UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

NOV 14 2017

Celine Gallon
Environmental Scientist
California Regional Water Quality Control Board
Los Angeles Region
320 W. 4th Street, Suite 200
Los Angeles, CA 90013

Dear Ms. Gallon:

This letter responds to the Regional Board's solicitation of public comments for input on the specified projects to be addressed during the 2017-2019 Triennial Review period. The U.S. Environmental Protection Agency (EPA) appreciates the opportunity to provide input to the Triennial Review process with the following comments:

As mentioned in the public notice, to comply with 40 CFR Section 131.20, the Triennial Review must include an explanation if the State does not adopt new or revised criteria for parameters for which EPA has published new or updated Clean Water Act (CWA) section 304(a) criteria recommendations. Tables containing the most recent 304(a) criteria recommendations can be found at the following websites: https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table and https://www.epa.gov/wqc/national-recommended-water-quality-criteria-human-health-criteria-table.

We support the Regional Board's plan to make the main focus of the 2017-2019 Triennial Review the consideration of these section 304(a) recommended criteria for incorporation into the Regional Board's Basin Plan. Additionally, we recommend the Regional Board identify freshwaters that support early life stages of salmonids and revise pentachlorophenol (PCP) water quality objectives, where appropriate, as part of this Triennial Review process. This request is a result of EPA's Endangered Species Act consultation with the U.S. Fish and Wildlife Service and National Marine Fisheries Service (the Services) for the California Toxics Rule (CTR). The Services' Biological Opinion for the CTR concluded that the CTR criteria for PCP were not protective of early life stages of salmonids under conditions of low dissolved oxygen and high temperatures. Protective criteria are outlined in US EPA's November 14, 2007 letter to the State and Regional Boards (see enclosure).

Thank you for the opportunity to comment on the 2017-2019 Triennial Review. If you have any questions, please contact me at (415) 972-3161 or Tachiki.Nicole@epa.gov.

Sincerely,

Nicole Tachiki

Nicole Tachiki
Water Quality Assessment Section

Enclosure

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

NOV 14 2007

Rik L. Rasmussen
Chief, Planning Standards and Implementation Unit
State Water Resources Control Board
P.O. Box 100
Sacramento, CA 95812

Re: Pentachlorophenol (PCP) Criteria

Dear Mr. Rasmussen:

Please find enclosed, a letter from Edward Ohanian, Director of Health and Ecological Criteria Division, Office of Water, dated August 24, 2007, to the US Fish and Wildlife (FWS) and the National Marine Fisheries Service (NMFS) (the Services) Offices for the California area. This letter concerns follow up actions stemming from the Endangered Species Act consultation on the California Toxics Rule (CTR), for pentachlorophenol (PCP). The Services' Biological Opinion for the CTR concluded that the CTR's PCP water quality criteria for the protection of aquatic life were not protective of early life stages of salmonid fish under conditions of low dissolved oxygen (DO) and high temperatures. EPA accepted the premise offered by the Services that more restrictive PCP criteria may be necessary to protect early life stage salmonid fish in California, and determined what those criteria values should be. However, EPA believes it is appropriate for the State to determine where those specific situations might occur, and to take appropriate action to protect those species at the relevant locations. Hence, we are writing to you, to request your and the Regional Boards' assistance in identifying where these areas occur and to adopt the appropriate PCP water quality criteria, during the next triennial review of each Regional Board Basin Plan.

Specifically, EPA is now recommending that in California, the weight of evidence supports the applicability of the current (CTR) PCP criteria on a statewide basis with site-specific adjustments when necessary to protect particularly sensitive species or address unusual water quality parameters. EPA recommends that the State, on a site-specific basis, adopt an aquatic life chronic value of 10 ug/l to protect early life-stage salmonids from the toxic effects of PCP at a pH of 7.8, and an aquatic life chronic value of 5 ug/l to adequately protect these life stages under conditions of low dissolved oxygen and high temperature. The scientific justification for our recommendation is attached to the enclosed letter. We recommend that each Regional Board consider where these conditions may occur and consider adopting appropriate site-specific objectives accordingly, in their Basin Plans.

