ENCLOSURE 2

Supplemental Technical Support Document

for

EPA Clean Water Act 303(c) Determinations

On Oregon's New and Revised Aquatic Life Criteria Submitted on July 8, 2004, and as Amended by Oregon's April 23, 2007 and July 21, 2011 Submissions

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Supplemental Technical Support Document for EPA CWA 303(c) Determinations on Oregon's Aquatic Life Criteria

This document provides additional scientific and technical information supporting EPA's decision on those proposed criteria that are consistent with EPA's CWA § 304(a) recommended criteria and that EPA is approving.

Consistent with EPA guidance on the development of aquatic life water quality criteria, Oregon adopted acute (maximum concentration) and chronic (continuous concentration) criteria for freshwater and saltwater. EPA's Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Life and Their Uses[1] (hereafter 1985 Guidelines), recommends that numeric aquatic life criteria be expressed as two numbers, so that the criteria more accurately reflect toxicological and practical realities. The combination of a maximum concentration and a continuous concentration protects aquatic organisms and their uses from acute and chronic toxicity (1985 Guidelines p. 4). Because freshwater and saltwater have different chemical compositions and because freshwater and saltwater (i.e., estuarine and true marine) species rarely inhabit the same water simultaneously, the 1985 Guidelines also provide for the derivation of separate criteria for these waters (p. 14).

In determining whether Oregon's new and revised chemical-specific criteria are protective of the Fish and Aquatic Life designated use in Oregon waters, EPA identified the available toxicity studies on the chemicals, reviewed the studies for data quality and relevance, and considered these quality-assured and relevant data in its evaluation of whether the Oregon criteria would protect fish and aquatic life in Oregon's waters. In making the determination as to whether the Fish and Aquatic Life designated use was protected by Oregon's criteria, EPA evaluated whether the criteria would cause mortality or adverse effects to enough members of a species such that aquatic ecosystems in Oregon would no longer reflect balanced, integrated, and adaptive communities of organisms having species composition and diversity of functional organization comparable to that of the natural habitat of Oregon.

Section 1 of this document describes EPA's additional methods (beyond those provided in the 1985 Guidelines) for assessing whether these criteria are protective of the Fish and Aquatic Life designated use, and includes a discussion of the sources of data and information EPA used in conducting its evaluation. Section 2 of this document describes EPA's evaluation of Oregon's acute and chronic criteria for each chemical and EPA's basis for concluding that the criterion is protective of Oregon's designated use.

Appendix A of this document describes the test result quality review (QA/QC) requirements that EPA used to review available toxicity studies for scientific data quality and relevance. Studies

[1] Stephan, C.E., D.I. Mount, D.J. Hanson, J.H. Gentile, G.A. Chapman, and W.A. Brungs. 1985. Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses. EPA PB85-227049.

that met the QA/QC requirements were deemed by EPA to be of sufficient scientific quality and relevance and were used by EPA to evaluate whether Oregon's criteria values would protect the Fish and Aquatic Life designated fish and aquatic life use.

Appendix B describes, in brief, the procedures that EPA used in its Endangered Species Act (ESA) Biological Evaluation (BE) of Oregon's criteria and how those procedures relate to this analysis. The BE was developed for the purpose of providing the U.S. Fish and Wildlife Service and the National Marine Fisheries Services (hereafter referred to as the Services) with the information that EPA understood the Services desired in order for the Services to complete their review of EPA's action under section 7(a)(2) of the Endangered Species Act (ESA). This information consists of a review of all available studies of the toxicity of these chemicals to aquatic species, including data that were not included, after due consideration, in EPA's determination of whether Oregon's criteria are protective of Oregon's Fish and Aquatic Life designated use due to significant scientific concerns over the viability of the tests.

Also included are Appendices (C-V) for each chemical evaluated in this assessment that contain studies not utilized in this determination complete with the codified reasons for QA/QC failure.

1.0 Methodology for Criteria Evaluation

This section describes the steps EPA used in the effects determination (Section 2) to determine whether the criteria under review would be expected to protect Oregon's Fish and Aquatic Life designated uses. Consistent with the federal water quality standards regulations at 40 CFR 131.11, EPA incorporated this analysis into its CWA section 303(c) determination.

This methodology consists of the following key steps: (1) identification of available studies of the acute and chronic toxicity to aquatic species for the revised chemicals (see table, Section 1), (2) review of available toxicity studies for data quality and relevance (see Appendix A for quality control methods) which occurs in two stages, as described below, (3) consideration of toxicity test data of sufficient quality and relevance to determine potential effects to fish and aquatic life in Oregon, and (4) determination of whether Oregon's criteria for each chemical is expected to be protective of aquatic communities residing in Oregon and thus protective of Oregon's Fish and Aquatic Life designated use.

Section 1.1 identifies sources of data EPA considered in making its CWA section 303(c) determinations and references the QA/QC requirements that EPA used in determining which data is considered to be of sufficient scientific quality and relevance for use in CWA determinations. Sections 1.2 and 1.3 discuss how EPA evaluated the effects to species based on Oregon's acute and chronic criteria, respectively, in light of the data and information contained in these sources. Section 1.4 discusses how EPA determined, on the basis of its review, whether a particular criterion would be protective of the aquatic communities in Oregon's waters and thereby support protection of Oregon's Fish and Aquatic Life designated use. A graphical summary of the process is provided in figure 1.

1.1 Sources of toxicity test data used in EPA determinations

EPA's evaluation of the relevant new or revised criteria was based on data referenced in the most recent EPA criteria document[2] for each chemical plus other data gathered during a literature search update for each chemical.

When EPA develops nationally recommended criteria for the protection of aquatic life under 304(a) of the CWA, EPA conducts a comprehensive search of available scientific literature to identify studies and data on the acute and chronic toxicity of a chemical to aquatic species. These studies are identified in the 304(a) criteria documents available online[3]. The ECOTOX database, maintained by EPA, is the primary source of information regarding toxicity to aquatic species. The ECOTOX process includes a QA/QC step, detailed in Appendix A and represented

[2]When EPA issues a CWA Section 304(a) national aquatic life criterion for a chemical, EPA publishes a criteria document that presents the recommended criterion, the data upon which it is based, and an explanation of the derivation of the criterion. The criteria recommendations are referred to as the 304(a) criteria or the national recommended water quality criteria.

[3] http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm

by the decision point 1 in Figure 1, that identifies tests deemed to be of potentially acceptable quality. EPA then moves into a more specific evaluation of each study that passes the ECOTOX screen (referred to as the Office of Water QA procedures, largely defined in the 1985 Guidelines and various EPA and ASTM standards, identified as decision point 3 in Figure 1).

EPA also prepared a biological evaluation (BE) for the purpose of providing the US Fish and Wildlife Service and National Marine Fishes Services (referred to together as 'the Services') with information that the Services indicated to EPA was necessary in order for the Services to complete their biological opinion (BO) under ESA section 7(a)(2) on EPA's action to approve Oregon's water quality standards. When EPA develops a BE, EPA typically uses the data referenced in the criteria document(s) and supplements these test data with data obtained from updated literature searches. This practice of conducting an updated literature search is in recognition of the fact that additional toxicity testing may have occurred between the time that the latest national recommended criteria were issued and the time of EPA's action to approve or disapprove a State's water quality standards. Not only did EPA conduct an updated literature search for the purposes of the BE, EPA also, in deference to the Services, was broadly inclusive with regard what information was identified in the BE. That is, EPA included some studies for consideration in the BE that it would typically have excluded in criteria development because they did not qualify as sufficiently scientifically robust in regards to study quality, in order to accommodate the Services desire to have access to as much information as possible.

Because EPA's objective in developing the BE was to be responsive to the Services' desire to have as much information as possible to consider as they developed their BO under the ESA, the information in the BE differs in some respects from what EPA considered as it evaluated the protectiveness of Oregon's criteria under the CWA (for a detailed explanation of these differences, see Appendix B, section B.3).

For this CWA determination, EPA considered those data referenced in the criteria document along with the new data referenced in the BE that met EPA test quality requirements described in Appendix A. Some of the data referenced in the BE did not meet the QA/QC requirements and were identified in their respective, chemical specific appendices following Section 2 of this document along with a reason for rejection for purposes of full transparency. Specifically, in the case of the acute and chronic toxicity studies used in the BE, EPA examined studies in greater depth when either: (1) the study results indicated toxicity that was near or below the recommended criteria value, or (2) the study included tests with a species associated with one the four most sensitive GMAVs for the pollutant.[4] EPA undertook this additional review of these particular studies because studies near the criteria values are most influential in determining in the adequacy of the criteria for protecting sensitive genera and species. Values considered to be above the criterion are not of concern due to lack of sensitivity. For each study

[4] Specifically, EPA double-checked its prior test quality evaluations for those studies yielding SMAVs less than 2 fold greater or SMCV values that were below the respective Oregon acute and chronic criterion values in addition to any study providing an acute or chronic toxicity value for a species associated with one of the four most sensitive genera used to calculate the corresponding criterion. The derivation of the SMAV and SMCV values is described in Sections 1.2 and 1.3.

that was potentially influential but did not pass the quality review, the study was not used in this determination and the rationale for its exclusion is detailed in each criterion's respective appendix. In addition, for each chemical, a list of all studies that were utilized in the determination is provided in a reference table located in each chemical specific subsection of Section 2.0.

Finally, for the purposes of this document, EPA did not consider it appropriate to make CWA determinations based on estimates or projections of potential toxicity to particular species in cases where no actual toxicity data are available for these species via use of models. This is because these projections involve a high degree of uncertainty. Projections based on these types of models have been shown in some cases to be 5 fold different from actual toxicity results when toxicity testing is actually undertaken on the species[5]**.** Accordingly, EPA has not used the model-based estimates or projections of potential toxicity of chemicals to aquatic species in its determination of whether Oregon's criteria are protective of Oregon's Fish and Aquatic Life designated use and considers the distribution of taxa represented by the minimum data requirements and the use of the fifth percentile genus protection sufficient for the purpose of offering protection to untested species and genera.

1.2 Evaluation of the protectiveness of Oregon's acute criterion concentration

After EPA verified the quality of available toxicity test data and identified those acute toxicity tests that were of sufficient quality and relevance, EPA analyzed the protectiveness of Oregon's acute criteria using these data.

Acute toxicity tests in the published literature are typically laboratory studies that determine the concentration of a chemical that causes 50% of the organisms in a given test to perish or be severely affected, typically in 96 hour toxicity tests for vertebrates and 48 hour tests for invertebrates such as Daphnid species. EPA often finds more than one scientifically sound and relevant acute toxicity study on a particular chemical for a particular species. Frequently, the reported toxicity value for a single species varies across studies in a given laboratory and across laboratories. Because of this, EPA calculates Species Mean Acute Values (SMAVs) from the acceptable toxicity tests for a given species that are found to be scientifically sound and relevant. The SMAV is the geometric mean of the acute toxicity values for a species (the most sensitive tested life stage of the species is always used if identified). The geometric mean of the acceptable acute toxicity values for a species is considered to be the most representative of the central tendency of those values.[6] If only one acceptable toxicity study is available for a species, then EPA uses that value to represent the SMAV in order to include as many species as possible in the criteria development. These values are then combined into a genus level estimate of

[5] Raimondo et al., Influence of Taxonomic Relatedness and Chemical Mode of Action in Acute Interspecies Estimation Models for Aquatic Species, *Environ. Sci. Technol.*, **2010**, *44* (19), pp 7711–7716

[6] Geometric means are used to calculate central tendency values for acute values, chronic values, and acute-chronic ratios because such data tend to be log normally distributed rather than normally distributed.

organism effects termed the Genus Mean Acute Value (GMAV). The GMAV is the geometric mean of the acute toxicity values for all available, acceptable species data in a genus and is considered to be the most representative of the central tendency of those values for the genus. These genus values are then loosely classified into taxanomic groups, per the 1985 Guidelines, in order to represent a cross-section of the expected natural composition of aquatic water bodies. Any criterion derived by this guidance will contain the requisite biodiversity in order to derive a protective level sufficient to be deemed protective of aquatic life.

The evaluation used in this effort consisted of a tiered process. As per the 1985 Guidelines, data at the genera level was evaluated first (GMAV, GMCV). A more focused evaluation was then performed.

This more focused step in the process involves calculating an estimate of the concentration that would result in little or no mortality or effect. This value is statistically indistinguishable from control mortality or effect in the acceptable tests found in the literature. EPA develops this low effect value for each chemical and species combination by dividing each SMAV by 2. EPA derived the factor of 2 and this approach from an analysis of 219 acute toxicity tests on a range of chemicals, as described in the *Federal Register* on May 18, 1978 (43 FR 21506-18).[7] As noted in the Federal Register notice:

> ”*The figure of 0.44 is an ‘adjustment factor’ applied to LC50 data to determine the concentration likely to be lethal to between 0 percent and 10 percent. It is based on 219 acute toxicity tests which showed that the mean concentration lethal to 0-10 percent of the test population was 0.44 times the LC50.”*

Thus, in EPA’s scientific judgment, the magnitude of acute effects to a particular species at the SMAV/2 would not be projected to significantly impact the population of the species, because it is expected to be statistically indistinguishable from effects to control (unexposed) organisms.

These SMAV/2 values were compared to the Oregon criterion to ascertain concentrations resulting in effects at the species level that are expected to be undistinguishable from control effects, in order to assist with the determination of the protectiveness of Oregon’s aquatic life designated use. When the SMAV/2 for a particular species was greater than the chemical criteria level adopted by Oregon, EPA determined that the chemical criteria adopted by Oregon would not result in significant impacts if members of the species were exposed at the criterion. When the SMAV/2 for a particular species that inhabits Oregon is less than the Oregon criteria for a particular chemical, EPA determined that there may be potential for impacts to members of the species.

[7] The analysis consisted of calculating the geometric mean of the ratios of the highest concentration (HC) affecting or causing lethality to 0 to 10% of organisms divided by the LC50 or EC50 for the same organisms in the same toxicity test. The geometric mean of the 219 HC/LC50 (or HC/EC50) ratios was 0.44; that is, the mean concentration that was lethal to 0 to 10% of the test population was 0.44 times the LC50 (or EC50). EPA used the reciprocal of 0.44, which is 2.27, and best professional judgment was used to round 2.27 to 2. (In 2006, the same data set was reanalyzed, and the geometric mean was corrected from 0.44 to 0.43).

If the test species of concern does not reside in Oregon, EPA determined that these test results were not relevant to the evaluation of criteria relative to protecting Oregon's waters and did not include this test result in the final CWA determination. Where EPA confirmed that the species is present in Oregon but there is no significant difference between the Oregon criterion and the SMAV/2, EPA concluded that the acute criterion adopted by Oregon would not result in significant impacts to exposed members of the species, and therefore, will not impact the species in the aquatic ecosystem if exposed beyond the frequency and duration requirements. Where there was a significant difference between the test result and the criterion, EPA examined the details underlying the value to make a final determination for that species. It should be noted that EPA's protection goal of "fishable" as presented in the CWA and codified by the Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses, is to protect approximately the 5th percentile genera of the full distribution of data, and by extension the 5th percentile of potential organisms in the aquatic ecosystem. Based on this approach, it is not uncommon for a species to be sensitive at the criterion concentration. This fact is why EPA recommends that the national 304(a) criterion be adjusted for recreationally or commercially important species and pertains to this more in-depth review of the available, scientifically sound information.

It is also important to note that water quality criteria provide recommendations for specific concentrations (or magnitudes) that are protective, and importantly, provide additional protection by limiting how long (duration) and how often (frequency) such concentrations should be limited to in order to provide additional protection to aquatic organisms. EPA's acute criteria generally recommend that the specific concentration identified as sufficiently protective of aquatic ecosystems not be exceeded instantaneously or for more than one hour (duration) once every three years (frequency). It is useful to consider that toxicity values upon which acute criteria magnitudes are based are determined in multi-day tests (generally 2-4 days tests), not one-hour tests. Thus, comparing the low-to-no-level acute effect magnitudes (SMAVs/2) from multi-day tests to criteria magnitudes that may not be exceeded for more than 1 hour every three years provides a substantial level of additional protection to aquatic organisms. This added protection is not quantitatively evaluated in this effort, but should be considered and addressed in any subsequent, species specific, determinations.

In cases where individual species may be affected, EPA noted such in the technical support for each chemical in Section 2 of this document. The weight of evidence was then evaluated for each criterion and a determination made as to the protection of Oregon's aquatic life designated use.

Note: In this evaluation, the reporting of calculated values (SMAV, GMAV, SMCV, GMCV) has been limited to a minimum of four significant figures for convenience with the exception of very high values, which are reported as whole numbers. The results of such calculations in aquatic life criteria documents are given to four significant figures to prevent roundoff error in subsequent calculations, not to reflect the precision of the values.

1.3 Evaluation of the protectiveness of Oregon's chronic criterion concentration

After EPA evaluated available acute toxicity data, EPA identified those chronic toxicity tests that were of sufficient data quality and relevance to analyze the protectiveness of Oregon's chronic criteria using the test quality acceptability requirements identified in Appendix A.

In general, there are far fewer published chronic toxicity tests than published acute toxicity tests. Chronic toxicity tests are typically run for 7 to 365 days during which time scientists evaluate the adverse effects of the chemical on tested species. These effects may include, but are not limited to, weight loss or growth effects, impacts on reproduction and development, mortality or any effect quantitatively linked to those endpoints.

In order to fully evaluate potential effects to aquatic life due to exposure to the criterion concentration, EPA developed the following approach, which is different and significantly more detailed than outlined in the 1985 Guidelines, that examines the relative responses across all genera and species relative to the state adopted chronic standard value. The intention of this section is to examine all existing species sensitivity information, related to species which occur in the state, in order to inform the final risk management decision relative to Oregon's aquatic life designated use. EPA notes here, however, that much of this information is exracted from the results of acute tests and extrapolated to chronic effects. This method is novel and is intended only as a further screen by which to determine confidence in the existing criteria in regards to the protection provided to Oregon's aquatic life designated use.

EPA's evaluation of Oregon's new or revised chronic standard concentrations was based either on experimentally determined Species Mean Chronic Values (SMCVs) or on predicted Genus Mean Chronic Values (GMCVs). EPA calculated a predicted GMCV for a genera and chemical combination by dividing the GMAV by the Final Acute-Chronic Ratio (ACR) in order to derive consistent measures of chronic sensitivity for all genera for which acute values were available. An ACR is the quotient of an acceptable experimentally determined acute toxicity test value divided by an acceptable experimentally determined chronic toxicity test value, when the acute value and the chronic value are determined in the same dilution water using organisms from the same source when available. Many of the ACRs come directly from the national recommended water quality criteria documents. In cases where new data was available from the updated literature search, this data was used to calculate a revised ACR.

EPA summarized experimentally determined SMCVs and ACRs from the data contained in the studies which passed the test quality requirements. By definition, an experimentally determined SMCV was derived by taking either the geometric mean between the No Observed Effects Concentration (NOECs) and the Lowest Observable Effects Concentration (LOECs), which is also termed the Maximum Acceptable Test Concentration (MATC), or a point estimate determined via regression analysis (*e.g.,* an EC20)[8] from a scientifically sound and relevant chronic test.

EPA then compared the experimentally determined SMCVs or estimated GMCVs to the Oregon chronic criterion. When the experimentally determined SMCV or estimated GMCV for a particular species was greater than the chronic criteria concentration adopted by Oregon, EPA determined that this chronic criteria concentration should be protective of exposed members of the genera and therefore will not be expected to significantly impact local populations. When the GMCV for a particular genus is less than the Oregon criteria for a particular chemical, EPA further analyzed the data to determine whether the species that comprise the genus value reside in Oregon and whether there is a significant difference between the criteria level adopted by Oregon and the GMCV, considering the inherent uncertainties in the analyses. This information was used to evaluate the protectiveness of Oregon's aquatic life designated use against chronic effects.

If a test species of concern does not reside in Oregon, EPA determined that these test results were not relevant to the evaluation of criteria relative to protecting Oregon's waters and did not include this test result in the final CWA determination; however they are noted at the end of each chemical specific section for full transparency. Where EPA found that the species did exist in Oregon but there was no significant difference between the Oregon criterion and the GMCV, EPA concluded that the chronic standard concentration adopted by Oregon would not be expected to result in significant impacts in reproduction or growth and therefore would be expected to neither impact local populations or the biological integrity of the ecological communities in the waterbody where criteria are met.

As described in the acute section above, it is also essential to note that water quality criteria provide recommendations for specific concentrations, and also, importantly, provide additional protection by limiting how long (duration) and how often (frequency) such concentrations should be limited to in order to provide additional protection to aquatic organisms. EPA's chronic criteria generally recommend that the specific concentration identified as sufficiently protective of chronic effects in aquatic ecosystems not be exceeded for more than four days (duration), once every three years (frequency). Thus, comparing low level chronic effect magnitudes (GMCVs) based on long-duration tests, (generally, weeks-to-months long tests) to criteria magnitudes that may not be exceeded for more than 4 days every three years provides a substantial level of additional protection to aquatic organisms. A more detailed response to the frequency and duration components of criteria is included in the response to comments document.

A final determination regarding the protection of the aquatic life designated use by each criterion is made based on the summation of the data or weight of evidence based on the relevant data as provided in this document.

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[8] An EC20 is the statistically derived concentration that is expected to cause a 20% reduction in survival, growth, or reproduction, depending on which endpoint is most sensitive to the chemical of concern. On the average, the EC20 from an acceptable chronic test is similar to the geometric mean of the NOEC and the LOEC (the MATC used here) from the same chronic test.

1.4 Final determination method

As discussed above in sections 1.1, 1.2, and 1.3, in making this determination, EPA collected aquatic toxicity test results for the chemicals for which Oregon adopted new or revised aquatic life criteria. EPA then reviewed the data using established test quality requirements (Appendix A), and used the resulting scientifically acceptable data to determine whether Oregon's criteria for each chemical would be sufficiently protective of the diversity of aquatic organisms and the associated aquatic life designated use if organisms were exposed at the criterion concentration acutely or chronically. When the data for a genera or species was greater than the Oregon criterion for a particular chemical, EPA determined that the species and genera would be protected by the criterion.

When the SMAV/2 or estimated GMCV (SMCV, if available in the literature) for a particular species was less than the Oregon criterion for a particular chemical, EPA performed additional analyses to determine if the species resided in Oregon, and if so, if the difference between the test results and the criterion were significant.

If the species resides in Oregon, EPA conducted analyses to determine if the difference between the test results and the criterion was significant. If a species was found to be sensitive, EPA noted the expected sensitivity in the technical evaluation for each chemical (Section 2).

Under EPA's guidance, in order to protect aquatic life designated uses, the Agency has derived a nationally relevant method designed to protect the majority of species in the majority of environments. The selected level of protection is the 5^{th} percentile of all tested genera, which is designed to represent ecologically relevant populations in the environment, based on the minimum eight taxa data requirements. In effect, this approach is intended to protect 95% of genera from negative effects on survival, growth, or reproduction, if exposed to criterion concentrations for no more than four days chronically or one day acutely once every three years on average. Due to the use of a calculated fifth percentile of a species sensitivity distribution for each determination, a simple count of acceptable studies that are above and below the criterion value is insufficient for final decision making.

Final approval or disapproval of Oregon's individual standards is based on the relevant facts and weight of evidence for each criterion. Ecologically (including ESA listed species), commercially, or recreationally important species, if sensitive, may require the consideration of site or state specific adjustments to the nationally recommended 304(a) criteria to account for that sensitivity as directed in the 1985 Guidlines. All science based decisions are supported by the technical evaluation presented in Section 2.

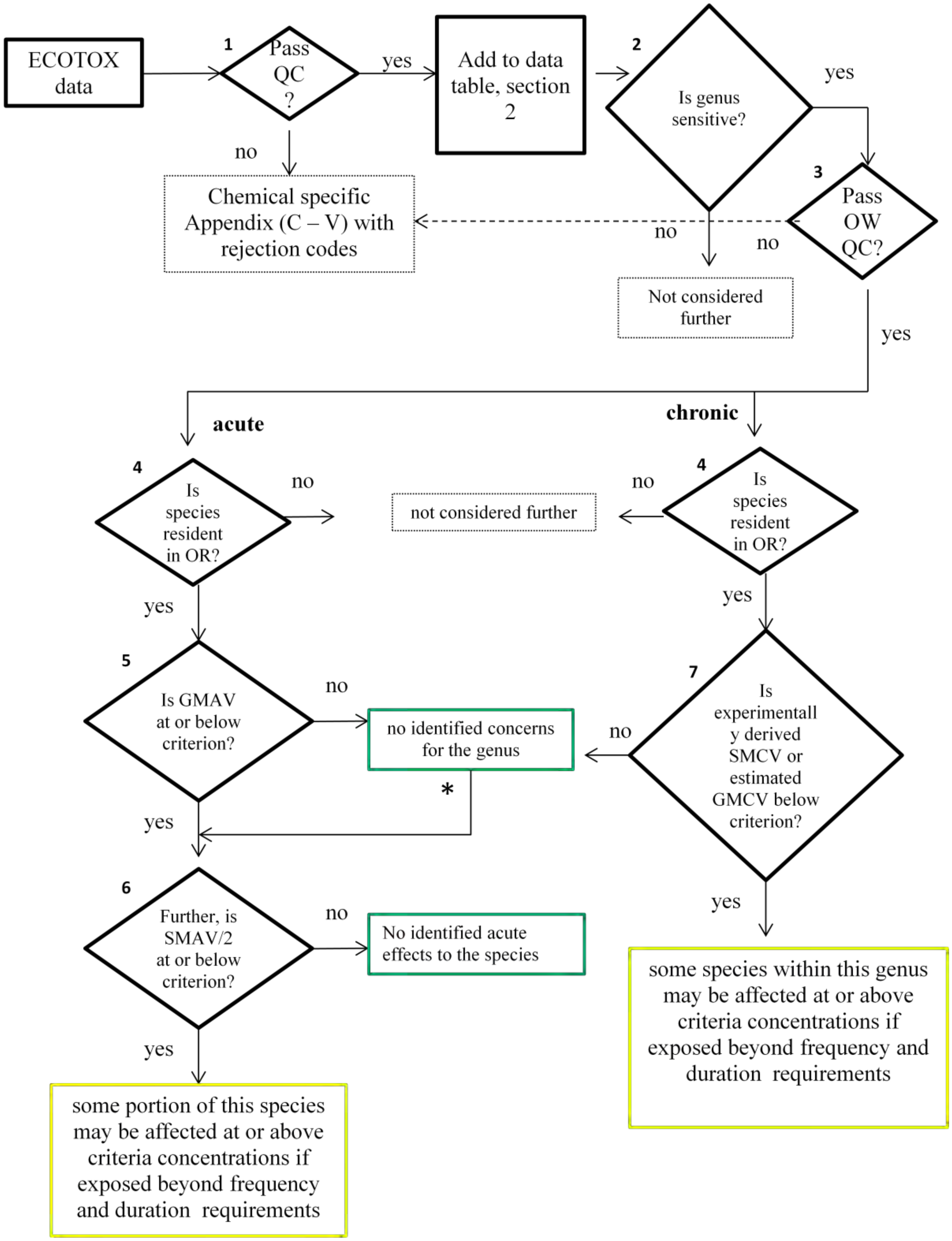

Figure 1. Flow diagram describing the decision framework within which EPA evaluated the available, acceptable scientific data. The end determination was based on the sensitivity of genera identified by the above process.

2.0 Criteria Evaluation

2.1 Freshwater

2.1.1 AMMONIA

Please see the main decision document for information regarding the disapproval of this criterion.

2.1.2 CADMIUM

2.1.2.1 Evaluation of the Acute Freshwater Criterion Concentration for Cadmium

Please see the primary decision document for information regarding the disapproval of this criterion.

2.1.2.2 Evaluation of the Chronic Freshwater Criterion Concentration for Cadmium

A. Presentation of Toxicological Data

Oregon adopted a freshwater chronic criterion concentration of 0.25 µg/L for cadmium expressed as the dissolved metal concentration at a total hardness of 100 mg/L $CaCO_3$ in the water column. This concentration is the same as the freshwater CCC recommended for use nationally by EPA for the protection of aquatic life[9]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 3.1.2-1 presents a compilation of SMAVs and GMAVs calculated in support of EPA's on-going review of available acute toxicity data, any experimentally determined SMCVs obtained from the criteria document and EPA ECOTOX download used for the BE, and estimated GMCVs based on the GMAV/FACR. The 2001 criteria document for cadmium did not report a FACR. However, the acute-chronic ratios included in the document ranged from 0.9021 for the chinook salmon to 433.8 for the flagfish (greater than a factor of ten), with eighteen other values scattered throughout this range (see Tables 2e and 3c in the 2001 criteria document). Because salmonids are among the most sensitive genera, EPA determined the ACR of 0.9021 is the most appropriate ACR to protect sensitive species in general. However, in accordance with the Guidelines, the FACR cannot be less than 2 due to testing considerations, so it is adjusted up to 2. Since no additional acceptable ACRs are available, EPA calculated the predicted GMCVs for cadmium in Table 3.1.2-1 using an FACR of 2 and the following equation: Predicted GMCV = GMAV/FACR.

EPA compared the GMCVs for each species to Oregon's cadmium chronic criterion to determine whether the chronic criterion will protect the aquatic life designated use.

[9] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are from U.S. EPA. 2001. 2001 Update of Ambient Water Quality Criteria for Cadmium. EPA-822-R-01-001.

Table 2.1.2-1: Genus Mean Chronic Values (GMCVs) for Cadmium

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*	SMCV (µg/L) *(experimentally derived)*	Chronic References *(used in the calculation of the SMCV)*	Predicted GMCV (µg/L)
Chironomus	***riparius***	***Midge***	185025	-	68			-
Chironomus	***tentans***	***Midge***	22930	-	25,100	4.260	7	-
Chironomus	***plumosus***	***Midge***	15042	39962	98,99			19981 (4.260)
Oreochromis	aureus	Blue tilapia	-	-	-	>35.90	17	-
Oreochromis	niloticus	Nile tilapia	65456	-	97			-
Oreochromis	mossambica	Mozambique tilapia	14675	30993	95,96			15497 (>35.90)
Cyprinus	carpio	Common carp	28454	28454	71,93,94			14227
Dendrocoelum	lacteum	Turbellarian, planarian	26865	26865	92			13433
Rhithrogena	hageni	Mayfly	21488	21488	23,91			10744
Gambusia	affinis	Western mosquitofish	12412	12412	41			6206
Rhyacodrilus	montanus	Oligochaete	11782	11782	83			5891
Branchiura	sowerbyi	Oligochaete	11469	11469	71,83			5734
Gasterosteus	aculeatus	Threespine stickleback	10387	10387	89,90			5194
Stylodrilus	heringianus	Oligochaete	10286	10286	83			5143
Ictalurus	punctatus	Channel catfish	9654	9654	13			4827
Lepomis	macrochirus	Bluegill	11513	-	13,88	26.40	15	-
Lepomis	cyanellus	Green sunfish	5662	8074	87			4037 (26.40)
Hexagenia	rigida	Mayfly	7428	7428	86			3714
Spirosperma	nikolskyi	Oligochaete	8416	-	83			-
Spirosperma	ferox	Tubificid worm, Oligochaete	6545	7422	83			3711
Cyprinella	lutrensis	Red shiner, Rainbow dace	7328	7328	85			3664
Varichaeta	pacifica	Earthworm	7107	7107	83			3553
Perca	flavescens	Yellow perch	6763	6763	18			3381
Catostomus	commersoni	White sucker	5989	5989	84	11.86	8	2995 (11.86)
Quistadrilus	multisetosus	Oligochaete	5984	5984	83			2992
Jordanella	floridae	Flagfish	5437	5437	81,82	8.079	10,11	2719 (8.079)
Poecilia	reticulata	Guppy	4702	4702	79,80			2351
Ephemerella	grandis	Mayfly	4350	4350	78			2175

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*	SMCV (µg/L) *(experimentally derived)*	Chronic References *(used in the calculation of the SMCV)*	Predicted GMCV (µg/L)
Tubifex	tubifex	Tubificid worm	3950	3950	20,74,75,76,77			1975
Crangonyx	pseudogracilis	Amphipod	3247	3247	73			1623
Xenopus	laevis	African clawed frog	2920	2920	72			1460
Diaptomus	forbesi	Copepod	2879	2879	71			1439
Procambarus	alleni	Crayfish	6410	-	69			-
Procambarus	clarkii	Red swamp crayfish	2180	-	66,70			-
Procambarus	acutus	Crayfish	791.2	2228	69			1114
Carassius	auratus	Goldfish	1612	1612	13			806.0
Limnodrilus	hoffmeisteri	Tubificid worm, Oligochaete	1480	1480	68			740.1
Orconectes	virilis	Crayfish	22649	-	67			-
Orconectes	immunis	Crayfish	21981	-	13			-
Orconectes	juvenilis	Crayfish	130.5	-	66			-
Orconectes	placidus	Crayfish	64.14	1429	66			714.4
Gammarus	pseudolimnaeus	Scud	150.3	1366	39,40			682.9
Ambystoma	gracile	Northwestern salamander	995.7	995.7	65			497.9
Asellus	bicrenata	Isopod	901.7	901.7	52			450.8
Physa	acuta	Snail	2096	-	64			-
Physa	gyrina	Pouch snail	191.3	633.2	63			316.6
Coregonus	clupeaformis	Lake whitefish	619.8	619.8	62			309.9
Plumatella	emarginata	Bryozoan	496.0	496.0	43			248.0
Alona	affinis	Water flea	472.2	472.2	59			236.1
Lymnaea	stagnalis	Pond snail	452.9	452.9	61			226.4
Ptychocheilus	oregonensis	Northern squawfish	4243	-	60			-
Ptychocheilus	lucius	Colorado squawfish	43.04	427.3	44			213.7
Cyclops	varicans	Cyclopoid copepod	426.4	426.4	59			213.2
Glossiphonia	complanata	Leech	367.7	367.7	58			183.9
Pectinatella	magnifica	Bryozoa	318.5	318.5	43			159.3
Lumbriculus	variegatus	Worm	249.5	249.5	57			124.7
Aplexa	hypnorum	Snail	198.4	198.4	13,56	7.323	9	99.19 (7.323)
Hydra	vulgaris	Hydra	177.2	-	53,54,55			-
Hydra	oligactis	Hydra	142.1	-	54			-
Hydra	viridissima	Hydra	37.30	97.92	53,54			48.96
Lirceus	alabamae	Aquatic sowbug	92.51	92.51	52			46.26

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*	SMCV (µg/L) *(experimentally derived)*	Chronic References *(used in the calculation of the SMCV)*	Predicted GMCV (µg/L)
Utterbackia	imbecillis	Mussel	85.75	85.75	29,42,51			42.88
Moina	macrocopa	Water flea	82.30	82.30	50			41.15
Gila	elegans	Bonytail	73.95	73.95	44			36.98
Ceriodaphnia	reticulata	Water flea	78.45	-	33,34			-
Ceriodaphnia	dubia	Water flea	66.78	72.38	25,31,42,45, 46,47,48,49	41.27	18	36.19 (41.27)
Xyrauchen	texanus	Razorback sucker	69.94	69.94	44			34.97
Lophopodella	carteri	Bryozoa	68.26	68.26	43			34.13
Villosa	vibex	Southern rainbow mussel	67.18	67.18	29			33.59
Lasmigona	subviridis	Mussel	65.11	65.11	42			32.56
Actinonaias	pectorosa	Mussel	64.56	64.56	29			32.28
Lampsilis	straminea claibornensis	Southern fatmucket	91.05	-	29			-
Lampsilis	teres	Yellow sandshell	45.65	64.47	29			32.24
Aeolosoma	headleyi	Oligochaete	-	-	-	31.51	12,16	(31.51)
Simocephalus	serrulatus	Water flea	57.69	57.69	39,40,41			28.85
Daphnia	***pulex***	***Water flea***	90.51	-	31,33,34,35, 36,37,38	9.369	12	-
Daphnia	***magna***	***Water flea***	41.93	-	32	<0.5764	1,2,3	-
Daphnia	***ambigua***	***Water flea***	24.25	45.15	31			22.57 (2.324)
Pimephales	promelas	Fathead minnow	28.71	28.71	30	24.88	14	14.35 (24.88)
Micropterus	dolomieui	Smallmouth bass	-	-	-	12.34	8	(12.34)
Esox	lucius	Northern pike	-	-	-	12.29	8	(12.29)
Anodonta	couperiana	Mussel	22.92	22.92	29			11.46
Prosopium	williamsoni	Mountain whitefish	15.21	15.21	4			7.607
Cottus	bairdi	Mottled sculpin	10.70	10.70	19,22,23			5.349
Oncorhynchus	***kisutch***	***Coho salmon***	11.88	-	9	6.479	8	-
Oncorhynchus	***tshawytscha***	***Chinook salmon***	8.222	-	9,10,20,21	3.968	5	-
Oncorhynchus	***mykiss***	***Rainbow trout***	4.397	7.545	2,4,9,10,11,12,13,14, 15,16,17,18,19	1.987	4	3.773 (3.710)
Morone	***saxatilis***	***Striped bass***	5.586	5.586	8			2.793
Salmo	salar	Atlantic salmon	-	-	-	12.03	13	-
Salmo	***trutta***	***Brown trout***	5.445	5.445	4,5,6,7	7.602	4	2.723 (9.563)
Etheostoma	fonticola	Fountain darter	4.612	4.612	3			2.306
Salvelinus	namaycush	Lake trout	-	-	-	12.29	8	-
Salvelinus	***confluentus***	***Bull trout***	4.110	-	2			-

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*	SMCV (µg/L) (*experimentally derived*)	Chronic References *(used in the calculation of the SMCV)*	Predicted GMCV (µg/L)
Salvelinus	***fontinalis***	***Brook trout***	3.420	3.749	1	4.015	6	1.875 (7.025)
Hyalella	***azteca***	***Amphipod***	*H. azteca* is sensitive to chloride concentration. EPA has decided to not use data for this species until additional tests are conducted. Chronic data for this species from Ingersoll and Kemble (Manuscript) is designated as Unused - Failed QA_QC.					

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV in the 2001 update of the ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision.

B. Evaluation of the Protectiveness of the Oregon Freshwater Chronic Criterion for Cadmium

Following the review of the GMCV in Table 2.1.2-1, all tested genera and species have values greater than Oregon's chronic criterion for cadmium. Therefore, EPA concluded that chronic effects are not expected to occur at ambient concentrations equal to or lower than the criterion and the aquatic life designated use is protected.

2.1.2.3 References for Cadmium

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the chronic table, and are the source from which EPA obtained SMAVs (for SMCV estimation) and experimentally-derived SMCVs.

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in Table 2.1.2-1*)
Acute References	
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2	Stratus Consulting, Inc. 1999. Sensitivity of bull trout (Salvelinus confluentus) to cadmium and zinc in water characteristic of the Coeur D'Alene River Basin: acute toxicity report. Final Report to U.S. EPA Region X. 55 pp.
3	Southwest Texas State University. 2000.Comparison of EPA Target Toxicity Aquatic Test Organisms to the Fountain Darter. 7 Day Chronic Toxicity Test Using Cadmium Chloride. Performed 11/12/99 - 3/6/00 (5 parts). Edwards Aquifer Res. and Data Center (EARDC), Southwest Texas State Univ., San Marcos, TX. Fed. Assist. Agree. No. X-986345-01: 179 p. (Author Communication Used).
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5	Davies, P.H. and S.F. Brinkman. 1994c. Toxicology and chemical data on unregulated pollutants. Water Pollution Studies, Federal Aid in Fish and Wildlife Restoration, Project #33: Fort Collins, CO, Colorado Division of Wildlife.
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Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in Table 2.1.2-1*)
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Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in Table 2.1.2-1*)
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Chronic References	
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2	Borgmann, U., K.M. Ralph and W.P. Norwood. 1989. Toxicity test procedures for *Hyalella azteca*, and chronic

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in Table 2.1.2-1*)
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3	Chapman, G.A., S. Ota and F. Recht. 1980 (Manuscript). Effects of water hardness on the toxicity of metals to *Daphnia magna*. U.S. EPA, Corvallis, OR.
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9	Holcombe, G.W., G.L. Phipps and J.W. Marier. 1984. Methods for conducting snail (*Aplexa hypnorum*) embryo through adult exposures: effects of cadmium and reduced pH levels. Arch. Environ. Contam. Toxicol. 13: 627.
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13	Rombough, P.J. and E.T. Garside. 1982. Cadmium toxicity and accumulation in eggs and alevins of Atlantic salmon *Salmo salar*. Can. J. Zool. 60: 2006.
14	Pickering, Q.H. and M.H. Gast. 1972. Acute and chronic toxicity of cadmium to the fathead minnow (*Pimephales promelas*) J. Fish. Res. Board Can. 29: 1099.
15	Eaton, J.G. 1974. Chronic cadmium toxicity to the bluegill (*Lepomis macrochirus* Rafinesque). Trans. Am. Fish. Soc. 4: 729.
16	Niederlehner, B.R., A.L. Buikema Jr., C.A. Pittinger and J. Cairns Jr. 1984. Effects of cadmium on the population growth of a benthic invertebrate *Aeolosoma headleyi* (Oligochaeta). Environ. Toxicol. Chem. 3(2): 255-262.
17	Papoutsoglou, S.E. and P.D. Abel. 1988. Sublethal toxicity and accumulation of cadmium in *Tilapia aurea*. Bull. Environ. Contam. Toxicol. 41: 404-411.
18	Jop, K.M., A.M. Askew and R.B. Foster. 1995. Development of a water-effect ratio for copper, cadmium, and lead for the Great Works River in Maine using *Ceriodaphnia dubia* and *Salvelinus fontinalis*. Bull. Environ. Contam. Toxicol. 54: 29-33.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For specific study determinations, see Appendix C.

2.1.3 CHROMIUM III

2.1.3.1 Evaluation of the Acute Freshwater Criterion Concentration for Chromium III

A. Presentation of Toxicological Data

Oregon adopted a freshwater acute criterion concentration of 570 µg/L for chromium III that is expressed as a function of total hardness in the water column and in terms of the dissolved concentration of the metal. This dissolved metal concentration reflects the criterion normalized to a total hardness of 100 mg/L as $CaCO_3$ and is the same as the freshwater CMC recommended for use nationally by EPA for the protection of aquatic life[10]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.3-1 provides available GMAVs based on available acute toxicity data for chromium III to aquatic life from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.1.3-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Chromium III

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Crangonyx	pseudogracilis	Amphipod	162227	162227	11
Hydropsyche	betteni	Caddisfly	39615	39615	1
Caddisfly (unidentified)		Caddisfly (unidentified)	27874	27874	3
Damselfly (unidentified)		Damselfly (unidentified)	24027	24027	3
Fundulus	diaphanus	Banded killifish	8713	8713	9
Lepomis	gibbosus	Pumpkinseed	8764	-	9
Lepomis	macrochirus	Bluegill	8373	8566	4
Morone	saxatilis	Striped bass	9126	-	9
Morone	americana	White perch	7426	8232	9
Anguilla	rostrata	American eel	7169	7169	9
Chironomus	sp.	Midge	6132	6132	3
Amnicola	sp.	Spire snail	5692	5692	3
Cyprinus	carpio	Common carp	5285	5285	9,10
Nais	sp.	Worm	5185	5185	3
Pimephales	promelas	Fathead minnow	4951	4951	8
Carassius	***auratus***	***Goldfish***	4841	4841	4
Oncorhynchus	mykiss	Rainbow trout	4191	4191	5
Poecilia	***reticulata****	***Guppy***	3932	3932	4
Daphnia	magna	Cladoceran	4563	-	6,7

[10] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are from the 1995 Great Lakes Initiative Updates to these criteria as cited in: U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Daphnia	pulex	Cladoceran	1353	2485	2
Gammarus	***sp.***	***Scud, Amphipod***	1784	1784	3
Ephmerella	***subvaria****	***Mayfly***	1238	1238	1

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV in the 1995 GLI update of the ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera used in the derivation of the 304(a) criteria are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision, particularly for metals such as chromium III which are normalized to a water hardness of 100 mg/L as $CaCO_3$ and expressed on a dissolved metal basis for a comparison with the acute criterion concentration.

B. Evaluation of the Protectiveness of the Oregon Freshwater Acute Criterion

Following review of GMAV and SMAV/2 values in Table 2.1.3-1, all tested genera and species are protected by Oregon's acute criterion magnitude for chromium III. Therefore, EPA concluded that acute effects are not expected to occur at ambient concentrations equal to or lower than the criterion and the aquatic life designated use is protected.

2.1.3.2 Evaluation of the Chronic Freshwater Criterion Concentration for Chromium III

A. Presentation of Toxicological Data

Oregon adopted a freshwater chronic criterion concentration of 74 µg/L for chromium III expressed as the dissolved metal concentration at a total hardness of 100 mg/L $CaCO_3$ in the water column. This concentration is the same as the freshwater chronic criterion concentration recommended for use nationally by EPA for the protection of aquatic life[11]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 3.1.3-2 presents a compilation of the experimentally determined GMCVs obtained from the criteria document and EPA ECOTOX download used for the BE, and estimated GMCVs based on the GMAV/ACR. The 1984 criteria document for chromium[12] reported an FACR of 41.84, which includes the two lowest values of three experimentally determined ACRs (expressed on a total recoverable metal basis) of 64.11, 27.30, and >356.4 for rainbow trout, fathead minnow, and the acutely insensitive (at the time) cladoceran, *Daphnia magna*, respectively. New acute toxicity data for *D. magna* used in this evaluation indicates that this cladoceran is not as acutely insensitive as previously determined. Therefore, EPA determined that the use of an ACR for *D. magna* is appropriate to protect sensitive species in general. The three ACRs for rainbow trout, fathead minnow and *D. magna*, when expressed on dissolved metal basis and normalized to a water hardness of 100 mg/L as $CaCO_3$, equate to 10.03, 23.56 and 67.76, respectively. (Note that this latter ACR of 67.76 for *D. magna* excludes one of the three ACRs for *D. magna* determined at 206 mg/L as $CaCO_3$ which is a greater than value per

[11] See footnote 12 above.
[12] U.S. EPA. 1985. Ambient Water Quality Criteria Document for Chromium-1984. EPA-440/5-84-029.

the 1985 Guidelines). Since no additional acceptable ACRs are available, EPA calculated the predicted GMCVs for chromium III in Table 2.1.3-2 using an FACR of 25.20 and the following equation: Predicted GMCV = GMAV/FACR.

EPA compared the GMCVs for each species to Oregon's chromium III chronic criterion magnitude to determine whether the chronic criterion will protect these genera.

Table 2.1.3-2: Genus Mean Chronic Values (GMCVs) for Chromium III

Genus	**Species**	**Common name**	**GMAV (µg/L)**	**SMCV (µg/L)** (*experimentally derived*)	**Chronic References** *(used in the calculation of the SMCV)*	**Predicted GMCV (µg/L)**
Crangonyx	pseudogracilis	Amphipod	162227			6438
Hydropsyche	betteni	Caddisfly	39615			1572
Caddisfly (unidentified)		Caddisfly (unidentified)	27874			1106
Damselfly (unidentified)		Damselfly (unidentified)	24027			953.5
Fundulus	diaphanus	Banded killifish	8713			345.8
Lepomis	gibbosus	Pumpkinseed	-			-
Lepomis	macrochirus	Bluegill	8566			339.9
Morone	saxatilis	Striped bass	-			-
Morone	americana	White perch	8232			326.7
Anguilla	rostrata	American eel	7169			284.5
Chironomus	sp.	Midge	6132			243.3
Amnicola	sp.	Spire snail	5692			225.9
Cyprinus	carpio	Common carp	5285			209.7
Nais	sp.	Worm	5185			205.7
Pimephales	promelas	Fathead minnow	4951	493.6	3	196.5 (493.6)
Carassius	***auratus***	***Goldfish***	4841			192.1
Oncorhynchus	mykiss	Rainbow trout	4191	177.9	2	166.3 (177.9)
<u>Poecilia</u>	***<u>reticulata*</u>***	***Guppy***	3932			156.0
Daphnia	magna	Cladoceran	-	69.71	1	-
Daphnia	pulex	Cladoceran	2485			98.61 (69.71)
Gammarus	***sp.***	***Scud, Amphipod***	1784			70.79
<u>Ephmerella</u>	***<u>subvaria*</u>***	***Mayfly***	1238			49.13

See same notes as above under Table 2.1.3-1.

B. Evaluation of the Protectiveness of the Oregon Freshwater Chronic Criterion

Following the review of the GMCVs in Table 2.1.3-2, 17 of 19 genera (including 19 of 22 species) had values greater than Oregon's chronic criterion for chromium III. Therefore, EPA concluded that chronic effects are not expected to occur at ambient concentrations equal to or lower than the criterion for these genera and all except a small proportion of genera are protected.

The mayfly, *Ephmerella subvaria*, is not a resident species and is not considered further.

When compared to Oregon's chronic criterion for chromium III, estimated SMCV values for two test species (an insect, and an amphipod) were lower than the chronic criterion concentration of

74 µg/L dissolved chromium III. Experimental test data for *Daphnia magna* was also lower than the criterion. Of these species, only the planktonic crustaceans *Daphnia magna and pulex* and the amphipod *Gammarus sp*. are expected to reside in Oregon waters. Therefore, EPA reviewed the data from the studies that make up the most representative data for each of the these species.

The SMCV for *D. pulex* was estimated by applying the ACR of 25.20 described above to the SMAV obtained from Stackhouse and Benson (1989). Since additional information or confidence intervals were reported in the study, the SMCV for comparison with the CCC for chromium III is 53.70 µg/L. Because the Oregon chronic criterion for dissolved chromium III is greater than SMCV for *D. pulex*, EPA concludes that the Oregon CCC for chromium III is not protective of all individuals within this species.

The SMCV for *D. magna* was calculated as the geometric mean of the measured NOECs and LOECs for growth rate reported for three tests performed at different water hardness levels by Chapman et al. (1980) to obtain a hardness normalized dissolved SMCV of 69.71 µg/L. It is worth noting that the NOEC for the chronic test performed at a water hardness of 206 mg/L as $CaCO_3$ was the control treatment, as the lowest test concentration significantly affected daphnid growth over the exposure. Using the LOEC as the chronic value for this test, the resultant LOEC at this hardness level (206 mg/L as $CaCO_3$) is less than 20.94 µg/L. This surrogate chronic value was used along with the two other chronic values obtained from chronic tests conducted at water hardness levels of 52 and 100 mg/L as $CaCO_3$, respectively, to obtain a geometric mean across the three tests of 69.71 µg/L (see text box A – *D. magna*). The geometric mean of the LOECs of the three tests was 89.46 µg/L, which is above the criterion. Because the geometric mean of the LOEC values surrounding the SMCV for *D. magna* is greater than the Oregon chronic criterion for chromium III, EPA concludes that the Oregon CCC for chromium III is protective of this species.

The SMCV for *Gammarus* sp. was estimated by applying the ACR of 25.20 described above to the SMAV from table 3.1.3-1. Since no additional information or confidence intervals were reported in the study, the SMCV of 70.79 ug/L was directly compared with the CCC for chromium III. Because the Oregon CCC for dissolved chromium III is greater than SMCV for for *Gammarus* sp., EPA concludes that the Oregon CCC for chromium III is not protective of all individuals within this species. As noted above, 17 of 19 genera had GMCVs greater than the chronic criterion so that chronic effects are not expected to occur at concentrations equal to or lower than the criterion concentration for these genera, and all except a small proportion of genera are protected at ambient concentrations equal to or lower than the chronic criterion value for chromium III. Thus the Oregon criterion concentration for chromium III is expected to protect the aquatic life designated use.

Freshwater chromium III chronic criterion comparison

Text Box A – Basis for the meta analysis comparing the SMCV for the cladoceran (*D. magna*) to the chronic criterion for chromium III (74 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Daphnia magna							
	Reported Values:			**Normalized Dissolved Chronic Values:**			
Hardness	NOEC	LOEC	CV	NOEC	LOEC	CV	CCC
52	47	93	66.11	69.05	136.6	97.13	74
100	129	291	193.7	110.9	250.3	166.6	
206	0	44	44	0	20.94	20.94	
						SMCV	
Geomean		106.0	82.60		89.46	69.71	

2.1.3.3 References for Chromium III

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in Tables 2.1.3-1 and 2.1.3-2*)
Acute References	
1	Warnick, S. L. and H.L. Bell. 1969. The acute toxicity of some heavy metals to different species of aquatic insects. J. Water Pollut. Control Fed. 41(2): 280-284.
2	Stackhouse, R.A. and W.H. Benson. 1989. The effect of humic acid on the toxicity and bioavailability of trivalent chromium. Ecotoxicol. Environ. Saf. 17(1): 105-111.
3	Rehwoldt, R., L. Lasko, C. Shaw and E. Wirhowski. 1973. The acute toxicity of some heavy metal ions toward benthic organisms. Bull. Environ. Contam. Toxicol. 10(5): 291-294.
4	Pickering, Q. H. and C. Henderson. 1964. The acute toxicity of some heavy metals to different species of warmwater fishes. Proc. 19th Ind. Waste Conf., Purdue University, West Lafayette, IN: 578-591; Air Water Pollut. Int. J. 10: 453-463 (1966) (Author Communication Used).
5	Stevens, D. G. and G.A. Chapman. 1984. Toxicity of trivalent chromium to early life stages of steelhead trout. Environ. Toxicol. Chem. 3(1): 125-133.
6	Guilhermino, L., T.C. Diamantion, R. Ribeiro, F. Goncalves and A. Soares. 1997. Suitability of test media containing EDTA for the evaluation of acute metal toxicity to *Daphnia magna* Straus. Ecotoxicol. Environ. Saf. 38(3): 292-295.
7	Chapman, G.A., S. Ota and F. Recht. 1980. Effects of water hardness on the toxicity of metals to *Daphnia magna*. Manuscript. U.S. EPA, Corvallis, OR.
8	Pickering, Q. H. 1980. Chronic toxicity of trivalent chromium to the fathead minnow (*Pimephales promelas*) in hard water. Manuscript, U.S. EPA, Cincinnati, OH.
9	Rehwoldt, R., L.W. Menapace, B. Nerrie and D. Allessandrello. 1972. The effect of increased temperature upon the acute toxicity of some heavy metal ions. Bull. Environ. Contam. Toxicol. 8(2): 91-96.
10	Virk, S. and R.C. Sharma. 1995. Effect of nickel and chromium on various life stages of *Cyprinus carpio* Linn. Indian J. Ecol. 22(2):77-81.
11	Martin, T.R. and D.M. Holdich. 1986. The acute lethal toxicity of heavy metals to peracarid crustaceans (with particular reference to fresh-water asellids and gammarids). Wat. Res. 20(9): 1137-1147.
Chronic References	
1	Chapman, G. A., S. Ota and F. Recht. 1980. Effects of water hardness on the toxicity of metals to *Daphnia magna*. Manuscript. U.S. EPA, Corvallis, OR.
2	Stevens, D. G. and G.A. Chapman. 1984. Toxicity of trivalent chromium to early life stages of steelhead trout. Environ. Toxicol. Chem. 3(1):125-133.
3	Pickering, Q. H. 1980. Chronic toxicity of trivalent chromium to the fathead minnow (*Pimephales promelas*) in hard water. Manuscript, U.S. EPA, Cincinnati, OH.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For full details, see Appendix D.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[13], EPA is providing a transparent rationale as to why they were not utilized (see below).
2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable.

[13] U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

CHROMIUM VI

2.1.3.4 Evaluation of the Acute Freshwater Criterion Concentration for Chromium VI

A. Presentation of Toxicological Data

Oregon adopted a freshwater acute criterion with a magnitude of 16 µg/L that is expressed in terms of the dissolved concentration of the metal in the water column. This dissolved metal concentration is the same as the freshwater CMC recommended for use nationally by EPA for the protection of aquatic life[14]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.4-1 provides available SMAVs and GMAVs based on available acute toxicity data for chromium VI to aquatic life from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Tables 2.1.4-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Chromium VI

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Agnetina	capitata	Stonefly	1836340	1836340	28
Cyprinus	carpio	common carp	176899	176899	44,45
Orconectes	rusticus	Crayfish	172832	172832	28
Thymallus	arcticus	Arctic grayling	166071	166071	40
Enallagma	aspersum	Damselfly	137480	137480	28
Lepomis	macrochirus	Bluegill	131281	-	43
Lepomis	cyanellus	Green sunfish	112637	121602	33
Carassius	auratus	Goldfish	117371	117371	29
Clioperla	clio	Stonefly	101525	101525	41
Oncorhynchus	tshawytscha	Chinook salmon	124152	-	42
Oncorhynchus	kisutch	Coho salmon	101381	-	40
Oncorhynchus	mykiss	Rainbow trout	67758	94832	39
Gila	elegans	Bonytail	90130	90130	37
Ptychocheilus	lucius	Colorado squawfish	88478	88478	37
Luxilus	chrysocephalus	Striped shiner	84059	84059	28
Pomoxis	annularis	White crappie	71293	71293	28
Salvelinus	fontinalis	Brook trout	57938	57938	39
Tanytarsus	dissimilis	Midge	56269	56269	4
Notropis	stramineus	Sand shiner	73257	-	28
Notropis	buccatus	Silverjaw minnow	48707	-	28
Notropis	atherinoides	Emerald shiner	47529	55352	28
Notemigonus	crysoleucas	Golden shiner	54010	54010	38
Campostoma	anomalum	Central stoneroller	50328	50328	28
Xyrauchen	texanus	Razorback sucker	46477	46477	37
Pimephales	notatus	Bluntnose minnow	53249	-	28
Pimephales	promelas	Fathead minnow	40394	46378	8,29,30,31,32,33
Poecilia	reticulata	Guppy	45681	45681	34,35,36
Etheostoma	nigrum	Johnny darter	45172	45172	28

[14] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are from the 1995 Great Lakes Initiative Updates to these criteria as cited in: U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Perca	flavescens	Yellow perch	35647	35647	28
Gasterosteus	aculeatus	Threespine stickleback	35528	35528	26,27
Morone	saxatilis	Striped bass	34966	34966	24,25
Physa	heterostropha	Snail	22596	22596	22,23
Ictalurus	punctatus	Channel catfish	14534	14534	21
Dugesia	tigrina	Planarian	12679	12679	5
Chironomus	tentans	Midge	11588	11588	20
Helisoma	trivolvis	Ramshorn snail	10802	10802	5
Lumbriculus	variegatus	Oligochaete	10802	10802	5
Asellus	intermedius	Aquatic sowbug	5205	5205	5
Lymnaea	luteola	Pond snail	3810	3810	19
Tubifex	tubifex	Tubificid worm	2946	2946	13,14,15,16,17,18
Lophopodella	carteri	Bryozoan	1532	1532	12
Pectinatella	magnifica	Bryozoan	1414	1414	12
Plumatella	emarginata	Bryozoan	638.3	638.3	12
Hyalella	azteca		619.0	619.0	11
Crangonyx	pseudogracilis	Amphipod	572.5	572.5	10
Moina	macrocopa	Cladoceran	353.5	353.5	9
Gammarus	***fasciatus***	***Scud***	108.0	-	5
<u>***Gammarus***</u>	<u>***pseudolimnaeus****</u>	***Amphipod***	65.89	84.37	4
Ceriodaphnia	***dubia***	***Cladoceran***	141.4	-	8
Ceriodaphnia	***reticulata***	***Cladoceran***	44.29	79.14	1,2
Caenorhabditis	elegans	Nematode	58.92	58.92	3
<u>***Daphnia***</u>	<u>***obtusa****</u>	***Cladoceran***	116.3	-	6,7
Daphnia	***pulex***	***Cladoceran***	35.65	-	1
Daphnia	***magna***	***Cladoceran***	22.65	45.46	1,2
Simocephalus	***serrulatus***	***Cladoceran***	40.16	-	1
Simocephalus	***vetulus***	***Cladoceran***	31.72	35.69	1

<u>Note 1</u>: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV in the 1995 GLI update of the ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera used in the derivation of the 304(a) criteria are identified as such.
<u>Note 2</u>: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision.

B. Evaluation of the Protectiveness of the Oregon Freshwater Acute Criterion

Following review of GMAV values in Table 2.1.4-1, all tested genera are protected by Oregon's acute criterion magnitude for chromium VI. Therefore, EPA concluded that acute effects to these genera are not expected to occur at ambient concentrations equal to or lower than the criterion and thus these species would be protected.

When compared to Oregon's acute criterion for chromium VI, SMAV/2 values for the two most sensitive test species (both planktonic cladocerans) of the 56 species tested are near the acute criterion concentration of 16 µg/L dissolved chromium VI, therefore were low enough to warrant further consideration. These two cladoceran species, *Daphnia magna* and *Simocephalus vetulus*, are both expected to reside in Oregon waters. Therefore, EPA reviewed the data from the studies that comprise the most representative SMAV for *D. magna* and *S. vetulus* and compared the confidence intervals of the SMAV for these species to determine whether the values are quantitatively less than the criterion value of 16 µg/L.

The SMAV for *D. magna* was 22.65 µg/L with no 5 or 95 percent confidence intervals reported for either test (Mount 1982; Mount and Norberg 1984).

The SMAV for *S. vetulus* was 31.72 µg/L with no 5 or 95 percent confidence intervals reported (Mount 1982).

Due to the lack of additional supporting information or confidence intervals for these species, EPA opted to assume that the process by which the GMAV is compared to a level at which the test is indifferentiabe from controls (eg, GMAV/2) may also apply to the SMAV.

Because the Oregon acute criterion for chromium VI is greater than the estimate of SMAV/2 for *D. magna*, EPA concludes that the occurrence of ambient concentrations of chromium VI at or above the Oregon CMC for could result in acute toxicity to some individuals of this species. Because the Oregon acute criterion for chromium VI is equivalent to the estimate of SMAV/2 for *S. vetulus*, EPA concludes that the Oregon CMC for chromium VI is protective of this species. As noted above, the Oregon criterion is protective of all tested organisms at the genus level, and thus would be expected to be protective of the aquatic life designated use.

2.1.3.5 Evaluation of the Chronic Freshwater Criterion Concentration for Chromium VI

A. Presentation of Toxicological Data

Oregon adopted a freshwater chronic criterion concentration of 11 µg/L for chromium VI similarly expressed as the dissolved metal concentration in the water column. This concentration is the same as the freshwater CCC recommended for use nationally by EPA for the protection of aquatic life developed in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.4-2 presents a compilation of the GMAVs from Table 2.1.4-1, any experimentally determined SMCVs obtained from the criteria document and EPA ECOTOX download used for the BE, and estimated GMCVs based on the GMAV/ACR. The 1984 criteria document for chromium reported an FACR of 2.917, which is the geometric mean value of four experimentally determined ACRs of 1.130, 2.055, 5.920, and 5.267 for four cladocerans: *Ceriodaphnia reticulata, Simocephalus serrulatus, Daphnia pulex, and S. vetulus*, respectively. EPA determined that these four ACRs from the acutely sensitive cladocerans were the most appropriate ACRs to protect sensitive species in general. One other ACR of 6.957 for *D. magna* was excluded because it represented a greater than ">" value, and three other ACRs of 18.55, 223.0, and 260.8, respectively, from insensitive fish species were also excluded. Thus, since no additional acceptable ACRs are available, EPA calculated the predicted GMCVs for chromium in Table 2.1.4-2 using an FACR of 2.917 and the following equation: Predicted GMCV = GMAV/FACR.

EPA compared the GMCVs for each species to Oregon's chromium VI chronic criterion to determine whether the chronic criterion is protective of the aquatic life designated use.

Table 2.1.4-2: Genus Mean Chronic Values (GMCVs) for Chromium VI

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) (*experimentally derived*)	Chronic References (*used in the calculation of the SMCV*)	Predicted GMCV (µg/L)
Agnetina	capitata	Stonefly	1836340			629530
Cyprinus	carpio	common carp	176899			60644
Orconectes	rusticus	Crayfish	172832			59250
Thymallus	arcticus	Arctic grayling	166071			56932
Enallagma	aspersum	Damselfly	137480			47131
Lepomis	macrochirus	Bluegill	-			-
Lepomis	cyanellus	Green sunfish	121602			41687
Carassius	auratus	Goldfish	117371			40237
Clioperla	clio	Stonefly	101525			34805
Oncorhynchus	tshawytscha	Chinook salmon	-			-
Oncorhynchus	kisutch	Coho salmon	-			-
Oncorhynchus	mykiss	Rainbow trout	94832	133.9	3	32510 (133.9)
Gila	elegans	Bonytail	90130			30898
Ptychocheilus	lucius	Colorado squawfish	88478			30332
Luxilus	chrysocephalus	Striped shiner	84059			28817
Pomoxis	annularis	White crappie	71293			24441
Salvelinus	fontinalis	Brook trout	57938	254.5	3	19862 (254.5)
Tanytarsus	dissimilis	Midge	56269			19290
Notropis	stramineus	Sand shiner	-			-
Notropis	buccatus	Silverjaw minnow	-			-
Notropis	atherinoides	Emerald shiner	55352			18976
Notemigonus	crysoleucas	Golden shiner	54010			18516
Campostoma	anomalum	Central stoneroller	50328			17253
Xyrauchen	texanus	Razorback sucker	46477			15933
Pimephales	notatus	Bluntnose minnow	-			-
Pimephales	promelas	Fathead minnow	46378	1864	4,5,6	15899 (1864)
Poecilia	reticulata	Guppy	45681			15660
Etheostoma	nigrum	Johnny darter	45172			15486
Perca	flavescens	Yellow perch	35647			12220
Gasterosteus	aculeatus	Threespine stickleback	35528			12180
Morone	saxatilis	Striped bass	34966			11987
Physa	heterostropha	Snail	22596			7746
Ictalurus	punctatus	Channel catfish	14534			4982
Dugesia	tigrina	Planarian	12679			4347
Chironomus	tentans	Midge	11588			3972
Helisoma	trivolvis	Ramshorn snail	10802			3703
Lumbriculus	variegatus	Oligochaete	10802			3703
Asellus	intermedius	Aquatic sowbug	5205			1784
Lymnaea	luteola	Pond snail	3810			1306
Tubifex	tubifex	Tubificid worm	2946			1010
Lophopodella	carteri	Bryozoan	1532			525.2
Pectinatella	magnifica	Bryozoan	1414			484.8
Plumatella	emarginata	Bryozoan	638.3			218.8
Hyalella	azteca		619.0			212.2
Crangonyx	pseudogracilis	Amphipod	572.5			196.3
Moina	macrocopa	Cladoceran	353.5			121.2
Gammarus	***fasciatus***	***Scud***	-			-

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) *(experimentally derived)*	Chronic References *(used in the calculation of the SMCV)*	Predicted GMCV (µg/L)
Gammarus	***pseudolimnaeus****	***Amphipod***	84.37			28.92
Ceriodaphnia	***dubia***	***Cladoceran***	-			-
Ceriodaphnia	***reticulata***	***Cladoceran***	79.14	38.48	2	27.13 (38.48)
Caenorhabditis	elegans	Nematode	58.92			20.20
Daphnia	***obtusa****	***Cladoceran***	-			-
Daphnia	***pulex***	***Cladoceran***	-	5.899	2	-
Daphnia	***magna***	***Cladoceran***	45.46	<4.810	1,2	15.58 (5.327)
Simocephalus	***serrulatus***	***Cladoceran***	-	19.14	2	-
Simocephalus	***vetulus***	***Cladoceran***	35.69	5.899	2	12.24 (10.63)

See same notes as above under Table 2.1.4-1.

B. Evaluation of the Protectiveness of the Oregon Freshwater Chronic Criterion

Following the review of the GMCV values in Table 2.1.4-2, all genera should be protected at or below the criterion concentration because all GMCVs are greater than the criterion. The majority of species had experimentally determined SMCVs greater than Oregon's chronic criterion for chromium VI. Therefore, EPA concluded that chronic effects are not expected to occur at concentrations lower than the criterion for these species and thus these species would be protected.

When compared to Oregon's chronic criterion for chromium VI, SMCV values for three test species (all planktonic cladocerans – *D. magna, S. vetulus*, and *D. pulex*) were lower than the CCC of 11 µg/L dissolved chromium VI. All of these species are expected to reside in Oregon waters. Therefore, EPA reviewed the data from the studies that make up the SMCVs for this species and compared the confidence intervals of these SMCVs to determine whether the SMCV values were quantitatively different from the criterion value of 11 µg/L.

The SMCV for *D. magna* was calculated as the geometric mean of the measured LOECs for reproduction reported by Mount (1982) and Mount and Norberg (1984) to obtain the dissolved SMCV of 4.810 µg/L (text box A – *D. magna* chronic). For both tests, the NOEC was the control treatment; therefore, the respective LOECs for the tests were used as estimated chronic values to calculate the SMCV for the species. The geometric mean of the CVs for the two tests (4.810 µg/L) is lower than the CCC for chromium VI of 11 µg/L.

The SMCV for *S. vetulus* was calculated as the geometric mean of the measured NOEC and LOEC for reproduction reported by Mount (1982) to obtain a SMCV of 5.899 µg/L (text box B – *D. magna* chronic). The LOEC for this test of 7.700 µg/L is below the CCC for chromium VI of 11 µg/L.

The SMCV for *D. pulex* was calculated as the geometric mean of the measured NOEC and LOEC for reproduction reported by Mount (1982) to obtain a SMCV of 5.899 µg/L (text box C –

D. pulex chronic). The LOEC for this test of 7.700 µg/L is lower than the CCC for chromium VI of 11 µg/L.

Because the measured LOEC values for *D. magna, S. vetulus,* and *D. pulex* are lower than the Oregon chronic criterion for dissolved chromium VI, EPA concludes that the sustained occurrence (greater than four days exposure) of ambient concentrations at or above the Oregon CCC for chromium VI could result in chronic effects to these three planktonic crustacean species. As noted above, the Oregon criterion is protective of all tested organisms at the genus level, and thus would be expected to be protective of the aquatic life designated use

Freshwater chromium VI chronic criterion comparison

Text Box A (chronic) – Basis for the meta analysis comparing the SMCV for the cladoceran (*D. pulex*) to the chronic criterion for chromium VI (11 µg/L dissolved metal concentration).

Dapnia magna							
	Reported Chronic Values			**Dissolved Chronic Values**			
Hardness	NOEC	LOEC	CV	NOEC	LOEC	CV	CCC
45.0	0	2.500	2.500	0.000	2.410	2.410	11
45.0	0	10.00	10.00	0.000	9.620	9.620	
						SMCV	
Geomean	0	5.000	5.000	0.000	4.810	4.810	

Notes: Because NOEC=0, CV reported as the LOEC. Final SMCV reported was the geometric mean of the LOEC of the two studies.

Text Box B (chronic) – Basis for the meta analysis comparing the SMCV for the cladoceran (*S. vetulus*) to the chronic criterion for chromium VI (11 µg/L dissolved metal concentration).

Simocephalus vetulus							
	Reported Chronic Values			**Dissolved Chronic Values**			
Hardness	NOEC	LOEC	SMCV	NOEC	LOEC	SMCV	CCC
45.0	4.7	8	6.132	4.520	7.700	5.899	11

Text Box C (chronic) – Basis for the meta analysis comparing the SMCV for the cladoceran (*D. pulex*) to the chronic criterion for chromium VI (11 µg/L dissolved metal concentration).

Dapnia pulex							
	Reported Chronic Values			**Dissolved Chronic Values**			
Hardness	NOEC	LOEC	SMCV	NOEC	LOEC	SMCV	CCC
45.0	4.7	8	6.132	4.520	7.700	5.899	11

2.1.3.6 References for Chromium VI

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	Used Reference Citation (*associated with reference numbers and provided above inTables 2.1.4-1 and 2.1.4-2*)
Acute References	
1	Mount, D.I. 1982. Memorandum to Charles E. Stephan. U.S. EPA, Duluth, MN. June 7.
2	Mount, D.I. and T.J. Norberg. 1984. A seven-day life-cycle cladoceran toxicity test. Environ. Toxicol. Chem. 3: 425.
3	Williams, P.L. and D.B. Dusenbery. 1990. Aquatic toxicity testing using the nematode, *Caenorhabditis elegans*. Environ. Toxicol. Chem. 9(10): 1285-1290.
4	Call, D.J., L.T. Brooke, N. Ahmad and J.E. Richter. 1983. Toxicity and metabolism studies with EPA priority pollutants and related chemicals in freshwater organisms. PB83-263665. National Technical Information Service, Springfield, VA.
5	Ewell, W.S., J.W. Gorsuch, R.O. Kringle, K.A. Robillard and R.C. Spiegel. 1986. Simultaneous evaluation of the acute effects of chemicals on seven aquatic species. Environ. Toxicol. Chem. 5(9): 831-840.
6	Rossini, G.D.B. and A.E. Ronco. 1996. Acute toxicity bioassay using *Daphnia obtusa* as a test organism. Environ. Toxicol. Water Qual. 11(3): 255-258.
7	Coniglio, L. and R. Baudo. 1989. Life-tables of *Daphnia obtusa* (Kurz) surviving exposure to toxic concentrations of chromium. Hydrobiologia 188/189: 407-410.
8	Spehar, R.L. and J.T. Fiandt. 1986. Acute and chronic effects of water quality criteria-based metal mixtures on three aquatic species. Environ. Toxicol. Chem. 5(10): 917-931.
9	Wong, C.K. 1992. Effects of chromium, copper, nickel, and zinc on survival and feeding of the cladoceran *Moina macrocopa*. Bull. Environ. Contam. Toxicol. 49: 593-599.
10	Martin, T.R. and D.M. Holdich. 1986. The acute lethal toxicity of heavy metals to peracarid crustaceans (with particular reference to fresh-water asellids and gammarids). Water Res. 20(9): 1137-1147.
11	Call, D.J., L.T. Brooke, N. Ahmad and D.D. Vaishnav. 1981. Aquatic Pollutant Hazard Assessments and Development of a Hazard Prediction Technology by Quantitative Structure-activity Relationships. Second Quarterly Report to EPA. Center for Lake Superior Environmental Studies, University of Wisconsin-Superior, Superior, WI: 74 p.
12	Pardue. W.J. and T.S. Wood. 1980. Baseline toxicity data for freshwater bryozoa exposed to copper, cadmium, chromium, and zinc. J. Tenn. Acad. Sci. 55:27.
13	Khangarot, B.S. 1991. Toxicity of metals to a freshwater tubificid worm, *Tubifex tubifex* (Muller). Bull. Environ. Contam. Toxicol. 46: 906-912.
14	Fargasova, A. 1994. Toxicity of metals on *Daphnia magna* and *Tubifex tubifex*. Ecotoxicol. Environ. Saf. 27(2): 210-213.
15	Fargasova, A. 1994. Comparative toxicity of five metals on various biological subjects. Bull. Environ. Contam. Toxicol. 53(2): 317-324.
16	Fargasova, A. 1999. Ecotoxicology of metals related to freshwater benthos. Gen. Physio. Biophys. 18: 48-53.
17	Rathore, R.S. and B.S. Khangarot. 2002. Effects of temperature on the sensitivity of sludge worm *Tubifex tubifex* Muller to selected heavy metals. Ecotoxicol. Environ. Saf. 53(1):27-36.
18	Reynoldson, T.B., P. Rodriguez and M.M. Madrid. 1996. A comparison of reproduction, growth and acute toxicity in two populations of *Tubifex tubifex* (Muller, 1774) from the North American Great Lakes and Northern Spain. Hydrobiologia 334(1-3): 199-206.
19	Khangarot, B.S. and P.K. Ray. 1988. Sensitivity of freshwater pulmonate snails, *Lymnaea luteola* L., to heavy metals. Bull. Environ. Contam. Toxicol. 41(2): 208-213.
20	Khangarot, B.S. and P.K. Ray. 1989. Sensitivity of midge larvae of *Chironomus tentans* Fabricius (Diptera Chironomidae) to heavy metals. Bull. Environ. Contam. Toxicol. 42(3): 325-330.
21	Gendusa, T.C., T.L. Beitinger and J.H. Rodgers. 1993. Toxicity of hexavalent chromium from aqueous and sediment dources to *Pimephales promelas* and *Ictalurus punctatus*. Bull. Environ. Contam. Toxicol. 50(1): 144-151.
22	Academy of Natural Sciences. 1960. The Sensitivity of Aquatic Life to Certain Chemicals Commonly Found in Industrial Wastes. Philadelphia, PA.
23	Patrick, R., J. Cairns, Jr. and A. Scheier. 1968. The relative sensitivity of diatoms, snails, and fish to twenty common constituents of industrial wastes. Prog. Fish-Cult. 30: 137-140.

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above inTables 2.1.4-1 and 2.1.4-2*)
24	Palawski, D., J.B. Hunn and F.J. Dwyer. 1985. Sensitivity of young striped bass to organic and inorganic contaminants in fresh and saline waters. Trans. Am. Fish. Soc. 114: 748-753.
25	Hughes, J.S. 1973. Acute toxicity of thirty chemicals to striped bass (*Morone saxatilis*). Presented at the Western Association of State Game and Fish Commissioners, Salt Lake city, Utah. July.
26	Van den Dikkenberg, R.P., H.H. Canton, L.A.M. Mathijssen-Spiekman and C.J. Roghair. 1989. The Usefulness of *Gasterosteus aculeatus* - the Three-Spined Stickleback - as a Test Organism in Routine Toxicity Testing. Rep. No. 718625003, Natl. Inst. Public Health E
27	Jop, K.M., T.F. Parkerton, J.H. Rodgers Jr., K.L. Dickson and P.B. Dorn. 1987. Comparative toxicity and speciation of two hexavalent chromium salts in acute toxicity tests. Environ. Toxicol. Chem. 6(9): 697-703.
28	White, A.M. Manuscript. The Toxicity of Hexavalent Chromium (Cr^{+6}) to Twenty-one Species of Aquatic Animals Native to Ohio. John Carroll University, University Heights, OH.
29	Adelman, I.R. and L.L. Smith, Jr. 1976. Standard Test Fish Development. Part 1. Fathead Minnows (*Pimephales promelas*) and Goldfish (*Carassius auratus*) as Standard Fish in Bioassays and Their Reaction to Potential Reference Toxicants. EPA-600/3-76-061a, Duluth, MN.
30	Broderius, S.J. and L.L. Smith, Jr. 1979. Lethal and sublethal effects of binary mixtures of cyanide and hexavalent chromium, zinc, or ammonia to the fathead minnow (*Pimephales promelas*) and rainbow trout (*Salmo gairdneri*). Jour. Fish. Res. Board Can.
31	Pickering, Q.H. 1980. Chronic toxicity of hexavalent chromium to the fathead minnow (*Pimephales promelas*). Arch. Environ. Contam. Toxicol. 9: 405.
32	Ruesink, R.G. and L.L. Smith, Jr. 1975. The relationship of the 96-hour LC50 to the lethal threshold concentration of hexavalent chromium, phenol and sodium pentachlorophenate for fathead minnows (*Pimephales promelas* Rafinesque). Trans. Am. Fish. Soc. 3: 567.
33	Waheda, M.F. 1977. Effect of Size of Fathead Minnows (*Pimephales promelas*) and Green Sunfish (*Lepomis cyanellus*) on Hexavalent Chromium Toxicity. Thesis. Wright State University, Dayton, OH.
34	Khangarot, B.S. and P.K. Ray. 1990. Acute toxicity and toxic interaction of chromium and nickel to common guppy *Poecilia reticulata* (Peters). Bull. Environ. Contam. Toxicol. 44(6): 832-839.
35	Oliveira-Filho, E.C. and F.J.R. Paumgartten. 1997. Comparative study on the acute toxicities of alpha, beta, gamma, and delta isomers of hexachlorocyclohexane to freshwater fishes. Bull. Environ. Contam. Toxicol. 59(6): 984-988.
36	Pickering, Q.H. and C. Henderson. 1966. The acute toxicity of some heavy metals to different species of warmwater fishes. Air Water Pollut. Int. J. 10: 453.
37	Buhl, K.J. 1997. Relative sensitivity of three endangered fishes, Colorado squawfish, bonytail, and razorback sucker, to selected metal pollutants. Ecotoxico. Environ. Saf. 37: 186-92
38	Hartwell, S.I., J.H. Jin, D.S. Cherry and J. Cairns Jr. 1989. Toxicity versus avoidance response of golden shiner, *Notemigonus crysoleucas*, to five metals. J. Fish Biol. 35(3): 447-456.
39	Benoit, D.A. 1976. Toxic effects of hexavalent chromium on brook trout (*Salvelinus fontinalis*) and rainbow trout (*Salmo gairdneri*). Water Res. 10:497.
40	Buhl, K.J. and S.J. Hamilton. 1991. Relative sensitivity of early life stages of Arctic grayling, Coho salmon, and rainbow trout to nine inorganics. Ecotoxicol. Environ. Saf. 22: 184-197.
41	Poulton, B.C., T.L. Beitinger and K.W. Stewart. 1989. The effect of hexavalent chromium on the critical thermal maximum and body burden of *Clioperla clio* (Plecoptera: Perlodidae). Arch. Environ. Contam. Toxicol. 18(4): 594-600.
42	Hamilton, S.J. and K.J. Buhl. 1990. Safety assessment of selected inorganic elements to fry of Chinook salmon (*Oncorhynchus tshawytscha*). Ecotoxicol. Environ. Saf. 20(3): 307-324.
43	Cairns, J., Jr., K. W. Thompson and A. C. Hendricks. 1981. Effects of Fluctuating Sublethal Applications of Heavy Metal Solutions upon the Gill Ventilatory Response of Bluegills (*Lepomis macrochirus*). National Technical Information Service, Springfield, VA. PB81-150 997. 90 pp.
44	Al-Akel, A.S. 1996. Chromium toxicity and its impact on behavioural responses in freshwater carp, *Cyprinus carpio*, from Saudi Arabia. Pakistan J. Zool. 28: 361-363.
45	Thatheyus, A.J. 1992. Behavioral alterations induced by nickel and chromium in common carp *Cyprinus carpio var communis* (Linn). Environ. Ecol. 10(4): 911-913.
Chronic References	
1	Trabalka, J.R. and C.W. Gehrs. 1977. An observation on the toxicity of hexavalent chromium to Daphnia magna. Toxicol. Letters 1: 131.
2	Mount, D.I. 1982. Memorandum to Charles E. Stephan. U.S. EPA, Duluth, Minnesota. June 7.
3	Benoit, D.A. 1976. Toxic effects of hexavalent chromium on brook trout (*Salvelinus fontinalis*) and rainbow trout (*Salmo gairdneri*). Water Res. 10: 497.
4	Barron, M.G. and I.R. Adelman. 1984. Nucleic acid, protein content, and growth of larval fish sublethally exposed to various toxicants. Can. J. Fish. Aquat. Sci. 41(1): 141-150.
5	Spehar, R.L. and J.T. Fiandt. 1986. Acute and chronic effects of water quality criteria-based metal mixtures on three aquatic species. Environ. Toxicol. Chem. 5(10): 917-931.
6	Pickering, Q.H. 1980. Chronic toxicity of hexavalent chromium to the fathead minnow (*Pimephales promelas*). Arch. Environ. Contam. Toxicol. 9:405.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

1) For the studies that were not utilized, but the most representative GMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC, EPA is providing a transparent rationale as to why they were not utilized (see below).
2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix E).

