Mayflies, stoneflies, caddisflies, water-penny and riffle beetles are especially intolerant to inputs of excess nutrients. These species, which are critical food for salmonids, will be replaced by more nutrient tolerant species such as chironomids and blackflies in a polluted aquatic environment.

High algal productivity impairs the photosynthesis of submersed aquatic vegetation due to shading. This decline in aquatic vegetation may dangerously reduce food sources and essential habitat for aquatic life as well as waterfowl and terrestrial species.

Algal production is directly related to the levels and correlation of nitrogen (N) and phosphorus (P) in the water. Algal cells have a N:P ratio of approximately 7:1. Theoretically, 7:1 ratio or greater will perpetuate significant algal growth.

Nutrients alone do not control or determine the presence and extent of algae growth. Attached and planktonic algae in a river or stream are controlled by various environmental parameters.
The greatest influences are from flow, substrate type, riparian vegetation for shading, water clarity or turbidity, and nutrients. The general view that phosphorus is the major limiting factor to algae growth may be overly simplistic. Other environmental factors will be limiting not only in different watersheds and stream reaches but also within the same site depending on season or other dynamic conditions such as weather.

Phytoplankton and attached algae readily use nitrate and ammonia forms of nitrogen and the phosphorus in the form of orthophosphate. Horne and Goldman (1994) present nutrient concentrations for typical rivers:

Nitrate:	0.003 to 7.0 mg-N/L
Ammonia:	0.005 to 10.0 mg-N/L
Orthophosphate:	0.001 to 1.0 mg-P/L

Maximum concentrations for unpolluted rivers were predicted to be approximately:

Nitrate:	5.0 mg-N/L
Orthophosphate:	0.01 mg-P/L

Where there is adequate riparian canopy cover, attached and planktonic algae growth will be limited due to lack of sunlight. Riparian vegetation also utilize nutrients and prevent or reduce nutrient movement into the water body.

Water flow has an affect on the quantity and type of algae growth in a river or stream. In shallow conditions where fast flow and the flushing rate exceeds the algal growth rate, attached algae production is high. Where there is a slower rate of flow and the algal growth rate exceeds the flushing rate, the suspended phytoplankton will dominate. This is where large algal blooms are found.

Life History Requirements
While nitrogen and phosphorus are essential nutrients for fish, life history requirments for water column chemistry are not appropriate, nor available. The concern for protection of the Species with regard to nutrients comes in the relationships of biostimulation from nutrient inputs to dissolved oxygen, pH and other factors as discussed above, and from concerns about toxic components in the broad category of "nutrients," such as ammonia.

Water Quality Objectives
National standards are not currently established for algae populations, per se. Some states and other levels of government may use narrative language addressing eutrophications or excessive plant growth within their water quality criteria/standards for nitrogen and phosphorus.

USEPA is evaluating excessive aquatic plant growth such as algae in surface water. Stream nutrient dynamics, stream habitat, including temperature and shading, turbidity, and algal growth processes will be analyzed. This will lead to EPAs development of numeric nutrient criteria guidance to protect against eutrophication of lakes, streams, rivers, wetlands, and estuaries near coastal waters. The goal is to complete development of these criteria guidances by the end of the calendar year 2000. EPA anticipates that states will adopt nutrient criteria for waters that have not already adopted nutrient standards for over-enrichment no later than the end of calendar year 2003.

The North Coast Region's Basin Plan contains a narrative standard that applies to nutrients in general by prohibiting biostimulatory substances:

> Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.

The Lahontan Regional Water Quality Control Board's narrative "Algal Growth Potential" water quality objective for certain hydrologic units within its region reads,

> "The mean monthly mean of algal growth potential shall not be altered to the

extent that such alterations are discernible at the 10 percent significance level."

The Santa Ana Regional Water Quality Control Board's narrative water quality objective for "Algae" states: "Waste discharges shall not contribute to excessive algal growth in inland surface receiving waters."

1. Nitrogen
   Using historical nutrient concentrations from the Pajaro River and Llagas Creek watersheds, from undeveloped areas of the watershed, from nearby rivers and streams, and nutrient water quality objectives for other rivers in California, a water quality objective for total inorganic nitrogen (ammonia, nitrite and nitrate summed as N) of 1.2 mg-N/L inorganic nitrogen was recommended as a water quality objective for the Central Coast Regional Water Quality Control Board (San Jose State University and Merritt Smith Consulting 1994).

   In December, 1999, USEPA published the 1999 Ammonia Update which contains EPA's current freshwater aquatic life criteria for ammonia. The revisions in the new criteria from the previous 1984 criteria are:

   - Acute ammonia criterion is now dependent on pH and fish species and not on temperature;
   - Chronic ammonia criterion is now dependent on pH and temperature;
   - Chronic ammonia criterion is now dependent on the presence or absence of early life stages (ELS) of fish;
   - Ammonia criteria are expressed only as total (un-ionized plus inonized) ammonia, whereas the 1984 criteria were based on un-ionized ammonia.