We thank you for your attention to this issue. If you have any questions concerning the justification, please contact William Swietlik of Mr. Ohanian's staff at (202) 566-1129 or for questions concerning implementation, please contact me or Diane Fleck at 415 972-3420 and 415 972-3480, respectively.

Sincerely,

Douglas E. Eberhardt, Chief
Clean Water Act Standards and Permits Office

Enclosure

cc: Holly Lundborg, North Coast RWQCB
Naomi Feger, San Francisco RWQBC
Lisa Horowitz McCann, Central Coast RWQCB
Sam Unger, Los Angeles RWQCB
Betty Yee, Central Valley RWQCB
Judith Unsicker, Lahonton RWQCB
Cliff Raley, Colorado River Basin RWQCB
Mark Adelson, Santa Ana RWQCB
Julie Chan, San Diego RWQCB
Daniel Russell, US Fish and Wildlife
Thomas Maurer, US Fish and Wildlife
Joseph Dillon, National Marine Fisheries Service

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

AUG 24 2007

OFFICE OF
WATER

Mr. Steve Thompson
Manager
California/Nevada Operations Office
U.S. Department of the Interior
Fish and Wildlife Service
2800 Cottage Way, Room W-2606
Sacramento, CA 95825-1846

Mr. Rodney R. McInnis
Regional Administrator
Southwest Region
National Marine Fisheries Service
501 West Ocean Boulevard, Suite 4200
Long Beach, CA 90802-4213

Dear Mr. Thompson and Mr. McInnis:

On August 3, 2004, I sent a letter to the Services responding to Reasonable and Prudent Measures (RPMs) in the Incidental Take Statement for pentachlorophenol (PCP) in the California Toxics Rule (CTR). In response to my letter, I received a letter from each of the Services (Mr. McInnis's letter - dated November 18, 2004, and Mr. Henson's letter - dated November 22, 2004) expressing concerns with our decision on the PCP criteria and requesting additional information and clarification.

The additional information requested, including all materials provided to us by Dr. Chapman, Dr. Woltering, and Dr. Erickson that were utilized in making our decision on PCP criteria, was then forwarded to your offices.

In addition, the Environmental Protection Agency and Fish and Wildlife Service (FWS) staff met in a face-to-face meeting in San Francisco, CA, in April 2005 to further discuss the PCP criteria with the objective of identifying and resolving all lingering issues and questions. At this meeting FWS staff clarified their concerns and identified even more information they needed to better understand our decision. This information was provided to your staff shortly thereafter.

Your staff also requested we develop a more comprehensive justification for our PCP decision beyond that stated in the original August 3, 2004, letter. If we did this, your staff indicated they would be in a better position to agree with our decision.

I am enclosing the final additional justification for our PCP decision. We believe we have now answered all lingering questions and provided all requested information, and as such, now meet the terms and conditions under the Biological Opinion for PCP.

If you have any questions about the enclosure, please contact William Swietlik of my staff at (202) 566-1129, or e-mail at swietlik.william@epa.gov.

Sincerely,

Edward V. Ohanian, Director
Health and Ecological Criteria Division

Enclosure

EPA JUSTIFICATION OF SITE-SPECIFIC AND STATE-SPECIFIC PCP CRITERIA FOR CALIFORNIA

Background

On August 5, 1997, EPA proposed freshwater acute and chronic criteria for pentachlorphenol (PCP) for the protection of aquatic life in California's waters as a part of the California Toxics Rule (CTR). At that time, EPA made the determination that the national ambient water quality criteria for PCP were adequately protective of species in California waters. The current Clean Water Act (CWA) 304(a) acute and chronic freshwater PCP criteria promulgated by EPA for California under the CTR are 19 and 15 µg/L at pH 7.8, respectively., As a part of the Endangered Species Act (ESA) consultation on the CTR, the U.S. Fish and Wildlife Service and the U.S. National Marine Fisheries Service (collectively the Services) jointly prepared a Biological Opinion (BO) which reviewed the PCP criteria proposed in the CTR. The BO concluded that the proposed PCP criteria for the protection of aquatic life in California waters were not protective of early life-stage salmonid fish under conditions of low dissolved oxygen (DO) and high temperature. For example, the BO concluded that at pH 7.8, acute and chronic freshwater PCP criteria of 7.13 µg/L and 0.2 µg/L, respectively, would be necessary to provide protection for early life-stage salmonids under conditions of low DO and high temperature.