2.1.4 COPPER

Please see the primary decision document regarding the disapproval of this criterion.

2.1.5 DIELDRIN

2.1.5.1 Evaluation of the Acute Freshwater Criterion Concentration for Dieldrin

A. Presentation of Toxicological Data

Oregon adopted a freshwater acute criterion with a magnitude of 0.24 µg/L for dieldrin. This concentration is the same as the freshwater CMC recommended for use nationally by EPA for the protection of aquatic life[15]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.6-1 provides available SMAVs based on available acute toxicity data for dieldrin to aquatic life from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.1.6-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Dieldrin

Genus	**Species**	**Common name**	**Most Representative SMAV (µg/L)**	**GMAV (µg/L)**	**Acute References** *(used in the calculation of the SMAV)*
Orconectes	nais	Crayfish	740.0	740.0	4
Chironomus	tentans	Midge	560.0	560.0	17
Gammarus	fasciatus	Scud	620.0	-	4
Gammarus	lacustris	Scud	460.0	534.0	16
Simocephalus	serrulatus	Cladoceran	214.0	214.0	14
Bufo	woodhousei	Fowler's toad	150.0	150.0	1
Daphnia	pulex	Cladoceran	228.0	-	14,15
Daphnia	magna	Cladoceran	81.40	136.2	12
Pseudacris	triseriata	Western chorus frog	100.0	100.0	13
Gambusia	affinis	Western mosquitofish	31.00	31.00	10
Lumbriculus	variegatus	Oligochaete, worm	21.80	21.80	12
Palaemonetes	kadiakensis	Grass shrimp, freshwater prawn	20.00	20.00	4
Pimephales	promelas	Fathead minnow	17.70	17.70	1,3,9
Ischnura	verticalis	Damselfly	12.00	12.00	1
Ameiurus	melas	Black bullhead	10.00	10.00	1
Oreochromis	mossambica	Mozambique tilapia	10.00	10.00	10
Lepomis	macrochirus	Bluegill	11.50	-	1,3,4,9,11
Lepomis	cyanellus	Green sunfish	8.082	-	9
Lepomis	gibbosus	Pumpkinseed	6.700	8.539	8
Poecilia	reticulata*	Guppy	5.500	5.500	5
Asellus	brevicaudus*	Isopod	5.000	5.000	4
Carassius	auratus	Goldfish	4.906	4.906	1,3
Ictalurus	punctatus	Channel catfish	4.500	4.500	1
Oncorhynchus	kisutch	Coho salmon	10.80	-	6
Oncorhynchus	***clarki***	***Cutthroat trout***	6.197	-	1,7
Oncorhynchus	***tshawytscha***	***Chinook salmon***	6.100	-	6
Oncorhynchus	***mykiss***	***Rainbow trout***	0.6200	3.989	2
Micropterus	salmoides	Largemouth bass	3.500	3.500	1
Claassenia	***sabulosa****	***Stonefly***	0.5800	0.5800	1

[15] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are from the 1995 Great Lakes Initiative Updates to these criteria as cited in: U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Pteronarcella	***badia***	***Stonefly***	0.5000	0.5000	1
Pteronarcys	***californicus***	***Stonefly***	0.5000	0.5000	1

__Note 1__: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV in the 1995 GLI update of the ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera used in the derivation of the 304(a) criteria are identified as such.
__Note 2__: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision.

B. Evaluation of the Protectiveness of the Oregon Freshwater Acute Criterion

Following review of GMAV values in Table 2.1.6-1, all genera and species had values significantly greater than Oregon's acute criterion concentration for dieldrin. Therefore, EPA concluded that acute effects to these species and genera are not expected to occur at concentrations equal to or lower than the acute criterion and thus the aquatic life designated use would be protected.

2.1.5.2 Evaluation of the Chronic Freshwater Criterion Concentration for Dieldrin

A. Presentation of Toxicological Data

Oregon adopted a freshwater chronic criterion with a concentration of 0.056 µg/L for dieldrin. This concentration is the same as the freshwater CCC recommended for use nationally by EPA for the protection of aquatic life. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.6-2 presents a compilation of the GMAVs from Table 2.1.6-1, any experimentally determined SMCVs obtained from the criteria document and EPA ECOTOX literature download used for the BE, and estimated GMCVs based on the GMAV/ACR. The 1980 criteria document for dieldrin[16] reported an FACR of 8.530, which EPA calculated as the geometric mean of three experimentally determined ACRs ranging from 6.2 for an acutely sensitive saltwater invertebrate, the mysid (*Americamysis bahia*) to 11.0 for an acutely sensitive fish, rainbow trout (*Onchorhynchus mykiss*). EPA determined the FACR of 8.530 with the ACRs from two freshwater species (*Poecilia reticulata*, rainbow trout) and one saltwater species (*Americamysis bahia*). Since no additional acceptable ACRs are available, EPA calculated the predicted GMCVs for dieldrin in Table 2.1.6-2 using the FACR of 8.530 and the following equation: Predicted GMCV = GMAV/FACR.

[16] U.S. EPA. 1980. Ambient Water Quality Criteria Document for Aldrin/Dieldrin. EPA-440/5-80-019.

EPA compared the GMCVs for the data set to Oregon's dieldrin chronic criterion to determine whether the value will protect the designated use.

Table 2.1.6-2: Genus Mean Chronic Values (GMCVs) for Dieldrin

Genus	**Species**	**Common name**	**GMAV (µg/L)**	**SMCV (µg/L)** (*experimentally derived*)	**Chronic References** *(used in the calculation of the SMCV)*	**Predicted GMCV (µg/L)**
Orconectes	nais	Crayfish	740.0			86.75
Chironomus	tentans	Midge	560.0			65.65
Gammarus	lacustris	Scud	534.0			62.61
Simocephalus	serrulatus	Cladoceran	214.0			25.09
Bufo	woodhousei	Fowler's toad	150.0			17.58
Daphnia	pulex	Cladoceran	-			-
Daphnia	magna	Cladoceran	136.2	57.00	1	15.97 (57.00)
Pseudacris	triseriata	Western chorus frog	100.0			11.72
Gammarus	fasciatus	Scud	-			-
Gambusia	affinis	Western mosquitofish	31.00			3.634
Lumbriculus	variegatus	Oligochaete, worm	21.80			2.556
Palaemonetes	kadiakensis	Grass shrimp, freshwater prawn	20.00			2.345
Pimephales	promelas	Fathead minnow	17.70			2.075
Ischnura	verticalis	Damselfly	12.00			1.407
Ameiurus	melas	Black bullhead	10.00			1.172
Oreochromis	mossambica	Mozambique tilapia	10.00			1.172
Lepomis	macrochirus	Bluegill	-			-
Lepomis	cyanellus	Green sunfish	-			-
Lepomis	gibbosus	Pumpkinseed	8.539			1.001
Poecilia	reticulata*	Guppy	5.500	0.4500	4	0.6448 (0.4500)
Asellus	brevicaudus*	Isopod	5.000			0.5862
Carassius	auratus	Goldfish	4.906			0.5751
Ictalurus	punctatus	Channel catfish	4.500			0.5275
Oncorhynchus	kisutch	Coho salmon	-			-
Oncorhynchus	***clarki***	***Cutthroat trout***	-			-
Oncorhynchus	***tshawytscha***	***Chinook salmon***	-			-
Oncorhynchus	***mykiss***	***Rainbow trout***	3.989	0.4000	2,3	0.4676 (0.4000)
Micropterus	salmoides	Largemouth bass	3.500			0.4103
Claassenia	***sabulosa****	***Stonefly***	0.5800			0.0680
Pteronarcella	***badia***	***Stonefly***	0.5000			0.0586
Pteronarcys	***californicus***	***Stonefly***	0.5000			0.0586

See notes as above under Table 2.1.6-1.

B. Evaluation of the Protectiveness of the Oregon Freshwater Chronic Criterion

Following the review of the GMCV values in Table 2.1.6-2, all genera and species had values greater than Oregon's chronic criterion for dieldrin. Therefore, EPA concluded that chronic effects are not expected to occur at concentrations equal to or lower than the criterion acute and thus the aquatic life designated use would be protected.

2.1.5.3 References for Dieldrin

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the sources from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in tables 2.1.6-1 and 2.1.6-2*)
Acute References	
1	Mayer, F.L. and M.R. Ellersieck. 1986. Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Fresh-water Animals. Resource Publ. No. 160, U.S. Dep. Interior, Fish Wildl. Serv., Washington, DC: 505 p. (USGS Data File)
2	Shubat, P.J. and L.R. Curtis. 1986. Ration and toxicant preexposure influence on dieldrin accumulation by rainbow trout (*Salmo gairdneri*). Environ. Toxicol. Chem. 5: 69-77.
3	Henderson, C., Q.H. Pickering and C.M. Tarzwell. 1959. Relative toxicity of ten chlorinated hydrocarbon insecticides to four species of fish. Trans. Am. Fish. Soc. 88(1): 23-32.
4	Sanders, H.O. 1972. Toxicity of Some Insecticides to Four Species of Malacostracan Crustaceans. Tech. Pap. No. 66, Bur. Sports Fish. Wildl., Fish Wildl.Serv., U.S.D.I., Washington, D.C.: 19 p. (Publ in Part As 6797).
5	Anderson, P.D. and L.J. Weber. 1975. Toxic response as a quantitative function of body size. Toxicol. Appl. Pharmacol. 33(3): 471-483.
6	Katz, M. 1961. Acute toxicity of some organic insecticides to three species of salmonids and to the threespine stickleback. Trans. Am. Fish. Soc. 90(3): 264-268.
7	Swedburg, D. 1969. Chronic toxicity of insecticides to cold-water fish. Prog. Sport Fish Res., Div. Fish. Res., Bureau Sport Fish Wildl. 88: 8-9.
8	Cairns, J., Jr. and A. Scheier. 1964. The effect upon the pumpkinseed sunfish *Lepomis gibbosus* (Linn.) of chronic exposure to lethal and sublethal concentrations of dieldrin. Not. Nat. (Phila.) 370: 1-10.
9	Tarzwell, C.M. and C. Henderson. 1957. Toxicity of dieldrin to fish. Trans. Am. Fish. Soc. 86: 245-257.
10	Nunogawa, J.H., N.C. Burbank, Jr., R.H.F. Young and L.S. Lau. 1970. Relative Toxicities of Selected Chemicals to Several Species of Tropical Fish. Water Resour. Res. Center, University of Hawaii, Honululu, HI: 38 p. (U.S. NTIS PB-196312).
11	Macek, K.J., C. Hutchinson and O.B. Cope. 1969. The effects of temperature on the susceptibility of bluegills and rainbow trout to selected pesticides. Bull. Environ. Contam. Toxicol. 4(3): 174-183 (Publ in Part As 6797).
12	Brooke, L.T. 1993. Conducting Toxicity Tests with Freshwater Organisms Exposed to Dieldrin, Fluoranthene and Phenanthrene. U.S. EPA Contract No. 68-C1-0034, Work Assignment No. 5, to R.L. Spehar, U.S. EPA, Duluth, MN: 18 p.
13	Sanders, H.O. 1970. Pesticide toxicities to tadpoles of the Western chorus frog *Pseudacris triseriata* and Fowler's toad *Bufo woodhousii fowleri*. Copeia 2: 246-251 (Author Communication Used) (Publ in Part As 6797).
14	Sanders, H.O. and O.B. Cope. 1966. Toxicities of several pesticides to two species of cladocerans. Trans. Am. Fish. Soc. 95: 165.
15	Daniels, R.E. and J.D. Allan. 1981. Life table evaluation of chronic exposure to a pesticide. Can. J. Fish. Aquat. Sci. 38: 485-494.
16	Sanders, H.O. 1969. Toxicity of pesticides to the crustacean, *Gamnarus lacustris*. Bur. Sport Fish. Wildl. Tech. Pap. No. 25.
17	Hansen, C.R.J. and J.A. Kawatski. 1976. Application of 24-hour postexposure observation to acute toxicity studies with invertebrates. J. Fish. Res. Board Can. 33(5): 1198-1201.
Chronic References	
1	Adema, D.M.M. 1978. *Daphnia magna* as a test animal in acute and chronic toxicity tests. Hydrobiol. 59: 125.
2	Brooke, L.T. 1993. Conducting Toxicity Tests with Freshwater Organisms Exposed to Dieldrin, Fluoranthene and Phenanthrene. U.S. EPA Contract No. 68-C1-0034, Work Assignment No. 5, to R.L. Spehar, U.S. EPA, Duluth, MN: 18 p.
3	Chadwick, G. and D.L. Shumway. 1969. Effects of dieldrin on the growth and development of steelhead trout. In: J.W. Gillett (Ed.), The Biological Impact of Pesticides in the Environment, Environmental Health Ser. No. 1, Oregon State Univ., Corvallis, OR: 90-96.
4	Roelofs, T.D. 1971. Effects of Dieldrin on the Intrinsic Rate of Increase of the Guppy, *Poecilia reticulata* Peters. Ph.D. Thesis, Oregon State Univ., Corvallis, OR: 88 p.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For a full description, see Appendix F.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[17], EPA is providing a transparent rationale as to why they were not utilized (see below).
2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix F).

[17] U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

2.1.7 ENDRIN

2.1.7.1 Evaluation of the Acute Freshwater Criterion Concentration for Endrin

A. Presentation of Toxicological Data

Oregon adopted a freshwater acute criterion concentration of 0.086 µg/L for endrin. This concentration is the same as the freshwater CMC recommended for use nationally by EPA for the protection of aquatic life[18]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.7-1 provides available SMAVs and GMAVs based on available acute toxicity data for endrin to aquatic animals from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.1.7-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Endrin

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Pseudacris	*triseriata*	Western chorus frog	180.0	180.0	1,17
Bufo	*woodhousei*	Fowler's toad	120.0	120.0	1
Hexagenia	*bilineata*	Mayfly	62.99	62.99	1,8
Daphnia	*pulex*	Cladoceran	60.44	-	1,14,16
Daphnia	*magna*	Cladoceran	49.78	54.85	1,2,14
Orconectes	*immunis*	Crayfish	89.00	-	2
Orconectes	*nais*	Crayfish	32.00	53.37	8
Lumbriculus	*variegatus*	Oligochaete, worm	42.60	42.60	15
Simocephalus	*serrulatus*	Cladoceran	34.21	34.21	1,3
Ceriodaphnia	*reticulata*	Cladoceran	24.00	24.00	14
Tipula	*sp.*	Cranefly	12.00	12.00	1
Oreochromis	*mossambica*	Mozambique tilapia	5.600	5.600	1
Atherix	*variegata*	Snipefly	4.600	4.600	1
Gammarus	*fasciatus*	Scud, Amphipod	3.100	-	8
Gammarus	*lacustris*	Scud, Amphipod	3.000	3.050	1,13
Rana	*catesbeiana*	Bullfrog	2.500	2.500	2
Clarias	*batrachus*	Walking catfish	2.470	2.470	12
Ishnura	*verticalis*	Damselfly	2.090	2.090	1,8
Cypridopsis	*vidua*	Ostracod, Seed shrimp	1.800	1.800	1
Tilapia	*zillii*	Tilapia	1.620	1.620	11
Poecilia	*reticulata*	Guppy	1.600	1.600	10
Asellus	*brevicaudus*	Aquatic sowbug	1.500	1.500	1,8
Palaemonetes	*kadiakensis*	Grass shrimp	1.265	1.265	1,8
Carassius	*auratus*	Goldfish	0.9500	0.9500	2
Baetis	*sp.*	Mayfly	0.9000	0.9000	1
Jordanella	*floridae*	Flagfish	0.8500	0.8500	9
Tanytarsus	*dissimilis*	Midge	0.8400	0.8400	2
Claassenia	*sabulosa*	Stonefly	0.7600	0.7600	3

[18] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are from: U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Gambusia	*affinis*	Western mosquitofish	0.6900	0.6900	2
Pteronarcella	*badia*	Stonefly	0.5400	0.5400	1
Pimephales	*promelas*	Fathead minnow	0.4899	0.4899	2,7
Ameiurus	*melas*	Black bullhead	0.4500	0.4500	4
Gasterosteus	*aculeatus*	Threespine stickleback	0.4400	0.4400	6
Oncorhynchus	*tshawytscha*	Chinook salmon	1.200	-	6
Oncorhynchus	*mykiss*	Rainbow trout	0.3000	-	2
Oncorhynchus	*kisutch*	Coho salmon	0.2130	0.4249	1,6
Ictalurus	*punctatus*	Channel catfish	0.4200	0.4200	2
Acroneuria	*pacifica*	Stonefly	0.3900	0.3900	5
Brachycentrus	*americanus*	Caddisfly	0.3400	0.3400	4
Cyprinus	*carpio*	Common carp	0.3200	0.3200	1
Micropterus	***salmoides***	***Largemouth bass***	0.3100	0.3100	1
Pteronarcys	***californica***	***Stonefly***	0.2500	0.2500	3
Lepomis	***macrochirus***	***Bluegill***	0.2090	0.2090	2
Perca	***flavescens***	***Yellow perch***	0.1500	0.1500	1

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV or FCV in the 1995 GLI update of the ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera used in the derivation of the 304(a) criteria are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision.

B. Evaluation of the Protectiveness of the Oregon Freshwater Acute Criterion

Following review of SMAV and GMAV values in Table 2.1.7-1, all species and genera have acute effects values greater than Oregon's acute criterion concentration for endrin. Therefore, EPA concluded that acute effects to these species are not expected to occur at concentrations equal to or lower than the criterion, and thus these genera and species and the aquatic life designated use would be protected by the criterion.

When EPA examined the SMAV/2 and GMAV/2 values to consider low level toxicity effects (levels nearly indistinguishable from controls), 43 of 44 species and 38 of 39 genera had SMAV/2 and GMAV/2 values, respectively, greater than the acute criterion value, indicating that all but a very small proportion of species would be expected to be fully protected at the ambient concentrations equal to or lower than the acute criterion, thus these genera and species and the aquatic life designated use would be fully protected by the criterion. For one species, the yellow perch (*Perca flavescens*) the SMAV/2 was 0.075 µg/L endrin, lower than the acute criterion of 0.086 µg/L endrin. Thus, the occurrence of ambient concentrations at or above the criterion may result in acute toxicity to some individuals of this species. This species is expected to reside in Oregon waters..

The SMAV for *Perca flavescens* was 0.1500 µg/L, with 5 and 95 percent confidence intervals of 0.1200 µg/L and 0.1800 µg/L, respectively (Mayer and Ellersieck 1986).

Freshwater endrin acute criterion comparison

Text Box A – Basis for the meta analysis comparing the SMAV/2 for the yellow perch (*P. flavescens*) to the acute criterion for endrin (0.086 µg/L).

Perca flavescens				
Reported Values			**Reported Values/2**	
LC50	5% CI	95% CI	LC50 / 2	CMC
0.1500 **(SMAV)**	0.1200	0.1800	0.0750 (**SMAV/2)**	0.0860

2.1.7.2 Evaluation of the Chronic Freshwater Criterion Concentration for Endrin

A. Presentation of Toxicological Data

Oregon adopted a freshwater chronic criterion concentration of 0.036 µg/L for endrin. This concentration is the same as the freshwater CCC recommended for use nationally by EPA for the protection of aquatic life[19]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.7-2 presents a compilation of the GMAVs from Table 2.1.7-1, any experimentally determined SMCVs obtained from the criteria document and EPA ECOTOX download used for the BE, and estimated GMCVs based on the GMAV/ACR. The 1996 criteria document for endrin reported an ACR of 4.833, which EPA calculated as the geometric mean of three experimentally determined ACRs of 1.9, 18, and 3.3. EPA determined the ACR of 3.3 with the freshwater flagfish (*Jordanella floridae*) (Hermanutz 1978), while EPA determined the other two ACRs with saltwater species. Since no additional acceptable ACRs are available, EPA calculated the predicted GMCVs for endrin in Table 2.1.7-2 using an ACR of 4.833 and the following equation: Predicted GMCV = GMAV/FACR.

EPA compared the GMCVs for each species to Oregon's endrin chronic criterion concentration to determine whether the chronic criterion will protect the species.

Table 2.1.7-2: Genus Mean Chronic Values (GMCVs) for Endrin

Genus	**Species**	**Common name**	**GMAV (µg/L)**	**SMCV (µg/L)** (*experimentally derived*)	**Chronic References** *(used in the calculation of the SMCV)*	**Predicted GMCV (µg/L)**
Pseudacris	*triseriata*	Western chorus frog	180.0			37.24
Bufo	*woodhousei*	Fowler's toad	120.0			24.83
Hexagenia	*bilineata*	Mayfly	62.99			13.03
Daphnia	*pulex*	Cladoceran	-			-
Daphnia	*magna*	Cladoceran	54.85			11.35
Orconectes	*immunis*	Crayfish	-			-

[19] U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) (*experimentally derived*)	Chronic References (*used in the calculation of the SMCV*)	Predicted GMCV (µg/L)
Orconectes	*nais*	Crayfish	53.37			11.04
Lumbriculus	*variegatus*	Oligochaete, worm	42.60			8.814
Simocephalus	*serrulatus*	Cladoceran	34.21			7.078
Ceriodaphnia	*reticulata*	Cladoceran	24.00			4.966
Tipula	*sp.*	Cranefly	12.00			2.483
Oreochromis	*mossambica*	Mozambique tilapia	5.600			1.159
Atherix	*variegata*	Snipefly	4.600			0.9518
Gammarus	*fasciatus*	Scud, Amphipod	-			-
Gammarus	*lacustris*	Scud, Amphipod	3.050			0.6310
Rana	*catesbeiana*	Bullfrog	2.500			0.5173
Clarias	*batrachus*	Walking catfish	2.470			0.5111
Ishnura	*verticalis*	Damselfly	2.090			0.4324
Cypridopsis	*vidua*	Ostracod, Seed shrimp	1.800			0.3724
Tilapia	*zillii*	Tilapia	1.620			0.3352
Poecilia	*reticulata*	Guppy	1.600			0.3311
Asellus	*brevicaudus*	Aquatic sowbug	1.500			0.3104
Palaemonetes	*kadiakensis*	Grass shrimp	1.265			0.2617
Carassius	*auratus*	Goldfish	0.9500			0.1966
Baetis	*sp.*	Mayfly	0.9000			0.1862
Jordanella	*floridae*	Flagfish	0.8500	0.2600	1	0.1759 (0.2600)
Tanytarsus	*dissimilis*	Midge	0.8400			0.1738
Claassenia	*sabulosa*	Stonefly	0.7600			0.1573
Gambusia	*affinis*	Western mosquitofish	0.6900			0.1428
Pteronarcella	*badia*	Stonefly	0.5400			0.1117
Pimephales	*promelas*	Fathead minnow	0.4899			0.1014
Ameiurus	*melas*	Black bullhead	0.4500			0.0931
Gasterosteus	*aculeatus*	Threespine stickleback	0.4400			0.0910
Oncorhynchus	*tshawytscha*	Chinook salmon	-			-
Oncorhynchus	*mykiss*	Rainbow trout	-			-
Oncorhynchus	*kisutch*	Coho salmon	0.4249			0.0879
Ictalurus	*punctatus*	Channel catfish	0.4200			0.0869
Acroneuria	*pacifica*	Stonefly	0.3900			0.0807
Brachycentrus	*americanus*	Caddisfly	0.3400			0.0703
Cyprinus	*carpio*	Common carp	0.3200			0.0662
Micropterus	***salmoides***	***Largemouth bass***	0.3100			0.0641
Pteronarcys	***californica***	***Stonefly***	0.2500			0.0517
Lepomis	***macrochirus***	***Bluegill***	0.2090			0.0433
Perca	***flavescens***	***Yellow perch***	0.1500			0.0310

See same notes as above under Table 2.1.7-1.

B. Evaluation of the Protectiveness of the Oregon Freshwater Chronic Criterion

Following the review of the GMCV values in Table 2.1.7-2, 38 of 39 genera have GMCVs greater than Oregon's chronic criterion for endrin. Therefore, EPA found that all but a very small proportion of species would be expected to be protected at the ambient concentrations equal to or lower than the chronic criterion, thus the aquatic life designated use would be protected by the criterion.

When compared to Oregon's CCC for endrin, using the SMCV value for one test species (the yellow perch *Perca flavescens*) was lower than the chronic criterion concentration of 0.036 µg/L endrin. This species is expected to reside in Oregon waters. Therefore, EPA reviewed the data from the studies that make up the most representative SMCVs for this species and compared the confidence intervals of these SMCVs to determine whether the SMCV values were quantitatively different from the criterion value of 0.036 µg/L.

The SMCV for *P. flavescens* was estimated by applying the ACR of 4.833 described above to the SMAV.

The Oregon chronic criterion for endrin of 0.036 µg/L lies within the calculated confidence bounds around the SMCV for *P. flavescens*, indicating that there is some uncertainity whether there would actually be chronic effects at the chronic criterion value for this species.

An alternative analysis would be to use the freshwater fish ACR of 3.3 and apply it to the freshwater yellow perch species under analysis, because an ACR for a freshwater species may be most useul for evaluating effects to other freshwater fish species. Using this approiach, the SMCV for perch would be calculated as 0.045 µg/L endrin, which is greater than the acute criterion.

Given these analyses, there is uncertainty whether there would be expected to be any chronic effects to even one of the tested species, yellow perch, at ambient concentrations equal to or less than the criterion.

Thus, given that at a minimum, 38 of 39 tested species have predicted chronic values greater than the criterion, EPA concludes that the aquatic life designated use would be protected by the chronic criterion.

Freshwater endrin chronic criterion comparison

Text Box B – Basis for the meta analysis comparing the SMCV for the yellow perch (*P. flavescens*) to the chronic criterion for endrin (0.036 µg/L).

Perca flavescens						
Reported Acute Values				**Chronic Values**		
LC50	5%CI	95%CI	ACR	(LC50 / ACR)		CCC
0.1500	0.1200	0.1800	4.833	0.0310		0.036
0.1500	0.1200	0.1800	3.3	0.045	**SMCV**	

2.1.7.3 References for Endrin

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in tables 2.1.7-1 and 2.1.7-2*)
Acute references	
1	Mayer, F.L.J. and M.R. Ellersieck. 1986. Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals. Resour. Publ. No. 160, U.S. Dep. Interior, Fish Wildl. Serv., Washington, DC: 505 p. (USGS Data File).
2	Thurston, R.V., T.A. Gilfoil, E.L. Meyn, R.K. Zajdel, T.L. Aoki and G.D. Veith. 1985. Comparative toxicity of ten organic chemicals to ten common aquatic species. Water Res. 19(9): 1145-1155.
3	Sanders, H.O. and O.B. Cope. 1968. The relative toxicities of several pesticides to naiads of three species of stoneflies. Limnol. Oceanogr. 13: 112-117.
4	Anderson, R.L. and D.L. De Foe. 1980. Toxicity and bioaccumulation of endrin and methoxychlor in aquatic invertebrates and fish. Environ. Pollut. Ser. A Ecol. Biol. 22(2):111-121 (Author Communication Used).
5	Jensen, L.D. and A.R. Gaufin. 1964. Effects of ten organic insecticides on two species of stonefly naiads. Trans. Am. Fish. Soc. 93(1): 27-34.
6	Katz, M. 1961. Acute toxicity of some organic insecticides to 3 species of salmonids and the threespine stickleback. Trans. Am. Fish. Soc. 90: 264.
7	Brungs, W.A. and G.W. Bailey. 1966. Influence of suspended solids on the acute toxicity of endrin to fathead minnows. Proc. Zlst Purdue Ind. Waste Conf., Part 1. 50: 4.
8	Sanders, H.O. 1972. Toxicity of Some Insecticides to Four Species of Malacostracan Crustaceans. U.S. Dep. Inter. Bur. Sport Fish. and Wildl. Tech. Paper 66.
9	Hermanutz, R. 1978. Endrin and malathion toxicity to flagfish (*Jordanella floridae*). Arch. Environ. Contam. Toxicol. 7: 159.
10	Henderson, C., Q.H. Pickering and C.M. Tarzwell. 1959. Relative toxicity of ten chlorinated hydrocarbon insecticides to four species of fish. Trans. Am. Fish. Soc. 88: 23-32.
11	El Sebae, A.H., M.A. El Amayem, I. Sharaf and M. Massod. 1986. Factors Affecting Acute and Chronic Toxicity of Chlorinated Pesticides and Their Biomagnification in Alexandria Region. In: Papers Presented at the FAO/UNEP Meeting on the Toxicity and Bioaccumulation of Selected Substances in Marine Organisms, Rovinj, Yugoslavia, 5-9 Nov., 1984, FAO Fish. Rep. No. 334 (Suppl.): 73-79.
12	Bhattacharya, S., S. Mukherjee and S. Bhattacharya. 1975. Toxic effects of endrin on hepatopancreas of the teleost fish, *Clarias batrachus* (Linn.). Indian J. Exp. Biol. 13(2):185-186.
13	Sanders, H.O. 1969. Toxicity of Pesticides to the Crustacean *Gammarus lacustris*. U.S. Dep. Inter. Bur. Sport Fish. Wildl. Tech. Paper 25.
14	Elnabarawy, M.T., A.N. Welter and R.R. Robideau. 1986. Relative sensitivity of three daphnid species to selected organic and inorganic chemicals. Environ. Toxicol. Chem. 5(4): 393-398.
15	Brooke, L. 1993. Acute and Chronic Toxicity of Several Pesticides to Five Species of Aquatic Organisms. Report to R. Spehar, U.S. EPA, Duluth, MN.: 31 pp.
16	Priester, L.E., Jr. 1965. The Accumulation and Metabolism of DDT, Parathion, and Endrin by Aquatic Food-Chain Organisms. Ph.D. Thesis, Clemson University, Clemson, SC: 74.
17	Sanders, H.O. 1970. Pesticide toxicities to tadpoles of the Western chorus frog *Pseudacris triseriata* and Fowler's toad *Bufo woodhousii fowleri*. Copeia 2:246-251 (Author Communication Used) (Publ in Part As 6797).
Chronic references	
1	Hermanutz, R. 1978. Endrin and malathion toxicity to flagfish (*Jordanella floridae*). Arch. Environ. Contam. Toxicol. 7: 159.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For full descriptions, see Appendix G.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the

FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[20], EPA is providing a transparent rationale as to why they were not utilized (see below).

2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix G).

[20] U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

2.1.8 LEAD

2.1.8.1 Evaluation of the Acute Freshwater Criterion Concentration for Lead

A. Presentation of Toxicological Data

Oregon adopted a freshwater acute criterion concentration of 65 µg/L for lead that is expressed as a function of total hardness in the water column and in terms of the dissolved concentration of the metal. This dissolved metal concentration reflects the criterion normalized to a total hardness of 100 mg/L as $CaCO_3$ and is the same as the freshwater acute criterion concentration recommended for use nationally by EPA for the protection of aquatic life[21]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.8-1 provides available SMAVs and GMAVs based on available acute toxicity data for lead to aquatic life from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.1.8-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Lead

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Procambarus	clarkii	Red swamp crayfish	2752779	2752779	26
Tanytarsus	dissimilis	Midge	450938	450938	5
Carassius	auratus	Goldfish	193259	193259	24
Poecilia	reticulata	Guppy	126431	126431	24
Amnicola	limosa	Snail	109029	109029	25
Lepomis	macrochirus	Bluegill	99994	99994	24
Chironomus	tentans	Midge	63440	63440	21
Gila	elegans	Bonytail	>56000	>56000	23
Xyrauchen	texanus	Razorback sucker	>56000	>56000	23
Ptychocheilus	lucius	Colorado squawfish	>56000	>56000	23
Crangonyx	pseudogracilis	Amphipod	52759	52759	22
Lethocerus	sp.	Water bug	48745	48745	21
Salvelinus	fontinalis	Brook trout	9214	9214	20
Oncorhynchus	***kisutch***	***Coho salmon***	25445	-	19
Oncorhynchus	***mykiss***	***Rainbow trout***	1455	6085	13,14,15,16
Pimephales	promelas	Fathead minnow	4737	4737	3
Thymallus	arcticus	Arctic grayling	2009	2009	19
Aplexa	***hypnorum***	***Snail***	1988	1988	18
Lumbriculus	variegatus	Oligochaete, worm	1665	1665	17
Micropterus	dolomieui	Smallmouth bass	1311	1311	12
Daphnia	***pulex***	***Cladoceran***	519.8	-	7
Daphnia	***magna***	***Cladoceran***	391.8	451.3	6,7,8,9,10,11
Ceriodaphnia	reticulata	Cladoceran	487.4	-	7
Ceriodaphnia	dubia	Cladoceran	205.6	316.6	1,2,3
Gammarus	***pseudolimnaeus****	***Scud***	272.6	272.6	4,5

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV in the 1984 ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for

[21] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are from: U.S. EPA. 1984. Ambient Water Quality Criteria for Lead. EPA-440/5-84-027.

this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera used in the derivation of the 304(a) criteria are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision, particularly for metals such as lead which are normalized to a water hardness of 100 mg/L as $CaCO_3$ and expressed on a dissolved metal basis for a comparison with the acute criterion concentration.

B. Evaluation of the Protectiveness of the Oregon Freshwater Acute Criterion

Following review of GMAV and SMAV/2 values in Table 2.1.8-1, all tested genera and species had values greater than Oregon's acute criterion concentration for lead. Therefore, EPA concluded that acute effects to these species are not expected to occur at concentrations equal to or lower than the criterion and thus these genera and species and the aquatic life designated use will be protected.

2.1.8.2 Evaluation of the Chronic Freshwater Criterion Concentration for Lead

A. Presentation of Toxicological Data

Oregon adopted a freshwater chronic criterion concentration of 2.5 µg/L for lead expressed as the dissolved metal concentration at a total hardness of 100 mg/L $CaCO_3$ in the water column. This concentration is the same as the freshwater chronic criterion concentration recommended for use nationally by EPA for the protection of aquatic life[22]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.8-2 presents a compilation of the GMAVs from Table 2.1.8-1, any experimentally determined SMCVs obtained from the criteria document and EPA ECOTOX download used for the BE, and estimated GMCVs based on the GMAV/ACR. The 1984 criteria document for lead[23] reported an FACR of 24.39, which EPA calculated as the geometric mean of experimentally determined ACRs for five freshwater species and one saltwater species ranging from 4.769 for an acutely sensitive freshwater invertebrate, the cladoceran *Ceriodaphnia dubia*, to 61.97 for an acutely sensitive fish, rainbow trout (*Onchorhynchus mykiss*). However, upon further review of the data, EPA concludes that the ACRs for the six species increase as the SMAV increases, and thus, as recommended by the Guidelines, calculated an FACR of 9.299 from the two most acutely sensitive freshwater species, *C. dubia* and *Daphnia magna*. Since no additional acceptable ACRs are available, EPA calculated the predicted GMCVs for lead in Table 2.1.8-2 using the FACR of 9.299 and the following equation: Predicted GMCV = GMAV/FACR.

EPA compared the GMCVs for each species to Oregon's lead chronic criterion to determine whether the chronic criterion will protect the species.

Table 2.1.8-2: Genus Mean Chronic Values (GMCVs) for Lead

[22] See footnote 23 above.
[23] U.S. EPA. 1984. Ambient Water Quality Criteria Document for Lead. EPA-440/5-84-027.

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) *(experimentally derived)*	Chronic References *(used in the calculation of the SMCV)*	Predicted GMCV (µg/L)
Procambarus	clarkii	Red swamp crayfish	2752779			296030
Tanytarsus	dissimilis	Midge	450938			48493
Carassius	auratus	Goldfish	193259			20783
Poecilia	reticulata	Guppy	126431			13596
Amnicola	limosa	Snail	109029			11725
Lepomis	macrochirus	Bluegill	99994			10753
Chironomus	tentans	Midge	63440			6822
Gila	elegans	Bonytail	>56000			>6022
Xyrauchen	texanus	Razorback sucker	>56000			>6022
Ptychocheilus	lucius	Colorado squawfish	>56000			>6022
Crangonyx	pseudogracilis	Amphipod	52759			5674
Lethocerus	sp.	Water bug	48745			5242
Salvelinus	fontinalis	Brook trout	9214	185.3	9	990.8 (185.3)
Oncorhynchus	***kisutch***	***Coho salmon***	-			-
Oncorhynchus	***mykiss***	***Rainbow trout***	6085	152.1	5,6,7,8	654.3 (152.1)
Pimephales	promelas	Fathead minnow	4737	742.2	4	509.4 (742.2)
Thymallus	arcticus	Arctic grayling	2009			216.0
Aplexa	***hypnorum***	***Snail***	1988			213.8
Lumbriculus	variegatus	Oligochaete, worm	1665			179.1
Micropterus	dolomieui	Smallmouth bass	1311	>186.4	10	140.9 (>186.4)
Daphnia	***pulex***	***Cladoceran***	-			-
Daphnia	***magna***	***Cladoceran***	451.3	49.66	2	48.53 (49.66)
Ceriodaphnia	reticulata	Cladoceran	-			-
Ceriodaphnia	dubia	Cladoceran	316.6	133.9	3,4	34.04 (133.9)
Gammarus	***pseudolimnaeus****	***Scud***	272.6			29.31
Lymnaea	palustris	Marsh snail	-	13.24	1	(13.24)

See same notes as above under Table 2.1.8-1.

B. Evaluation of the Protectiveness of the Oregon Freshwater Chronic Criterion

Following the review of the values in Table 2.1.8-2, all tested genera and species had GMCVs and SMCVs greater than Oregon's chronic criterion for lead. Therefore, EPA concluded that chronic effects are not expected to occur at concentrations equal to or lower than the criterion and thus these genera and species and the aquatic life designated use will be protected by the lead chronic criterion.

2.1.8.3 References for Lead

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in tables 2.1.8-1 and 2.1.8-2*)
Acute References	
1	Bitton, G., K. Rhodes and B. Koopman. 1996. CerioFAST: An acute toxicity test based on *Ceriodaphnia dubia* feeding behavior. Environ. Toxicol. Chem. 15(2): 123-125.
2	Diamond, J.M., D.E. Koplish, J. McMahon III and R. Rost. 1997. Evaluation of the water-effect ratio procedure for metals in riverine system. Environ. Toxicol. Chem. 16(3): 509-520.
3	Spehar, R.L. and J.T. Fiandt. 1986. Acute and chronic effects of water quality criteria-based metal mixtures on three aquatic species. Environ. Toxicol. Chem. 5(10): 917-31.
4	Spehar, R.L., R.L. Anderson and J.T. Fiandt. 1978. Toxicity and bioaccumulation of cadmium and lead in aquatic invertebrates. Environ. Pollut. 15: 195-208.
5	Call, D.J., L.T. Brooke, N. Ahmad and J.E. Richter. 1983. Toxicity and metabolism studies with EPA priority pollutants and related chemicals in freshwater organisms. PB83-263665. National Technical Information Service, Springfield, VA.
6	Chapman, G.A., S. Ota and F. Recht. 1980. Effects of water hardness on the toxicity of metals to *Daphnia magna*. U.S. EPA, Corvallis, OR.
7	Elnabarawy, M.T., A.N. Welter and R.R. Robideau. 1986. Relative sensitivity of three daphnid species to selected organic and inorganic chemicals. Environ. Toxicol. Chem. 5(4): 393-8.
8	LeBlanc, G. A. 1982. Laboratory investigation into the development of resistance of *Daphnia magna* (Straus) to environmental pollutants. Environ. Pollut. Ser. A 27(4): 309-322.
9	McWilliam, R. A. and D. J. Baird. 2002. Postexposure feeding depression: A new toxicity endpoint for use in laboratory studies with *Daphnia magna*. Environ. Toxicol. Chem. 21(6): 1198-1205.
10	Wilson, J. B. 1980. The effects of temperature on the acute toxicity of lead and cadmium to *Daphnia magna* and three naturally-occurring species of Great Lakes crustacean. In: J. F. Klaverkamp, S. L. Leonhard and K. E. Marshall (Eds.), Proc. 6th Annual Aquatic Toxicity Workshop, Nov. 6-7, 1979, Winnipeg, Manitoba, Can. Tech. Rep. Fish. Aquat. Sci. No. 975: 73-80.
11	Ziegenfuss, P. S., W. J. Renaudette and W. J. Adams. 1986. Methodology for assessing the acute toxicity of chemicals sorbed to sediments: Testing the equilibrium partitioning theory. In: T. M. Poston and R. Purdy (Eds.), Aquatic Toxicology and Environmental Fate, 9th Volume, ASTM STP 921, Philadelphia, PA. 479-493.
12	Coughlan, D.J., S.P. Gloss and J. Kubota. 1986. Acute and sub-chronic toxicity of lead to the early life stages of smallmouth bass (*Micropterus dolomieui*). Water Air Soil Pollut. 28(3-4): 265-75.
13	Davies, P.H., J.P. Goettl, Jr., J.R. Sinley and N.F. Smith. 1976. Acute and chronic toxicity of lead to rainbow trout (*Oncorhynchus mykiss*) in hard and soft water. Water Res. 10: 199-206.
14	Goettl, J.P., et al. 1972. Laboratory water pollution studies. Colorado Fisheries Research Review.
15	Davies, P.H. and W.E. Everhart. 1973. Effects of chemical variations in aquatic environments: Lead toxicity to rainbow trout and testing application factor concept. EPA-R3-73-011C. National Technical Information Service, Springfield, VA.
16	Rogers, J. T., J. G. Richards and C. M. Wood. 2003. Ionoregulatory disruption as the acute toxic mechanism for lead in the rainbow trout (*Oncorhynchus mykiss*). Aquat. Toxicol. 64(2): 215-234.
17	Phipps, G.L., V.R. Mattson, and G.T. Ankley. 1995. Relative sensitivity of three freshwater benthic macroinvertebrates to ten contaminants. Arch. Environ. Contam. Toxicol. 28(3): 281-286.
18	Call, D.J., L.T. Brooke, N. Ahmad and D.D. Vaishnav. 1981. Aquatic pollutant hazard assessments and development of a hazard prediction technology by quantitative structure-activity relationships. First Quarterly Report to EPA. Center for Lake Superior Environmental Studies University of Wisconsin-Superior, Superior, WI.
19	Buhl, K.J. and S.J. Hamilton. 1990. Comparative toxicity of inorganic contaminants released by placer mining to early life stages of salmonids. Ecotoxicol. Environ. Saf. 20(3): 325-342.
20	Holcombe, G.W., D.A. Benoit, E.N. Leonard and J.M. McKim. 1976. Long term effects of lead exposure on three generations of brook trout (*Salvelinus fontinalis*). J. Fish. Res. Board Can. 33: 1731-1741.
21	Oladimeji A.A. and B.O. Offem. 1989. Toxicity of lead to *Clarias lazera*, *Oreochromis niloticus*, *Chironomus tentans* and *Benacus species*. Water Air Soil Pollut. 44(3-4): 191-201.
22	Martin, T.R. and D.M. Holdich. 1986. The acute lethal toxicity of heavy metals to peracarid crustaceans (with particular reference to fresh-water asellids and gammarids). Water Res. 20(9): 1137-1147.
23	Buhl, K. J. 1997. Relative sensitivity of three endangered fishes, Colorado squawfish, bonytail, and razorback sucker to selected metal pollutants. Ecotoxicol. Environ. Saf. 37: 182-192.
24	Pickering, Q.H. and C. Henderson. 1966. The acute toxicity of some heavy metals to different species of warmwater fishes. Air Water Pollut. Int. J. 10: 453-463. (Author Communication Used).
25	Mackie, G.L. 1989. Tolerances of five benthic invertebrates to hydrogen ions and metals (cadmium, lead, aluminum). Arch. Environ. Contam. Toxicol. 18(1-2): 215-223.
26	Naqvi, S.M and R.D. Howell. 1993. Toxicity of cadmium and lead to juvenile red swamp crayfish, *Procambarus clarkii*, and effects on fecundity of adults. Bull. Environ. Contam. Toxicol. 51(2): 303-308.
Chronic References	

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in tables 2.1.8-1 and 2.1.8-2*)
1	Borgmann, U., O. Kramar and C. Loveridge. 1978. Rates of mortality, growth, and biomass production of *Lymnaea palustris* during chronic exposure to lead. J. Fish. Res. Board Can. 35: 1109-1115.
2	Chapman, G.A., S. Ota and F. Recht. 1980. Effects of water hardness on the toxicity of metals to *Daphnia magna*. U.S. EPA, Corvallis, OR.
3	Jop, K.M., A.M. Askew and R.B. Foster. 1995. Development of a water-effect ratio for copper, cadmium, and lead for the Great Works River in Maine using *Ceriodaphnia dubia* and *Salvelinus fontinalis*. Bull. Environ. Contam. Toxicol. 54(1): 29-35.
4	Spehar, R.L. and J.T. Fiandt. 1986. Acute and chronic effects of water quality criteria-based metal mixtures on three aquatic species. Environ. Toxicol. Chem. 5(10): 917-31.
5	Goettl, J.P., et al. 1972. Laboratory water pollution studies. Colorado Fisheries Research Review.
6	Sauter, S., K. S. Buxton, K.J. Macek and S.R. Petrocelli. 1976. Effects of exposure to heavy metals on selected freshwater fish. Toxicity of copper, cadmium, chromium and lead to eggs and fry of seven fish species. EPA-600/3-76-105. National Technical Information Service, Springfield, VA.
7	Davies, P.H., J.P. Goettl, Jr., J.R. Sinley and N.F. Smith. 1976. Acute and chronic toxicity of lead to rainbow trout (Oncorhynchus mykiss) in hard and soft water. Water Res. 10: 199-206.
8	Davies, P.H. and W.E. Everhart. 1973. Effects of chemical variations in aquatic environments: Lead toxicity to rainbow trout and testing application factor concept. EPA-R3-73-011C. National Technical Information Service, Springfield, VA.
9	Holcombe, G.W., D.A. Benoit, E.N. Leonard and J.M. McKim. 1976. Long term effects of lead exposure on three generations of brook trout (*Salvelinus fontinalis*). J. Fish. Res. Board Can. 33: 1731-1741.
10	Coughlan, D.J., S.P. Gloss and J. Kubota. 1986. Acute and sub-chronic toxicity of lead to the early life stages of smallmouth bass (*Micropterus dolomieui*). Water Air Soil Pollut. 28(3-4): 265-75.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For a full description, see Appendix H.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[24], EPA is providing a transparent rationale as to why they were not utilized (see below).
2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix H).

[24] U.S. EPA. 1984. Ambient Water Quality Criteria Documents for Lead. EPA-440/5-84-027.

2.1.9 LINDANE (GAMMA-BHC)

2.1.9.1 Evaluation of the Acute Freshwater Criterion Concentration for Lindane

A. Presentation of Toxicological Data

Oregon adopted a freshwater acute criterion concentration of 0.95 µg/L for lindane (gamma-BHC). This concentration is the same as the freshwater CMC recommended for use nationally by EPA for the protection of aquatic life[25]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.9-1 provides available GMAVs based on available acute toxicity data for lindane to aquatic life from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.1.9-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Lindane

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Bufo	woodhousei	Fowler's toad	3752	3752	1,32
Pseudacris	triseriata	Western chorus frog	2675	2675	1,32
Simocephalus	serrulatus	Cladoceran	676.5	676.5	27
Anguilla	anguilla	Common eel	512.9	512.9	28,29,30
Limnodrilus	hoffmeisteri	Tubificid worm, Oligochaete	430.0	430.0	22
Physa	fontinalis	Bladder snail	430.0	430.0	22
Polycelis	tenuis	Turbellarian	430.0	430.0	22
Hydropsyche	angustipennis	Caddisfly	330.0	330.0	22
Daphnia	magna	Cladoceran	630.2	-	13,16,31
Daphnia	pulex	Cladoceran	460.0	-	1,27
Daphnia	carinata	Cladoceran	100.0	307.2	18
Anabas	testudineus	Climbing perch	240.3	240.3	25,26
Hypophthalmichthys	nobilis	Carp	170.0	170.0	24
Poecilia	reticulata	Guppy	138.0	138.0	20
Cyprinus	carpio	Carp	134.2	134.2	5,23
Gambusia	affinis	Western mosquitofish	130.0	130.0	21
Leuctra	moselyi	Stonefly	130.0	130.0	22
Protonemura	meyeri	Stonefly	130.0	130.0	22
Carassius	auratus	Goldfish	117.0	117.0	1,5,20
Pimephales	promelas	Fathead minnow	111.0	111.0	19
Chironomus	thummi	Midge	235.0	-	22
Chironomus	tentans	Midge	207.0	-	13
Chironomus	plumosus	Midge	20.59	100.1	8
Lepomis	microlophus	Redear sunfish	83.00	-	5
Lepomis	cyanellus	Green sunfish	76.22	-	1
Lepomis	macrochirus	Bluegill	50.40	68.32	1,15,16
Ameiurus	melas	Black bullhead	64.00	64.00	1
Gammarus	pulex	Scud	225.0	-	22
Gammarus	lacustris	Scud	64.99	-	1,17

[25]See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are from: U.S. EPA. 1980. Ambient Water Quality Criteria for Hexachlorocyclohexane. EPA-440/5-80-054.

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Gammarus	fasciatus	Scud	10.49	53.53	7
Tilapia	zillii	Tilapia	50.27	50.27	14
Cloeon	sp.	Mayfly	50.00	50.00	3
Ictalurus	punctatus	Channel catfish	46.43	46.43	1,5
Perca	flavescens	Yellow perch	40.00	40.00	1
Salvelinus	fontinalis	Brook trout	44.30	-	13
Salvelinus	namaycush	Lake trout, siscowet	27.71	35.04	1
Oncorhynchus	tshawytscha	Chinook salmon	40.00	-	12
Oncorhynchus	kisutch	Coho salmon	37.29	-	1,5,12
Oncorhynchus	mykiss	Rainbow trout	25.69	33.71	10,11
Micropterus	salmoides	Largemouth bass	32.00	32.00	5
Hyalella	azteca	Scud	23.50	23.50	9
Lestes	congener	Damselfly	20.00	20.00	2
Peltodytes	sp.	Beetle	20.00	20.00	2
Asellus	***brevicaudus****	***Aquatic sowbug***	10.00	10.00	1
Salmo	trutta	Brown trout	8.519	8.519	1,5,6
Chaoborus	flavicans	Midge	4.000	-	4
Chaoborus	sp.	Phantom midge	3.300	3.633	3
Lymnaea	***stagnalis***	***Great pond snail***	3.300	3.300	3
Notonecta	***undulata***	***Backswimmer***	3.000	3.000	2
Pteronarcys	***californica***	***Stonefly***	2.121	2.121	1

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV in the 1980 ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera used in the derivation of the 304(a) criteria are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision.

B. Evaluation of the Protectiveness of the Oregon Freshwater Acute Criterion

Following review of GMAV values in Table 2.1.9-1, all tested genera and species had values greater than Oregon's acute criterion concentration for lindane. Further, all SMAV/2 values are greater than the criterion. Therefore, EPA concluded that acute effects to these species are not expected to occur at concentrations equal to or lower than the criterion and thus these species and the aquatic life designated use would be fully protected by the lindance acute criterion.

2.1.9.2 References for Lindane

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute table, and are the source from which EPA obtained SMAVs (acute table).

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in Table 2.1.9-1*)
Acute References	
1	Mayer, F.L.J. and M.R. Ellersieck. 1986. Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals. Resour. Publ. No. 160, U.S. Dep. Interior, Fish Wildl. Serv., Washington, DC: 505 p. (USGS Data File)
2	Federle, P.F. and W.J. Collins. 1976. Insecticide toxicity to three insects from Ohio ponds. Ohio J. Sci. 76(1): 19-

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in Table 2.1.9-1*)
	24.
3	Bluzat, R. and J. Seuge. 1979. Effects of three insecticides (lindane, fenthion, and carbaryl) on the acute toxicity to four aquatic invertebrate species and the chronic toxicity. Environ. Pollut. 18(1): 51-70 (FRE) (ENG ABS)
4	Maund, S.J., A. Peither, E.J. Taylor, I. Juttner, R. Beyerle-Pfnur, J.P. Lay and D. Pascoe. 1992. Toxicity of lindane to freshwater insect larvae in compartments of an experimental pond. Ecotoxicol. Environ. Saf. 23: 76-88 (OECDG Data File)
5	Macek, K.J. and W.A. McAllister. 1970. Insecticide susceptibility of some common fish family representatives. Trans. Am. Fish. Soc. 99(1): 20-27 (Publ in Part As 6797)
6	Office of Pesticide Programs. 2000. Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB)). Environmental Fate and Effects Division, U.S. EPA, Washington, D.C.
7	Sanders, H.O. 1972. Toxicity of some insecticides to four species of malacostracan crustaceans. U.S. Bur. Sport Fish. Wildl. Tech. Pap. 66: 3.
8	Hooftman, R.N., D.M.M. Adema and J. Kauffman-Van Bommel. 1989. Developing a Set of Test Methods for the Toxicological Analysis of the Pollution Degree of Waterbottoms. Rep. No. 16105, Netherlands Organization for Applied Scientific Research: 68 p.(DUT)
9	Blockwell, S.J., S.J. Maund and D. Pascoe. 1998. The Acute toxicity of lindane to *Hyalella azteca* and the development of a sublethal bioassay based on precopulatory guarding behavior. Arch. Environ. Contam. Toxicol. 35(3):432-440
10	Tooby, T.E. and F.J. Durbin. 1975. Lindane residue accumulation and elimination in rainbow trout (*Salmo gairdnerii* Richardson) and roach (*Rutilus rutilus* Linnaeus). Environ. Pollut. 8(2): 79-89
11	Tooby, T.E., P.A. Hursey and J.S. Alabaster. 1975. The acute toxicity of 102 pesticides and miscellaneous substances to fish. Chem. Ind. (Lond.) 21: 523-526
12	Katz, M. 1961. Acute toxicity of some organic insecticides to three species of salmonids and to the threespine stickleback. Trans. Am. Fish. Soc. 90(3): 264-268
13	Macek, K.J., K.S. Buxton, S.K. Derr, J.W. Dean and S. Sauter. 1976. Chronic Toxicity of Lindane to Selected Aquatic Invertebrates and Fishes. EPA-600/3-76-046, U.S. EPA, Duluth, MN: 50 p.
14	El Sebae, A.H., M.A. El Amayem, I. Sharaf and M. Massod. 1986. Factors affecting acute and chronic toxicity of chlorinated pesticides and their biomagnification in Alexandria Region. In: Papers Presented at the FAO/UNEP Meeting on the Toxicity and Bioaccumulation of Selected Substances in Marine Organisms, Rovinj, Yugoslavia, 5-9 Nov., 1984, FAO Fish. Rep. No. 334 (Suppl.): 73-79.
15	Macek, K.J., C. Hutchinson and O.B. Cope. 1969. The effects of temperature on the susceptibility of bluegills and rainbow trout to selected pesticides. Bull. Environ. Contam. Toxicol. 4(3): 174-183 (Publ in Part As 6797)
16	Randall, W.F., W.H. Dennis and M.C. Warner. 1979. Acute toxicity of dechlorinated DDT, chlordane and lindane to bluegill (*Lepomis macrochirus*) and *Daphnia magna*. Bull. Environ. Contam. Toxicol. 21(6): 849-854
17	Sanders, H.O. 1969. Toxicity of pesticides to the crustacean *Gammarus lacustris*. Tech. Pap. No. 25, Bur. Sports Fish. Wildl., Fish Wildl. Serv., U.S.D.I., Washington, D.C.: 18 p. (Author Communication Used) (Used with Reference 732) (Publ in Part As 6797)
18	Santharam, K.R., B. Thayumanavan and S. Krishnaswamy. 1976. Toxicity of some insecticides to *Daphnia carinata* King, an important link in the food chain in the freshwater ecosystems. Indian J. Ecol. 3(1): 70-73 (OECDG Data File)
19	Call, D.J., L.T. Brooke, N. Ahmad and D.D. Vaishnav. 1981. Aquatic Pollutant Hazard Assessments and Development of a Hazard Prediction Technology by Quantitative Structure-Activity Relationships. Second Quarterly Report, U.S. EPA Cooperative Agreement No. CR 809234-01-0, Center for Lake Superior Environmental Studies, University of Wisconsin, Superior, WI: 74 p. (Publ in Part As 12448)
20	Henderson, C., Q.H. Pickering and C.M. Tarzwell. 1959. Relative toxicity of ten chlorinated hydrocarbon insecticides to four species of fish. Trans. Am. Fish. Soc. 88(1): 23-32
21	Nunogawa, J.H., N.C. Burbank Jr., R.H.F. Young and L.S. Lau. 1970. Relative Toxicities of Selected Chemicals to Several Species of Tropical Fish. Water Resour. Res. Center, University of Hawaii, Honululu, HI: 38 p. (U.S. NTIS PB-196312)
22	Green, D.W.J., K.A. Williams and D. Pascoe. 1986. Studies on the acute toxicity of pollutants to freshwater macroinvertebrates. 4. Lindane (gamma-Hexachlorocyclohexane). Arch. Hydrobiol. 106(2): 263-273
23	Chin, Y.N. and K.I. Sudderuddin. 1979. Effect of methamidophos on the growth rate and esterase activity of the common carp *Cyprinus carpio* L. Environ. Pollut. 18(3): 213-220.
24	Zhang, F. and X. Li. 1987. Toxicity of HCH towards the eggs and larvas of pond frog and fish. C. A. Sel.-Environ. Pollut. 25: 107-213 327B / China Environ. Sci.(Zhongguo Huanjing Kexue) 7(2): 39-42 (CHI)
25	Bakthavathsalam, R. and Y.S. Reddy. 1982. Toxicity and behavioural responses of *Anabas testudineus* (Bloch) exposed to pesticides. Indian J. Environ.Health 24(1): 65-68.
26	Zayapragassarazan, A. and V. Anandan. 1996. Effect of gamma-HCH on the protein profiles of selected tissues of the air-breathing fish *Anabas testudineus* (Bloch). Environ. Ecol. 14(1): 55-59.
27	Sanders , H.O and O.B. Cope. 1966. Toxicities of several pesticides to tow species of clacoderns. Trans. Am. Soc. 95: 165.
28	Ferrando, M.D., E. Andreu-Moliner, M.M. Almar, C. Cebrian and A. Nunez. 1987. Acute toxicity of organochlorined pesticides to the European eel, *Anguilla anguilla*: The dependency on exposure time and temperature. Bull. Environ. Contam. Toxicol. 39(3): 365-369 (OECDG Data File)

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in Table 2.1.9-1*)
29	Ferrando, M.D., E. Sancho and E. Andreu-Moliner. 1991. Comparative acute toxicities of selected pesticides to *Anguilla anguilla*. J. Environ. Sci. Health B26(5/6): 491-498.
30	Ferrando, M.D., M.M. Almar and E. Andreu. 1988. Lethal toxicity of lindane on a teleost fish, *Anguilla anguilla* from Albufera Lake (Spain): Hardness and temperature effects. J. Environ. Sci. Health B23(1): 45-52
31	Hermens, J., H. Canton, N. Steyger and R. Wegman. 1984. Joint effects of a mixture of 14 chemicals on mortality and inhibition of reproduction of *Daphnia magna*. Aquat. Toxicol. 5(4): 315-322.
32	Sanders, H.O. 1970. Pesticide toxicities to tadpoles of the Western chorus frog *Pseudacris triseriata* and Fowler's toad *Bufo woodhousii fowleri*. Copeia 2: 246-251 (Author Communication Used) (Publ in Part As 6797)

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For full descriptions, see Appendix I.

1) For the studies that were not utilized, but the most representative SMAV/2 fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[26], EPA is providing a transparent rationale as to why they were not utilized (see below).
2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix I).

[26] U.S. EPA. 1980. Ambient Water Quality Criteria for Hexachlorocyclohexane. EPA-440/5-80-054.

2.1.10 NICKEL

2.1.10.1 Evaluation of the Acute Freshwater Criterion Concentration for Nickel

A. Presentation of Toxicological Data

Oregon adopted a freshwater acute criterion concentration of 470 µg/L for nickel that is expressed as a function of total hardness in the water column and in terms of the dissolved concentration of the metal. This dissolved metal concentration reflects the criterion normalized to a total hardness of 100 mg/L as $CaCO_3$ and is the same as the freshwater CMC recommended for use nationally by EPA for the protection of aquatic life[27]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.10-1 provides available SMAVs and GMAVs based on available acute toxicity data for nickel to aquatic animals from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.1.10-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Nickel

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Asellus	aquaticus	Aquatic sowbug	213476	213476	26
Chironomus	tentans	Midge	224108	-	30
Chironomus	riparis	Midge	131329	171557	27
Salmo	salar	Atlantic salmon	161455	161455	29
Gambusia	affinis	Mosquitofish	142295	142295	28
Crangonyx	pseudogracilis	Amphipod	118578	118578	26
Fundulus	diaphanus	Banded killifish	77582	77582	13,14
Acroneuria	lycorias	Stonefly	72582	72582	11
Carassius	auratus	Goldfish	44470	44470	21,25
Tubifex	tubifex	Tubificid worm	31214	31214	24
Oncorhynchus	kisutch	Coho salmon	34655	-	20
Oncorhynchus	mykiss	Rainbow trout	24003	28841	23
Nais	sp.	Oligochaete	25294	25294	22
Gammarus	sp.	Scud, Amphipod	23321	23321	22
Amnicola	sp.	Spire snail	22908	22908	22
Lepomis	macrochirus	Bluegill	38695	-	17
Lepomis	gibbosus	Pumpkinseed	13533	22884	17
Anguilla	rostrata	American eel	21850	21850	13,14
Poecilia	reticulata	Guppy	17331	17331	21
Thymallus	arcticus	Arctic grayling	16882	16882	20
Morone	americana	White perch	22944	-	13,14
Morone	saxatilis	Striped bass	10609	15602	12,13,14
Bufo	melanostictus	Common Indian toad	15016	15016	19
Philodina	acuticornis	Rotifer	14436	14436	18
Dugesia	tigrina	Turbellarian,	12904	12904	15,16

[27] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are from the 1995 Great Lakes Initiative Updates to these criteria as cited in: U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
		Flatworm			
Ephemerella	***subvaria****	***Mayfly***	8317	8317	11
Ambloplites	***rupestris****	***Rock bass***	7735	7735	5
Cyprinus	carpio	Common carp	2681	2681	10
Daphnia	***pulicaria***	***Cladoceran***	3663	-	5
Daphnia	***magna***	***Cladoceran***	1977	-	7,8,9
Daphnia	***pulex***	***Cladoceran***	743.8	1753	2
Pimephales	promelas	Fathead minnow	1230	1230	5,6
Moina	macrocopa[40]	Cladoceran	921.5	921.5	4
Physa	***gyrina***	***Snail***	746.3	746.3	3
Utterbackia	imbecillis*	Mussel	259.8	259.8	1

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV or FCV in the 1995 GLI update of the ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera used in the derivation of the 304(a) criteria are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision, particularly for metals such as nickel which are normalized to a water hardness of 100 mg/L as $CaCO_3$ and expressed on a dissolved metal basis for a comparison with the acute criterion concentration.

B. Evaluation of the Protectiveness of the Oregon Freshwater Acute Criterion

Following review of GMAV values in Table 2.1.10-1, 28 of 29 genera have values greater than Oregon's acute criterion concentration for nickel. The most sensitive genera is not expected to reside in the state, indicating all resident genera are protected by the criterion. Therefore, EPA concluded that acute effects to these genera are not expected to occur at concentrations equal to or lower than the criterion, and thus these genera and the aquatic life designated use would be protected by the criterion.

When compared to Oregon's acute criterion concentration for nickel, SMAV/2 values for four test species (the mussel *Utterbackia (=Anodonta) imbecillis*, the cladocerans *Daphnia pulex* and *Moina macrocopa*, and the gastropod *Physa gyrina*) were lower than the acute criterion concentration of 470.0 µg/L dissolved nickel. Three of these species (*D. pulex, P. gyrina*, and *M. macrocopa*) are expected to reside in Oregon waters. Therefore, EPA reviewed the data from the studies that make up the most representative SMAV for these three resident species and determined whether the SMAV/2 values are quantitatively different from the criterion value of 470.0 µg/L.

The overall hardness adjusted SMAV for *D. pulex* was 743.8 µg/L, with 5 and 95 percent confidence intervals of 688.8 and 803.3 µg/L. When divided by two, the SMAV/2 for *D. pulex* was 371.9 µg/L (text box A – *D. pulex* acute).

The overall hardness adjusted SMAV for *P. gyrina* was 746.3 µg/L. Five and 95 percent confidence intervals were not reported for the single test run used to determine the SMAV for this species. When divided by two, the SMAV/2 for *P. gyrina* was 373.1 µg/L

The overall hardness adjusted SMAV for *M. macrocopa* was 921.5 µg/L, with 5 and 95 percent confidence intervals of 575.5 and 1475 µg/L. When divided by two, the SMAV/2 for *M. macrocopa* was 460.7 µg/L (text box B – *M. macrocopa* acute). Given that uncertainty bounds at the low end of the acute toxicity spectra are generally expected to be broader than the bounds around the central value, this SMAV/2 value of 460.7 µg/L maybe be statistically indistinguishable from the criterion value of 470 µg/L. Thus it is likely that the acute criterion value would be sufficiently protective of this species.

Because the Oregon acute criterion for nickel is greater SMAV/2 for *D. pulex*, *P. gyrina*, and *M. macrocopa*, the occurrence of ambient concentrations equal to or greater than the Oregon CMC for nickel may result in acute toxicity to some individuals of these species. However, as noted above, 29 of 30 genera have values greater than Oregon's acute criterion concentration for nickel, indicating that all except a small proportion of genera are protected at ambient concentrations equal to or lower than the chronic criterion and thus the aquatic life designated use would be expected to be protected by the criterion.

Freshwater nickel acute criterion comparison

Text Box A (acute) – Basis for the meta analysis comparing the SMAV/2 for the cladoceran (*D. pulex*) to the acute criterion for nickel (470.0 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Daphnia pulex								
	Reported Values			**Hardness Normalized Values**			**Hardness Normalized Values/2**	
Hardness	LC50	5% CI	95% CI	LC50	5% CI	95% CI	LC50 / 2	CMC
130	912.3	844.9	985.3	743.8 **(SMAV)**	688.8	803.3	371.9 **(SMAV/2)**	470

Text Box B (acute) – Basis for the meta analysis comparing the SMAV/2 for the cladoceran (*M. macrocopa*) to the acute criterion for nickel (470.0 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Moina macrocopa								
	Reported Values			**Hardness Normalized Values**			**Hardness Normalized Values/2**	
Hardness	LC50	5% CI	95% CI	LC50	5% CI	95% CI	LC50 / 2	CMC
44	461.0	288.0	738.0	921.5 **(SMAV)**	575.7	1475	460.7 **(SMAV/2)**	470

2.1.10.2 Evaluation of the Chronic Freshwater Criterion Concentration for Nickel

A. Presentation of Toxicological Data

Oregon adopted a freshwater chronic criterion concentration of 52 µg/L for nickel expressed as the dissolved metal concentration at a total hardness of 100 mg/L $CaCO_3$ in the water column. This concentration is the same as the freshwater CCC recommended for use nationally by EPA for the protection of aquatic life[28]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.10-2 presents a compilation of the GMAVs from Table 2.1.10-1, any experimentally determined SMCVs obtained from the criteria document and EPA ECOTOX download used for the BE, and estimated GMCVs based on the GMAV/ACR. The 1995 update of the criteria document for nickel[29] reported an FACR of 17.99, which EPA calculated as the geometric mean of three experimentally determined ACRs ranging from 5.478 for a saltwater invertebrate, the mysid (*Americamysis bahia*) to 35.58 for a fish, *Pimephales promelas*. EPA determined the FACR of 17.99 with the ACRs from two freshwater species (*Daphnia magna*, *Pimephales promelas*) and one saltwater species (*Americamysis bahia*). Since no additional acceptable ACRs are available, EPA calculated the predicted SMCVs for nickel in Table 2.1.10-2 using an FACR of 17.99 and the following equation: Predicted GMCV = GMAV/FACR.

EPA compared the GMCVs for each species to Oregon's nickel chronic criterion to determine whether the chronic criterion will protect the species.

Table 2.1.10-2: Genus Mean Chronic Values (GMCVs) for Nickel

Genus	**Species**	**Common name**	**GMAV (µg/L)**	**SMCV (µg/L)** (*experimentally derived*)	**Chronic References** *(used in the calculation of the SMCV)*	**Predicted GMCV (µg/L)**
Asellus	aquaticus	Aquatic sowbug	213476			11866
Chironomus	tentans	Midge	-			-
Chironomus	riparis	Midge	171557			9536
Salmo	salar	Atlantic salmon	161455			8975
Gambusia	affinis	Mosquitofish	142295			7910
Crangonyx	pseudogracilis	Amphipod	118578			6591
Fundulus	diaphanus	Banded killifish	77582			4312
Acroneuria	lycorias	Stonefly	72582			4035
Carassius	auratus	Goldfish	44470			2472
Tubifex	tubifex	Tubificid worm	31214			1735
Oncorhynchus	kisutch	Coho salmon	-			-
Oncorhynchus	mykiss	Rainbow trout	28841	263.1	3	1603 (263.1)
Nais	sp.	Oligochaete	25294			1406
Gammarus	sp.	Scud, Amphipod	23321			1296
Amnicola	sp.	Spire snail	22908			1273
Lepomis	macrochirus	Bluegill	-			-
Lepomis	gibbosus	Pumpkinseed	22884			1272
Anguilla	rostrata	American eel	21850			1215
Poecilia	reticulata	Guppy	17331			963.4
Thymallus	arcticus	Arctic grayling	16882			938.4
Morone	americana	White perch	-			-
Morone	saxatilis	Striped bass	15602			867.3
Bufo	melanostictus	Common Indian	15016			834.7

[28] See footnote 29 above.

[29] U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

		toad				
Philodina	acuticornis	Rotifer	14436			802.5
Dugesia	tigrina	Turbellarian, Flatworm	12904			717.3
<u>Ephemerella</u>	***<u>subvaria*</u>***	***Mayfly***	8317			462.3
<u>Ambloplites</u>	***<u>rupestris*</u>***	***Rock bass***	7735			430.0
Clistoronia	magnifica	Caddisfly	-	215.6	2	(215.6)
Cyprinus	carpio	Common carp	2681			149.0
Daphnia	***pulicaria***	***Cladoceran***	-			-
Daphnia	***magna***	***Cladoceran***	-	84.05	1	-
Daphnia	***pulex***	***Cladoceran***	1753			97.44 (84.05)
Pimephales	promelas	Fathead minnow	1230	345.5	4, 5	68.37 (345.5)
Moina	macrocopa	Cladoceran	921.5			51.22
Physa	***gyrina***	***Snail***	746.3			41.48
<u>Utterbackia</u>	<u>imbecillis*</u>	Mussel	259.8			14.44

See same notes as above under Table 2.1.10-1.

B. Evaluation of the Protectiveness of the Oregon Freshwater Chronic Criterion

Following the review of the measured SMCV values in Table 2.1.10-2, all tested species were shown to have chronic values greater than Oregon's chronic criterion of 52 µg/L for nickel. Therefore, EPA concluded that all species with measured chronic data would be protected by the chronic criterion. In extrapolating chronic values from acute data using the ACR, 27 of the 30 genera tested had predicted GMCVs greater than Oregon's chronic criterion for nickel. Therefore, EPA concluded that chronic effects are not expected to occur at concentrations equal to or lower than the criterion for these 27 genera, and all except a small proportion of genera are protected at ambient concentrations equal to or lower than the chronic criterion, and thus the designated use would be protected at ambient concentrations equal to or lower than the chronic criterion.

When compared to Oregon's chronic criterion concentration for nickel, SMCV values for four test species (the mussel *Utterbackia (=Anodonta) imbecillis*, the cladocerans *Daphnia pulex* and *Moina macrocopa*, and the gastropod *Physa gyrina*) were lower than the chronic criterion concentration of 52.0 µg/L dissolved nickel. Three of these species (*D. pulex, P. gyrina*, and *M. macrocopa*) are expected to reside in Oregon waters. Therefore, EPA reviewed the data from the studies that make up the most representative SMAV for these three resident species and after applying the ACR for nickel to these values, examined the SMCV values to determine whether the SMCV values are quantitatively different from the criterion value of 52.0 µg/L.

The SMCV for *D. pulex* was estimated by applying the ACR of 17.99 described above to the hardness normalized SMAV of 743.9. The final SMCV was 41.35 µg/L (text box C – *D. pulex* chronic).

The SMCV for *P. gyrina* was estimated by applying the ACR of 17.99 described above to the SMAV. The final SMCV was 41.48 µg/L. Five and ninety five percent confidence intervals were not reported for the single test used to calculate the SMAV for this test species.

The SMCV for *M. macrocopa* was estimated by applying the ACR of 17.99 described above to the SMAV. The final SMCV was 51.22 µg/L (text box D – *M. macrocopa* chronic).

Because the Oregon acute criterion for nickel is greater than the SMCV for *D. pulex*, *P. gyrina, and M. macrocopa*, EPA concludes that the occurrence of ambient concentration at or above the Oregon CCC for nickel for more than 4 days every 3 years, may result in chronic effects in individuals within these species.

EPA concluded that chronic effects not expected to occur for any species with actual chronic test data , nor are chronic effects predicted to occur in 27 of 30 genera for which predicted chronic values were generated, at concentrations equal to or lower than the criterion.

Freshwater nickel chronic criterion comparison

Text Box C (chronic) – Basis for the meta analysis comparing the SMCV for the cladoceran (*D. pulex*) to the chronic criterion for nickel (52.0 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Daphnia pulex									
	Reported Values			**Hardness Normalized Values**				**Hardness Normalized SMCV**	
Hardness	LC50	5% CI	95% CI	LC50	5% CI	95% CI	ACR	(LC50 / ACR)	CCC
130	912.3	844.9	985.3	743.8	688.8	803.3	17.99	41.35 **(SMCV)**	52

Text Box D (chronic) – Basis for the meta analysis comparing the SMCV for the cladoceran (*M. macrocopa*) to the chronic criterion for nickel (52.0 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Moina macrocopa									
	Reported Values			**Hardness Normalized Values**				**Hardness Normalized SMCV**	
Hardness	LC50	5% CI	95% CI	LC50	5% CI	95% CI	ACR	(LC50 / ACR)	CCC
44	461.0	288.0	738.0	921.5	575.7	1475	17.99	51.22 **(SMCV)**	52

2.1.10.3 References for Nickel

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in Tables 2.1.10-1 and 2.1.10-2*)
Acute References	

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in Tables 2.1.10-1 and 2.1.10-2*)
1	Keller, A.E. and S.G. Zam. 1991. The acute toxicity of selected metals to the freshwater mussel, *Anodonta imbecilis*. Environ. Toxicol. Chem. 10(4): 539-546.
2	Jindal, R. and A. Verma. 1990. Heavy metal toxicity to *Daphnia pulex*. Indian J. Environ. Health 32(3): 289-292.
3	Nebeker, A.V., A. Stinchfield, C. Savonen and G.A. Chapman. 1986. Effects of copper, nickel and zinc on three species of Oregon freshwater snails. Environ. Toxicol. Chem. 5(9): 807-811.
4	Pokethitiyook, P., E.S. Upatham and O. Leelhaphunt. 1987. Acute toxicity of various metals to *Moina macrocopa*. Nat. Hist. Bull. Siam. Soc. 35(1/2): 47-56.
5	Lind, D., K. Alto and S. Chatterton. 1978. Regional Copper-Nickel Study. Draft Report, Minnesota Environmental Quality Board, St. Paul, MN: 54 p.
6	Pickering, Q.H. 1974. Chronic toxicity of nickel to the fathead minnow. J. Water Pollut. Control Fed. 46: 760-765.
7	Biesinger, K.E. and G.M. Christensen. 1972. Effects of various metals on survival, growth, reproduction and metabolism of *Daphnia magna*. J. Fish Res. Board Can. 29: 1691-1700.
8	Call, D.J., L.T. Brooke, N. Ahmad and J.E. Richter. 1983. Toxicity and Metabolism Studies with EPA Priority Pollutants and Related Chemicals in Freshwater Organisms. EPA 600/3-83-095, U.S. EPA, Duluth, MN: 120 p. (U.S. NTIS PB83-263665).
9	Chapman, G.A., S. Ota and F. Recht. 1980. Effects of Water Hardness on the Toxicity of Metals to *Daphnia magna*. Manuscript. U.S. EPA, Corvallis, OR: 17 p.(Author Communication Used).
10	Virk, S. and R.C. Sharma. 1995. Effect of nickel and chromium on various life stages of *Cyprinus carpio* Linn. Indian J. Ecol. 22(2): 77-81.
11	Warnick, S.L. and H.L. Bell. 1969. The acute toxicity of some heavy metals to different species of aquatic insects. J. Water Pollut. Control Fed. 41(2): 280-284.
12	Palawski, D., J.B. Hunn and F.J. Dwyer. 1985. Sensitivity of young striped bass to organic and inorganic contaminants in fresh and saline waters. Trans. Am. Fish. Soc. 114: 748-753.
13	Rehwoldt, R., G. Bida and B. Nerrie. 1971. Acute toxicity of copper, nickel, and zinc ions to some Hudson River fish species. Bull. Environ. Contam. Toxicol. 6(5): 445-448.
14	Rehwoldt, R., L.W. Menapace, B. Nerrie and D. Allessandrello. 1972. The effect of increased temperature upon the acute toxicity of some heavy metal ions. Bull. Environ. Contam. Toxicol. 8(2): 91-96.
15	See, C.L. 1976. The Effect of Sublethal Concentrations of Selected Toxicants on the Negative Phototactic Response of *Dugesia tigrina*. Ph.D. Thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA: 79 p.
16	See, C.L., A.L. Buikema, Jr. and J. Cairns, Jr. 1974. The effects of selected toxicants on survival of *Dugesia tigrina* (Turbellaria). ASB (Assoc. Southeast. Biol.) Bull. 21(2): 82.
17	Cairns, J., Jr., K.W. Thompson and A.C. Hendricks. 1981. Effects of Fluctuating, Sublethal Applications of Heavy Metal Solutions upon the Gill Ventilation Response of Bluegills (*Lepomis macrochirus*). EPA-600/3-81-003, U.S. EPA, Cincinnati, OH: 104 p. (U.S. NTIS PB81-150997).
18	Buikema, A.L., Jr., J. Cairns, Jr. and G.W. Sullivan. 1974. Evaluation of *Philodina acuticornis* (Rotifera) as bioassay organisms for heavy metals. Water Resour. Bull. Am. Water Res. Assoc. 10(4): 648-661.
19	Khangarot, B.S. and P.K. Ray. 1987. Sensitivity of toad tadpoles, *Bufo melanostictus* (Schneider), to heavy metals. Bull. Environ. Contam. Toxicol. 38(3): 523-527.
20	Buhl, K.J. and S.J. Hamilton. 1991. Relative sensitivity of early life stages of Arctic grayling, Coho salmon, and rainbow trout to nine inorganics. Ecotoxicol. Environ. Saf. 22: 184-197.
21	Pickering, Q.H. and C. Henderson. 1966. The acute toxicity of some heavy metals to different species of warmwater fishes. Air Water pollut. Int. J. 10: 453-463.
22	Rehwoldt, R., L. Lasko, C. Shaw and E. Wirhowski. 1973. The acute toxicity of some heavy metal ions toward benthic organisms. Bull. Environ. Contam. Toxicol. 10(5): 291-294.
23	Nebeker, A.V., C. Savonen and D.G. Stevens. 1985. Sensitivity of rainbow trout early life stages to nickel chloride. Environ. Toxicol. Chem. 4(2): 233-239.
24	Khangarot, B.S. 1991. Toxicity of metals to a freshwater tubificid worm, *Tubifex tubifex* (Muller). Bull. Environ. Contam. Toxicol. 46: 906-912.
25	Ding, S.R. 1980. Acute toxicities of vanadium, nickel and cobalt to several species of aquatic organisms. Environ. Qual. 1: 17-21 (CHI) (ENG ABS).
26	Martin, T.R. and D.M. Holdich. 1986. The acute lethal toxicity of heavy metals to peracarid crustaceans (with particular reference to fresh-water asellids and gammarids). Water Res. 20(9): 1137-1147.
27	Powlesland, C. and J. George. 1986. Acute and chronic toxicity of nickel to larvae of *Chironomus riparis* (Meigan). Environ. Poll., (Series A). 42: 47-64.
28	Kallanagoudar, Y.P. and H.S. Patil. 1997. Influence of water hardness on copper, zinc and nickel toxicity to *Gambusia affinis* (B&G). J. Environ. Biol. 18(4): 409-413.
29	Grande, M. and S. Andersen. 1983. Lethal effects of hexavalent chromium, lead and nickel on young stages of Atlantic salmon (*Salmo salar* L.) in soft water. Vatten 39(4): 405-416.
30	Khangarot, B.S. and P.K. Ray. 1989. Sensitivity of midge larvae of *Chironomus tentans* Fabricius (Diptera Chironomidae) to heavy metals. Bull. Environ. Contam. Toxicol. 42(3): 325-330.