1999 Acute (CMC) Values for Ammonia as Functions of pH and Fish Species (Freshwater)

pH	Salmonids present	Salmonids absent
7	24.1 mg N/L	36.1 mg N/L
8	5.62 mg N/L	8.40 mg N/L

1999 Chronic (CCC) (example)Values for Ammonia as Functions of Temperature and pH Early Life Stages of Fish Present (Freshwater)

Temperature	pH=7	pH=8
0 deg. C	5.91 mg N/L	2.43 mg N/L
10 deg. C	5.91 mg N/L	2.43 mg N/L
20 deg. C	4.15 mg N/L	1.71 mg N/L
30 deg. C	2.18 mg N/L	0.897 mg N/L

USEPA recommends that the ELS-absent ammonia criteria be administered specifically to the various classes of waterbodies. States and Tribes should consider they types of watersheds and eco-regions and fisheries diversity. In California and the Pacific Northwest where different speices of salmonids spawn throughout the year, modification of the criteria based on ELS presence or absence may not be reasonable. (USEPA 1999)

2. Phosphorus
The USEPA (1986) total phosphorus water quality criteria for freshwater to control algal growth should not exceed:

   0.05 mg/L in streams discharging into lakes or reservoirs
   0.025 mg/L within a lake or reservoir
   0.1 mg/L total phosphorus in streams or flowing waters not discharging into lakes or reservoirs.

The Central Coast Regional Water Quality Control Board recommended a phosphate objective based on a calculation derived from the "cellular composition of algae which corresponds to a ratio of approximately 7-10:1 N:P by weight." The recommended objective for phosphorus was 0.12 mg-P/L phosphate (San Jose State University and Merritt Smith Consulting 1994).

A summary of water quality objectives in California relating to nutrients appears below:

Regional Water Quality Control Boards	Water Quality Objectives
North Coast , Region 1	**Biostimulatory** narrative: "Water shall not contain biostimulatory substances which promote aquatic growths in concentrations that cause nuisance or adversely affect beneficial uses." Nitrate-N (as NO_3): 45mg/L for MUN beneficial uses.
Central Valley, Region 5	Biostimulatory: narrative
Central Coast, Region 3	Biostimulatory: narrative Nitrate (NO_3): 45 mg/L for MUN uses 0.06 mg/L N – San Lorenzo River
Colorado River Basin, Region 7	Biostimulatory: narrative Nitrate and Phosphate Narrative: Nitrate and phosphate limitations will be placed on industrial discharges to New and Alamo Rivers and irrigation basins on a case-by-case basis, taking into consideration the beneficial uses of these streams.
Lahontan, Region 6	Biostimulatory: narrative Algal Growth Potential: The monthly mean of algal growth potential shall not be altered to the extent that such alterations are discernible at the 10 percent significance level N, P, NO_3-N, PO_4,$N0_3$ as NO_3: See Water Quality Control Plan for the Lahontan Region 10/94.
San Diego, Region 9	Biostimulatory Narrative: " Inland surface waters, bays and estuaries and coastal lagoon waters shall not contain biostimulatory substances in concentrations that promote

	aquatic growth to the extent that such growths cause nuisance or adversely affect beneficial uses. Concentrations of nitrogen and phosphorus, by themselves or in combination with other nutrients, shall be maintained at levels below those which stimulate algae and emergent plant growth. Threshold total phosphorus(P) concentrations shall not exceed 0.05 mg/L in any stream at the point where it enters any standing body of water, nor 0.025 mg/L in any standing body of water. A desired goal in order to prevent plant nuisance in streams and other flowing waters appears to be 0.1 mg/L total P. These values are not to be exceeded more than 10% of the time unless studies of the specific water body in question clearly show that water quality objective changes are permissible and changes are approved by the Regional Board. Analogous threshold values have not been set for nitrogen compounds; however, natural ratios of nitrogen to phosphorus are to be determined by surveillance and monitoring and upheld. If data are lacking, a ration of N:P = 10:1, on a weight to weight basis shall be used. Nitrate as NO_3): 45 mg/L for MUN uses Nitrate + Nitrite (sum as Nitrogen): 10 mg/L for MUN uses Nitrite (as Nitrogen): 1 mg/L for MUN uses
San Francisco, Region 2	Biostimulatory: narrative "Chlorophyll-a narrative: "changes in chlorophyll-a and associated phytoplankton communities follow complex dynamics that are sometimes associated with a discharge of biostimulatory substances. Irregular and extreme levels of chlorphyll a or phytoplankton booms may indicate exceedance of this objective and require investigation." and 50 µg/L chlorophyll-a upstream from Carquinez Bridge??? Nitrate (NO_3): 45 mg/L for MUN uses Nitrate + Nitrite: 10 mg/L for MUN uses Nitrite: 1 mg/L for MUN uses
Santa Ana, Region 8	Algae Narrative: "Waste discharges shall not contribute to excessive algal growth in inland surface receiving waters." Nitrate-nitrogen concentrations shall not exceed 45 mg/L (as NO_3) or 10 mg/L (as N) in inland