Since the time of that conclusion, and following a series of activities to resolve jeopardy concerns for the CTR per agreement with the Services (see March 24, 2000 BO in the Reasonable and Prudent Measures for the Incidental Take Statement for PCP), EPA summarily accepted the premise offered by the Services that early life-stage salmonid fish in California are more sensitive than other fish, and that more restrictive PCP criteria may be necessary to protect these species in California waters. In acknowledging as much, however, EPA also believes that it is appropriate for the state to determine where those specific situations might occur, and to take the appropriate action to protect those species at the relevant locations.

This EPA position was recently communicated to Mr. Paul Henson (Assistant Manager for Ecological Services, U.S. Fish and Wildlife Service, California/Nevada Operations Office) and Mr. Tim Price (Acting Assistant Regional Administrator, NOAA Fisheries Southwest Region) in a letter from Mr. Edward Ohanian, Director of U.S. EPA's Health and Ecological Criteria Division) dated (August, 3, 2004). In brief, EPA's reassessment of the PCP criteria found that the weight of evidence supports the applicability of the current criteria on a national basis with site-specific and state-specific adjustments when necessary to protect particularly sensitive species or address unusual water quality parameters.

Given our re-evaluation of this original decision, since then, EPA maintains that the current CWA 304(a) criteria for PCP will protect against acute and chronic toxicity of commercial grade PCP under normal conditions found in most parts of California and the rest of the country. In the case of a state-specific chronic criterion for California, EPA still recommends that the state adopt where necessary, on a site-specific basis, a value of 10 µg/L to protect early life-stage salmonids

from the toxic effects of PCP at a pH of 7.8, and a value of 5 µg/L to adequately protect these life-stages under conditions of low dissolved oxygen and high temperature.

In support of our re-evaluation, EPA completed a comprehensive literature review for any new chronic PCP toxicity data published since the 1970's on early life-stage salmonids, with emphasis on studies conducted under conditions of low dissolved oxygen and high temperature. The results of the review, which were shared with FWS staff, are summarized below and conclusively confirm our PCP criteria recommendations for California.

Chronic PCP toxicity Data Applicable to Ambient Water Quality Criteria

Toxicity data for aquatic animals acceptable for use in ambient water quality criteria derivation, either acute toxicity data or chronic toxicity data, must conform with recommendations provided by Stephan et al. (1985), *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and their Uses*; hereafter referred to as the Guidelines. Specifically, inclusion of data requires that chronic tests (for fish and most other animals) be based on flow-through exposures where the "test material in test solutions were properly measured at appropriate times during the test." Among other stipulations, the chronic values (calculated as the geometric mean of the no-observed and lowest-observed effect concentrations, NOEC and LOEC, respectively) should be based on "endpoints and lengths of exposure appropriate to the species." Such a requirement includes life-cycle, partial-life cycle and early life-stage toxicity tests typically based on measures of survival, growth or reproduction. Full and partial life-cycle tests are not commonly available for any species, thus the preponderance of chronic data in criteria documents consist of data from early life-stage tests. For salmonids, early life-stage tests should last from shortly after fertilization to a minimum 60 days post-hatch, with survival and growth as endpoints. All other applicable chronic toxicity data that do not meet these and other general stipulations are typically not used for criteria derivations.

The only salmonid chronic toxicity data included in the 1986 pentachlorophenol ambient water quality criteria (AWQC) are from a study by Dominquez and Chapman (1984). The early-life stage of steelhead trout (*Oncorhynchus mykiss*) was exposed to sodium pentachlorophenate (NaPCP; 99% purity) under flow-through conditions for 72 d (fertilized egg to approximately 46 d post-hatch). The exposure consisted of ten un-replicated concentrations and a duplicated control. Test concentrations were not measured. The average DO concentration and pH level from multiple samples collected periodically during the test from the highest PCP and control treatments were 10 mg/L and 7.4, respectively. The pH of the test solutions dictated predominance of the phenate form of PCP in the study. Alevins were found to be more sensitive to PCP than embryos. Alevin mortality at the nominal 19 µg/L test concentration was approximately 3 times that of controls (32 versus 9 percent post-hatch, respectively), while embryo mortality was similar (8 versus 4 percent pre-hatch). A significant reduction in alevin growth occurred at the same level. No adverse effects were exhibited by fish at nominal PCP concentrations of 11 µg/L or lower. The chronic value for the study was 14.46 µg/L.