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in Tables 2.1.10-1 and 2.1.10-2*)
Chronic References	
1	Chapman, G.A., S. Ota and F. Recht. 1980. Effects of Water Hardness on the Toxicity of Metals to *Daphnia magna*. Manuscript. U.S. EPA, Corvallis, OR.
2	Nebeker, A.V., C. Savonen, R.J. Baker and J.K. McCrady. 1984. Effects of copper, nickel, and zinc on the life cycle of the caddisfly *Clistoronia magnifica* (Limnephilidae). Environ. Toxicol. Chem. 3: 645-649.
3	Nebeker, A.V., C. Savonen and D.G. Stevens. 1985. Sensitivity of rainbow trout early life stages to nickel chloride. Environ. Toxicol. Chem. 4(2): 233-239.
4	Lind, D., K. Alto and S. Chatterton. 1978. Regional Copper-Nickel Study. Draft Report, Minnesota Environmental Quality Board, St.Paul, MN: 54 p.
5	Pickering, Q.H. 1974. Chronic toxicity of nickel to the fathead minnow. J. Water Pollut. Control Fed. 46: 760-765.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For full descriptions, see Appendix J.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[30], EPA is providing a transparent rationale as to why they were not utilized (see below).
2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix J).

[30] U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

2.1.11 PENTACHLOROPHENOL

2.1.11.1 Evaluation of the Acute Freshwater Criterion Concentration for Pentachlorophenol

A. Presentation of Toxicological Data

Oregon adopted a freshwater acute criterion concentration of 19 µg/L (at pH 7.8) for pentachlorophenol that is expressed as a function of pH. This concentration is the same as the freshwater acute criterion concentration recommended for use nationally by EPA for the protection of aquatic life[31]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.11-1 provides available SMAVs and GMAVs based on available acute toxicity data for arsenic to aquatic life from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.1.11-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Pentachlorophenol

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Orconectes	immunis	Crayfish	162206	162206	4
Caenorhabditis	elegans	Nematode	56093	56093	54
Mysis	relicta	Opossum shrimp	44249	44249	41
Tanytarsus	dissimilis	Midge	41586	41586	38
Sepedon	fuscipennis	Marsh fly	39185	39185	53
Asellus	intermedius	Aquatic sowbug	13680	13680	40
Lumbriculus	variegatus	Oligochaete, worm	4326	4326	40
Pteronarcys	dorsata	Stonefly	1809	1809	52
Brachionus	calyciflorus	Rotifer	1771	1771	55
Rhyacodrilus	montana	Tubificid worm	1543	1543	15
Stylodrilus	heringianus	Oligochaete	1508	1508	15,42
Gillia	altilis	Buffalo pebblesnail	1489	1489	51
Utterbackia	imbecillis	Mussel	1363	1363	50
Spirosperma	nikolskyi	Oligochaete	2016	-	15
Spirosperma	ferox	Tubificid worm	884.5	1335	15
Quistadrilus	multisetosus	Oligochaete	1173	1173	15
Jordanella	floridae	Flagfish	1133	1133	11
Tubifex	tubifex	Tubificid worm	828.0	828.0	15,42,49
Helisoma	trivolvis	Ramshorn snail	740.5	740.5	40
Xenopus	laevis	Clawed toad	736.2	736.2	48
Poecilia	reticulata	Guppy	721.7	721.7	43,44,45,46,47
Limnodrilus	hoffmeisteri	Tubificid worm, Oligochaete	674.0	674.0	15,42,49
Crangonyx	pseudogracilis	Amphipod	635.6	635.6	18
Branchiura	sowerbyi	Oligochaete	575.8	575.8	15

[31] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001. The data which serve as the basis for the current nationally-recommended criteria are from: U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Pontoporeia	hoyi	Scud	490.7	490.7	41
Physa	gyrina	Pouch snail	487.9	487.9	14
Micropterus	salmoides	Largemouth bass	387.8	387.8	39
Gammarus	fasciatus	Scud	429.2	-	40
Gammarus	pseudolimnaeus	Scud	337.9	380.8	18,38
Daphnia	pulex	Cladoceran	312.6	-	26,32,33,34,37
Daphnia	magna	Cladoceran	270.4	290.8	4,26,27,28,29,30,31,32, 33,34,35,36,37
Salmo	salar	Atlantic salmon	264.9	264.9	25
Pimephales	promelas	Fathead minnow	260.8	260.8	3,4,10,16,18,19,20,21, 22,23,24
Ceriodaphnia	reticulata	Cladoceran	247.9	247.9	14
Nais	communis	Oligochaete	245.8	245.8	17
Carassius	auratus	Goldfish	242.0	242.0	3,4,16
Xyrauchen	texanus	Razorback sucker	229.0	229.0	1
Gambusia	affinis	Western mosquitofish	223.4	223.4	4
Aplexa	hypnorum	Snail	223.2	223.2	3
Varichaeta	pacifica	Worm	215.9	215.9	15
Simocephalus	vetulus	Cladoceran	213.2	213.2	14
Lepomis	macrochirus	Bluegill	208.3	208.3	3,4
Gila	elegans	Bonytail	188.1	188.1	1
Salvelinus	fontinalis	Brook trout	126.0	126.0	10
Rana	***catesbeiana***	***Bullfrog***	125.2	125.2	4
Ptychocheilus	lucius	Colorado squawfish	114.5	114.5	1
Ictalurus	***punctatus***	***Channel catfish***	98.02	98.02	3,4
Oncorhynchus	***clarki (henshawi)***	***Lahontan cutthroat trout***	139.0	-	1
Oncorhynchus	***mykiss***	***Rainbow trout***	130.5	-	4,11,12,13
Oncorhynchus	***nerka***	***Sockeye salmon***	121.3	-	5,9
Oncorhynchus	***tshawytscha***	***Chinook salmon***	118.6	-	7,8
Oncorhynchus	***kisutch***	***Coho salmon***	117.5	-	5,6
<u>Oncorhynchus</u>	***<u>gilae*</u>***	***Apache trout***	89.97	-	1
Oncorhynchus	***clarki (includes 1 henshawi and 1 stomias)***	***Cutthroat trout***	33.72	-	1
<u>Oncorhynchus</u>	***<u>clarki (stomias)*</u>***	***Greenback cutthroat trout***	8.179	93.53[32]	1
Cyprinus	***carpio***	***Common carp***	16.08	16.08	2

<u>Note 1</u>: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV in the 1995 GLI update of the ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera used in the derivation of the 304(a) criteria are identified as such.
<u>Note 2</u>: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision.

B. Evaluation of the Protectiveness of the Oregon Freshwater Acute Criterion

Following review of GMAV values in Table 2.1.11-1, 45 of the 46 genera had values greater than Oregon's acute criterion concentration for pentachlorophenol. The most sensitive genera is not expected to reside in Oregon indicating all resident tested genera are protected by the

[32] This value was calculated as the geometric mean of *Oncorhynchus clarki* combined (33.72), *O. gilae* (89.97), *O. kisutch* (117.5), *O. tshawytscha* (118.6), *O. nerka* (121.3), and *O. mykiss* (130.5). Subspecies SMAVs retained for transparency.

criterion. Therefore, EPA concluded that acute effects to these species are not expected to occur at concentrations lower than the criterion, and thus these species and the designated use would be protected by the criterion.

When compared to Oregon's acute criterion concentration for pentachlorophenol, SMAV/2 values for two test species were lower than the acute criterion concentration of 19 µg/L pentachlorophenol. The first SMAV/2 value lower than the acute criterion concentration pertains to the common carp. This species is exotic to, but currently residing in, Oregon waters. The subspecies *O. clarkii henshaw* are expected to reside in Oregon waters, however the subspecies *O. clarki stomias* is not. Therefore, EPA reviewed the data from the studies that make up the most representative SMAV for the resident species and compared the confidence intervals of the SMAV for these species to determine whether the SMAV/2 values are quantitatively different from the criterion value of 19 µg/L.

The pH normalized SMAV for *C. carpio* was 16.08 µg/L. This value was based on a single study by Verna et al. (1981), and no confidence intervals were reported. The pH normalized SMAV/2 of 8.042 µg/L was less than the criterion for pentachlorophenol of 19 µg/L.

The overall pH normalized SMAV/2 for cutthroat trout of 16.86 µg/L is based on the geometric mean of one LC50 value for each of two subspecies – *O. clarki stomias* (greenback cutthroat trout, and *O. clarki henshawi* (Lahontan cutthroat trout), respectively. The greenback cutthroat trout is not expected to reside in Oregon waters, and thus, exclusion of this LC50 value from the SMAV for the species increases the SMAV to well above the criterion; i.e, the SMAV for cutthroat trout based on *O. clarki henshawi* alone is 139.01 ug/L, SMAV/2 = 69.52 ug/L (see Table 3.1.14-1 above).

Because the Oregon acute criterion for pentachlorophenol is greater than the SMAV/2 for the invasive *Cyprinus carpio*, EPA concludes that the Oregon CMC for pentachlorophenol may not be protective of all individuals within this species. Because the Oregon acute criterion for pentachlorophenol is substantially lower than the SMAV/2 for the Oregon resident *Onchorhynchus clarki henshawi*, EPA concludes that the Oregon CMC for pentachlorophenol is protective of this species.

2.1.11.2 Evaluation of the Chronic Freshwater Criterion Concentration for Pentachlorophenol

A. Presentation of Toxicological Data

Oregon adopted a freshwater chronic criterion concentration of 15 µg/L (at pH 7.8) for pentachlorophenol that is expressed as a fuction of pH. This concentration is the same as the freshwater chronic criterion concentration recommended for use nationally by EPA for the protection of aquatic life[33]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.11-2 presents a compilation of the GMAVs from Table 2.1.11-1, any experimentally determined SMCVs obtained from the criteria document and the BE, and estimated GMCVs based on the GMAV/ACR. The 1986 criteria document for pentachlorophenol[34] reported an FACR of 3.166, which EPA calculated as the geometric mean of five experimentally determined ACRs ranging from 0.8945 for the cladoceran (*Simocephalus vetulus*) to 6.873 for the saltwater fish species *Cyprinodon variegatus*. Note: the 1995 GLI Update to the freshwater criteria for pentachlorophenol excludes this ACR for sheepshead minnow (*C. variegatus*) because the update was for the freshwater criterion only. Since no additional acceptable ACRs are available, EPA calculated the predicted GMCVs for pentachlorophenol in Table 2.1.11-2 using an FACR of 3.166 and the following equation: Predicted GMCV = GMAV/FACR.

EPA compared the GMCVs for each species to Oregon's pentachlorophenol chronic criterion to determine whether the chronic criterion will protect the genera.

Table 2.1.11-2: Genus Mean Chronic Values (GMCVs) for Pentachlorophenol

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) (*experimentally derived*)	Chronic References (*used in the calculation of the SMCV*)	Predicted GMCV (µg/L)
Orconectes	immunis	Crayfish	162206			51234
Caenorhabditis	elegans	Nematode	56093			17717
Mysis	relicta	Opossum shrimp	44249			13976
Tanytarsus	dissimilis	Midge	41586			13135
Sepedon	fuscipennis	Marsh fly	39185			12377
Asellus	intermedius	Aquatic sowbug	13680			4321
Lumbriculus	variegatus	Oligochaete, worm	4326			1366
Pteronarcys	dorsata	Stonefly	1809			571.3
Brachionus	calyciflorus	Rotifer	1771			559.4
Rhyacodrilus	montana	Tubificid worm	1543			487.3
Stylodrilus	heringianus	Oligochaete	1508			476.2
Gillia	altilis	Buffalo pebblesnail	1489			470.3
Utterbackia	imbecillis	Mussel	1363			430.5
Spirosperma	nikolskyi	Oligochaete	-			-
Spirosperma	ferox	Tubificid worm	1335			421.8
Quistadrilus	multisetosus	Oligochaete	1173			370.4
Jordanella	floridae	Flagfish	1133			357.8
Tubifex	tubifex	Tubificid worm	828.0			261.5
Helisoma	trivolvis	Ramshorn snail	740.5			233.9
Xenopus	laevis	Clawed toad	736.2			232.5
Poecilia	reticulata	Guppy	721.7			227.9
Limnodrilus	hoffmeisteri	Tubificid worm, Oligochaete	674.0			212.9
Crangonyx	pseudogracilis	Amphipod	635.6			200.8
Branchiura	sowerbyi	Oligochaete	575.8			181.9
Pontoporeia	hoyi	Scud	490.7			155.0
Physa	gyrina	Pouch snail	487.9	<31.79	1	154.1 (<31.79)
Micropterus	salmoides	Largemouth bass	387.8			122.5
Gammarus	fasciatus	Scud	-			-

[33] See footnote 34 above.

[34] U.S. EPA. 1986. Ambient Water Quality Criteria Document for Pentachlorophenol-1986. EPA 440/5-86-005.

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) (*experimentally derived*)	Chronic References (*used in the calculation of the SMCV*)	Predicted GMCV (µg/L)
Gammarus	pseudolimnaeus	Scud	380.8			120.3
Daphnia	pulex	Cladoceran	-			-
Daphnia	magna	Cladoceran	290.8			91.84
Salmo	salar	Atlantic salmon	264.9			83.67
Pimephales	promelas	Fathead minnow	260.8	64.19	3,4,5	82.37 (64.19)
Ceriodaphnia	reticulata	Cladoceran	247.9	<6.780	1	78.31 (<6.780)
Nais	communis	Oligochaete	245.8			77.63
Carassius	auratus	Goldfish	242.0			76.44
Xyrauchen	texanus	Razorback sucker	229.0			72.34
Gambusia	affinis	Western mosquitofish	223.4			70.57
Aplexa	hypnorum	Snail	223.2			70.49
Varichaeta	pacifica	Worm	215.9			68.21
Simocephalus	vetulus	Cladoceran	213.2	208.6	1	67.33 (208.6)
Lepomis	macrochirus	Bluegill	208.3			65.80
Gila	elegans	Bonytail	188.1			59.42
Salvelinus	fontinalis	Brook trout	126.0			39.81
Rana	***catesbeiana***	***Bullfrog***	125.2			39.56
Ptychocheilus	lucius	Colorado squawfish	114.5			36.17
Ictalurus	***punctatus***	***Channel catfish***	98.02			30.96
Oncorhynchus	***clarki (henshawi)***	***Lahontan cutthroat trout***	-			-
Oncorhynchus	***mykiss***	***Rainbow trout***	-	20.93	2	-
Oncorhynchus	***nerka***	***Sockeye salmon***	-			-
Oncorhynchus	***tshawytscha***	***Chinook salmon***	-			-
Oncorhynchus	***kisutch***	***Coho salmon***	-			-
Oncorhynchus	***gilae****	***Apache trout***	-			-
Oncorhynchus	***clarki (includes 1 henshawi and 1 stomias)***	***Cutthroat trout***	-			-
Oncorhynchus	***clarki (stomias)****	***Greenback cutthroat trout***	93.53			29.54 (20.93)
Cyprinus	***carpio***	***Common carp***	16.08			5.080

See same notes as above under Table 2.1.11-1.

B. Evaluation of the Protectiveness of the Oregon Freshwater Chronic Criterion

Following the review of the GMCV values in Table 2.1.11-2, 45 of the 46 genera had values greater than Oregon's chronic criterion for pentachlorophenol. No test data is below the criterion. Therefore, EPA concluded that chronic effects are not expected to occur at concentrations lower than the criterion and thus these species and designated use would be protected by the criterion.

When compared to Oregon's chronic criterion concentration for pentachlorophenol, SMCV values for three test species were lower than the acute criterion concentration of 15 µg/L pentachlorophenol. The first SMCV value lower than the acute criterion concentration pertains to the common carp. This species is expected to reside in Oregon waters. The second SMCV is for *Ceriodaphnia reticulate*, which is also expected to reside in Oregon waters. The subspecies of *Onchorhynchus clarki*, *O. clarki henshawi* is expected to reside in Oregon waters, however the subspecies *O. clarki stomias* is not. Therefore, EPA reviewed the data from the studies that make up the most representative SMCVs for this species and compared the confidence intervals of these SMCVs to determine whether the SMCV values were quantitatively different from the criterion value of 15 µg/L.

Of the test species with SMCV values lower than the chronic criterion concentration for pentachlorophenol, the cutthroat trout (*O. clarki*) is excluded from consideration for reasons described above in section 3.1.16.1.B. Although the overall SMCV for cutthroat trout of 10.65 µg/L is lower than the CCC for pentachlorophenol of 15 µg/L, when the SMCV of the non-resident greenback cutthroat trout (*O. clarki* stomias) is excluded from the analysis, the SMCV for the resident Lahontan cutthroat trout subspecies (*O. clarki henshawi*) is well above the CCC for pentachlorophenol (43.92 µg/L vs. 15 µg/L).

The SMCV for the common carp was estimated by applying the FACR of 3.166 to the SMAV of 16.08 µg/L described in section 3.1.14.1.B to obtain a pH-normalized SMCV of 5.079 µg/L (see Verna et al. 1981).

The SMCV for the freshwater cladoceran *Ceriodaphnia reticulata* was determined to be less than the pH normalized LOEC value of 6.780 µg/L (text box A – *C. reticulata* chronic). Because the NOEC value in the single study used to determine the SMCV for this test species was the control or nominal "zero" concentration (Hedtke et al. 1986), a SMCV based on the geometric mean could not be calculated. However, the pH normalized LOEC, which represents the upper boundary of the probable "true" SMCV for *C. reticulata*, falls below the CCC.

Because the Oregon chronic criterion for pentachlorophenol is substantially lower than the SMCV for the Oregon resident *O. clarki henshawi*, EPA concludes that the Oregon CCC for pentachlorphenol is protective of this species. Because the Oregon chronic criterion for pentachlorophenol is greater than the SMCV for *Cyprinus carpio*, EPA concludes that the Oregon CMC for pentachlorophenol may not be protective of all individuals within this species. Because the Oregon chronic criterion for pentachlorophenol is greater than the LOEC for *Ceriodaphnia reticulata*, Oregon's chronic WQC for pentachlorophenol may not be protective of all individuals within this species.

Freshwater pentachlorophenol chronic criterion comparison

Text Box A – Basis for the meta analysis comparing the SMCV for the cladoceran (*C. reticulata*) to the acute criterion for pentachlorophenol (15.0 µg/L).

Ceriodaphnia reticulata							
	Reported Values			**pH Normalized Values**			
pH	NOEC	LOEC	CV	NOEC	LOEC	CV	CCC
7.3	0	4.100	<4.100	0	6.780	<6.780 **(SMCV)**	15

2.1.11.3 References for Pentachlorophenol

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in tables 2.1.11-1 and 2.1.11-2*)
Acute References	
1	Sappington, L.C., F.L. Mayer, F.J. Dwyer, D.R. Buckler, J.R. Jones and M.R. Ellersieck. 2001. Contaminant sensitivity of threatened and endangered fishes compared to standard surrogate species. Environ. Toxicol. Chem. 20(12): 2869-2876.
2	Verma, S.R., I.P. Tonk and R.C. Dalela. 1981. Determination of the maximum acceptable toxicant concentration (MATC) and the safe concentration for certain aquatic pollutants. Acta Hydrochim. Hydrobiol. 9(3): 247-254.
3	Phipps, G.L. and G.W. Holcombe. 1985. A method for aquatic multiple species toxicant testing: Acute toxicity of 10 chemicals to 5 vertebrates and 2 invertebrates. Environ. Pollut. Ser. A Ecol. Biol. 38(2): 141-157 (Author Communication Used) (OECDG Data File).
4	Thurston, R.V., T.A. Gilfoil, E.L. Meyn, R.K. Zajdel, T.L. Aoki and G.D. Veith. 1985. Comparative toxicity of ten organic chemicals to ten common aquatic species. Water Res. 19(9): 1145-1155.
5	Davis, J.C. and R.A.W. Hoos. 1975. Use of sodium pentachlorophenate and dehydroabietic acid as reference toxicants for salmonid bioassays. J. Fish. Res. Board Can. 32(3): 411-416.
6	Iwama, G.K. and G.L. Greer. 1980. Effect of a bacterial infection on the toxicity of sodium pentachlorophenate to juvenile Coho salmon. Trans. Am. Fish. Soc. 109(2): 290-292.
7	Mayer, F.L.J. and M.R. Ellersieck. 1986. Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals. Resour. Publ. No. 160, U.S. Dep. Interior, Fish Wildl. Serv., Washington, DC: 505 p. (USGS Data File).
8	Johnson, W.W. and M.T. Finley. 1980. Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates. Resorce Publ. 137. U.S. Fish and Wildlife Service, Washington, DC: 58.
9	Webb, P.W. and J.R. Brett. 1973. Effects of sublethal concentrations of sodium pentachlorophenate on growth rate, food conversion efficiency and swimming performance in underyearling sockeye salmon (*Oncorhynchus nerka*). J. Fish. Res. Board Can. 30(4): 499-507.
10	Cardwell, R.D., D.G. Foreman, T.R. Payne and D.J. Wilbur. 1976. Acute Toxicity of Selected Toxicants to Six Species of Fish. EPA-600/3-76-008, U.S. EPA, Duluth, MN: 125 p. (Publ in Part As 2149).
11	Fogels, A. and J.B. Sprague. 1977. Comparative short-term tolerance of zebrafish, blagfish, and rainbow trout to five poisons including potential reference toxicants. Water Res. 11(9): 811-817.
12	Hodson, P.V., D.G. Dixon and K.L.E. Kaiser. 1984. Measurement of median lethal dose as a rapid indication of contaminant toxicity to fish. Environ. Toxicol. Chem. 3(2): 243-254.
13	McCarty, L.S., P.V. Hodson, G.R. Craig and K.L.E. Kaiser. 1985. The use of quantititative structure activity relationships to predict the acute and chronic toxicities of organic chemcials to fish. Environ. Toxicol. Chem. 4: 595-606.
14	Hedtke, S.F., C.W. West, K.N. Allen, T.J. Norberg-King and D.I. Mount. 1986. Toxicity of pentachlorophenol to aquatic organisms under naturally varying and controlled environmental conditions. Environ. Toxicol. Chem. 5(6): 531-542.
15	Chapman, P.M., M.A. Farrell and R.O. Brinkhurst. 1982*a*. Relative tolerances of selected aquatic oligochaetes to individual pollutants and environmental factors. Aquat. Toxicol. 2(1): 47-67.
16	Adelman, I.R., Jr. 1976. Standard Test Fish Development. Part I. Fathead Minnows (*Pimephales promelas*) and Goldfish (*Carassius auratus*) as Standard Fish in Bioassays and Their Reaction to Potential Reference Toxicants. EPA-600/3-76-061A, U.S. EPA, Duluth, MN: 77.
17	Chapman, P.M. and D.G. Mitchell. 1986. Acute tolerance tests with the oligochaetes *Nais communis* (Naididae) and *Ilyodrilus frantzi* (Tubificidae). Hydrobiologia 137(1): 61-64.
18	Spehar, R.L., H.P. Nelson, M.J. Swanson and J.W. Renoos. 1985. Pentachlorophenol toxicity to amphipods and fathead minnows at different test pH values. Environ. Toxicol. Chem. 4: 389-397.
19	Phipps, G.L., G.W. Holcombe and J.T. Fiandt. 1981. Acute toxicity of phenol and substituted phenols to the fathead minnow. Bull. Environ. Contam. Toxicol. 26(5): 585-593 (Author Communication Used) (OECDG Data File).

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in tables 2.1.11-1 and 2.1.11-2*)
20	Ruesink, R.G. and L.L. Smith, Jr. 1975. The relationship of the 96-hour LC50 to the lethal threshold concentration of hexavalent chromium, phenol, and sodium pentachlorophenate for fathead minnows (*Pimephales promelas* Rafinesque). Trans. Am. Fish. Soc. 104: 567-570.
21	Broderius, S.J., M.D. Kahl and M.D. Hoglund. 1995. Use of joint toxic response to define the primary mode of toxic action for diverse industrial organic chemicals. Environ. Toxicol. Chem. 14(9): 1591-1605 (Author Communication Used).
22	Geiger, D.L., C.E. Northcott, D.J. Call and L.T. Brooke. 1985. Acute Toxicities of Organic Chemicals to Fathead Minnows (*Pimephales promelas*), Vol. 2. Center for Lake Superior Environmental Stud., Univ. of Wisconsin-Superior, Superior, WI: 326.
23	Geiger, D.L., L.T. Brooke and D.J. Call. 1990. Acute Toxicities of Organic Chemicals to Fathead Minnows (*Pimephales promelas*), Vol. 5. Center for Lake Superior Environmental Stud., Univ. of Wisconsin-Superior, Superior, WI: 332.
24	Hall, L.H., L.B. Kier and G. Phipps. 1984. Structure-activity relationship studies on the toxicities of benzene derivatives: I. An additivity model. Environ. Toxicol. Chem. 3: 355-365.
25	Burridge, L.E. and K. Haya. 1990. Seasonal lethality of pentachlorophenol to juvenile Atlantic salmon. Bull. Environ. Contam. Toxicol. 45(6):888-892.
26	Canton, J.H. and D.M.M. Adema. 1978. Reproducibility of short-term and reproduction toxicity experiments with *Daphnia magna* and comparison of *Daphnia magna* with *Daphnia pulex* and *Daphnia cucullata* in short-term experiments. Hydrobiologia 59: 135-140.
27	LeBlanc, G.A. 1980. Acute toxicity of priority pollutants to Water Flea (*Daphnia magna*). Bull. Environ. Contam. Toxicol. 24(5): 684-691 (OECDG Data File).
28	Adema, D.M.M. 1978. *Daphnia magna* as a test animal in acute and chronic toxicity tests. Hydrobiologia 59: 125-134
29	Adema, D.M.M. and G.J. Vink. 1981. A comparative study of the toxicity of 1,1,2-trichloroethane, dieldrin, pentachlorophenol and 3,4-dicloroaniline for marine and fresh water organisms. Chemosphere 10: 533-554.
30	Hermens, J., P. Leuwangh and A. Musch. 1984. Joint toxicity of mixtures of groups of organic aquatic pollutants to the guppy (*Poecilia reticulata*). Ecotoxicol. Environ. Safety 9: 321-326.
31	Mount, D.I. and T.J. Norberg. 1984. A seven-day life-cycle cladoceran toxicity test. Environ. Toxicol. Chem. 3(3): 425-434 (Author Communication Used).
32	Lewis, P.A. and C.I. Weber. 1985. A study of the reliability of *Daphnia* acute toxicity tests. In: R.D. Cardwell, R. Purdy and R.C. Bahner (Eds.), Aquatic Toxicology and Hazard Assessment, 7th Symposium, ASTM STP 854, Philadelphia, PA: 73-86.
33	Hall, W.S., R.L. Paulson, L.W. Hall, Jr. and D.T. Burton. 1986. Acute toxicity of cadmium and sodium pentachlorophenate to daphnids and fish. Bull. Environ. Contam. Toxicol. 37(2): 308-316.
34	Elnabarawy, M., A.N. Welter and R.R. Robideau. 1986. Relative sensitivity of three daphnid species to selected organic and inorganic chemcials. Environ. Toxicol. Chem. 5: 393-398.
35	Brooke, L.T., D.J. Call, D.E. Hammermeister, A. Hoffman and C.E. Northcott. Manuscript. Acute Toxicities of Five Chemicals in Different Natural Waters. Center for Lake Superior Environmental Studies, University of Wisconsin-Superior, Superior, WI.
36	Kuhn, R., M. Pattard, K. Pernak and A. Winter. 1989. Results of the harmful effects of selected water pollutants (anilines, phenols, aliphatic compounds) to *Daphnia magna*. Water Res. 23(4): 495-499 (OECDG Data File).
37	Lewis, P.A. and W.B. Horning II. 1991. Differences in acute toxicity test results of three reference toxicants on *Daphnia* at two temperatures. Environ. Toxicol. Chem. 10: 1351-1357.
38	Call, D.J., L.T. Brooke, N. Ahmad, and J.E. Richter. 1983. Toxicity and Metabolism Studies with EPA Priority Pollutants and Related Chemicals in Freshwater Organisms. EPA 600/3-83-095, U.S.EPA, Duluth, MN :120 p.(U.S.NTIS PB83-263665).
39	Johansen, P.H., R.A.S. Mathers, J.A. Brown and P.W. Colgan. 1985. Mortality of early life stages of largemouth bass, *Micropterus salmoides* due to pentachlorophenol exposure. Bull. Environ. Contam. Toxicol. 34(3): 377-384.
40	Ewell, W.S., J.W. Gorsuch, R.O. Kringle, K.A. Robillard and R.C. Spiegel. 1986. Simultaneous evaluation of the acute effects of chemicals on seven aquatic species. Environ. Toxicol. Chem. 5(9):831-840.
41	Landrum, P.F. and W.S. Dupuis. 1990. Toxicity and toxicokinetics of pentachlorophenol and carbaryl to *Pontoporeia hoyi* and *Mysis relicta*. In: W.G. Landis and W.H. Van der Schalie (Eds.), Aquatic Toxicology and Risk Assessment, 13th Volume, ASTM STP 1096, Philadelphia, PA: 278-289.
42	Chapman, P.M., M.A. Farrell and R.O. Brinkhurst. 1982b. Relative tolerances of selected aquatic oligochaetes to combinations of pollutants and environmental factors. Aquat. Toxicol. 2(1): 69-78.
43	Brown, J.A., P.H. Johansen, P.W. Colgan and R.A. Mathers. 1985. Changes in the predator-avoidance behavior of juvenile guppies (*Poecilia reticulata*) exposed to pentachlorophenol. Can. J. Zool. 63: 2001-2005.
44	Khangarot, B.S. 1983. Acute toxicity of pentachlorophenol and antimycin to common guppy (*Lebistes reticulatus* Peters). Indian J. Phys. Nat. Sci. 3: 25-29.
45	Gupta, P.K., V.S. Mujumdar, P.S. Rao and V.S. Durve. 1982a. Toxicity of phenol, pentachlorophenol and

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in tables 2.1.11-1 and 2.1.11-2*)
	sodium pentachlorophenolate to a freshwater teleost *Lebistes reticulatus* (Peters). Acta Hydrochim. Hydrobiol. 10(2): 177-181.
46	Saarikoski, J. and M. Viluksela. 1981. Influence of pH on the toxicity of substituted phenols to fish. Arch. Environ. Contam. Toxicol. 10(6): 747-753.
47	Salkinoja-Salonen, M., M. Saxelin and J. Pere. 1981. Analysis of toxicity and biodegradability of organochlorine compounds released into the environment in bleaching effluents of kraft pulping. In: L. H. Keith (Ed.), Advances in the Identification and Analysis of Organic Pollutants in Water, Butterworth, Stoneham, MA 2: 1131-1164.
48	Fort, D.J., E.L. Stover and J.A. Bantle. 1996. Integrated ecological hazard assessment of waste site soil extracts using FETAX and short-term fathead minnow teratogenesis assay. In: T.W. La Point, F.T. Price, and E.E. Little (Eds.), Environmental Toxicology and Risk Assessment, 4th Volume, ASTM STP 1262, Philadelphia, PA: 93-109.
49	Chapman, P.M., M.A. Farrell and R.O. Brinkhurst. 1982c. Effects of species interactions on the survival and respiration of *Limnodrilus hoffmeisteri* and *Tubifex tubifex* (Oligochaeta, Tubificidae) exposed to various pollutants and environmental factors. Water Res. 16: 1405-1408.
50	Keller, A.E. 1993. Acute toxicity of several pesticides, organic compounds, and a wastewater effluent to the freshwater mussel, *Anodonta imbecilis*, *Ceriodaphnia dubia*, and *Pimephales promelas*. Bull Environ. Contam. Toxicol. 51(5): 696-702.
51	Stuart, R.J. and J.B. Robertson. 1985. Acute toxicity of pentachlorophenol to the freshwater snail, *Gillia altilis*. Bull. Environ. Contam. Toxicol. 35(5): 633-640.
52	Call, D.J. and L.T. Brooke. 1982. Report on Stonefly Toxicity Tests with Priority Pollutants. Center for Lake Superior Environmental Stud., Univ. of Wisconsin-Superior, Superior, WI: 2.
53	Mccoy, L.E. and J.E. Joy. 1977. Tolerance of *Sepedon fuscipennis* and *Dictya sp*. larvae (Diptera: Sciomyzidae) to the molluscicides Bayer 73 and sodium pentachlorophenate. Environ. Entomol. 6(2): 198-202.
54	Kammenga, J.E., C.A.M. Van Gestel and J. Bakker. 1994. Patterns Of sensitivity To cadmium and pentachlorophenol among nematode species From different taxonomic and ecological groups. Arch. Environ. Contam. Toxicol. 27(1): 88-94.
55	Radix, P., M. Leonard, C. Papantoniou, G. Roman, E. Saouter, S. Gallotti-Schmitt, H. Thiebaud and P. Vasseur. 1999. Comparison of *Brachionus calyciflorus* 2-d and microtox chronic 22-h tests with *Daphnia magna* 21-d test for the chronic toxicity assessment of chemicals. Environ. Toxicol. Chem. 18(10): 2178-2185.
Chronic References	
1	Hedtke, S.F., C.W. West, K.N. Allen, T.J. Norberg-King and D.I. Mount. 1986. Toxicity of pentachlorophenol to aquatic organisms under naturally varying and controlled environmental conditions. Environ. Toxicol. Chem. 5(6): 531-542.
2	Dominguez, S.E. and G.A. Chapman. 1984. Effect of pentachlorophenol on the growth and mortality of embryonic and juvenile steelhead trout. Arch. Environ. Contam. Toxicol. 13: 739-743.
3	Holcombe, G.W., G.L. Phipps and J.T. Fiandt. 1982. Effects of phenol, 2,4-dimethylphenol, 2,4-dichlorophenol, and pentachlorophenol on embryo, larval, and juvenile fathead minnows (*Pimephales promelas*). Arch. Environ. Contam. Toxicol. 11(1): 73-78
4	Spehar, R.L., H.P. Nelson, M.J. Swanson and J.W. Renoos. 1985. Pentachlorophenol toxicity to amphipods and fathead minnows at different test pH values. Environ. Toxicol. Chem. 4: 389-397.
5	Arthur, A.D. and D.G. Dixon. 1994. Effects of rearing density on the growth response of juvenile fathead minnow (*Pimephales promelas*) under toxicant-induced stress. Can. J. Fish. Aquat. Sci. 51(2): 365-371.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For full descriptions, see Appendix K.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria

dataset used to derive the CMC[35], EPA is providing a transparent rationale as to why they were not utilized (see below).

2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix K).

[35] U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

2.1.12 SELENIUM (SELENATE AND SELENITE)

Please see the primary decision document regarding the disapproval of this criterion.

2.1.13 SILVER

2.1.13.1 Evaluation of the Acute Freshwater Criterion Concentration for Silver

A. Presentation of Toxicological Data

Oregon adopted a freshwater acute criterion concentration of 3.2 µg/L for silver that is expressed as a function of total hardness in the water column and in terms of the dissolved concentration of the metal. This dissolved metal concentration reflects the criterion normalized to a total hardness of 100 mg/L as $CaCO_3$ and is the same as the freshwater CMC recommended for use nationally by EPA for the protection of aquatic life[36]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.13-1 provides available SMAVs and GMAVs based on available acute toxicity data for silver to aquatic life from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.1.13-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Silver

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Orconectes	immunis	Crayfish	1901	1901	3
Tanytarsus	dissimilis	Midge	1426	1426	3
Aplexa	hypnorum	Snail	433.1	433.1	3,12
Gambusia	affinis	Western mosquitofish	120.3	120.3	18
Nephelopsis	obscura	Leech	98.47	98.47	3
Chironomus	tentans	Midge	95.94	95.94	19
Hydra	sp.	Hydra	82.18	82.18	8
Ictalurus	punctatus	Channel catfish	59.42	59.42	12
Simocephalus	vetulus	Water flea	50.35	50.35	5
Lepomis	macrochirus	Bluegill	44.14	44.14	3
Oncorhynchus	kisutch	Coho salmon	46.40	-	17
Oncorhynchus	mykiss	Rainbow trout	31.81	38.42	3,11,14,15,16
Isonychia	bicolor	Mayfly	34.82	34.82	18
Thymallus	arcticus	Arctic grayling	33.97	33.97	17
Jordanella	***floridae****	***Flagfish***	31.72	31.72	10
Pimephales	***promelas***	***Fathead minnow***	23.23	23.23	3,10,11,12,13
Gammarus	***pseudolimnaeus****	***Scud***	15.52	15.52	10
Crangonyx	pseudogracilis	Amphipod	14.00	14.00	9
Leptophlebia	sp.	Mayfly	13.88	13.88	8
Cottus	bairdi	Mottled sculpin	9.242	9.242	7
Rhinichthys	osculus	Speckled dace	8.887	8.887	7
Tubifex	tubifex	Tubificid worm	5.642	5.642	6
Daphnia	***pulex***	***Cladoceran***	4.103	-	4,5
Daphnia	***magna***	***Cladoceran***	3.056	3.541	3
Cyprinus	carpio	Common Carp	1.543	1.543	20

[36] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are from: U.S. EPA. 1980. Ambient Water Quality Criteria Documents for Silver. Unpublished document authored by W. A. Brungs and D.J. Hansen, U.S. EPA ERL-Narragansett and Gulf Breeze, respectively.

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Ceriodaphnia	reticulata	Cladoceran	3.122	-	4,5
Ceriodaphnia	dubia	Cladoceran	0.4211	1.147	1
Poecilia	reticulata*	Guppy	1.132	1.132	2

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV in the 1980 unpublished ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera used in the derivation of the 304(a) criteria are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision, particularly for metals such as silver which are normalized to a water hardness of 100 mg/L as $CaCO_3$ and expressed on a dissolved metal basis for a comparison with the acute criterion concentration.

B. Evaluation of the Protectiveness of the Oregon Freshwater Acute Criterion

Following review of GMAV values in Table 2.1.13-1, 22 of the 25 tested genera have values greater than Oregon's acute criterion concentration for silver. Therefore, EPA concluded that acute effects to these species and genera are not expected to occur at concentrations equal to or lower than the acute criterion. *P. reticulata* is an exotic not expected to reside in Oregon waters. *C. carpio* is a non-native, invasive species. When these two values are removed from the table, 22 of 23 genera have values greater than Oregon's acute criterion concentration for silver.

When compared to Oregon's acute criterion concentration for silver, SMAV/2 values for five test species (four planktonic cladocerans and a tubificid worm) were lower than the acute criterion concentration of 3.2 µg/L dissolved silver. *Ceriodaphnia dubia*, *Daphnia magna, C. reticulata, D. pulex* and *T. tubifex* are expected to reside in Oregon waters. Therefore, EPA reviewed the data from the studies that make up the most representative SMAV for these five species and compared the SMAV for this species to determine whether the SMAV/2 values are quantitatively different from the criterion value of 3.2 µg/L.

The hardness normalized dissolved SMAV for *Ceriodaphnia dubia* was 0.4211 µg/L, with 5 and 95 percent confidence intervals of 0.4211 and 0.5264 µg/L. When divided by two, the SMAV/2 for *C. dubia* was 0.2106 µg/L (text box A – *C. dubia*).

The hardness normalized dissolved SMAV for D*aphnia magna* was 3.056 µg/L, with 5 and 95 percent confidence intervals of 2.716 and 3.395 µg/L. When divided by two, the SMAV/2 for *D. magna* was 1.528 µg/L (text box B – *D. magna*).

The hardness normalized dissolved SMAV for *Ceriodaphnia reticulata* was 3.122 µg/L, with 5 and 95 percent confidence intervals of 2.358 and 3.881 µg/L. When divided by two, the SMAV/2 for *C. reticulata* was 1.561 µg/L (text box C – *C. reticulata*).

The hardness normalized dissolved SMAV for D*aphnia pulex* was 4.103 µg/L. For the one study with confidence intervals, the hardness normalized dissolved SMAV was 0.3583 µg/L, with 5 and 95 percent confidence intervals of 0.3206 and 0.4337 µg/L. When divided by two, the

SMAV/2 for *D. pulex* was 2.052 µg/L. For the study with confidence intervals, the SMAV/2 was 0.1792 µg/L (text box D – *D. pulex*).

The hardness normalized dissolved SMAV for *Tubifex tubifex* was 5.642 µg/L, with 5 and 95 percent confidence intervals of 3.822 and 10.01 µg/L. When divided by two, the SMAV/2 for *T. tubifex* was 2.821 µg/L (text box E – *T. tubifex*).

Because the Oregon CMC for silver is greater than the SMAV/2 values for *C. dubia, D. magna*, *C. reticulata, D. pulex*, *and T. tubifex*, EPA concludes that the occurrence of ambient concentrations equal to or greater than the Oregon CMC for silver may result in acute toxicity to some individuals within these species. As noted above, however, 22 of the 23 native, tested genera have values greater than Oregon's acute criterion concentration for silver, and all except a small proportion of genera are expected to be protected at ambient concentrations equal to or lower than the chronic criterion, therefore EPA believes the aquatic life designated use will be protected.

Freshwater silver acute criterion comparison

Text Box A (acute) – Basis for the meta analysis comparing the SMAV/2 for the cladoceran (*C. dubia*) to the acute criterion for silver (3.2 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Ceriodaphnia dubia								
	Reported Values			**Hardness Normalized Values**			**Hardness Normalized Values/2**	
Hardness	LC50	5% CI	95% CI	LC50	5% CI	95% CI	LC50 / 2	CMC
88.30	0.40	0.40	0.50	0.4211 **(SMAV)**	0.4211	0.5264	0.2106 **(SMAV/2)**	3.2

Text Box B (acute) – Basis for the meta analysis comparing the SMAV/2 for the cladoceran (*D. magna*) to the acute criterion for silver (3.2 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Daphnia magna								
	Reported Values			**Hardness Normalized Values**			**Hardness Normalized Values/2**	
Hardness	LC50	5% CI	95% CI	LC50	5% CI	95% CI	LC50 / 2	CMC
44.70	0.90	0.80	1.00	3.056 **(SMAV)**	2.716	3.395	1.528 **(SMAV/2)**	3.2

Text Box C (acute) – Basis for the meta analysis comparing the SMAV/2 for the cladoceran (*C. reticulata*) to the acute criterion for silver (3.2 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Ceriodaphnia reticulata								
	Reported Values			**Hardness Normalized Values**			**Hardness Normalized Values/2**	
Hardness	LC50	5% CI	95% CI	LC50	5% CI	95% CI	LC50 / 2	CMC
240	1.40	1.10	1.70	0.26	0.21	0.32	0.13	3.2

45	11.00	8.00	14.00	36.92	26.85	46.99	18.46	
				SMAV			**SMAV/2**	
Geomean (all)	3.92	2.97	4.88	3.122	2.358	3.881	1.561	

Text Box D (acute) – Basis for the meta analysis comparing the SMAV/2 for the cladoceran (*D. pulex*) to the acute criterion for silver (3.2 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Daphnia pulex								
	Reported Values			**Hardness Normalized Values**			**Hardness Normalized Values/2**	
Hardness	LC50	5% CI	95% CI	SMAV	5% CI	95% CI	SMAV / 2	CMC
240	1.90	1.70	2.30	0.36	0.32	0.43	0.18	3.2
45	14.00	NR	NR	46.99	NR	NR	23.50	
Geomean (all)	5.16			4.103			2.052	
CI Only	1.90	1.70	2.30	0.3583	0.3206	0.4337	0.1792	

Text Box E (acute) – Basis for the meta analysis comparing the SMAV/2 for the oligochaete (*T. tubifex*) to the acute criterion for silver (3.2 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Tubifex tubifex								
	Reported Values			**Hardness Normalized Values**			**Hardness Normalized Values/2**	
Hardness	LC50	5% CI	95% CI	LC50	5% CI	95% CI	LC50 / 2	CMC
245.00	31.00	21.00	55.00	5.642	3.822	10.01	2.821	3.2
				(SMAV)			**(SMAV/2)**	

2.1.13.2 Evaluation of the Chronic Freshwater Criterion Concentration for Silver

A. Presentation of Toxicological Data

Oregon adopted a freshwater chronic criterion concentration of 0.10 µg/L for silver expressed as the dissolved metal concentration in the water column. This concentration is effectively the same as the freshwater CCC (0.12 µg/L) recommended in the 1987 draft silver criterion produced by EPA that was never finalized[37].

Table 2.1.13-2 presents a compilation of the GMAVs from Table 2.1.13-1, any experimentally determined SMCVs obtained from the criteria document and EPA ECOTOX download used for the BE, and estimated GMCVs based on the GMAV/ACR. The 1980 criteria document for silver did not report an FACR for silver because of the "variation in the results of chronic tests with rainbow trout and the problem with determining an acute-chronic ratio for *Daphnia magna*," in which case an FACR was not determined. A recent draft of the silver ALC document, however, did provide an FACR for silver based on the values of three experimentally determined ACRs

[37] Ambient Aquatic LifeWater Quality Criteria for Silver. Draft. 1987. EPA publication # 440/5-87-011.

(expressed on a total recoverable metal basis) of 7.719, 13.66, and 33.37 for the saltwater shrimp species *Americamysis bahia*, the fathead minnow, and rainbow trout, respectively. Thus, since no additional acceptable ACRs are available, EPA calculated the predicted GMCVs for silver in Table 2.1.13-2 using an FACR of 15.21 and the following equation: Predicted GMCV = GMAV/FACR.

EPA compared the GMCVs for each species to Oregon's silver chronic criterion to determine whether the chronic criterion will protect the aquatic life designated use.

Table 2.1.13-2: Genus Mean Chronic Values (GMCVs) for Silver

Genus	**Species**	**Common name**	**GMAV (µg/L)**	**SMCV (µg/L)** *(experimentally derived)*	**Chronic References** *(used in the calculation of the SMCV)*	**Predicted GMCV (µg/L)**
Orconectes	immunis	Crayfish	1901			125.0
Tanytarsus	dissimilis	Midge	1426			93.75
Aplexa	hypnorum	Snail	433.1			28.48
Gambusia	affinis	Western mosquitofish	120.3			7.912
Nephelopsis	obscura	Leech	98.47			6.474
Chironomus	tentans	Midge	95.94			6.308
Hydra	sp.	Hydra	82.18			5.403
Ictalurus	punctatus	Channel catfish	59.42			3.907
Simocephalus	vetulus	Water flea	50.35			3.310
Lepomis	macrochirus	Bluegill	44.14			2.902
Oncorhynchus	kisutch	Coho salmon	-			-
Oncorhynchus	mykiss	Rainbow trout	38.42	0.1596	1,2	2.526 (0.1596)
Isonychia	bicolor	Mayfly	34.82			2.290
Thymallus	arcticus	Arctic grayling	33.97			2.233
Jordanella	***floridae****	***Flagfish***	31.72			2.086
Pimephales	***promelas***	***Fathead minnow***	23.23	0.4168	3	1.527 (0.4168)
Gammarus	***pseudolimnaeus****	***Scud***	15.52			1.020
Crangonyx	pseudogracilis	Amphipod	14.00			0.9205
Leptophlebia	sp.	Mayfly	13.88			0.9123
Cottus	bairdi	Mottled sculpin	9.242			0.6076
Rhinichthys	osculus	Speckled dace	8.887			0.5843
Tubifex	tubifex	Tubificid worm	5.642			0.3709
Daphnia	***pulex***	***Cladoceran***	-			-
Daphnia	***magna***	***Cladoceran***	3.541	6.722	4	0.2328 (6.722)
Cyprinus	carpio	Common Carp	1.543			0.1014
Ceriodaphnia	reticulata	Cladoceran	-			-
Ceriodaphnia	dubia	Cladoceran	1.147			0.07541
Poecilia	reticulata*	Guppy	1.132			0.07442

See same notes as above under Table 2.1.13-1. Also note that the chronic criterion for silver is not hardness normalized, therefore, the hardness-normalized SMAV cannot be used with the ACR to calculate the SMCV. Instead, the SMAV expressed only on a dissolved metal basis is used here with the ACR to calculate the most representative SMCV (the SMAV expressed only a dissolved metal basis is not provided in the table above).

B. Evaluation of the Protectiveness of the Oregon Freshwater Chronic Criterion

Following the review of the GMCV values in Table 2.1.13-2, 23 of 25 genera have GMCVs greater than Oregon's chronic criterion for silver. Therefore, EPA concluded that acute effects to these species and genera are not expected to occur at concentrations equal to or lower than the acute criterion. Two of the two genera (*P. reticulata and C. carpio*) are not native. The guppy is not expected to reside in Oregon and the common carp is considered invasive, therefore these species will not be considered further.

When compared to Oregon's chronic criterion concentration for silver, SMCV values for one test species (*Ceriodaphnia dubia*) expected to reside in Oregon waters was lower than the chronic criterion concentration of 0.10 µg/L dissolved silver. Therefore, EPA reviewed the data from the study that makes up the most representative SMCV for this species and compared the SMCV to determine whether the SMCV value was quantitatively different from the criterion value of 0.10 µg/L.

The dissolved SMCV for *C. dubia* was estimated by applying the ACR of 15.21 described above to the dissolved SMAV obtained from Brooke et al. (1993). The dissolved SMCV for *C. dubia* was 0.02235 µg/L (text box F (chronic) – *C. dubia*).

Because the Oregon CCC for dissolved silver is greater than the SMCV for *C. dubia*, EPA concludes that the occurrence of ambient concetraitons equal to or greater than Oregon CCC for silver may result in chronic effects tosome individuals of this species. As noted above, 23 of 25 genera have GMCVs greater than Oregon's chronic criterion for silver, and all except a small proportion of genera are expected to be protected at ambient concentrations equal to or lower than the chronic criterion, therefore EPA believes the aquatic life designated use will be protected.

Freshwater silver chronic criterion comparison

Text Box F (chronic) – Basis for the meta analysis comparing the SMCV for the cladoceran (*C. dubia*) to the chronic criterion for silver (0.10 µg/L dissolved metal concentration).

Ceriodaphnia dubia									
	Reported Values			**Dissolved Normalized Values**				**Dissolved Normalized Chronic Values**	
Hardness	LC50	5% CI	95% CI	LC50	5% CI	95% CI	ACR	(LC50/ACR)	CCC
88.30	0.4000	0.4000	0.5000	0.3400	0.3400	0.4250	15.21	0.02235 **(SMCV)**	0.10

2.1.13.3 References for Silver

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Ref No.	**Used Reference Citation** (*associated with reference numbers and provided above in Tables 2.1.13-1 and 2.1.13-2*)
Acute References	
1	Brooke, L.T. 1993. Effects of Food and Test Solution Age on the Toxicity of Silver to Three Freshwater Organisms.

Ref No.	**Used Reference Citation** (*associated with reference numbers and provided above in Tables 2.1.13-1 and 2.1.13-2*)
	Progress Report to U.S. EPA for Contract No. 68-C1-0034, Work Assignment 1-10, September. Environmental Health Laboratory, University of Wisconsin-Superior, Superior, WI.
2	Khangarot, B.S. and P.K. Ray. 1988. The acute toxicity of silver to some freshwater fishes. Acta Hydrochim. Hydrobiol. 16(5): 541-545.
3	Holcombe, G.W., G.L. Phipps, A.H. Sulaiman and A.D. Hoffman. 1987. Simultaneous multiple species testing: Acute toxicity of 13 chemicals to 12 diverse freshwater families. Arch. Environ. Contam. Toxicol 16: 697-710.
4	Elnabarawy, M.T., A.N. Welter and R.R. Robideau. 1986. Relative sensitivity of three daphnid species to selected organic and inorganic chemicals. Environ. Toxicol. Chem. 5: 393-398.
5	Mount, D.I. and T.J. Norberg. 1984. A seven-day life-cycle cladoceran toxicity test. Environ. Toxicol. Chem. 3: 425-434.
6	Khangarot, B.S. 1991. Toxicity of metals to a freshwater tubificid worm, *Tubifex tubifex* (Muller). Bull. Environ. Contam. Toxicol. 46: 906-912.
7	Goettl, J.P., Jr. and P.H. Davies. 1978. Water Pollution Studies. Job Progress Report. Colorado Division of Wildlife, Department of Natural Resources, Boulder, CO.
8	Brooke, L.T., D.J. Call, C.A. Lindberg, T.P. Markee, S.H. Poirier and D.J. McCauley. 1986. Acute Toxicity of Silver to Selected Freshwater Invertebrates. Center for Lake Superior Environmental Studies, University of Wisconsin-Superior, Superior, WI. Report to Battelle Memorial Research Institute, Columbus, OH.
9	Martin, T.R. and D.M. Holdich. 1986. The acute lethal toxicity of heavy metals to peracarid crustaceans (with particular reference to freshwater asellids and gammarids). Water Res. 20: 1137-1147.
10	Lima, A.R., C. Curtis, D.E. Hammermeister, D.J. Call and T.A. Felhaber. 1982. Acute toxicity of silver to selected fish and invertebrates. Bull. Environ. Contam. Toxicol. 29: 184-189.
11	Lemke, A.E. 1981. Interlaboratory comparison acute testing set. EPA 600/3-81-005 or PB81-160772. National Technical Information Service, Springfield, VA.
12	Holcombe, G.W., G.L. Phipps and J.T. Fiandt. 1983. Toxicity of selected priority pollutants to various aquatic organisms. Ecotoxicol. Environ. Safety 7: 400-409.
13	EG & G Bionomics. 1979. The acute toxicity of various silver compounds to the fathead minnow (Pimephales promelas). Report No. BW-79-12-576. Wareham, MA.
14	Davies, P.H., J.P. Goettl, Jr. and J.R. Winley. 1978. Toxicity of silver to rainbow trout (*Salmo gairdneri*). Water Res. 12:113-117.
15	Karen, D.J., D.R. Ownby, B.L. Forsythe, T.P. Bills, T.W. La Point, G.B. Cobb and S.J. Klaine. 1999. Influence of water quality on silver toxicity to rainbow trout (*O. mykiss*), fathead minnows (*P. promelas*), and the waterflea (*D. magna*). Environ. Toxicol. Chem. 18(1): 63-70.
16	Nebeker, A.V., C.K. McAuliffe, R. Mshar and D.G. Stevens. 1983. Toxicity of silver to steelhead and rainbow trout, fathead minnows and *Daphnia magna*. Environ. Toxicol. Chem. 2:95-104.
17	Buhl, K.J. and S.J. Hamilton. 1991. Relative sensitivity of early life stages of Arctic grayling, coho salmon, and rainbow trout to nine inorganics. Ecotoxicol. Environ. Saf. 22:184-197.
18	Diamond, J.M., D.G. Mackler, M. Collins and D. Gruber. 1990. Derivation of a freshwater silver criteria for the New River, Virginia, using representative species. Environ. Toxicol. Chem. 9(11): 1425-1434.
19	Khangarot, B.S. and P.K. Ray. 1987. Sensitivity of toad tadpoles, *Bufo melanostrictus* (Schneider), to heavy metals. Bull. Environ. Contam. Toxicol. 38: 523-527.
20	Rao, T.S., M.S. Rao and S.B.S.K. Prasad. 1975. Median tolerance limits of some chemicals to the fresh water fish "*Cyprinus carpio.*" Indian J. Environ. Health 17(2): 140-146.
Chronic References	
1	Davies, P.H., J.P. Goettl, Jr. and J.R. Winley. 1978. Toxicity of silver to rainbow trout (*Salmo gairdneri*). Water Res. 12: 113-117.
2	Nebeker, A.V., C.K. McAuliffe, R. Mshar and D.G. Stevens. 1983. Toxicity of silver to steelhead and rainbow trout, fathead minnows and *Daphnia magna*. Environ. Toxicol. Chem. 2: 95-104.
3	Holcombe, G.W., G.L. Phipps and J.T. Fiandt. 1983. Toxicity of selected priority pollutants to various aquatic organisms. Ecotoxicol. Environ. Safety 7: 400-409.
4	Nebeker, A.V. 1982. Evaluation of a *Daphnia magna* renewal life-cycle test method with silver and endosulfan. Water Res. 16: 739-744.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For full description, see Appendix L.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[38], EPA is providing a transparent rationale as to why they were not utilized (see below).
2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix L).

[38] U.S. EPA. 1980. Ambient Water Quality Criteria Documents for Silver. Unpublished document authored by W. A. Brungs and D.J. Hansen, U.S. EPA ERL-Narragansett and Gulf Breeze, respectively.

2.1.14 TRIBUTYLTIN

2.1.14.1 Evaluation of the Acute Freshwater Criterion Concentration for Tributyltin

A. Presentation of Toxicological Data

Oregon adopted a freshwater acute criterion concentration of 0.46 µg/L for tributyltin. This concentration is the same as the freshwater CMC recommended for use nationally by EPA for the protection of aquatic life[39]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.14-1 provides available SMAVs and GMAVs based on available acute toxicity data for tributyltin to aquatic life from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.1.14-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Tributyltin

Genus	**Species**	**Common name**	**Most Representative SMAV (µg/L)**	**GMAV (µg/L)**	**Acute References** *(used in the calculation of the SMAV)*
Elliptio	complanata	Mussel, Eastern elliptio	24600	24600	7
Salvelinus	naymaycush	Lake Trout	12.73	12.73	5
Culex	sp.	Mosquito	10.20	10.20	3
Lepomis	macrochirus	Bluegill	8.300	8.300	6
Ictalurus	punctatus	Channel catfish	5.500	5.500	3
Lumbriculus	variegatus	Annelid	5.400	5.400	3
Oncorhynchus	mykiss	Rainbow trout	4.571	4.571	3,4,5
Daphnia	magna	Cladoceran	4.300	4.300	3
Gammarus	***pseudolimnaeus****	***Scud***	3.700	3.700	3
Pimephales	***promelas***	***Fathead minnow***	2.600	2.600	3
Chlorohydra	***viridissima****	***Hydra***	1.800	1.800	2
Hydra	***littoralis****	***Hydra***	1.201	-	1,2
Hydra	***oligactis****	***Hydra***	1.140	1.170	1

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV in the 2003 ALC document. Underlined species with an asterisk (*)indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera used in the derivation of the 304(a) criteria are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision.

B. Evaluation of the Protectiveness of the Oregon Freshwater Acute Criterion

Following review of GMAV and SMAV/2 values in Table 2.1.14-1, all tested genera and species had values greater than Oregon's acute criterion concentration for tributyltin. Therefore, EPA concluded that acute effects to these genera are not expected to occur at concentrations equal to

[39] U.S. EPA. 2003. Ambient Water Quality Criteria Document for Tributyltin (TBT) - Final. EPA-822/R-03-031.

or lower than the criterion, and thus these genera and the aquatic life designated use would be protected. by the criterion.

2.1.14.2 Evaluation of the Chronic Freshwater Criterion Concentration for Tributyltin

A. Presentation of Toxicological Data

Oregon adopted a freshwater chronic criterion concentration of 0.063 µg/L for tributyltin. This concentration is the same as the freshwater chronic criterion concentration recommended for use nationally by EPA for the protection of aquatic life[40]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a). The process used in the criteria document clearly outlines the consideration of sublethal effects data from which this criterion was derived.

Table 2.1.14-2 presents a compilation of the GMAVs from Table 2.1.14-1, any experimentally determined SMCVs obtained from the criteria document and EPA ECOTOX download used for the BE, and estimated SMCVs based on the GMAV/ACR. The 2003 criteria document for tributyltin[41] reported an FACR of 12.69, which EPA calculated as the geometric mean of four experimentally determined ACRs ranging from 4.7 for an acutely sensitive saltwater invertebrate, the mysid (*Acanthomysis sculpta*) to 36.6 for an acutely sensitive invertebrate, *Daphnia magna*. EPA determined the FACR of 12.69 with the ACRs from two freshwater species (*Daphnia magna*, *Pimephales promelas*) and two saltwater species (*Acanthomysis sculpta, Eurytemora affinis*). Since no additional acceptable ACRs are available, EPA calculated the predicted GMCVs for tributyltin in Table 2.1.14-2 using the FACR of 12.69 and the following equation: Predicted GMCV = GMAV/FACR.

EPA compared the SMCVs for each species to Oregon's tributyltin chronic criterion to determine whether the chronic criterion will protect the aquatic life designated use.

Table 2.1.14-2: Species Mean Chronic Values (SMCVs) for Tributyltin

Genus	**Species**	**Common name**	**GMAV (µg/L)**	**SMCV (µg/L)** (*experimentally derived*)	**Chronic References** (*used in the calculation of the SMCV*)	**Predicted GMCV (µg/L)**
Elliptio	complanata	Mussel, Eastern elliptio	24600			1939
Salvelinus	naymaycush	Lake Trout	12.73			1.003
Culex	sp.	Mosquito	10.20			0.8038
Lepomis	macrochirus	Bluegill	8.300			0.6541
Ictalurus	punctatus	Channel catfish	5.500			0.4334
Lumbriculus	variegatus	Annelid	5.400			0.4255
Oncorhynchus	mykiss	Rainbow trout	4.571			0.3602
Daphnia	magna	Cladoceran	4.300	0.1896	1,2	0.3388 (0.1896)
Gammarus	***pseudolimnaeus****	***Scud***	3.700			0.2916

[40] See footnote 41 above.
[41] U.S. EPA. 2003. Ambient Water Quality Criteria Document for Tributyltin (TBT) - Final. EPA-822/R-03-031.

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) (*experimentally derived*)	Chronic References (*used in the calculation of the SMCV*)	Predicted GMCV (µg/L)
Pimephales	***promelas***	***Fathead minnow***	2.600	0.2598	1	0.2049 (0.2598)
Chlorohydra	***viridissima****	***Hydra***	1.800			0.1418
Hydra	***littoralis****	***Hydra***	-			-
Hydra	***oligactis****	***Hydra***	1.170			0.09220

See same notes as above under Table 2.1.14-1.

B. Evaluation of the Protectiveness of the Oregon Freshwater Chronic Criterion

Following the review of the SMCV values in Table 2.1.14-2, all tested genera and species had values greater than Oregon's chronic criterion for tributyltin. Therefore, EPA concluded that chronic effects are not expected to occur at concentrations lower than the criterion and thus these species would be protected.

2.1.14.3 References for Tributyltin

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in Tables 2.1.14-1 and 2.1.148-2*)
Acute References	
1	TAI Environmental Sciences Inc. 1989a. Toxicity of Tri-butyl Tin Oxide to Two Species of Hydra. Mobile, AL: 31 pp.
2	TAI Environmental Sciences Inc. 1989b. Toxicity of Tri-butyl Tin Oxide to *Hydra littoralis* and *Chlorohydra viridissima*. Mobile, AL: 25 pp.
3	Brooke, L.T., D.J. Call, S.H. Poirier, T.P. Markee, C.A. Lindberg, D.J. McCauley and P.G. Simonson. 1986. Acute Toxicity and Chronic Effects of Bis(tri-n-butyltin) Oxide to Several Species of Freshwater Organisms. Center for Lake Superior Environmental Studies, University of Wisconsin-Superior, Superior, WI: 20 pp.
4	ABC Laboratories, Inc. 1990a. Acute 96-hour Flow-Through Toxicity of Bis(tri-n-butyltin) Oxide to Rainbow Trout (*Oncorhynchus mykiss*). ABC study number 38306. Analytical Bio-Chemistry Laboratories, Inc., Columbia, MO: 277 pp.
5	Martin, R.C., D.G. Dixon, R.J. Maguire, P.J. Hodson and R.J. Tkacz. 1989. Acute toxicity, uptake, depuration and tissue distribution of tri-n-butyltin in rainbow trout, *Salmo gardneri*. Aquat. Toxicol. 15: 37-52.
6	ABC Laboratories, Inc. 1990b. Acute 96-hour Flow-through Toxicity of Bis(tri-n-butyltin) Oxide to Bluegill (*Lepomis macrochirus*). ABC study number 38307. Analytical Bio-Chemistry Laboratories, Inc.,Columbia, MO: 279 pp.
7	Buccafusco, R. 1976a. Acute Toxicity of Tri-n-butyltin Oxide to Channel Catfish (*Ictalurus punctatus*), the Freshwater Clam (*Elliptio camplanatus*), the Common Mummichog (*Fundulus heteroclitus*) and the Eastern Oyster (*Crassostrea virginica*). U.S. EPA-OPP Registration Standard.
Chronic References	
1	Brooke, L.T., D.J. Call, S.H. Poirier, T.P. Markee, C.A. Lindberg, D.J. McCauley and P.G. Simonson. 1986. Acute Toxicity and Chronic Effects of Bis(tri-n-butyltin) Oxide to Several Species of Freshwater Organisms. Center for Lake Superior Environmental Studies, University of Wisconsin-Superior, Superior, WI: 20 pp.
2	ABC Laboratories, Inc. 1990d. Chronic Toxicity of Bis(tributyltin) Oxide to *Daphnia magna*. ABC report number 38310. Analytical Bio-Chemistry Laboratories, Inc., Columbia, MO: 318 pp.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For full descriptions, see Appendix M.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[42], EPA is providing a transparent rationale as to why they were not utilized (see below).
2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix M).

[42] U.S. EPA. 2003. Ambient Water Quality Criteria Document for Tributyltin (TBT) - Final. EPA-822/R-03-031.

2.1.15 ZINC

2.1.15.1 Evaluation of the Acute Freshwater Criterion Concentration for Zinc

A. Presentation of Toxicological Data

Oregon adopted a freshwater criterion concentration of 120 µg/L for zinc that is expressed as a function of total hardness in the water column and in terms of the dissolved concentration of the metal. This dissolved metal concentration reflects the criterion normalized to a total hardness of 100 mg/L as $CaCO_3$ and is the same as the freshwater CMC recommended for use nationally by EPA for the protection of aquatic life[43]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.15-1 provides available GMAVs based on available acute toxicity data for zinc to aquatic life from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.1.15-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Zinc

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Argia	sp.	Damselfly	156530	156530	25
Gambusia	affinis	Mosquitofish	57309	57309	63
Crangonyx	pseudogracilis	Amphipod	34839	34839	61
Xenopus	laevis	Clawed toad	33741	33741	62
Nais	sp.	worm	32376	32376	56
Fundulus	diaphanus	Banded killifish	31566	31566	53,54
Amnicola	sp.	Spire snail	29596	29596	56
Carassius	auratus	Goldfish	29256	29256	49,50,59,60
Chironomus	tentans	Midge	25958	25958	58
Anguilla	rostrata	American eel	23983	23983	53,54
Asellus	aquaticus	Aquatic sowbug	32024	-	61
Asellus	communis	Isopod	20428	-	25
Asellus	bicrenata	Isopod	10084	18755	42
Lepomis	gibbosus	Pumpkinseed	33062	-	53,54
Lepomis	macrochirus	Bluegill	10446	18584	47,48
Lumbriculus	variegatus	Oligochaete, worm	17089	17089	57
Gammarus	sp.	Scud, Amphipod	14252	14252	56
Cyprinus	carpio	Common carp	12727	12727	53,54,55
Poecilia	reticulata	Guppy	10651	10651	49,50,51
Notemigonus	crysoleucas	Golden shiner	10557	10557	49
Corbicula	manilensis	Asiatic clam	8622	8622	44,45
Xiphophorus	maculatus	Southern platyfish	7638	7638	43
Ptychocheilus	oregonensis	Northern squawfish	11578	-	52
Ptychocheilus	lucius	Colorado squawfish	3026	5919	32,33,34
Lirceus	alabamae	Isopod	5745	5745	42
Pimephales	promelas	Fathead minnow	5185	5185	36,37,38,39,40,41

[43] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are from the 1995 Great Lakes Initiative Updates to these criteria as cited in: U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	**Acute References** *(used in the calculation of the SMAV)*
Salmo	salar	Atlantic salmon	3829	3829	35
Xyrauchen	texanus	Razorback sucker	3816	3816	32,33,34
Salvelinus	fontinalis	Brook trout	3695	3695	21
Gila	elegans	Bonytail	3229	3229	33,34
Catostomus	commersoni	White sucker	9199	-	46
Catostomus	latipinnis	Flannelmouth sucker	1063	3127	15
Lophopodella	carteri	Bryozoa	3004	3004	28
Jordanella	floridae*	Flagfish	2942	2942	29,30
Plumatella	emarginata	Bryozoan	2828	2828	28
Helisoma	campanulatum	Snail	2777	2777	24
Physa	gyrina	Pouch snail	2961	-	31
Physa	heterostropha	Snail	1914	2381	24,25,26,27
Pectinatella	magnifica	Bryozoa	2300	2300	28
Limnodrilus	hoffmeisteri	Tubificid worm	2224	2224	25
Oncorhynchus	kisutch	Coho salmon	2865	-	19
Oncorhynchus	nerka	Sockeye salmon	2643	-	12,29
Oncorhynchus	mykiss	Rainbow trout	1135	-	12,13,16,17,18,19,20,21,22
Oncorhynchus	tshawytscha	Chinook salmon	785.5	1612	12,13,14
Oreochromis	mossambica	Mozambique tilapia	1390	1390	23
Utterbackia	imbecillis	Mussel	582.1	582.1	10
Daphnia	***magna***	***Water flea***	625.5	-	11
Daphnia	***pulex***	***Water flea***	445.0	527.6	1,9
Agosia	***chrysogaster****	***Longfin dace***	400.8	400.8	8
Morone	***saxatilis***	***Striped bass***	210.1	210.1	7
Ceriodaphnia	***dubia***	***Water flea***	117.0	-	3,4,5,6
Ceriodaphnia	***reticulata***	***Water flea***	89.21	102.2	1,2

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV in the 1995 GLI update of the ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera used in the derivation of the 304(a) criteria are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision, particularly for metals such as zinc which are normalized to a water hardness of 100 mg/L as $CaCO_3$ and expressed on a dissolved metal basis for a comparison with the acute criterion concentration.

B. Evaluation of the Protectiveness of the Oregon Freshwater Acute Criterion

Following review of GMAV values in Table 2.1.15-1, 40 of the 41 tested genera had values greater than Oregon's acute criterion concentration for zinc. Therefore, EPA concluded that acute effects to these genera are not expected to occur at concentrations equal to or lower than the criterion, and thus these genera and the aquatic life designated use would be expected to be protected.

When compared to Oregon's acute criterion concentration for zinc, SMAV/2 values for three test species (two planktonic cladocerans and one non-salmonid fish) were lower than the acute criterion concentration of 120 µg/L dissolved zinc. All three of these species are expected to reside in Oregon waters. Therefore, EPA reviewed the data from the studies that make up the most representative SMAV for *C. reticulata, C. dubia,* and *M. saxatilis* and compared the confidence intervals of the SMAV for these species to determine whether the SMAV/2 values are quantitatively different from the criterion value of 120 µg/L.

The overall hardness adjusted SMAV for *C. reticulata* was 89.21 µg/L, with 5 and 95 percent confidence intervals of 71.23 and 111.3 µg/L. When divided by two, the SMAV/2 for *C. reticulata* was 44.60 µg/L (text box A - *C. reticulata* acute), less than the Oregon criterion concentration of 120 µg/L.

The overall hardness adjusted SMAV for *C. dubia* was 117.0 µg/L, with 5 and 95 percent confidence intervals of 96.29 and 142.8 µg/L. When divided by two, the SMAV/2 for *C. reticulata* was 58.52 µg/L (text box B - *C. dubia* acute) , less than the Oregon criterion concentration of 120 µg/L.

The overall hardness adjusted SMAV for *M. saxatilis* was 210.1 µg/L, with 5 and 95 percent confidence intervals of 118.4 and 272.4 µg/L. When divided by two, the SMAV/2 for *C. reticulata* was 105.0 µg/L (text box C – *M. saxatilis* acute), less than the Oregon criterion concentration of 120 µg/L.

Because the Oregon acute criterion for zinc is greater than the SMAV/2 for *C. reticulata ,C. dubia*, and *M. saxatilis*, EPA concludes that the occurrence of ambient concentrations equal to or greater than the Oregon CMC for zinc may result in some level of acute toxicity to individuals of this species.

Freshwater zinc acute criterion comparison

Text Box A (acute) – Basis for the meta analysis comparing the SMAV/2 for the cladoceran (*C. reticulata*) to the acute criterion for zinc (120 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Ceriodaphnia reticulata								
	Reported Values			**Hardness Normalized Values**			**Hardness Normalized Values/2**	
Hardness	LC50	5% CI	95% CI	LC50	5% CI	95% CI	LC50 / 2	CMC
45	41.00	32.00	52.00	78.88	61.56	100.0	39.44	120
45	32.00	26.00	40.00	61.56	50.02	76.95	30.78	
45	76.00	61.00	93.00	146.2	117.4	178.9	73.11	
				SMAV			**SMAV/2**	
Geomean	46.37	37.02	57.83	89.21	71.23	111.3	44.60	

Text Box B (acute) – Basis for the meta analysis comparing the SMAV/2 for the cladoceran (*C. dubia*) to the acute criterion for zinc (120 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Ceriodaphnia dubia								
	Reported Values			**Hardness Normalized Values**			**Hardness Normalized Values/2**	
Hardness	LC50	5% CI	95% CI	LC50	5% CI	95% CI	LC50 / 2	CMC

207	360	300	440	190.1	158.4	232.3	95.04	120
52	180	105	305	306.4	178.7	519.1	153.2	
114	65	41	93	57.06	35.99	81.64	28.53	
114	120	101	162	105.3	88.66	142.2	52.67	
114	131	112	154	115.0	98.32	135.2	57.50	
182	105	96	115	61.83	56.53	67.71	30.91	
182	123	108	140	72.42	63.59	82.43	36.21	
182	153	147	164	90.09	86.56	96.57	45.04	
98	70	60	81	69.88	59.90	80.87	34.94	
98	101	92	112	100.8	91.85	111.8	50.42	
98	109	93	126	108.8	92.85	125.8	54.41	
207	500	410	620	264.0	216.5	327.4	132.0	
80	199	170	229	235.5	200.3	270.7	117.7	
				SMAV			**SMAV/2**	
Geomean	142.6	117.3	173.9	117.0	96.29	142.8	58.52	

Text Box C (acute) – Basis for the meta analysis comparing the SMAV/2 for the striped bass (*M. saxatilis*) to the acute criterion for zinc (120 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Monroe saxatilis								
	Reported Values			**Hardness Normalized Values**			**Hardness Normalized Values/2**	
Hardness	LC50	5% CI	95% CI	LC50	5% CI	95% CI	LC50 / 2	CMC
42	120	80	170	255.1	96.65	361.4	127.5	120
285	430	360	510	173.1	145.0	205.4	86.55	
				SMAV			**SMAV/2**	
Geomean	227.2	169.7	294.4	210.1	118.4	272.4	105.0	

2.1.15.2 Evaluation of the Chronic Freshwater Criterion Concentration for Zinc

A. Presentation of Toxicological Data

Oregon adopted a freshwater chronic criterion concentration of 120 µg/L for zinc expressed as the dissolved metal concentration at a total hardness of 100 mg/L $CaCO_3$ in the water column. This concentration is the same as the freshwater CCC recommended for use nationally by EPA for the protection of aquatic life[44]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.1.15-2 presents a compilation of the GMAVs from Table 2.1.15-1, any experimentally determined SMCVs obtained from the criteria document and EPA ECOTOX download used for the BE, and estimated GMCVs based on the GMAV/ACR. The 1995 update of the criteria document for zinc[45] reported an FACR of 2.0. Because of the large range in ACRs (0.7027 to 41.20) and trend of lower ACRs for the most acutely sensitive species, EPA determined that only the experimentally- determined ACRs for the freshwater *Daphnia magna*, chinook salmon, and

[44] See footnote 45 above.
[45] U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

rainbow trout, were the most appropriate ACRs to protect sensitive species in general. The geometric mean of the three species ACRs is 1.994. However, according to the 1985 Guidelines, the FACR cannot be less than 2.0. Since no additional acceptable ACRs are available, EPA calculated the predicted GMCVs for zinc in Table 2.1.15-2 using an ACR of 2.0 and the following equation: Predicted GMCV = GMAV/FACR.

EPA compared the GMCVs for each species to Oregon's zinc chronic criterion to determine whether the chronic criterion will protect Oregon's aquatic life designated use.

Table 2.1.15-2: Genus Mean Chronic Values (GMCVs) for Zinc

Genus	**Species**	**Common name**	**GMAV (µg/L)**	**SMCV (µg/L)** (*experimentally derived*)	**Chronic References** *(used in the calculation of the SMCV)*	**Predicted GMCV (µg/L)**
Argia	sp.	Damselfly	156530			78265
Gambusia	affinis	Mosquitofish	57309			28655
Crangonyx	pseudogracilis	Amphipod	34839			17420
Xenopus	laevis	Clawed toad	33741			16871
Nais	sp.	worm	32376			16188
Fundulus	diaphanus	Banded killifish	31566			15783
Amnicola	sp.	Spire snail	29596			14798
Carassius	auratus	Goldfish	29256			14628
Clistoronia	magnifica	Caddisfly	-	>13945	13	(>13945)
Chironomus	tentans	Midge	25958			12979
Anguilla	rostrata	American eel	23983			11991
Asellus	aquaticus	Aquatic sowbug	-			-
Asellus	communis	Isopod	-			-
Asellus	bicrenata	Isopod	18755			9377
Lepomis	gibbosus	Pumpkinseed	-			-
Lepomis	macrochirus	Bluegill	18584			9292
Lumbriculus	variegatus	Oligochaete, worm	17089			8544
Gammarus	sp.	Scud, Amphipod	14252			7126
Cyprinus	carpio	Common carp	12727			6363
Poecilia	reticulata	Guppy	10651	<473.1	7	5325 (<473.1)
Notemigonus	crysoleucas	Golden shiner	10557			5279
Corbicula	manilensis	Asiatic clam	8622			4311
Xiphophorus	maculatus	Southern platyfish	7638			3819
Ptychocheilus	oregonensis	Northern squawfish	-			-
Ptychocheilus	lucius	Colorado squawfish	5919			2959
Lirceus	alabamae	Isopod	5745			2872
Pimephales	promelas	Fathead minnow	5185	268.2	5,6	2593 (268.2)
Salmo	salar	Atlantic salmon	3829			1914
Xyrauchen	texanus	Razorback sucker	3816			1908
Salvelinus	fontinalis	Brook trout	3695	1630	12	1848 (1630)
Gila	elegans	Bonytail	3229			1615
Catostomus	commersoni	White sucker	-			-
Catostomus	latipinnis	Flannelmouth sucker	3127			1563
Lophopodella	carteri	Bryozoa	3004			1502
Jordanella	floridae*	Flagfish	2942	71.99	1,2	1471 (71.99)
Plumatella	emarginata	Bryozoan	2828			1414
Helisoma	campanulatum	Snail	2777			1388

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) (*experimentally derived*)	Chronic References (*used in the calculation of the SMCV*)	Predicted GMCV (µg/L)
Physa	gyrina	Pouch snail	-			-
Physa	heterostropha	Snail	2381			1190
Pectinatella	magnifica	Bryozoa	2300			1150
Limnodrilus	hoffmeisteri	Tubificid worm	2224			1112
Oncorhynchus	kisutch	Coho salmon	-			-
Oncorhynchus	nerka	Sockeye salmon	-	>595.2	8	-
Oncorhynchus	mykiss	Rainbow trout	-	1282	10,11	-
Oncorhynchus	tshawytscha	Chinook salmon	1612	1184	8,9	805.9 (>966.9)
Oreochromis	mossambica	Mozambique tilapia	1390			695.0
Utterbackia	imbecillis	Mussel	582.1			291.0
Daphnia	***magna***	***Water flea***	-	100.1	3,4	-
Daphnia	***pulex***	***Water flea***	527.6			263.8 (100.1)
Agosia	***chrysogaster****	***Longfin dace***	400.8			200.4
Morone	***saxatilis***	***Striped bass***	210.1			105.0
Ceriodaphnia	***dubia***	***Water flea***	-			-
Ceriodaphnia	***reticulata***	***Water flea***	102.2			51.09

See same notes as above under Table 2.1.15-1.

B. Evaluation of the Protectiveness of the Oregon Freshwater Chronic Criterion

Following the review of the GMCV values in Table 2.1.15-2, 39 of the 41 genera have GMCVs greater than Oregon's chronic criterion for zinc. Therefore, EPA concluded that chronic effects are not expected to occur at concentrations lower than the criterion and thus these species and designated use would be protected.

When compared to Oregon's CCC for zinc, SMCV values for four Oregon resident test species (three planktonic cladocerans – *C. reticulata, C. dubia*, and *D. magna*, and the striped bass *M. saxatilis*) were lower than the CCC of 120 µg/L for zinc. Therefore, EPA reviewed the data from the studies that make up the most representative SMCVs for each of those species and, depending on whether the SMCV was estimated based on the use of the ACR or experimentally determined based on NOEC and LOECs, compared the confidence intervals (ACR approach) or LOEC values surrounding these SMCVs to determine whether the SMCV values were quantitatively different from the chronic criterion value for zinc of 120 µg/L. A fifth species, the flagfish *J. floridae*, also had a SMCV below the CCC for zinc, but it is not resident in Oregon waters and was therefore not included in this analysis.

The SMCV for *C. reticulata* was estimated by applying the ACR of 2.0 described above to the SMAV and the 5 and 95 percent confidence intervals surrounding the SMAV for each test performed by Carlson and Roush (1985), and taking the geometric mean of the values. The final SMCV was 44.60 µg/L (text box D - *C. reticulata* chronic).