	surface waters designated MUN as a result of controllable water quality factors." Phosphorus and Nitrates: total P/N load will be reduced by 50% by 2012 ????
Los Angeles, Region 4	Biostimulatory: narrative Nitrate-N (NO_3): 45 mg/L for MUN uses Nitrite (NO_3-N): 10 mg/L for MUN uses Nitrite (NO_2-N): 1 mg/L for MUN uses

Effects Of Nutrients On The Species
Critical to life history requirements (LHR) of the Species are high levels of DO. Inadequate conditions may affect the growth and development of embryos and alevins, the growth of fry, and the swimming ability of adult and juvenile migrants (Spence, et al. 1996). Reductions in DO levels from excessive nutrient enrichment and other factors are deleterious to the Species as well as invertebrates and other aquatic organisms.

In natural freshwater ecosystems, nitrate-nitrogen dissipates readily and its concentrations are rarely toxic to the Species. Nitrate, formed by nitrification, the oxidation of ammonia, may exist in high concentrations in surface waters. It is essentially nontoxic to aquatic vertebrates and invertebrates. Nitrate levels greater than 1300 ppm result in acute LC50 for salmonids (Spence et al. 1996). The deleterious effects of nitrates on the Species are associated with eutrophication and lowered DO levels Ammonia acts as an acute toxicant to salmonids dependent on pH and temperature when all other factors are held constant. As discussed in the objectives section above, the unionized fraction is the toxic form and increases with increased pH. Low DO will exacerbate the toxic effects of ammonia.

Phosphorus, which occurs in surface water in the form of phosphate, is found in very minimal concentrations in natural freshwater systems. Considered nontoxic to aquatic vertebrates and invertebrates, it's effects on the Species are related to eutrophication of the aquatic ecosystem.

Permitting and Monitoring
NPDES permits issued by the Regional Board within the Russian River watershed do not contain nutrient effluent limitations. Requirements for monitoring effluent and the receiving water are as follows:

Nitrate Nitrogen: Five of 18 dischargers' permits have requirements for monitoring effluent and/or the receiving water

Ammonia Nitrate and Unionized Ammonia: Four of 18 dischargers' permits have requirements for monitoring effluent and/or the receiving water

Phosphorous: Three of 18 dischargers' permits have requirements for monitoring effluent and/or the receiving water

Analysis of LHR versus Water Quality Objectives
The current narrative nutrient (Biostimulatory Substances) objective and the Nitrate-N (as NO3) objective for the Municipal Supply beneficial use by themselves may not be protective of the Species. Numeric objectives for dissolved oxygen and pH are intended to protect the Species in the event of biostimulation in a waterbody. However, specific numeric objectives for Nitrate–Nitrogen (NO3), Phosphorus,

Ammonia, and Chlorophyll-a would serve to more adequately define the narrative objective and protect aquatic life.

Recommendations

Develop site-specific objectives for nutrients using as a framework EPAs guidance to develop numeric nutrient criteria, expected to be available by January 1, 2001. Such objectives would be site-specific taking into account local conditions and seasonal variation. A priority would be to incorporate the ammonia criteria into the Basin Plan to address waterbodies identified as impaired by nutrients (Estero Americano, Estero de San Antonio, Americano Creek, Klamath River, and Stemple Creek) and protect those not yet impaired. Nitrate and phosphorus need to be addressed separately, while retaining the current narrative objectives.

In order to best protect the Species, it will be necessary to conduct site-specific surveys and develop objectives accordingly to ensure that general one-number objectives for the entire watershed do not compromise highly sensitive species and/or sensitive habitats. Site specificity may also be necessary to designate objectives that can be realistically obtained in less sensitive locations within the Russian watershed such as the Laguna de Santa Rosa. The development of site-specific objectives will have to be prioritized to the most important areas in the watershed regarding the Species, whether that be protecting refugia, restoring prior areas of Species distribution, or addressing the worst problem areas first.

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APPENDIX A

Analysis of Russian River Water Quality Conditions With Respect to Water Quality Objectives for the period 1988 through 1999

DRAFT INTERIM REPORT

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by

Peter W. Otis
Environmental Specialist
Regional Water Quality Control Board
5550 Skylane Boulevard, Suite A
Santa Rosa, CA 95403
707-576-2662
otisp@rb1.swrcb.ca.gov

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