Chronic PCP Toxicity Data Not Used in the AWQC Derivation Along with Other Relevant Salmonid Data

The Dominguez and Chapman (1984) data above for alevins compare favorably to earlier results reported for similar life-stages of steelhead trout by Chapman (1969) and Chapman and Shumway (1978). The two studies are the same, but the results and study details reported in Chapman (1969) are more complete because it is a thesis manuscript. In this study, embryos and alevins were exposed to three different concentrations of technical grade sodium pentachlorphenate (minimum 90 percent purity) and a control under flow-through conditions and different levels of normoxic (10 mg/L) and hypoxic (3 and 5 mg/L) DO concentrations. In all experiments filtered stream water of approximately pH 7.8 was used for dilution water and tests were conducted at either 10 or 15°C. As above, embryos were less sensitive than alevins. Nominal (unmeasured) PCP concentrations of 50, 80 and 180 µg/L caused 100 percent mortality, with most of the mortality occurring after hatching at 50 and 80 µg/L, and before hatching at 180 µg/L. After 24 d of exposure to 40 µg PCP/L, the alevins reared at 3 mg DO/L suffered 76 percent mortality compared to 20 percent at 40 µg PCP/L and the 5 mg DO/L concentration, and only 7 percent at normoxic DO. The DO levels themselves were non-lethal to control fish, and DO only had a slight effect on growth of control alevins.

In a separate experiment in the study, the authors determined the effect of PCP exposure to developing steelhead trout from fertilization to the time of complete yolk utilization, each in water with DO concentrations of 3, 5 or 10 mg/L. Control embryos at all DO concentrations, and embryos reared in PCP (10, 20 and 40 µg/L) at DO levels of 5 and 10 mg/L exhibited 90 percent survival at the eyed stage. Likewise, there was no effect of PCP on alevin mortality at 10 mg DO/L. At 5 mg DO/L, mortality increased from 14 percent in controls to 27, 90 and 100 percent at 10, 20 and 40 µg PCP/L, respectively. This effect of low dissolved oxygen on PCP toxicity to alevins was even more pronounced at the 3 mg/L DO level. Similarly, there was no effect of PCP exposure at 10 mg/L DO on maximum dry weight of alevins, but at 5 mg DO/L, dry weight decreased by about 11 and 37 percent at 10 and 20 µg PCP/L, respectively, when compared to the controls. These results indicate that alevins in particular are less able to cope with the stress of PCP exposure when the DO is low; by a factor of approximately two at a PCP toxicity threshold concentration of 10 µg/L.

The two studies presented above form the foundation for EPA's current recommendation for site-specific DO criteria in California. Other relevant chronic studies with salmonids include those from Hodson and Blunt (1981), Matida et al. (1971) and Webb and Brett (1973). The results and scientific merits of each of these studies were reviewed and summarized in a gray literature report prepared for EPA by Great Lakes Environmental Center (see Chapman 1998). Included in that report are additional reviews and summaries of studies by Iwama et al. (1986), Little et al. (1990) and Nagler et al. (1986). These are summarized again here in Table 1.

Only one of the seven chronic values calculated from these studies (Table 1), which include effects on survival, growth, swimming performance, feeding behavior and immune health of early and juvenile stages of salmonids, lies slightly below EPA's recommended chronic criterion for early life-stages of salmonids (i.e., 10 µg/L at pH 7.8). This is the chronic value of 9.86 µg/L EPA estimates for growth rate and food conversion efficiency of juvenile sockeye salmon from

Webb and Brett (1973). The EC20 calculated using dry weight of fish exposed to the various concentrations of PCP from 42 to 56 days in this study is 20.8 µg/L, and the EC10 is 16.1 µg/L (see Table 1). The EC20 and EC20 point estimates were calculated using U.S. EPA Office of Research and Development's (NHEERL/MED laboratory) Toxicity Relationship Analysis Program (TRAP, version 1.0). As the pH of this study was only 6.8, the chronic value and point estimates provided for this study above might be expected to be even higher at pH 7.8, where acute PCP toxicity is known to be decreased.