The SMCV for *C. dubia* was estimated by applying the ACR of 2.0 described above to the SMAV and the 5 and 95 percent confidence intervals surrounding the SMAV for all studies with this test species, and taking the geometric mean of the values. The final SMCV was 58.52 µg/L (text box E - *C. dubia* chronic).

The SMCV for *D. magna* was calculated as the geometric mean of the measured LOEC and NOEC for two replicate tests in Biesenger et al. (1986) and three tests across a water hardness gradient by Chapman et al. (1980). The final hardness normalized dissolved SMCV was 100.1 µg/L, with hardness normalized dissolved NOEC and LOEC values of 79.08 and 126.7 µg/L, respectively (text box F – *D. magna* chronic).

The SMCV for *M. saxatilis* was estimated by applying the ACR of 2.0 described above to the SMAV and the 5 and 95 percent confidence intervals surrounding the SMAV for both tests with this species, and taking the geometric mean of the values. The final SMCV was 105.0 µg/L (text box G – *M. saxatilis* chronic).

Because the Oregon chronic criterion for zinc is greater than the SMCV for *C. reticulata* and *C. dubia*, EPA concludes that the Oregon CMC for silver may not protect all individuals of this species. Because the Oregon chronic criterion for zinc is below the upper confidence interval surrounding the SMCV for *M. saxatilis*, EPA concludes that the Oregon CCC for zinc is protective of this species. Finally, because the Oregon chronic criterion for zinc is below the LOEC for *D. magna*, EPA concludes that the Oregon CCC for zinc is protective of this species.

Freshwater zinc chronic criterion comparison

Text Box D (chronic) – Basis for the meta analysis comparing the SMCV for the cladoceran (*C. reticulata*) to the chronic criterion for zinc (120 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Ceriodaphnia reticulata											
	Reported Values			**Hardness Normalized Values**				**Hardness Normalized Chronic Values**			
Hardness	LC50	5% CI	95% CI	LC50	5% CI	95% CI	ACR	LC50 / ACR	5% CI / ACR	95% CI / ACR	CCC
45	41	32	52	78.88	61.56	100.0	2.0	39.44	30.78	50.02	120
45	32	26	40	61.56	50.02	76.95		30.78	25.01	38.48	
45	76	61	93	146.2	117.4	178.9		73.11	58.68	89.46	
								SMCV			
Geomean	46.37	37.02	57.83	89.21	71.23	111.3		44.60	35.61	55.63	

Text Box E (chronic) – Basis for the meta analysis comparing the SMCV for the cladoceran (*C. dubia*) to the chronic criterion for zinc (120 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Ceriodaphnia dubia									
	Reported Values			**Hardness Normalized Values**				**Hardness Normalized Chronic Values**	
Hardness	LC50	5% CI	95% CI	LC50	5% CI	95% CI	ACR	LC50 / ACR	CCC
207	360	300	440	190.1	158.4	232.3	2.0	95.04	120
52	180	105	305	306.4	178.7	519.1		153.2	
114	65	41	93	57.06	35.99	81.64		28.53	

114	120	101	162	105.3	88.66	142.2		52.67	
114	131	112	154	115.0	98.32	135.2		57.50	
182	105	96	115	61.83	56.53	67.71		30.91	
182	123	108	140	72.42	63.59	82.43		36.21	
182	153	147	164	90.09	86.56	96.57		45.04	
98	70	60	81	69.88	59.90	80.87		34.94	
98	101	92	112	100.8	91.85	111.8		50.42	
98	109	93	126	108.8	92.85	125.8		54.41	
207	500	410	620	264.0	216.5	327.4		132.0	
80	199	170	229	235.5	200.3	270.7		117.7	
								SMCV	
Geomean	142.6	117.3	173.9	117.0	96.3	142.8		58.52	

Text Box F (chronic) – Basis for the meta analysis comparing the SMCV for the cladoceran (*D. magna*) to the chronic criterion for zinc (120 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Daphnia magna							
	Reported Chronic Values			**Hardness Normalized Chronic Values**			
Hardness	NOEC	LOEC	CV	NOEC	LOEC	CV	CCC
45	74	140.3	101.9	143.5	272.1	197.6	120
45	74	140.3	101.9	143.5	272.1	197.6	
52	97	190	135.8	166.4	326.0	233.0	
104	43	52	47.29	41.01	49.60	45.10	
211	42	52	46.73	22.00	27.23	24.48	
						SMCV	
Geomean	62.57	100.2	79.19	79.08	126.7	100.1	

Text Box G (chronic) – Basis for the meta analysis comparing the SMCV for the striped bass (*M. saxatilis*) to the chronic criterion for zinc (120 µg/L dissolved metal concentration normalized to a hardness of 100 mg/L as $CaCO_3$).

Monroe saxatilis									
	Reported Values			**Hardness Normalized Values**				**Hardness Normalized Chronic Values**	
Hardness	LC50	5% CI	95% CI	LC50	5% CI	95% CI	ACR	LC50 / ACR	CCC
40	120	80	170	255.1	96.65	361.4	2.0	127.5	120
285	430	360	510	173.2	145.0	205.4		86.58	
								SMCV	
Geomean	227.2	169.7	294.4	210.1	118.4	272.4		105.0	

2.1.15.3 References for Zinc

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in tables 2.1.15-1 and 2.1.15-2*)
Acute References	
1	Mount, D.I. and T.J. Norberg. 1984. A seven-day life-cycle cladoceran toxicity test. Environ. Toxicol. Chem. 3(3): 425-434 (Author Communication Used).
2	Carlson, A.R. and T.H. Roush. 1985. Site-specific Water Quality Studies of the Straight River, Minnesota: Complex Effluent Toxicity, Zinc Toxicity, and Biological Survey Relationships. EPA-600/3-85-005. National Technical Information Service, Springfield, VA.
3	Carlson, A.R., H. Nelson and D. Hammermeister. 1986. Evaluation of Site-Specific Criteria for Copper and Zinc: An Integration of Metal Addition Toxicity, Effluent and Receiving Water Toxicity, and Ecological Survey Data. EPA-600/3-86-026, U.S. EPA, Duluth, MN: 68 p. (U.S. NTIS PB86-183928) (Publ in Part As 12161).
4	Magliette, R.J., F.G. Doherty, D. McKinney and E.S. Venkataramani. 1995. Need for environmental quality guidelines based on ambient freshwater quality criteria in natural waters--Case study "zinc". Bull. Environ. Contam. Toxicol. 54(4): 626-632.
5	Belanger, S.E. and D.S. Cherry. 1990. Interacting effects of pH acclimation, pH, and heavy metals on acute and chronic toxicity to *Ceriodaphnia dubia* (Cladocera). J. Crustac. Biol. 10(2): 225-235
6	Diamond, J.M., D.E. Koplish, J. McMahon III and R. Rost. 1997. Evaluation of the water-effect ratio procedure for metals in a riverine system. Environ. Toxicol. Chem. 16(3): 509-520.
7	Palawski, D., J.B. Hunn and F.J. Dwyer. 1985. Sensitivity of young striped bass to organic and inorganic contaminants in fresh and saline waters. Trans. Am. Fish. Soc. 114: 748-753
8	Lewis, M. 1978. Acute toxicity of copper, zinc, and manganese in single and mixed salt solutions to juvenile longfin dace, *Agosia chrysogaster*. J. Fish Biol. 13(6): 695-700.
9	Cairns, J., Jr., A.L. Buikema, A.G. Heath and B.C. Parker. 1978. Effects of Temperature on Aquatic Organism Sensitivity to Selected Chemicals. Va. Water Resour. Res. Center, Bull. 106, Office of Water Res. and Technol., OWRT Project B-084-VA, VA. Polytech. Inst. State Univ., Blacksburg, VA: 1-88
10	Keller, A.E. and S.G. Zam. 1991. The acute toxicity of selected metals to the freshwater mussel, *Anodonta imbecilis*. Environ. Toxicol. Chem. 10(4): 539-546
11	Attar, E.N. and E.J. Maly. 1982. Acute toxicity of cadmium, zinc, and cadmium-zinc mixtures to *Daphnia magna*. Arch. Environ. Contam. Toxicol. 11(3): 291-296.
12	Chapman, G.A. 1975. Toxicity of Copper, Cadmium and Zinc to Pacific Northwest Salmonids. Interim report. U.S. EPA, Corvallis, OR. Available from: C.E. Stephan, U.S. EPA, Duluth, MN.
13	Chapman, G.A. 1978b. Toxicities of cadmium, copper, and zinc to four juvenile stages of Chinook salmon and steelhead. Trans. Am. Fish. Soc. 107(6): 841-847
14	Finlayson, B.J. and K.M. Verrue. 1982. Toxicities of copper, zinc, and cadmium mixtures to juvenile Chinook salmon. Trans. Am. Fish. Soc. 111(5): 645-650.
15	Hamilton, S.J. and K.J. Buhl. 1997a. Hazard evaluation of inorganics, singly and in mixtures, to flannelmouth sucker *Catostomus latipinnis* in the San Juan River, New Mexico. Ecotoxicol. Environ. Saf. 38(3): 296-308
16	Alsop, D.H. and C.M. Wood. 1999. Influence of waterborne cations on zinc uptake and toxicity in rainbow trout, *Oncorhynchus mykiss*. Can. J. Fish. Aquat. Sci. 56(11): 2112-2119
17	Goettl, J.P., Jr., J.R. Sinley and P.H. Davies. 1974. Water pollution studies. In: Colorado Fisheries Research Review. Review No. 9. Colorado Division of Wildlife, Fort Collins, CO: 36-44.
18	Goettl, J.P., Jr., P.H. Davies and J.R. Sinley. 1976. Water pollution studies. In: D.B. Cope (Ed.), Colorado Fisheries Research Review 1972-1975, DOW-R-R-F72-75, Colorado Division of Wildlife, Boulder, CO :68-75
19	Chapman, G.A. and D.G. Stevens. 1978. Acute lethal levels of cadmium, copper, and zinc to adult male Coho salmon and steelhead. Trans. Am. Fish. Soc. 107(6): 837-840.
20	Sinley, J.R., J.P. Goettl, Jr. and P.H. Davies, 1974. The effects of zinc on rainbow trout (*Salmo gairdneri*) in hard and soft water. Bull. Environ. Contam. Toxicol. 12(2): 193-201.
21	Holcombe, G.W. and R.W. Andrew. 1978. The Acute Toxicity of Zinc to Rainbow and Brook Trout: Comparisons in Hard and Soft Water. EPA-600/3-78-094, U.S. EPA, Duluth, MN.
22	Cusimano, R.F., D.F. Brakke and G.A. Chapman. 1986. Effects of pH on the toxicities of cadmium, copper, and zinc to steelhead trout (*Salmo gairdneri*). Can. J. Fish. Aquat. Sci. 43(8): 1497-1503.
23	Qureshi, S.A. and A.B. Saksena. 1980. The acute toxicity of some heavy metals to *Tilapia mossambica* (Peters). Aqua 1: 19-20.
24	Wurtz, C.B. 1962. Zinc effects on fresh water mollusks. Nautilus 76: 53-61.
25	Wurtz, C.B. and C.H. Bridges. 1961. Preliminary results from macroinvertebrate bioassays. Proc. Pa. Acad. Sci. 35: 51-56.
26	Cairns, J., Jr. and A. Scheier. 1958. The effects of temperature and hardness of water upon the toxicity of zinc to the pond snail, Physa heterostropha (Say). Notulae Naturae, No. 308-1-11.
27	Academy of Natural Sciences. 1960. The Sensitivity of Aquatic Life to Certain Chemical Commonly Found in Industrial Wastes. Philadelphia, PA.
28	Pardue, W.J. and T.S. Wood. 1980. Baseline toxicity data for freshwater bryozoa exposed to copper, cadmium, chromium, and zinc. J. Tenn. Acad. Sci. 55(1): 27-31
29	Chapman, G.A. 1978a. Effects of continuous zinc exposure on sockeye salmon during adult-to-smolt freshwater residency. Trans. Am. Fish. Soc. 107(6): 828-836
29	Spehar, R.L. 1976a. Cadmium and Zinc Toxicity to *Jordanella floridae*. EPA-600/3-76-096. National Technical

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in tables 2.1.15-1 and 2.1.15-2*)
	Information Service, Springfield, VA.
31	Nebeker, A.V., A. Stinchfield, C. Savonen and G.A. Chapman. 1986. Effects of copper, nickel and zinc on three species of Oregon freshwater snails. Environ. Toxicol. Chem. 5(9): 807-811.
32	Hamilton, S.J. and K.J. Buhl. 1997b. Hazard assessment of inorganics, individually and in mixtures, to two endangered fish in the San Juan River, New Mexico. Environ. Toxicol. Water Qual. 12: 195-209
33	Hamilton, S.J. 1995. Hazard assessment of inorganics to three endangered fish in the Green River, Utah. Ecotoxicol. Environ. Saf. 30(2): 134-142.
34	Buhl, K.J. and S.J. Hamilton. 1996. Toxicity of inorganic contaminants, individually and in environmental mixtures, to three endangered fishes (Colorado squawfish, bonytail, and razorback sucker). Arch. Environ.Contam. Toxicol. 30(1): 84-92
35	Carson, W.G. and W.V. Carson. 1972. Toxicity of Copper and Zinc to Juvenile Atlantic Salmon in the Presence of Humic Acid and Lignosulfonates. Fisheries Research Board of Canada Manuscript Report Series No. 1181. Biological Stations, St. Andrews, N.B., Canada.
36	Pickering, Q.H. and W.N. Vigor. 1965. The acute toxicity of zinc to eggs and fry of the fathead minnow. Prog. Fish-Cult. 27(3): 153-157.
37	Mount, D.I. 1966. The effect of total hardness and pH on acute toxicity of zinc to fish. Int. J. Air Water Pollut. 10: 49-56.
38	Brungs, W.A. 1969. Chronic toxicity of zinc to the fathead minnow. Trans. Am. Fish. Soc. 98(2): 272-279.
39	Benoit, D.A. and G.W. Holcombe. 1978. Toxic effects of zinc on fathead minnows (*Pimephales promelas*) in soft water. J. Fish Biol. 13(6): 701-708.
40	Broderius, S.J. and L.L. Smith, Jr. 1979. Lethal and sublethal effects of binary mixtures of cyanide and hexavalent chromium, zinc, or ammonia to the fathead minnow and rainbow trout. J. Fish. Res. Board Can. 36(2): 164-172.
41	Norberg-King, T.J. 1987. An Evaluation of the Fathead Minnow Seven-Day Subchronic Test for Estimating Chronic Toxicity. M.S. Thesis, University of Wyoming, Laramie, WY: 80 p.
42	Bosnak, A.D. and E.L. Morgan. 1981. Acute toxicity of cadmium, zinc, and total residual chlorine to epigean and hypogean isopods (Asellidae). Natl. Speleological Soc. Bull. 43: 12-18.
43	Rachlin, J.W. and A. Perlmutter. 1968. Response of an inbred strain of platyfish and the fathead minnow to zinc. Prog. Fish-Cult. 30(4): 203-207.
44	Cherry, D.S., J.H. Rodgers, Jr., R.L. Graney and J. Cairns, Jr. 1980. Dynamics and control of the Asiatic clam in the New River, Virginia. Bull. Va. Water Resour. Res. Cent. 123: 72.
45	Rodgers, J.H., Jr., D.S. Cherry, R.L. Graney, K.L. Dickson and J. Cairns, Jr. 1980. Comparison of heavy metal interactions in acute and artificial stream bioassay techniques for the Asiatic clam (*Corbicula fluminea*). In: Aquatic toxicology. Eaton, J.G., P.R. Parrish and A.C. Hendricks (Eds.). ASTM STP 707. American Society for Testing and Materials, Philadelphia, PA: 266-280.
46	Duncan, D.A. and J.F. Klaverkamp. 1983. Tolerance and resistance to cadmium in white suckers (*Catostomus commersoni*) previously exposed to cadmium, mercury, zinc, or selenium. Can. J. Fish. Aquat. Sci. 40(2): 128-138.
47	Cairns, J., Jr., T.K. Bahns, D.T. Burton, K.L. Dickson, R.E. Sparks and W.T. Waller. 1971. The effects of pH, solubility and temperature upon the acute toxicity of zinc to the bluegill sunfish (*Lepomis macrochirus* Raf.). Trans. Kans. Acad. Sci. 74: 81-92.
48	Cairns, J., Jr. and A. Scheier. 1959. The Relationship of Bluegill Sunfish Body Size to Tolerance for Some Common Chemicals. Proc. Ind. Waste Conf. Purdue Univ. 13: 243-252.
49	Cairns, J., Jr., W.T. Waller and J.C. Smrchek. 1969. Fish bioassays contrasting constant and fluctuating input of toxicants. Rev. Biol. 7: 75-91.
50	Pickering, Q.H. and C. Henderson. 1966. The acute toxicity of some heavy metals to different species to warmwater fishes. Air Water Pollut. Int. J. 10: 453-463.
51	Pierson, K.B. 1981. Effects of chronic zinc exposure on the growth, sexual maturity, reproduction, and bioaccumulation of the guppy, *Poecilia reticulata*. Can. J. Fish. Aquat. Sci. 38: 23-31.
52	Andros, J.D. and R.R. Garton. 1980. Acute lethality of copper, cadmium, and zinc to Northern squawfish. Trans. Am. Fish. Soc. 109(2): 235-238.
53	Rehwoldt, R., G. Bida and B. Nerrie. 1971. Acute Toxicity of copper, nickel, and zinc ions to some Hudson River fish species. Bull. Environ. Contam. Toxicol. 6(5): 445-448.
54	Rehwoldt, R., L.W. Menapace, B. Nerrie and D. Allessandrello. 1972. The effect of increased temperature upon the acute toxicity of some heavy metal ions. Bull. Environ. Contam. Toxicol. 8(2): 91-96.
55	Khangarot, B.S., A. Sehgal and M.K. Bhasin. 1983. Man and the biosphere-studies on Sikkim Himalayas. Part 1: Acute toxicity of copper and zinc to common carp *Cyprinus carpio* (Linn.) in soft water. Acta Hydrochim. Hydrobiol. 11(6):667-673.
56	Rehwoldt, R., L. Lasko, C. Shaw and E. Wirhowski. 1973. The acute toxicity of some heavy metal ions toward benthic organisms. Bull. Environ. Contam. Toxicol. 10(5): 291-294.
57	Bailey, H.C. and D.H.W. Liu. 1980. *Lumbriculus variegatus*, a benthic oligochaete, as a bioassay organism. In: J.C. Eaton, P.R. Parrish and A.C. Hendricks (Eds.), Aquatic Toxicology and Hazard Assessment, 3rd Symposium, ASTM STP 707, Philadelphia, PA: 205-215.
58	Khangarot, B.S. and P.K. Ray. 1989. Sensitivity of midge larvae of *Chironomus tentans fabricius* (Diptera Chironomidae) to heavy metals. Bull. Environ. Contam. Toxicol. 42(3): 325-330.

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in tables 2.1.15-1 and 2.1.15-2*)
59	Pickering, Q.H. and C. Henderson. 1964. The acute toxicity of some heavy metals to different species of warm water fishes. Proc. 19th Ind. Waste Conf., Purdue University, West Lafayette, IN: 578-591; Int. J. Air Water Pollut.10: 453-463 (1966) (Author Communication Used).
60	Nor, Y.M. 1990. Effects of organic ligands on toxicity of copper and zinc to *Carassius auratus*. Chem. Spec. Bioavail. 3(3): 111-115.
61	Martin, T.R. and D.M. Holdich. 1986. The acute lethal toxicity of heavy metals to peracarid crustaceans (with particular reference to fresh-water asellids and gammarids). Water Res. 20(9):1137-1147.
62	Dawson, D.A., E.F. Stebler, S.L. Burks and J.A. Bantle. 1988. Evaluation of the developmental toxicity of metal-contaminated sediments using short-term fathead minnow and frog embryo-larval assays. Environ. Toxicol. Chem. 7: 27-34.
63	Kallanagoudar, Y.P. and H.S. Patil. 1997. Influence of water hardness on copper, zinc and nickel toxicity to *Gambusia affinis* (B&G). J. Environ. Biol. 18(4): 409-413.
Chronic References	
1	Spehar, R.L. 1976a. Cadmium and Zinc Toxicity to *Jordanella floridae*. EPA-600/3-76-096, U.S.EPA, Duluth, MN: 34 (1976) / M.S. Thesis, Univ. of Minnesota, Minneapolis, MN: 67 p.
2	Spehar, R.L. 1976b. Cadmium and zinc toxicity to flagfish, *Jordanella floridae*. J. Fish. Res. Board. Can. 33: 1939-1945.
3	Biesinger, K.E., G.M. Christensen and J.T. Fiandt. 1986. Effects of metal salt mixtures on *Daphnia magna*. Ecotoxicol. Environ. Saf. 11: 9-14.
4	Chapman, G.A., S. Ota and F. Recht. Manuscript. Effects of Water Hardness on the Toxicity of Metals to *Daphnia magna*. Available from: C.E. Stephan, U.S. EPA, Duluth, MN.
5	Benoit, D.A. and G.W. Holcombe. 1978. Toxic effects of zinc on fathead minnows (*Pimephales promelas*) in soft water. J. Fish Biol. 13(6): 701-708.
6	Norberg-King, T.J. 1987. An Evaluation of the Fathead Minnow Seven-Day Subchronic Test for Estimating Chronic Toxicity. M.S. Thesis, University of Wyoming, Laramie, WY: 80 p.
7	Pierseon, K.B. 1981. Effects of chronic zinc exposure on the growth, sexual maturity, reproduction, and bioaccumulation of the guppy, *Poecilia reticulata*. Can. J. Fish. Aquat. Sci. 38: 23-31.
8	Chapman, G.A. 1978. Effects of continuous zinc exposure on sockeye salmon during adult-to-smolt freshwater residency. Trans. Am. Fish. Soc. 107(6): 828-836.
9	Chapman, G.A. 1975. Toxicity of copper, cadmium and zinc to Pacific northwest salmonids. Interim report. U.S. EPA, Corvallis, OR. Available from: C.E. Stephan, U.S. EPA, Duluth, MN.
10	Sinley, J.R., J.P. Goettl, Jr. and P.H. Davies. 1974. The effects of zinc on rainbow trout (*Salmo gairdneri*) in hard and soft water. Bull. Environ. Contam. Toxicol. 12(2): 193-201.
11	Cairns, M.A., R.R. Garton and R.A. Tubb. 1982. Use of fish ventilation frequency to estimate chronically safe toxicant concentrations. Trans. Am. Fish. Soc. 111(1): 70-77.
12	Holcombe, G.W., D.A. Benoit and E.N. Leonard. 1979. Long-term effects of zinc exposures on brook trout (*Salvelinus fontinalis*). Trans. Am. Fish. Soc. 108(1): 76-87.
13	Nebeker, A.V., C. Savonen, R.J. Baker and J.K. McCrady. 1984. Effects of copper, nickel and zinc on the life cycle of the caddisfly *Clistoronia magnifica* (Limnephilidae). Environ. Toxicol. Chem. 3(4): 645-649.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For full descriptions, see Appendix N.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[46], EPA is providing a transparent rationale as to why they were not utilized (see below).

[46] U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix N).

2.2 Saltwater

2.2.1 CADMIUM

2.2.1.1 Evaluation of the Acute Saltwater Criterion Concentration for Cadmium

A. Presentation of Toxicological Data

Oregon adopted a saltwater acute criterion concentration of 40 µg/L for cadmium that is expressed in terms of the dissolved concentration of the metal. This dissolved metal concentration is the same as the saltwater CMC recommended for use nationally by EPA for the protection of aquatic life[47]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.2.1-1 provides available GMAVs based on available acute toxicity data for cadmium to aquatic animals from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.2.1-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Cadmium

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Monopylephorus	cuticulatus	Tubificid	134190	134190	68
Tilapia	mossambica	Mozambique tilapia	79520	79520	74
Scorpaena	guttata	Scorpionfish	61628	61628	73
Cyprinodon	variegatus	Sheepshead minnow	49700	49700	25
Eohaustorius	estuarius	Amphipod	27824	27824	72
Tautogolabrus	adspersus	Cunner	25745	25745	71
Tubificoides	gabriellae	Oligochaete	23856	23856	68
Uca	pugilator	Fiddler crab	21111	21111	70
Fundulus	majalis	Striped killifish	20874	-	25
Fundulus	heteroclitus	Mummichog	18091	19433	69
Nassarius	obsoletus	Eastern mud snail	19055	19055	24,25
Neanthes	arenaceodentata	Polychaete worm	12759	12759	16,59
Cymatogaster	aggregata	Shiner perch	10934	10934	17
Loligo	opalescens	California market squid	10139	10139	17
Lagodon	rhomboides	Pinfish	9940	9940	67
Limnodriloides	verrucosus	Oligochaete	9940	9940	68
Mugil	curema	White mullet	11928	-	66
Mugil	cephalus	Striped mullet	7037	9161	65
Excirolana	sp.	Isopod	7952	7952	55
Dendraster	excentricus	Sand dollar	7356	7356	17
Limnoria	tripunctata	Wood borer	7077	7077	22
Nereis	virens	Polychaete worm	10054	-	24,25
Nereis	grubei	Polychaete	4672	6853	64
Diporeia	spp.	Amphipod	6660	6660	63
Urosalpinx	cinerea	Atlantic oyster drill	6560	6560	25

[47] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are from the 2001 ALC document as cited in: U.S. EPA. 2001. 2001 Update of Ambient Water Quality Criteria for Cadmium. EPA-822-R-01-001.

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Eurypanopeus	depressus	Mud crab	4871	4871	62
Carcinus	maenas	Green crab	4075	4075	25
Marinogammarus	obtusatus	Scud	3479	3479	61
Ctenodrilus	serratus	Polychaete worm	3149	3149	56
Pseudopleuronectes	americanus	Winter flounder	2916	2916	32
Ampelisca	abdita	Amphipod	2883	2883	60
Pectinaria	californiensis	Cone worm	2584	2584	59
Callinectes	sapidus	Blue crab	2578	2578	58
Asterias	forbesii	Common starfish	2398	2398	24,25
Ophryotrocha	diadema	Polychaete	2155	2155	56,57
Emerita	analoga	Pacific sand crab	2097	2097	55
Morula	granulata	Gastropod	2048	2048	54
Perna	viridis	Green mussel	1969	-	52,53
Perna	indica	Brown mussel	1933	1951	50,51
Nematostella	vectensis		1926	1926	49
Pseudodiaptomus	coronatus	Copepod	1698	1698	11
Mya	arenaria	Soft shell clam	1662	1662	24,25,48
Oncorhynchus	kisutch	Coho salmon	1491	1491	17
Litopenaeus	vannamei		1622	-	46,47
Litopenaeus	setiferus	Northern white shrimp	984.1	1264	45
Palaemonetes	pugio	Daggerblade grass shrimp	1972	-	43,44
Palaemonetes	vulgaris	Marsh grass shrimp	755.4	1220	42
Grandidierella	japonica	Scud	1163	1163	22
Corophium	insidiosum	Scud	1056	1056	22,27,41
Strongylocentrotus	droebachiensis	Green sea urchin	1789	-	17
Strongylocentrotus	purpuratus	Purple sea urchin	411.2	857.8	17,40
Crangon	sp.	Caridean shrimp	2246	-	39
Crangon	septemspinosa	Bay shrimp, Sand shrimp	318.1	845.3	25
Crassostrea	virginica	Eastern oyster	3777	-	38
Crassostrea	gigas	Pacific oyster	172.1	806.3	19,37
Rivulus	marmoratus	Rivulus	795.2	795.2	36
Nitocra	spinipes	Harpacticoid copepod	789.7	789.7	34,35
Palaemon	elegans	Rockpool prawn	775.3	775.3	33
Menidia	menidia	Atlantic silverside	775.2	775.2	32
Argopecten	irradians	Bay scallop	1471	-	31
Argopecten	ventricosus	Pacific calico scallop	393.6	761.0	30
Mytilus	edulis	Common bay mussel, blue mussel	1067	-	19,29
Mytilus	trossolus		502.0	731.8	28
Elasmopus	bampo	Scud	711.9	711.9	22,27
Mytilopsis	sallei	Santo Domingo, or falsemussel	705.7	705.7	26
Pagurus	longicarpus	Longwrist hermit crab	641.1	641.1	24,25
Chelura	terebrans	Amphipod	626.2	626.2	22
Leptocheirus	plumulosus	Amphipod	587.0	587.0	23
Jaeropsis	sp.	Isopod	407.5	407.5	22
Penaeus	duorarum	Northern pink shrimp	308.6	308.6	21
Cancer	irroratus	Rock crab	248.5	-	20
Cancer	magister	Dungeness crab	220.9	234.3	17,19
Amphiascus	tenuiremis	Harpacticoid copepod	222.7	222.7	18
Capitella	capitata	Polychaete worm	198.8	198.8	16
Scorpaenichthys	marmoratus	Cabezon	198.8	198.8	17
Tresus	nuttalli	Horse clam, Pacific gaper	586.5	-	15
Tresus	capax	Horse clam	55.66	180.7	15
Limulus	polyphemus	Horseshoe crab	166.7	166.7	14
Balanus	improvisus	Barnacle	159.0	159.0	13
Eurytemora	affinis	Calanoid copepod	146.8	146.8	12

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Acartia	clausi	Copepod	143.1	-	11
Acartia	tonsa	Calanoid copepod	118.0	129.9	9,10
Homarus	***americanus***	American lobster	77.53	77.53	8
Morone	***saxatilis***	Striped bass	74.55	74.55	7
Americamysis	***bigelowi****	Shrimp	109.3	-	4
Americamysis	***bahia****	Opossum shrimp	42.59	68.24	3,4,5,6
Nucella	lapillus*	Dog whelk, Atlantic dogwinkle	23.06	23.06	2
Praunus	flexuosus*		13.86	13.86	1
Neomysis	integer*		8.434	8.434	1

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV or FCV in the 2001 ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision, particularly for metals such as cadmium which are expressed on a dissolved metal basis for a comparison with the acute criterion concentration.

B. Evaluation of Protectiveness of the Oregon Saltwater Acute Criterion

Following review of GMAV values in Table 2.2.1-1, 71 of the 74 tested genera have values greater than Oregon's acute criterion concentration for cadmium. Therefore, EPA concluded that acute effects to these species are not expected to occur at concentrations lower than the criterion and thus these species would be protected. The three most acutely sensitive tested species are non-resident. Removing those from the data set indicates that 72 of 75 resident genera are above the criterion. EPA believes Oregon's aquatic life designated use will be protected.

When compared to Oregon's acute criterion concentration for cadmium, SMAV/2 values for seven test species (dog whelk, *Nucella lapillus*; opossum shrimp, *Americamysis bahia*; horse clam, *Tresus capax*; striped bass, *Morone saxatilis*; and American lobster, *Homarus americanus)* were lower than the acute criterion concentration of 40 µg/L dissolved cadmium. Of the seven, only four of these species (horse clam, striped bass, American lobster, and the oyster) are expected to reside in Oregon waters. Therefore, EPA reviewed the data from the studies which make up the most representative SMAV for these four species, and compared the confidence intervals of the SMAV for the species to determine whether the SMAV/2 values are quantitatively different from the criterion value of 40 µg/L.

The SMAV for horse clam (*Tresus capax*) was based on a single LC50 of 55.66 µg/L dissolved cadmium, with 5 and 95 percent confidence intervals of 46.72 and 66.60 µg/L. When divided by two, the SMAV/2 for *T. capax* was 27.83 µg/L (text box A – *T. capax* acute).

The SMAV for striped bass (*Morone saxatilis*) was based on a single LC50 of 74.55 µg/L dissolved cadmium, with 5 and 95 percent confidence intervals of 58.65 and 95.42 µg/L. The SMAV/2 for *M. saxatilis* was 37.28 µg/L (text box B – *M. saxatilis* acute).

The SMAV for American lobster (*Homarus americanus*) was based on a single LC50 of 77.53 µg/L dissolved cadmium. The 5 and 95 percent confidence intervals were not reported for the test. The SMAV/2 for *H. americanus* was 38.77 µg/L.

Because the Oregon acute criterion for cadmium is greater than SMAV/2 for the horse clam, *Tresus capax* , EPA concludes that the ambient concentrations equal to or greater than the Oregon CMC for cadmium may result in acute toxicity to some individuals of this species. Because the Oregon acute criterion for cadmium is approximately equal to the SMAV/2 for striped bass, *M. saxatilis*, and *Homarus americanus*, it is EPA's judgement that these populations would be unlikely to be affected.

Saltwater cadmium acute criterion comparison

Text Box A (acute) – Basis for the meta analysis comparing the SMAV/2 for the horse clam (*Tresus capax*) to the acute criterion for cadmium (40 µg/L dissolved metal concentration).

Tresus capax							
Reported Values			**Dissolved Normalized Values**			**Dissolved Normalized Values/2**	
LC50	5% CI	95% CI	LC50	5% CI	95% CI	LC50 / 2	CMC
56.00	47.00	67.00	55.66 **(SMAV)**	46.72	66.60	27.83 **(SMAV/2)**	40

Text Box B (acute) – Basis for the meta analysis comparing the SMAV/2 for the striped bass (*Morone saxatilis*) to the acute criterion for cadmium (40 µg/L dissolved metal concentration).

Morone saxatilis							
Reported Values			**Dissolved Normalized Values**			**Dissolved Normalized Values/2**	
LC50	5% CI	95% CI	LC50	5% CI	95% CI	LC50 / 2	CMC
75.00	59.00	96.00	74.55 **(SMAV)**	58.65	95.42	37.28 **(SMAV/2)**	40

2.2.1.2 Evaluation of the Chronic Saltwater Criterion Concentration for Cadmium

A. Presentation of Toxicological Data

Oregon adopted a saltwater chronic criterion concentration of 8.8 µg/L for cadmium expressed as the dissolved metal concentration in the water column. This concentration is the same as the saltwater CCC recommended for use nationally by EPA for the protection of aquatic life[48]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.2.1-2 presents a compilation of the GMAVs from Table 2.2.1-1, any experimentally determined SMCVs obtained from the criteria document and EPA ECOTOX download used for the BE, and estimated GMCVs based on the GMAV/ACR. The 2001 criteria document for

[48] See Footnote 49 above.

cadmium[49] reported an FACR of 9.106 for saltwater species. EPA determined that the experimentally-determined ACRs of 5.384 and 15.40 µg/L for the saltwater mysids, *Americamysis bahia* and *Americamysis bigelowi*, respectively, were the most appropriate ACRs to protect sensitive saltwater species in general. The decision to use only the two ACRs from the saltwater mysids was made because the wide range of ACRs available for freshwater organisms seemed inappropriate. Since no additional acceptable ACRs are available for saltwater species, EPA calculated the predicted GMCVs for cadmium in Table 2.2.1-2 using an ACR of 9.106 and the following equation: Predicted GMCV = GMAV/FACR.

EPA compared the SMCVs for each species to Oregon's cadmium chronic criterion to determine whether the chronic criterion will protect Oregon's aquatic life designated use.

Table 2.2.1-2: Species Mean Chronic Values (SMCVs) for Cadmium

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) *(experimentally derived)*	Chronic References *(used in the calculation of the SMCV)*	Predicted GMCV (µg/L)
Monopylephorus	cuticulatus	Tubificid	134190			14736
Tilapia	mossambica	Mozambique tilapia	79520			8733
Scorpaena	guttata	Scorpionfish	61628			6768
Cyprinodon	variegatus	Sheepshead minnow	49700			5458
Eohaustorius	estuarius	Amphipod	27824			3056
Tautogolabrus	adspersus	Cunner	25745			2827
Tubificoides	gabriellae	Oligochaete	23856			2620
Uca	pugilator	Fiddler crab	21111			2318
Fundulus	majalis	Striped killifish	-			-
Fundulus	heteroclitus	Mummichog	19433			2134
Nassarius	obsoletus	Eastern mud snail	19055			2093
Neanthes	arenaceodentata	Polychaete worm	12759			1401
Cymatogaster	aggregata	Shiner perch	10934			1201
Loligo	opalescens	California market squid	10139			1113
Lagodon	rhomboides	Pinfish	9940			1092
Limnodriloides	verrucosus	Oligochaete	9940			1092
Mugil	curema	White mullet	-			-
Mugil	cephalus	Striped mullet	9161			1006
Excirolana	sp.	Isopod	7952			873.3
Dendraster	excentricus	Sand dollar	7356			807.8
Limnoria	tripunctata	Wood borer	7077			777.2
Nereis	virens	Polychaete worm	-			-
Nereis	grubei	Polychaete	6853			752.6
Diporeia	spp.	Amphipod	6660			731.4
Urosalpinx	cinerea	Atlantic oyster drill	6560			720.4
Eurypanopeus	depressus	Mud crab	4871			534.9
Carcinus	maenas	Green crab	4075			447.6
Marinogammarus	obtusatus	Scud	3479			382.1
Ctenodrilus	serratus	Polychaete worm	3149			345.8
Pseudopleuronectes	americanus	Winter flounder	2916			320.2
Ampelisca	abdita	Amphipod	2883			316.6
Pectinaria	californiensis	Cone worm	2584			283.8
Callinectes	sapidus	Blue crab	2578			283.1
Asterias	forbesii	Common starfish	2398			263.4

[49] U.S. EPA. 2001. 2001 Update of Ambient Water Quality Criteria for Cadmium. EPA-822-R-01-001.

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) (*experimentally derived*)	Chronic References (*used in the calculation of the SMCV)*	Predicted GMCV (µg/L)
Ophryotrocha	diadema	Polychaete	2155			236.6
Emerita	analoga	Pacific sand crab	2097			230.3
Morula	granulata	Gastropod	2048			224.9
Perna	viridis	Green mussel	-			-
Perna	indica	Brown mussel	1951			214.3
Nematostella	vectensis		1926			211.5
Pseudodiaptomus	coronatus	Copepod	1698			186.4
Mya	arenaria	Soft shell clam	1662			182.5
Oncorhynchus	kisutch	Coho salmon	1491			163.7
Litopenaeus	vannamei		-			-
Litopenaeus	setiferus	Northern white shrimp	1264			138.8
Palaemonetes	pugio	Daggerblade grass shrimp	-			-
Palaemonetes	vulgaris	Marsh grass shrimp	1220			134.0
Grandidierella	japonica	Scud	1163			127.7
Corophium	insidiosum	Scud	1056			116.0
Strongylocentrotus	droebachiensis	Green sea urchin	-			-
Strongylocentrotus	purpuratus	Purple sea urchin	857.8			94.20
Crangon	sp.	Caridean shrimp	-			-
Crangon	septemspinosa	Bay shrimp, Sand shrimp	845.3			92.83
Crassostrea	virginica	Eastern oyster	-			-
Crassostrea	gigas	Pacific oyster	806.3			88.55
Rivulus	marmoratus	Rivulus	795.2			87.33
Nitocra	spinipes	Harpacticoid copepod	789.7			86.73
Palaemon	elegans	Rockpool prawn	775.3			85.14
Menidia	menidia	Atlantic silverside	775.2			85.13
Argopecten	irradians	Bay scallop	-			-
Argopecten	ventricosus	Pacific calico scallop	761.0			83.57
Mytilus	edulis	Common bay mussel, blue mussel	-			-
Mytilus	trossolus		731.8			80.36
Elasmopus	bampo	Scud	711.9			78.18
Mytilopsis	sallei	Santo Domingo, or falsemussel	705.7			77.50
Pagurus	longicarpus	Longwrist hermit crab	641.1			70.41
Chelura	terebrans	Amphipod	626.2			68.77
Leptocheirus	plumulosus	Amphipod	587.0			64.46
Jaeropsis	sp.	Isopod	407.5			44.76
Penaeus	duorarum	Northern pink shrimp	308.6			33.89
Cancer	irroratus	Rock crab	-			-
Cancer	magister	Dungeness crab	234.3			25.73
Amphiascus	tenuiremis	Harpacticoid copepod	222.7			24.45
Capitella	capitata	Polychaete worm	198.8			21.83
Scorpaenichthys	marmoratus	Cabezon	198.8			21.83
Tresus	nuttalli	Horse clam, Pacific gaper	-			-
Tresus	capax	Horse clam	180.7			19.84
Limulus	polyphemus	Horseshoe crab	166.7			18.31
Balanus	improvisus	Barnacle	159.0			17.47
Eurytemora	affinis	Calanoid	146.8			16.12

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) (*experimentally derived*)	Chronic References (*used in the calculation of the SMCV*)	Predicted GMCV (µg/L)
		copepod				
Acartia	clausi	Copepod	-			-
Acartia	tonsa	Calanoid copepod	129.9			14.27
Homarus	***americanus***	American lobster	77.53			8.514
Morone	***saxatilis***	Striped bass	74.55			8.187
Americamysis	***bigelowi****	Shrimp	-	7.098	2	-
Americamysis	***bahia****	Opossum shrimp	68.24	6.136	1,2,3	7.494 (6.599)
Nucella	lapillus*	Dog whelk, Atlantic dogwinkle	23.06			2.532
Praunus	flexuosus*		13.86			1.522
Neomysis	integer*		8.434			0.9262

See same notes as above under Table 2.2.1-1.

B. Evaluation of the Protectiveness of the Oregon Saltwater Chronic Criterion

Following the review of the GMCV values in Table 2.2.1-2, 72 of 78 genera had GMCVs greater than Oregon's chronic criterion for cadmium. The three most acutely sensitive tested species are non-resident. Removing those from the data set indicates that 72 of 75 resident genera are above the criterion. Therefore, EPA concluded that chronic effects to nearly all genera are not expected to occur at concentrations equal to or lower than the criterion, and thus the aquatic life designated use would be protected by the chronic criterion.

When compared to Oregon's CCC for cadmium, the SMCV value for eight test species (*Nassarius festivus*, *Nucella lapillus*, *Americamysis bahia*, *Americamysis bigelowi*, *Tresus capax*, *Morone saxatilis*, *Homarus americanus*, and *Saccostrea cuccullata*) were lower than the chronic criterion concentration of 8.8 µg/L cadmium. Only four of these species (*Tresus capax*, *Morone saxatilis*, *Homarus americanus*, and *Saccostrea cuccullata*) are expected to reside in Oregon waters. Therefore, EPA reviewed the data from the studies that make up the most representative SMCVs for these resident species and compared the confidence intervals of these SMCVs to determine whether the SMCV values were quantitatively different from the criterion value of 8.8 µg/L.

The SMCV for horse clam (*T. capax*) was estimated by applying the ACR of 9.106 described above to the SMAV and the 5 and 95 percent confidence intervals surrounding the SMAV for the single test with this test species. The final SMCV was 6.113 µg/L (text box C – *T. capax* chronic).

The SMCV for striped bass (*M. saxatilis*) was estimated by applying the ACR of 9.106 to the SMAV and the 5 and 95 percent confidence intervals surrounding the SMAV for the single test with this test species. The final SMCV was 8.187 µg/L (text box D – *M. saxatilis* chronic).

The SMCV for American lobster (*H. americanus*) was estimated by applying the ACR of 9.106 to the SMAV for the single test with this test species. The 5 and 95 percent confidence intervals were not reported for the test. The final SMCV was 8.514 µg/L.

The SMCV for oyster (*S. cuccullata*) was estimated by applying the ACR of 9.106 to the SMAV for the single test with this test species. The 5 and 95 percent confidence intervals were not reported for the test. The final SMCV was 8.733 µg/L.

Because the Oregon chronic criterion for cadmium is greater than the SMCV for the horse clam, *Tresus capax* , EPA concludes that the occurance of ambient concentration equal to or greater than the Oregon CCC for cadmium may not protect all individuals of this species. Because the Oregon chronic criterion for cadmium is approximately equal to the SMCV for striped bass, *M. saxatilis*, *Homarus americanus* and *Saccostrea cuccullata*, it is EPA's professional judgement that these populations would not be significantly negatively affected.

Saltwater cadmium chronic criterion comparison

Text Box C (chronic) – Basis for the meta analysis comparing the SMCV estimated for the horse clam (*Tresus capax*) to the chronic criterion for cadmium (8.8 µg/L dissolved metal concentration).

Tresus capax								
Reported Value			**Dissolved Normalized Value**				**Chronic Dissolved Value**	
LC50	5% CI	95% CI	LC50	5% CI	95% CI	ACR	LC50 / ACR	CCC
56.00	47.00	67.00	55.66	46.72	66.60	9.106	6.113 **(SMCV)**	8.8

Text Box D (chronic) – Basis for the meta analysis comparing the SMCV estimated for the striped bass (*Morone saxatilis*) to the chronic criterion for cadmium (8.8 µg/L dissolved metal concentration).

Morone saxatilis								
Reported Values			**Dissolved Normalized Values**				**Chronic Dissolved Values**	
LC50	5% CI	95% CI	LC50	5% CI	95% CI	ACR	LC50 / ACR	CCC
75.00	59.00	96.00	74.55	58.65	95.42	9.106	8.187 **(SMCV)**	8.8

2.2.1.3 References for Cadmium

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in Tables 2.2.1-1 and 2.2.1-2*)
Acute References	
1	Roast, S.D., J. Widdows and M.B. Jones. 2001b. Effects of salinity and chemical speciation on cadmium accumulation and toxicity to two mysid species. Environ. Toxicol. Chem. 20(5): 1078-1084.
2	Leung, K.M.Y., and R.W. Furness. 1999. Induction of Metallothionein in Dogwhelk Nucella lapillus During and After Exposure to Cadmium. Ecotoxicol.Environ.Saf. 43(2):156-164.
3	Nimmo, D.R., L.H. Bahner, R.A. Rigby, J.M. Sheppard, and A.J. Wilson Jr. 1977a. Mysidopsis Bahia: An Estuarine Species Suitable for Life-Cycle Toxicity Tests to Determine the Effects of a Pollutant. In: F.L.Mayer and J.L.Hamelink (Eds.), Aquatic Toxicology and Hazard Evaluation, 1st Symposium, ASTM STP 634, Philadelphia, PA :109-116.
4	Gentile, S.M., J.H. Gentile, J. Walker, and J.F. Heltshe. 1982. Chronic Effects of Cadmium on Two Species of Mysid Shrimp: Mysidopsis bahia and Mysidopsis bigelowi. Hydrobiologia 93(1/2):195-204.
5	Lussier, S.M., J.H. Gentile and J. Walker. 1985. Acute and chronic effects of heavy metals and cyanide on Mysidopsis bahia (Crustacea:Mysidacea). Aquat. Toxicol. 7(1-2): 25-35.
6	Voyer, R.A. and G. Modica. 1990. Influence of salinity and temperature on acute toxicity of cadmium to Mysidopsis bahia Molenock. Arch. Environ. Contam. Toxicol. 19: 124-131.
7	Palawski, D., J.B. Hunn and F.J. Dwyer. 1985. Sensitivity of young striped bass to organic and inorganic contaminants in fresh and saline water. Trans. Am. Fish. Soc. 114: 748-753.
8	Johnson, M.W., and J.H. Gentile. 1979. Acute Toxicity of Cadmium, Copper, and Mercury to Larval American Lobster Homarus americanus. Bull.Environ.Contam.Toxicol. 22(1/2):258-264.
9	Sosnowski, S.L., and J.H. Gentile. 1978. Toxicological Comparison of Natural and Cultured Populations of Acartia tonsa to Cadmium, Copper, and Mercury. J.Fish.Res.Board Can. 35(10):1366-1369.
10	Toudal, K., and H.U. Riisgard. 1987. Acute and Sublethal Effects of Cadmium on Ingestion, Egg Production and Life-Cycle Development in the Copepod Acartia tonsa. Mar.Ecol.Prog.Ser. 37(2-3):141-146.
11	Gentile, S. M. 1982. Memorandum to John H. Gentile. U.S. EPA, Narragansett, Rhode Island.
12	Sullivan, B.K., E. Buskey, D.C. Miller, and P.J. Ritacco. 1983. Effects of Copper and Cadmium on Growth, Swimming and Predator Avoidance in Eurytemora affinis (Copepoda). Mar.Biol. 77(3):299-306.
13	Lang, W.H., D.C. Miller, P.J. Ritacco, and M. Marcy. 1981. The Effects of Copper and Cadmium on the Behavior and Development of Barnacle Larvae. In: F.J.Vernberg, A.Calabrese, F.P.Thurberg, and W.B.Vernberg (Eds.), Biological Monitoring of Marine Pollutants, Academic Press :165-203.
14	Botton, M.L. 2000. Toxicity of Cadmium and Mercury to Horseshoe Crab (Limulus polyphemus) Embryos and Larvae. Bull.Environ.Contam.Toxicol. 64(1):137-143.
15	Cardwell, R.D., C.E. Woelke, M.I. Carr, and E.W. Sanborn. 1979. Toxic Substances and Water Quality Effects on Larval Marine Organisms. Tech.Rep.No.45, State of Washington, Dep.of Fish, Olympia, W A:71.
16	Reish, D.J., J.M. Martin, F.M. Piltz, and J.Q. Word. 1976. The Effect of Heavy Metals on Laboratory Populations of Two Polychaetes with Comparisons to the Water Quality Conditions and Standards in Southern Ca. Water Res. 10:299-302.
17	Dinnel, P.A., J.M. Link, Q.J. Stober, M.W. Letourneau, and W.E. Roberts. 1989. Comparative Sensitivity of Sea Urchin Sperm Bioassays to Metals and Pesticides. Arch.Environ.Contam.Toxicol. 18(5):748-755.
18	Green, A.S., G.T. Chandler, and E.R. Blood. 1993. Aqueous-, Pore-Water-, and Sediment-Phase Cadmium: Toxicity Relationships for a Meiobenthic Copepod. Environ.Toxicol.Chem. 12(8):1497-1506.
19	Martin, M., K.E. Osborn, P. Billig, and N. Glickstein. 1981. Toxicities of Ten Metals to Crassostrea gigas and Mytilus edulis Embryos and Cancer magister Larvae. Mar.Pollut.Bull. 12(9):305-308 (Author Communication Used).
20	Johns, D.M., and D.C. Miller. 1982. The Use of Bioenergetics to Investigate the Mechanisms of Pollutant Toxicity in Crustacean Larvae. In: W.B.Vernberg, A.Calabrese, F.P.Thurberg, and F.J.Vernberg (Eds.), Physiological Mechanisms of Marine Pollutant Toxicity, Academic Press, New York, NY :261-288.
21	Cripe, G.M. 1994. Comparative Acute Toxicities of Several Pesticides and Metals to Mysidopsis bahia and Postlarval Penaeus duorarum. Environ.Toxicol.Chem. 13(11):1867-1872.
22	Hong, J.S., and D.J. Reish. 1987. Acute Toxicity of Cadmium to Eight Species of Marine Amphipod and Isopod Crustaceans From Southern California. Bull.Environ.Contam.Toxicol. 39(5):884-888.
23	Mcgee, B.L., D.A. Wright, and D.J. Fisher. 1998. Biotic Factors Modifying Acute Toxicity of Aqueous Cadmium to Estuarine Amphipod Leptocheirus plumulosus. Arch.Environ.Contam.Toxicol. 34(1):34-40.
24	Eisler, R., and R.J. Hennekey. 1977. Acute Toxicities of Cd2+, Cr+6, Hg2+, Ni2+ and Zn2+ to Estuarine Macrofauna. Arch.Environ.Contam.Toxicol. 6(2/3):315-323.
25	Eisler, R. 1971. Cadmium Poisoning in Fundulus heteroclitus (Pisces: Cyprinodontidae) and Other Marine Organisms. J.Fish.Res.Board Can. 28(9):1225-1234.
26	Devi, V.U. 1996. Bioaccumulation and metabolic effects of cadmium on marine fouling dressinid bivalve, Mytilopsis sallei (Recluz). Arch. Environ. Contam. Toxicol. 31: 47-53.
27	Reish, D.J. 1993. Effects of metals and organic compounds on survival and bioaccumulation in two species of marine gammaridean amphipod, together with a summary of toxicological research on this group. J. Nat.Hist. 27: 781-794.
28	Nadella, S.R., J.L. Fitzpatrick, N. Franklin, C. Bucking, S. Smith and C.M. Wood. 2009. Toxicity of dissolved Cu, Zn, Ni and Cd to developing embryos of the blue mussel (Mytilus trossolus) and the protective effect of dissolved organic carbon. Comp. Biochem. Physiol. C 149(3): 340-348.
29	Nelson, D.A., J.E. Miller, and A. Calabrese. 1988. Effect of Heavy Metals on Bay Scallops, Surf Clams, and Blue Mussels in Acute and Long-Term Exposures. Arch.Environ.Contam.Toxicol. 17(5):595-600

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in Tables 2.2.1-1 and 2.2.1-2*)
30	Sobrino-Figueroa, A.S., C. Caceres-Martinez, A.V. Botello and G. Nunez-Nogueira. 2007. Effect of cadmium, chromium, lead and metal mixtures on survival and growth of juveniles of the scallop Argopecten ventricosus (Sowerby II, 1842). J. Environ. Sci. Health Part A 42: 1443-1447.
31	Nelson, D.A., A. Calabrese, B.A. Nelson, J.R. MacInnes, and D.R. Wenzloff. 1976. Biological Effects of Heavy Metals on Juvenile Bay Scallops, Argopecten irradians, in Short-Term Exposures. Bull.Environ.Contam.Toxicol. 16(3):275-282.
32	Cardin, J.A. 1982. Memorandum to J.H. Gentile. U.S. EPA, Narragansett, Rhode Island.
33	Lorenzon, S., M. Francese and E.A. Ferrero. 2000. Heavy metal toxicity and differential effects on the hyperglycemic stress response in the shrimp Palaemon elegans. Arch. Environ. Contam. Toxicol. 39(2): 167-176.
34	Bengtsson, B.E., and B. Bergstrom. 1987. A Flowthrough Fecundity Test with Nitocra spinipes (Harpacticoidea Crustacea) for Aquatic Toxicity. Ecotoxicol.Environ.Saf. 14:260-268.
35	Bengtsson, B.E. 1978. Use of a Harpacticoid Copepod in Toxicity Tests. Mar.Pollut.Bull. 9:238-241.
36	Park, E.H., H.H. Chang, W.N. Joo, H.S. Chung, and H.S. Kwak. 1994. Assessment of the Estuarine Hermaphroditic Fish Rivulus marmoratus as a Useful Euryhaline Species for Acute Toxicity Tests as Shown Using Cadmium. Can.J.Fish.Aquat.Sci. 5(2):280-285.
37	Watling, H.R. 1982. Comparative Study of the Effects of Zinc, Cadmium, and Copper on the Larval Growth of Three Oyster Species. Bull.Environ.Contam.Toxicol. 28:195-201.
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B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For a full description, see Appendix O.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[50], EPA is providing a transparent rationale as to why they were not utilized (see below).
2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix

[50] U.S. EPA. 2001. 2001 Update of Ambient Water Quality Criteria for Cadmium. EPA-822-R-01-001.

A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix O).

2.2.2 COPPER

2.2.2.1 Evaluation of the Acute Saltwater Criterion Concentration for Copper

A. Presentation of Toxicological Data

Oregon adopted a saltwater acute criterion concentration of 4.8 µg/L for copper that is expressed in terms of the dissolved concentration of the metal. This dissolved metal concentration is the same as the saltwater CMC recommended for use nationally by EPA for the protection of aquatic life[51]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.2.2-1 provides available GMAVs based on available acute toxicity data for copper to aquatic animals from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.2.2-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Copper

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Gammarus	duebeni	Scud	8300	8300	67
Rangia	cuneata	Common rangia or clam	6386	6386	66
Morone	saxatilis	Striped bass	5107	5107	64,65
Micropogonias	undulatus	Atlantic croaker	4698	4698	56
Portunus	pelagicus	Crab	1919	1919	63
Nitocra	spinipes	Harpacticoid copepod	1494	1494	62
Monhystera	disjuncta	Nematode	>1453	1453	61
Fundulus	heteroclitus	Killifish	1403	1403	60
Rivulus	marmoratus	Rivulus	1177	1177	60
Metapenaeus	dobsoni	Kadal shrimp	1141	1141	59
Eurythoe	complanata	Fireworm	1079	1079	57,58
Archosargus	probatocephalus	Sheepshead	946.2	946.2	56
Citharichthys	stigmaeus	Speckled sanddab	664.0	664.0	15
Oncorhynchus	kisutch	Coho salmon	498.8	498.8	24
Carcinus	maenas	Green or Europeon shore crab	498.0	498.0	55
Sciaenops	ocellatus	Red drum	430.0	430.0	54
Crangon	sp.	Caridean shrimp	745.3	-	24
Crangon	crangon	Common shrimp, sand shrimp	240.7	423.6	47
Hediste	diversicolor	Ragworm	420.2	420.2	52,53
Allorchestes	compressa	Scud, Amphipod	398.4	398.4	51
Cymatogaster	aggregata	Shiner perch	346.9	346.9	24
Trachinotus	carolinus	Florida pompano	341.7	341.7	50
Cyprinodon	variegatus	Sheepshead minnow	305.4	305.4	49
Loligo	opalescens	California market squid	256.5	256.5	24
Nereis	diversicolor	Polychaete worm	302.0	-	48

[51] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are from the 1995 draft addendum to the saltwater criteria as cited in: U.S. EPA. 1995. Ambient Water Quality Criteria – Saltwater Copper Addendum. U.S. EPA, Narragansett, RI.

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Nereis	virens	Polychaete worm	>206.7	249.8	43
Ctenodrilus	serratus	Polychaete worm	249.0	249.0	38
Penaeus	setiferus	Northern white shrimp	296.4	-	45
Penaeus	duorarum	Northern pink shrimp	207.5	248.0	45
Leiostomus	xanthurus	Spot	232.4	232.4	35
Caenorhabditis	elegans	Nematode	215.8	215.8	46
Elasmopus	bampo	Amphipod	207.5	207.5	44
Atherinops	affinis	Topsmelt	201.7	201.7	42
Tigriopus	californicus	Harpacticoid copepod	195.8	195.8	41
Pectinaria	californiensis	Cone worm	166.0	166.0	28
Pseudodiaptomus	coronatus	Calanoid copepod	150.1	150.1	22,23
Americamysis	bahia	Opossum shrimp	150.2	-	40
Americamysis	bigelowi	Mysid	117.0	132.6	36
Capitella	capitata	Polychaete worm	128.6	128.6	28,38,39
Menidia	peninsulae	Tidewater silverside	116.2	-	35
Menidia	menidia	Atlantic silverside	112.5	-	8
Menidia	beryllina	Inland silverside	111.1	113.3	6
Neomysis	mercedis	Opposum Shrimp	112.6	112.6	34
Pleuronectes	americanus	Winter flounder	107.0	107.0	8
Neanthes	arenaceodentata	Polychaete worm	125.0	-	37
Neanthes	grubei	Polychaete	83.00	101.9	28
Anaitides	maculata	Polychaete worm	99.60	99.60	33
Corophium	insidiosum	Amphipod	498.0	-	44
Corophium	sp.	Euryhaline amphipod	13.29	81.35	13
Scorpaenichthys	marmoratus	Cabezon	78.85	78.85	24
Ophryotrocha	diadema	Polychaete	132.8	-	28
Ophryotrocha	labronica	Polychaete	41.50	74.24	28
Tisbe	battagliai	Harpacticoid copepod	62.29	62.29	31
Homarus	americanus	American lobster	57.50	57.50	29,30
Cancer	magister	Dungeness or edible crab	56.93	56.93	3,24
Haliotis	rufescens	Red abalone	71.45	-	27
Haliotis	cracherodii	Black abalone	41.50	54.45	27
Spisula	solidissima	Surf clam	42.33	42.33	20
Mya	arenaria	Soft shell clam	32.37	32.37	26
Pandalus	danae	Coon stripe shrimp	31.98	31.98	25
Acartia	clausi	Calanoid copepod	41.81	-	22,23
Acartia	tonsa	Calanoid copepod	24.28	31.86	15,21,22,23
Dendraster	excentricus	Sand dollar	27.39	27.39	24
Argopecten	irradians	Bay scallop	24.07	24.07	20
Eurytemora	affinis	Calanoid copepod	23.95	23.95	18,19
Crassostrea	***madrasensis****	***Oyster***	73.04	-	32
Crassostrea	***virginica****	***Eastern oyster***	14.35	-	14
Crassostrea	***gigas***	***Pacific oyster***	12.38	23.50	3,9,10,11,12
Arbacia	punctulata	Sea urchin	21.40	21.40	7
Acanthomysis	costata	Mysid	17.85	17.85	16,17
Mulinia	***lateralis***	***Clam***	17.70	17.70	7
Metamysidopsis	elongata	Mysid	14.94	14.94	15
Strongylocentrotus	purpuratus	Purple sea urchin	11.84	11.84	5
Paralichthys	***dentatus***	***Summer Flounder***	11.56	11.56	8
Mytilus	***edulis***	***Common bay mussel, blue mussel***	7.374	7.374	2,3,4,5,6,7
Isognomon	californicum*	Black purse shells	5.810	5.810	1

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV or FCV in the 1995 ALC draft addendum. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision, particularly for metals such as copper which are expressed on a dissolved metal basis for a comparison with the acute criterion concentration.

B. Evaluation of the Protectiveness of the Oregon Saltwater Acute Criterion

Following review of GMAV and SMAV/2 values in Table 2.2.2-1, all genera have GMAVs greater than Oregon's acute criterion concentration for copper. Thus the aquatic life designated use would be protected by the chronic criterion.

When compared to Oregon's acute criterion concentration for copper, SMAV/2 values for two test species (both bivalve mollusks) were lower than the acute criterion concentration of 4.8 µg/L dissolved copper. Only one of these species is known to reside in Oregon waters: the common (blue) mussel, *Mytilus edulis*. Therefore, EPA reviewed the data from the studies that make up the most representative SMAV for the resident species and the SMAV values to determine whether the SMAV/2 values are quantitatively different from the criterion value of 4.8 µg/L.

Confidence intervals were reported for 31 of the 37 tests used to calculate the SMAV for *Mytilus edulis.* The SMAV for dissolved copper was 7.374 µg/L, and the SMAV for the subset of studies with reported confidence intervals was 6.663 µg/L, with 5 and 95 percent confidence intervals of 6.352 µg/L and 7.133 µg/L, respectively (text box A – *M. edulis*). When divided by two, the SMAV/2 was 3.687.

Because the Oregon acute criterion for copper is greater than the the SMAV/2 for the common mussel, *Mytilus edulis*, EPA concludes that the occurrence of ambient concentration equal to or greater than the Oregon CMC for copper may result in acute toxicity to some individuals within this species.

Saltwater copper acute criterion comparison

Text Box A (acute) – Basis for the meta analysis comparing the SMAV/2 for common mussel (*Mytilus edulis*) to the acute criterion for copper (4.8 µg/L dissolved metal concentration).

Mytillus edulis	Reported Values			Dissolved Normalized Values			Dissolved Normalized Values/2	
	LC50	5% CI	95% CI	LC50	5% CI	95% CI	LC50 / 2	CMC
	5.800	3.840	7.760	4.814	3.187	6.441	2.407	4.8
	17.46	15.11	19.06	14.49	12.54	15.82	7.246	
	22.81	19.15	36.13	18.93	15.89	29.99	9.466	
	27.37	24.08	54.86	22.72	19.99	45.54	11.36	
	19.14			19.14			9.568	
	4.679			4.679			2.340	
	5.393			5.393			2.697	
	22.07			22.07			11.03	
	20.75			20.75			10.38	
	16.85			16.85			8.425	
	7.210	6.820	7.620	5.984	5.661	6.325	2.992	
	6.400	6.070	6.740	5.312	5.038	5.594	2.656	
	5.840	5.740	5.940	4.847	4.764	4.930	2.424	
	12.45	11.98	12.82	12.45	11.98	12.82	6.225	
	14.10	13.50	14.61	14.10	13.50	14.61	7.050	
	11.30	10.90	11.58	11.30	10.90	11.58	5.650	
	11.90	11.28	12.17	11.90	11.28	12.17	5.950	
	5.560	5.457	5.665	4.392	4.311	4.475	2.196	
	8.479	8.332	8.629	7.497	7.367	7.630	3.749	
	7.362	7.259	7.466	6.789	6.694	6.885	3.395	
	9.500	9.355	9.648	7.806	7.687	7.928	3.903	
	7.159	7.024	7.293	5.587	5.481	5.691	2.793	
	5.847	5.808	5.886	4.890	4.857	4.922	2.445	
	5.028	4.958	5.099	4.745	4.679	4.812	2.373	
	3.821	3.749	3.894	3.523	3.456	3.590	1.761	
	4.696	4.609	4.784	3.571	3.505	3.638	1.785	
	6.418	6.290	6.548	4.662	4.569	4.756	2.331	
	6.215	6.112	6.320	5.374	5.285	5.465	2.687	
	6.205	6.121	6.290	5.481	5.407	5.556	2.741	
	5.874	5.874	5.965	5.107	5.107	5.186	2.553	
	5.404	5.337	5.471	4.456	4.401	4.511	2.228	
	5.998	5.894	6.105	4.788	4.705	4.873	2.394	
	9.049	8.898	9.204	7.795	7.665	7.928	3.897	
	7.194	7.035	7.356	4.717	4.613	4.823	2.359	
	8.019	7.892	8.148	6.405	6.304	6.508	3.203	
	7.291	7.165	7.420	5.249	5.159	5.342	2.625	
	8.932	8.658	9.214	5.963	5.780	6.151	2.982	
				SMAV			**SMAV/2**	
Geomean (all)	8.546			7.374			3.687	
Geomean (CI only)	7.946	7.574	8.506	6.663	6.352	7.133	3.332	

2.2.2.2 Evaluation of the Chronic Saltwater Criterion Concentration for Copper

A. Presentation of Toxicological Data

Oregon adopted a saltwater CCC of 3.1 µg/L for copper expressed as the dissolved metal concentration in the water column. This concentration is the same as the saltwater chronic criterion concentration recommended for use nationally by EPA for the protection of aquatic life[52]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.2.2-2 presents a compilation of the GMAVs from Table 2.2.2-1, any experimentally determined SMCVs obtained from the criteria document and EPA ECOTOX download used for the BE, and estimated SMCVs based on the SMAV/ACR. The 1995 saltwater addendum to the criteria document for copper[53] reported an FACR of 3.127. This FACR represents the geometric mean of four species, including two freshwater species with GMAVs within a factor of two of the freshwater FAV, *Daphnia magna* and *Gammarus pseudolimnaeus* (ACR of 2.418 and 3.297, respectively), a sensitive freshwater mollusk, *Physa integra* (ACR of 3.585), and a saltwater mysid, *Americamysis bahia* (ACR of 3.346). Since no additional acceptable ACRs are available, EPA calculated the predicted GMCVs for copper in Table 2.2.2-2 using an ACR of 3.127 and the following equation: Predicted GMCV = GMAV/FACR

EPA compared the GMCVs for each species to Oregon's copper chronic criterion to determine whether the chronic criterion will protect Oregon's aquatic life designated use.

Table 2.2.2-2: Genus Mean Chronic Values (GMCVs) for Copper

Genus	**Species**	**Common name**	**GMAV (µg/L)**	**SMCV (µg/L)** (*experimentally derived*)	**Chronic References** (*used in the calculation of the SMCV*)	**Predicted GMCV (µg/L)**
Gammarus	duebeni	Scud	8300			2654
Rangia	cuneata	Common rangia or clam	6386			2042
Morone	saxatilis	Striped bass	5107			1633
Micropogonias	undulatus	Atlantic croaker	4698			1502
Portunus	pelagicus	Crab	1919			613.7
Nitocra	spinipes	Harpacticoid copepod	1494			477.8
Monhystera	disjuncta	Nematode	>1453			>464.5
Fundulus	heteroclitus	Killifish	1403			448.7
Rivulus	marmoratus	Rivulus	1177			376.5
Metapenaeus	dobsoni	Kadal shrimp	1141			364.9
Eurythoe	complanata	Fireworm	1079			345.1
Archosargus	probatocephalus	Sheepshead	946.2			302.6
Citharichthys	stigmaeus	Speckled sanddab	664.0			212.3
Oncorhynchus	kisutch	Coho salmon	498.8			159.5
Carcinus	maenas	Green or Europeon shore crab	498.0			159.3
Sciaenops	ocellatus	Red drum	430.0			137.5
Crangon	sp.	Caridean shrimp	-			-
Crangon	crangon	Common shrimp, sand shrimp	423.6			135.5
Hediste	diversicolor	Ragworm	420.2			134.4
Allorchestes	compressa	Scud, Amphipod	398.4			127.4

[52] See footnote 53 above.
[53] U.S. EPA. 1995. Ambient Water Quality Criteria – Saltwater Copper Addendum. U.S. EPA, Narragansett, RI.

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) (*experimentally derived*)	Chronic References (*used in the calculation of the SMCV*)	Predicted GMCV (µg/L)
Cymatogaster	aggregata	Shiner perch	346.9			110.9
Trachinotus	carolinus	Florida pompano	341.7			109.3
Cyprinodon	variegatus	Sheepshead minnow	305.4	207.1	2	97.67 (207.1)
Loligo	opalescens	California market squid	256.5			82.02
Nereis	diversicolor	Polychaete worm	-			-
Nereis	virens	Polychaete worm	249.8			79.89
Ctenodrilus	serratus	Polychaete worm	249.0			79.63
Penaeus	setiferus	Northern white shrimp	-			-
Penaeus	duorarum	Northern pink shrimp	248.0			79.30
Leiostomus	xanthurus	Spot	232.4			74.32
Caenorhabditis	elegans	Nematode	215.8			69.01
Elasmopus	bampo	Amphipod	207.5			66.36
Atherinops	affinis	Topsmelt	201.7			64.50
Tigriopus	californicus	Harpacticoid copepod	195.8			62.61
Pectinaria	californiensis	Cone worm	166.0			53.09
Pseudodiaptomus	coronatus	Calanoid copepod	150.1			48.01
Americamysis	bahia	Opossum shrimp	-	44.89	1	-
Americamysis	bigelowi	Mysid	132.6			42.40 (44.89)
Capitella	capitata	Polychaete worm	128.6			41.12
Menidia	peninsulae	Tidewater silverside	-			-
Menidia	menidia	Atlantic silverside	-			-
Menidia	beryllina	Inland silverside	113.3			36.22
Neomysis	mercedis	Opposum Shrimp	112.6			36.02
Pleuronectes	americanus	Winter flounder	107.0			34.22
Neanthes	arenaceodentata	Polychaete worm	-			-
Neanthes	grubei	Polychaete	101.9			32.57
Anaitides	maculata	Polychaete worm	99.60			31.85
Corophium	insidiosum	Amphipod	-			-
Corophium	sp.	Euryhaline amphipod	81.35			26.02
Scorpaenichthys	marmoratus	Cabezon	78.85			25.22
Ophryotrocha	diadema	Polychaete	-			-
Ophryotrocha	labronica	Polychaete	74.24			23.74
Tisbe	battagliai	Harpacticoid copepod	62.29			19.92
Homarus	americanus	American lobster	57.50			18.39
Cancer	magister	Dungeness or edible crab	56.93			18.21
Haliotis	rufescens	Red abalone	-			-
Haliotis	cracherodii	Black abalone	54.45			17.41
Spisula	solidissima	Surf clam	42.33			13.54
Mya	arenaria	Sand gaper, soft shell clam	32.37			10.35
Pandalus	danae	Coon stripe shrimp	31.98			10.23
Acartia	clausi	Calanoid copepod	-			-
Acartia	tonsa	Calanoid copepod	31.86			10.19
Dendraster	excentricus	Sand dollar	27.39			8.759
Argopecten	irradians	Bay scallop	24.07			7.697
Eurytemora	affinis	Calanoid copepod	23.95			7.659
Crassostrea	***madrasensis****	***Oyster***	-			-
Crassostrea	***virginica****	***Eastern oyster***	-			-

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) (*experimentally derived*)	Chronic References (*used in the calculation of the SMCV*)	Predicted GMCV (µg/L)
Crassostrea	***gigas***	***Pacific oyster***	23.50			7.515
Arbacia	punctulata	Sea urchin	21.40			6.844
Acanthomysis	costata	Mysid	17.85			5.708
Mulinia	***lateralis***	***Clam***	17.70			5.660
Metamysidopsis	elongata	Mysid	14.94			4.778
Strongylocentrotus	purpuratus	Purple sea urchin	11.84			3.786
Paralichthys	***dentatus***	***Summer Flounder***	11.56			3.697
Mytilus	***edulis***	***Common bay mussel, blue mussel***	7.374			2.358
Isognomon	californicum*	Black purse shells	5.810			1.858

See same notes as above under Table 2.2.2-1.

B. Evaluation of the Protectiveness of the Oregon Saltwater Chronic Criterion

Following the review of the SMCV values in Table 2.2.2-1, 43 of 45 genera have GMCVs greater than Oregon's chronic criterion for copper. Therefore, EPA concluded that chronic effects to nearly all genera are not expected to occur at concentrations equal to or lower than the criterion, and thus the aquatic life designated use would be protected by the chronic criterion.

When compared to Oregon's chronic criterion concentration for copper, SMCV values for two test species (both bivalve mollusks) were lower than the chronic criterion concentration of 3.1 µg/L dissolved copper. Only one of these species is known to reside in Oregon waters: the common (blue) mussel, *Mytilus edulis*. Therefore, EPA reviewed the data from the studies that make up the most representative SMAV for the resident species and after applying the ACR for copper to these values, compared the confidence intervals of the SMCV values to determine whether the SMCV values are quantitatively different from the criterion value of 3.1 µg/L.

The SMCV for *Mytilus edulis* was estimated by applying the ACR of 3.127 (see above) to acute values (dissolved copper) for all tests, and to the 5 and 95 percent confidence intervals for the 31 acute tests with reported confidence intervals. The overall SMCV for copper was 2.358 µg/L, and the SMCV for the subset of studies with reported confidence intervals was 2.131 µg/L (text box B – *M. edulis* chronic).

Because the Oregon acute criterion for copper is greater than the SMCV for the common mussel, *Mytilus edulis*, EPA concludes that the Oregon CCC for copper may not be protective of all individuals within this species.

Saltwater copper chronic criterion comparison

Text Box B – Basis for the meta analysis comparing the SMCV for the common mussel (*M. edulis*) to the chronic criterion for copper (3.1 µg/L dissolved metal concentration).

Mytillus edulis	Reported Values			Dissolved Normalized Values				Dissolved Chronic Values	
	LC50	5% CI	95% CI	LC50	5% CI	95% CI	ACR	LC50 / ACR	CCC
	5.800	3.840	7.760	4.814	3.187	6.441	3.127	1.539	3.1
	17.46	15.11	19.06	14.49	12.54	15.82		4.634	
	22.81	19.15	36.13	18.93	15.89	29.99		6.054	
	27.37	24.08	54.86	22.72	19.99	45.54		7.265	
	19.14			19.14				6.119	
	4.679			4.679				1.496	
	5.393			5.393				1.725	
	22.07			22.07				7.057	
	20.75			20.75				6.636	
	16.85			16.85				5.388	
	7.210	6.820	7.620	5.984	5.661	6.325		1.914	
	6.400	6.070	6.740	5.312	5.038	5.594		1.699	
	5.840	5.740	5.940	4.847	4.764	4.930		1.550	
	12.45	11.98	12.82	12.45	11.98	12.82		3.981	
	14.10	13.50	14.61	14.10	13.50	14.61		4.509	
	11.30	10.90	11.58	11.30	10.90	11.58		3.614	
	11.90	11.28	12.17	11.90	11.28	12.17		3.806	
	5.560	5.457	5.665	4.392	4.311	4.475		1.405	
	8.479	8.332	8.629	7.497	7.367	7.630		2.398	
	7.362	7.259	7.466	6.789	6.694	6.885		2.171	
	9.500	9.355	9.648	7.806	7.687	7.928		2.496	
	7.159	7.024	7.293	5.587	5.481	5.691		1.787	
	5.847	5.808	5.886	4.890	4.857	4.922		1.564	
	5.028	4.958	5.099	4.745	4.679	4.812		1.518	
	3.821	3.749	3.894	3.523	3.456	3.590		1.127	
	4.696	4.609	4.784	3.571	3.505	3.638		1.142	
	6.418	6.290	6.548	4.662	4.569	4.756		1.491	
	6.215	6.112	6.320	5.374	5.285	5.465		1.719	
	6.205	6.121	6.290	5.481	5.407	5.556		1.753	
	5.874	5.874	5.965	5.107	5.107	5.186		1.633	
	5.404	5.337	5.471	4.456	4.401	4.511		1.425	
	5.998	5.894	6.105	4.788	4.705	4.873		1.531	
	9.049	8.898	9.204	7.795	7.665	7.928		2.493	
	7.194	7.035	7.356	4.717	4.613	4.823		1.509	
	8.019	7.892	8.148	6.405	6.304	6.508		2.048	
	7.291	7.165	7.420	5.249	5.159	5.342		1.679	
	8.932	8.658	9.214	5.963	5.780	6.151		1.907	
								SMCV	
Geomean (all)	8.546			7.374				2.358	
Geomean (CI only)	7.946	7.574	8.506	6.663	6.352	7.133		2.131	

2.2.2.3 References for Copper

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in Tables .2.2-1 and 2.2.2-2*)
Acute References	
1	Ringwood, A.H. 1992. Comparative sensitivity of gametes and early developmental stages of a sea urchin species (*Echinometra mathaei*) and a bivalve species (*Isognomon*). Arch. Environ. Contam. Toxicol. 22: 288-295.
2	City of San Jose. 1998. Toxicities of ten metals to *Crassostrea gigas* and *Mytilus edulis* embryos and *Cancer magister* larvae. Mar. Pollut. Bull. 12(9): 305-308 (Author Communication Used).
3	Martin, M., K.E. Osborn, P. Billig and N. Glickstein. 1981. Toxicities of ten metals to *Crassostrea gigas* and *Mytilus edulis* embryos and *Cancer magister* larvae. Mar. Pollut. Bull. 12(9): 305-308 (Author Communication Used).
4	CH2M Hill. 1999. Bioassy Report Acute Toxicity of Copper to Blue Mussel (*Mytilus edulis*). Final Report. Prepared for U.S. Navy. Norfolk, VA.
5	Tucker, D.W. 1998. Development of a Site-Specific Water Quality Criterion for Copper in South San Francisco Bay. Copper Site-Specific WQC Report, San Jose/Santa Clara Water Pollution Control Plant, Environmental Services Department, San Jose, CA: 171 p.
6	ToxScan. 1991. Toxicities of ten metals to *Crassostrea gigas* and *Mytilus edulis* embryos and *Cancer magister* larvae. Mar. Pollut. Bull. 12(9): 305-308 (Author Communication Used).
7	SAIC. 1993. Toxicities of ten metals to *Crassostrea gigas* and *Mytilus edulis* embryos and *Cancer magister* larvae. Mar. Pollut. Bull. 12(9): 305-308 (Author Communication Used).
8	Cardin, J.A. 1985. Results of Acute Toxicity Tests Conducted with Copper at ERL, Narragansett. U.S. EPA, Narragansett, RI: 10 p.
9	Knezovich, J.P., F.L. Harrison and J.S. Tucker. 1981. The Influence of organic chelators on the toxicity of copper to embryos of the Pacific oyster, *Crassostrea gigas*. Arch. Environ. Contam. Toxicol. 10(2): 241-249.
10	Coglianese, M. and M. Martin. 1981. Individual and interactive effects of environmental stress on the embryonic development of the Pacific oyster, *Crassostrea gigas*. Part I. Toxicity of copper and silver. Mar. Environ. Res. 5: 13.
11	Dinnel, P.A., Q.J. Stober, J.M. Link, M.W. Letourneau, W.E. Roberts, S.P. Felton and R.E. Nakatani. 1983. Methodology and Validation of a Sperm Cell Toxicity Test for Testing Toxic Substances in Marine Waters. Final Report, FRI-UW-8306, Fisheries Research Inst., School of Fisheries, University of Washington, Seattle, WA: 208.
12	S.R. Hansen and Associates. 1992. Devlopment of site-specific criterion for copper for San Fransico Bay--Final report. Prepared for California Regional Water Quality Control Board, Oakland, CA. October.
13	Hyne, R.V. and D.A. Everett. 1998. Application of a benthic euryhaline amphipod, *Corophium sp*., as a sediment toxicity testing organism for both freshwater and estuarine systems. Arch. Environ. Contam. Toxicol. 34(1): 26-33.
14	MacInnes, J.R. and A. Calabrese. 1978. Response of Embryos of the American Oyster, *Crassostrea virginica*, to Heavy Metals at Different Temperatures. In: D.S. McLusky and A.J. Berry (Eds.), Physiology and Behaviour of Marine Organisms, Permagon Press, New York, NY: 195-202.
15	Salazar, M.H. and S.M. Salazar. 1989. Acute Effects of (bis)Tributyltin Oxide on Marine Organisms. Tech. Rep. No. 1299, Naval Ocean Systems Center, San Diego, CA: 87 p. (U.S. NTIS AD-A214005).
16	Martin, M., J.W. Hunt, B.S. Anderson and S.L. Turpen. 1989. Experimental evaluation of the mysid *Holmesimysis costata* as a test organism for effluent toxicity testing. Environ. Toxicol. Chem. 8(11): 1003-1012.
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21	Sosnowski, S.L. and J.H. Gentile. 1978. Toxicological comparison of natural and cultured populations of *Acartia tonsa* to cadmium, copper, and mercury. J. Fish. Res. Board Can. 35(10): 1366-1369.
22	Gentile, S. and J. Cardin. 1982. Unpublished Laboratory Data. U.S. EPA, Narragansett, RI: 5 p.

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in Tables .2.2-1 and 2.2.2-2*)
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33	McLusky, D.S. and C.N.K. Phillips. 1975. Some effects of copper on the polychaete *Phyllodoce maculata*. Estuar. Coast. Mar. Sci. 3(1): 103-108.
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39	Reish, D.J., J.M. Martin, F.M. Piltz and J.Q. Word. 1976. The effect of heavy metals on laboratory populations of two polychaetes with comparisons to the water quality conditions and standards in Southern CA. Water Res. 10: 299-302.
40	Lussier, S.M., J.H. Gentile and J. Walker. 1985. Acute and chronic effects of heavy metals and cyanide on *Mysidopsis bahia* (Crustacea: Mysidacea). Aquat. Toxicol. 7(1-2): 25-35.
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49	Hughes, M.M., M.A. Heber, G.E. Morrison, S.C. Schimmel and W.J. Berry. 1989. An evaluation of a short-term chronic effluent toxicity test using sheepshead minnow (*Cyprinodon variegatus*) Larvae. Environ. Pollut. 60(1): 1-14.
50	Birdsong, C.L. and J.W. Avault, Jr. 1971. Toxicity of certain chemicals to juvenile pompano. Prog. Fish-Cult. 33(2): 76-80.
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1	Lussier, S.M., J.H. Gentile and J. Walker. 1985. Acute and chronic effects of heavy metals and cyanide on *Mysidopsis bahia* (Crustacea: Mysidacea). Aquat. Toxicol. 7(1-2): 25-35.
2	Hughes, M.M., M.A. Heber, G.E. Morrison, S.C. Schimmel and W.J. Berry. 1989. An evaluation of a short-term chronic effluent toxicity test using sheepshead minnow (*Cyprinodon variegatus*) larvae. Environ. Pollut. 60(1): 1-14.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For full descriptions, see Appendix P.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[54], EPA is providing a transparent rationale as to why they were not utilized (see below).

[54] U.S. EPA. 1995. Ambient Water Quality Criteria – Saltwater Copper Addendum. U.S. EPA, Narragansett, RI.

2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix P).

2.2.3 LEAD

2.2.3.1 Evaluation of the Acute Saltwater Criterion Concentration for Lead

A. Presentation of Toxicological Data

Oregon adopted a saltwater acute criterion concentration of 210 µg/L for lead that is expressed in terms of the dissolved concentration of the metal. This dissolved metal concentration is the same as the saltwater CMC recommended for use nationally by EPA for the protection of aquatic life[55]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.2.3-1 provides available SMAVs based on available acute toxicity data for lead to aquatic life from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.2.3-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Lead

Genus	**Species**	**Common name**	**Most Representative SMAV (µg/L)**	**GMAV (µg/L)**	**Acute References** *(used in the calculation of the SMAV)*
Pandalus	montagui	Aesop shrimp	356625	356625	21
Fundulus	***heteroclitus****	***Mummichog***	299565	299565	20
Mya	arenaria	Soft-shell clam	25677	25677	19
Epinephelus	sp.	Rockcod, Grouper	16167	16167	18
Polyodon	spathula	Paddlefish	14227	14227	8
Ctenodrilus	serratus	Polychaete worm	11742	11742	8
Elasmopus	bampo	Amphipod	>9510	>9510	13
Nereis	arenaceodentata	Polychaete worm	8541	8541	8,16
Argopecten	irradians	Bay scallop	8179	8179	15
Menidia	menidia	Atlantic silverside	>9510	-	17
Menidia	beryllina	Inland silverside	>2986	>5329	11,12
Corophium	insidiosum	Amphipod	>4755	>4755	13
Pectinaria	californiensis	Cone worm	>4755	>4755	14
Onisimus	litoralis	Amphipod	>3329	>3329	4
Cyprinodon	variegatus	Sheepshead minnow	>2986	>2986	11,12
Americamysis	bahia	Opossum shrimp	2977	2977	10
Ophryotrocha	labronica	Polychaete	>4755	-	14
Ophryotrocha	diadema	Polychaete	1643	>2795	8
Crangon	sp.	Caridean shrimp	>1997	>1997	2
Loligo	opalescens	California market squid	>1988	>1988	2,3
Scorpaenichthys	marmoratus	Cabezon	1441	1441	2,3
Crassostrea	virginica	Eastern oyster	2330	-	9
Crassostrea	gigas	Pacific oyster	587.3	1170	1,3,4
Mercenaria	mercenaria	Northern quahog or Hard clam	741.8	741.8	6
Cancer	***anthonyi****	***Yellow rock crab***	>951.0	-	7
Cancer	***magister***	***Dungeness or edible crab***	558.6	>728.8	1,2
Acartia	clausi	Copepod	635.3	635.3	5
Mytilus	***edulis***	***Common bay mussel,***	452.7	452.7	1

[55] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are from: U.S. EPA. 1984. Ambient Water Quality Criteria for Lead. EPA-440/5-84-027.

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
		blue mussel			

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV in the 1984 ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision, particularly for metals such as lead which are expressed on a dissolved metal basis for a comparison with the acute criterion concentration.

B. Evaluation of the Protectiveness of the Oregon Saltwater Acute Criterion

Following review of GMAV and SMAV/2 values in Table 2.2.33-1, all tested genera and species values are greater than Oregon's acute criterion concentration for lead. Therefore, EPA concluded that acute effects are not expected to occur at concentrations equal to or lower than the criterion, and thus the aquatic life designated use would be protected by the criterion.

2.2.3.2 Evaluation of the Chronic Saltwater Criterion Concentration for Lead

A. Presentation of Toxicological Data

Oregon adopted a saltwater chronic criterion concentration of 8.1 µg/L for lead expressed as the dissolved metal concentration in the water column. This concentration is the same as the saltwater CCC recommended for use nationally by EPA for the protection of aquatic life[56]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.2.3-2 presents a compilation of the GMAVs from Table 2.2.3-1, any experimentally determined SMCVs obtained from the criteria document and EPA ECOTOX download used for the BE, and estimated GMCVs based on the GMAV/ACR. The 1984 criteria document for lead[57] reported an FACR of 51.29, which EPA calculated as the geometric mean of experimentally determined ACRs for three freshwater species and one saltwater species ranging from 18.13 for an acutely sensitive freshwater invertebrate, the cladoceran *Daphnia magna*, to 124.8 for a relatively insensitive saltwater invertebrate species, *Americamysis bahia*. However, considering an update of the lead dataset in 1998, the number of ACRs was increased to six freshwater and one saltwater species, although the smallmouth bass ratio was not definitive. The five remaining valid freshwater Species Mean ACRs range from 4.77 to 61.97, whereas the saltwater mysid ratio remains 124.8. For the six acceptable ACRs (4.77, 6.38, 18.13, 49.35, 61.97 and 124.8) the highest ACR is 26 fold greater than the lowest value. If the saltwater mysid ratio is deleted, the

[56] See footnote 57 above.
[57] U.S. EPA. 1984. Ambient Water Quality Criteria Document for Lead. EPA-440/5-84-027.

ratios differ by a factor of only 13. Since the mysid is acutely insensitive but chronically sensitive to lead, inclusion of the mysid ratio provides the necessary safety margin to be chronically protective of sensitive saltwater invertebrates. Thus, the EPA calculated the predicted GMCVs for lead in Table 2.2.3-2 using the FACR of 24.39 (geomean of the six ACRs above) and the following equation: Predicted GMCV = GMAV/FACR.

EPA compared the SMCVs for each species to Oregon's lead chronic criterion to determine whether the chronic criterion will protect Oregon's aquatic life designated use.

Table 2.2.3-2: Genus Mean Chronic Values (SMCVs) for Lead

Genus	**Species**	**Common name**	**GMAV (µg/L)**	**SMCV (µg/L)** (*experimentally derived*)	**Chronic References** (*used in the calculation of the SMCV*)	**Predicted GMCV (µg/L)**
Pandalus	montagui	Aesop shrimp	356625			14622
<u>Fundulus</u>	***<u>heteroclitus*</u>***	***Mummichog***	299565			12282
Mya	arenaria	Soft-shell clam	25677			1053
Epinephelus	sp.	Rockcod, Grouper	16167			662.9
Polyodon	spathula	Paddlefish	14227			583.3
Ctenodrilus	serratus	Polychaete worm	11742			481.4
Elasmopus	bampo	Amphipod	>9510			>389.9
Nereis	arenaceodentata	Polychaete worm	8541			350.2
Argopecten	irradians	Bay scallop	8179			335.3
Menidia	menidia	Atlantic silverside	-			-
Menidia	beryllina	Inland silverside	>5329			>218.5
Corophium	insidiosum	Amphipod	>4755			>195.0
Pectinaria	californiensis	Cone worm	>4755			>195.0
Onisimus	litoralis	Amphipod	>3329			>136.5
Cyprinodon	variegatus	Sheepshead minnow	>2986			>122.4
Americamysis	bahia	Opossum shrimp	2977	23.85	1	122.0 (23.85)
Ophryotrocha	labronica	Polychaete	-			-
Ophryotrocha	diadema	Polychaete	>2795			>114.6
Crangon	sp.	Caridean shrimp	>1997			>81.88
Loligo	opalescens	California market squid	>1988			>81.49
Scorpaenichthys	marmoratus	Cabezon	1441			59.07
Crassostrea	virginica	Eastern oyster	-			-
Crassostrea	gigas	Pacific oyster	1170			47.96
Mercenaria	mercenaria	Northern quahog or Hard clam	741.8			30.41
<u>Cancer</u>	***<u>anthonyi*</u>***	***Yellow rock crab***	-			-
Cancer	***magister***	***Dungeness or edible crab***	>728.8			>29.88
Acartia	clausi	Copepod	635.3			26.05
Mytilus	***edulis***	***Common bay mussel, blue mussel***	452.7			18.56

See same notes as above under Table 3.2.5-1.

B. Evaluation of the Protectiveness of the Oregon Saltwater Chronic Criterion

Following the review of the SMCV values in Table 2.2.3-2, all of the genera and species had values greater than Oregon's chronic criterion for lead. Therefore, EPA concluded that chronic effects are not expected to occur at concentrations equal to or lower than the criterion, and thus the aquatic life designated use would be protected by the chronic criterion.

2.2.3.3 References for Lead

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in Tables 2.2.3-1 and 2.2.3-2*)
Acute References	
1	Martin, M., K.E. Osborn, P. Billig and N. Glickstein. 1981. Toxicities of ten metals to *Crassostrea gigas* and *Mytilus edulis* embryos and *Cancer magister* larvae. Mar. Pollut. Bull. 12(9): 305-308 (Author Communication Used).
2	Dinnel, P.A., J.M. Link, Q.J. Stober, M.W. Letourneau and W.E. Roberts. 1989. Comparative sensitivity of sea urchin sperm bioassays to metals and pesticides. Arch. Environ. Contam. Toxicol. 18(5): 748-755.
3	Dinnel, P.A., Q.J. Stober, J.M. Link, M.W. Letourneau, W.E. Roberts, S.P. Felton and R.E. Nakatani. 1983. Methodology and validation of a sperm cell toxicity test for testing toxic substances in marine waters. Final Rep. FRI-UW-8306, Fish. Res. Inst., School of Fish., Univ. of Washington, Seattle, WA: 208 p.
4	Chapman, P.M. and C. McPherson. 1993. Comparative zinc and lead toxicity tests with arctic marine invertebrates and implications for toxicant discharges. Polar Record 29(168): 45-54.
5	Gentile, S.M. 1982. Memorandum to John H. Gentile. U.S. EPA, Narragansett, RI.
6	Calabrese, A. and D.A. Nelson. 1974. Inhibition of embryonic development of the hard clam, *Mercenaria mercenaria*, by heavy metals. Bull. Environ. Contam. Toxicol. 11(1): 92-97.
7	Macdonald, J.M., J.D. Shields and R.K. Zimmer-Faust. 1988. Acute toxicities of eleven metals to early life-history stages of the yellow crab *Cancer anthonyi*. Mar. Biol. (Berlin) 98(2): 201-207.
8	Reish, D.J., T.V. Gerlinger, C.A. Phillips and P.D. Schmidtbauer. 1977. Toxicity of formulated mine tailings on marine polychaete. Marine Biological Consultants, Costa Mesa, CA: 133 p.
9	Calabrese, A., R.S. Collier, D.A. Nelson and J.R. Mac Innes. 1973. The toxicity of heavy metals to embryos of the American oyster *Crassostrea virginica*. Mar. Biol. 18(3): 162-166.
10	Lussier, S.M., J.H. Gentile and J. Walker. 1985. Acute and chronic effects of heavy metals and cyanide on *Mysidopsis bahia* (Crustacea: Mysidacea). Aquat. Toxicol. 7(1-2): 25-35.
11	Cardin, J.A. 1981. Memorandum to John H. Gentile. U.S. EPA, Narragansett, RI.
12	Cardin, J.A. 1985. Results of acute toxicity tests conducted with lead at ERL, Narragansett. U.S. EPA, Narragansett, RI: 2 p.
13	Reish, D.J. 1993. Effects of metals and organic compounds on survival and bioaccumulation in two species of marine gammaridean amphipod, together with a summary of toxicological research on this group. J. Nat. Hist. 27(4): 781-794.
14	Reish, D.J. and J.E. LeMay. 1991. Toxicity and bioconcentration of metals and organic compounds by polychaeta. Ophelia (Suppl) 5: 653-660.
15	Nelson, D.A., J.E. Miller and A. Calabrese. 1988. Effect of heavy metals on bay scallops, surf clams and blue mussels in acute and long-term exposures. Arch. Environ. Contam. Toxicol. 17(5): 595-600.
16	Reish, D.J. and T.V. Gerlinger. 1984. The effects of cadmium, lead, and zinc on survival and reproduction in the polychaetous annelid *Neanthes arenaceodentata* (*F. nereididae*). In: P. A. Hutchings (Ed.), Proc. of the First Int. Polychaete Conf., Sydney, Aust., July 1983, The Linnean Society of New South Wales, Australia: 383-389.
17	Berry, W.J. 1981. Memorandum to John H. Gentile. U.S. EPA, Narragansett, RI.
18	Siammai, H. and S. Chiayvareesajja. 1988. Acute toxicity of lead on grouper (*Epinephelus spp.*). Songklanakarin J. Sci. Technol.10(2): 179-184.
19	Eisler, R. 1977. Acute toxicities of selected heavy metals to the soft-shell clam, *Mya arenaria*. Bull. Environ. Contam. Toxicol. 17: 137.
20	Dorfman, D. 1977. Tolerance of *Fundulus heteroclitus* to different metals in salt waters. Bull. N.J. Acad. Sci. 22(2): 21-23.
21	Portmann, J.E. and K.W. Wilson. 1971. The toxicity of 140 substances to the brown shrimp and other marine animals. Shellfish Information Leaflet No. 22 (2nd Ed.), Ministry of Agric. Fish. Food, Fish. Lab. Burnham-on-Crouch,

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in Tables 2.2.3-1 and 2.2.3-2*)
	Essex, and Fish Exp. Station Conway, North Wales: 12 p
Chronic References	
1	Lussier, S.M., J.H. Gentile and J. Walker. 1985. Acute and chronic effects of heavy metals and cyanide on *Mysidopsis bahia* (Crustacea: Mysidacea). Aquat. Toxicol. 7(1-2): 25-35.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For full descriptions, see Appendix Q.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[58], EPA is providing a transparent rationale as to why they were not utilized (see below).
2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix Q).

[58] U.S. EPA. 1984. Ambient Water Quality Criteria Documents for Lead. EPA-440/5-84-027.

2.2.4 NICKEL

2.2.4.1 Evaluation of the Acute Saltwater Criterion Concentration for Nickel

A. Presentation of Toxicological Data

Oregon adopted a saltwater acute criterion concentration of 74 µg/L for nickel that is expressed in terms of the dissolved concentration of the metal. This dissolved metal concentration is the same as the saltwater acute criterion concentration recommended for use nationally by EPA for the protection of aquatic life[59]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.2.4-1 provides available GMAVs based on available acute toxicity data for nickel to aquatic animals from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.2.4-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Nickel

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Mya	arenaria	Sand gaper, soft shell clam	316800	316800	13
Macoma	balthica	Balthica macoma or clam	291555	291555	11
Asterias	forbesii	Common starfish	148500	148500	13
Fundulus	heteroclitus	Mummichog	148401	148401	13,17
Penaeus	duorarum	Northern pink shrimp	110880	110880	16
Nassarius	obsoletus	Eastern mud snail	71280	71280	13
Leiostomus	xanthurus	Spot	69300	69300	15
Capitella	capitata	Polychaete worm	>49500	>49500	10
Neanthes	arenaceodentata	Polychaete worm	48510	48510	10
Pagurus	longicarpus	Longwrist hermit crab	46530	46530	13
Allorchestes	compressa	Scud, Amphipod	34333	34333	14
Atherinops	affinis	Topsmelt	26294	26294	1
Nereis	viridis	Polychaete worm	24750	24750	13
Morone	saxatilis	Striped bass	20790	20790	12
Corophium	volutator	Scud	18761	18761	11
Menidia	peninsulae	Tidewater silverside	37620	-	14
Menidia	menidia	Atlantic silverside	7878	17216	2
Ctenodrilus	serratus	Polychaete worm	16830	16830	10
Monhystera	disjuncta	Nematode	14850	14850	9
Eurytemora	affinis	Calanoid copepod	10586	10586	2,7
Nitocra	spinipes	Harpacticoid copepod	5940	5940	8
Acartia	clausi	Calanoid copepod	2656	2656	2,7
Strongylocentrotus	purpuratus	Purple sea urchin	2475	2475	6
Mytilus	edulis	Common bay mussel, Blue mussel	882.1	882.1	4
Crassostrea	***virginica****	***Eastern oyster***	1168	-	5
Crassostrea	***gigas***	***Pacific oyster***	345.5	635.3	4
Americamysis	***bigelowi****	***Shrimp***	627.7	-	2

[59] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are from: U.S. EPA. 1986. Ambient Water Quality Criteria for Nickel – 1986. EPA 440-5-86-004.

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Americamysis	***bahia****	***Opossum shrimp***	502.9	561.8	2
Mercenaria	***mercenaria****	***Northern quahog or Hard clam***	306.9	306.9	3
Heteromysis	***formosa****	***Opossom Shrimp***	150.2	150.2	2
Mysidopsis	intii*	Shrimp	147.1	147.1	1
Haliotis	rufescens	Red abalone	144.0	144.0	1

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV or FCV in the 1986 ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision, particularly for metals such as nickel which are expressed on a dissolved metal basis for a comparison with the acute criterion concentration.

B. Evaluation of the Protectiveness of the Oregon Saltwater Acute Criterion

Following review of GMAV values in Table 2.2.4-1, all tested genera have values greater than Oregon's acute criterion concentration for nickel. Therefore, EPA concluded that acute effects to nearly all genera are not expected to occur at concentrations equal to or lower than the criterion, and thus the aquatic life designated use would be protected by the criterion.

When compared to Oregon's acute criterion concentration for nickel, SMAV/2 values for two test species (the red abalone, *Haliotis rufescens*, and the shrimp, *Mysidopsis intii*) were lower than the acute criterion concentration of 74µg/L dissolved nickel. Of these two species, only the red abalone is expected to reside in Oregon waters. Therefore, EPA reviewed the data from the study that makes up the most representative SMAV for this resident species and compared the SMAV value to determine whether the SMAV/2 value is quantitatively different from the criterion value of 74 µg/L.

The SMAV based on a single LC50 for *Haliotis rufescens* was 144.0 µg/L dissolved nickel, with 5 and 95 percent confidence intervals of 135.6 and 152.5 µg/L. When divided by two, the SMAV/2 for *H. rufescens* is 72.00 µg/L (text box A – *H. rufescens* acute).

Because the Oregon acute criterion for nickel is approximately equal to the SMAV/2, a value estimated to represent an effect concentration indistinguishable from control levels for this species it is expected that the criterion would be sufficiently protective of this species, especially when considering the uncertainty in the low range of toxicity curve being considered.

Saltwater nickel acute criterion comparison

Text Box A (acute) – Basis for the meta analysis comparing the SMAV/2 for the red abalone (*H. rufescens*) to the acute criterion for nickel (74 µg/L dissolved metal concentration).

Haliotis rufescens							
Reported Values			**Dissolved Normalized Values**			**Dissolved Normalized Values/2**	
LC50	5% CI	95% CI	LC50	5% CI	95% CI	LC50 / 2	CMC
145.5	137.0	154.0	144.0 **(SMAV)**	135.6	152.5	72.00 **(SMAV/2)**	74

2.2.4.2 Evaluation of the Chronic Saltwater Criterion Concentration for Nickel

A. Presentation of Toxicological Data

Oregon adopted a saltwater chronic criterion concentration of 8.2 µg/L for nickel expressed as the dissolved metal concentration in the water column. This concentration is the same as the saltwater CCC recommended for use nationally by EPA for the protection of aquatic life[60]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.2.4-2 presents a compilation of the GMAVs from Table 2.2.4-1, any experimentally determined SMCVs obtained from the criteria document and EPA ECOTOX download used for the BE, and estimated GMCVs based on the GMAV/FACR. The 1986 criteria document for nickel[61] reported an FACR of 17.99, which EPA calculated as the geometric mean of the ACRs 29.86 and 35.58 from two freshwater species (*Daphnia magna* and *Pimephales promelas*, respectively) and the ACR of 5.478 for one acutely sensitive saltwater species (*Americamysis bahia*). However, new ACRs were recently made available in the literature for three new saltwater species: red abalone, *Haliotis rufescens* (ACR of 5.505), *Mysidopsis intii* (ACR of 6.727) and topsmelt, *Atherinops affinis* (ACR of 6.220). The new ACR for saltwater species correspond well the ACR of 5.478 for *A. bahia*, which is in contrast to the freshwater ACR values used in the 1986 nickel criteria document, which are 29.86 for *Daphnia magna* and 35.58 for *Pimephales promelas.* The FACR calculated as the geometric mean of only the four saltwater ACR values is 5.960, compared to the 17.99 ACR presented in the 1986 criteria document. Because the freshwater ACRs were an order of magnitude larger than the saltwater ACRs, EPA calculated the predicted GMCVs for nickel in Table 2.2.4-2 using an FACR of 5.960 and the following equation: Predicted GMCV = GMAV/FACR.

EPA compared the SMCVs for each species to Oregon's nickel chronic criterion to determine whether the chronic criterion will protect Oregon's aquatic life designated use.

Table 2.2.4-2: Genus Mean Chronic Values (GMCVs) for Nickel

Genus	**Species**	**Common name**	**GMAV (µg/L)**	**SMCV (µg/L)** (*experimentally derived*)	**Chronic References** (*used in the calculation of the SMCV*)	**Predicted GMCV (µg/L)**
Mya	arenaria	Sand gaper, soft shell clam	316800			53154
Macoma	balthica	Balthica macoma	291555			48919

[60] See footnote 61 above.
[61] U.S. EPA. 1986. Ambient Water Quality Criteria for Nickel – 1986. EPA 440-5-86-004.

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) (*experimentally derived*)	Chronic References (*used in the calculation of the SMCV*)	Predicted GMCV (µg/L)
		or clam				
Asterias	forbesii	Common starfish	148500			24916
Fundulus	heteroclitus	Mummichog	148401			24899
Penaeus	duorarum	Northern pink shrimp	110880			18604
Nassarius	obsoletus	Eastern mud snail	71280			11960
Leiostomus	xanthurus	Spot	69300			11628
Capitella	capitata	Polychaete worm	>49500			>8305
Neanthes	arenaceodentata	Polychaete worm	48510			8139
Pagurus	longicarpus	Longwrist hermit crab	46530			7807
Allorchestes	compressa	Scud, Amphipod	34333			5761
Atherinops	affinis	Topsmelt	26294	4228	1	4412 (4228)
Nereis	viridis	Polychaete worm	24750			4153
Morone	saxatilis	Striped bass	20790			3488
Corophium	volutator	Scud	18761			3148
Menidia	peninsulae	Tidewater silverside	-			-
Menidia	menidia	Atlantic silverside	17216			2889
Ctenodrilus	serratus	Polychaete worm	16830			2824
Monhystera	disjuncta	Nematode	14850			2492
Eurytemora	affinis	Calanoid copepod	10586			1776
Nitocra	spinipes	Harpacticoid copepod	5940			996.6
Acartia	clausi	Calanoid copepod	2656			445.6
Strongylocentrotus	purpuratus	Purple sea urchin	2475			415.3
Mytilus	edulis	Common bay mussel, Blue mussel	882.1			148.0
Crassostrea	***virginica****	***Eastern oyster***	-			-
Crassostrea	***gigas***	***Pacific oyster***	635.3			106.6
Americamysis	***bigelowi****	***Shrimp***	-			-
Americamysis	***bahia****	***Opossum shrimp***	561.8	91.81	2,3	94.27 (91.81)
Mercenaria	***mercenaria****	***Northern quahog or Hard clam***	306.9			51.49
Heteromysis	***formosa****	***Opossom Shrimp***	150.2			25.20
Mysidopsis	intii*	Shrimp	147.1	21.87	1	24.68 (21.87)
Haliotis	rufescens	Red abalone	144.0	26.17	1	24.16 (26.17)

See same notes as above under Table 2.2.4-1.

B. Evaluation of the Protectiveness of the Oregon Saltwater Chronic Criterion

Following the review of the GMCV values in Table 2.2.4-2, all genera and species have values greater than Oregon's chronic criterion for nickel. Therefore, EPA concluded that chronic effects are not expected to occur at concentrations lower than the criterion and thus these species would be protected.

2.2.4.3 References for Nickel

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in Tables 2.2.4-1 and 2.2.4-2*)
Acute References	
1	Hunt, J.W., B.S. Anderson, B.M. Phillips, R.S. Tjeerdema, H.M. Puckett, M. Stephenson, D.W. Tucker and D. Watson. 2002. Acute and chronic toxicity of nickel to marine organisms: Implications for water quality criteria. Environ. Toxicol. Chem. 21(11): 2423-2430
2	Gentile, S. and J. Cardin. 1982. Unpublished Laboratory Data. U.S. EPA, Narragansett, RI: 5 p.
3	Calabrese, A. and D.A. Nelson. 1974. Inhibition of embryonic development of the hard clam, *Mercenaria mercenaria*, by heavy metals. Bull. Environ. Contam. Toxicol. 11(1): 92-97.
4	Martin, M., K.E. Osborn, P. Billig and N. Glickstein. 1981. Toxicities of ten metals to *Crassostrea gigas* and *Mytilus edulis* embryos and *Cancer magister* larvae. Mar. Pollut. Bull. 12(9): 305-308 (Author Communication Used).
5	Calabrese, A., R.S. Collier, D.A. Nelson and J.R. Mac Innes. 1973. The toxicity of heavy metals to embryos of the American oyster *Crassostrea virginica*. Mar. Biol. 18(3): 162-166.
6	Garman, G.D., S.L. Anderson and G.N. Cherr. 1997. Developmental abnormalities and DNA-protein crosslinks in sea urchin embryos exposed to three metals. Aquat. Toxicol. 39: 247-265
7	Lussier, S.M. and J.A. Cardin. 1985. Results of Acute Toxicity Tests Conducted with Nickel at ERL, Narragansett. U.S. EPA, Narragansett, RI: 4.
8	Bengtsson, B.E. 1978. Use of a harpacticoid copepod in toxicity tests. Mar. Pollut. Bull. 9: 238-241.
9	Vranken, G., R. Vandergaeghen and C. Heip. 1991. Effects of pollutants on life-history parameters of the marine nematode *Monhystera disjuncta*. ICES J. Mar. Sci. 48: 325-334.
10	Petrich, S.M. and D.J. Reish. 1979. Effects of aluminum and nickel on survival and reproduction in polychaetous annelids. Bull. Environ. Contam. Toxicol. 23(4/5): 698-702.
11	Bryant, V., D.M. Newbery, D.S. McLusky and R. Campbell. 1985. Effect of temperature and salinity on the toxicity of nickel and zinc to two estuarine invertebrates (*Corophium volutator*, *Macoma balthica*). Mar. Ecol. Prog. Ser. 24(1-2): 139-153.
12	Palawski, D., J.B. Hunn and F.J. Dwyer. 1985. Sensitivity of young striped bass to organic and inorganic contaminants in fresh and saline waters. Trans. Am. Fish. Soc. 114: 748-753.
13	Eisler, R. and R.J. Hennekey. 1977. Acute toxicities of Cd2+, Cr+6, Hg2+, Ni2+ and Zn2+ to estuarine macrofauna. Arch. Environ. Contam. Toxicol. 6(2/3): 315-323.
14	Ahsanullah, M. 1982. Acute toxicity of chromium, mercury, molybdenum and nickel to the amphipod *Allorchestes compressa*. Aust. J. Mar. Freshwater Res. 33(3): 465-474.
15	Hansen, D.J. 1983. Section on Acute Toxicity Tests to be Inserted in the April 1983 Report on Site Specific FAV's. U.S. EPA, Narragansett, RI :7.
16	Bentley, R.E., T. Heitmuller, B.H. Sleight III and P.R. Parrish. 1975. Acute Toxicity of Nickel to Bluegill (*Lepomis macrochirus*), Rainbow Trout (*Salmo gairdneri*), and Pink Shrimp (*Penaeus duorarum*). U.S. EPA, Criteria Branch, WA-6-99-1414-B, Washington, D.C.: 14.
17	Dorfman, D. 1977. Tolerance of *Fundulus heteroclitus* to different metals in salt water. Bull. N.J. Acad. Sci. 22: 21-23.
Chronic References	
1	Hunt, J.W., B.S. Anderson, B.M. Phillips, R.S. Tjeerdema, H.M. Puckett, M. Stephenson, D.W. Tucker and D. Watson. 2002. Acute and chronic toxicity of nickel to marine organisms: Implications for water quality criteria. Environ. Toxicol. Chem. 21(11): 2423-2430
2	Gentile, J.H., S.M. Gentile, N.G. Hairston Jr. and B.K. Sullivan. 1982. The use of life-tables for evaluating the chronic toxicity of pollutants to *Mysidopsis bahia*. Hydrobiologia 93(1/2): 179-182.
3	Lussier, S.M., J.H. Gentile and J. Walker. 1985. Acute and chronic effects of heavy metals and cyanide on *Mysidopsis bahia* (Crustacea: Mysidacea). Aquat. Toxicol. 7: 25-35.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For full descriptions, see Appendix R.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[62], EPA is providing a transparent rationale as to why they were not utilized (see below).
2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable.

[62] U.S. EPA. 1986. Ambient Water Quality Criteria for Nickel – 1986. EPA 440-5-86-004.

2.2.5 PENTACHLOROPHENOL

2.2.5.1 Presentation of Acute Saltwater Data in Support of Chronic Pentachlorophenol

A. Presentation of Toxicological Data

Table 2.2.5-1 provides available GMAVs based on available acute toxicity data for pentachlorophenol to aquatic life from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE. This information is provided to support the analysis of the chronic criterion.

Table 2.2.5-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Pentachlorophenol

Genus	**Species**	**Common name**	**Most Representative SMAV (µg/L)**	**GMAV (µg/L)**	**Acute References** *(used in the calculation of the SMAV)*
Crangon	crangon	Common shrimp, Sand shrimp	7800	7800	24
Monhystera	disjuncta	Nematode	2100	2100	22
Crepidula	fornicata	Slipper limpet	1200	1200	11
Penaeus	duorarum	Northern pink shrimp	5600	-	23
Penaeus	aztecus	Brown shrimp	>195.0	>1045	5
Brachionus	plicatilis	Rotifer	900.0	900.0	21
Ophryotrocha	diadema	Polychaete	862.6	862.6	11,20
Arbacia	punctulata	Purple-spined sea urchin	785.9	785.9	19
Platichthys	flesus	Starry, European flounder	728.9	728.9	17
Monopylephorus	cuticulatus	Tubificid	598.2	598.2	14
Neanthes	succinea	Clam worm	>672.0	-	8
Neanthes	arenaceodentata	Polychaete worm	435.0	>540.7	15
Palaemonetes	pugio	Daggerblade grass shrimp	491.3	491.3	4,18
Mulinia	lateralis	Clam	482.0	482.0	8
Solea	solea	Dover sole	450.0	450.0	17
Peloscolex	gabriellae	Oligochaete	423.4	423.4	14
Limnodriloides	verrucosus	Oligochaete worm	403.1	403.1	14
Gammarus	tigrinus	Scud	371.0	371.0	13
Ensis	minor	Jackknife clam	344.0	344.0	8
Mytilus	edulis	Common bay mussel, Blue mussel	328.8	328.8	2
Fundulus	similis	Longnose killifish	>306.0	>306.0	5
Mercenaria	mercenaria	Northern quahog or Hard clam	<250.0	<250.0	12
Cyprinodon	variegatus	Sheepshead minnow	442.0	-	16
Cyprinodon	bovinus	Leon Springs pupfish	80.00	188.0	9
Temora	longicornis	Calanoid copepod	170.0	170.0	11
Laevicardium	mortoni	Morton's egg cockle	163.0	163.0	8
Mugil	cephalus	Striped mullet	112.1	112.1	3
Nitocra	spinipes	Harpacticoid copepod	102.5	102.5	10
Corophium	acherusicum	Scud	82.00	82.00	8
Heteromastus	filiformis	Capitellid thread worm	67.00	67.00	8
Pseudodiaptomus	***coronatus****	***Calanoid copepod***	62.81	62.81	7
Haliotis	rufescens	Red abalone	56.02	56.02	6
Lagodon	***rhomboides****	***Pinfish***	53.20	53.20	5
Crassostrea	***virginica****	***Eastern oyster***	42.55	-	3,4
Crassostrea	***gigas***	***Pacific oyster***	40.83	41.68	2
Clupea	***pallasii***	***Pacific herring***	25.29	25.29	1

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV in the 1986 ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for

this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision.

2.2.5.2 Evaluation of the Chronic Saltwater Criterion Concentration for Pentachlorophenol

A. Presentation of Toxicological Data

Oregon adopted a saltwater chronic criterion concentration of 7.9 µg/L for pentachlorophenol. This concentration is the same as the saltwater chronic criterion concentration recommended for use nationally by EPA for the protection of aquatic life[63]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.2.5-2 presents a compilation of the GMAVs from Table 2.2.5-1, any experimentally determined SMCVs obtained from the criteria document and EPA ECOTOX download used for the BE, and estimated GMCVs based on the GMAV/ACR. The 1986 criteria document for pentachlorophenol reported an FACR of 3.166, which EPA calculated as the geometric mean of five experimentally determined ACRs ranging from 0.8945 for the cladoceran (*Simocephalus vetulus*) to 6.873 for the saltwater fish species *Cyprinodon variegatus*. Since no additional acceptable ACRs are available, and since there is only one ACR available for a saltwater species, and this one ACR is probably not sufficiently representative of all saltwater species, especially when the freshwater ACRs suggest lower values possible for invertebrates, EPA calculated the predicted GMCVs for pentachlorophenol in Table 2.2.5-2 using an FACR of 3.166 and the following equation: Predicted GMCV = GMAV/FACR.

EPA compared the GMCVs for each species to Oregon's pentachlorophenol chronic criterion to determine whether the chronic criterion will protect Oregon's aquatic life designated use.

[63] See Footnote 64 above.

Table 2.2.5-2: Genus Mean Chronic Values (SMCVs) for Pentachlorophenol

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) (*experimentally derived*)	Chronic References (*used in the calculation of the SMCV*)	Predicted GMCV (µg/L)
Crangon	crangon	Common shrimp, Sand shrimp	7800			2464
Monhystera	disjuncta	Nematode	2100			663.3
Crepidula	fornicata	Slipper limpet	1200			379.0
Penaeus	duorarum	Northern pink shrimp	-			-
Penaeus	aztecus	Brown shrimp	>1045			>330.1
Americamysis	bahia	Opossum shrimp	-	298.4	2	(298.4)
Brachionus	plicatilis	Rotifer	900.0			284.3
Ophryotrocha	diadema	Polychaete	862.6			272.4
Arbacia	punctulata	Purple-spined sea urchin	785.9			248.2
Platichthys	flesus	Starry, European flounder	728.9			230.2
Monopylephorus	cuticulatus	Tubificid	598.2			189.0
Neanthes	succinea	Clam worm	-			-
Neanthes	arenaceodentata	Polychaete worm	>540.7			>170.8
Palaemonetes	pugio	Daggerblade grass shrimp	491.3			155.2
Mulinia	lateralis	Clam	482.0			152.2
Solea	solea	Dover sole	450.0			142.1
Peloscolex	gabriellae	Oligochaete	423.4			133.7
Limnodriloides	verrucosus	Oligochaete worm	403.1			127.3
Gammarus	tigrinus	Scud	371.0			117.2
Ensis	minor	Jackknife clam	344.0			108.7
Mytilus	edulis	Common bay mussel, Blue musse"	328.8			103.9
Fundulus	similis	Longnose killifish	>306.0			>96.65
Mercenaria	mercenaria	Northern quahog or Hard clam	<250.0			<78.96
Cyprinodon	variegatus	Sheepshead minnow	-	64.31	1	-
Cyprinodon	bovinus	Leon Springs pupfish	188.0			59.39 (64.31)
Temora	longicornis	Calanoid copepod	170.0			53.70
Laevicardium	mortoni	Morton's egg cockle	163.0			51.48
Mugil	cephalus	Striped mullet	112.1			35.41
Nitocra	spinipes	Harpacticoid copepod	102.5			32.37
Corophium	acherusicum	Scud	82.00			25.90
Heteromastus	filiformis	Capitellid thread worm	67.00			21.16
<u>Pseudodiaptomus</u>	***<u>coronatus*</u>***	***Calanoid copepod***	62.81			19.84
Haliotis	rufescens	Red abalone	56.02			17.69
<u>Lagodon</u>	***<u>rhomboides*</u>***	***Pinfish***	53.20			16.80
<u>Crassostrea</u>	***<u>virginica*</u>***	***Eastern oyster***	-			-
Crassostrea	***gigas***	***Pacific oyster***	41.68			13.17
Clupea	***pallasii***	***Pacific herring***	25.29			7.988

See same notes as above under Table 2.2.5-1.

B. Evaluation of the Protectiveness of the Oregon Saltwater Chronic Criterion

Following the review of the GMCV values in Table 2.2.5-2, all genera and species have values greater than Oregon's chronic criterion for pentachlorophenol. Therefore, EPA concluded that chronic effects are not expected to occur at concentrations equal to or lower than the criterion and thus these genera, species, and Oregon's aquatc life designated use would be protected by the criterion.

2.2.5.3 References for Pentachlorophenol

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in Tables 2.2.5-1 and 2.2.5-2*)
Acute References	
1	Vigers, G.A., J.B. Marliave, R.G. Janssen and P. Borgmann. 1978. Use of larval herring in bioassays. In: J.C. Davis, G.L. Greer and I.K. Birtwell (Eds.), Proc. 4th Annual Aquatic Toxicol. Workshop, Nov. 8-10, 1977, Vancouver, B.C., Can. Fish. Mar. Serv. Tech. Rep. No. 818: 31-52.
2	Woelke, C.E. 1972. Development of a Receiving Water Quality Bioassay Criterion Based on the 48-Hour Pacific Oyster (*Crassostrea gigas*) Embryo. Wash. Dep. Fish. Tech. Rep. No. 9, Seattle, WA: 93p.
3	Office of Pesticide Programs. 2000. Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB)). Environmental Fate and Effects Division, U.S. EPA, Washington, D.C.
4	Borthwick, P.W. and S.C. Schimmel. 1978. Toxicity of pentachlorphenol and related compounds to early life stages of selected estuarine animals. In: K.R. Rao (Ed.), Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology, Plenium Press, NY: 141-146 / EPA-600/J-78-076, Environ. Res. Lab., U.S. Environ. Prot. Agency, Gulf Breeze, FL.
5	Schimmel, S.C., J.M. Patrick, Jr. and L.F. Faas. 1978. Effects of sodium pentachlorophenate on several estuarine animals: Toxicity, uptake, and depuration. In: K.R. Rao (Ed.), Pentachlorophenol, Plenum Publ. Corp., New York, NY: 147-155; EPA-600/J-78/ 078, U.S.EPA, Gulf Breeze, FL: 147-155 (U.S. NTIS PB-291127/9ST).
6	Hunt, J.W., B.S. Anderson, S. Tudor, M.D. Stephenson, H.M. Puckett, F.H. Palmer and M.W. Reeve. 1996. Marine Bioassay Project. 8th Report: Refinement and Implementation of Four Effluent Toxicity Testing Methods Using Indigenous Marine Species. Report #94-4. State Water Resources Control Board, Sacramento, CA. pp. 85-104.
7	Hauch, R.G., D.R. Norris and R.H. Pierce, Jr. 1980. Acute and chronic toxicity of sodium pentachlorophenate to the copepod, *Pseudodiaptomus coronatus*. Bull. Environ. Contam. Toxicol.25(4): 562-568 / Fla. Sci. 43 (Suppl.1): 36 (ABS).
8	Tagatz, M.E. and R.S. Stanley. 1987. Sensitivity Comparisons of Estuarine Benthic Animals Exposed to Toxicants in Single Species Acute Tests and Community Tests. EPA 600/X-87-167, U.S. EPA, Gulf Breeze, FL: 16.
9	Sappington, L.C., F.L. Mayer, F.J. Dwyer, D.R. Buckler, J.R. Jones and M.R. Ellersieck. 2001. Contaminant sensitivity of threatened and endangered fishes compared to standard surrogate species. Environ. Toxicol. Chem. 20(12): 2869-2876.
10	Bengtsson, B.E. and B. Bergstrom. 1987. A flow through fecundity test with *Nitocra spinipes* (Harpacticoidea Crustacea) for aquatic toxicity. Ecotoxicol. Environ. Saf. 14: 260-268.
11	Adema, D.M.M. and G.J. Vink. 1981. A comparative study of the toxicity of 1,1,2-trichloroethane, dieldrin, pentacholorophenol, and 3,4 dichloroaniline for marine and fresh water. Chemosphere 10(6): 533-554 (OECDG Data File).
12	Davis, H.C. and H. Hidu. 1969. Effects of pesticides on embryonic development of clams and oysters and on survival and growth of the larvae. Fish. Bull. 67(2): 393-404.
13	Kierstead, W.G. and F. Barlocher. 1989. Ecological effects of pentachlorophenol on the brackish-water amphipod *Gammarus tigrinus*. Arch. Hydrobiol. 115(1): 149-156.
14	Chapman, P.M., M.A. Farrell and R.O. Brinkhurst. 1982. Relative tolerances of selected aquatic oligochaetes to combinations of pollutants and environmental factors. Aquat. Toxicol. 2(1): 69-78.
15	Rubinstein, N. 1981. Effect of PCP on *Neanthes areaceodentata*. Memorandum to S. Tagatz, U.S. EPA, Gulf Breeze, FL.: 2p.
16	Parrish, P.R., E.E. Dyar, J.M. Enos and W.G. Wilson. 1978. Chronic toxicity of chlordane, trifluralin, and pentachlorophenol to sheepshead minnows (*Cyprinodon variegatus*). EPA-600/3-78-010, U.S. EPA, Gulf Breeze, FL: 53 p. (U.S. NTIS PB-278269).

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in Tables 2.2.5-1 and 2.2.5-2*)
17	Smith, S., V.J. Furay, P.J. Layiwola and J.A. Menezes-Filho. 1994. Evaluation of the toxicity and quantitative structure-activity relationships (QSAR) of chlorophenols to the copepodid stage of a marine copepod (*Tisbe battagliai*) and two species of benthic flatfish, the flounder (*Platichthys flesus*) and sole (*Solea solea*). Chemosphere 28(4): 825-836.
18	Conklin, P.J. and K.R. Rao. 1978. Toxicity of sodium pentachlorophenate (NA-PCP) to the grass shrimp, *Palaemonetes pugio*, at different stages of the molt cycle. Bull. Environ. Contam. Toxicol. 20(2): 275-279.
19	Jackim, E. and D. Nacci. 1984. A rapid aquatic toxicity assay utilizing labeled thymidine incorporation in sea urchin embryos. Environ. Toxicol. Chem. 3(4): 631-636.
20	Hooftman, R.N. and G.J. Vink. 1980. The determination of toxic effects of pollutants with the marine polychaete worm *Ophryotrocha diadema*. Ecotoxicol. Environ. Saf. 4(3): 252-262.
21	Snell, T.W., B.D. Moffat, C. Janssen and G. Persoone. 1991. Acute toxicity tests using rotifers. III. Effects of temperature, strain, and exposure time on the sensitivity of *Brachionus plicatilis*. Environ. Toxicol. Water Qual. 6: 63-75.
22	Vranken, G., R. Vandergaeghen and C. Heip. 1991. Effects of pollutants on life-history parameters of the marine nematode *Monhystera disjuncta*. ICES J Mar Sci 48: 325-334.
23	Bentley, R.E., T. Heitmuller, B.H. Sleight III and P.R. Parrish. 1975. Acute Toxicity of Pentachlorophenol to Bluegill (*Lepomis macrochirus*), Rainbow Trout (*Salmo gairdneri*), and Pink Shrimp (*Penaeus duorarum*). U.S. EPA, Criteria Branch, WA-6-99-1414-B, Washington, D.C.: 13.
24	Bowmer, T., R.G.V. Boelens, B.F. Keegan and J. O'Neill. 1986. The use of marine benthic 'key' species in ecotoxicological testing: *Amphiura filiformis* (O.F. Muller) (Echinodermata: Ophiuroidea). Aquat. Toxicol. 8(2): 93-109.
Chronic References	
1	Parrish, P.R., E.E. Dyar, J.M. Enos and W.G. Wilson. 1978. Chronic Toxicity of Chlordane, Trifluralin, and Pentachlorophenol to Sheepshead Minnows (*Cyprinodon variegatus*). EPA-600/3-78-010, U.S. EPA, Gulf Breeze, FL: 53 p. (U.S. NTIS PB-278269).
2	Goodfellow, Jr., W.L. and W.J. Rue. 1989. Evaluation of a chronic estimation toxicity test using *Mysidopsis bahia*. In: U.M. Cowgill and L.R. Williams (Eds.), Aquatic Toxicology and Hazard Assessment, 12th Volume, ASTM STP 1027, Philadelphia, PA: 333-344.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For full description, see Appendix S.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[64], EPA is providing a transparent rationale as to why they were not utilized (see below).
2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix S).

[64] U.S. EPA. 1986. Ambient Water Quality Criteria for Pentachlorophenol - 1986. EPA-440-5-86-009.

2.2.6 SELENIUM

2.2.6.1 Evaluation of the Acute Saltwater Criterion Concentration for Selenium

A. Presentation of Toxicological Data

Oregon adopted a saltwater CMC of 290 µg/L for selenium that is expressed in terms of the dissolved concentration of the metal. This dissolved metal concentration is the same as the saltwater acute criterion concentration recommended for use nationally by EPA for the protection of aquatic life[65]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.2.6.1 provides available GMAVs based on available acute toxicity data for pentachlorophenol to aquatic life from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.2.6.1. Species Mean Acute Values (SMAVs) and GMAVs for Selenium

Genus	**Species**	**Common name**	**Most Representative SMAV (µg/L)**	**GMAV (µg/L)**	**Acute References** *(used in the calculation of the SMAV)*
Oncorhynchus	tshawytscha	Chinook salmon	65337	-	9
Oncorhynchus	kisutch	Coho salmon,silver salmon	26963	41972	9
Apeltes	quadracus	Fourspine stickleback	17315	17315	2
Pseudopleuronectes	americanus	Winter flounder	14620	14620	2
Crassostrea	gigas	Pacific oyster	9980	9980	4,8
Mytilus	edulis	Common bay mussel,blue mussel	9980	9980	8
Menidia	menidia	Atlantic silverside	9706	9706	2
Cyprinodon	variegatus	Sheepshead minnow	7385	7385	5
Callinectes	sapidus	Blue crab	4591	4591	5
Lagodon	rhomboides	Pinfish	4391	4391	5
Paralichthys	dentatus	Summer flounder	3490	3490	2
Morone	saxatilis	Striped bass	3029	3029	6,7
Americamysis	bahia	Opossum shrimp	1497	1497	5
Acartia	***clausi***	***Copepod***	2106	-	3
Acartia	***tonsa***	***Copepod***	837.3	1328	3
Penaeus	***aztecus***	***Brown shrimp***	1198	1198	5
Cancer	***magister***	***Dungeness or edible crab***	1038	1038	4
Melanogrammus	***aeglefinus***	***Haddock***	597.8	597.8	2
Argopecten	irradians	Bay scallop	254.5	254.5	1

[65] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001. The data which serve as the basis for the current nationally-recommended criteria are cited in: U.S. EPA. 1987. Ambient Water Quality Criteria for Selenium - 1987. EPA-440-5-87-006.

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV in the 1987 ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.3 of this evaluation for an explanation of this decision, particularly for metals such as selenium which are expressed on a dissolved metal basis for a comparison with the acute criterion concentration.

B. Evaluation of Protectiveness of the Oregon Saltwater Acute Criterion

Following review of GMAV and SMAV/2 values in Table 2.2.6.1, 18 of the 19 genera and test species had values greater than Oregon's acute criterion concentration for selenium. Therefore, EPA concluded that acute effects to these genera and species are not expected to occur at concentrations equal to or lower than the criterion and thus these genera, species, and aquatic life designted use would be protected.

When compared to Oregon's acute criterion concentration for selenium, the SMAV/2 value for a single species (bay scallop, *Argopecten irradians*) was lower than the acute criterion concentration of 290 µg/L dissolved selenium. This species is not expected to reside in Oregon waters.

2.2.6.2. Evaluation of the Chronic Saltwater Criterion Concentration for Selenium

A. Presentation of Toxicological Data

Oregon adopted a saltwater CCC of 71 µg/L for selenium expressed as the dissolved metal concentration in the water column. This concentration is the same as the saltwater chronic criterion concentration recommended for use nationally by EPA for the protection of aquatic life[66] developed in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.2.6.2 presents a compilation of the GMAVs from Table 2.2.6.1, any experimentally determined SMCVs obtained from the criteria document, and estimated GMCVs based on the GMAV/ACR. The 1987 criteria document for selenium[67] reported an FACR of 8.314, which EPA calculated as the geometric mean of five experimentally determined ACRs ranging from 6.880 for an acutely sensitive freshwater fish, fathead minnow (*Pimephales promelas*) to 13.31 for an acutely sensitive invertebrate, the cladoceran *Daphnia magna*. EPA determined the FACR of 8.314 with the ACRs from three freshwater species (*Daphnia magna*, *Daphnia pulex*, fathead minnow) and two saltwater species (*Americamysis bahia* and sheepshead minnow). Since the geometric mean of the ACRs for the two saltwater species (8.812) was so similar to the geometric mean of ACRs for all species (8.314), and since no additional acceptable ACRs are available, EPA calculated the predicted GMCVs for selenium in Table 2.2.6.2 using the FACR of 8.314 and the following equation: Predicted GMCV = GMAV/FACR.

[66] See footnote 67 above.

[67] U.S. EPA. 1987. Ambient Water Quality Criteria Document for Selenium-1987. EPA-440/5-87-006.

EPA compared the GMCVs for each species to Oregon's selenium chronic criterion to determine whether the chronic criterion will protect the species.

Table 2.2.6.2. Species Mean Chronic Values (SMCVs) for Selenium

Genus	**Species**	**Common name**	**GMAV (μg/L)**	**SMCV (μg/L)** (*experimentally derived*)	**Chronic References** (used in the calculation of the SMCV)	**Most Representative GMCV (μg/L)**
Oncorhynchus	tshawytscha	Chinook salmon	-			-
Oncorhynchus	kisutch	Coho salmon,silver salmon	41972			5048
Apeltes	quadracus	Fourspine stickleback	17315			2083
Pseudopleuronectes	americanus	Winter flounder	14620			1758
Crassostrea	gigas	Pacific oyster	9980			1200
Mytilus	edulis	Common bay mussel,blue mussel	9980			1200
Menidia	menidia	Atlantic silverside	9706			1167
Cyprinodon	variegatus	Sheepshead minnow	7385	673.8	1	888.3 (673.8)
Callinectes	sapidus	Blue crab	4591			552.2
Lagodon	rhomboides	Pinfish	4391			528.2
Paralichthys	dentatus	Summer flounder	3490			419.8
Morone	saxatilis	Striped bass	3029			364.4
Americamysis	bahia	Opossum shrimp	1497	211.3	1	180.1 (211.3)
Acartia	***clausi***	***Copepod***	-			-
Acartia	***tonsa***	***Copepod***	1328			159.7
Penaeus	***aztecus***	***Brown shrimp***	1198			144.0
Cancer	***magister***	***Dungeness or edible crab***	1038			124.8
Melanogrammus	***aeglefinus***	***Haddock***	597.8			71.90
Argopecten	irradians	Bay scallop	254.5			30.61

See same notes as above under Table 2.2.6.1.

B. Evaluation of the Protectiveness of the Oregon Saltwater Chronic Criterion

Following the review of the GMCV values in Table 2.2.6.2, 18 of the 19 genera have GMCVs greater than Oregon's chronic criterion for selenium. Therefore, EPA concluded that chronic effects are not expected to occur at concentrations equal to or lower than the criterion and thus these species would be protected.

When compared to Oregon's chronic criterion concentration for selenium, the GMCV for a single species (bay scallop, *Argopecten irradians*) was lower than the chronic criterion concentration of 71 μg/L dissolved selenium. This species is not expected to reside in Oregon waters.

2.2.6.3 References for Selenium

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained GMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in tables 2.2.6.1 and 2.2.6.2*)
Acute References	
1	Nelson, D.A., J.E. Miller and A. Calabrese. 1988. Effect of heavy metals on bay scallops, surf clams, and blue mussels in acute and long-term exposures. Arch. Environ. Contam. Toxicol. 17(5): 595-600.
2	Cardin, J.A. 1986. Memorandum to D.J. Hansen, U.S. EPA, Narragansett, RI.
3	Lussier, S.M. 1986. Memorandum to D.J. Hansen, U.S. EPA, Narragansett, RI.
4	Glickstein, N. 1978. Acute toxicity of mercury and selenium to *Crassostrea gigas* embryos and *Cancer magister* larvae. Mar. Biol. 49(2): 113-117.
5	Ward, G.S., T.A. Hollister, P.T. Heitmuller and P.R. Parrish. 1981. Acute and chronic toxicity of selenium to estuarine organisms. Northeast Gulf Sci. 4(2):73-78.
6	Chapman, D.C. 1992. Failure of gas bladder inflation in striped bass: Effect on selenium toxicity. Arch. Environ. Contam. Toxicol. 22: 296-299
7	Palawski, D., J.B. Hunn and F.J. Dwyer. 1985. Sensitivity of young striped bass to organic and inorganic contaminants in fresh and saline waters. Trans. Am. Fish. Soc. 114: 748-753.
8	Martin, M., K.E. Osborn, P. Billig and N. Glickstein. 1981. Toxicities of ten metals to *Crassostrea gigas* and *Mytilus edulis* embryos and *Cancer magister* larvae. Mar. Pollut. Bull. 12(9): 305-308 (Author Communication Used).
9	Hamilton, S.J. and K.J. Buhl. 1990. Acute toxicity of boron, molybdenum, and selenium to fry of Chinook salmon and Coho salmon. Arch. Environ. Contam. Toxicol. 19(3): 366-373.
Chronic References	
1	Ward, G.S., T.A. Hollister, P.T. Heitmuller and P.R. Parrish. 1981. Acute and chronic toxicity of selenium to estuarine organisms. Northeast Gulf Sci. 4(2): 73-78.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[68], EPA is providing a transparent rationale as to why they were not utilized (see below).

[68] U.S. EPA. 1987. Ambient Water Criteria for Selenium - 1987. EPA-440-5-87-006.

2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable.

General QA/QC failure because non-resident species in Oregon

Tests with the following species were used in the EPA BE of OR WQS for selenium in saltwater, but were not considered in the CWA review and approval/disapproval action of the standards because these species do not have a breeding wild population in Oregon's waters:

Argopecten	*irradians*	Bay scallop	Nelson et al. 1988
Melanogrammus	*aeglefinus*	Haddock	Cardin 1986
Penaeus	*aztecus*	Brown shrimp	Ward et al. 1981

Other Acute tests failing QA/QC by species

Cancer magister - Dungeness or edible crab

Glickstein, N. 1978. Acute toxicity of mercury and selenium to Crassostrea gigas embryos and Cancer magister larvae. Mar. Biol. 49(2): 113-117.
Two LC50s from this study were used in BE: the 48 and 96 h LC50. The 1987 ALC document, however, only included the 96 h LC50, as per the recommendations in the Guidelines.

2.2.7.1 Evaluation of the Acute Saltwater Criterion Concentration for Silver

A. Presentation of Toxicological Data

Oregon adopted a saltwater acute criterion concentration of 1.9 µg/L for silver that is expressed in terms of the dissolved concentration of the metal in the water column. This dissolved metal concentration is the same as the saltwater CMC recommended for use nationally by EPA for the protection of aquatic life [69]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.2.7-1 provides available SMAVs based on available acute toxicity data for silver to aquatic life from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.2.7-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Silver

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Cyprinodon	variegatus	Sheepshead minnow	924.4	924.4	12
Crangon	sp.	Caridean shrimp	712.3	712.3	7
Parophrys	vetulus	English sole	680.0	680.0	7
Scorpaenichthys	marmoratus	Cabezon	680.0	680.0	19
Oligocottus	maculosus	Tidepool sculpin	564.4	564.4	18
Apeltes	quadracus	4-spine stickleback	464.6	464.6	9
Oncorhynchus	kisutch	Coho salmon	414.4	-	7
Oncorhynchus	mykiss	Rainbow trout	341.3	376.1	17
Cymatogaster	aggregata	Shiner perch	302.3	302.3	7
Pleuronectes	americanus	Winter flounder	166.9	166.9	9
Americamysis	bahia	Opossum shrimp	166.7	166.7	12,15,16
Nereis	arenaceodentata	Polychaete worm	151.8	151.8	14
Menidia	menidia	Atlantic silverside	93.59	93.59	9
Cancer	magister	Dungeness or edible crab	36.27	36.27	3,7
Fundulus	heteroclitus	Mummichog	34.00	34.00	13
Argopecten	***irradians****	***Bay scallop***	28.05	28.05	11
Acartia	tonsa	Calanoid copepod	30.99	-	2,12
Acartia	clausi	Calanoid copepod	11.31	18.72	2
Mercenaria	***mercenaria****	***Northern quahog or Hard clam***	17.85	17.85	10
Paralichthys	***dentatus****	***Summer Flounder***	15.37	15.37	9
Crassostrea	***gigas***	***Pacific oyster***	14.07	-	3,7,8
Crassostrea	***virginica****	***Eastern oyster***	12.03	13.01	4,5,6
Mytilus	edulis	Common bay mussel, Blue mussel	11.90	11.90	3
Carcinus	maenas*	Green or Europeon shore crab	5.400	5.400	1

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV in the 1980 ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for

[69] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are from the 1980 ALC document as cited in: U.S. EPA. 1980. Ambient Water Quality Criteria Document for Silver. EPA-440/5-80-071.

this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision, particularly for metals such as silver which are expressed on a dissolved metal basis for a comparison with the acute criterion concentration.

B. Evaluation of Protectiveness of the Oregon Saltwater Acute Criterion

Following review of GMAV in Table 2.2.7-1, all tested genera and species have values greater than Oregon's acute criterion concentration for silver. Further, all SMAV/2 values are greater than the criterion. Therefore, EPA concluded that acute effects to these genera and species are not expected to occur at concentrations equal to or lower than the criterion and thus these genera, species, and aquatic life designted use would be protected.

2.2.7.2 References for Silver

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in Tables 2.2.7-1*)
Acute References	
1	Amiard, J.C. 1976. Experimental study on the acute toxicity of cobalt, antimony, strontium and silver salts in some crustacea and their larvae and some teleostei. Rev. Int. Oceanogr. Med. 43: 79-95 (Fre) (Eng Abs).
2	Lussier, S.M. and J.A. Cardin. 1985. Results of Acute Toxicity Tests Conducted with Silver at ERL, Narragansett. U.S. EPA, Narragansett, RI: 14 p.
3	Martin, M., K.E. Osborn, P. Billig and N. Glickstein. 1981. Toxicities of ten metals to *Crassostrea gigas* and *Mytilus edulis* embryos and *Cancer magister* larvae. Mar. Pollut. Bull. 12(9): 305-308 (Author Communication Used).
4	MacInnes, J.R. and A. Calabrese. 1978. Response of embryos of the American oyster, *Crassostrea virginica*, to heavy metals at different temperatures. In: D.S. McLusky and A.J. Berry (Eds.), Physiology and Behaviour of Marine Organisms, Permagon Press, New York, NY: 195-202.
5	Zaroogian, G.E. Interlaboratory Comparison - Acute Toxicity Tests Using the 48 hour Oyster Embryo-larval Assay. U.S. EPA, Narragansett, RI.
6	Calabrese, A., R.S. Collier, D.A. Nelson and J.R. Mac Innes. 1973. The toxicity of heavy metals to embryos of the American oyster *Crassostrea virginica*. Mar. Biol. 18(3): 162-166.
7	Dinnel, P.A., Q.J. Stober, J.M. Link, M.W. Letourneau, W.E. Roberts, S.P. Felton and R.E. Nakatani. 1983. Methodology and Validation of a Sperm Cell Toxicity Test for Testing Toxic Substances in Marine Waters. Final Report, FRI-UW-8306, Fisheries Research Inst., School of Fisheries, University of Washington, Seattle, WA: 208.
8	Coglianese, M.P. and M. Martin. 1981. Individual and interactive effects of environmental stress on the embryonic development of the Pacific oyster, *Crassostrea gigas*. Mar. Environ. Res. 5(1): 13-27
9	Cardin, J.A. 1980. Unpublished Laboratory Data. U.S. EPA, Narragansett, RI: 9.
10	Calabrese, A. and D.A. Nelson. 1974. Inhibition of embryonic development of the hard clam, *Mercenaria mercenaria*, by heavy metals. Bull. Environ. Contam. Toxicol. 11(1): 92-97.
11	Nelson, D.A., A. Calabrese, B.A. Nelson, J.R. MacInnes and D.R. Wenzloff. 1976. Biological effects of heavy metals on juvenile bay scallops, *Argopecten irradians*, in short-term exposures. Bull. Environ. Contam. Toxicol. 16(3): 275-282.
12	Schimmel, S.C. 1981. Results: Interlaboratory Comparison - Acute Toxicity Tests Using Estuarine Animals. Final Draft, EPA 600/4-81-003, U.S. EPA, Gulf Breeze, FL: 13 p.
13	Jackim, E., J.M. Hamlin and S. Sonis. 1970. Effects of metal poisoning on five liver enzymes in the killifish (*Fundulus heteroclitus*) (Auth. communication used). J. Fish. Res. Board Can. 27(2): 383-390.
14	Pesch, C.E. and G.L. Hoffman. 1983. Interlaboratory comparison of a 28-day toxicity test with the polychaete

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in Tables 2.2.7-1*)
	Neanthes arenaceodentata. In: W.E. Bishop, R.D. Cardwell and B.B. Heidolph (Eds.), Aquatic Toxicology and Hazard Assessment, 6th Symposium, ASTM STP 802, Philadelphia, PA: 482-493.
15	Ward and Kramer. 2002. Silver speciation during chronic toxicity tests with the mysid, *Americamysis bahia*. Comar. Biochem. Physiol. Toxicol. Pharmacol.: CBP 133(1-2): 75-86
16	Lussier, S.M., J.H. Gentile and J. Walker. 1985. Acute and chronic effects of heavy metals and cyanide on *Mysidopsis bahia* (Crustacea: Mysidacea). Aquat. Toxicol. 7(1-2): 25-35.
17	Ferguson, E.A. and C. Hogstrand. 1998. Acute silver toxicity to seawater-acclimated rainbow trout: Influence of salinity on toxicity and silver speciation. Environ. Toxicol. Chem. 17(4): 589-593.
18	Shaw, J.R., C.M. Wood, W.J. Birge and C. Hogstrand. 1998. Toxicity of silver to the marine teleost (*Oligocottus maculosus*): Effects of salinity and ammonia. Environ. Toxicol. Chem. 17(4): 594-600.
19	Dinnel, P.A., J.M. Link, Q.J. Stober, M.W. Letourneau and W.E. Roberts. 1989. Comparative sensitivity of sea urchin sperm bioassays to metals and pesticides. Arch.Environ.Contam.Toxicol. 18(5): 748-755.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For detailed discussion, see Appendix T.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[70], EPA is providing a transparent rationale as to why they were not utilized (see below).
2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix T).

[70] U.S. EPA. 1980. Ambient Water Quality Criteria Document for Silver. EPA-440/5-80-071.

2.2.8 TRIBUTYLTIN

2.2.8.1 Evaluation of the Acute Saltwater Criterion Concentration for Tributyltin

A. Presentation of Toxicological Data

Oregon adopted a saltwater acute criterion concentration of 0.37 µg/L for tributyltin. Oregon adopted EPA's draft guidance acute criterion concentration which was issued in 2002, EPA's final guidance acute criterion concentration for tributyltin was issued in December 2003. The saltwater acute criterion concentration recommended for use nationally by EPA for the protection of aquatic life[71] is 0.42 ug/L. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.2.7-1 provides available GMAVs based on available acute toxicity data for tributyltin to aquatic life from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.2.7-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Tributyltin

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Ostrea	edulis	European flat oyster	204.4	204.4	6
Rhepoxynius	abronius	Amphipod	108.0	108.0	14
Hemigrapsus	nudus	Shore crab	83.28	83.28	8
Nucella	lapillus*	Atlantic dogwhinkle	72.70	72.70	23
Rhithropanopeus	harrisii	Mud crab	34.90	34.90	22
Armandia	brevis	Polychaete	25.00	25.00	14
Fundulus	heteroclitus	Mummichog	21.24	21.24	4,21
Orchestia	traskiana	Amphipod	>14.60	>14.60	20
Platichthys	stallatus	Starry flounder	10.10	10.10	14
Branchiostoma	caribaeum	Caribbean lancelet	<10.00	<10.00	18
Carcinus	maenas	Shore crab	9.732	9.732	6
Eohaustorius	estuarius	Amphipod	10.00	-	19
Eohaustorius	washingtonianus	Amphipod	9.000	9.487	14
Cyprinodon	variegatus	Sheepshead minnow	9.037	9.037	4,15,16,17
Palaemonetes	pugio	Grass shrimp	20.00	-	18
Palaemonetes	sp.	Grass shrimp	4.070	9.022	12
Neanthes	arenaceodentata	Polychaete	6.812	6.812	11
Gammarus	sp.	Amphipod	5.300	5.300	4
Menidia	menidia	Atlantic silverside	8.900	-	4
Menidia	beryllina	Inland silverside	3.000	5.167	4
Brevoortia	tyrannus	Atlantic menhaden	4.944	4.944	4
Arenicola	cristata	Lugworm	4.740	4.740	13
Metamysidopsis	elongata	Mysid	3.183	3.183	11
Mytilus	edulis	Blue mussel	2.238	2.238	6
Eurytemora	affinis	Copepod	1.975	1.975	4,10
Nitocra	spinipes	Copepod	1.911	1.911	9
Homarus	americanus	American lobster	1.745	1.745	8
Americamysis	bahia	Mysid	1.692	1.692	7

[71] See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are from the 2003 ALC document as cited in: U.S. EPA. 2003. Ambient Water Quality Criteria for Tributyltin (TBT) - Final. EPA-882-R-03-031.

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Mercenaria	***mercenaria****	***Hard clam***	1.650	1.650	3
Oncorhynchus	***tshawytscha***	***Chinook salmon***	1.460	1.460	5
Acartia	***tonsa***	***Copepod***	1.100	1.100	4
Crassostrea	gigas	Pacific oyster	1.557	-	6
Crassostrea	virginica*	Eastern oyster	0.7100	1.051	2,3
Holmesimysis	***sculpta***	***Mysid***	0.6100	0.6100	1

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV in the 2003 ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera are identified as such.
Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 1.2 of this evaluation for an explanation of this decision.

B. Evaluation of the Protectiveness of the Oregon Saltwater Acute Criterion

Following review of GMAV values in Table 2.2.7-1, all tested genera have values greater than Oregon's acute criterion concentration for tributyltin. Therefore, EPA concluded that these genera and the aquatic life designated use would be protected by the criterion.

When compared to Oregon's acute criterion concentration for tributyltin, SMAV/2 values for two test species (the mysid shrimp *Holmesimysis sculpta*, and the Eastern oyster *Crassostrea virginica*) were lower than the acute criterion concentration of 0.37 µg/L tributyltin. Only the mysid shrimp is expected to reside in Oregon waters. Therefore, EPA reviewed the data from the study that made up the most representative SMAV for the species and compared the confidence intervals of the SMAV value to determine whether the SMAV/2 value is quantitatively different from the criterion value of 0.37 µg/L.

The SMAV for *Holmesimysis sculpta* was based on a single LC50 of 0.6100 µg/L. The 5 and 95 percent confidence intervals around the LC50 were not reported in the study. When divided by two, the SMAV/2 for *Holmesimysis sculpta* was 0.3050 µg/L. The Oregon acute criterion for tributyltin is greater than the SMAV/2 for *Holmesimysis sculpta*. Therefore, EPA concludes that the occurrence of ambient concentrations equal to or greater than the Oregon CMC for tributyltin may result in some acute effects to individuals within this species. However, the aquatic life designated use would be protected by the criterion.

2.2.8.2 Evaluation of the Chronic Saltwater Criterion Concentration for Tributyltin

A. Presentation of Toxicological Data

Oregon adopted a saltwater chronic criterion concentration of 0.01 µg/L for tributyltin. Oregon adopted EPA's draft guidance chronic criterion concentration which was issued in 2002, EPA's final guidance chronic criterion concentration was issued in December 2003. The saltwater chronic criterion concentration recommended for use nationally by EPA for the protection of aquatic life[72]. EPA developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a) which is 0.0074 µg/L for tributyltin. The difference between the 0.01 ug/L adopted value and the 0.0074 ug/L final value is negligible and orders of magnitude below detection of environmental concentrations of this chemical and is of no concern to EPA.

Table 2.2.7-2 presents a compilation of the SMAVs from Table 2.2.7-1, any experimentally determined SMCVs obtained from the criteria document and EPA ECOTOX download used for the BE, and estimated GMCVs based on the GMAV/ACR. The 2003 criteria document for tributyltin reported an FACR of 12.69, which EPA calculated as the geometric mean of four experimentally determined ACRs ranging from 4.7 for an acutely sensitive saltwater invertebrate, the mysid (*Acanthomysis sculpta,* identified in this evaluation as *Holmesimysis sculpta*) to 36.6 for an acutely sensitive invertebrate, *Daphnia magna*. The FACR of 12.69 included ACRs from two freshwater species (*Daphnia magna* and *Pimephales promelas*) and two saltwater species (*Holmesimysis sculpta and Eurytemora affinis*). Since no additional acceptable ACRs are available, EPA calculated the predicted GMCVs for tributyltin in Table 2.2.7-2 using the FACR of 12.69 and the following equation: Predicted GMCV = GMAV/FACR.

EPA compared the GMCVs for each species to Oregon's tributyltin chronic criterion to determine whether the chronic criterion will protect Oregon's aquatic life designated use.

Table 2.2.7-2: Genus Mean Chronic Values (GMCVs) for Tributyltin

Genus	**Species**	**Common name**	**GMAV (µg/L)**	**SMCV (µg/L)** (*experimentally derived*)	**Chronic References** (*used in the calculation of the SMCV*)	**Predicted GMCV (µg/L)**
Ostrea	edulis	European flat oyster	204.4			16.11
Rhepoxynius	abronius	Amphipod	108.0			8.511
Hemigrapsus	nudus	Shore crab	83.28			6.563
Nucella	lapillus*	Atlantic dogwhinkle	72.70	0.01430	1	5.729 (0.01430)
Rhithropanopeus	harrisii	Mud crab	34.90			2.750
Armandia	brevis	Polychaete	25.00			1.970
Fundulus	heteroclitus	Mummichog	21.24			1.674
Orchestia	traskiana	Amphipod	>14.60			>1.151
Platichthys	stallatus	Starry flounder	10.10			0.7959
Branchiostoma	caribaeum	Caribbean lancelet	<10.00			<0.7880
Carcinus	maenas	Shore crab	9.732			0.7669
Eohaustorius	estuarius	Amphipod	-			-
Eohaustorius	washingtonianus	Amphipod	9.487			0.7476
Cyprinodon	variegatus	Sheepshead minnow	9.037			0.7121
Palaemonetes	pugio	Grass shrimp	-			-
Palaemonetes	sp.	Grass shrimp	9.022			0.7110
Neanthes	arenaceodentata	Polychaete	6.812			0.5368
Gammarus	sp.	Amphipod	5.300			0.4177
Menidia	menidia	Atlantic silverside	-			-
Menidia	beryllina	Inland silverside	5.167			0.4072
Brevoortia	tyrannus	Atlantic	4.944			0.3896

[72] See Footnote 73 above.

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) (*experimentally derived*)	Chronic References (*used in the calculation of the SMCV*)	Predicted GMCV (µg/L)
		menhaden				
Arenicola	cristata	Lugworm	4.740			0.3735
Metamysidopsis	elongata	Mysid	3.183			0.2508
Mytilus	edulis	Blue mussel	2.238			0.1764
Eurytemora	affinis	Copepod	1.975	<0.1130	2	0.1556 (<0.1130)
Nitocra	spinipes	Copepod	1.911			0.1506
Homarus	americanus	American lobster	1.745			0.1375
Americamysis	bahia	Mysid	1.692			0.1333
Mercenaria	***mercenaria****	***Hard clam***	1.650			0.1300
Oncorhynchus	***tshawytscha***	***Chinook salmon***	1.460			0.1151
Acartia	***tonsa***	***Copepod***	1.100			0.08668
Crassostrea	gigas	Pacific oyster	-			-
Crassostrea	virginica*	Eastern oyster	1.051			0.08285
Holmesimysis	***sculpta***	***Mysid***	0.6100	0.1308	3, 4	0.04807 (0.1308)

See same notes as above under Table 2.2.7-1.

B. Evaluation of the Protectiveness of the Oregon Saltwater Chronic Criterion

Following the review of the GMCV values in Table 2.2.7-2, all tested genera and species have values greater than Oregon's chronic criterion for tributyltin. It should be noted that the saltwater criterion for tributyltin was derived from field studies on gastropods including the uptake and bioaccumulation properties of the metal. This evaluation found no data to indicate that Oregon's adopted criteria, and by extension, the 304(a) nationally recommended value were not protective of any speces. Therefore, EPA concluded that chronic effects are not expected to occur at concentrations equal to or lower than the criterion and thus these species and the aquatic life designated use would be protected by the criterion.

2.2.8.3 References for Tributyltin

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in Tables 2.2.7-1 and 2.2.7-2*)
Acute References	
1	Valkirs, A.O., B.M. Davidson and P.F. Seligman. 1985. Sublethal Growth Effects and Mortality to Marine Bivalves and Fish from Long-term Exposure to Tributyltin. NOSC-TR-1042 or AD-A162-629-0. National Technical Information Service, Springfield, VA.
2	Office of Pesticide Programs. 2000. Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB)). Environmental Fate and Effects Division, U.S. EPA, Washington, D.C.
3	Roberts, M.H.J. 1987. Acute toxicity of tributyltin chloride to embryos and larvae of two bivalve mollusks, *Crassostrea virginica* and *Mercenaria mercenaria*. Bull. Environ. Contam. Toxicol. 39: 1012-1019.

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in Tables 2.2.7-1 and 2.2.7-2*)
4	Bushong, S.J., L.W. Hall, Jr., W.S. Hall, W.E. Johnson and R.L. Herman. 1988. Acute toxicity of tributyltin to selected Chesapeake Bay fish and invertebrates. Water Res. 22(8): 1027-1032.
5	Short, J.W. and F.P. Thrower. 1987. Toxicity of tri-n-butyl-tin to Chinook salmon, *Oncorhynchus tshawytscha,* adapted to seawater. Aquaculture 61(3-4): 193-200.
6	Thain, J.E. 1983. The Acute Toxicity of Bis(tributyltin) Oxide to the Adults and Larvae of Some Marine Organisms. Int. Counc. Explor. Sea, Mariculture Committee E: 13. 5 pp.
7	Goodman, L.R., G.M. Cripe, P.H. Moody and D.G. Halsell. 1988. Acute toxicity of malathion, tetrabromobisphenol-a, and tributyltin chloride to mysids (*Mysidopsis bahia*) of three ages. Bull. Environ. Contam. Toxicol. 41(5):746-753.
8	Laughlin, R.B.J. and W.J. French. 1980. Comparative study of the acute toxicity of a homologous series of trialkyltins to larval shore crabs *Hemigrapsus nudus*, and lobster, *Homarus americanus*. Bull. Environ. Contam. Toxicol. 25(5): 802-809.
9	Linden, E., B.E. Bengtsson, O. Svanberg and G. Sundstrom. 1979. The acute toxicity of 78 chemicals and pesticide formulations against two brackish water organisms, the bleak (*Alburnus alburnus*) and the harpacticoid. Chemosphere 8(11/12): 843-851 (Author Communication Used) (OECDG Data File).
10	Hall, L.W., Jr., S.J. Bushong, W.S. Hall and W.E. Johnson. 1988. Acute and chronic effects of tributyltin on a Chesapeake Bay copepod. Environ. Toxicol. Chem. 7: 41-46.
11	Salazar, M.H. and S.M. Salazar. 1989. Acute Effects of (bis)Tributyltin Oxide on Marine Organisms. Tech. Rep. No. 1299, Naval Ocean Systems Center, San Diego, CA: 87 p. (U.S. NTIS AD-A214005).
12	Khan, A.T., J.S. Weis, C.E. Saharig and A.E. Polo. 1993. Effect of tributyltin on mortality and telson regeneration of grass shrimp, *Palaemonetes pugio*. Bull. Environ. Contam. Toxicol. 50(1): 152-157.
13	Walsh, G.E., M.K. Louie, L.L. McLaughlin and E.M. Lores. 1986. Lugworm (*Arenicola cristata*) larvae in toxicity tests: Survival and development when exposed to organotins. Environ. Toxicol. Chem. 5: 749-754.
14	Meador, J.P. 1997. Comparative toxicokinetics of tributyltin in five marine species and its utility in predicting bioaccumulation and acute toxicity. Aquat. Toxicol. 37: 307-326.
15	EG&G Bionomics. 1979. Acute Toxicity of Three Samples of TBTO (Tributyltin Oxide) to Juvenile Sheepshead Minnows (*Cyprinodon variegatus*). Report L14-500 to M&T Chemicals Inc., Rahway, NJ.
16	EG&G Bionomics. 1981. Unpublished Laboratory Data on Acute Toxicity of Tributyltin to Sheepshead Minnow, *Cyprinodon variegatus*. Pensacola, FL.
17	Walker, W.W. 1989a. Acute Toxicity of Bis(tributyltin)oxide to the Sheepshead Minnow in a Flow-through System. Final Report to M&T Chemicals, Inc. and Sherex Chemical Co., Inc. 94 pp.
18	Clark, J.R., J.M. Patrick, Jr., J.C. Moore and E.M. Lores. 1987. Waterborne and sediment-source toxicities of six organic chemicals to grass shrimp (*Palaemonetes pugio*) and amphioxus (*Branchiostoma caribaeum*). Arch. Environ. Contam. Toxicol. 16: 401-407.
19	Meador, J.P. 1993. The effect of laboratory holding on the toxicity response of marine infaunal amphipods to cadmium and tributyltin. J. Exp. Mar. Biol. Ecol. 174: 227-242.
20	Laughlin, R.B., O. Linden and H.E. Guard. 1982. Acute Toxicity of Tributyltins and Tributyltin Leachates from Marine Antibiofouling Paints. Office of Naval Research, Arlington, VA: 26 p. (U.S. NTIS AD-A184224).
21	Pinkney, A.E., D.A. Wright and G.M. Hughes. 1989. A morphometric study of the effects of tributyltin compounds on the gills of the mummichog, *Fundulus heteroclitus*. J. Fish Biol. 34(5): 665-677.
22	Laughlin, R., W. French and H.E. Guard. 1983. Acute and sublethal toxicity of tributyltin oxide (TBTO) and its putative environmental product, tributyltin sulfide (TBTS) to zoeal mud crabs, *Rhithropanopeus harrisii*. Water Air Soil Pollut. 20(1): 69-79.
23	Harding, M.J.C., S.K. Bailey and I.M. Davies. 1996. Effects of TBT on the Reproductive Success of the Dogwhelk *Nucella lapillus*. Napier University of Edinburgh and The Scottish Office of Agriculture, Environment and Fisheries Department, Aberdeen, Scotland. 75 pp.
Chronic References	
1	Harding, M.J.C., S.K. Bailey and I.M. Davies. 1996. Effects of TBT on the Reproductive Success of the Dogwhelk *Nucella lapillus*. Napier University of Edinburgh and The Scottish Office of Agriculture, Environment and Fisheries Department, Aberdeen, Scotland. 75 pp.
2	Hall, L.W., Jr., S.J. Bushong, W.S. Hall and W.E. Johnson. 1988. Acute and chronic effects of tributyltin on a Chesapeake Bay copepod. Environ. Toxicol. Chem. 7: 41-46.
3	Davidson, B.M., A.O. Valkirs and P.F. Seligman. 1986a. Acute and Chronic Effects of Tributyltin on the Mysid *Acanthomysis sculpta* (Crustacea, Mysidacea). NOSC-TR-1116 or AD-A175-294-8. National Technical Information Service, Springfield, VA.
4	Davidson, B.M., A.O. Valkirs and P.F. Seligman. 1986b. Acute and Chronic Effects of Tributyltin on the Mysid *Acanthomysis sculpta* (Crustacea, Mysidacea). In: Oceans 86, Vol. 4. Proceeding International Organotin Symposium. Marine Technology Society, Washington, DC. pp. 1219-1225.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For details, see Appendix U.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[73], EPA is providing a transparent rationale as to why they were not utilized (see below).
2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix U).