In addition to the effects data for alevin, fry and juvenile life-stages of salmonids, the study of the effects of PCP on egg viability of adult female rainbow trout by Nalger et al. (1986) yielded a chronic value of ≥16.24 µg/L. Since this value is substantially higher than EPA's recommended site-specific value for salmonids, it further substantiates the anticipated level of protectiveness of EPA's recommended site-specific value of 10 µg/L for early-life stages of salmonids. (Note: the data from studies with salmonid embryos to date clearly indicate that they are consistently less sensitive to PCP compared to the later developmental stages, e.g., alevins and fry).

A recent literature search (May 2007) revealed only one additional study relevant to this compendium of chronic and sublethal toxicity effects of PCP to salmonids. Korstrom et al. (1997) examined the sublethal toxicological stress of adult sockeye salmon (*Oncorhynchus nerka*) exposed to a combination of sodium pentachlorphenate (99% pure) and fresh water hypoxia. The study was designed to mimic the conditions which adult sockeye salmon may confront in streams during their migration back to natal lakes to spawn. Survival was measured along with ventilation frequency and swimming stamina as performance capacity variables. Seven consecutive experiments were conducted on a weekly basis from August through September, 1996. The experimental period coincided with the time when adult sockeye would be encountering hypoxic conditions in the sub-halocline waters of some coastal inlets during their spawning migration. Each period consisted of a 30 h exposure under either normoxic (70-100% oxygen saturation, or approximately 7 – 10 mg/L DO) or hypoxic (30-40% oxygen saturation, about 2.5 – 40 mg/L DO) conditions. Measured PCP concentrations were about 88 percent of nominal (5, 10, 20 and 40 µg/L, respectively). Water temperature was progressively increased over a 6 h period to 20°C (from 9.9-14.3°C) upon initiation of the toxicant exposure. Following hypoxic exposure, raceways reached normoxic equilibrium throughout an 18 h recovery period. The fish were then challenged with two 6 h fixed velocity swim tests with another 18 h recovery period allowed between each test. Observations of breathing frequency were recorded daily throughout the acclimation and experimental periods. No fish died after 30 h exposure to 5, 10 and 20 µg/L PCP in normoxic exposures, whereas mortality reached 25 percent at 40 µg/L under normoxic conditions. Conversely, all fish died at 20 and 40 µg/L PCP under hypoxia, although none did at 5 µg/L PCP (NOEC). Thus, adult sockeye were approximately three times more sensitive to PCP under the conditions of low dissolved oxygen and increasing temperature, compared to adult fish exposed under normoxia. While there were no apparent effects of PCP under the short-term sublethal test conditions with respect to swimming stamina, breathing frequency was elevated at concentrations that coincided with survival.

Basis and Justification for Recommended Site-specific PCP Criteria in California

The chronic values provided in Table 1 are plotted in a cumulative probability plot of rank order sensitivity in Figure 1. The pH of the test solutions or dilution waters associated with the chronic effect concentrations from the various studies ranged from 6.5 to 8.1 S.U. No attempt was made to normalize and adjust chronic values to values expected at pH 7.8. However, assuming the slope of 1.005 similar to that derived for the relationship between pH and acute PCP toxicity (LC50), chronic values from studies at pH 6.8 may be up to 2.5 times lower (more toxic) than those reported at pH 7.8 in Table 1. Note also, as explained in Chapman (1998), that the pH in studies from static exposures will typically become more acidic due to CO_2 accumulation. This downward pH shift of just a few tenths could appreciably increase the toxicity of PCP, thus giving the appearance of greater sensitivity at a concentration considered safe in other tests carried out under pH-stable flow-through conditions.

As indicated Figure 1, the site-specific chronic PCP value of 10 µg/L for early-life stages of salmonids at pH 7.8 for California under the CTR is protective under normal conditions except possibly at low DO and high water temperature. Under the latter scenario, the recommended value of 5 µg/L at pH 7.8 will prevent unnecessary exposure and toxicity to early life-stages of salmonids inhabiting such waters in California and other parts of the country.