[73] U.S. EPA. 2003. Ambient Water Quality Criteria for Tributyltin (TBT) - Final. EPA-882-R-03-031.

2.2.9 ZINC

2.2.9.1 Evaluation of the Acute Saltwater Criterion Concentration for Zinc

A. Presentation of Toxicological Data

Oregon adopted a saltwater acute criterion concentration of 90 µg/L for zinc that is expressed in terms of the dissolved concentration of the metal. This dissolved metal concentration is the same as the saltwater CMC recommended for use nationally by EPA for the protection of aquatic life[74]. EPA developed the recommended criterion in accordance with the *Guidelines* pursuant to CWA section 304(a).

Table 2.2.8-1 provides available SMAVs based on available acute toxicity data for zinc to aquatic life from the criteria document and from EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) subsequently used to support the BE.

Table 2.2.8-1: Species Mean Acute Values (SMAVs) and Genus Mean Acute Values (GMAVs) for Zinc

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Macoma	balthica	Balthica macoma or clam	303098	303098	38
Rivulus	marmoratus	Rivulus	137311	137311	44
Eurythoe	complanata	Fireworm	132062	132062	45
Fundulus	heteroclitus	Mummichog	122507	122507	44
Nassarius	obsoletus	Eastern mud snail	47300	47300	18
Asterias	forbesii	Common starfish	36894	36894	18
Leiostomus	xanthurus	Spot	35948	35948	39
Portunus	pelagicus	Crab	15005	15005	41
Nereis	diversicolor	Polychaete worm	16990	-	42,43
Nereis	virens	Polychaete worm	7663	11410	18
Pseudopleuronectes	americanus	Winter flounder	8955	8955	34
Menidia	beryllina	Inland silverside	19866	-	37
Menidia	peninsulae	Tidewater silverside	5298	-	39
Menidia	menidia	Atlantic silverside	3444	7130	34
Mya	arenaria	Soft-shell clam	5986	5986	18,40
Corophium	volutator	Scud	4430	4430	38
Cyprinodon	variegatus	Sheepshead minnow	4146	4146	36,37
Eurytemora	affinis	Calanoid copepod	3854	3854	16
Pectinaria	californiensis	Cone worm	2649	2649	27
Capitella	capitata	Polychaete worm	2327	2327	26,27
Ctenodrilus	serratus	Polychaete worm	2285	2285	28,33
Argopecten	irradians	Bay scallop	2129	2129	32
Allorchestes	compressa	Scud, Amphipod	1892	1892	31
Loligo	opalescens	California market squid	>1816	1816	9,12
Monhystera	disjuncta	Nematode	1797	1797	30
Nitocra	spinipes	Harpacticoid copepod	1785	1785	28,29
Pseudodiaptomus	coronatus	Calanoid copepod	1687	1687	25

74 See U.S. EPA. 2004. National Recommended Water Quality Criteria. EPA-822-H-04-001.
The data which serve as the basis for the current nationally-recommended criteria are cited in: U.S. EPA. 1987. Ambient Water Quality Criteria for Zinc - 1987. EPA-440-5-87-003.

Genus	Species	Common name	Most Representative SMAV (µg/L)	GMAV (µg/L)	Acute References *(used in the calculation of the SMAV)*
Ophryotrocha	labronica	Polychaete	1703	-	27
Ophryotrocha	diadema	Polychaete	1324	1502	28
Neanthes	arenaceodentata	Polychaete worm	1272	1272	26,27
Penaeus	duorarum	Northern pink shrimp	993.3	993.3	24
Metapenaeus	dobsoni	Kadal shrimp	955.4	955.4	23
Carcinus	maenas	Green or Europeon shore crab	946.0	946.0	22
Mytilus	edulis (planulatus)	Common bay mussel,blue mussel	3722	-	35
Mytilus	galloprovincialis	Mediterranean mussel	137.2	714.5	7
Acartia	clausi	Calanoid copepod	1132	-	16,25
Acartia	tonsa	Calanoid copepod	278.3	561.3	16
Cancer	magister	Dungeness or edible crab	554.5	554.5	9
Americamysis	bigelowi	Shrimp	559.4	-	21
Americamysis	bahia	Opossum shrimp	472.1	513.9	20
Morone	saxatilis	Striped bass	406.8	406.8	19
Pagurus	longicarpus	Longwrist hermit crab	378.4	378.4	18
Homarus	***americanus***	***American lobster***	360.0	360.0	17
Crassostrea	***virginica****	***Eastern oyster***	248.3	-	14,15
Crassostrea	***gigas***	***Pacific oyster***	179.5	211.1	8,9,10,11
Mercenaria	***mercenaria****	***Northern quahog or hard clam***	184.5	184.5	13
Scorpaenichthys	***marmoratus***	***Cabezon***	181.1	181.1	12
Nanosesarma	sp.*	Crab	118.3	118.3	6
Acanthomysis	costata	Mysid	91.02	91.02	4, 5
Haliotis	rufescens	Red abalone	50.95	50.95	1,2,3,4

Note 1: Species that are bold and italicized indicate those associated with the four most sensitive genera used to derive the FAV in the 1987 ALC document. Underlined species with an asterisk (*) indicate known or suspected Oregon non-resident species, and for this evaluation, only those non-resident species below the criterion or related to the four most sensitive genera are identified as such.

Note 2: The reporting of calculated values has been limited to a minimum of four significant figures for convenience and use in this evaluation with the exception of very high values, which are reported as whole numbers - see text in section 2.2 of this evaluation for an explanation of this decision, particularly for metals such as zinc which are expressed on a dissolved metal basis for a comparison with the acute criterion concentration.

B. Evaluation of Protectiveness of the Oregon Saltwater Acute Criterion

Following review of GMAV values in Table 2.2.8-1, 39 of the 42 genera have values greater than Oregon's acute criterion concentration for zinc. Therefore, EPA concluded that acute effects to these genera are not expected to occur at concentrations equal to or lower than the criterion such that these nearly all genera would be protected, and thus the aquatic life designated use would be protected.

When compared to Oregon's acute criterion concentration for zinc, SMAV/2 values for five test species: three mollusks (*Haliotis rufescens*, *Mytilus galloprovincialis*, and *Crassostrea gigas*) and two crustaceans (*Acanthomysis costata* and *Nanosesarma* sp.) were lower than the acute criterion concentration of 90 µg/L dissolved zinc. All but one of these species (*Nanosesarma* sp.) resides in Oregon waters. Therefore, EPA reviewed the data from the studies that make up the most representative SMAV for the four resident species and compared the SMAV for these species to determine whether the SMAV/2 values are quantitatively different from the criterion value of 90 µg/L.

The SMAV for *Haliotis rufescens* based on dissolved zinc was 50.95 µg/L, and the SMAV for the subset of studies with reported confidence intervals was 50.80 µg/L (text box A – *H. rufescens* acute). The SMAV/2 was 25.48 µg/L.

The SMAV for *Acanthomysis costata* based on dissolved zinc was 91.02 µg/L, and the SMAV for the subset of studies with reported confidence intervals was 107.4 µg/L (text box B – *A. costata* acute). The SMAV/2 was 53.72 µg/L.

The SMAV for *Mytilus galloprovincialis* was based on a single LC50 of 137.2 µg/L dissolved zinc. The 5 and 95 percent confidence intervals were not reported for the test. The SMAV/2 for *M. galloprovincialis* was 68.59 µg/L.

The SMAV for *Crassostrea gigas* based on dissolved zinc was 179.5 µg/L, and the SMAV for the subset of studies with reported confidence intervals was 176.3 µg/L, with 5 and 95 percent confidence intervals of 139.5 µg/L and 219.3 µg/L, respectively (text box C – *C. gigas* acute). The SMAV/2 is 89.75 µg/L.

Because the Oregon acute criterion for zinc is greater than the SMAV/2 for *Haliotis rufescens*,*Acanthomysis costata*, and *Mytilus galloprovincialis*, EPA concludes that the occurrence of ambient concentrations equal to or greater than the Oregon CMC for zinc may result in mortality to some individuals within these speciesFor *Crassostrea gigas*, Because the Oregon acute criterion for zinc is approximately equal to the SMAV/2, a value estimated to represent acute effect levels indistinguishable from control levels, EPA concludes that the Oregon CMC for zinc is sufficiently protective of this species.

Saltwater zinc acute criterion comparison

Text Box A (acute) – Basis for the meta analysis comparing the SMAV/2 for the red abalone (*Haliotis rufescens*) to the acute criterion for zinc (90 µg/L dissolved metal concentration).

Haliotis rufescens								
	Reported Values			**Dissolved Normalized Values**			**Dissolved Normalized Values/2**	
	LC50	5% CI	95% CI	LC50	5% CI	95% CI	LC50 / 2	CMC
	40.00	39.40	41.00	37.84	37.27	38.79	18.92	90
	55.00	NR	NR	52.03	NR	NR	26.02	
	76.00	68.60	83.10	71.90	64.90	78.61	35.95	
	64.00	56.60	71.40	60.54	53.54	67.54	30.27	
	64.00	58.90	69.10	60.54	55.72	65.37	30.27	
	47.00	41.30	52.70	44.46	39.07	49.85	22.23	
	44.00	38.50	49.50	41.62	36.42	46.83	20.81	
	50.00	45.60	54.40	47.30	43.14	51.46	23.65	
				SMAV			**SMAV/2**	
Geomean (all)	53.86			50.95			25.48	
Geomean (CI Only)	53.70	48.74	58.64	50.80	46.11	55.48	25.40	

Text Box B (acute) – Basis for the meta analysis comparing the SMAV/2 for the mysid shrimp (*Acanthomysis costata*) to the acute criterion for zinc (90 µg/L dissolved metal concentration).

Acanthomysis costata								
	Reported Values			**Dissolved Normalized Values**			**Dissolved Normalized Values/2**	
	LC50	5% CI	95% CI	LC50	5% CI	95% CI	LC50 / 2	CMC
	80.70	NR	NR	76.34	NR	NR	38.17	90
	88.40	NR	NR	83.63	NR	NR	41.81	
	73.20	NR	NR	69.25	NR	NR	34.62	
	70.20	NR	NR	66.41	NR	NR	33.20	
	93.60	NR	NR	88.55	NR	NR	44.27	
	78.80	NR	NR	74.54	NR	NR	37.27	
	88.40	NR	NR	83.63	NR	NR	41.81	
	89.00	77.00	101.00	84.19	72.84	95.55	42.10	
	138.0	122.0	152.0	130.5	115.41	143.79	65.27	
	87.00	75.00	100.00	82.30	70.95	94.60	41.15	
	81.00	73.00	91.00	76.63	69.06	86.09	38.31	
	212.0	177.0	260.0	200.6	167.4	246.0	100.3	
	151.0	138.0	167.0	142.8	130.55	157.98	71.42	
	88.00	77.00	101.00	83.25	72.84	95.55	41.62	
				SMAV			**SMAV/2**	
Geomean (all)	96.22			91.02			45.51	
Geomean (CI only)	113.6	99.53	129.6	107.4	94.15	122.6	53.72	

Text Box C (acute) – Basis for the meta analysis comparing the SMAV/2 for the Pacific oyster (*Crassostrea gigas*) to the acute criterion for zinc (90 µg/L dissolved metal concentration).

Crassostrea gigas								
		Reported Values		**Dissolved Normalized Values**			**Dissolved Normalized Values/2**	
	LC50	5% CI	95% CI	LC50	5% CI	95% CI	LC50 / 2	CMC
	200.0	NR	NR	189.2	NR	NR	94.60	90
	206.5	160.0	280.0	195.3	151.4	264.9	97.67	
	263.5	187.2	339.8	249.3	177.1	321.4	124.64	
	119.0	107.0	131.0	112.6	101.2	123.9	56.29	
				SMAV			**SMAV/2**	
Geomean (all)	189.7			179.5			89.75	
Geomean (CI only)	186.4	147.4	231.9	176.3	139.5	219.3	88.15	

2.2.9.2 Evaluation of the Chronic Saltwater Criterion Concentration for Zinc

A. Presentation of Toxicological Data

Oregon adopted a saltwater chronic criterion concentration of 81 µg/L for zinc expressed as the dissolved metal concentration in the water column. This concentration is the same as the saltwater CCC recommended for use nationally by EPA for the protection of aquatic life[75]. EPA

[75] See footnote 76 above.

developed the recommended criterion in accordance with the 1985 Guidelines pursuant to CWA section 304(a).

Table 2.2.8-2 presents a compilation of the GMAVs from Table 2.2.8-1, any experimentally determined SMCVs obtained from the criteria document and EPA ECOTOX download used for the BE, and estimated GMCVs based on the GMAV/ACR. The 1987 criteria document for zinc[76] reported an FACR of 2.208. Because of the large range in ACRs (0.7027 to 41.20) and trend of lower ACRs for the most acutely sensitive species, EPA determined that only the experimentally-determined ACRs for the freshwater *Daphnia magna*, chinook salmon, and rainbow trout, and the saltwater opossum shrimp, *Americamysis bahia*, were the most appropriate ACRs to protect sensitive species in general. Since no additional acceptable ACRs are available, EPA calculated the predicted GMCVs for zinc in Table 2.2.8-2 using an ACR of 2.208 and the following equation: Predicted GMCV = GMAV/FACR.

EPA compared the SMCVs for each species to Oregon's zinc chronic criterion to determine whether the chronic criterion will protect Oregon's aquatic life designated use.

Table 2.2.8-2: Genus Mean Chronic Values (GMCVs) for Zinc

Genus	**Species**	**Common name**	**GMAV (µg/L)**	**SMCV (µg/L)** (*experimentally derived*)	**Chronic References** (*used in the calculation of the SMCV*)	**Predicted GMCV (µg/L)**
Macoma	balthica	Balthica macoma or clam	303098			137273
Rivulus	marmoratus	Rivulus	137311			62188
Eurythoe	complanata	Fireworm	132062			59811
Fundulus	heteroclitus	Mummichog	122507			55483
Nassarius	obsoletus	Eastern mud snail	47300			21422
Asterias	forbesii	Common starfish	36894			16709
Leiostomus	xanthurus	Spot	35948			16281
Portunus	pelagicus	Crab	15005			6796
Nereis	diversicolor	Polychaete worm	-			-
Nereis	virens	Polychaete worm	11410			5168
Pseudopleuronectes	americanus	Winter flounder	8955			4056
Menidia	beryllina	Inland silverside	-			-
Menidia	peninsulae	Tidewater silverside	-			-
Menidia	menidia	Atlantic silverside	7130			3229
Mya	arenaria	Soft-shell clam	5986			2711
Corophium	volutator	Scud	4430			2007
Cyprinodon	variegatus	Sheepshead minnow	4146			1878
Eurytemora	affinis	Calanoid copepod	3854			1745
Pectinaria	californiensis	Cone worm	2649			1200
Capitella	capitata	Polychaete worm	2327			1054
Ctenodrilus	serratus	Polychaete worm	2285			1035
Argopecten	irradians	Bay scallop	2129			964.0
Allorchestes	compressa	Scud, Amphipod	1892			856.9
Loligo	opalescens	California market	1816			822.6
Monhystera	disjuncta	Nematode	1797			814.0
Nitocra	spinipes	Harpacticoid copepod	1785			808.3

[76] U.S. EPA. 1987. Ambient Water Criteria for Zinc - 1987. EPA-440-5-87-003.

Genus	Species	Common name	GMAV (µg/L)	SMCV (µg/L) (*experimentally derived*)	Chronic References (*used in the calculation of the SMCV*)	Predicted GMCV (µg/L)
Pseudodiaptomus	coronatus	Calanoid copepod	1687			763.9
Ophryotrocha	labronica	Polychaete	-			-
Ophryotrocha	diadema	Polychaete	1502			680.1
Neanthes	arenaceodentata	Polychaete worm	1272			576.0
Penaeus	duorarum	Northern pink shrimp	993.3			449.9
Metapenaeus	dobsoni	Kadal shrimp	955.4			432.7
Carcinus	maenas	Green or Europeon shore crab	946.0			428.4
Mytilus	edulis (planulatus)	Common bay mussel, blue mussel	-			-
Mytilus	galloprovincialis	Mediterranean mussel	714.5			323.6
Acartia	clausi	Calanoid copepod	-			-
Acartia	tonsa	Calanoid copepod	561.3			254.2
Cancer	magister	Dungeness or edible crab	554.5			251.1
Americamysis	bigelowi	Shrimp	-			-
Americamysis	bahia	Opossum shrimp	513.9	157.5	2	232.7 (157.5)
Morone	saxatilis	Striped bass	406.8			184.2
Pagurus	longicarpus	Longwrist hermit crab	378.4			171.4
Homarus	***americanus***	***American lobster***	360.0			163.0
Crassostrea	***virginica***	***Eastern oyster***	-			-
Crassostrea	***gigas***	***Pacific oyster***	211.1			95.62
Mercenaria	***mercenaria****	***Northern quahog or hard clam***	184.5			83.55
Scorpaenichthys	***marmoratus***	***Cabezon***	181.1			82.00
Nanosesarma	sp.*	Crab	118.3			53.56
Acanthomysis	costata	Mysid	91.02	63.46	1	41.22 (63.46)
Haliotis	rufescens	Red abalone	50.95			23.08

See same notes as above under Table 2.2.8-1.

B. Evaluation of the Protectiveness of the Oregon Saltwater Chronic Criterion

Following the review of the SMCV values in Table 2.2.8-2, 39 of 42 genera, all but a small proportion of genera, have values greater than Oregon's chronic criterion for zinc. Therefore, EPA concluded that chronic effects to these genra are not expected to occur at concentrations equal to or lower than the criterion and thus these genera and the aquatic life designated use would be protected.

When compared to Oregon's chronic criterion concentration for zinc, SMCVs for four of the five test species noted above (*Haliotis rufescens*, *Mytilus galloprovincialis*, *Acanthomysis costata* and *Nanosesarma* sp.) were lower than the chronic criterion concentration of 81 µg/L dissolved zinc. All but one of these species (*Nanosesarma* sp.) is expected to reside in Oregon waters. Therefore, EPA reviewed the data from the studies that make up the most representative SMCVs for each of those species resident in Oregon waters and, depending on whether the SMCV was estimated based on the use of the ACR or experimentally determined based on NOEC and LOECs, compared the confidence intervals (ACR approach) or LOEC values surrounding these

SMCVs to determine whether the SMCV values were quantitatively different from the chronic criterion value for zinc of 81 µg/L.

The SMCV for *H. rufescens* was estimated by applying the ACR of 2.208 described above to the SMAV. The final SMCV was 23.01 (text box D – *H. rufescens* chronic).

The SMCV for *Acanthomysis costata* was calculated as the geometric mean of the measured LOEC and NOEC for two replicate tests in Anderson et al. (1988). The final dissolved SMCV is 63.46 µg/L (text box E – *A. costata* chronic).

The SMCV for *M. galloprovincialis* was estimated by applying the ACR of 2.208 to the SMAV Five and ninety five percent confidence intervals were not reported for the single test used to calculate the SMAV for this test species. The final SMCV was 62.12 µg/L.

Because the Oregon chronic criterion for zinc is greater than the SMCV for *Haliotis rufescens* and *Mytilus galloprovincialis*, EPA concludes that the Oregon CCC for zinc may not be protective of chronic effects for all individuals within this species. Because the Oregon chronic criterion for zinc is below the LOEC for *Acanthomysis costata*, EPA concludes that the Oregon CCC for zinc is sufficiently protective of this species.

Saltwater zinc chronic criterion comparison

Text Box D (chronic) – Basis for the meta analysis comparing the SMCV for the red abalone (*Haliotis rufescens*) to the chronic criterion for zinc (81 µg/L dissolved metal concentration).

Haliotis rufescens	Reported Values			Dissolved Normalized Values				Dissolved Chronic Values	
	LC50	5% CI	95% CI	LC50	5% CI	95% CI	ACR	LC50 / ACR	CCC
	40.00	39.40	41.00	37.84	37.27	38.79	2.208	17.14	81
	55.00	NR	NR	52.03	NR	NR	2.208	26.02	
	76.00	68.60	83.10	71.90	64.90	78.61	2.208	32.56	
	64.00	56.60	71.40	60.54	53.54	67.54	2.208	27.42	
	64.00	58.90	69.10	60.54	55.72	65.37	2.208	27.42	
	47.00	41.30	52.70	44.46	39.07	49.85	2.208	20.14	
	44.00	38.50	49.50	41.62	36.42	46.83	2.208	18.85	
	50.00	45.60	54.40	47.30	43.14	51.46	2.208	21.42	
								SMCV	
Geomean (all)	53.86			50.95				23.08	
Geomean (CI Only)	53.70	48.74	58.64	50.80	46.11	55.48		23.01	

Text Box E (chronic) – Basis for the meta analysis comparing the SMCV for the mysid shrimp (*Acanthomysis costata*) to the chronic criterion for zinc (81 µg/L dissolved metal concentration).

Acanthomysis costata

	Reported Chronic Values			Dissolved Normalized Chronic Values			
	NOEC	LOEC	CV	NOEC	LOEC	CV	CCC
	45	100	67.08	42.57	94.60	63.46 **(SMCV)**	81

2.2.9.3 References for Zinc

A. Studies That EPA Utilized in this Determination

EPA determined that these studies were acceptable to be utilized in this determination based on the data quality acceptance criteria established in the 1985 Guidelines. The studies listed below were used in the acute and chronic tables, and are the source from which EPA obtained SMAVs (acute table) and experimentally-derived SMCVs (chronic table).

Reference No.	Used Reference Citation (*associated with reference numbers and provided above in Tables 2.2.8-1 and 2.2.8-2*)
Acute References	
1	Conroy, P.T., J.W. Hunt and B.S. Anderson. 1996. Validation of a short-term toxicity test endpoint by comparison with longer-term effects on larval red abalone *Haliotis rufescens*. Environ. Toxicol. Chem. 15(7): 1245-1250.
2	Anderson, B.S., J.W. Hunt, M. Martin, S.L. Turpen and F.H. Palmer. 1988. Marine Bioassay Project. 3rd Report. Protocol Development: Reference Toxicant and Initial Complex Effluent Testing. No. 88-7WQ, State Water Resources Control Board, State of California, Sacramento, CA: 154.
3	Hunt, J.W. and B.S. Anderson. 1989. Sublethal effects of zinc and municipal effluents on larvae of the red abalone *Haliotis rufescens*. Mar. Biol. 101(4): 545-552.
4	Hunt, J.W., B.S. Anderson, S.L. Turpen, A.R. Coulon, M. Martin, F.H. Palmer and J.J. Janik. 1989. Marine Bioassay Project. 4th Report. Experimental Evaluation of Effluent Toxicity Testing Protocols with Giant Kelp, Mysids, Red Abalone. No. 89-5WQ, State Water Resources Control Board, State of California, Sacramento, CA: 144.
5	Martin, M., J.W. Hunt, B.S. Anderson and S.L. Turpen. 1989. Experimental evaluation of the mysid *Holmesimysis costata* as a test organism for effluent toxicity testing. Environ. Toxicol. Chem. 8(11): 1003-1012.
6	Selvakumar, S., S.A. Khan and A.K. Kumaraguru. 1996. Acute toxicity of some heavy metals, pesticides and water soluble fractions of diesel oil to the larvae of some brachyuran crabs. J. Environ. Biol. 17(3): 221-226.
7	Pavicic, J., M. Skreblin, I. Kregar, M. Tusek-Znidaric and P. Stegnar. 1994. Embryo-larval tolerance of *Mytilus galloprovincialis*, exposed to the elevated sea water metal concentrations - I. Toxic effects of Cd, Zn and Hg in relation to the metallothionein level. Comp. Biochem. Physiol. C 107(2): 249-257.
8	Chapman, P.M. and C. McPherson. 1993. Comparative zinc and lead toxicity tests with Arctic marine invertebrates and implications for toxicant discharges. Polar Rec. 29 (168): 45-54; In: E.G.Baddaloo, S. Ramamoorthy and J.W. Moore (Eds.), Proc. 19th Annual Aquatic Toxicity Workshop, Oct. 4-7, 1992, Edmondton, Alberta, Can. Tech. Rep. Fish. Aquat. Sci. No. 1942: 7-22.
9	Dinnel, P.A., Q.J. Stober, J.M. Link, M.W. Letourneau, W.E. Roberts, S.P. Felton and R.E. Nakatani. 1983. Methodology and Validation of a Sperm Cell Toxicity Test for Testing Toxic Substances in Marine Waters. Final Report, FRI-UW-8306, Fisheries Research Inst., School of Fisheries, University of Washington, Seattle, WA: 208.
10	Nelson, V.A. 1972. Effects of Strontium-90 + Yttrium-90, Zinc-65, and Chromium-51 on the Larvae of the Pacific Oyster *Crassostrea gigas*. In: A.T. Proter and D.L. Alverson (Eds.), The Columbia River Estuary and Adjacent Ocean Waters, Chapter 32, University of Washington Press, Seattle, WA: 819-832.
11	Martin, M., K.E. Osborn, P. Billig and N. Glickstein. 1981. Toxicities of ten metals to *Crassostrea gigas* and *Mytilus edulis* embryos and *Cancer magister* larvae. Mar. Pollut. Bull. 12(9): 305-308 (Author Communication Used).
12	Dinnel, P.A., J.M. Link, Q.J. Stober, M.W. Letourneau and W.E. Roberts. 1989. Comparative sensitivity of sea urchin sperm bioassays to metals and pesticides. Arch. Environ. Contam. Toxicol. 18(5): 748-755.
13	Calabrese, A. and D.A. Nelson. 1974. Inhibition of embryonic development of the hard clam, *Mercenaria mercenaria*, by heavy metals. Bull. Environ. Contam. Toxicol. 11(1): 92-97.
14	MacInnes, J.R. and A. Calabrese. 1978. Response of embryos of the American oyster, *Crassostrea virginica*, to heavy metals at different temperatures. In: D.S. McLusky and A.J. Berry (Eds.), Physiology and Behaviour of Marine Organisms, Permagon Press, New York, NY: 195-202.
15	Calabrese, A., R.S. Collier, D.A. Nelson and J.R. Mac Innes. 1973. The toxicity of heavy metals to embryos of the American oyster *Crassostrea virginica*. Mar. Biol. 18(3): 162-166.
16	Lussier, S. and J.A. Cardin. 1985. Results of Acute Toxicity Tests Conducted with Zinc at ERL, Narragansett. U.S. EPA, Narragansett, RI: 6.
17	Johnson, M. 1985. Results of Acute Toxicity Tests Conducted with Zinc at ERL, Narragansett. Memo to D. Hansen, U.S. EPA, Narragansett, RI: 3.

Reference No.	**Used Reference Citation** (*associated with reference numbers and provided above in Tables 2.2.8-1 and 2.2.8-2*)
18	Eisler, R. and R.J. Hennekey. 1977. Acute toxicities of Cd2+, Cr+6, Hg2+, Ni2+ and Zn2+ to estuarine macrofauna. Arch. Environ. Contam. Toxicol. 6(2/3): 315-323
19	Palawski, D., J.B. Hunn and F.J. Dwyer. 1985. Sensitivity of young striped bass to organic and inorganic contaminants in fresh and saline waters. Trans. Am. Fish. Soc. 114: 748-753.
20	Lussier, S.M., J.H. Gentile and J. Walker. 1985. Acute and chronic effects of heavy metals and cyanide on *Mysidopsis bahia* (Crustacea: Mysidacea). Aquat. Toxicol. 7(1-2): 25-35.
21	Lussier, S. and J.H. Gentile. 1985. Results of Acute Toxicity Tests Conducted with Zinc at ERL, Narragansett. U.S. EPA, Narragansett, RI: 2.
22	Connor, P.M. 1972. Acute toxicity of heavy metals to some marine larvae. Mar. Pollut. Bull. 3(12): 190-192.
23	Sivadasan, C.R., P.N.K. Nambisan and R. Damodaran. 1986. Toxicity of mercury, copper and zinc to the prawn *Metapenaeus dobsoni* (Mier). Curr. Sci. 55(7): 337-340.
24	Cripe, G.M. 1994. Comparative acute toxicities of several pesticides and metals to *Mysidopsis bahia* and postlarval *Penaeus duorarum*. Environ. Toxicol. Chem. 13(11): 1867-1872.
25	Gentile, S. and J. Cardin. 1982. Unpublished Laboratory Data. U.S. EPA, Narragansett, RI: 5 p.
26	Reish, D.J., J.M. Martin, F.M. Piltz and J.Q. Word. 1976. The effect of heavy metals on laboratory populations of two polychaetes with comparisons to the water quality conditions and standards in Southern CA. Water Res. 10: 299-302.
27	Reish, D.J. and J.A. Lemay. 1991. Toxicity and bioconcentration of metals and organic compounds by polychaeta. Ophelia (Suppl.) 5: 653-660.
28	Reish, D.J. 1978. The effects of heavy metals on polychaetous annelids. Rev. Int. Oceanogr. Med. 49(3): 99-104.
29	Bengtsson, B.E. 1978. Use of a harpacticoid copepod in toxicity tests. Mar. Pollut. Bull. 9: 238-241.
30	Vranken, G., R. Vandergaeghen and C. Heip. 1991. Effects of pollutants on life-history parameters of the marine nematode *Monhystera disjuncta*. ICES J. Mar. Sci. 48: 325-334.
31	Ahsanullah, M., M.C. Mobley and P. Rankin. 1988. Individual and combined effects of zinc, cadmium and copper on the marine amphipod *Allorchestes compressa*. Aust. J. Mar. Freshwater Res. 39(1): 33-37.
32	Nelson, D.A., J.E. Miller and A. Calabrese. 1988. Effect of heavy metals on bay scallops, surf clams, and blue mussels in acute and long-term exposures. Arch. Environ. Contam. Toxicol. 17(5): 595-600.
33	Reish, D.J., T.V. Gerlinger, C.A. Phillips and P.D. Schmidtbauer. 1977. Toxicity of Formulated Mine Tailings on Marine Polychaete. Marine Biological Consultants, Coasta Mesa, CA: 133.
34	Cardin, J.A. 1985. Acute toxicity data for zinc and the saltwater fish, *Fundulus heteroclitus*, *Menidia menidia* and *Pseudopleuronectes americanus*. (Memorandum to D.J. Hansen, U.S. EPA, Narragansett, RI).
35	Ahsanullah, M. 1976. Acute toxicity of cadmium and zinc to seven invertebrate species from Western Port, Victoria. Aust. J. Mar. Freshwater Res. 27(2): 187-196.
36	Moreau, C.J., P.L. Klerks and C.N. Haas. 1999. Interaction between phenanthrene and zinc in their toxicity to the sheepshead minnow (*Cyprinodon variegatus*). Arch. Environ. Contam. Toxicol. 37(2): 251-257.
37	Lewis, W.M. 1993. Acute and Chronic Responses of *Menidia beryllina*, *Rivulus marmoratus*, and *Cyprinodon variegatus* to Malathion and Zinc Chloride. M.S. Thesis, Florida Inst. of Technol.: 71.
38	Bryant, V., D.M. Newbery, D.S. McLusky and R. Campbell. 1985. Effect of temperature and salinity on the toxicity of nickel and zinc to two estuarine invertebrates (*Corophium volutator*, *Macoma balthica*). Mar. Ecol. Prog. Ser. 24(1-2): 139-153.
39	Hansen, D.J. 1983. Section on Acute Toxicity Tests to be Inserted in the April 1983 Report on Site Specific FAV's. U.S. EPA, Narragansett, RI: 7.
40	Eisler, R. 1977a. Toxicities of selected heavy metals to the soft-shell clam, *Mya arenaria*. Bull. Environ. Contam. Toxicol. 17: 137-145.
41	Hilmy, A.M., N.F. Abdel-Hamid and K.S. Ghazaly. 1985. Toxic effects of both zinc and copper on size and sex of *Portunus pelagicus* (L) (Crustacea: Decapoda). Bull. Inst. Oceanogr. Fish. (Cairo) 11: 207-215.
42	Bryan, G.W. and L.G. Hummerstone. 1973. Adaptation of the polychaete *Nereis diversicolor* to estuarine sediments containing high concentrations of zinc and cadmium. J. Mar. Biol. Assoc. U.K. 53(4): 839-857.
43	Fernandez, T.V. and N.V. Jones. 1990. The influence of salinity and temperature on the toxicity of zinc to *Nereis diversicolor*. Trop. Ecol. 31(1): 40-46.
44	Lin, H.C. and W.A. Dunson. 1993. The effect of salinity on the acute toxicity of cadmium to the tropical, estuarine, hermaphroditic fish, *Rivulus marmoratus*: A comparison of Cd, Cu, and Zn tolerance with *Fundulus heteroclitus*. Arch. Environ. Contam. Toxicol. 25: 41-47.
45	Marcano, L., O. Nusetti, J. Rodriguez-Grau and J. Vilas. 1996. Uptake and depuration of copper and zinc in relation to metal-binding protein in the polychaete *Eurythoe camplanata*. Comp. Biochem. Physiol. C 114(3): 179-184.
Chronic References	
1	Anderson, B.S., J.W. Hunt, M. Martin, S.L. Turpen and F.H. Palmer. 1988. Marine Bioassay Project. 3rd Report. Protocol Development: Reference Toxicant and Initial Complex Effluent Testing. No. 88-7WQ, State Water Resources Control Board, State of California, Sacramento, CA: 154.
2	Lussier, S.M., J.H. Gentile and J. Walker. 1985. Acute and chronic effects of heavy metals and cyanide on *Mysidopsis bahia* (Crustacea: Mysidacea). Aquat. Toxicol. 7(1-2): 25-35.

B. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For details, see Appendix V.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[77], EPA is providing a transparent rationale as to why they were not utilized (see below).
2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix V).

[77] U.S. EPA. 1987. Ambient Water Criteria for Zinc - 1987. EPA-440-5-87-003.

APPENDIX A: QA/QC PROCEDURES

Sections II.B - F, IV.B - E, IV.H, and VI.B - E of the *Guidelines* give reasons why the results of some toxicity tests should not be used, should be rejected, or should not be used in calculations, whereas sections II.G, X, XI.C, XII.A.14, and XII.B allow the use of "questionable data" and "other data" in some situations. In other words, sections II.B - F, IV.B - E, IV.H, VI.B - E give reasons why the results of some toxicity tests using aquatic animals should not be directly used in the derivation of a Final Acute Value (FAV) or a Final Chronic Value (FCV), whereas sections II.G, X, XI.C, XII.A.14, and XII.B describe other possible uses of test results with aquatic animals that should not be directly used in the derivation of a FAV or a FCV.

The *Guidelines* say the following concerning the use of results of toxicity tests using aquatic animals:

1. General guidance:
    a. All data should be available in typed, dated, and signed hard copy (publication, manuscript, letter, memorandum, etc.) with enough supporting information to indicate that acceptable test procedures were used and that the results are probably reliable. (section II.B)
    b. Information that is confidential or privileged or otherwise not available for distribution should not be used. (section II.B)
    c. Questionable data, whether published or unpublished, should not be used. For example, a test result should usually be rejected if it is from:
        i. a test that did not contain a control treatment.
        ii. a test in which too many organisms in the control treatment died or showed signs of stress or disease.
        iii. a test in which distilled or deionized water was used as the dilution water without addition of appropriate salts.

       (section II.C)
    d. A result of a test on technical-grade material may be used if appropriate, but a result of a test on a formulated mixture or an emulsifiable concentrate of the test material should not be used. (section II.D)
    e. For some highly volatile, hydrolyzable, or degradable materials it is probably appropriate to use only results of flow-through tests in which the concentrations of test material in the test solutions were measured often enough using acceptable analytical methods. (section II.E)
    f. Data should be rejected if they were obtained using:
        i. Brine shrimp.
        ii. A species that does not have a reproducing wild population in North America.
        iii. Organisms that were previously exposed to substantial concentrations of the test material or other contaminants. (section II.F)

2. Guidance specifically regarding results of acute tests:

g. Acute toxicity tests should have been conducted using acceptable procedures. (section IV.B) The following two American Society for Testing and Materials (ASTM) Standards are referenced as examples of acceptable procedures:
   i. ASTM Standard E 729, Practice for Conducting Acute Toxicity Tests with Fishes, Macroinvertebrates, and Amphibians. (The title was later changed to "Standard Guide for Conducting Acute Toxicity Tests on Test Materials with Fishes, Macroinvertebrates, and Amphibians".)

   Some of the most important items in Standard E 729 include:
   (1) "The test material should be reagent-grade or better, unless a test on a formulation, commercial product, or technical-grade or use-grade material is specifically needed." ("Reagent-grade" is referenced to the American Chemical Society specifications.) (section 9.1)
   (2) "If an organic solvent is used, it should be reagent-grade or better and its concentration in any test solution must not exceed 0.5 mL/L. A surfactant must not be used in the preparation of a stock solution because it might affect the form and toxicity of the test material in the test solutions." (section 9.2.3)
   (3) "For static tests the concentration of dissolved oxygen in each test chamber must be from 60 to 100 % of saturation during the first 48 h of the test and must be between 40 and 100 % of saturation after 48 h. For renewal and flow-through tests the concentration of dissolved oxygen in each test chamber must be between 60 and 100 % of saturation at all times during the test." (section 11.2.1)

   ii. ASTM Standard E 724, Practice for Conducting Static Acute Toxicity Tests with Larvae of Four Species of Bivalve Molluscs. (The title was later changed to "Standard Guide for Conducting Static Acute Toxicity Tests Starting with Embryos of Four Species of Saltwater Bivalve Molluscs".)

   When water quality criteria for aquatic life are derived, EPA does not automatically accept all toxicity tests that are performed according to an ASTM Standard or according to "Standard Methods". EPA reviews results of all aquatic toxicity tests for acceptability using best professional judgment. Although written methodologies are very useful, no such methodology can appropriately address all aspects of toxicity tests, especially all organism-specific and all chemical-specific aspects. In addition, written methodologies often do not keep up with the newest information that is available.

h. Except for tests using saltwater annelids and mysids, results of acute tests during which the test organisms were fed should not be used, unless data indicate that the food did not affect the toxicity of the test material. (section II.C)

i. Results of acute tests conducted in unusual dilution water, e.g., dilution water in which total organic carbon or particulate matter exceeded 5 mg/L, should not be used, unless a relationship is developed between acute toxicity and organic carbon or particulate matter or unless data show that organic carbon, particulate matter, etc., do not affect toxicity. (section IV.D)

j. Acute values should be based on endpoints which reflect the total severe acute adverse impact of the test material on the organisms used in the test. Therefore, only the following kinds of data on acute toxicity to aquatic animals should be used:

(1) Tests with daphnids and other cladocerans should be started with organisms less than 24 hours old and tests with midges should be started with second- or third-instar larvae. The result should be the 48-hr EC50 based on the percentage of organisms immobilized plus percentage of organisms killed. If such an EC50 is not available from a test, the 48-hr LC50 should be used in place of the desired 48-hr EC50. An EC50 or LC50 of longer than 48 hr can be used as long as the animals were not fed and the control animals were acceptable at the end of the test.

(2) The result of a test with embryos and larvae of barnacles, bivalve molluscs (clams, mussels, oysters, and scallops), sea urchins, lobsters, crabs, shrimp, and abalones should be the 96-hr EC50 based on the percentage of organisms with incompletely developed shells plus the percentage of organisms killed. If such an EC50 is not available from a test, the lower of the 96-hr EC50 based on the percentage of organisms with incompletely developed shells and the 96-hr LC50 should be used in place of the desired 96-hr EC50. If the duration of the test was between 48 and 96-hr, the EC50 or LC50 at the end of the test should be used.

(3) The acute values from tests with all other freshwater and saltwater animal species and older life stages of barnacles, bivalve molluscs, sea urchins, lobsters, crabs, shrimps, and abalones should be the 96-hr EC50 based on the percentage of organisms exhibiting loss of equilibrium plus the percentage of organisms immobilized plus the percentage of organisms killed. If such an EC50 is not available from a test, the 96-hr LC50 should be used in place of the desired 96-hr EC50.

(4) Tests with single-celled organisms are not considered acute tests, even if the duration was 96 hours or less.

(5) If the tests were conducted properly, acute values reported as "greater than" values and those which are above the solubility of the test material should be used, because rejection of such acute values would unnecessarily lower the FAV by eliminating acute values for resistant species.

(section IV.E)

k. The agreement of the data within and between species should be considered. Acute values that appear to be questionable in comparison with other acute and chronic data for the same species and for other species in the same genus probably should not be used in the calculation of a Species Mean Acute Value (SMAV). For example, if the acute values available for a species or genus differ by more than a factor of 10, some or all of the values probably should not be used in calculations. (section IV.H)

3. Guidance specifically regarding results of chronic tests:

l. Chronic values should be based on results of flow-through (except renewal is acceptable for daphnids) chronic tests in which the concentrations of test material in the test solutions were properly measured at appropriate times during the test. (section VI.B)

m. Results of chronic tests in which survival, growth, or reproduction in the control treatment was unacceptably low should not be used. The limits of acceptability will depend on the species. (section VI.C)

n. Results of chronic tests conducted in unusual dilution water, e.g., dilution water in which total organic carbon or particulate matter exceeded 5 mg/L, should not be used, unless a relationship is developed between chronic toxicity and organic carbon or particulate matter or unless data show that organic carbon, particulate matter, etc., do not affect toxicity. (section VI.D)

o. Chronic values should be based on endpoints and lengths of exposure appropriate to the species. Therefore, only data on chronic toxicity to aquatic animals that satisfy the species-specific requirements given in sections VI.E.1, VI.E.2, and VI.E.3 should be used.

4. Guidance regarding other possible uses of results of toxicity tests using aquatic animals:

p. Questionable data, data on formulated mixtures and emulsifiable concentrates, and data obtained with non-resident species or previously exposed organisms may be used to provide auxiliary information but should not be used in the derivation of criteria. (section II.F)

q. Pertinent information that could not be used in earlier sections might be available concerning adverse effects on aquatic organisms and their uses. The most important of these are data on cumulative and delayed toxicity, flavor impairment, reduction in survival, growth, or reproduction, or any other adverse effect that has been shown to be biologically important. Especially important are data for species for which no other data are available. Data from behavioral, biochemical, physiological, microcosm, and field studies might also be available. Data might be available from tests conducted in unusual dilution water, from chronic tests in which the concentrations were not measured, from tests with previously exposed organisms, and from tests on formulated mixtures or emulsifiable concentrates. Such data might affect a criterion if the data were obtained with an important species, the test concentrations were measured, and the endpoint was biologically important. (section X)

r. The Criterion Continuous Concentration (CCC) is equal to the lowest of the Final Chronic Value (FCV), Final Plant Value (FPV), and Final Residue Value (FRV), unless other data show that a lower value should be used. (section XI.C)

s. Are any of the other data important? (section XII.A.14)

t. On the basis of all available pertinent laboratory and field information, determine if the criterion is consistent with sound scientific information. If it is not, another criterion, either higher or lower, should be derived using appropriate modifications of these *Guidelines*. (section XII.B)

In addition, the following aquatic life criteria documents published by U.S. EPA in 1985, 1986, 1987, and 1988 gave a variety of reasons for classifying specific test results as “unused”:

U.S. EPA. 1985. Ambient Water Quality Criteria for Cadmium - 1984. EPA 440/5-84-032. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1985. Ambient Water Quality Criteria for Chlorine - 1984. EPA 440/5-84-030. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1985. Ambient Water Quality Criteria for Copper - 1984. EPA 440/5-84-031. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1985. Ambient Water Quality Criteria for Lead - 1984. EPA 440/5-84-027. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1985. Ambient Water Quality Criteria for Mercury - 1984. EPA 440/5-84-026. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1986. Ambient Water Quality Criteria for Chlorpyrifos - 1986. EPA 440/5-86-005. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1986. Ambient Water Quality Criteria for Parathion - 1986. EPA 440/5-86-007. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1986. Ambient Water Quality Criteria for Pentachlorophenol - 1986. EPA 440/5-86-009. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1986. Ambient Water Quality Criteria for Toxaphene - 1986. EPA 440/5-86-006. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1987. Ambient Water Quality Criteria for Selenium - 1987. EPA 440/5-87-006. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1987. Ambient Water Quality Criteria for Zinc - 1987. EPA 440/5-87-003. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1988. Ambient Water Quality Criteria for Chloride - 1988. EPA 440/5-88-001. U.S. Environmental Protection Agency, Washington, DC.

The following is a list of common reasons why the results of some toxicity tests should not be used. Most of these reasons can be considered to be based on items "a" through "o" listed above.

1. The document is a secondary publication of the test result.
2. The test procedures, test material, dilution water, and/or results were not adequately described.
3. The test species is not resident in North America.
4. The test species was not obtained in North America and was not identified well enough to determine whether it is resident in North America.
5. The test organisms were not identified specifically, for example, "crayfish" or "minnows."
6. There is reason to believe that the test organisms were possibly stressed by disease or parasites.
7. The test organisms were exposed to elevated concentrations of the test material before the test and/or the control organisms contained high concentrations of the test material.
8. The test organisms were obtained from a sewage oxidation pond.
9. By the end of the test, the test organisms had not been fed for too long a period of time.
10. The water quality varied too much during the test.
11. The test was conducted with brine shrimp, which are from a unique saltwater environment.
12. The exposed biological material was an enzyme, excised or homogenized tissue, tissue extract, plasma, or cell culture.

13. The test organisms were not acclimated to the dilution water for a sufficiently long time period.
14. The test organisms were exposed to the test material via gavage, injection, or food.
15. There is reason to believe that the test organisms were probably crowded during the test.
16. The test organisms reproduced during an acute test, and the new individuals could not be distinguished from the original test individuals at the end of the test.
17. The test material was a component of a mixture, effluent, fly ash, sediment, drilling mud, sludge, or formulation.
18. In a test on zinc, the dilution water contained a phosphate buffer.
19. The test material was chlorine and it was not measured acceptably during the test.
20. The test chamber contained sediment.
21. The test was conducted in plastic test chambers without measurement of the test material.
22. The test was a field study and the concentration of test material was not measured adequately.
23. A known volume of stock solution was placed on a wall of the test chamber and evaporated and then dilution water was placed in the test chamber; the investigators assumed that all of the test material dissolved in the dilution water, but the concentrations of the test material in the test solutions were not measured.
24. The test only studied metabolism of the test material.
25. The only effects studied were biochemical, histological, and/or physiological.
26. The data concerned the selection, adaptation, or acclimation of organisms for increased resistance to the test material.
27. The percent survival in the control treatment was too low.
28. The concentration of solvent in some or all of the test solutions was too high.
29. The study was a microcosm study.
30. The concentration of test material fluctuated too much during the exposure.
31. Too few test organisms were used in the test.
32. The dilution factor was ten.
33. There was no control treatment.
34. The pH was below 6.5.
35. The dilution water was chlorinated or "tap" water.
36. The dilution water contained an excessive amount of a chelating agent such as EDTA or other organic matter.
37. The acceptability of the dilution water was questionable because of its origin or content.
38. The dilution water was distilled or deionized water without the addition of appropriate salts.
39. The measured test temperature fluctuated too much.
40. Neither raw data nor a clearly defined endpoint was reported.
41. The results were not adequately presented or could not be interpreted.
42. The results were only presented graphically.
43. The test was a chronic test and the concentration of test material was not measured.

Appendix B: Procedures Used In EPA's Biological Evaluation and Comparison to this Analysis Regarding Data Acceptability

This appendix describes the procedures that EPA used in developing the biological evaluation (BE) for the purpose of initiating formal consultation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Services (hereafter, the Services) under section 7(a)(2) of the Endangered Species Act (ESA) and compares the analyses and conclusions made in this evaluation relative to EPA's CWA decision on Oregon's criteria. This BE was developed for the purpose of providing the U.S. Fish and Wildlife Service and the National Marine Fisheries Services (hereafter referred to as the Services) with the information that EPA understood the Services desired in order for the Services to complete their review of EPA's action under section 7(a)(2) of the Endangered Species Act (ESA). This information consisted of a wider universe of studies of the toxicity of chemicals to aquatic species than what was finally considered in EPA's determination of whether Oregon's criteria are protective of Oregon's Fish and Aquatic Life designated use. In addition, in the BE, EPA included model-based estimates or projections of potential toxicity of chemicals to threatened and endangered aquatic species in cases where no data existed.

Because EPA's objective in developing the BE was to be responsive and deferential to the Services' desire to have as much information as possible to consider they developed their Biological Opinion (BO) under the ESA, the information in the BE differs in some respects from what EPA considered as it evaluated the protectiveness of Oregon's criteria under the CWA.

B.1 Consulting Under Endangered Species Act Section 7(a)(2) on the Approval of Oregon's Water Quality Criteria

When taking the federal action to approve Oregon's aquatic life criteria under CWA section 303(c), EPA has interpreted ESA section 7(a)(2) as applying to EPA's action. Accordingly, EPA developed a Biological Evaluation (BE) to submit to the Services in order to initiate formal consultation[78].

In order to collect the best scientific and commercial data available for the review of the effects of the action on each of these listed species and critical habitat (50 CFR part 402.14(d)), EPA compiled toxicological data from the ECOTOX[79] database and its extensive literature holdings compiled from monthly searches of online abstracting services (American Chemistry Society's STN-CAS and Cambridge Scientific Abstracts), manual searches of table of contents from high-impact journals, and the bibliographies of review articles. The target of these searches are documents containing information regarding lethal and sublethal adverse effects on, and

[78] US. EPA Region 10. 2008. "5.1.2 Biological Evaluation Effects Assessment Methodology", In Biological Evaluation of Oregon's Water Quality Criteria for Toxics. (pp. 5-10 – 5-54).

[79] There are over 5,000 journals, 2, 000 published books, 3,000 government reports, and 600 theses represented in the literature holdings of ECOTOX. U.S. EPA. 2007. Ecotoxicity Database (ECOTOX) Mid-Continent Ecology Division, National Health and Environmental Effects Research Laboratory. U.S. Environmental Protection Agency, Office of Research and Development. http://cfpub.epa.gov/ecotox/.

bioaccumulation by, freshwater and/or saltwater aquatic plants and animals, as well as chronic feeding studies and long-term field studies using wildlife species that regularly consume aquatic organisms. To ensure comprehensive coverage of the literature for these chemicals, EPA also conducted a chemical specific using STN-CAS, Cambridge Scientific Abstract, Dissertation Abstracts, Science Direct, and Toxline.

EPA developed, along with the Services, specific literature search strategies and QA/QC requirements for data for inclusion in the BE. These are described in Appendix D of the BE. As a result of the differing QA/QC requirements, and as a result of EPA's review of its prior QA/QC determinations for potentially influential studies,[80] some studies referenced in the BE were not used in the development of EPA's CWA determinations on whether to approve or disapprove Oregon's new or revised aquatic life criteria.

The literature search for the BE did not reveal data that directly tested the toxicity of each chemical to each of the listed species. However, in order to help EPA understand whether any listed species may be affected and to help the Services complete their BO, when toxicity data was lacking, EPA developed model based estimates or projections of the toxicity of pollutants to T&E species in cases where toxicity data for T&E species were lacking. Although these model-based projections were presented in the BE to help understand the potential toxicity of these chemicals to listed species and screen out those species where EPA and the Services could easily conclude that they were not likely to adversely affect T&E species, EPA does not consider it appropriate to make CWA determinations based on these model-based estimates of toxicity because these estimates are less certain than laboratory toxicity tests at predicting the concentrations where effects to species will be observed.

In the BE, EPA evaluated existing toxicological information and determined whether each new or revised criteria "may affect" or was "not likely to adversely affect" each listed species. It is important to note that EPA made these determinations in the context of the ESA in preparation for the Services' review and their development of the BO. The BE was an analysis prepared for purposes of formal consultation pursuant to ESA Section 7(a)(2). The ESA has a general prohibition on the taking of individuals of listed species and requires Federal Agencies to ensure that their actions do not jeopardize those species. The approach differs from how EPA evaluates criteria under the CWA where EPA evaluates the protectiveness of criteria at an aquatic ecosystem or community level. This is consistent with the purposes of the CWA, which provides for the "protection and propagation of fish, shellfish and wildlife" and for the "restoration and maintenance of the chemical, physical, and biological integrity of the Nation's waters." CWA § 101(a).

Given the different goals of the ESA and CWA noted above, a determination of "may affect" in the BE does not translate to a disapproval determination under CWA section 303. Nor does it mean that EPA concludes that effects to listed species are likely. Rather, it means that EPA has determined that there is at least a potential for take to occur to an individual of a given species and that this circumstance requires consultation with the Services.

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[80] See Section 1.1 for additional discussion.

B.2 Comparative Analysis of the Biological Evaluation and the CWA Decision

In January 2008, EPA submitted a 1500 page biological evaluation to the Services for the purpose of ESA Section 7(a)(2) consultation on EPA's approval of Oregon's water quality standards.

In the BE, EPA determined whether each criteria was either "not likely to adversely affect" or "may affect" each of the listed species potentially affected by an approval action. For those species where EPA could readily make a "not likely to adversely affect" determination because the species passed the initial screen, there was no need for further analysis

For those species that did not pass the initial screen but for which EPA concluded that the criteria were nevertheless "not likely to adversely affect" the species based on a broader assessment of toxicity and an analysis of exposure, the detailed explanation of how EPA reached that conclusion is available in the BE. This appendix summarizes that analysis for each applicable criterion.

For those species and chemicals where EPA concluded in the BE that the approval of the criteria "may affect" a listed species for the purpose of initiating formal consultation, this appendix provides additional analysis to explain how this information is consistent with EPA's CWA decision.

B.3 Cross-Walk of Similar and Different QA/QC Procedures for Data Acceptability in the BE

As indicated in the introduction of this document, and further elaborated on in Section 1.1 (Sources of data and toxicity studies used in EPA determinations whether to approve or disapprove Oregon's criteria), the BE of Oregon's criteria was developed for the purpose of providing the information that EPA understood the Services desired in order for the Services to complete their review of EPA's action under section 7(a)(2) of the ESA. For the reasons stated earlier in those sections, this information consisted of a wider universe of studies of the toxicity of chemicals to aquatic species than was considered in EPA's determination of whether Oregon's criteria are protective of Oregon's Fish and Aquatic Life designated use. Therefore, as previously stated, the information in the BE differs in some respects from what EPA considered as it evaluated the protectiveness of Oregon's criteria under the CWA.

This appendix provides a cross-walk of the similarities and differences between the QA/QC requirements described in Appendix A which establish the data acceptability requirements for deriving ambient water quality criteria for the protection of aquatic life, and the data acceptability criteria EPA's subcontractor utilized for supporting the effect determinations in this BE. For nearly all the priority pollutants for which Oregon provides toxics criteria (the only exceptions being freshwater ammonia, chromium III and chromiumVI), EPA's subcontractor relied on aquatic toxicity data from EPA's ECOTOX database to develop the core dataset utilized to make the effects determinations provided in that document.

Background on EPA's ECOTOX Database

The primary literature source used in the determinations made in Oregon's criteria was from EPA's ECOTOX literature holdings. Therefore, a brief overview of the procedures used to establish the origin and purpose of these data is provided here to establish data use and acceptability. A more complete documentation on the ECOTOX literature search strategy is located at: http://lester.dul.epa.gov/qa/sop/#DAM.

ECOTOX Overview

ECOTOX is a comprehensive web-based database, compiled and maintained by EPA's Office of Research and Development (ORD) that provides information on the effects of single chemical exposures to ecologically relevant species (http://www.epa.gov/ecotox/). The database supports research in ORD and the broader scientific community, providing data to create and evaluate predictive effects models developed through intra- and extramural research efforts (e.g., advanced species, dose, and chemical extrapolation modeling). It is used by the Agency's Regional and Program Offices, as well as other Federal, State, Tribal and local government agencies, and the regulated community as a primary source of literature on ecological effects to meet responsibilities under Agency-delegated programs and/or data submissions and analyses required by EPA.

ECOTOX Literature Searches

Literature searches conducted of the ECOTOX database do not use chemical specific terms because the purpose is to capture all the literature on the toxicity of anthropogenic substances to ecologically relevant species. Therefore, the search includes habitat terms (e.g., pond, soil), effect terms (e.g., mortality, reproduction, growth), species terms (e.g., bird, worm, salamander), general chemical terms (e.g., metal, organic, pesticide), and/or sub-file category codes within abstracting databases relevant to ecotoxicology.

The identification of studies that are potentially applicable to the ECOTOX database is accomplished through comprehensive searches of the open literature. These searches include use of electronic bibliographic abstracting services (e.g., STN, ScienceDirect, Cambridge Scientific Abstracts, Dialog), the manual review of bibliographies associated with summary or review publications, and the manual review of library holdings at EPA/ORD's Mid-Continent Ecology Division (Duluth, MN).

ECOTOX Minimum Data Requirements

For publications identified using the manual and electronic literature search methods, citations for potentially applicable publications (for inclusion in the database) are either manually entered or electronically downloaded into a bibliographic file. Publications acquired using the ECOTOX literature searching and acquisition protocols must meet five minimum data requirements to be considered eligible for inclusion in the database. The publication is eligible for the ECOTOX database if it reports (1) observed biological responses related to an exposure to a single chemical, and the chemical's name and Chemical Abstract Services Registry number can be verified in reliable chemical reference manuals; (2) a taxonomically verifiable test species that is an aquatic or terrestrial plant or animal with the exception of yeast, bacteria and viruses; (3) results based on the exposure of live, intact organisms; (4) a concurrent environmental chemical concentration/dose or application rate (e.g., the application of pesticide formulations) with the exception of concentrations reported in the sediment without concurrent pore water concentrations and air exposures; and (5) a duration of exposure. Those that are not considered eligible for incorporation into the database include publications that are only available in a language other than English, publications that are not the primary source of the effects data (i.e., review or summary publications), and studies that are only available in a brief abstract.

Each citation that has been identified, either through the electronic literature searches or the manual searches, is examined to determine whether or not it is potentially applicable to the ECOTOX database. With the exception of review/summary and methods publications, publications that are clearly not relevant to the ECOTOX database effort are not ordered, and the electronic bibliographic record is annotated with the reason for exclusion (See Attachment 1.) If a clear decision of applicability cannot be made based on the information available (e.g., citation and or abstract), then the publication is acquired. All acquired publications that are assessed as to relevance to the ECOTOX database based on the full publication, and if excluded, the citation is annotated with the reason.

EPA Subcontractor ECOTOX Download and Data Review and Selection Process for BE Development

The following general procedure was used by EPA's subcontractor to conduct a screen of the ECOTOX data for its potential use in the ESA BE of Oregon's new and proposed criteria. These data are screened to assess their applicability for use in the BE for each chemical for which Oregon provides criteria (see Table 1.3, Section 1.3 of this document). Useful data (referred to as **Core** data hereafter) were transformed into a format suitable (MS Excel) for entry into the BE. The entire process was performed largely by mid and senior subcontractor staff levels (P3 and P4 level).

Steps for Gathering Core Data from ECOTOX

Note: The ECOTOX database is to be used in conjunction with the ECOTOX Code List (printable on-line at www.epa.gov/ecotox/help/codelist.htm) and Effects List (available at www.epa.gov/cgi-bin/ecotox_effects_browse).

1. Download ECOTOX data file for the chemical of interest. Be sure to use a search term or terms that will find all appropriate forms of the chemical (e.g., the water soluble inorganic salts of metals). Save the file unchanged and save the amended file (below) with a new file name as described in the procedure below:

a. Open internet Site- www.epa.gov/ecotox
b. Click on **Advanced Database Query**
c. Click on **Report Format** (the frog picture)
d. Select **Delimited Report** in **Aquatic and Terrestrial Report Formats**
e. Add the fields (in **Fields Available**) to **Fields Selected** in **Aquatic Lab Output Selections**:
    1. Chemical Analysis Method
    2. Chemical Comment
    3. Control Type
    4. Document Code
    5. Hardness
    6. Organic Carbon Type/Value
    7. Organism Comment (this gives life stage information)
    8. pH
    9. Publication year
    10. Salinity
    11. Species Number
    12. Temperature
f. Repeat for **Aquatic Field Output Selections** (Note: only field data with a Test Location coded FieldA (Field Artificial) will be considered (i.e., mesocosm studies).
g. Add the fields (in **Fields Available**) to **Fields Selected** in **Terrestrial Field Output Selections**:
    1. Control Type
    2. Result % dry/Wet Weight
    3. Chemical Purity
    4. Significance/Level
    5. Species Number
    6. Chemical Comment
    7. Chemical Formulation (we do not use tests where the chemical is applied as a spray)
    8. Test Comments
h. Remove all fields (in **Fields Selected**) with the word "soil" in **Terrestrial Field Output Selections**
i. Click on **Test Results** in **Advanced Query Menu**
j. Click on the Accumulation, Growth, Mortality, Reproduction, Population, Physiology and No Effect Groups, as well as Histological and Feeding Behavior, in **Effects and Measurements**
k. Click on all three boxes in **Documentation Codes**
l. Click on **Test Conditions** in **Advanced Query Menu**
m. Click on:
    1. Lab and All Field Tests in **Test Locations**;
    2. Fresh Water, Salt Water, and Not Reported in <u>Water</u>, and Hydroponic and Not Reported in <u>Artificial</u> in **Exposure Media**;

3. Diet, Not Reported, Flow-through, Lentic, Lotic, Renewal Aquatic, Static Aquatic, and Tidal in **Exposure Sites**;
4. Measured, Unmeasured, and Not Reported in Method of Chemical Analysis.

n. Click on **Chemical** in **Advanced Query Menu**

o. Select all appropriate forms of the chemical (for an example for some common metals, see Attachment 2)

2. Click on Perform Query
3. Save delimited text files for aquatic and terrestrial species separately with ".tsv" extension as "ecotox_chemical abbrevBE_aq or terr for aquatic or terrestrial data-month–day-yr.tsv" (e.g., ecotox_Cr3BE_terr_12-02-04.tsv) in a designated SHPD, or HECD WA File Folder on c:/drive.
4. Open the data into a unique Excel Workbook (.xls) file similarly named, e.g., "ecotox_Cr3BE_terr_12-02-04.xls"
   1. Select "delimited" option and click Next
   2. Select "other" and type "|" in blank box ("|" key is above "enter" key use the shift)
   3. Select "none" in Text qualifier box and then click Finish.
5. Open and save each chemical as a separate Excel Workbook (.xls) file.

Directions for identifying useful aquatic toxicity information

1. Within each aquatic file uniquely identified by chemical name, label the tab for worksheet #1 "All Data" then create two new worksheets and name each FH2O Core and SH2O Core, respectively.
2. Select and copy all entries in "All Data" and paste into FH2O.
3. Sort data by "Aquatic Media Type" and cut and paste all saltwater data (SW) for the chemical in SH2O.
4. Add a new column A to the FH2O and SH2O worksheets for code entry. The code in this column will be for populating your Core worksheets referred to above.
5. Add a new column on the right side of the worksheet for comments (use liberally, including any change to recorded ECOTOX information, i.e., unit changes or value conversions/corrections).
6. Perform a data sort using year of publication
7. All publications approximately 6-12 months prior to the publication date of the latest AWQC update are "new."
8. Search the "old" data and identify all papers previously cited in the AWQC document and check the data endpoint and concentration; code the rows containing data from the AWQC document with a letter (e.g., A-awqc = acute data in Table 1 of the AWQC document; C-awqc = chronic data in Table 2 of the AWQC document; P-awqc = plant data in Table 4 of the AWQC document; B-awqc = BCF data in Table 5 of the AWQC document). Remember that some Table 6 data (identified as other data in the AWQC document) may be of value. Also, for the ESA BE of Oregon's new and proposed criteria, non-resident species

to North American which do not have a naturally reproducing population in North American waters (usually identified in the Unused List of the AWQC document) are automatically rejected.

9. Enter data from all papers cited Tables 1, 2, 4, and 5 (and potentially useful papers in Table 6) of the AWQC document that are not in the ECOTOX database.
10. Note all data from the AWQC document that are in the ECOTOX database, but do not have the same endpoint or concentration. Record any changes made to the ECOTOX entry based on what is reported in the AWQC document in the newly added "Comments" column.
11. Review the remaining "old" data and any "new" data for potentially useful values. Code the potentially useful lines of data with A for acute, C for chronic, P for plant, B for bioaccumulation/bioconcentration, and D for dietary.
12. Establish blank worksheets for rejected lines of data: a worksheet for rejected FW animal data, a worksheet for rejected SW animal data, a worksheet for rejected BCF and bioaccumulation data (coded ACC in the Effect column) and worksheets for rejected FW and SW plant data. Cut and paste lines of rejected data into the appropriate worksheet. Add rejection codes (see Attachment 3 of this file) in Column A if this has not already been done.
13. Note and reject all tests conducted with inappropriate forms of the metal, e.g., if Concentration Type indicates use of a chemical Formulation (F), unless the Chemical Purity and Chemical Comments columns indicate otherwise (i.e., as per the QC/QA requirements in Appendix A).
14. Note and reject all tests without a specific test duration specified (i.e., all rows of data where only a minimum or maximum duration has been provided).
15. Note and reject all ACC (bioacummulation) data that are of too short duration for the chemical of interest (i.e., indicating steady-state was not achieved, this will vary with chemical, but use 10 to 20 days as a rule of thumb).
16. Note and reject all data that are for inappropriate endpoints (e.g., this requires scrutiny of Effect Measurement Codes and will most likely be the Physiological endpoints coded PHY, possibly HIST).
17. Examine the rejected papers (steps 12, 13, 14, 15 and 16) for those with species or specified or potential endpoints that might provide acute LC50s for a new taxon, new ACRs, new BCFs, effect values near or below the AWQC criteria, and dietary effect data. Also, for chemical criteria that are hardness or pH dependent, to see if those required parameters values are absent in ECOTOX. (Note: dietary effect data for aquatic organisms should be relegated to a separate worksheet labeled as such).
18. If data look otherwise acceptable, you may wish to confirm the chemical form if the CAS designation is ambiguous (e.g., if the CAS # provided is for the general "Arsenic" element and not the specific salt for the desired arsenic III form).

As noted above, attachment 3 contains a list of rejection codes for use in separating data. Most of the codes will not apply at this point because of the strict selection of initial criteria used to create the ECOTOX download file. The most common criteria which will be used to select/reject data in the downloaded file will be test Duration (Dur) (**<u>note</u>**: test durations may deviate slightly from the *Guidelines* as provided in the QC/QA requirements found in Appendix A of this document, but must be of sufficient duration to produce a reliable acute or chronic effect), and inappropriate test exposure (chronic tests that were not flow-through, especially for those chemicals that are highly biodegradable, hydrolyzable, oxidizable, reducible, or volatile). As a rule of thumb, consider acute and chronic toxicity data for fish from 48 to 120 h and 21+ days, respectively. For cladocerans, consider acute and chronic toxicity data from 24 to 96 h and 7 to 14+ days, respectively.

All ECOTOX data records remaining in the Core fresh- and saltwater data sheets (FH2O Core and SH2O Core, respectively) will be used to support the effect determinations in the BE.

Quality Control

1. Certify that all records have data on critical fields (see **Required Toxicity Data Fields for BE** sheet below).
2. Check that all records express concentrations of the same chemical form and fraction (e.g., total or dissolved) in the same units. **Note**: the national new or proposed criteria for all metals of interest are expressed as the concentration of dissolved metal in the water column. Use the appropriate conversion factor to convert toxicity values expressed as total metal to dissolved metal. Appropriate conversion factors are those provided in EPA 823-B-96-007: *The Metals Translator: Guidance for Calculating a Total Recoverable Permit Limit from a Dissolved Criterion*.
3. If appropriate, check that records have been appropriately converted.

Backup

Copy your file to an external storage media (e.g., CD-R/RW) at least once a week.

Required Toxicity Data Fields for BE (aquatic species only)

Critical information is highlighted in bold.

Information	*Comment*
Chemical Name	Check that it is an acceptable form of the contaminant
Chemical Comment	
CAS Number	Easy to find through a web search[1], if not available.
Scientific Name	Records that do not identify genus and species have low priority
Common Name	Easy to find through a web search[2], if not available.
Organism Comment	Information on life stage
Effect + Effect Meas.	Classification of response type and response measured, respectively.
Endpt1	Classify endpoint as acute or chronic (list endpoints or add column)
Habitat	*NA in Ecotox*. Aquatic or Terrestrial (Aquatic dependent spp.).
Plant / Animal	*Not Available in Ecotox*.
Media Type	Freshwater (FW) or Saltwater (SW)
Dur + Dur Unit	Duration of exposure period: value + time unit
Concentration1 mean	Endpoint value. If necessary, convert to appropriate unit.
Concentration Unit	Ecotox records values in original units.
Concentration Type	Active, Dissolved, or Total (A, D, T, respectively)
Chemical Analysis	Information on measured or unmeasured test concentrations
Temperature + Unit	
pH	
Hardness + Unit	Required value if criteria are expressed as a function of hardness
Exposure Type	Static, Renewal, Flow through
Ecotox Reference #	Reference number in Ecotox series
Author + Year	
Ref. Source + Title	

[1] Search for: *chemical name* CAS

[2] Search at www.itis.usda.gov/ or www.gbif.net/portal/index.jsp

Cross-walk of Primary Differences between Data Accepted for Use in the BE versus Data Acceptable for Criteria Derivation

The following table (replete with codes) denotes the primary differences between the majority of toxicological data accepted for inclusion in the BE versus the toxicological data that is accepted for criteria derivation (as per Appendix A this document) because of the use of ECOTOX as the primary toxicological data source and instrument. ECOTOX was selected as the primary data instrument due to the time and resource constraints required to develop the BE of Oregon's new and proposed criteria, and also because ECOTOX does represent a comprehensive toxicological database useful for such a purpose. The cross-walk between the QA/QC procedures provided in Appendix A for AWQC development and the codes denoting whether those requirements could be met using ECOTOX is used here to identify which of the *Guidelines* requirements were and were not be met in the BE. For more on the "wider universe of studies of the toxicity of chemicals to aquatic species" EPA considered in its BE, see the subsection above entitled: *Directions for identifying useful aquatic toxicity information* (last paragraph in particular), to which the coded table below is meant to coincide.

Note: the following codes indicate which of the general and specific data requirements given by the *Guidelines* were met using ECOTOX for development of the core data used in the BE (i.e., for all chemicals except freshwater ammonia, chromium III, chromium IV, as noted above).
X – Indicates the requirement has been met by convention of using ECOTOX
O – Indicates the requirement has not been met by convention using ECOTOX
P – Indicates the requirement only partially met by convention using ECOTOX, and includes an explanation.

Indication of whether a requirement was met in the BE using ECOTOX (codes as defined above)	**General and specific requirements for ALC derivation from APPENDIX A: QA/QC PROCEDURES**	**I.D. Associated with the Guidelines Requirement**
	General guidance:	1
P, as indicated above in ECOTOX Minimum Data Requirements	All data should be available in typed, dated, and signed hard copy (publication, manuscript, letter, memorandum, etc.) with enough supporting information to indicate that acceptable test procedures were used and that the results are probably reliable. (section II.B).	1.a
X	Information that is confidential or privileged or otherwise not available for distribution should not be used. (section II.B).	1.b
P	Questionable data, whether published or unpublished, should not be used. For example, a test result should usually be rejected if it is from:	1.c
X, ECOTOX documents whether the author(s) present information	A test that did not contain a control treatment.	1.c.i

Indication of whether a requirement was met in the BE using ECOTOX **(codes as defined above)**	**General and specific requirements for ALC derivation from APPENDIX A: QA/QC PROCEDURES**	**I.D. Associated with the Guidelines Requirement**
about the type of control that was used. Note: Many entries exist in ECOTOX where insufficient information was reported to ascertain type of control, but the toxicity value was used to derive a criterion in the corresponding AWQC document		
O, ECOTOX does not make assessments on whether the controls were satisfactory or insufficient	A test in which too many organisms in the control treatment died or showed signs of stress or disease	1.c.ii
P, ECOTOX does not provide specific information on dilution water, but does provide dilution water chemistry values (pH, hardness, salinity, etc).	A test in which distilled or deionized water was used as the dilution water without addition of appropriate salts. (section II.C)	1.c.iii
P, ECOTOX provides chemical codes indicating grade and formulation. Together with chemical comments, relevant information can be gleaned (e.g, percentage active ingredient)	A result of a test on technical-grade material may be used if appropriate, but a result of a test on a formulated mixture or an emulsifiable concentrate of the test material should not be used. (section II.D)	1.d
P, ECOTOX provides information on exposure type (flow-through, static, renewal, diet, etc.) and chemical analysis (measured, unmeasured, not reported), but does provide information on frequency of measurements	For some highly volatile, hydrolyzable, or degradable materials it is probably appropriate to use only results of flow-through tests in which the concentrations of test material in the test solutions were measured often enough using acceptable analytical methods. (section II.E)	1.e
	Data should be rejected if they were obtained using:	1.f
X, ECOTOX provides species common and scientific names	Brine shrimp.	1.f.i
O, no habitat or geographical information is provided in ECOTOX for test species. EPA's contractor determines residency using specific internet searches; databases made available to the public, e.g., FishBase; and via personal communication to wildlife scientists and other contacts	A species that does not have a reproducing wild population in North America.	1.f.ii
P, ECOTOX does not provide specific information on pre-exposure. EPA's contractor,	Organisms that were previously exposed to substantial concentrations of the test material or other contaminants. (section II.F)	1.f.iii

Indication of whether a requirement was met in the BE using ECOTOX **(codes as defined above)**	**General and specific requirements for ALC derivation from APPENDIX A: QA/QC PROCEDURES**	**I.D. Associated with the Guidelines Requirement**
does, however, screen test location (natural field, lab) and exposure type (lentic, lotic, environmental)		
	Guidance specifically regarding results of acute tests:	2
O, ECOTOX does not report test procedures	Acute toxicity tests should have been conducted using acceptable procedures. (section IV.B) The following two American Society for Testing and Materials (ASTM) Standards are referenced as examples of acceptable procedures:	2.g
O, ECOTOX does not report test procedures	ASTM Standard E 729, Practice for Conducting Acute Toxicity Tests with Fishes, Macroinvertebrates, and Amphibians. (The title was later changed to "Standard Guide for Conducting Acute Toxicity Tests on Test Materials with Fishes, Macroinvertebrates, and Amphibians".) Some of the most important items in Standard E 729 include:	2.g.i
P, ECOTOX provides chemical codes indicating grade and formulation. Together with chemical comments, relevant information can be gleaned (e.g, percentage active ingredient)	(1). "The test material should be reagent-grade or better, unless a test on a formulation, commercial product, or technical-grade or use-grade material is specifically needed." ("Reagent-grade" is referenced to the American Chemical Society specifications.) (section 9.1)	
O, ECOTOX does not provide specific information on dilution water, but does provide control type, including solvent controls. Note, no information is provided in ECOTOX regarding concentration of solvent in the test solution	(2). "If an organic solvent is used, it should be reagent-grade or better and its concentration in any test solution must not exceed 0.5 mL/L. A surfactant must not be used in the preparation of a stock solution because it might affect the form and toxicity of the test material in the test solutions." (section 9.2.3)	
O, ECOTOX does not provide specific information on DO in exposure chambers, but does provide dilution water chemistry values including DO	(3). "For static tests the concentration of dissolved oxygen in each test chamber must be from 60 to 100 % of saturation during the first 48 h of the test and must be between 40 and 100 % of saturation after 48 h. For renewal and flow-through tests the concentration of dissolved oxygen in each test chamber must be between 60 and 100 % of saturation at all times during the test." (section 11.2.1)	
O, ECOTOX does not report test procedures	ASTM Standard E 724, Practice for Conducting Static Acute Toxicity Tests with Larvae of Four Species of Bivalve Molluscs. (The title was later changed to "Standard Guide for Conducting Static Acute Toxicity Tests Starting with Embryos of Four Species of Saltwater Bivalve Molluscs".)	2.g.ii
O, ECOTOX does not report test procedures, but it does require certain minimum Data requirements, as noted above in this Appendix.	When water quality criteria for aquatic life are derived, EPA does not automatically accept all toxicity tests that are performed according to an ASTM Standard or according to "Standard Methods". EPA reviews results of all aquatic toxicity tests for acceptability using best professional	General

Indication of whether a requirement was met in the BE using ECOTOX **(codes as defined above)**	**General and specific requirements for ALC derivation from APPENDIX A: QA/QC PROCEDURES**	**I.D. Associated with the Guidelines Requirement**
	judgment. Although written methodologies are very useful, no such methodology can appropriately address all aspects of toxicity tests, especially all organism-specific and all chemical-specific aspects. In addition, written methodologies often do not keep up with the newest information that is available.	
O, ECOTOX does not report feeding of test organisms, only if the exposure was oral via uptake from food or by gavage	Except for tests using saltwater annelids and mysids, results of acute tests during which the test organisms were fed should not be used, unless data indicate that the food did not affect the toxicity of the test material. (section II.C)	2.h
X, ECOTOX provides dilution water chemistry values, including organic carbon concentration and type, if reported	Results of acute tests conducted in unusual dilution water, e.g., dilution water in which total organic carbon or particulate matter exceeded 5 mg/L, should not be used, unless a relationship is developed between acute toxicity and organic carbon or particulate matter or unless data show that organic carbon, particulate matter, etc., do not affect toxicity. (section IV.D)	2.i
X, ECOTOX provides endpoint codes, including LC50, EC50, EC20, NOEC, LOEC, etc.	Acute values should be based on endpoints which reflect the total severe acute adverse impact of the test material on the organisms used in the test. Therefore, only the following kinds of data on acute toxicity to aquatic animals should be used:	2.j
X, ECOTOX provides endpoint codes (LC50, EC50), test duration, and organism life-stage comments. ECOTOX does not provide information on feeding test organisms	(1). Tests with daphnids and other cladocerans should be started with organisms less than 24 hours old and tests with midges should be started with second- or third-instar larvae. The result should be the 48-hr EC50 based on the percentage of organisms immobilized plus percentage of organisms killed. If such an EC50 is not available from a test, the 48-hr LC50 should be used in place of the desired 48-hr EC50. An EC50 or LC50 of longer than 48 hr can be used as long as the animals were not fed and the control animals were acceptable at the end of the test.	
X, ECOTOX provides endpoint (LC50, EC50) and effect codes (mortality, growth, reproduction); test duration; and organism life-stage comments	(2). The result of a test with embryos and larvae of barnacles, bivalve molluscs (clams, mussels, oysters, and scallops), sea urchins, lobsters, crabs, shrimp, and abalones should be the 96-hr EC50 based on the percentage of organisms with incompletely developed shells plus the percentage of organisms killed. If such an EC50 is not available from a test, the lower of the 96-hr EC50 based on the percentage of organisms with incompletely developed shells and the 96-hr LC50 should be used in place of the desired 96-hr EC50. If the duration of the test was between 48 and 96-hr, the EC50 or LC50 at the end of the test should be used.	
X, ECOTOX provides endpoint (LC50, EC50) and effect codes (mortality, growth, reproduction); test duration; and organism life-stage comments	(3). The acute values from tests with all other freshwater and saltwater animal species and older life stages of barnacles, bivalve molluscs, sea urchins, lobsters, crabs, shrimps, and abalones should be the 96-hr EC50 based on the percentage of organisms exhibiting loss of equilibrium plus the	

Indication of whether a requirement was met in the BE using ECOTOX **(codes as defined above)**	**General and specific requirements for ALC derivation from APPENDIX A: QA/QC PROCEDURES**	**I.D. Associated with the Guidelines Requirement**
	percentage of organisms immobilized plus the percentage of organisms killed. If such an EC50 is not available from a test, the 96-hr LC50 should be used in place of the desired 96-hr EC50.	
X, ECOTOX provides species common and scientific names, as well as test duration	(4). Tests with single-celled organisms are not considered acute tests, even if the duration was 96 hours or less.	
X, ECOTOX provides result qualifiers such as “>” and “<” values	(5). If the tests were conducted properly, acute values reported as “greater than” values and those which are above the solubility of the test material should be used, because rejection of such acute values would unnecessarily lower the FAV by eliminating acute values for resistant species. (section IV.E)	
X, see above. Data can downloaded from ECOTOX and sorted by species name, test duration, endpoint, effect, etc.	The agreement of the data within and between species should be considered. Acute values that appear to be questionable in comparison with other acute and chronic data for the same species and for other species in the same genus probably should not be used in the calculation of a Species Mean Acute Value (SMAV). For example, if the acute values available for a species or genus differ by more than a factor of 10, some or all of the values probably should not be used in calculations. (section IV.H)	2.k
	Guidance specifically regarding results of chronic tests:	3
P, ECOTOX provides information on exposure type (flow-through, static, renewal, diet, etc.) and chemical analysis (measured, unmeasured, not reported), but does provide information on frequency of measurements	Chronic values should be based on results of flow-through (except renewal is acceptable for daphnids) chronic tests in which the concentrations of test material in the test solutions were properly measured at appropriate times during the test. (section VI.B)	3.l
O, ECOTOX does not make assessments of whether the controls were satisfactory or insufficient	Results of chronic tests in which survival, growth, or reproduction in the control treatment was unacceptably low should not be used. The limits of acceptability will depend on the species. (section VI.C)	3.m
X, ECOTOX provides dilution water chemistry values, including organic carbon concentration and type, if reported. ECOTOX does not report on the relationship between chronic toxicity and organic carbon concentration	Results of chronic tests conducted in unusual dilution water, e.g., dilution water in which total organic carbon or particulate matter exceeded 5 mg/L, should not be used, unless a relationship is developed between chronic toxicity and organic carbon or particulate matter or unless data show that organic carbon, particulate matter, etc., do not affect toxicity. (section VI.D)	3.n
X, ECOTOX provides endpoint (NOEC, LOEC, EC20) and effect codes (mortality, growth, reproduction)	Chronic values should be based on endpoints and lengths of exposure appropriate to the species. Therefore, only data on chronic toxicity to aquatic animals that satisfy the species-specific requirements given in sections VI.E.1, VI.E.2, and VI.E.3 should be used.	3.o

Indication of whether a requirement was met in the BE using ECOTOX **(codes as defined above)**	**General and specific requirements for ALC derivation from APPENDIX A: QA/QC PROCEDURES**	**I.D. Associated with the Guidelines Requirement**
	Guidance regarding other possible uses of results of toxicity tests using aquatic animals:	4
P, ECOTOX provides chemical codes indicating grade and formulation, but no habitat or geographical information is provided in ECOTOX for test species. EPA's contractor determines residency using specific internet searches; databases made available to the public, e.g., FishBase; and via personal communication to wildlife scientists and other contacts	Questionable data, data on formulated mixtures and emulsifiable concentrates, and data obtained with non-resident species or previously exposed organisms may be used to provide auxiliary information but should not be used in the derivation of criteria. (section II.F)	4.p
X, ECOTOX provides endpoint (LC50, EC50) and effect codes (mortality, growth, reproduction); test duration; species name and organism life-stage comments; as well as exposure type and chemical analysis (measured, unmeasured, not reported)	Pertinent information that could not be used in earlier sections might be available concerning adverse effects on aquatic organisms and their uses. The most important of these are data on cumulative and delayed toxicity, flavor impairment, reduction in survival, growth, or reproduction, or any other adverse effect that has been shown to be biologically important. Especially important are data for species for which no other data are available. Data from behavioral, biochemical, physiological, microcosm, and field studies might also be available. Data might be available from tests conducted in unusual dilution water, from chronic tests in which the concentrations were not measured, from tests with previously exposed organisms, and from tests on formulated mixtures or emulsifiable concentrates. Such data might affect a criterion if the data were obtained with an important species, the test concentrations were measured, and the endpoint was biologically important. (section X)	4.q
X, ECOTOX provides acute toxicity and bioaccumulation results for aquatic plants and animals, as well as for aquatic-dependent wildlife	The Criterion Continuous Concentration (CCC) is equal to the lowest of the Final Chronic Value (FCV), Final Plant Value (FPV), and Final Residue Value (FRV), unless other data show that a lower value should be used. (section XI.C)	4.r
O, ECOTOX does not provide data subject to interpretation, only what has been reported by the author(s)	Are any of the other data important? (section XII.A.14)	4.s
X, ECOTOX requires certain Minimum Data Requirements as indicated above, plus many additional details and results sufficient to ascertain sound scientific integrity	On the basis of all available pertinent laboratory and field information, determine if the criterion is consistent with sound scientific information. If it is not, another criterion, either higher or lower, should be derived using appropriate modifications of these Guidelines. (section XII.B)	4.t

Indication of whether a requirement was met in the BE using ECOTOX **(codes as defined above)**	**General and specific requirements for ALC derivation from APPENDIX A: QA/QC PROCEDURES**	**I.D. Associated with the Guidelines Requirement**
	The following is a list of common reasons why the results of some toxicity tests should not be used. Most of these reasons can be considered to be based on items "a" through "o" listed above.	General:
X, ECOTOX excludes secondary data sources because they do not meet the minimum data requirements for inclusion into the database	The document is a secondary publication of the test result.	1
X, explained elsewhere	The test procedures, test material, dilution water, and/or results were not adequately described.	2
O, explained elsewhere	The test species is not resident in North America.	3
O, explained elsewhere	The test species was not obtained in North America and was not identified well enough to determine whether it is resident in North America.	4
X, ECOTOX provides species common and scientific names when reported, or to the lowest identifiable taxon reported, i.e., ECOTOX does include data for broad taxonomic groups such as mayflies.	The test organisms were not identified specifically, for example, "crayfish" or "minnows."	5
P, ECOTOX does not normally provide information on diseased or stressed organisms, but does provide an organism comment which may contain such information	There is reason to believe that the test organisms were possibly stressed by disease or parasites.	6
O, ECOTOX does not report such specific or unique exposure conditions	The test organisms were exposed to elevated concentrations of the test material before the test and/or the control organisms contained high concentrations of the test material.	7
O, ECOTOX does not report such specific or unique exposure conditions	The test organisms were obtained from a sewage oxidation pond.	8
O, explained elsewhere	By the end of the test, the test organisms had not been fed for too long a period of time.	9
O, ECOTOX does not report such specific or unique exposure conditions	The water quality varied too much during the test.	10
X, explained elsewhere	The test was conducted with brine shrimp, which are from a unique saltwater environment.	11
X, ECOTOX only reports results based on the exposure of live, intact organisms	The exposed biological material was an enzyme, excised or homogenized tissue, tissue extract, plasma, or cell culture.	12
O, ECOTOX does not report such specific or unique exposure conditions	The test organisms were not acclimated to the dilution water for a sufficiently long time period.	13
X, ECOTOX reports exposure	The test organisms were exposed to the test material via	14

Indication of whether a requirement was met in the BE using ECOTOX **(codes as defined above)**	**General and specific requirements for ALC derivation from APPENDIX A: QA/QC PROCEDURES**	**I.D. Associated with the Guidelines Requirement**
type, including gavage, injection and oral uptake via the diet	gavage, injection, or food.	
O, ECOTOX does not report such specific or unique exposure conditions	There is reason to believe that the test organisms were probably crowded during the test.	15
O, ECOTOX does not report such unique test results	The test organisms reproduced during an acute test, and the new individuals could not be distinguished from the original test individuals at the end of the test.	16
P, ECOTOX provides chemical codes indicating grade and formulation. Data from sediment-only exposures must provide concurrent pore water concentrations	The test material was a component of a mixture, effluent, fly ash, sediment, drilling mud, sludge, or formulation.	17
O, ECOTOX does not report such specific or unique exposure conditions, but chemical CAS number is included	In a test on zinc, the dilution water contained a phosphate buffer.	18
O, ECOTOX does provide chemical analysis (measured, unmeasured) and chemical comment, however, data on acceptability of analytical chemistry measurements is not	The test material was chlorine and it was not measured acceptably during the test.	19
X, ECOTOX only includes data from sediment exposures that also provide concurrent pore water concentrations	The test chamber contained sediment.	20
P, ECOTOX provides chemical analysis (measured, unmeasured) and chemical comment, but not exposure container	The test was conducted in plastic test chambers without measurement of the test material.	21
X, ECOTOX provides exposure location (natural field, lab) and exposure type (lentic, lotic, environmental), as well as chemical analysis (measured, unmeasured)	The test was a field study and the concentration of test material was not measured adequately.	22
P, ECOTOX only provides information on chemical analysis (measured, unmeasured) and a chemical comment	A known volume of stock solution was placed on a wall of the test chamber and evaporated and then dilution water was placed in the test chamber; the investigators assumed that all of the test material dissolved in the dilution water, but the concentrations of the test material in the test solutions were not measured.	23
X, a taxonomically verifiable test species (or group of species) is required	The test only studied metabolism of the test material.	24
X, ECOTOX provides well-	The only effects studied were biochemical, histological,	25

Indication of whether a requirement was met in the BE using ECOTOX **(codes as defined above)**	**General and specific requirements for ALC derivation from APPENDIX A: QA/QC PROCEDURES**	**I.D. Associated with the Guidelines Requirement**
defined effect codes, including biochemical, histological and/or physiological	and/or physiological.	
O, explained elsewhere	The data concerned the selection, adaptation, or acclimation of organisms for increased resistance to the test material.	26
O, explained elsewhere	The percent survival in the control treatment was too low.	27
O, explained elsewhere	The concentration of solvent in some or all of the test solutions was too high.	28
P, ECOTOX provides test location, but not specifically microcosm tests	The study was a microcosm study.	29
O, explained elsewhere	The concentration of test material fluctuated too much during the exposure.	30
O, ECOTOX does not report such specific or unique exposure conditions	Too few test organisms were used in the test.	31
O, ECOTOX only provides information on chemical analysis (measured, unmeasured) and a chemical comment; not dilution factors	The dilution factor was ten.	32
X, explained elsewhere	There was no control treatment.	33
X, explained elsewhere	The pH was below 6.5.	34
O, explained elsewhere	The dilution water was chlorinated or “tap” water.	35
O, explained elsewhere	The dilution water contained an excessive amount of a chelating agent such as EDTA or other organic matter.	36
P, ECOTOX provides test location, including natural field or lab	The acceptability of the dilution water was questionable because of its origin or content.	37
O, explained elsewhere	The dilution water was distilled or deionized water without the addition of appropriate salts.	38
X, ECOTOX provides a mean, minimum and maximum test temperature, if reported	The measured test temperature fluctuated too much.	39
X, ECOTOX requires observed biological responses related to an exposure to a single chemical	Neither raw data nor a clearly defined endpoint was reported.	40
X, certain minimum data requirements must be met as indicated above	The results were not adequately presented or could not be interpreted.	41
O, ECOTOX does not provide data subject to interpretation, only what has been reported by the author(s)	The results were only presented graphically.	42
X, explained elsewhere	The test was a chronic test and the concentration of test material was not measured.	43

Attachment 1. Guidance for marking publications "applicable" or "not applicable" to the ECOTOX Database effort

Some publications obtained from literature searches do not meet minimum data requirements for the ECOTOX database. For publications identified using an electronic literature search method, the citation and abstract information are downloaded electronically into a bibliographic file. Each citation and abstract is reviewed to determine if the publication is potentially applicable to the ECOTOX database. When a publication is identified as not applicable to ECOTOX, the citation entry is annotated with the reason the study was excluded (see list of terms below), and a copy of the publication is not acquired. Publications identified as potentially applicable to the ECOTOX database are acquired. As publications are received, the ECOTOX eligibility criteria are applied, and citations for rejected studies are annotated with the reason for exclusion. For the most part, non-applicable publications are not retained, but some non-applicable publications may be identified as useful to the ECOTOX database effort (e.g., review publications, methods publications), and these are assigned an ECOTOX reference number and retained in the ECOTOX literature holdings. All citations that have been excluded from the ECOTOX database are retained electronically in a Reference Manager file. Procedures used in literature searches and acquisition as they relate to the ECOTOX database can be found at: http://lester.dul.epa.gov/qa/sop/#DAM.

Keyword	**Usage**
ABSTRACT	study results published as an abstract
BACTERIA	bacteria and microbes - for microbes, enter bacteria as keyword, Microbe in Reference Manager field 6 (Notes)
BIOLOGICAL TOXICANT	general biological toxicants including venoms, fungal toxins, Bacillus thuringiensis, and other plant, animal or microbial extracts or toxins <u>not purified</u> (Purified single chemicals (with CAS numbers) of biological origin may be applicable. See the following websites for examples of applicable toxicants with biological origin: www.hort.purdue.edu/newcrop/proceedings1990/v1-511.html and www.epa.gov/pesticides/biopesticides/ingredients/index.htm).
CAS # UNAVAILABLE	chemical is not verifiable, no CAS # is available
DRUG	testing for drug effects and side-effects on humans (drugs used as environmental toxicants are applicable)
EFFLUENT	includes sewage and polluted runoff
FATE	chemical distribution, metabolism

HUMAN HEALTH	studies with human subjects or with surrogate animal subjects for human health risk assessment
INCIDENT	reports of animal deaths by poison, etc.; lacks usable concentration and/or duration
INCOMPLETE CITATION	citation is not complete; order status ARCHIVE
INCORRECT CITATION	citation is wrong; order status ARCHIVE
IN VITRO	in vitro studies, including exposure of cell cultures and excised tissues
METABOLISM	what happens to the chemical rather than to the organism
METHODS	no usable toxicity tests; describes methods for conducting tests, purification or determination of chemicals, etc. Some methods publications are ordered for the ECOTOX methods information file (METHFILE); documentation provided for toxicology test methods, experimental design, statistical methods, standard terminology, and recently developed test methods. Methfile publications are chosen to support development and interpretation of coding guidelines and to assist in reviewer training.
MICROTOX	Microtox tests; studies conducted with bacteria
MIXTURE	no single chemical tests reported
MODELING	modeling only, no new organism exposure data; modeling studies may report original toxicity tests performed as comparisons or as a basis for extrapolation, if so, publications are ordered

NO CONC	no usable dose or concentration reported after examination of the entire publication; includes lead shot studies lacking dose information and which report only the number of pellets. Concentrations reported in log units only are not coded.
NO DURATION	no duration reported (entire publication examined)
NO EFFECT	no organism effect reported, including water quality studies with no effect on organisms reported
NO QUANTIFIABLE TOXICITY RESULT	no specific data values to code, authors used general statements such as "the animals decreased in weight", used only for terrestrial publications
NO SOURCE	source of publication undetermined; order status ARCHIVE
NO SPECIES	-no organism present or tested -exposure of a dead organism -reviewer unable to verify species
NO TOX DATA	- chemicals in water, sediment or soil without organism effect data - ecological interactions with no toxicity tests - food studies - chemicals found in foods, food safety studies - genetics studies - including recombinant DNA and mutant strains - physiology - effects of the level of chemicals biologically present in an organism, including hormones and vitamins - risk assessment publications (related to regulation and legislation)
NO TOXICANT	no chemical toxicant - includes ambient air component chemicals (ozone, CO_2, SO_2) and pollution - includes vapor studies where the toxicant is delivered through inhalation/respiration -other ambient conditions including changes in conditions (other than chemical addition), including radioactivity, ultraviolet light (UV), temperature, pH, salinity, dissolved oxygen (DO), or other water, air or soil parameters
NON-ENGLISH	publication in a language other than English - (these publications receive ECOREF numbers UNLESS a second keyword is assigned); AUTH orders only (not ILL), if not received in 6 months, citations should be ARCHIVE
NUTRIENT	in situ chemicals tested as nutrients

OIL	only report toxic effects associated with exposure to oil and/or petroleum products
PUBL AS	publication was published in another journal or book, ECOREF number of other publication listed in Reference Manager citation Ex. PUBL AS ECOREF #####
QSAR	Quantitative Structure Activity Relationships; not primary source of data; bibliography skimmed to identify empirical studies
REVIEW	all toxicity tests reported elsewhere; REVIEW bibliography may be skimmed to identify relevant citations
SEDIMENT CONC	chemical concentration reported in sediment only (see applicable conditions)
SURVEY	measured chemical present, but lacking quantification of exposure; lacks usable concentration and/or duration
VIRUS	virus used as test organism
YEAST	yeast used as test organism

Attachment 2 - CAS Numbers for Appropriate Forms of Select Metals

(**<u>Note</u>**: In general, the chloride, nitrate, and sulfate salts of most metals are acceptable, but metal mixtures are excluded as are organic metal salts)

Chemical Abbrev	Chemical Names	CAS Registry Numbers
As	arsenic, arsenite, arsenate	7440382 Arsenic 7631892 Arsenic acid, Sodium salt 7645252 Arsenic acid, Lead salt 7778394 Arsenic acid (H3AsO4) 7778430 Arsenic acid, Disodium salt 7784341 Arsenous trichloride 7784409 Arsenic acid, Lead(2+) salt (1:1) 7784443 Arsenic acid, Diammonium salt 7784465 Arsenenous acid, Sodium salt 10048950 Arsenic acid, Disodium salt, Heptahydrate 15120179 Sodium arsenate (NaAsO3) 13464385 Sodium arsenate (Na3AsO4) 7631892 Sodium arsenate (generic form) 13466063 Sodium arsenite (Na2HAsO3) 13464374 Sodium arsenite (Na3AsO3)
Cd	cadmium	7440439 Cadmium 543908 Cadmium acetate 7789426 Cadmium bromide 10108642 Cadmium chloride 7790809 Cadmium iodide (CdCI2) 10022681 Nitric acid, Cadmium salt tetrahydrate 10325947 Cadmium nitrate 10124364 Cadmium sulfate 7790785 Cadmium chloride hydrate 7790843 Cadmium sulfate 8/3H2O 89759808 Cadmium acetate hydrate 34330648 Cadmium chloride hydrate
Pb	lead	7439921 Lead 301042 Lead acetate 7758954 Lead chloride 10099748 Lead nitrate 7446142 Lead sulfate 546678 Acetic acid, Lead (4+) salt 13826658 Nitrous acid, Lead (2+) salt

Chemical Abbrev	Chemical Names	CAS Registry Numbers
Ni	nickel	373024 Acetic acid, Nickel (2+) salt 7791200 Nickel chloride hexahydrate 69098153 Nickel chloride hydrate 15060625 Nickel (II) selenate 7440020 Nickel 7718549 Nickelous chloride 13138459 Nickelous nitrate 7786814 Sulfuric acid, nickel(2+)salt (1:1) 10101970 Nickel sulfate hexahydrate 373024 Nickelous acetate tetrahydrate 13478007 Nickel (II) chloride hydrate
Ag	silver	506649 Silver cyanide 563633 Acetic acid, Silver (1+) salt 7440224 Silver 7761888 Silver nitrate 7783906 Silver chloride 7783962 Silver iodide 10294265 Silver sulfate
Zn	zinc	7440666 Zinc 7646857 Zinc chloride 7779886 Zinc nitrate 7733020 Zinc sulfate 557346 Zinc acetate 1314223 Zinc peroxide 1314847 Zinc phosphide 7446200 Zinc sulfate heptahydrate 7699458 Zinc bromide 10139476 Zinc iodide 13597449 Sulfurous acid, Zinc salt (1:1) 10196186 Zinc nitrate hydrate 5970456 Zinc acetate dihydrate

Attachment 3. BE Data Rejection Code List (from approved SHPD WA 2-18 QAPP)

(**Note**: This list is meant to cover the majority of test conditions for which ecotoxicological data used in the BE might be rejected from use in ALC documents. Not all codes will apply in this case, and new codes might be added or modified as needed).

ABIOTIC FACTOR (AF)	Studies where an abiotic factor such as total water hardness, pH, or temperature are not reported for a criteria for which this information is necessary to derive a Species Mean Acute or Chronic Value, i.e., several freshwater metals, pentachlorophenol, ammonia.
ACELLULAR (Ace)	Studies of acellular organisms (protozoa) and yeast.
BACTERIA (Bact)	Studies describing only the results on bacteria.
BIOMARKER (Biom)	Studies reporting results for a biomarker having no reported association with a biologically significant adverse effect (survival, growth, or reproduction of an individual or population) and an exposure dose (or concentration).
CONTROL (Con)	Studies where control mortality is insufficient or unsatisfactory, i.e., where survival is less than 90% in acute tests or 80% in chronic tests; or where no control is used.
DETAIL (Det)	Insufficient detail regarding test methodology or statistical analysis.
DURATION (Dur)	Laboratory and field studies where duration of exposure is inappropriate (e.g., too short) for the type of test (i.e., acute or chronic), or was not reported or could not be easily estimated.
EFFLUENT (Efflu)	Studies reporting only effects of effluent, sewage, or polluted runoff where individual pollutants are not measured.
EFFECT (Eff)	Studies where the biologically significant adverse effect was not survival, growth, or reproduction of an individual or population.
ENDPOINT (UEndp)	Studies reported in ECOTOX where an endpoint (LC50, EC50, NOEC, LOEC, MATC, EC20, etc.) was not provided, where none of the concentrations tested in a chronic test were deleterious (no LOEC); or where all concentrations tested in a chronic test caused a statistically significant adverse effect (no NOEC).
FIELD (Field)	Chronic, long-term studies conducted in a field setting (stream segment, pond, etc.) where source/dilution water is not characterized for other possible contaminants.
FORMULATION (Form)	Studies where the chemical is a primary ingredient in a commercial formulation, e.g., biocide, fertilizer, etc.

IN VITRO (In Vit)	*In vitro* studies, including only exposure of the chemical to cell cultures and excised tissues and not related to whole organism toxicity.
LETHAL TIME (LT)	Laboratory studies reporting only lethal time to mortality, except under special conditions (no other applicable information is available for species pivotal in making a finding).
NO DOSE or CONC (No Dose or Conc)	Studies with too few concentrations to establish a dose-response, or no usable dose or concentration reported in either primary or sister article(s), except under special conditions (no other applicable information is available for species pivotal in making a finding).
NOMINAL (Nom)	Chronic studies where test concentrations were not measured.
NON-RESIDENT (NonRes)	Species that are not resident to North America, or where there is no reported evidence of their reproducing naturally in North America.
NO ORGANISM (No Org)	Laboratory and field studies where no one organism is studied (e.g., periphyton community) or where no scientific/common name is given in either a primary or sister article(s).
PURITY (Pur)	Studies where the chemical purity of the toxicant was less than 80% pure (active ingredient).
ROUTE OF EXPOSURE (RouExp)	Dietary or un-natural exposure routes for aquatic chemicals, e.g., injection, spray, inhalation.
TOXICANT (Tox)	Inappropriate form of toxicant used or none identified in a laboratory or field study. Note: Inappropriate form includes mixtures.
UNACCEPTABLE CHRONIC (UChron)	Chronic studies which were not based on flow-through exposures (exception for cladocerans and other small, planktonic organisms where test water is continuously renewed) and/or where test concentrations were not measured.
UNUSUAL DILUTION WATER (Dilut)	Laboratory or field studies where the dilution water contained unusual amounts or ratios of inorganic ions or was without addition of appropriate salts (i.e., distilled or de-ionized water).
VARIABLE EXPOSURE (VarExp)	Excessive variability in contaminant concentrations during the exposure period.
WATER QUALITY (WatQual)	Studies where the measured test pH is below 6 or greater than 9, where dissolved oxygen was less than 40% saturation for any length of time, or where total or dissolved organic carbon is greater than 5 mg/L.

Appendix C Cadmium (freshwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Abbasi, S.A., and R. Soni. 1986. An Examination of Environmentally Safe Levels of Zinc (II), Cadmium (II) and Lead (II) with Reference to Impact on Channelfish Nuria denricus. Environ.Pollut.Ser.A Ecol.Biol. 40(1):37-51.	11078	AF, Dur, Con	
Abdelghani, A.A., Y.V. Pramar, T.K. Mandal, P.B. Tchounwou, and L. Heyer. 1995. Levels and Toxicities of Selected Inorganic and Organic Contaminants in a Swamp Environment. J.Environ.Sci.Health Part B 30(5):717-731.	45166	AF	
Abel, P.D., and S.E. Papoutsoglou. 1986. Lethal Toxicity of Cadmium to Cyprinus carpio and Tilapia aurea. Bull.Environ.Contam.Toxicol. 37(3):382-386.	11925	UEndp	
Abel, P.D., and S.M. Garner. 1986. Comparisons of Median Survival Times and Median Lethal Exposure Times for Gammarus pulex Exposed to Cadmium, Permethrin and Cyanide. Water Res. 20(5):579-582.	7616	AF, UEndp, Dur, Con	
Abel, T., and F. Baerlocher. 1988. Uptake of Cadmium by Gammarus fossarum (Amphipoda) From Food and Water. J.Appl.Ecol. 25(1):223-231.	6805	NonRes	
Abel, T.H., and F. Barlocher. 1984. Effects of Cadmium on Aquatic Hyphomycetes. Appl.Environ.Microbiol. 48(2):245-251.	11030	Plant, Dur, Con	
Abraham, T.J., K.Y.M. Salih, and J. Chacko. 1986. Effects of Heavy Metals on the Filtration Rate of Bivalve Villorita cyprinoides (Hanley) Var. Cochinensis. Indian J.Mar.Sci. 15(3):195-196.	12315	AF, Con	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Achazi, R.K., G. Chroszcz, C. Duker, M. Henneken, B. Rothe, K. Schaub, and I. Steudel. 1995. The Effect of Fluoranthene (Fla), Benzo(a)pyrene (BaP) and Cadmium (Cd) upon Survival Rate and Life Cycle Parameter of Two Terrestrial Annelids in Laboratory Test Systems. Newslett.Enchytraeidae 4:7-14.	58146	AF	
Al Akel, A.S., M.J.K. Shamsi, H.F. Al Kahem, M.A. Chaudhary, and Z. Ahmad. 1988. Effect of Cadmium on the Cichlid Fish, Oreochromis niloticus: Behavioural and Physiological Responses. J.Univ.Kuwait Sci. 15(2):341-345.	130	AF, Con	
Alazemi, B.M., J.W. Lewis, and E.B. Andrews. 1996. Gill Damage in the Freshwater Fish Gnathonemus petersii (Family: Mormyridae) Exposed to Selected Pollutants: An Ultrastructural Study. Environ.Technol. 17(3):225-238.	19563	UEndp, Dur	
Albergoni, V., and A. Viola. 1995. Effects of Cadmium on Catfish, Ictalurus melas, Humoral Immune Response. Fish Shellfish Immunol. 5(2):89-95.	18698	AF, Uendp	
Alkahem, H.F.. 1993. Ethological Responses and Changes in Hemoglobin and Glycogen Content of the Common Carp, Cyprinus carpio, Exposed to Cadmium. Asian Fish.Sci. 6(1):81-90.	4234	Con	
Alkahem, H.F.. 1995. Acute and Sublethal Exposure of Catfish (Clarias gariepinus) to Cadmium Choride: Survival, Behavioural and Physiological Responses. Pak.J.Zool. 27(1):33-37.	18022	NonRes	
Allen, P.. 1993. Accumulation Profiles of Cadmium and Their Modification by Interaction with Lead and Mercury in the Edible Tissues of Oreochromis aureus. Fresenius Environ.Bull. 2(12):745-751.	16695	AF, UEndp	
Allen, P.. 1995. Chronic Accumulation of Cadmium in the Edible Tissues of Oreochromis aureus (Steindachner): Modification by Mercury and Lead. Arch.Environ.Contam.Toxicol. 29(1):8-14.	14920	AF, UEndp	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Allen, P.. 1995. Accumulation Profiles of Lead and Cadmium in the Edible Tissues of Oreochromis aureus During Acute Exposure. J.Fish Biol. 47(4):559-568.	16322	UEndp	
Allen, Y., P. Calow, and D.J. Baird. 1995. A Mechanistic Model of Contaminant-Induced Feeding Inhibition in Daphnia magna. Environ.Toxicol.Chem. 14(9):1625-1630.	10203	Acute test with adults	Table 6 in 2001 ALC document because <24 h neonates preferred
Anadu, D.I., G.A. Chapman, L.R. Curtis, and R.A. Tubb. 1989. Effect of Zinc Exposure on Subsequent Acute Tolerance to Heavy Metals in Rainbow Trout. Bull.Environ.Contam.Toxicol. 43(3):329-336.	791	See note	Not used in ALC document because animals acclimated or exhibited increased resistance to cadmium
Andaya, A.A., and E.U. Gotopeng. 1982. Cadmium Toxicity and Uptake in Tilapia nilotica. Kalikasan (Philipp.J.Biol.) 11(2/3):390-318.	12458	AF, Dur	
Anderson, B.G.. 1948. The Apparent Thresholds of Toxicity to Daphnia magna for Chlorides of Various Metals when Added to Lake Erie Water. Trans.Am.Fish.Soc. 78:96-113.	2054	AF, Dur	
Anderson, R.L., C.T. Walbridge, and J.T. Fiandt. 1980. Survival and Growth of Tanytarsus dissimilis (Chironomidae) Exposed to Copper, Cadmium, Zinc, and Lead. Arch.Environ.Contam.Toxicol. 9(3):329-335 (Author Communication Used).	5249	Con	
Angadi, S.B., and P. Mathad. 1998. Effect of Copper, Cadmium and Mercury on the Morphological, Physiological and Biochemical Characteristics of Scenedesmus quadricauda (Turp.) de Breb. J.Environ.Biol. 19(2):119-124.	19132	Plant, AF, UEndp	
Angadi, S.B., S. Hiremath, and S. Pujari. 1996. Toxicity of Copper, Nickel, Manganese and Cadmium on Cyanobacterium Hapalosiphon stuhlmannii. J.Environ.Biol. 17(2):107-113.	17771	Plant, AF, UEndp	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Annune, P.A., and T.T. Iyaniwura. 1993. Accumulation of Two Trace Metals in Tissues of Freshwater Fishes, Oreochromis niloticus and Clarias gariepinus. J.Aquat.Food Product Technol. 2(3):5-18.	16167	AF, UEndp	
Annune, P.A., S.O. Ebele, and A.A. Oladimeji. 1994. Acute Toxicity of Cadmium to Juveniles of Clarias gariepinus (Teugels) and Oreochromis niloticus (Trewavas). J.Environ.Sci.Health A29(7):1357-1365.	17299	NonRes	
Aoki, Y., S. Hatakeyama, N. Kobayashi, Y. Sumi, T. Suzuki, and K.T. Suzuki. 1989. Comparison of Cadmium-Binding Protein Induction Among Mayfly Larvae of Heavy Metal Resistant (Baetis thermicus) and Susceptible Species (B.. Comp.Biochem.Physiol.C 93(2):345-347.	2390	AF, UEndp	
Aoyama, I., and H. Okamura. 1993. Interactive Toxic Effect and Bioconcentration Between Cadmium and Chromium Using Continuous Algal Culture. Environ.Toxicol.Water Qual. 8(3):255-269.	9948	Plant, AF, UEndp	
Azeez, P.A., and D.K. Banerjee. 1986. Effect of Copper and Cadmium on Carbon Assimilation and Uptake of Metals by Algae. Toxicol.Environ.Chem. 12(1-2):77-86.	12317	Plant, AF, UEndp, Con	
Back, H.. 1983. Interactions, Uptake and Distribution of Barium, Cadmium, Lead and Zinc in Tubificid Worms (Annelida, Oligochaeta). In: 4th Int.Conf.on Heavy Metals in the Environment, Heidelberg, Vol.1, Sept.1983, CEP Consultants Ltd., Edinburgh, U.K. :370-371.	11865	AF, UEndp	
Back, H.. 1990. Epidermal Uptake of Pb, Cd, and Zn in Tubificid Worms. Oecologia 85(2):226-232.	20568	AF, UEndp	
Bailey, H.C., and D.H.W. Liu. 1980. Lumbriculus variegatus, a Benthic Oligochaete, As a Bioassay Organism. In: J.C.Eaton, P.R.Parrish, and A.C.Hendricks (Eds.), Aquatic Toxicology and Hazard Assessment, 3rd Symposium, ASTM STP 707, Philadelphia, PA :205-215.	6502	Dur	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Baillieul, M., and R. Blust. 1999. Analysis of the Swimming Velocity of Cadmium-Stressed Daphnia magna. Aquat.Toxicol. 44:245-254.	20334	AF, Uendp, Eff	
Baird, D.J., I. Barber, and P. Calow. 1990. Clonal Variation in General Responses of Daphnia magna Straus to Toxic Stress. I. Chronic Life-History Effects. Funct.Ecol. 4(3):399-407.	3711	AF, UEndp	
Ball, I.R.. 1967. Short Communication: The Toxicity of Cadmium to Rainbow Trout (Salmo gairnderii Richardson). Water Res. 1:805-806.	4252	Con	
Balogh, K., and J. Salanki. 1984. The Dynamics of Mercury and Cadmium Uptake Into Different Organs of Anodonta cygnea L. Water Res. 18(11):1381-1387.	10766	AF, UEndp, Con, Eff	
Banerjee, V., and K. Kumari. 1988. Effect of Zinc, Mercury and Cadmium on Erythrocyte and Related Parameters in the Fish Anabas testudineus. Environ.Ecol. 6(3):737-739.	803	AF, Dur, Con	
Barata, C., and D.J. Baird. 2000. Determining the Ecotoxicological Mode of Action of Chemicals from Measurements Made on Individuals: Results from Instar-Based Tests with Daphnia magna Straus. Aquat.Toxicol. 48(2/3):195-209.	47311	AF, Eff	
Barber, I., D.J. Baird, and P. Calow. 1994. Effect of Cadmium and Ration Level on Oxygen Consumption, RNA Concentration and RNA-DNA Ratio in Two Clones of Daphnia magna Straus. Aquat.Toxicol. 30(3):249-258.	16639	AF, UEndp, Eff	
Bartlett, L., F.W. Rabe, and W.H. Funk. 1974. Effects of Copper, Zinc and Cadmium on Selanastrum capricornutum. Water Res. 8(3):179-186.	2254	UEndp	
Battaglini, P., G. Andreozzi, R. Antonucci, N. Arcamone, P. De Girolamo, L. Ferrara, and G. Gargiulo. 1993. The Effects of Cadmium on the Gills of the Goldfish Carassius auratus L.: Metal Uptake and Histochemical Changes. Comp.Biochem.Physiol.C 104(2):239-247.	6879	UEndp, Eff	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Baudouin, M.F., and P. Scoppa. 1974. Acute Toxicity of Various Metals to Freshwater Zooplankton. Bull.Environ.Contam.Toxicol. 12(6):745-751.	5339	AF, Eff, Dur	
Baudrimont, M., J. Metivaud, R. Maury-Brachet, F. Ribeyre, and A. Boudou. 1997. Bioaccumulation and Metallothionein Response in the Asiatic Clam (Corbicula fluminea) After Experimental Exposure to Cadmium and Inorganic Mercury. Environ.Toxicol.Chem. 16(10):2096-2105.	18269	AF, UEndp	
Beach, M.J., and D. Pascoe. 1998. The Role of Hydra vulgaris (Pallas) in Assessing the Toxicity of Freshwater Pollutants. Water Res. 32(1):101-106.	18616	Dur	
Beattie, J.H., and D. Pascoe. 1978. Cadmium Uptake by Rainbow Trout, Salmo gairdneri Eggs and Alevins. J.Fish Biol. 13(5):631-637.	15554	UEndp	
Beena, S., and S. Viswaranjan. 1987. Effect of Cadmium and Mercury on the Hematological Parameters of the Fish Cyprinus carpio. Environ.Ecol. 5(4):726-730.	7734	AF, UEndp, Eff, Dur	
Belanger, S.E., and D.S. Cherry. 1990. Interacting Effects of pH Acclimation, pH, and Heavy Metals on Acute and Chronic Toxicity to Ceriodaphnia dubia (Cladocera). J.Crustac.Biol. 10(2):225-235.	8661	UEndp, Eff	
Bellavere, C., and J. Gorbi. 1981. A Comparative Analysis of Acute Toxicity of Chromium, Copper, and Cadmium to Daphnia magna, Biomphalaria glabrata, and Brachydanio rerio. Environ.Technol.Lett. 2(3):119-128.	5268	Dur, Con	
Bengtsson, B.E., and B. Bergstrom. 1987. A Flowthrough Fecundity Test with Nitocra spinipes (Harpacticoidea Crustacea) for Aquatic Toxicity. Ecotoxicol.Environ.Saf. 14:260-268.	2332	AF, Con	
Benhra, A., C.M. Radetski, and J.F. Ferard. 1997. Cryoalgotox: Use of Cryopreserved Alga in a Semistatic Microplate Test. Environ.Toxicol.Chem. 16(3):505-508.	17613	Plant, AF, Dur	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Benson, W.H., and W.J. Birge. 1983. Heavy Metal Tolerance and Metallothionein Induction in Fathead Minnows: Results From Field and Laboratory Investigations. Environ.Toxicol.Chem.4(2):209-217 (1983) / J.Am.Coll.Toxicol. 2(2):240 (ABS).	10551	Dur, Con	
Benson, W.H., K.N. Baer, R.A. Stackhouse, and C.F. Watson. 1987. Influence of Cadmium Exposure on Selected Hematological Parameters in Freshwater Teleost, Notemigonus crysoleucas. Ecotoxicol.Environ.Saf. 13(1):92-96.	12205	Con	
Bentley, P.J.. 1991. Accumulation of Cadmium by Channel Catfish (Ictalurus punctatus): Influx from Environmental Solutions. Comp.Biochem.Physiol.C 99(3):527-529.	3865	AF, UEndp, Dur, Con	
Bentley, R.E., T. Heitmuller, B.H. Sleight III, and P.R. Parrish. 1975. Acute Toxicity of Cadmium to Bluegill (Lepomis macrochirus), Rainbow Trout (Salmo gairdneri), and Pink Shrimp (Penaeus duorarum). U.S.EPA, Criteria Branch, WA-6-99-1414-B, Washington, D.C .:14.	3780	Dur, Con	
Berglind, R.. 1985. The Effects of Cadmium on ALA-D Activity, Growth and Haemoglobin Content in the Water Flea, Daphnia magna. Comp.Biochem.Physiol.C 80(2):407-410.	10802	AF, UEndp	
Berglind, R.. 1986. Combined and Separate Effects of Cadmium, Lead and Zinc on Ala-D Activity, Growth and Hemoglobin Content in Daphnia magna. Environ.Toxicol.Chem. 5:989-995.	12155	UEndp	
Bervoets, L., and R. Blust. 2000. Effects of pH on Cadmium and Zinc Uptake by the Midge Larvae Chironomus riparius. Aquat.Toxicol. 49:145-157.	47526	AF, Uendp, Dur	
Bervoets, L., R. Blust, and R. Verheyen. 1996. Effect of Temperature on Cadmium and Zinc Uptake by the Midge Larvae Chironomus riparius. Arch.Environ.Contam.Toxicol. 31(4):502-511.	18235	AF, UEndp, Dur	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Besser, J.M., C.G. Ingersoll, E.N. Leonard, and D.R. Mount. 1998. Effect of Zeolite on Toxicity of Ammonia in Freshwater Sediments: Implications for Toxicity Identification Evaluation Procedures. Environ.Toxicol.Chem. 17(11):2310-2317.	19610	UEndp	
Bhattacharya, T., S. Bhattacharya, A.K. Ray, and S. Dey. 1989. Influence of Industrial Pollutants on Thyroid Function in Channa punctatus (Bloch). Indian J.Exp.Biol. 27(1):65-68.	3106	AF, UEndp, Dur	
Bilinski, E., and R.E.E. Jonas. 1973. Effects of Cadmium and Copper on the Oxidation of Lactate by Rainbow Trout (Salmo gairdneri) Gills. J.Fish.Res.Board Can. 30(10):1553-1558.	8692	UEndp, Dur	
Birge, W.J.. 1978. Aquatic Toxicology of Trace Elements of Coal and Fly Ash. In: J.H.Thorp and J.W.Gibbons (Eds.), Dep.Energy Symp.Ser., Energy and Environmental Stress in Aquatic Systems, Augusta, GA 48:219-240.	5305	UEndp,Dur	
Birge, W.J., A.G. Westerman, and O.W. Roberts. 1974. Lethal and Teratogenic Effects of Metallic Pollutants on Vertebrate Embryos. Proc.2nd Annu.NSF-Rann Trace Contam.Environ.Conf., Springfield, VA:316-320 (U.S.NTIS LBL-3217) (Used Ref.8703).	8488	AF, UEndp, Con	
Birge, W.J., J.A. Black, A.G. Westerman, and B.A. Ramey. 1983. Fish and Amphibian Embryos - A Model System for Evaluating Teratogenicity. Fundam.Appl.Toxicol. 3:237-242.	19124	UEndp, Dur	
Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson. 1979. The Effects of Mercury on Reproduction of Fish and Amphibians. In: O.Nriagu (Ed.), The Biogeochemistry of Mercury in the Environment, Chapter 23, Elsevier/North-Holland Biomedical Press :629-655.	10189	UEndp, Dur	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson. 1980. Aquatic Toxicity Tests on Inorganic Elements Occurring in Oil Shale. In: C.Gale (Ed.), EPA-600/9-80-022, Oil Shale Symposium: Sampling, Analysis and Quality Assurance, March 1979, U.S.EPA, Cincinnati, OH :519-534 (U.S.NTIS PB80-221435).	11838	UEndp,Dur	
Birge, W.J., J.A. Black, and A.G. Westerman. 1979. Evaluation of Aquatic Pollutants Using Fish and Amphibian Eggs as Bioassay Organisms. In: S.W.Nielsen, G.Migaki, and D.G.Scarpelli (Eds.), Symp.Animals Monitors Environ.Pollut., 1977, Storrs, CT 12:108-118.	4943	Dur	
Birge, W.J., J.A. Black, and A.G. Westerman. 1985. Short-Term Fish and Amphibian Embryo-Larval Tests for Determining the Effects of Toxicant Stress on Early Life Stages and Estimating Chronic Values. Environ.Toxicol.Chem. 4(6):807-821 (Publ in Part As 10485).	12156	AF, Con	
Birge, W.J., J.E. Hudson, J.A. Black, and A.G. Westerman. 1978. Embryo-Larval Bioassays on Inorganic Coal Elements and in Situ Biomonitoring of Coal-Waste Effluents. In: Symp.U.S.Fish Wildl.Serv., Surface Mining Fish Wildl.Needs in Eastern U.S., W.VA :97-104.	6199	Dur	
Birge, W.J., J.J. Just, A.G. Westerman, J.A. Black, and O.W. Roberts. 1975. Sensitivity of Vertebrate Embryos to Heavy Metals as a Criterion of Water Quality. Phase II. Bioassay Procedures Using Developmental Stages as Test Organisms. Res.Rep.No.84, Water Resour.Res.Inst., University of Kentucky, Lexington, KY :36 p.	15915	AF, UEndp, Con	
Birge, W.J., W.H. Benson, and J.A. Black. 1983. The Induction of Tolerance to Heavy Metals in Natural and Laboratory Populations of Fish. Res.Rep.No.141, Water Resour.Res.Inst., University of Kentucky, Lexington, Kentucky Y:26.	10237	Dur	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Bitton, G., K. Rhodes, B. Koopman, and M. Cornejo. 1995. Short-Term Toxicity Assay Based on Daphnid Feeding Behavior. Water Environ.Res. 67(3):290-293.	19602	AF, Eff, Dur, RouExp	
Black, J.A., and W.J. Birge. 1980. An Avoidance Response Bioassay for Aquatic Pollutants. Res.Report No.123, Water Resour.Res.Inst., University of Kentucky, Lexington, Kentucky Y:34-180490.	5272	Dur	
Blaise, C., R. Legault, N. Bermingham, R. Van Coillie, and P. Vasseur. 1986. A Simple Microplate Algal Assay Technique for Aquatic Toxicity Assessment. Toxic.Assess. 1:261-281.	12748	Plant, AF, Con	
Block, M., and A.W. Glynn. 1992. Influence of Xanthates on the Uptake of 109Cadmium by Eurasian Dace (Phoxinus phoxinus) and Rainbow Trout (Oncorhynchus mykiss). Environ.Toxicol.Chem. 11(7):873-879.	5908	AF, UEndp, Dur, Con	
Bodar, C.W.M., A.V.D. Zee, P.A. Voogt, H. Wynne, and D.I. Zandee. 1989. Toxicity of Heavy Metals to Early Life Stages of Daphnia magna. Ecotoxicol.Environ.Saf. 17(3):333-338.	3854	AF, UEndp, Dur, Con	
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Bodar, C.W.M., I. Van der Sluis, J.C.P. Van Montfort, P.A. Voogt, and D.I. Zandee. 1990. Cadmium Resistance in Daphnia magna. Aquat.Toxicol. 16(1):33-40.	3001	AF, Dur, Con	

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Bogaerts, P., J. Senaud, and J. Bohatier. 1998. Bioassay Technique Using Nonspecific Esterase Activities of Tetrahymena pyriformis for Screening and Assessing Cytotoxicity of Xenobiotics. Environ.Toxicol.Chem. 17(8):1600-1605.	18353	Ace, AF, UEndp, Dur	
Borgmann, U.. 1980. Interactive Effects of Metals in Mixtures on Biomass Production Kinetics of Freshwater Copepods. Can.J.Fish.Aquat.Sci. 37(8):1295-1302.	9757	AF, UEndp, Con	
Borgmann, U., and K.M. Ralph. 1986. Effects of Cadmium, 2,4-Dichlorophenol, and Pentachlorophenol on Feeding, Growth, and Particle-Size-Conversion Efficiency of White. Arch.Environ.Contam.Toxicol. 15(5):473-480.	11938	AF, Con	
Borgmann, U., R. Cove, and C. Loveridge. 1980. Effects of Metals on the Biomass Production Kinetics of Freshwater Copepods. Can.J.Fish.Aquat.Sci. 37(4):567-575.	9758	UEndp, Con	
Borgmann, U., V. Cheam, W.P. Norwood, and J. Lechner. 1998. Toxicity and Bioaccumulation of Thallium in Hyalella azteca, with Comparison to Other Metals and Prediction of Environmental Impact. Environ.Pollut. 99(1):105-114.	19137	Dur	
Borgmann, U., W.P. Norwood, and I.M. Babirad. 1991. Relationship Between Chronic Toxicity and Bioaccumulation of Cadmium in Hyalella azteca. Can.J.Fish.Aquat.Sci. 48(6):1055-1060.	3596	AF, UEndp	
Borovyagin, V., L. Hernadi, and J. Salanki. 1989. Mercury and Cadmium Induced Structural Alterations in the Taste Buds of the Fish Alburnus alburnus. Acta Biol.Hung. 40(3):237-254.	183	AF, UEndp, Eff	
Bouche, M.L., F. Habets, S. Biagianti-Risbourg, and G. Vernet. 2000. Toxic Effects and Bioaccumulation of Cadmium in the Aquatic Oligochaete Tubifex tubifex. Ecotoxicol.Environ.Saf. 46(3):246-251.	47714	AF, Dur	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Boutet, C., and C. Chaisemartin. 1973. Specific Toxic Properties of Metallic Salts in Austropotamobius pallipes pallipes and Orconectes limosus. C.R.Soc.Biol.(Paris) 167(12):1933-1938 (FRE) (ENG TRANSL).	5421	AF, Con	
Braginskiy, L.P., and E.P. Shcherban. 1979. Acute Toxicity of Heavy Metals to Aquatic Invertebrates Under Different Temperature Conditions. Hydrobiol.J.14(6):78-82 / Gidrobiol.Zh. 14(6):86-92 (RUS) (ENG ABS).	5565	AF, Dur, Con	
Bresch, H.. 1982. Investigation of the Long-Term Action of Xenobiotics on Fish with Special Regard to Reproduction. Ecotoxicol.Environ.Saf. 6(1):102-112.	10392	AF, UEndp, Con	
Bringmann, G., and R. Kuhn. 1959. Water Toxicological Studies with Protozoa as Test Organisms. TR-80-0058, Literature Research Company:13 p.; Gesund.-Ing.80:239-242 (GER); Chem.Abstr. 53:22630D-(GER)(ENG TRANSL).	2394	UEndp, Eff, Dur	
Bringmann, G., and R. Kuhn. 1959. Comparative Water-Toxicological Investigations on Bacteria, Algae, and Daphnia. Gesundheitsingenieur 80(4):115-120.	61194	UEndp	
Bringmann, G., and R. Kuhn. 1977. The Effects of Water Pollutants on Daphnia magna. Wasser-Abwasser-Forsch. 10(5):161-166(ENG TRANSL)(OECDG Data File)(GER)(ENG ABS).	5718	Dur, Con	
Bringmann, G., and R. Kuhn. 1978. Investigation of Biological Harmful Effects of Chemical Substances Which are Classified as Dangerous for Water on Protozoa. Z.Wasser-Abwasser-Forsch.11(6):210-215, TR-80-0307, Literature Research Company :13 p. (ENG TRANSL) (OECDG Data File).	6601	AF, UEndp, Dur	
Brkovic-Popovic, I., and M. Popovic. 1977. Effects of Heavy Metals on Survival and Respiration Rate of Tubificid Worms: Part 1-Effects on Survival. Environ.Pollut. 13(1):65-72.	8905	Dur	

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Brkovic-Popovic, I., and M. Popovic. 1977. Effects of Heavy Metals on Survival and Respiration Rate of Tubificid Worms: Part II-Effects on Respiration Rate. Environ.Pollut. 13(2):93-98.	15584	UEndp, Eff, Dur, Con	
Brown, B.T., and B.M. Rattigan. 1979. Toxicity of Soluble Copper and Other Metal Ions to Elodea canadensis. Environ.Pollut. 20(4):303-314.	2255	Plant, AF, UEndp, Con	
Brown, E.R., L. Keith, J.J. Hazdra, and T. Arndt. 1973. Tumors in Fish Caught in Polluted Waters: Possible Explanations. In: Y.Ito and R.M.Dutcher (Eds.), Comparative Leukemia Research 1973, Leukemogenesis, Bibl.Haematol.No.40, Univ.of Tokyo Press, Tokyo/Karger, Basel :47-57.	2143	AF, UEndp, Con	
Brown, M.W., D. Shurben, J.F.D. Solbe, A. Cryer, and J. Kay. 1987. Sequestration of Environmental Cadmium by Metallothionein in the Roach (Rutilus rutilus) and the Stone Loach (Noemacheilus barbatulus). Comp.Biochem.Physiol.C 87(1):65-69.	12707	AF, UEndp, Con	
Bryan, M.D., G.J. Atchison, and M.B. Sandheinrich. 1995. Effects of Cadmium on the Foraging Behavior and Growth of Juvenile Bluegill, Lepomis macrochirus. Can.J.Fish.Aquat.Sci. 52:1630-1638.	16188	UEndp	
Buhringer, H., K.R. Sperling, and W. Wunder. 1990. Spinal Shortening (Osteosclerosis) in Spawners of the Rainbow Trout (Salmo Gairdneri Rich.) Induced by Cadmium. Arch.Fischwiss. 40(3):205-228.	8394	AF, UEndp, Eff, RouExp	
Buikema, A.L.J., J. Cairns Jr., and G.W. Sullivan. 1974. Evaluation of Philodina acuticornis (Rotifera) as Bioassay Organisms for Heavy Metals. Water Resour.Bull.Am.Water Res.Assoc. 10(4):648-661.	2019	NonRes	
Busacker, G.P.. 1980. Osmoregulatory Effects of Acute Cadmium Toxicity In a Model Teleost. Diss.Abstr.Int.B Sci.Eng. 41(4):1269 (Author Communication Used).	460	96 h LC50 approx. 12,000 ug/L dissolved cadmium normalized to 100 mg/L as CaCO3 hardness. Test was	This study appears to provide an appropriate 96 h LC50 for Carassius auratus, but the paper should be

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
		static, unmeasured.	secured to ensure acceptability. Species is relatively insensitive to acute cadmium exposure
Cain, J.R., and R.K. Allen. 1980. Use of a Cell Wall-Less Mutant Strain to Assess the Role of the Cell Wall in Cadmium and Mercury Tolerance by Chlamydomonas reinhardtii. Bull.Environ.Contam.Toxicol. 25(5):797-801.	9672	Plant, AF, UEndp, Con	
Cairns, J.Jr., J.R. Pratt, and B.R. Niederlehner. 1985. A Provisional Multispecies Toxicity Test Using Indigenous Organisms. J.Test.Eval. 13(4):316-319.	2660	Ace, AF, UEndp	
Cairns, J.Jr., J.R. Pratt, B.R. Niederlehner, and P.V. McCormick. 1986. A Simple, Cost-Effective Multispecies Toxicity Test Using Organisms with a Cosmopolitan Distribution. Environ.Monit.Assess. 6:207-220.	9815	Ace, AF, UEndp	
Calamari, D., G.F. Gaggino, and G. Pacchetti. 1982. Toxicokinetics of Low Levels of Cd, Cr, Ni and Their Mixture in Long-Term Treatment on Salmo gairdneri Rich. Chemosphere 11(1):59-70.	15454	UEndp, Con	
Calamari, D., R. Marchetti, and G. Vailati. 1980. Influence of Water Hardness on Cadmium Toxicity to Salmo gairdneri Rich. Water Res. 14(10):1421-1426.	459	Dur, Con	
Calevro, F., C. Filippi, P. Deri, C. Albertosi, and R. Batistoni. 1998. Toxic Effects of Aluminium, Chromium and Cadmium in Intact and Regenerating Freshwater Planarians. Chemosphere 37(4):651-659.	19264	AF, UEndp	
Calevro, F., S. Campani, M. Ragghianti, S. Bucci, and G. Mancino. 1998. Tests of Toxicity in Biphasic Vertebrates Treated with Heavy Metals (Cr3+, Al3+, Cd2+). Chemosphere 37(14/15):3011-3017.	20095	AF, UEndp, Eff	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Calgan, D.T., and O. Yenigun. 1996. Toxicity of Arsenic, Cadmium and Nickel on the Cyanobacterium Anabaena cylindrica. Environ.Technol. 17(5):533-540.	19504	Plant, AF, UEndp, Eff	
Call, D.J., L.T. Brooke, N. Ahmad, and D.D. Vaishnav. 1981. Aquatic Pollutant Hazard Assessments and Development of a Hazard Prediction Technology by Quantitative Structure-Activity Relationships. Second Quarterly Report, U.S.EPA Cooperative Agreement No.CR 809234-01-0, Center for Lake Superior Environmental Studies, University of Wisconsin, Superior, WI:74 p.(Publ in Part As 12448).	3690	Con	
Canton, J.H., and D.M.M. Adema. 1978. Reproducibility of Short-Term and Reproduction Toxicity Experiments with Daphnia magna and Comparison of the Sensitivity of Daphnia magna with Daphnia pulex and Daphnia cucullata in Short-Term Experiments. Hydrobiologia 59(2):135-140 (Used Reference 2018).	2017	AF, Con	
Carlson, A.R., G.L. Phipps, V.R. Mattson, P.A. Kosian, and A.M. Cotter. 1991. The Role of Acid-Volatile Sulfide in Determining Cadmium Bioavailability and Toxicity in Freshwater Sediments. Environ.Toxicol.Chem. 10:1309-1319.	3919	UEndp, Con	
Carlson, A.R., H. Nelson, and D. Hammermeister. 1986. Development and Validation of Site-Specific Water Quality Criteria for Copper. Environ.Toxicol.Chem. 5:997-1012.	12161	AF, Con	
Carr, H.P., F.A. Carino, M.S. Yang, and M.H. Wong. 1998. Characterization of the Cadmium-Binding Capacity of Chlorella vulgaris. Bull.Environ.Contam.Toxicol. 60:433-440.	18838	Plant, AF, Con	
Carter, J.W., and I.L. Cameron. 1973. Toxicity Bioassay of Heavy Metals in Water using Tetrahymena-pyriformis. Water Res. 7(7):951-961.	15419	Ace, AF, UEndp	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Cassini, A., L. Tallandini, N. Favero, and V. Albergoni. 1986. Cadmium Bioaccumulation Studies in the Freshwater Molluscs Anodonta cygnea and Unio elongatulus. Comp.Biochem.Physiol.C 84(1):35-41.	11801	AF, UEndp	
Castren, M., and A. Oikari. 1987. Changes of the Liver UDP-Glucuronosyltransferase Activity in Trout (Salmo gairdneri Rich.) Acutely Exposed to Selected Aquatic Toxicants. Comp.Biochem.Physiol.C 86(2):357-360.	12208	AF, UEndp, Con	
Cearley, J.E., and R.L. Coleman. 1973. Cadmium Toxicity and Accumulation in Southern Naiad. Bull.Environ.Contam.Toxicol. 9(2):100-101.	8789	UEndp	
Chagnon, N.L., and S.I. Guttman. 1988. Differential Survivorship of Allozyme Genotypes in Mosquitofish (Gambusia affinis) Population Exposed to Copper or Cadmium. Ohio J.Sci.88(2):46 (Abs).	13098	AF, UEndp, Dur, Con	
Chagnon, N.L., and S.I. Guttman. 1989. Differential Survivorship of Allozyme Genotypes in Mosquitofish Populations Exposed to Copper or Cadmium. Environ.Toxicol.Chem. 8(4):319-326.	507	AF, Dur, Con	
Chandini, T.. 1988. Changes in Food [Chlorella] Levels and the Acute Toxicity of Cadmium to Daphnia carinata (Daphnidae) and Echinisca triserialis (Macrothricidae)(Crustacea: Cladocera). Bull.Environ.Contam.Toxicol. 41(3):398-403.	13136	AF, Con	
Chandini, T.. 1989. Survival, Growth and Reproduction of Daphnia carinata (Crustacea: Cladocera) Exposed to Chronic Cadmium Stress at Different Food (Chlorella) Levels. Environ.Pollut. 60(1):29-45.	977	AF, UEndp	
Chandini, T.. 1991. Reproductive Value and the Cost of Reproduction in Daphnia carinata and Echinisca triserialis (Crustacea: Cladocera) Exposed to Food and Cadmium Stress. Bull.Environ.Contam.Toxicol. 47(1):76-83.	3605	AF, UEndp	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Chandra, P., and P. Garg. 1992. Absorption and Toxicity of Chromium and Cadmium in Limnanthemum cristatum Griseb. Sci.Total Environ. 125:175-183.	7115	Plant, AF, UEndp	
Chapman, G.A., and D.G. Stevens. 1978. Acute Lethal Levels of Cadmium, Copper, and Zinc to Adult Male Coho Salmon and Steelhead. Trans.Am.Fish.Soc. 107(6):837-840.	2060	Dur	
Chapman, P.M., M.A. Farrell, and R.O. Brinkhurst. 1982. Relative Tolerances of Selected Aquatic Oligochaetes to Combinations of Pollutants and Environmental Factors. Aquat.Toxicol. 2(1):69-78.	10602	AF	
Chapman, P.M., M.A. Farrell, and R.O. Brinkhurst. 1982. Effects of Species Interactions on the Survival and Respiration of Limnodrilus hoffmeisteri and Tubifex tubifex (Oligochaeta, Tubificidae) Exposed to. Water Res. 16(9):1405-1408.	15207	AF, Con	
Charpentier, S., J. Garnier, and R. Flaugnatti. 1987. Toxicity and Bioaccumulation of Cadmium in Experimental Cultures of Duckweed, Lemna polyrrhiza L. Bull.Environ.Contam.Toxicol. 38(6):1055-1061.	12562	Plant, AF	
Chatterjee, S., and S. Bhattacharya. 1986. Inductive Changes in Hepatic Metallothionein Profile in the Climbing Perch, Anabas testudineus (Bloch) by Industrial Pollutants. Indian J.Exp.Biol. 24(7):455-457.	12321	AF, UEndp, Eff, Dur, Con	
Chauhan, T.P.S., M.M. Prakash, K.C. Gupta, and B.R. Varma. 1979. Observations on the Toxicity of Cadmium Chloride to Heteropneustes fossilis (Bloch). Comp.Physiol.Ecol. 4(2):59-60.	15710	AF, UEndp, Dur, Con	
Chawla, G., J. Singh, and P.N. Viswanathan. 1991. Effect of pH and Temperature on the Uptake of Cadmium by Lemna minor L. Bull.Environ.Contam.Toxicol. 47(1):84-90.	3603	Plant, AF, Con	

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Chen, C.Y., K.C. Lin, and D.T. Yang. 1997. Comparison of the Relative Toxicity Relationships Based on Batch and Continuous Algal Toxicity Tests. Chemosphere 35(9):1959-1965 (Publ in Part As 18103).	18447	Plant, AF	
Chen, H.C., and Y.K. Yuan. 1994. Acute Toxicity of Copper, Cadmium and Zinc to Freshwater Fish Acrosscheilus paradoxus. Acta Zool.Taiwan. 5(2):45-60.	18913	Dur	
Chouikhi, A.. 1979. Choice and Set Up of the Food Chains in Freshwater in Order to Show the Bioaccumulation Character of a Pollutant. OECD-IRCHA Universite Paris-Sud, Unite d'Enseignement et de Recherche d'Hygiene et Protection de l'Homme et de son Environnement (FRE).	3521	AF	
Christensen, G.M.. 1975. Biochemical Effects of Methylmercuric Chloride, Cadmium Chloride, and Lead Nitrate on Embryos and Alevins of the Brook Trout, Salvelinus fontinalis. Toxicol.Appl.Pharmacol. 32:191-197(Used Ref 2022, 9586).	2432	UEndp, Con	
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Chung, K.S.. 1978. Acute Toxicity of Cadmium and Copper in the Mangrove Oyster. Acta Cient.Venez. 29(2):14 (SPA).	8329	AF, Con	
Cinier, C.C., M. Petit-Ramel, R. Faure, D. Garin, and Y. Bouvet. 1999. Kinetics of Cadmium Accumulation and Elimination in Carp Cyprinus carpio Tissues. Comp.Biochem.Physiol. 122(2):345-352.	20069	UEndp	
Clubb, R.W., A.R. Gaufin, and J.L. Lords. 1975. Acute Cadmium Toxicity Studies upon Nine Species of Aquatic Insects. Environ.Res. 9:332-341.	2025	AF, UEndp, Con	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Clubb, R.W., A.R. Gaufin, and J.L. Lords. 1975. Synergism between Dissolved Oxygen and Cadmium Toxicity in Five Species of Aquatic Insects. Environ.Res. 9(3):285-289.	15828	AF, UEndp, Con	
Conto Cinier, C., M. Petit-Remel, R. Faure, and D. Garin. 1997. Cadmium Bioaccumulation in Carp (Cyprinus carpio) Tissues During Long-Term High Exposure: Analysis by Inductively Coupled Plasma-Mass Spectrometry. Ecotoxicol.Environ.Saf. 38(2):137-143.	18626	AF, UEndp	
Conway, H.L.. 1978. Sorption of Arsenic and Cadmium and Their Effects on Growth, Micronutrient Utilization, and Photosynthetic Pigment Composition of Asterionella formosa. J.Fish.Res.Board Can. 35(3):286-294.	15712	Plant, AF, UEndp	
Cosson, R.P.. 1994. Heavy Metal Intracellular Balance and Relationship with Metallothionein Induction in the Liver of Carp After Contamination by Silver, Cadmium and. Biometals 7(1):9-19.	4994	UEndp	
Couillard, Y., P. Ross, and B. Pinel-Alloul. 1989. Acute Toxicity of Six Metals to the Rotifer Brachionus calyciflorus, With Comparisons to Other Freshwater Organisms. Toxic.Assess. 4(4):451-462.	3091	Dur	
Craig, A., L. Hare, P.M. Charest, and A. Tessier. 1998. Effect of Exposure Regime on the Internal Distribution of Cadmium in Chironomus staegeri Larvae (Insecta, Diptera). Aquat.Toxicol. 41(3):265-275.	10733	AF, UEndp	
Cravedi, J.P., C. Gillet, and G. Monod. 1995. In Vivo Metabolism of Pentachlorophenol and Aniline in Arctic Charr (Salvelinus alpinus L.) Larvae. Bull.Environ.Contam.Toxicol. 54(5):711-716.	17842	AF, UEndp	
Dalal, R., and S. Bhattacharya. 1994. Effect of Cadmium, Mercury, and Zinc on the Hepatic Microsomal Enzymes of Channa punctatus. Bull.Environ.Contam.Toxicol. 52(6):893-897.	13692	AF	

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Daoust, P.Y.. 1981. Acute Pathological Effects of Mercury, Cadmium and Copper in Rainbow Trout. Ph.D.Thesis, Saskatoon, Saskatchewa n:331.	6116	Flow-through unmeasured test	Flow-through measured data exist for test species; O. mykiss
Das, B.K., and A. Kaviraj. 1990. Accumulation of Cadmium in Heteropneustes fossilis and Changes in Haematological Parameters. J.Nat.Conserv. 2(1):25-30.	8963	AF, UEndp	
Das, K.K., and S.K. Banerjee. 1980. Cadmium Toxicity in Fishes. Hydrobiologia 75(2):117-122.	2595	AF, Con	
Das, R.C.. 1988. Cadmium Toxicity to Gonads in a Freshwater Fish, Labeo bata (Hamilton). Arch.Hydrobiol. 112(3):467-474.	13068	AF, UEndp	
Datta, D.K., and G.M. Sinha. 1987. Estimation of Acute Toxicity of Cadmium, a Heavy Metal, in a Carnivorous Freshwater Teleost, Mystus vittatus (Bloch). C.A.Sel.-Environ.Pollut.2:108-17431N (1988) / Proc.Indian Natl.Sci.Acad.Part B 53(1):43-45.	5307	AF, Dur, Con	
Datta, D.K., and G.M. Sinha. 1988. Response Induced on the Mucous Cells of the Digestive Tract of a Carnivorous Indian Freshwater Teleost, Mystus vittatus (Bloch) Due to Long-Term. Bol.Fisiol.Anim.(Sao Paulo) 12:47-55.	5457	AF, UEndp, Eff	
Dave, G., K. Andersson, R. Berglind, and B. Hasselrot. 1981. Toxicity of Eight Solvent Extraction Chemicals and of Cadmium to Water Fleas, Daphnia magna, Rainbow Trout, Salmo gairdneri, and Zebrafish,. Comp.Biochem.Physiol.C 69(1):83-98.	2195	Dur, Con	
Davies, R.W., R.N. Singhal, and D.D. Wicklum. 1995. Changes in Reproductive Potential of the Leech Nephelopsis obscura (Erpobdellidae) as Biomarkers for Cadmium Stress. Can.J.Zool. 73(12):2192-2196.	19924	AF, UEndp, Dur	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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De March, B.G.E.. 1988. Acute Toxicity of Binary Mixtures of Five Cations (Cu2+, Cd2+, Zn2+, Mg2+, and K+) to the Freshwater Amphipod Gammarus lacustris (Sars): Alternative. Can.J.Fish.Aquat.Sci. 45(4):625-633.	13058	AF	
De Zwart, D., and W. Slooff. 1987. Toxicity of Mixtures of Heavy Metals and Petrochemicals to Xenopus laevis. Bull.Environ.Contam.Toxicol. 38:345-351.	12152	AF, Dur, Con	
Debelak, R.W.. 1975. Acute Toxicity of Mixtures of Copper, Chromium and Cadmium to Daphnia magna. M.S.Thesis, Miami University, Oxford, O H:54.	3528	Con	
Decoen, W.M., and C.R. Janssen. 1997. The Use of Biomarkers in Daphnia magna Toxicity Testing. II. Digestive Enzyme Activity in Daphnia magna Exposed to Sublethal Concentrations of. Chemosphere 35(5):1053-1067.	18286	AF, UEndp	
Deeds, J.R., and P.L. Klerks. 1999. Metallothionein-Like Proteins in the Freshwater Oligochaete Limnodrilus udekemianus and Their Role as a Homeostatic Mechanism Against Cadmium Toxicity. Environ.Pollut. 106(3):381-389.	20336	UEndp	
Del Ramo, J., A. Torreblanca, M. Martinez, A. Pastor, and J. Diaz-Mayans. 1995. Quantification of Cadmium-Induced Metallothionein in Crustaceans by the Silver-Saturation Method. Mar.Environ.Res. 39(1-4):121-125.	16911	AF	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Del Ramo, J., J. Diaz-Mayans, A. Torreblanca, and A. Nunez. 1987. Effects of Temperature on the Acute Toxicity of Heavy Metals (Cr, Cd, and Hg) to the Freshwater Crayfish, Procambarus clarkii (Girard). Bull.Environ.Contam.Toxicol. 38(5):736-741.	12565	See note	Not used in ALC document because animals acclimated or exhibited increased resistance to cadmium
Delgado, M., M. Bigeriego, and E. Guardiola. 1993. Uptake of Zn, Cr, and Cd by Water Hyacinths. Water Res. 27(2):269-272.	7114	Plant, AF, UEndp, Con	
Den Besten, P.J., E.G. Van Donselaar, H.J. Herwig, D.I. Zandee, and P.A. Voogt. 1991. Effects of Cadmium on Gametogenesis in the Sea Star Asterias rubens L. Aquat.Toxicol. 20:83-94.	5251	AF, UEndp, Dur	
Den Besten, P.J., H.J. Herwig, D.I. Zandee, and P.A. Voogt. 1989. Effects of Cadmium and PCBs on Reproduction of the Sea Star Asterias rubens: Aberrations in the Early Development. Ecotoxicol.Environ.Saf. 18(2)(2):173-180.	2395	AF, UEndp	
Devi, M., D.A. Thomas, J.T. Barber, and M. Fingerman. 1996. Accumulation and Physiological and Biochemical Effects of Cadmium in a Simple Aquatic Food Chain. Ecotoxicol.Environ.Saf. 33:38-43.	16846	UEndp	
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Diaz-Mayans, J., A. Torreblanca, J. Del Ramo, and A. Nunez. 1986. Oxygen Uptake by Excised Gills of Procambarus clarkii (Girard) From Albufera Lake of Valencia, Spain, Under Heavy Metal Treatments. Bull.Environ.Contam.Toxicol. 36(6):912-917.	11790	AF, UEndp, Con	
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Gerhardt, A.. 1992. Acute Toxicity of Cd in Stream Invertebrates in Relation to pH and Test Design. Hydrobiologia 239(2):93-100.	6054	AF, Con	
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Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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Goettl, J.P.J., and P.H. Davies. 1978. Water Pollution Studies. Job Progress Report, Federal Aid Project F-33-R-13, DNR, Boulder, C :46.	7341	UEndp	
Goettl, J.P.J., J.R. Sinley, and P.H. Davies. 1974. Water Pollution Studies. Job Progress Report, Federal Aid Project F-33-R-9, DNR, Boulder, CO :96 p..	285	Flow-through unmeasured test	Flow-through measured data exist for test species; O. mykiss
Goettl, J.P.Jr., P.H. Davies, and J.R. Sinley. 1976. Water Pollution Studies. In: D.B.Cope (Ed.), Colorado Fish.Res.Rev.1972-1975, DOW-R-R-F72-75, Colorado Div.of Wildl., Boulder, CO :68-75.	14367	UEndp	
Gomot, A.. 1998. Toxic Effects of Cadmium on Reproduction, Development, and Hatching in the Freshwater Snail Lymnaea stagnalis for Water Quality Monitoring. Ecotoxicol.Environ.Saf. 41(3):288-297.	20053	AF, UEndp, Eff	
Gossiaux, D.C., P.F. Landrum, and V.N. Tsymbal. 1992. Response of the Amphipod Diporeia spp. to Various Stressors: Cadmium, Salinity, and Temperature. J.Gt.Lakes Res. 18(3):364-371.	9649	AF, Dur, Con	
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Graney, R.L.J., D.S. Cherry, and J. Cairns Jr.. 1983. Heavy Metal Indicator Potential of the Asiatic Clam (Corbicula fluminea) in Artificial Stream Systems. Hydrobiologia 102(2):81-88.	10815	UEndp, Field	

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Grebe, E., and D.J. Schaeffer. 1991. Neurobehavioral Toxicity of Cadmium Sulfate to the Planarian Dugesia dorotocephala. Bull.Environ.Contam.Toxicol. 46:727-730.	3623	AF, UEndp, Dur, Con	
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Griffiths, P.R.E.. 1980. Morphological and Ultrastructural Effects of Sublethal Cadmium Poisoning on Daphnia. Environ.Res. 22(2):277-284.	5280	AF, UEndp, Eff, Dur	
Groenendijk, D., B. Van Opzeeland, L.M. Dionisio Pires, and J.F. Postma. 1999. Fluctuating Life-History Parameters Indicating Temporal Variability in Metal Adaptation in Riverine Chironomids. Arch.Environ.Contam.Toxicol. 37(2):175-181.	20448	AF, UEndp	
Guilhermino, L., O. Sobral, C. Chastinet, R. Ribeiro, F. Goncalves, M.C. Silva, and A.M.V.M. Soares. 1999. A Daphnia magna First-Brood Chronic Test: An Alternative to the Conventional 21-Day Chronic Bioassay?. Ecotoxicol.Environ.Saf. 42(1):67-74.	20061	UEndp	
Guilhermino, L., T.C. Diamantino, R. Ribeiro, F. Goncalves, and A.M.V.M. Soares. 1997. Suitability of Test Media Containing EDTA for the Evaluation of Acute Metal Toxicity to Daphnia magna Straus. Ecotoxicol.Environ.Saf. 38(3):292-295.	18978	AF, Eff, Dur	
Gulati, R.D., C.W.M. Bodar, A.L.G. Schuurmans, J.A.J. Faber, and D.I. Zandee. 1988. Effects of Cadmium Exposure on Feeding of Freshwater Planktonic Crustaceans. Comp.Biochem.Physiol.C 90(2):335-340.	5507	AF, UEndp, Eff, Dur	
Gupta, A.K.. 1988. Accumulation of Cadmium in the Fishes Heteropneustes fossilis and Channa punctatus. Environ.Ecol. 6(3):577-580.	802	AF, Con	

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Gupta, A.K., and V.K. Rajbanshi. 1988. Acute Toxicity of Cadmium to Channa punctatus (Bloch). Acta Hydrochim.Hydrobiol. 16(5):525-535.	3448	Dur, Con	
Gupta, A.K., and V.K. Rajbanshi. 1991. Toxicity of Copper and Cadmium to Heteropneustes fossilis (Bloch). Acta Hydrochim.Hydrobiol. 19(3):331-340.	3728	UEndp, Con	
Gupta, M., and S. Devi. 1992. Cadmium Sensitivity Inducing Structural Responses in Salvinia molesta Mitchell. Bull.Environ.Contam.Toxicol. 49(3):436-443.	5758	Plant, AF, UEndp, Dur	
Gupta, M., S. Devi, and J. Singh. 1992. Effects of Long-Term Low-Dose Exposure to Cadmium During the Entire Life Cycle of Ceratopteris thalictroides, a Water Fern. Arch.Environ.Contam.Toxicol. 23(2):184-189.	6366	Plant, AF, UEndp	
Gupta, P., S.S. Chaurasia, A. Kar, and P.K. Maiti. 1997. Influence of Cadmium on Thyroid Hormone Concentrations and Lipid Peroxidation in a Fresh Water Fish, Clarias batrachus. Fresenius Environ.Bull. 6(7/8):355-358.	59876	AF, UEndp, Eff	
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Hale, J.G.. 1977. Toxicity of Metal Mining Wastes. Bull.Environ.Contam.Toxicol. 17(1):66-73.	861	AF	

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Hameed, P.S., and A.I.M. Raj. 1989. Effects of Copper, Cadmium and Mercury on Crystalline Style of the Freshwater Mussel Lamellidens marginalis (Lamarck). Indian J.Environ.Health 31(2):131-136.	3311	AF, UEndp, Eff, Dur, Con	
Hamilton, S.J., P.M. Mehrle, and J.R. Jones. 1987. Evaluation of Metallothionein Measurement As a Biological Indicator of Stress From Cadmium in Brook Trout. Trans.Am.Fish.Soc.116(4):551-560; Diss.Abstr.Int.B Sci.Eng.46(11):DA8529659 (1986); Abstr.Pap.Am.Chem.Soc.194:289.	12776	UEndp	
Hamilton, S.J., P.M. Mehrle, and J.R. Jones. 1987. Cadmium-Saturation Technique for Measuring Metallothionein in Brook Trout. Trans.Am.Fish.Soc. 116(4):541-550.	12779	UEndp	
Handy, R.D.. 1992. The Assessment of Episodic Metal Pollution. II. The Effects of Cadmium and Copper Enriched Diets on Tissue Contaminant Analysis in Rainbow Trout (Oncorhynchus mykiss) After Short Waterborne Exposure to Cadmium or Copper. Arch.Environ.Contam.Toxicol. 22:82-87.	5001	AF, UEndp, Eff	
Handy, R.D.. 1992. The Assessment of Episodic Metal Pollution. I. Uses and Limitations of Tissue Contaminant Analysis in Rainbow Trout (Oncorhynchus mykiss) After Short Waterborne Exposure to Cadmium or Copper. Arch.Environ.Contam.Toxicol. 22:74-81.	5019	AF, UEndp, Dur	

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Handy, R.D.. 1993. The Effect of Acute Exposure to Dietary Cd and Cu on Organ Toxicant Concentrations in Rainbow Trout, Oncorhynchus mykiss. Aquat.Toxicol. 27(1/2):1-14.	8200	AF, UEndp, Dur	
Hansen, L.G., W.M. Tehseen, G.L. Foley, and D.J. Schaeffer. 1993. Modification by Polychlorinated Biphenyls (PCBs) of Cadmium Induced Lesions in the Planarian Model, Dugesia dorotocephala. Biomed.Environ.Sci. 6(4):367-384.	4108	AF, UEndp, Eff	
Hardy, J.K., and D.H. O'Keeffe. 1985. Cadmium Uptake by the Water Hyacinth: Effects of Root Mass, Solution Volume, Complexers and Other Metal Ions. Chemosphere 14(5):417-426.	10949	Plant, AF, UEndp, Dur, Con	
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Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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Lalande, M., and B. Pinel-Alloul. 1986. Acute Toxicity of Cadmium, Copper, Mercury and Zinc to Tropocyclops Prasinus mexicanus (Cyclopoida, Copepoda) From Three Quebec Lakes. Environ.Toxicol.Chem. 5(1):95-102.	12292	AF, Eff, Dur, Con	

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Lam, P.K.S., K.N. Yu, K.P. Ng, and M.W.K. Chong. 1997. Cadmium Uptake and Depuration in the Soft Tissues of Brotia hainanensis (Gastropoda: Prosobranchia: Thiaridae): A Dynamic Model. Chemosphere 35(11):2449-2461.	18638	AF, UEndp	
Langevoord, M., M.H.S. Kraak, M.H. Kraal, and C. Davids. 1995. Importance of Prey Choice for Cd Uptake by Carp (Cyprinus carpio) Fingerlings. J.N.Am.Benthol.Soc. 14(3):423-429.	14891	AF, UEndp, RouExp	
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Pascoe, D., S.A. Evans, and J. Woodworth. 1986. Heavy Metal Toxicity to Fish and the Influence of Water Hardness. Arch.Environ.Contam.Toxicol. 15(5):481-487.	11987	Dur	
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Pelgrom, S.M.G.J., L.P.M. Lamers, R.A.C. Lock, P.H.M. Balm, and S.E. Wendelaar Bonga. 1995. Interactions Between Copper and Cadmium Modify Metal Organ Distribution in Mature Tilapia, Oreochromis mossambicus. Environ.Pollut. 90(3):415-423.	16383	AF, UEndp	
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Radhakrishnaiah, K.. 1988. Effect of Cadmium on the Freshwater Mussel, Lamellidens marginalis (Lamarck) - A Physiological Approach. J.Environ.Biol.9(1 Suppl .):73-78.	12903	AF, UEndp, Eff, Dur	
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Rai, U.N., R.D. Tripathi, S. Sinha, and P. Chandra. 1995. Chromium and Cadmium Bioaccumulation and Toxicity in Hydrilla verticillata (l.f.) Royle and Chara corallina Wildenow. J.Environ.Sci.Health 30 A(3):537-551.	19941	Plant, AF, UEndp	
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Ramesha, A.M., T.R.C. Gupta, C. Lingdhal, K.V.B. Kumar, G. Gowda, and K.S. Udupa. 1997. Combined Toxicity of Mercury and Cadmium to the Common Carp Cyprinus carpio (Linn.). Environ.Ecol. 15(1):194-198.	18079	AF, Dur	
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Ravera, O.. 1977. Effects of Heavy Metals (Cadmium, Copper, Chromium and Lead) on a Freshwater Snail: Biomphalaria glabrata Say (Gastropoda, Prosobranchia). Malacologia 16(1):231-236.	15474	UEndp	
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Rishi, K.K., and M. Jain. 1998. Effect of Toxicity of Cadmium on Scale Morphology in Cyprinus carpio (Cyprinidae). Bull.Environ.Contam.Toxicol. 60:323-328.	18906	AF, UEndp, Eff	
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Ruparelia, S.G., Y. Verma, S.R. Saiyed, and U.M. Rawal. 1990. Effect of Cadmium on Blood of Tilapia, Oreochromis mossambicus (Peters), During Prolonged Exposure. Bull.Environ.Contam.Toxicol. 45(2):305-312.	3331	UEndp	

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Saksena, D.N.. 1986. Effect of Cadmium Chloride on the Ovarian Activity in Fresh Water Catfish Clarias batrachus (Linn.). Uttar Pradesh J.Zool. 6(1):108-114.	3257	AF, UEndp, Eff	
Salanki, J., and L. Hiripi. 1990. Effect of Heavy Metals on the Serotonin and Dopamine Systems in the Central Nervous System of the Freshwater Mussel (Anodonta cygnea L.). Comp.Biochem.Physiol.C 95(2):301-305.	3456	AF, UEndp, Eff, Dur, Con	
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Sandau, E., P. Sandau, and O. Pulz. 1996. Heavy Metal Sorption by Microalgae. Acta Biotechnol. 16(4):227-235.	45105	Plant, AF, UEndp, Dur	
Sangalang, G.B., and H.C. Freeman. 1979. Tissue Uptake of Cadmium in Brook Trout During Chronic Sublethal Exposure. Arch.Environ.Contam.Toxicol. 8(1):77-84 (Used 8701 for Reference).	7566	UEndp	
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Sangalang, G.B., and M.J. O'Halloran. 1973. Adverse Effects of Cadmium on Brook Trout Testis and on In Vitro Testicular Androgen Synthesis. Biol.Reprod. 9(4):394-403.	8968	UEndp, Eff, Con	
Sankaraperumal, G., M.K. Rajan, and A. Mohandoss. 1990. Synergistic Effect of Cadmium and Zinc on the Erythrocytes and Opercular Activity of the Fishes Lepidocephalichthyes thermalis and Amblypharyngodon. Environ.Ecol. 8(4):1213-1216.	5853	AF, UEndp, Eff	