References

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TABLE 1. SUMMARY OF CHRONIC AND SUBLETHAL PCP TOXICITY DATA FOR SALMONIDS

Reference	Species and Life Stage; (Duration)	Exposure Type and Chemical	Temp (°C)	D.O. (mg/L)	pH (S.U.)	Endpoints	Chronic Value (µg/L)	Comments
Dominquez and Chapman 1984	Steelhead trout (*Oncorhynchus mykiss*); embryos through juvenile; (72 d)	Flow-through, unmeasured; Purified PCP (>99%) Aldrich	12	7.2-10.6 (avg. = 10)	7.4 (test solutions)	Growth and survival	14.46	The LOEC for both growth and survival was 19 µg/L; the NOEC was 11 µg/L.
Chapman and Shumway 1978 (also Chapman 1969)	Steelhead trout (*O. mykiss*); fertilization through yolk absorption; (92 d)	Flow-through, unmeasured; Technical NaPCP (90%) Monsanto (Santobrite)	10 (embryos) 15 (alevins)	3, 5 and 10	7.8 (filtered stream dilution water)	Hatch, survival and growth	Embryo (Survival): 10 mg/L DO->40 5 mg/L DO-28.3 3 mg/L DO-<10 Alevin (Survival): 10 mg/L DO-28.3 5 mg/L DO-14.14 3 mg/L DO-<10 Alevin (Growth): 10 mg/L DO->20 5 mg/L DO-14.14 3 mg/L DO-<10	Alevins were more sensitive than embryos. The NOEC for mortality of embryos was 20 µg/L at 10 and 5 mg/L DO, and <10 µg/L at 3 mg/L DO. The NOEC for mortality of alevins was 20 µg/L at 10 mg/L DO, 10 µg/L at 5 mg/L DO, and <10 at 3 mg/l DO. Alevin growth was the most sensitive endpoint. The percent reduction in growth of alevins exposed to 20 µg/L was 11 at 10 mg/L DO and 37 at 5 mg/L DO, relative to controls. Low DO stressed fish without PCP; alevins at 5 and 3 mg/L DO exhibited slight increases in mortality, and those at 3 mg/L DO exhibited reduced growth.

Reference	Species and Life Stage; (Duration)	Exposure Type and Chemical	Temp (°C)	D.O. (mg/L)	pH (S.U.)	Endpoints	Chronic Value (µg/L)	Comments
Hodson and Blunt 1981	Rainbow trout (*O. mykiss*); fertilization through 4 wk post swim up; (ELS, >60 d)	Flow-through, measured; Analytical Grade NaPCP	Eggs: 5 and 10 Alevins: 5 and 15 Fry: 12 and 20	Eggs: 11 Alevins: 10-11 Fry: 9	7.8-8.1 (test solutions)	Growth and survival	Cold regime: 16.82 (growth rate) or 40.9 (biomass) Warm regime: 19.3 (growth rate and biomass)	Alevins were more sensitive than embryos. No effect on hatching up to 80 µg/L. Fish exposed from the egg stage were more sensitive than those exposed from hatch. Growth of fry was the most sensitive endpoint. The LOEC for growth rate was 22.3 and 26 µg/L in cold and warm water exposures, respectively; NOECs were 12.7 and 14.3 µg/L. Negative effect of temperature on PCP toxicity was greatest at lower temperatures prior to swim-up stage, but greater at higher temperatures with post swim-up stage fish.
Matida et al. 1971	Rainbow trout (*O. mykiss*); juvenile (2.1-2.5g); (28 d)	Flow-through measured; NaPCP (94.2%) unspecified formulation	16.8-17.2 (test solutions)	6.5	7.2 (well dilution water)	Growth and survival	12.65 (growth)	The NOEC for survival is > 20 µg/L. Growth was a more sensitive endpoint. The estimated LOEC for growth (based on wet weight) was 20 µg/L (31% reduction compared to controls). The corresponding NOEC for growth was 8 µg/L (13% reduction compared to controls).
Little et al. 1990	Rainbow trout (*O. mykiss*); fry; (96 h)	Static, unmeasured; Technical PCP (92%) Dow Chemical	Not reported	Not reported	7.8 (well dilution water)	Swimming capacity, spontaneous activity, feeding behavior and predator avoidance	No Dose-response: NOEC could range from 0.2 to >20 µg/L	No effect on swimming capacity or percent consuming daphnids. LOEC for strike frequency, # of daphnia consumed, and % survival from predation at 20 µg/L, although poor dose-response. Swimming activity most sensitive endpoint. Apparent LOEC for swimming activity of 2.0 µg/L; NOEC = 0.2 µg/L. Again, poor dose-response.

Reference	Species and Life Stage; (Duration)	Exposure Type and Chemical	Temp (°C)	D.O. (mg/L)	pH (S.U.)	Endpoints	Chronic Value (µg/L)	Comments
Nagler et al. 1986	Rainbow trout (*O. mykiss*); mature female; (18 d)	Flow-through, measured; Purified PCP (>99%) Sigma	12.5 (December) 12.8 (July)	10.7 (December) 10.2 (July)	7.50 (December) 7.46 (July) (test solutions)	No. of viable oocytes	16.24	The LOEC for viable oocytes was 22 µg/L (NOEC = 12 µg/L) with fish collected in July. There was no toxicity observed in exposures up to 22 µg/L with fish collected in December (differences in seasonal hormone levels may be the basis).
Iwama et al. 1986	Chinook salmon (*O. kisutch*); juvenile (15.9g); (40 d)	Flow-through, unmeasured; NaPCP (unspecified purity)	12.0-12.2	8-8.5	6.5-6.9	Survival to bacterial challenge and blood chemistry	12.33 (survival: infected) >39 (survival: uninfected)	Study designed to look at response to bacterial challenge and toxicant. The LOEC for survival of infected fish was 39 µg/L; NOEC = 3.9 µg/L. No effect on survival at either 3.9 or 39 µg/L exhibited by uninfected fish. Two blood parameters affected in the uninfected group. Blood urea nitrogen was elevated at 3.9 but not at 39 µg/L. Blood glucose was lowered at 39 but not at 3.9 µg/L The LOEC for blood effects was 39 µg/L; NOEC was 3.9 µg/L.
Webb and Brett 1973	Sockeye salmon (*O. nerka*); juvenile; (42-56 d)	Flow-through, measured; NaPCP (unspecified purity)	15	Aerated	6.8 (dilution water)	Swimming performance and growth	9.86 (growth rate and food conversion efficiency)	No significant effects on swimming performance. Discounting results from concentrations which were not run the entire length of the exposure, the LOEC for specific growth rate and food conversion efficiency was 13.6 µg/L and NOEC was 7.16 µg/L. Note: authors state that the best estimated threshold level was 1.7 µg/L based on extrapolation of all data dose-effect regression lines and zero response levels calculate from pooled data. The EC20 for mean dry weight calculated by EPA using TRAP (v. 1.00, US EPA-Duluth) is 20.8 µg/L, the EC10 is 16.1 µg/L.

Reference	Species and Life Stage; (Duration)	Exposure Type and Chemical	Temp (°C)	D.O. (mg/L)	pH (S.U.)	Endpoints	Chronic Value (µg/L)	Comments
Lorstrom et al. 997	Sockeye salmon (*O. nerka*); adult (30 h)	Flow-through, measured; Reagent grade NaPCP (99%) Aldrich	Progressively increased from 10 - 14 to 20	Normoxic (70-100% saturation) Hypoxic (30-40% saturation)	6.7-7.1 (test solutions)	Survival, swimming performance, breathing frequency	Survival under normoxic DO: 22.8 Survival under hypoxic DO: 6.24	After 30 h of exposure adult fish exposed to 40 µg/L PCP under normoxic conditions (7 – 10 mg/L DO) exhibited only 25% mortality (LOEC); NOEC was 13 µg/L. LOEC under hypoxic test conditions was 9.7 µg/L; NOEC was 4.02 µg/L. Appears to be no effect of PCP or hypoxia on swimming stamina at the concentrations and levels tested, and the LOEC on breathing frequency is 13 and 9.7 µg/L under normoxic and hypoxic DO levels; NOEC is 4 µg/L under both DO scenarios.

Fig. 1. Summary of Ranked PCP Chronic Values for Salmonids

Freshwater (No pH Adjustment to 7.8; toxicity decreases with increasing pH)