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Santojanni, A., G. Gorbi, and F. Sartore. 1995. Prediction of Mortality in Chronic Toxicity Tests on Daphnia magna. Water Res. 29(6):1453-1459.	15015	AF, UEndp	
Santojanni, A., G. Gorbi, and F. Sartore. 1998. Prediction of Fecundity in Chronic Toxicity Tests on Daphnia magna. Water Res. 32(10):3146-3156.	19658	AF, UEndp	
Sarkar, A., and S. Jana. 1986. Heavy Metal Pollutant Tolerance of Azolla pinnata. Water Air Soil Pollut. 27:15-18.	12367	Plant, AF, UEndp	
Sarma, S.S.S., T. Ramirez Perez, and S. Nandini. 2000. Comparison of the Sensitivitiy of Branchionus calyciflorus and Branchionus patulus (Rotifera) to Selected Heavy Metals Under Low and High Food (Chlorella vulgaris) Levels. Bull.Environ.Contam.Toxicol. 64(5):735-739.	53883	AF, Dur	
Sastry, K.V., and S. Subhadra. 1984. Effect of Cadmium and Zinc on Intestinal Absorption of Xylose and Tryptophan in the Fresh Water Teleost Fish, Heteropneustes fossilis. Chemosphere 13(8):889-898.	10483	AF, UEndp, Eff	
Sastry, K.V., and V. Shukla. 1993. Uptake and Distribution of Cadmium in Tissues of Channa punctatus. J.Environ.Biol. 14(2):137-142.	9225	UEndp	
Sastry, K.V., and V. Shukla. 1994. Influence of Protective Agents in the Toxicity of Cadmium to a Freshwater Fish (Channa punctatus). Bull.Environ.Contam.Toxicol. 53(5):711-717.	13746	UEndp, Eff	
Sathya, K.S., and K.P. Balakrishnan. 1988. Physiology of Phytoplankton in Relation to Metal Concentration. Water Air Soil Pollut. 38(3-4):283-297.	12966	Plant, AF, UEndp	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Sauser, K.R., J.K. Liu, and T.Y. Wong. 1997. Identification of a Copper-Sensitive Ascorbate Peroxidase in the Unicellular Green Alga Selenastrum capricornutum. Biometals 10(3):163-168.	19840	Plant, AF, UEndp	
Sauvant, M.P., D. Pepin, C.A. Groliere, and J. Bohatier. 1995. Effects of Organic and Inorganic Substances on the Cell Proliferation of L-929 Fibroblasts and Tetrahymena pyriformis GL Protozoa Used for Toxicological Bioassays. Bull.Environ.Contam.Toxicol. 55(2):171-178.	14980	Ace, AF, Dur	
Sauvant, M.P., D. Pepin, J. Bohatier, and C.A. Groliere. 1995. Microplate Technique for Screening and Assessing Cytotoxicity of Xenobiotics with Tetrahymena pyriformis. Ecotoxicol.Environ.Saf. 32(2):159-165.	16142	Ace, AF, Dur	
Saxena, A.B., D.S. Rao, and Z.U. Khan. 1982. Studies on the Acute Toxicities of Copper, Mercury, and Cadmium to Danio malabaricus and Puntius ticto. J.Environ.Sci.Health A17(5):657-665.	10570	Con	
Saxena, K.K., A.K. Dubey, and R.R.S. Chauhan. 1993. Experimental Studies on Toxicity of Zinc and Cadmium to Heteropneustes fossilis (Bl.). J.Freshw.Biol. 5(4):343-346.	16939	NonRes	
Saxena, M.P., K. Gopal, W. Jones, and P.K. Ray. 1992. Immune Responses to Aeromonas hydrophila in Catfish (Heteropneustis fossilis) Exposed to Cadmium and Hexachlorocyclohexane. Bull.Environ.Contam.Toxicol. 48(2):194-201.	5078	UEndp	
Saxena, O.P., and A. Parashari. 1983. Comparative Study of the Toxicity of Six Heavy Metals to Channa punctatus. J.Environ.Biol. 4(2):91-94.	10762	Dur, NonRes	

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Schafer, H., H. Hettler, U. Fritsche, G. Pitzen, G. Roderer, and A. Wenzel. 1994. Biotests Using Unicellular Algae and Ciliates for Predicting Long-Term Effects of Toxicants. Ecotoxicol.Environ.Saf. 27(1):64-81.	4008	Ace, AF	
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Schuytema, G.S., P.O. Nelson, K.W. Malueg, A.V. Nebeker, D.F. Krawczyk, and A.K. Ratcliff. 1984. Toxicity of Cadmium in Water and Sediment Slurries to Daphnia magna. Environ.Toxicol.Chem. 3(2):293-308.	10929	Tests included sediment	Possible 48 h LC50s available from study, but article requires review for acceptability; a large amountof other acceptable data exist for the species.
Schweiger, G.. 1957. The Toxic Action of Heavy Metals Salts on Fish and Organisms on Which Fish Feed. Arch.Fischereiwiss. 8:54-78.	725	AF, UEndp, Con	
See, C.L.. 1976. The Effect of Sublethal Concentrations of Selected Toxicants on the Negative Phototactic Response of Dugesia tigrina. Ph.D.Thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA :79.	6154	Con	
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Sehgal, R., and A.K. Pandey. 1984. Effect of Cadmium Chloride on Testicular Activities in Guppy Lebistes reticulatus. Comp.Physiol.Ecol. 9(3):225-230.	11166	AF, UEndp, Eff	
Sehgal, R., V. Tomar, and A.K. Pandey. 1984. Comparative Effects of Two Heavy Metallic Salts on the Testis of Viviparous Teleost, Lebistes reticulatus (Peters). J.Environ.Biol. 5(3):185-192.	11017	AF, UEndp, Eff	
Seidman, L.A.. 1983. Bioaccumulation and Toxicity of Cadmium in Aquatic Invertebrates. Ph.D.Thesis, University of Wisconsin, Milwaukee, W I:118.	12456	AF, UEndp, Con	
Seidman, L.A., G. Bergtrom, D.J. Gingrich, and C.C. Remsen. 1986. Accumulation of Cadmium by the Fourth Instar Larva of the Fly Chironomus thummi. Tissue & Cell 18(3):395-405.	12149	AF, UEndp, Con	
Selby, D.A., J.M. Ihnat, and J.J. Messer. 1985. Effects of Subacute Cadmium Exposure on a Hardwater Mountain Stream Microcosm. Water Res. 19(5):645-655.	10852	NoOrg, AF, UEndp	
Sharma, A., and M.S. Sharma. 1993. Vertebral Defects in Lebistes reticulatus (Peters) and Cyprinus carpio (Linnaeus) Exposed to Heavy Metals. Pollut.Res. 12(3):139-143.	14417	AF, UEndp	
Sharp, J.R., and J.L. Kaszubski. 1988. The Influence of Exposure Duration on the Embryotoxicity of Cadmium to the Freshwater Teleost, Etheostoma spectabile. In: D.D.Hemphill (Ed.), Trace Substances in Environ.Health, Univ.of Missouri, Annu.Conf.St.Louis, MO 22:277-289.	4144	Dur	
Shazili, N.A.M., and D. Pascoe. 1986. Variable Sensitivity of Rainbow Trout (Salmo gairdneri) Eggs and Alevins to Heavy Metals. Bull.Environ.Contam.Toxicol. 36(3):468-474.	11738	Dur, Con	

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Shcherban, E.P. 1977. Toxicity of Some Heavy Metals for Daphnia magna Strauss, As a Function of Temperature. Hydrobiol J.13(4):75-80 / Gidrobiol.Zh. 13(4):86-91 (RUS).	5924	AF, UEndp, Dur, Con	
Shedd, T.R., M.W. Widder, M.W. Toussaint, M.C. Sunkel, and E. Hull. 1999. Evaluation of the Annual Killifish Nothobranchius guentheri as a Tool for Rapid Acute Toxicity Screening. Environ.Toxicol.Chem. 18(10):2258-2261.	20487	Dur	
Sherman, R.E., S.P. Gloss, and L.W. Lion. 1987. A Comparison of Toxicity Tests Conducted in the Laboratory and in Experimental Ponds Using Cadmium and the Fathead Minnow (Pimephales promelas). Water Res. 21(3):317-323.	12647	Six 96 h LC50s from approx. 6,900 to 15,200 ug/L dissolved cadmium normalized to 100 mg/L as CaCO3 hardness. Tests were static, measured.	This study appears to provide appropriate 96 h LC50s for P. promelas, but the paper should be secured to ensure acceptability. Species is relatively insensitive to acute cadmium exposure
Shivaraj, K.M., and H.S. Patil. 1988. Toxicity of Cadmium and Copper to a Freshwater Fish Puntius arulius. Environ.Ecol. 6(1):5-8.	13240	Dur, Con	
Shivaraj, K.M., B.B. Hosetti, and H.S. Patil. 1989. Oxygen Consumption in Puntius arulius Following Exposure to Sublethal Levels of Cadmium and Copper. Environ.Ecol. 7(2):298-301.	2625	AF, UEndp, Eff	
Shrivastava, A., and A.K. Pandey. 1986. Effect of CdCl2 on Kidney in Puntius sophore - a Fresh Water Fish. Comp.Physiol.Ecol.11(4):203-207 / C.A.Sel.-Environ.Pollut.11:106-170538F(1987) / Indian J.Zool. 14(1):37-42.	12743	AF, UEndp, Eff	
Shukla, J.P., and K. Pandey. 1988. Toxicity and Long Term Effects of a Sublethal Concentration of Cadmium on the Growth of the Fingerlings of Ophiocephalus punctatus (Bl.). Acta Hydrochim.Hydrobiol. 16(5):537-540.	13173	AF, UEndp	
Sildanchandra, W., and M. Crane. 2000. Influence of Sexual Dimorphism in Chironomus riparius Meigen on Toxic Effects of Cadmium. Environ.Toxicol.Chem. 19(9):2309-2313.	56638	AF, UEndp, Eff	

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Silverman, H., J.W. Mcneil, and T.H. Dietz. 1987. Interaction of Trace Metals Zn, Cd, and Mn, with Ca Concretions in the Gills of Freshwater Unionid Mussels. Can.J.Zool. 65:828-832.	12688	AF, UEndp	
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Singh, J., P.N. Viswanathan, M. Gupta, and S. Devi. 1993. Uptake and Translocation of Cd109 by Two Aquatic Ferns in Relation to Relative Toxic Response. Bull.Environ.Contam.Toxicol. 51(6):914-919.	8119	Plant, AF, UEndp	
Singh, J., S. Devi, G. Chawla, M. Gupta, and P.N. Viswanathan. 1991. Ultrastructural and Biochemical Effects of Cadmium on the Aquatic Fern Marsilea minuta Linn. Ecotoxicol.Environ.Saf. 21(2):171-181.	384	Plant, AF	
Singhal, R.N., and M. Jain. 1997. Cadmium-Induced Changes in the Histology of Kidneys in Common Carp, Cyprinus carpio (Cyprinidae). Bull.Environ.Contam.Toxicol. 58(3):456-462.	17892	AF, UEndp, Eff	
Sinha, G.M.. 1999. Cadmium Intoxication and the Effects of Chelating Agents on the Gonadal Maturation of the Fish Heteropneustes fossilis (Bloch). Environ.Ecol. 17(1):191-198.	20000	AF, UEndp, Eff	
Sinha, G.M., A.B. Kesh, K. Sengupta, and A.K. Das. 1992. Studies on the Cadmium Intoxication and the Action of Antagonists on the Intestine of an Indian Air-Breathing Fish, Anabas testudineus (Bloch). J.Freshw.Biol. 4(4):273-281.	13586	AF, UEndp, Eff	
Siriwardena, P.P.G.S., K.J. Rana, and D.J. Baird. 1995. A Method for Partitioning Cadmium Bioaccumulated in Small Aquatic Organisms. Environ.Toxicol.Chem. 14(9):1575-1577.	15038	UEndp, Dur	

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Skowronski, T., S. Szubinska, B. Pawlik, M. Jakubowski, R. Bilewicz, and E. Cukrowska. 1991. The Influence of pH on Cadmium Toxicity to the Gree Alga Stichococcus bacillaris and on the Cadmium Forms Present in the Culture Medium. Environ.Pollut. 74:89-100.	3940	Plant, AF, UEndp	
Slabbert, J.L., and W.S.G. Morgan. 1982. A Bioassay Technique Using Tetrahymena pyriformis for the Rapid Assessment of Toxicants in Water. Water Res. 16(5):517-523.	11048	Ace, AF, UEndp, Dur	
Sloof, J.E., A. Viragh, and B. Van der Veer. 1995. Kinetics of Cadmium Uptake by Green Algae. Water Air Soil Pollut. 83(1/2):105-122.	16368	Plant, AF, UEndp, Dur	
Slooff, W. 1978. Biological Monitoring Based on Fish Respiration for Continuous Water Quality Control. In: O.Hutzinger, I.H.Van Lelyveld and B.C.Zoeteman (Eds.), Aquatic Pollutants: Transformation and Biological Effects, Pergamon Press, NY :501-506.	17278	UEndp, Eff, Dur	
Slooff, W. 1979. Detection Limits of a Biological Monitoring System Based on Fish Respiration. Bull.Environ.Contam.Toxicol. 23(4-5):517-523.	5938	Dur, Con	
Slooff, W. 1983. Benthic Macroinvertebrates and Water Quality Assessment: Some Toxicological Considerations. Aquat.Toxicol. 4:73-82.	15788	NoOrg, AF, Dur, Con	
Slooff, W., and R. Baerselman. 1980. Comparison of the Usefulness of the Mexican Axolotl (Ambystoma mexicanum) and the Clawed Toad (Xenopus laevis) in Toxicological Bioassays. Bull.Environ.Contam.Toxicol. 24(3):439-443.	9740	AF, Dur, Con	
Smith, B.P., E. Hejtmancik, and B.J. Camp. 1976. Acute Effects of Cadmium on Ictalurus punctatus (Catfish). Bull.Environ.Contam.Toxicol. 15(3):271-277.	8325	AF, UEndp, Con	

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Smith, S., K.H.M. Kwan, and S. Mannings. 1992. Bioavailability and Accumulated Forms of Trace Metals in Plants. In: E.Merian and W.Haerdi (Eds.), Metal Compounds in Environment and Life, Chapter 4, Science and Technology Letters, Northwood, UK :127-135.	18142	Plant, AF, UEndp	
Snell, T.W., and G. Persoone. 1989. Acute Toxicity Bioassays Using Rotifers. II. A Freshwater Test with Brachionus rubens. Aquat.Toxicol. 14(1):81-92.	310	UEndp, Dur	
Snell, T.W., and M.J. Carmona. 1995. Comparative Toxicant Sensitivity of Sexual and Asexual Reproduction in the Rotifer Brachionus calyciflorus. Environ.Toxicol.Chem. 14(3):415-420.	14212	UEndp, Dur	
Snell, T.W., B.D. Moffat, C. Janssen, and G. Persoone. 1991. Acute Toxicity Tests Using Rotifers IV. Effects of Cyst Age, Temperature, and Salinity on the Sensitivity of Barachionus calyciflorus. Ecotoxicol.Environ.Saf. 21(3):308-317 (OECDG Data File).	9385	AF, Dur	
Solbe, J.F.D., and V.A. Flook. 1975. Studies on the Toxicity of Zinc Sulphate and of Cadmium Sulphate to Stone Loach Noemacheilus barbatulus (L.) in Hard Water. J.Fish Biol. 7(5):631-637.	15989	NonRes	
Sosak-Swiderska, B., and D. Tyrawska. 1994. Cadmium Accumulation Ability of Chlorella vulgaris Beij. 1890, Strain A-8. Pol.Arch.Hydrobiol. 41(1):149-159.	18721	Plant, AF, UEndp	
Spehar, R.L., E.N. Leonard, and D.L. De Foe. 1978. Chronic Effects of Cadmium and Zinc Mixtures on Flagfish (Jordanella floridae). Trans.Am.Fish.Soc. 107(2):354-360.	15954	UEndp	
Spehar, R.L., R.L. Anderson, and J.T. Fiandt. 1978. Toxicity and Bioaccumulation of Cadmium and Lead in Aquatic Invertebrates. Environ.Pollut. 15(3):195-208.	2104	Eff, Con	

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Srivastava, A., and V.S. Jaiswal. 1989. Biochemical Changes in Duck Weed After Cadmium Treatment. Enhancement in Senescence. Water Air Soil Pollut. 50(1/2):163-170.	3264	Plant, AF, UEndp, Eff	
Srivastava, A., and V.S. Jaiswal. 1989. Effect of Cadmium on Turion Formation and Germination of Spirodela polyrrhiza L. J.Plant Physiol. 134(3):385-387.	17764	Plant, AF, UEndp	
Stackhouse, R.A., and W.H. Benson. 1989. Interaction of Humic Acid with Selected Trace Metals: Influence on Bioaccumulation in Daphnids. Environ.Toxicol.Chem. 8(7):639-644.	3556	AF, UEndp	
Stallwitz, E., and D.P. Hader. 1993. Motility and Phototatic Orientation of the Flagellate Euglena gracilis Impaired by Heavy Metal Ions. J.Photochem.Photobiol. B:Biol-74.	7299	AF, UEndp, Con	
Stary, J., and K. Kratzer. 1982. The Cumulation of Toxic Metals on Alga. J.Environ.Anal.Chem. 12:65-71.	14286	Plant, AF, UEndp	
Stary, J., B. Havlik, K. Kratzer, J. Prasilova, and J. Hanusova. 1983. Cumulation of Zinc, Cadmium and Mercury on the Alga Scenedesmus obliquus. Acta Hydrochim.Hydrobiol. 11(4):401-409.	14088	Plant, AF, UEndp	
Stary, J., K. Kratzer, B. Havlik, J. Prasilova, and J. Hanusova. 1982. The Cumulation of Zinc and Cadmium in Fish (Poecilia reticulata). Int.J.Environ.Anal.Chem. 11:117-120.	16091	AF, UEndp, RouExp	
Stauber, J.L., and T.M. Florence. 1987. Mechanism of Toxicity of Ionic Copper and Copper Complexes to Algae. Mar.Biol. 94(4):511-519.	12971	UEndp	
Stephenson, M., and G.L. Mackie. 1989. A Laboratory Study of the Effects of Waterborne Cadmium, Calcium, and Carbonate Concentrations on Cadmium Concentrations in Hyalella azteca (Crustacea: Amphipoda). Aquat.Toxicol. 15(1):53-62.	776	AF, UEndp	

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Stratton, G.W., and C.T. Corke. 1979. The Effect of Mercuric, Cadmium, and Nickel Ion Combinations on a Blue-Green Alga. Chemosphere 8(10):731-740.	15822	Plant, AF, UEndp	
Streit, B., and S. Winter. 1993. Cadmium Uptake and Compartmental Time Characteristics in the Freshwater Mussel Anodonta anatina. Chemosphere 26(8):1479-1490.	7031	UEndp, Con	
Stromberg, P.C., J.G. Ferrante, and S. Carter. 1983. Pathology of Lethal and Sublethal Exposure of Fathead Minnows, Pimephales promelas, to Cadmium: A Model for Aquatic Toxicity Assessment. J.Toxicol.Environ.Health 11(2):247-259.	11172	AF, UEndp, Eff, Dur	
Stubblefield, W.A., B.L. Steadman, T.W. La Point, and H.L. Bergman. 1999. Acclimation-Induced Changes in the Toxicity of Zinc and Cadmium to Rainbow Trout. Environ.Toxicol.Chem. 18(12):2875-2881.	20727	Det	
Stuijfzand, S.C., M.J. Jonker, E. Van Ammelrooy, and W. Admiraal. 1999. Species-Specific Responses to Metals in Organically Enriched River Water, with Emphasis on Effects of Humic Acids. Environ.Pollut. 106(1):115-121.	20353	AF, UEndp	
Subramanian, V.V., V. Sivasubramanian, and K.P. Gowrinathan. 1994. Uptake and Recovery of Heavy Metals by Immobilized Cells of Aphanocapsa pulchra (Kutz.) Rabenh. J.Environ.Sci.Health A29(9):1723-1733.	18777	Plant, AF, UEndp, Dur	
Suedel, B.C., J.H. Rodgers Jr., and E. Deaver. 1997. Experimental Factors that may Affect Toxicity of Cadmium to Freshwater Organisms. Arch.Environ.Contam.Toxicol. 33(2):188-193.	18420	AF	No definitive water hardness provided
Sultana, R., V.U. Devi, and M.N. Prasad. 1991. Effect of Heavy Metals on the Respiration of the Catfish, Mystus gulio. J.Ecotoxicol.Environ.Monit. 1(3):234-237.	4421	AF, UEndp, Eff, Dur	

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Sumi, Y., T. Suzuki, M. Yamamura, S. Hatakeyama, Y. Sugaya, and K.T. Suzuki. 1984. Histochemical Staining of Cadmium Taken Up by the Midge Larva, Chironomus yoshimatsui (Diptera: Chironomidae). Comp.Biochem.Physiol.A 79(3):353-357.	11481	AF, UEndp, Dur	
Suzuki, K.. 1959. The Toxic Influence of Heavy Metal Salts upon Mosquito Larvae. Hokkaido Univ.J.Fac.Sci.Ser. 6(14):196-209.	2701	AF, UEndp, Eff	
Suzuki, K.T., H. Sunaga, E. Kobayashi, and S. Hatakeyama. 1987. Environmental and Injected Cadmium Are Sequestered by Two Major Isoforms of Basal Copper, Zinc-Metallothionein in Gibel (Carassius auratus. Comp.Biochem.Physiol.C 87(1):87-93.	12736	AF, UEndp, Eff, Con	
Swinehart, J.H.. 1990. The Effects of Humic Substances on the Interactions of Metal Ions wiht Organisms and Liposomes. Final Tech.Rep., Dep.of Chem., Univ.California, Davis, CA :103.	17696	AF, UEndp, Dur	
Takamura, N., F. Kasai, and M.M. Watanabe. 1989. Effects of Cu, Cd and Zn on Photosynthesis of Freshwater Benthic Algae. J.Appl.Phycol. 1(1):39-52.	3095	Plant, AF, UEndp, Dur, Con	
Tarzwell, C.M., and C. Henderson. 1960. Toxicity of Less Common Metals to Fishes. Ind.Wastes 5:12.	2042	Con	
Tatara, C.P., M.C. Newman, J.T. McCloskey, and P.L. Williams. 1997. Predicting Relative Metal Toxicity with Ion Characteristics: Caenorhabditis elegans LC50. Aquat.Toxicol. 39(3/4):279-290.	18605	AF, Dur	
Tatara, C.P., M.C. Newman, J.T. McCloskey, and P.L. Williams. 1998. Use of Ion Characteristics to Predict Relative Toxicity of Mono-, Di- and Trivalent Metal Ions: Caenorhabditis elegans. Aquat.Toxicol. 42:255-269.	5072	AF, Dur	

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Taylor, G., D.J. Baird, and A.M.V.M. Soares. 1998. Surface Binding of Contaminants by Algae: Consequences for Lethal Toxicity and Feeding to Daphnia magna Straus. Environ.Toxicol.Chem. 17(3):412-419.	18779	Plant, AF, UEndp, Dur	
Teisseire, H., M. Couderchet, and G. Vernet. 1998. Toxic Responses and Catalase Activity of Lemna minor L. Exposed to Folpet, Copper, and Their Combination. Ecotoxicol.Environ.Saf. 40(3):194-200.	19278	Plant, AF	
Tessier, C., and J.S. Blais. 1996. Determination of Cadmium-Metallothioneins in Zebra Mussels Exposed to Subchronic Concentration of Cd2+. Ecotoxicol.Environ.Saf. 33(3):246-252.	17781	AF, UEndp	
Tessier, L., G. Vaillancourt, and L. Pazdernik. 1994. Temperature Effects on Cadmium and Mercury Kinetics in Freshwater Molluscs Under Laboratory Conditions. Arch.Environ.Contam.Toxicol. 26:179-184.	13597	AF, UEndp	
Tessier, L., G. Vaillancourt, G., and L. Pazdernik. 1996. Laboratory Study of Cd and Hg Uptake by Two Freshwater Molluscs in Relation to Concentration, Age and Exposure Time. Water Air Soil Pollut. 86(1-4):347-357.	17094	AF, UEndp	
Thomas, A.. 1915. Effects of Certain Metallic Salts upon Fishes. Trans.Am.Fish.Soc. 44:120-124.	2865	AF, UEndp, Dur	
Thomas, D.G., A. Cryer, J.F.D.E. Solbe, and J. Kay. 1983. A Comparison of the Accumulation and Protein Binding of Environmental Cadmium in the Gills, Kidney and Liver of Rainbow Trout (Salmo. Comp.Biochem.Physiol.C 76(2):241-246.	12383	AF, UEndp, Con	

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Thompson, P.A., and P. Couture. 1990. Aspects of Carbon Metabolism in the Recovery of Selenastrum capricornutum Populations Exposed to Cadmium. Aquat.Toxicol. 17(1):1-14.	3335	Plant, AF, UEndp, Dur	
Thompson, P.A., and P. Couture. 1993. Physiology of Carbon Assimilation in a Green Alga During Exposure to and Recovery from Cadmium. Ecotoxicol.Environ.Saf. 26(2):205-215.	8268	Plant, AF, UEndp, Dur	
Thompson, P.A., P. Couture, C. Thellen, and J.C. Auclair. 1987. Structure-Function Relationships for Monitoring Cellular Stress and Recovery Responses with Selenastrum capricornutum. Aquat.Toxicol. 10(5-6):291-305.	12916	Plant, AF, UEndp	
Thorp, V.J., and P.S. Lake. 1974. Toxicity Bioassays of Cadmium on Selected Freshwater Invertebrates and the Interaction of Cadmium and Zinc on the Freshwater Shrimp, Paratya. Aust.J.Mar.Freshwater Res. 25(1):97-104.	8731	NonRes	
Thuvander, A.. 1989. Cadmium Exposure of Rainbow Trout, Salmo gairdneri Richardson: Effects of Immune Functions. J.Fish Biol. 35(4):521-529.	3401	AF, UEndp, Eff	
Timmermans, K.R., and P.A. Walker. 1989. The Fate of Trace Metals During the Metamorphosis of Chironomids (Diptera, Chironomidae). Environ.Pollut. 62(1):73-85.	2729	AF, UEndp	
Timmermans, K.R., E. Spijkerman, M. Tonkes, and H. Govers. 1992. Cadmium and Zinc Uptake by Two Species of Aquatic Invertebrate Predators from Dietary and Aqueous Sources. Can.J.Fish.Aquat.Sci. 49(4):655-662.	13427	AF, UEndp	
Timmermans, K.R., W. Peeters, and M. Tonkes. 1992. Cadmium, Zinc, Lead and Copper in Chironomus riparius (Meigen) Larvae (Diptera, Chironomidae): Uptake and Effects. Hydrobiologia 241(2):119-134.	6029	AF, UEndp, Eff	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Ting, Y.P., F. Lawson, and I.G. Prince. 1989. Uptake of Cadmium and Zinc by the Alga Chlorella vulgaris: Part 1. Individual Ion Species. Biotechnol.Bioeng. 34(7):990-999.	3362	Plant, AF, UEndp, Dur, Con	
Torreblanca, A., J. Del Ramo, J.A. Arnau, and J. Diaz-Mayans. 1989. Cadmium, Mercury, and Lead Effects on Gill Tissue of Freshwater Crayfish Procambarus clarkii (Girard). Biol.Trace Elem.Res. 21:343-347.	2695	AF, UEndp	
Tripathi, R.D., U.N. Rai, M. Gupta, M. Yunus, and P. Chandra. 1995. Cadmium Transport in Submerged Macrophyte Ceratophyllum demersum L. in Presence of Various Metabolic Inhibitors and Calcium Channel Blockers. Chemosphere 31(7):3783-3791.	16157	AF, UEndp, Eff, Dur	
Tsuji, S., Y. Tonogai, Y. Ito, and S. Kanoh. 1986. The Influence of Rearing Temperatures on the Toxicity of Various Environmental Pollutants for Killifish (Oryzias latipes). J.Hyg.Chem./Eisei Kagaku 32(1):46-53 (JPN) (ENG ABS).	12497	AF, Dur, Con	
Turbak, S.C., S.B. Olson, and G.A. McFeters. 1986. Comparison of Algal Assay Systems for Detecting Waterborne Herbicides and Metals. Water Res. 20(1):91-96.	11780	Plant, AF, Eff, Dur	
Twagilimana, L., J. Bohatier, C.A. Groliere, F. Bonnemoy, and D. Sargos. 1998. A New Low-Cost Microbiotest with the Protozoan Spirostomum teres: Culture Conditions and Assessment of Sensitivity of the Ciliate to 14 Pure Chemicals. Ecotoxicol.Environ.Saf. 41(3):231-244.	20057	Ace, AF, Dur	
Tyrawska, D., K. Grochala, Z. Kowszylo, and L. Manusadzianas. 1994. The Effect of Cadmium on the Vital Activity of Nitellopsis obtusa Cells. Pol.Arch.Hydrobiol. 41(4):451-463.	17331	AF, UEndp, Eff	
Umezu, T.. 1991. Saponins and Surfactants Increase Water Flux in Fish Gills. Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 57(10):1891-1896.	7136	AF, UEndp, Dur	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Van der Heever, J.A., and J.U. Grobbelaar. 1996. Evaluation of Short-Incubation-Time Small-Volume Radiocarbon-Uptake Algal Toxicity Test. J.Appl.Phycol. 8(1):65-71.	18763	Plant, AF, Eff, Dur	
Van der Heever, J.A., and J.U. Grobbelaar. 1997. The Use of Oxygen Evolution to Assess the Short-Term Effects of Toxicants on Algal Photosynthetic Rates. Water S.A. 23(3):233-237.	19854	Plant, AF, UEndp, Eff, Dur	
Van der Werff, M., and M.J. Pruyt. 1982. Long-Term Effects of Heavy Metals on Aquatic Plants. Chemosphere 11(8):727-739.	14480	Plant, AF, UEndp	
Van Ginneken, L., M.J. Chowdhury, and R. Blust. 1999. Bioavailability of Cadmium and Zinc to the Common Carp, Cyprinus carpio, in Complexing Environments: A Test for the Validity of the Free Ion Activity. Environ.Toxicol.Chem. 18(10):2295-2304.	20483	AF, UEndp, Dur, Form	
Van Haaften, M., and D.C. Lasenby. 1994. Changes in the Amount of Cadmium in Food Ingested by the Creek Chub, Semotilus atromaculatus. Bull.Environ.Contam.Toxicol. 53(2):224-229.	13705	AF, UEndp, Dur, RouExp	
Van Hattum, B.P.D., L. Van den Bosch, N.M. Van Straalen, E.N.G. Joosse, and H. Govers. 1989. Bioaccumulation of Cadmium by the Freshwater Iospod Asellus aquaticus (L.) From Aqueous and Dietary Sources. Environ.Pollut. 62(2-3):129-151.	881	AF, UEndp	
Van Kessel, W.H.M., R.W. Brocades Zaalberg, and W. Seinen. 1989. Testing Environmental Pollutants on Soil Organisms: A Simple Assay to Investigate the Toxicity of Environmental Pollutants on Soil Organisms, Using CdCl2 and Nematodes. Ecotoxicol.Environ.Saf. 18:181-190.	20202	AF, UEndp	
Van Leeuwen, C.J., P.S. Griffioen, W.H.A. Vergouw, and J.L. Maas-Diepeveen. 1985. Differences in Susceptibility of Early Life Stages of Rainbow Trout (Salmo gairdneri) to Environmental Pollutants. Aquat.Toxicol. 7(1-2):59-78.	11519	AF, Con	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Van Leeuwen, C.J., W.J. Luttmer, and P.S. Griffioen. 1988. The Use of Cohorts and Populations in Chronic Toxicity Studies with Daphnia magna: A Cadmium Example. Ecotoxicol.Environ.Saf.9:26-39 (1985) / Aquat.Toxicol. 11(3/4):421-422 (ABS).	10589	AF	
Van Puymbroeck, S.L.C., W.J.J. Stips, and O.L.J. Vanderborght. 1982. The Antagonism between Selenium and Cadmium in a Freshwater Mollusc. Arch.Environ.Contam.Toxicol. 11(1):103-106.	12986	AF	
Vardia, H.K., P.S. Rao, and V.S. Durve. 1988. Effect of Copper, Cadmium and Zinc on Fish-Food Organisms, Daphnia lumholtzi and Cypris subglobosa. Proc.Indian Acad.Sci.Anim.Sci. 97(2):175-180.	12365	AF, Dur, Con	
Vasseur, P., P. Pandard, and D. Burnel. 1988. Influence of Some Experimental Factors on Metal Toxicity to Selenastrum capricornutum. Toxic.Assess. 3(3):331-444.	752	Plant, AF, UEndp, Con	
Vazquez, M.D., J. Lopez, and A. Carballeira. 1999. Uptake of Heavy Metals to the Extracellular and Intracellular Compartments in Three Species of Aquatic Bryophyte. Ecotoxicol.Environ.Saf. 44(1):12-24.	20585	Plant, AF, UEndp, Dur	
Verma, S.R., I.P. Tonk, A.K. Gupta, and M. Saxena. 1984. Evaluation of an Application Factor for Determining the Safe Concentration of Agricultural and Industrial Chemicals. Water Res. 18(1):111-115.	10575	Con	
Verma, S.R., I.P. Tonk, and R.C. Dalela. 1981. Determination of the Maximum Acceptable Toxicant Concentration (MATC) and the Safe Concentration for Certain Aquatic Pollutants. Acta Hydrochim.Hydrobiol. 9(3):247-254.	10385	Con	
Viale, G., and D. Calamari. 1984. Immune Response in Rainbow Trout Salmo gairdneri After Long-Term Treatment with Low Levels of Cr, Cd and Cu. Environ.Pollut.Ser.A Ecol.Biol. 35(3):247-257.	10732	AF, Eff	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Victor, B.. 1993. Responses of Hemocytes and Gill Tissues to Sublethal Cadmium Chloride Poisoning in the Crab Paratelphusa hydrodromous (Herbst). Arch.Environ.Contam.Toxicol. 24:432-439.	6773	Dur	
Victor, B.. 1993. Histopathological Progression of Hemic Neoplasms in the Tropical Crab Paratelphusa hydrodromous (Herbst) Treated with Sublethal Cadmium Chloride. Arch.Environ.Contam.Toxicol. 25:48-54.	6785	NonRes	
Victor, B., S. Mahalingam, and R. Sarojini. 1986. Toxicity of Mercury and Cadmium on Oocyte Differentiation and Vitellogenesis of the Teleost, Lepidocephalichtyhs thermalis (Bleeker). J.Environ.Biol. 7(4):209-214.	12099	AF, UEndp, Eff	
Vijayaraman, K., G. John, P. Sivakumar, and R.R. Mohamed. 1999. Uptake and Loss of Heavy Metals by the Freshwater Prawn, Macrobrachium malcolmsonii. J.Environ.Biol. 20(3):217-222.	55226	UEndp	
Vijayram, K., and P. Geraldine. 1996. Are the Heavy Metals Cadmium and Zinc Regulated in Freshwater Prawns?. Ecotoxicol.Environ.Saf. 34(2):180-183 (Publ in Part As 16442).	17782	UEndp	
Vijayram, K., P. Geraldine, T.S. Varadarajan, L. James, K. Periaswamy, G. John, and P. Loganathan. 1990. Vertebral Deformities and Decrease of Mineral Content in Anabas testudineus Exposed to Cadmium. Environ.Ecol. 8(2):672-674.	3441	UEndp, Eff	
Vincent, S., and T. Ambrose. 1994. Uptake of Heavy Metals Cadmium and Chromium in Tissues of the Indian Major Carp, Catla catla (Ham.). Indian J.Environ.Health 36(3):200-204.	19450	UEndp	
Vitale, A.M., J.M. Monserrat, P. Castilho, and E.M. Rodriguez. 1999. Inhibitory Effects of Cadmium on Carbonic Anhydrase Activity and Ionic Regulation of the Estuarine Crab Chasmagnathus granulata (Decapoda, Grapsidae). Comp.Biochem.Physiol.C 122(1):121-129.	19662	AF	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Vocke, R.W., K.L. Sears, J.J. O'Toole, and R.B. Wildman. 1980. Growth Responses of Selected Freshwater Algae to Trace Elements and Scrubber Ash Slurry Generated by Coal-Fired Power Plants. Water Res. 14(2):141-150.	5342	Plant	
Vykusova, B., and Z. Svobodova. 1987. Comparison of the Sensitivity of Male and Female Guppies (Poecilia reticulata Peters) to Toxic Substances. Bul.Vyzk.Ustav Ryb.Hydrobiol.Vodnany 23(3):20-23 (CZE) (ENG ABS).	312	AF, Dur, Con	
Vymazal, J.. 1990. Uptake of Lead, Chromium, Cadmium and Cobalt by Cladophora glomerata. Bull.Environ.Contam.Toxicol. 44(2):468-472.	2191	Plant, AF, Uendp, Dur	
Vymazal, J.. 1990. Uptake of Heavy Metals by Cladophora glomerata. Acta Hydrochim.Hydrobiol. 18(6):657-665.	45131	Plant, AF, Uendp, Dur	
Vymazal, J.. 1995. Influence of pH on Heavy Metals Uptake by Cladophora glomerata. Pol.Arch.Hydrobiol. 42(3):231-237.	45130	Plant, AF, Uendp, Dur	
Wagh, S.B., K. Shareef, and S. Shaikh. 1985. Acute Toxicity of Cadmium Sulphate, Zinc Sulphate and Copper Sulphate to Barbus ticto (Ham.): Effect on Oxygen Consumption and Gill Histology. J.Environ.Biol. 6(4):287-293.	11483	Dur, Con	
Wang, T.C., J.C. Weissman, G. Ramesh, R. Varadarajan, and J.R. Benemann. 1996. Parameters for Removal of Toxic Heavy Metals by Water Milfoil (Myriophyllum spicatum). Bull.Environ.Contam.Toxicol. 57(5):779-786.	20408	Plant, AF, UEndp, Dur	
Wang, W.. 1994. Rice Seed Toxicity Tests for Organic and Inorganic Substances. Environ.Monit.Assess. 29:101-107.	45060	Plant, AF	
Wani, G.P., and A.N. Latey. 1983. Toxic Effects of Cadmium on the Liver of a Freshwater Teleost Garra mullya (Sykes). Curr.Sci. 52(21):1034-1035.	11016	AF	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Water Pollution Research Board. 1968. Effects of Pollution on Fish: Chronic Toxicity of Ammonia to Rainbow Trout. In: Water Pollution Research 1967, Water Pollution Research Board, Dep.of Scientific and Industrial Research, H.M.Stationery Office, London :56-65.	10185	AF, UEndp, Con	
Watson, C.F.. 1988. Sublethal Effects of Cadmium Exposure on Freshwater Teleosts. Diss.Abstr.Int.B Sci.Eng.50(3):830 / Ph.D.Thesis, Northeast Louisiana University, Monroe, LA :136 p..	2707	AF, UEndp, Eff, Con	
Watson, C.F., and W.H. Benson. 1987. Comparative Activity of Gill Atpase in Three Freshwater Teleosts Exposed to Cadmium. Ecotoxicol.Environ.Saf. 14:252-259.	12806	AF, UEndp, Dur	
Wehrheim, B., and M. Wettern. 1994. Comparative Studies of the Heavy Metal Uptake of Whole Cells and Different Types of Cell Walls from Chlorella fusca. Biotechnol.Tech. 8(4):227-232.	16139	Plant, AF, UEndp, Dur	
Wehrheim, B., and M. Wettern. 1994. Influence of the External REDOX State on Heavy Metal Adsorption by Whole Cells and Isolated Cell Walls of Chlorella fusca. Biotechnol.Tech. 8:221-226.	45132	Plant, AF, UEndp, Dur	
Weis, J.S., and P. Weis. 1977. Effects of Heavy Metals on Development of the Killifish, Fundulus heterclitus. J.Fish Biol. 11(1):49-54.	45298	AF, UEndp, Eff, Dur	
Welsh, P.G.. 1996. Influence of Dissolved Organic Carbon on the Speciation, Bioavailability and Toxicity of Metals to Aquatic Biota in Soft Water Lakes. Ph.D.Thesis, University of Waterloo, Ontario, Canada :181 p..	45189	AF	
Wentsel, R.S.. 1977. Distributional and Sublethal Effects of Heavy Metals on Benthic Macroinvertebrates. Ph.D.Thesis, Purdue University, West Lafayette, I N:108.	6175	UEndp	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Wicklum, D., and R.W. Davies. 1996. The Effects of Chronic Cadmium Stress on Energy Acquisition and Allocation in a Freshwater Benthic Invertebrate Predator. Aquat.Toxicol. 35(3/4):237-252.	19521	AF, UEndp	
Wicklum, D., D.E.C. Smith, and R.W. Davies. 1997. Mortality, Preference, Avoidance, and Activity of a Predatory Leech Exposed to Cadmium. Arch.Environ.Contam.Toxicol. 32(2):178-183.	17876	AF	
Wicklund Glynn, A.. 1996. The Concentration Dependency of Branchial Intracellular Cadmium Distribution and Influx in the Zebrafish (Brachydanio rerio). Aquat.Toxicol. 35(1):47-58.	17192	AF, UEndp, Dur	
Wicklund, A., and P. Runn. 1988. Calcium Effects on Cadmium Uptake, Redistribution, and Elimination in Minnows, Phoxinus phoxinus, Acclimated to Different Calcium Concentrations. Aquat.Toxicol. 13(2):109-122.	13182	AF, UEndp, Dur	
Wicklund, A., L. Norrgren, and P. Runn. 1990. The Influence of Cadmium and Zinc on Cadmium Turnover in the Zebrafish, Brachydanio rerio. Arch.Environ.Contam.Toxicol. 19(3):348-353.	3171	AF, UEndp, Dur, Con	
Wicklund, A., P. Runn, and L. Norrgren. 1988. Cadmium and Zinc Interactions in Fish: Effects of Zinc on the Uptake, Organ Distribution, and Elimination of 109Cd in the Zebrafish, Brachydanio rerio. Arch.Environ.Contam.Toxicol. 17(3):345-354.	2428	AF, UEndp, Con	
Wikfors, G.H., A. Neeman, and P.J. Jackson. 1991. Cadmium-Binding Polypeptides in Microalgal Strains with Laboratory-Induced Cadmium Tolerance. Mar.Ecol.Prog.Ser. 79(1/2):163-190.	6385	Plant, AF, UEndp	
Wilczok, A., U. Mazurek, D. Tyrawska, and B. Sosak-Swiderska. 1994. Effect of Cadmium on the Cell Division of Chlorella vulgaris Beij. 1890, Strain A-8. Pol.Arch.Hydrobiol. 41(1):123-131.	18720	Plant, AF, UEndp, Dur	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Williams, D.R.Jr.. 1978. Relative Importance of Food and Water Sources to Cadmium Uptake by Gambusia affinis (Poeciliidae). Environ.Res. 16(1-3):326-332.	15673	UEndp, RouExp	
Williams, K.A., D.W.J. Green, D. Pascoe, and D.E. Gower. 1986. The Acute Toxicity of Cadmium to Different Larval Stages of Chironomus riparius (Diptera: Chironomidae) and its Ecological Significance for Pollutio. Oecologia 70(3):362-366.	12042	AF	
Williams, K.A., D.W.J. Green, D. Pascoe, and D.E. Gower. 1987. Effect of Cadmium on Oviposition and Egg Viability in Chironomus riparius (Diptera: Chironomidae). Bull.Environ.Contam.Toxicol. 38(1):86-90.	12395	AF, UEndp, Dur	
Williams, P.L., and D.B. Dusenbery. 1990. Aquatic Toxicity Testing Using the Nematode, Caenorhabditis elegans. Environ.Toxicol.Chem. 9(10):1285-1290.	3437	AF	
Willuhn, J., A. Otto, H. Koewius, and F. Wunderlich. 1996. Subtoxic Cadmium-Concentrations Reduce Copper-Toxicity in the Earthworm Enchytraeus buchholzi. Chemosphere 32(11):2205-2210.	20269	AF, Dur	
Winner, R.W.. 1984. The Toxicity and Bioaccumulation of Cadmium and Copper as Affected by Humic Acid. Aquat.Toxicol. 5(3):267-274.	11355	AF, Con	
Wong, C.K., and P.K. Wong. 1990. Life Table Evaluation of the Effects of Cadmium Exposure on the Freshwater Cladoceran, Moina macrocarpa. Bull.Environ.Contam.Toxicol. 44(1):135-141.	2800	AF, Dur	
Woo, P.T.K., Y.M. Sin, and M.K. Wong. 1993. The Effects of Short-Term Acute Cadmium Exposure on Blue Tilapia, Oreochromis aureus. Environ.Biol.Fish. 37(1):67-74.	9911	AF, UEndp	
Woodall, C., N. MacLean, and F. Crossley. 1988. Responses of Trout Fry (Salmo gairdneri) and Xenopus laevis Tadpoles to Cadmium and Zinc. Comp.Biochem.Physiol.C 89(1):93-99.	6074	Dur	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Woodworth, J., and D. Pascoe. 1983. Cadmium Uptake and Distribution in Sticklebacks Related to the Concentration and Method of Exposure. Ecotoxicol.Environ.Saf. 7(6):525-530 (Used Ref 10578).	10549	UEndp	
Wooldridge, C.R., and D.P. Wooldridge. 1969. Internal Damage in an Aquatic Beetle Exposed to Sublethal Concentrations of Inorganic Ions. Ann.Entomol.Soc.Am. 62(4):921-933.	2868	AF, UEndp, Eff	
Wren, M.J., and D. McCarroll. 1990. A Simple and Sensitive Bioassay for the Detection of Toxic Materials Using a Unicellular Green Alga. Environ.Pollut. 64(1):87-91.	3265	Plant, AF, Con	
Wright, D.A.. 1988. Dose-Related Toxicity of Copper and Cadmium in Striped Bass Larvae from the Chesapeake Bay: Field Considerations. Water Sci.Technol. 20(6-7):39-48.	910	AF	
Wright, D.A., and J.W. Frain. 1981. The Effect of Calcium on Cadmium Toxicity in the Freshwater Amphipod, Gammarus pulex (L.). Arch.Environ.Contam.Toxicol. 10(3):321-328.	9509	AF, Dur	
Wright, D.A., M.J. Meteyer, and F.D. Martin. 1985. Effect of Calcium on Cadmium Uptake and Toxicity in Larvae and Juveniles of Striped Bass (Morone saxatilis). Bull.Environ.Contam.Toxicol. 34(2):196-204.	10625	UEndp, Dur	
Xiaorong, W., J. Mei, S. Hao, and X. Ouyong. 1997. Effects of Chelation on the Bioconcentration of Cadmium and Copper by Carp (Cyprinus carpio L.). Bull.Environ.Contam.Toxicol. 59(1):120-124.	18423	UEndp	
Yager, C.M., and H.W. Harry. 1964. The Uptake of Radioactive Zinc, Cadmium and Copper by the Freshwater Snail, Taphius glabratus. Malacologia 1(3):339-353.	14058	AF, UEndp, Dur	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Yamamoto, Y., and M. Inoue. 1985. Lethal Tolerance of Acute Cadmium Toxicity in Rainbow Trout Previously Exposed to Cadmium. Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 51(10):1733-1735 (JPN) (ENG ABS).	12102	AF, UEndp, Con	
Yang, H.N., and H.C. Chen. 1996. Uptake and Elimination of Cadmium by Japanese Eel, Anguilla japonica, at Various Temperatures. Bull.Environ.Contam.Toxicol. 56(4):670-676.	17926	AF, Uendp, NonRes	
Yang, H.N., and H.C. Chen. 1996. The Influence of Temperature on the Acute Toxicity and Sublethal Effects of Copper, Cadmium and Zinc to Japanese Eel, Anguilla japonica. Acta Zool.Taiwan. 7(1):29-38.	18914	NonRes	
Yoshitomi, T., J. Koyama, A. Lida, N. Okamoto, and Y. Ikeda. 1998. Cadmium-Induced Scale Deformation in Carp (Cyprinus carpio). Bull.Environ.Contam.Toxicol. 60:639-644.	18754	AF, UEndp, RouExp	
Zettergren, L.D., B.W. Boldt, D.H. Petering, M.S. Goodrich, D.N. Weber, and J.G. Zettergren. 1991. Effects of Prolonged Low-Level Cadmium Exposure on the Tadpole Immune System. Toxicol.Lett.(Amst.) 55(1):11-19.	7384	AF, UEndp	
Zhang, F., Y. Zhou, and R. Zhou. 1988. Toxicities of Two Metals and Two Pesticides to Grass Carps at Different Development Stages. Acta Sci.Circumstant.(Huanjing Kexue Xuebao) 8(1):67-71 (CHI) (ENG ABS).	3477	AF, Dur, Con	
Zia, S., and D.G. McDonald. 1994. Role of the Gills and Gill Chloride Cells in Metal Uptake in the Freshwater-Adapted Rainbow Trout, Oncorhynchus mykiss. Can.J.Fish.Aquat.Sci. 51(11):2482-2492.	17464	AF, UEndp, Eff, Dur	
Zitko, V., and W.G. Carson. 1976. A Mechanism of the Effects of Water Hardness on the Lethality of Heavy Metals to Fish. Chemosphere 5(5):299-303.	8483	UEndp, Dur	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Zou, E., and S. Bu. 1994. Acute Toxicity of Copper, Cadmium, and Zinc to the Water Flea, Moina irrasa (Cladocera). Bull.Environ.Contam.Toxicol. 52(5):742-748.	13762	NonRes	

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A. For specific study determinations, see Appendix C.

1) For the studies that were not utilized, but the most representative value fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[81], EPA is providing a transparent rationale as to why they were not utilized (see below).
2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable.

<u>General QA/QC failure because non-resident species in Oregon</u>

All data considered in this CWA review and approval/disapproval action of OR WQS for cadmium below the chronic criterion or related to the four most sensitive genera were from species that are known or expected to have a breeding wild population in Oregon's waters.

<u>Other Acute tests failing QA/QC by species</u>

Salvelinus fontinalis – brook trout

Holcombe, G.W., G.L. Phipps and J.T. Fiandt. 1983. Toxicity of selected priority pollutants to various aquatic organisms. Ecotoxicol. Environ. Safety 7: 400-409.

[81] U.S. EPA. 2001. 2001 Update of Ambient Water Quality Criteria for Cadmium. EPA-822-R-01-001.

Data was significantly different than other data for species in the same genus, so it was considered an outlier and not included.

Oncorhynchus mykiss – rainbow trout

The following tests were included in EPA's BE of the OR WQS for cadmium in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because a more sensitive lifestage was available which provides greater protection for the species.

Chapman, G.A. 1978. Toxicities of cadmium, copper, and zinc to four juvenile stages of chinook salmon and steelhead. Trans. Am. Fish. Soc. 107: 841.
Other data from this study used for this species.

Chapman, G.A. 1975. Toxicity of copper, cadmium and zinc to Pacific Northwest salmonids. U.S. EPA, Corvallis, Oregon.
Other data from this study used for this species.

The following tests were not used in this CWA review and approval/disapproval action of these standards because the tests were not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for this species that was included.

Hollis, L., J.C. McGeer, D.G. McDonald and C.M. Wood. 1999. Cadmium Accumulation, Gill Cd Binding, Acclimation, and Physiological Effects During Long Term Sublethal Cd Exposure in Rainbow Trout. Aquat. Toxicol. 46(2): 101-119.
Two LC50 values from F,U tests ranging from 14.75 to 167.63 µg/L.

Buhl, K.J. and S.J. Hamilton. 1991. Relative sensitivity of early life stages of arctic grayling, coho salmon, and rainbow trout to nine inorganics. Ecotoxicol. Environ. Safety. 22: 184-197.
One LC50 value from S,U test of 3.51 µg/L.

Spehar, R.L. and A.R. Carlson. 1984a. Derivation of site-specific water quality criteria for cadmium and the St. Louis River Basin, Duluth, Minnesota. PB84-153196. National Technical Information Service, Springfield, VA.
One LC50 value from S,M test of 5.06 µg/L.

Spehar, R.L. and A.R. Carlson. 1984b. Derivation of site-specific water quality criteria for cadmium and the St. Louis River Basin, Duluth, Minnesota. Environ. Toxicol. Chem. 3: 651.

One LC50 value from S,M test of 5.06 µg/L.

Kumada H., S. Kimura and M. Yokote. 1980. Accumulation and biological effects of cadmium in rainbow trout. Bull. Jap. Soc. Sci. Fish. 46: 97-103.
Two LC50 values from S,U tests ranging from 6.00 to 7.00 µg/L, with no hardness adjustment; water hardness level was not available for this test.

Kumada, H., S. Kimura, M. Yokote and Y. Matida. 1973. Acute and chronic toxicity, uptake and retention of cadmium in freshwater organisms. Bull. Freshwater Fish. Res. Lab. 22: 157-165.
One LC50 value from S,U test of 6.00 µg/L, with no hardness adjustment; water hardness level was not available for this test.

The following test was not used in this CWA review and approval/disapproval action of these standards because no water hardness level was available for the test.

Hale, J.G. 1977. Toxicity of metal mining wastes. Bull. Environ. Contam. Toxicol. 17: 66.

Oncorhynchus tshawytscha– Chinook salmon

The following tests were included in EPA's BE of the OR WQS for cadmium in freshwater, but were not used for determining the most representative SMAV in this CWA review and approval/disapproval action of these standards because a more sensitive lifestage was available.

Chapman, G.A. 1978. Toxicities of cadmium, copper, and zinc to four juvenile stages of chinook salmon and steelhead. Trans. Am. Fish. Soc. 107: 841.
Other data from this study used for this species.

Chapman, G.A. 1975. Toxicity of copper, cadmium and zinc to Pacific Northwest salmonids. U.S. EPA, Corvallis, OR.
Other data from this study used for this species.

The following tests were not used in this CWA review and approval/disapproval action of these standards because the tests were not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for these species.

Hamilton, S.J. and K.J. Buhl. 1990. Safety assessment of selected inorganic elements to fry of chinook salmon (*Oncorhynchus tshawytscha*). Ecotoxicol. Environ. Safety. 20: 307-324.
Two LC50 values from S,U tests ranging from 11.49 to 15.37 µg/L.

Oncorhynchus kisutch– Coho salmon

The following tests were included in EPA's BE of the OR WQS for cadmium in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because a more sensitive lifestage was available.

Chapman, G.A. 1975. Toxicity of copper, cadmium and zinc to Pacific Northwest salmonids. U.S. EPA, Corvallis, OR.
Other data from this study used for this species.

The following tests were not used in this CWA review and approval/disapproval action of these standards because the tests were not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for this species.

Buhl, K.J. and S.J. Hamilton. 1991. Relative sensitivity of early life stages of arctic grayling, coho salmon, and rainbow trout to nine inorganics. Ecotoxicol. Environ. Safety. 22: 184-197.
Two LC50 values from S,U tests ranging from 7.95 to 14.02 µg/L.

Lorz, H.W., R.H. Williams and C.A. Fustish. 1978. Effects of several metals on smolting of coho salmon. EPA-600/3-78-090. National Technical Information Service, Springfield, VA.
One LC50 value from S,U test of 10.93 µg/L.

Oncorhynchus nerka– Sockeye salmon

The following tests were included in EPA's BE of the OR WQS for cadmium in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because of inappropriate test duration.

Servizi, J.A. and D.W. Martens. 1978. Effects of Selected Heavy Metals on Early Life of Sockeye and Pink Salmon. Rep. No. 39, Int. Pacific Salmon Fish. Comm. (Br. Col.): 26.
7-day acute fish test.

Oncorhynchus gorbuscha– Pink salmon

The following tests were included in EPA's BE of the OR WQS for cadmium in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because of inappropriate test duration.

Servizi, J.A. and D.W. Martens. 1978. Effects of Selected Heavy Metals on Early Life of Sockeye and Pink Salmon. Rep. No. 39, Int. Pacific Salmon Fish. Comm. (Br. Col.): 26.
7-day acute fish test.

Morone saxatilis – striped bass

The following tests were not used in this CWA review and approval/disapproval action of these standards due to questionable treatment of organisms or inappropriate test conditions or methodology, according to ASTM standards for toxicity testing methodologies.

Rehwoldt, R., L.W. Menapace, B. Nerrie and D. Allessandrello. 1972. The effect of increased temperature upon the acute toxicity of some heavy metal ions. Bull. Environ. Contam. Toxicol. 8(2): 91-96.

The following tests were included in EPA's BE of the OR WQS for cadmium in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because of inappropriate test duration.

Hughes, J.S. 1973. Acute Toxicity to Thirty Chemicals to Striped Bass (*Morone saxatilis*). Western Assoc. State Game Fish Comm., Salt Lake City, UT.
72-hr acute fish test.

Morone americana – white perch

The following tests were not used in this CWA review and approval/disapproval action of these standards due to questionable treatment of organisms or inappropriate test conditions or methodology, according to ASTM standards for toxicity testing methodologies.

Rehwoldt, R., L.W. Menapace, B. Nerrie and D. Allessandrello. 1972. The effect of increased temperature upon the acute toxicity of some heavy metal ions. Bull. Environ. Contam. Toxicol. 8(2): 91-96.
This species is also an Oregon nonresident species.

Chironomus tetans – midge

The following tests were included in EPA's BE of the OR WQS for cadmium in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because because the dilution water for the test was from an uncharacterized natural water source. Note: this data was relegated to Table 6 in the 2001 criteria document for the same reason.

Khangarot, B.S. and P.K. Ray. 1989b. Sensitivity of midge larvae of *Chironomus tentans* Fabricius (Diptera: Chironomidea) to heavy metals. Bull. Environ. Contam. Toxicol. 1989. 42: 325-330.

Chironomus riparius– midge

The following tests were not used in this CWA review and approval/disapproval action of these standards because the tests were not based on the preferred flow-through measured test conditions; however other flow-through measured test concentrations were available for this species.

Pascoe, D., A.F. Brown, B.M.J. Evans and C. McKavanagh. 1990. Effects and fate of cadmium during toxicity tests with *Chironomus riparius* - the influence of food and artificial sediment. Arch. Environ. Contam. Toxicol. 19: 872-877.
One LC50 value from R,U test of 106,201 µg/L.

Chironomus sp. – midge

The following tests were not used in this CWA review and approval/disapproval action of these standards due to questionable treatment of organisms or inappropriate test conditions or methodology, according to ASTM standards for toxicity testing methodologies.

Rehwoldt, R., L. Lasko, C. Shaw and E. Wirhowski. 1973. The acute toxicity of some heavy metal ions toward benthic organisms. Bull. Environ. Contam. Toxicol. 10(5): 291-294.

Hyalella azteca - amphipod

The following tests were included in EPA's BE of the OR WQS for cadmium in freshwater, but were not in this CWA review and approval/disapproval action of these standards because *H. azteca* is sensitive to chloride concentration (see EPA (2009) for more details). EPA has decided to not use data for this species until additional tests are conducted.

Collyard, S.A., G.T. Ankley, R.A. Hoke and T. Goldenstein. 1994. Influence of age on the relative sensitivity of *Hyalella azteca* to diazinon, alkylphenol ethoxylates, copper, cadmium, and zinc. Arch. Environ. Contam. Toxicol. 26: 110-113.

McNulty, E.W., F.J. Dwyer, M.R. Ellersieck, E.I. Greer, C.G. Ingersoll and C.F. Rabeni. 1999. Evaluation of ability of reference toxicity tests to identify stress in laboratory populations of the amphipod *Hyalella azteca*. Environ. Toxicol. Chem. 18(3): 544-548.

Daphnia magna - cladoceran

Stuhlbacher, A., M.C. Bradley, C. Naylor and P. Calow. 1993. Variation in the development of cadmium resistance in *Daphnia magna* Straus; effect of temperature, nutrition, age and genotype. Environ. Pollut. 80(2): 153-158.
Data for a more sensitive lifestage was available for this species.

Anderson, B.G. 1948. The apparent thresholds of toxicity to *Daphnia magna* for chlorides of various metals when added to Lake Erie water. Trans. Am. Fish. Soc. 78: 96.
This less than value was not used because more definitive data was available.

The following tests were included in EPA's BE of the OR WQS for cadmium in freshwater, but were not in this CWA review and approval/disapproval action of these standards because the dilution water for the test was from an uncharacterized natural water source. Note: this data was relegated to Table 6 in the 2001 criteria document for the same reason.

Hickey, C.W. and M.L. Vickers. 1992. Comparison of the sensitivity to heavy metals and pentachlorophenol of the mayflies *Deleatidium spp*. and the cladoceran *Daphnia magna*. N. Z. J. Mar. Freshwater Res. 26(1): 87-93.

Khangarot, B.S. and P.K. Ray. 1989a. Investigation of correlation between physicochemical properties of metals and their toxicity to the water flea *Daphnia magna* Straus. Ecotoxicol. Environ. Saf. 18(2): 109-120.

The following test was not used in this CWA review and approval/disapproval action of these standards because the water hardness the test was performed at was not provided.

Canton, J.H. and D.M.M. Adema. 1978. Reproducibility of short-term and reproduction toxicity experiments with Daphnia magna and comparison of the sensitivity of *Daphnia magna* with *Daphnia pulex* and *Daphnia cucullata* in short-term experiments. Hydrobiol. 59: 135.

The following test was not used in this CWA review and approval/disapproval action of these standards because the test organisms were fed.

Mount, D.I. and T.J. Norberg. 1984. A seven-day life-cycle cladoceran toxicity test. Environ. Toxicol. Chem. 3(3): 425-434 (Author Communication Used).

Daphnia pulex - cladoceran

The following test was not used in this CWA review and approval/disapproval action of these standards because the water hardness the test was performed at was not provided.

Canton, J.H. and D.M.M. Adema. 1978. Reproducibility of short-term and reproduction toxicity experiments with Daphnia magna and comparison of the sensitivity of *Daphnia magna* with *Daphnia pulex* and *Daphnia cucullata* in short-term experiments. Hydrobiol. 59: 135.

The following test was not used in this CWA review and approval/disapproval action of these standards because the test organisms were fed.

Mount, D.I. and T.J. Norberg. 1984. A seven-day life-cycle cladoceran toxicity test. Environ. Toxicol. Chem. 3(3): 425-434 (Author Communication Used).

Other Chronic tests failing QA/QC by species

Salmo trutta – brown trout

Eaton, J. G., J.M. McKim and G.W. Holcombe. 1978. Metal toxicity to embryos and larvae of seven freshwater fish species - I. cadmium. Bull. Environ. Contam. Toxicol. 19: 95-103.
CV from this study was not used to calculate the SMCV in the 2001 ALC, because it is from an ELS test as opposed to the life-cycle test conducted by Brown et al. (1994).

Salmo salar – Atlantic salmon

Peterson, R.H., J.L. Metcalfe and S. Ray. 1985. Uptake of cadmium by eggs and alevins of Atlantic salmon (*Salmo salar*) as influenced by acidic conditions. Bull. Environ. Contam. Toxicol. 34: 359-368.
This test is listed in Table 6 of the ALC document as Peterson et al. 1983, because of unspecified test methods (which ECOTOX specifies as R,M).

Rombough, P.J. and E.T. Garside. 1982. Cadmium toxicity and accumulation in eggs and alevins of Atlantic salmon *Salmo salar*. Can. J. Zool. 60: 2006.
Results from this test were included in Table 2 of the 2001 ALC document, but the value includes footnotes stating that it was not used to calculate the SMCV for *S. salar*, and to see the text for an explanation. The text in the ALC document, however, does not mention this specific test or study.

The mean measured NOEC for *S. salar* in the BE included three values; two of which were values from this same study: a 45-day LC50 of 7.34 ug/L and a concentration associated with no effect on growth at 1.38 ug/L after 46 days of exposure. Both of these values were used as reported in ECOTOX, but the test fails QA/QC for ALC development because: 1) it was too short to qualify as an acceptable ELS test for a salmonid species, and 2) the exposure was based on the renewal of test solutions instead of the required flow-through test conditions..

Salvelinus fontinalis – brook trout

Eaton, J. G., J.M. McKim and G.W. Holcombe. 1978. Metal toxicity to embryos and larvae of seven freshwater fish species - I. cadmium. Bull. Environ. Contam. Toxicol. 19: 95-103.
CV from this study was not used to calculate the SMCV in the 2001 ALC, because it is from an ELS test as opposed to the life-cycle test conducted by Brown et al. (1994).

Sauter, S., K. S. Buxton, K.J. Macek and S.R. Petrocelli. 1976. Effects of exposure to heavy metals on selected freshwater fish. Toxicity of copper, cadmium, chromium and lead to eggs and fry of seven fish species. EPA-600/3-76-105. National Technical Information Service, Springfield, Virginia.
CV from this study was not used to calculate the SMCV in the 2001 ALC, because it is from an ELS test as opposed to the life-cycle test conducted by Brown et al. (1994).

Jop, K.M., A.M. Askew and R.B. Foster. 1995. Development of a water-effect ratio for copper, cadmium, and lead for the Great Works River in Maine using *Ceriodaphnia dubia* and *Salvelinus fontinalis*. Bull. Environ. Contam. Toxicol. 54(1): 29-35.
10-day chronic fish test.

Oncorhynchus mykiss – rainbow trout

The following tests were included in EPA's BE of the OR WQS for cadmium in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because they were non-qualifying ELS tests for salmonids according to the 1985 guidelines.

Davies, P.H. and W.C. Gorman. 1987. Effects of chemical equilibria and kinetics on the bioavailability and toxicity of cadmium to rainbow trout. Am. Chem. Soc. Natl. Meeting. 194: 646-650.

Davies, P.H., W.C. Gorman, C.A. Carlson and S.F. Brinkman. 1993. Effect of hardness on bioavailability and toxicity of cadmium to rainbow trout. Chem. Spec. Bioavail. 5(2): 67-77.

Hyalella azteca - amphipod

The following tests were included in EPA's BE of the OR WQS for cadmium in freshwater, but were not used in this CWA review and approval of these standards because *H. azteca* is sensitive to chloride concentration (U.S. EPA (2009) for more details). Further, EPA is currently involved with testing and will be developing interim draft guidance regarding best husbandry practices, including feeding regimes and water quality characteristics, for Hyalella tests to ensure that tests used in criteria development are of sufficient quality and are reproducible. This guidance will be applied prospectively to Hyallela tests in future criteria development. EPA has decided not to use data for this species until these analyses are conducted to ensure that the analyses are based on studies of assured quality and reproducibility.

Ingersoll, C.G. and N. Kemble. 2000. Unpublished. Methods development for long-term sediment toxicity tests with the amphipod *Hyalella azteca* and the midge *Chironomus tentans*.

Daphnia pulex - cladoceran

Ingersoll, C.G. and R.W. Winner. 1982. Effect on *Daphnia pulex* (De Geer) of daily pulse exposures to copper or cadmium. Environ. Toxicol. Chem. 1: 321.
The data from this test was relegated to Table 6 in the ALC document, because test methods (whether renewal or measured or non-measured) were not provided.

Winner, R.W. 1986. Interactive effects of water hardness and humic acid on the chronic toxicity of cadmium to *Daphnia pulex*. Aquat. Toxicol. 8: 281-293.
Unmeasured chronic tests. Note: these data were entered into the BE core data as test data for *Ceriodaphnia dubia*, instead of *Daphnia magna*.

Appendix D Chromium III (freshwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Abbasi, S.A., P.C. Nipaney and R. Soni. 1988. Studies on environmental management of mercury (II), chromium (VI) and zinc (II) with respect to the impact on some arthropods and protozoans -. Int. J. Environ. Stud. 32: 181-187.	13255	AF, Tox, Dur	
Al Akel, A.S. and M.J.K. Shamsi. 1996. Hexavalent chromium: Toxicity and impact on carbohydrate metabolism and haematological parameters of carp (*Cyprinus carpio* L.) from Saudi Arabia. Aquat. Sci. 58(1): 24-30.	19485	AF, Tox	
Al-Sabti, K., M. Franko, B. Andrijanic, S. Knez and P. Stegnar. 1994. Chromium-induced micronuclei in fish. J. Appl. Toxicol. 14(5): 333-336.	14448	AF, UEndp, Dur	
Anderson, B.G. 1948. The apparent thresholds of toxicity to *Daphnia magna* for chlorides of various metals when added to Lake Erie water. Trans. Am. Fish. Soc. 78: 96-113.	2054	AF, Dur	
Anusuya, D. and I. Christy. 1999. Effects of chromium toxicity on hatching and development of tadpoles of *Bufo melanostictus*. J. Environ. Biol. 20(4): 321-323.	47043	AF, Tox	
Baekken, T. and K.J. Aanes. 1994. Sublethal effects of the insecticide fimethoate on invertebrates in experimental streams. Norw. J. Agric. Sci. Suppl. 13: 167-177.	16081	AF, UEndp, Dur	
Banerjee, V. and M. Banerjee. 1988. Effect of heavy metal poisoning on peripheral haemogram in *Heteropneustes fossilis* (Bloch) mercury, chromium and zinc chlorides (LC50). Comp. Physiol. Ecol. 13(2): 128-134.	3131	AF, NonRes, UEndp, Dur	
Baudouin, M.F. and P. Scoppa. 1974. Accumulation and retention of chromium-51 by freshwater zooplankton. Comm.of the European Communities, Joint Nuclear Res. Center, Ispra, Italy: 23.	14542	AF, UEndp, Dur	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Biesinger, K.E., and G.M. Christensen. 1972. Effects of Various Metals on Survival, Growth, Reproduction and Metabolism of Daphnia magna. J.Fish Res.Board Can. 29:1691-1700.	2022	UEndp	
Billard, R. and P. Roubaud. 1985. The effect of metals and cyanide on fertilization in rainbow trout (*Salmo gairdneri*). Water Res. 19(2): 209-214.	10552	AF, UEndp, Dur	
Birge, W.J., J.A. Black and A.G. Westerman. 1979. Evaluation of aquatic pollutants using fish and amphibian eggs as bioassay organisms. In: S.W. Nielsen, G. Migaki, and D.G. Scarpelli (Eds.), Symp. Animals Monitors Environ. Pollut., 1977, Storrs, CT 12: 108-118.	4943	AF, Tox	
Boutet, C. and C. Chaisemartin. 1973. Specific toxic properties of metallic salts in *Austropotamobius pallipes pallipes* and *Orconectes limosus*. C. R. Soc. Biol. (Paris) 167(12): 1933-1938 (FRE) (ENG TRANSL).	5421	AF	
Brady, D., B. Letebele, J.R. Duncan and P.D. Rose. 1994. Bioaccumulation of metals by *Scenedesmus*, *Selenastrum* and *Chlorella* Algae. Water S.A. 20(3): 213-218.	45157	AF, UEndp, Dur	
Bringmann, G. and R. Kuhn. 1959. The toxic effects of waste water on aquatic bacteria, algae, and small crustaceans. Tr-Ts-0002; Gesund. Ing. 80: 115-120 53: 17390G-(GER)(ENG TRANSL).	607	AF, UEndp	
Bringmann, G. and R. Kuhn. 1959. Water toxicological studies with protozoa as test organisms. TR-80-0058, Literature Research Company: 13 p.; Gesund.-Ing. 80: 239-242 (GER); Chem. Abstr. 53: 22630D-(GER)(ENG TRANSL).	2394	AF, UEndp, Ace, Dur	
Bringmann, G. and R. Kuhn. 1959. Comparative water-toxicological investigations on bacteria, algae, and *Daphnia*. Gesundheitsingenieur 80(4): 115-120.	61194	AF, UEndp	
Bringmann, G. and R. Kuhn. 1960. The water-toxicological detection of insecticides (Zum wasser-toxikologischen nachweis von insektiziden). Gesund. Ing. 8: 243-244 (GER).	58990	AF, RouExp, Tox	
Calevro, F., C. Filippi, P. Deri, C. Albertosi and R. Batistoni. 1998. Toxic effects of aluminium, chromium and cadmium in intact and regenerating freshwater planarians. Chemosphere 37(4): 651-659.	19264	AF, UEndp, Dur	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Calevro, F., S. Campani, M. Ragghianti, S. Bucci and G. Mancino. 1998. Tests of toxicity in biphasic vertebrates treated with heavy metals (Cr3+, Al3+, Cd2+). Chemosphere 37(14/15): 3011-3017.	20095	NonRes	
Call, D.J., L.T. Brooke and N. Ahmad. 1981. Estimates of "No Effect" Concentrations of Selected Pesticides in Freshwater Organisms. Fourth Quarterly Progress Report to EPA, EPA Cooperative Agreement No. CR 806864030, University of Wisconsin, Superior, WI : 84.	4154	AF, UEndp, Dur	
Chin, H.C. and F.F. Chou. 1978. Acute chromium toxicity of the freshwater mussel, *Hyriopsis cumingii* Lea. Nan-Ching Ta Hsueh Hsueh Pao, Tzu Jan K'O Hsueh 4: 96-101 (CHI).	8328	NonRes	
Den Dooren de Jong, L.E. 1965. Tolerance of *Chlorella vulgaris* for metallic and non-metallic Ions. Antonie Leeuwenhoek J. Microbiol. Serol. 31: 301-313.	2849	AF, UEndp, Dur	
Dive, D., P. Vasseur, O. Hanssen and P.J. Gravil. 1988. Studies on interactions between components of electroplating wastes. Can. Tech. Rep. Fish. Aquat. Sci. No. 1607: 23-33.	4928	Ace, AF, Dur	
Dorn, P.B., J.P. Salanitro, S.H. Evans and L. Kravetz. 1993. Assessing the aquatic hazard of some branched and linear nonionic surfactants by biodegradation and toxicity. Environ. Toxicol. Chem. 12(10): 1751-1762.	20415	Tox / AF, Tox / AF, Tox, UEndp	
Dowden, B.F. 1961. Cumulative toxicities of some inorganic salts to *Daphnia magna* as determined by median tolerance limits. Proc. La. Acad. Sci. 23: 77-85.	2465	AF	
Dowden, B.F. and H.J. Bennett. 1965. Toxicity of selected chemicals to certain animals. J. Water Pollut. Control Fed. 37(9): 1308-1316.	915	AF	
Draggan, S. 1977. Interactive effect of chromium compounds and a fungal parasite on carp eggs. Bull. Environ. Contam. Toxicol. 17(6): 653-659.	14240	AF, UEndp, NoOrg, Dur	
Falk, M.R. and M.J. Lawrence. 1973. Acute Toxicity of Petrochemical Drilling Fluids Components and Wastes to Fish. Tech. Rep. Ser. No. CEN T-73-1, Canada Dep. of the Environ., Fisheries and Marine Service Resour. Manag. Branch, Winnipeg, Manitoba, Canada: 112.	6215	AF, Tox	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Fargasova, A. 1994. Comparative toxicity of five metals on various biological subjects. Bull. Environ. Contam. Toxicol. 53(2): 317-324.	13707	Plant, Tox	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Fromm, P.O. and R.M. Stokes. 1962. Assimilation and metabolism of chromium by trout. J. Water Pollut. Control Fed. 34(11): 1151-1155.	10362	AF, UEndp, Tox	
Gendusa, A.C. 1990. Toxicity of chromium and fluoranthene from aqueous and sediment sources to selected freshwater fish. Ph.D. Thesis, University of North Texas: 138 p. (Publ in Part As 9393, 5091).	4087	AF, UEndp	
Gendusa, T.C. and T.L. Beitinger. 1992. External biomarkers to assess chromium toxicity in adult *Lepomis macrochirus*. Bull. Environ. Contam. Toxicol. 48(2): 237-242.	5091	AF, UEndp	
Godet, F., M. Babut, D. Burnel, A.M. Veber and P. Vasseur. 1996. The genotoxicity of iron and chromium in electroplating effluents. Mutat. Res. 370(1): 19-28.	20537	AF, UEndp, Dur	
Gorbi, G., M.G. Corradi, A. Torelli and M. Bassi. 1996. Comparison between a normal and a Cr-tolerant strain of *Scenedesmus acutus* as a food source to *Daphnia magna*. Ecotoxicol. Environ. Saf. 35(2): 109-111.	18532	AF, UEndp, Tox, Dur, RouExp	
Guilhermino, L., T. Diamantino, M.C. Silva and A.M.V.M. Soares. 2000. Acute toxicity test with *Daphnia magna*: An alternative to mammals in the prescreening of chemical toxicity? Ecotoxicol. Environ. Saf. 46(3): 357-362.	49794	AF	
Hale, J.G. 1977. Toxicity of metal mining wastes. Bull. Environ. Contam. Toxicol. 17(1): 66-73.	861	AF	
Holland, G.A., J.E. Lasater, E.D. Neumann and W.E. Eldridge. 1960. Toxic Effects of Organic and Inorganic Pollutants on Young Salmon and Trout. Res. Bull. No. 5, State of Washington Dept. Fish., Seattle, WA: 263.	14397	AF, UEndp, Dur	
Jaworska, M., J. Sepiol and P. Tomasik. 1996. Effect of metal ions under laboratory conditions on the entomopathogenic *Steinernema carpocapsae* (Rhabditida: Steinernematidae). Water Air Soil Pollut. 88(3/4): 331-341.	17002	AF, UEndp	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Jones, J.R.E. 1939. The relation between the electrolytic solution pressures of the metals and their toxicity to the stickleback (*Gasterosteus aculeatus* L.). J. Exp. Biol. 16(4): 425-437.	2851	AF, UEndp, Dur	
Jones, J.R.E. 1940. A further study of the relation between toxicity and solution pressure, with *Polycelis nigra* as test animal. J. Exp. Biol. 17:408-415.	10012	AF, UEndp, Dur	
Kapu, M.M. and D.J. Schaeffer. 1991. Planarians in toxicology. Responses of asexual *Dugesia dorotocephala* to selected metals. Bull. Environ. Contam. Toxicol. 47(2): 302-307.	10581	AF, UEndp, Tox, Dur	
Keller, A.E. and S.G. Zam. 1991. The acute toxicity of selected metals to the freshwater mussel, *Anodonta imbecilis*. Environ. Toxicol. Chem. 10(4) :539-546.	108	AF, Tox, Dur	
Kuhnert, P.M. and B.R. Kuhnert. 1976. The effect of in vivo chromium exposure on Na/K- and Mg-ATPase activity in several tissues of the rainbow trout (*Salmo gairdneri*). Bull. Environ. Contam. Toxicol. 15(4): 383-390.	14243	AF, UEndp, Biom, Dur	
Lenzi, E., E.B. Luchese and S.B. De Lima. 1994. Improvement of the *Eichhornia crassipes* - water hyacinth - use in the decontamination of chrominum contaminated solution. Arq. Biol. Tecnol. (Curitiba) 37(3): 603-609 (POR) (ENG ABS).	14325	AF, UEndp, Dur	
Lewis, J.W., A.N. Kay and N.S. Hanna. 1994. Responses of electric fish (Family Mormyridae) to chemical changes in water quality: III. Heavy metals. Environ. Technol. 15(10): 969-978.	17039	AF, UEndp, Dur	
Mao, S. and C. Wang. 1990. The effect of some pollutants on SCE of grass carp (*Ctenopharyngodon idellus*) cells. Oceanol. Limnol. Sin./Haiyang Yu Huzhao 21(3): 205-211 (CHI) (ENG ABS).	9540	AF, UEndp, Tox, Dur	
Mayer, F.L.J. and M.R. Ellersieck. 1986. Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals. Resour. Publ. No. 160, U.S. Dep. Interior, Fish Wildl. Serv., Washington, DC: 505 p. (USGS Data File).	6797	AF, Tox	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Mount, D.I. and T.J. Norberg. 1984. A seven-day life-cycle cladoceran toxicity test. Environ. Toxicol. Chem. 3(3): 425-434 (Author Communication Used).	11181	Tox / AF, Tox	
Mukai, H. 1977. Effects of chemical pretreatment on the germination of statoblasts of the freshwater bryozoan, *Pectinatella gelatinosa*. Biol. Zentralbl. 96: 19-31.	705	AF, UEndp, Dur	
Munzinger, A. and F. Monicelli. 1991. A comparison of the sensitivity of three *Daphnia magna* populations under chronic heavy metal stress. Ecotoxicol. Environ. Saf. 22: 24-31.	3950	AF, UEndp, Tox	
Munzinger, A. and F. Monicelli. 1992. Heavy metal co-tolerance in a chromium tolerant strain of *Daphnia magna*. Aquat. Toxicol. 23(3/4): 203-216.	6162	AF, UEndp, Tox	
Muramoto, S. 1981. Influence of complexans (NTA, EDTA) on the toxicity of trivalent chromium (chromium chloride, sulfate) at levels lethal to fish. J. Environ. Sci. Health A16(6): 605-610.	15431	AF, UEndp, Dur	
Nalecz-Jawecki, G. and J. Sawicki. 1998. Toxicity of inorganic compounds in the spirotox test: A miniaturized version of the *Spirostomum ambiguum* test. Arch. Environ. Contam. Toxicol. 34(1): 1-5.	18997	AF, Ace	
Nath, K. and N. Kumar. 1987. Effect of hexavalent chromium on the carbohydrate metabolism of a freshwater tropical teleost *Colisa fasciatus*. C. A. Sel.-Environ. Pollut.25: 107-213161T / Bull. Inst. Zool. Acad. Sin.(Taipei) 26(3): 245-248.	12719	AF, UEndp, Tox, Dur	
Nath, K. and N. Kumar. 1987. Toxic impact of hexavalent chromium on the blood pyruvate of *Colisa fasciatus*. Acta Hydrochim. Hydrobiol. 15(5): 531-534.	12803	AF, UEndp, Tox, Dur	
Pardue, W.J. and T.S. Wood. 1980. Baseline toxicity data for freshwater bryozoa exposed to copper, cadmium, chromium, and zinc. J. Tenn. Acad. Sci. 55(1): 27-31.	6703	AF, Tox	
Patrick, F.M. and M.W. Loutit. 1978. Passage of metals to freshwater fish from their food. Water Res. 12: 395-398 (Used Ref 15021).	2709	AF, RouExp, Tox, UEndp	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Patrick, R., T. Bott and R. Larson. 1975. The Role of Trace Elements in Management of Nuisance Growths. EPA 600/2-75-008, U.S. EPA, Corvallis, OR: 250 p. (U.S. NTIS PB-241985).	14692	AF, Plant, NoOrg, Tox, UEndp, Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Pickering, Q.H. 1988. Evaluation and comparison of two short-term fathead minnow tests for estimating chronic toxicity. Water Res. 22(7): 883-893.	13227	Tox / AF, Tox	
Rai, U.N. and P. Chandra. 1989. Removal of heavy metals from polluted waters by *Hydrodictyon reticulatum* (Linn.) Lagerheim. Sci. Total Environ. 87/88: 509-515.	3348	AF, Plant, Tox, UEndp, Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Rehwoldt, R., L. Lasko, C. Shaw and E. Wirhowski. 1973. The acute toxicity of some heavy metal ions toward benthic organisms. Bull. Environ. Contam. Toxicol. 10(5): 291-294.	2020	AF, Plant, NoOrg	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Richter, J.E. 1982. Memo to C.E. Stephan, U.S. EPA, Duluth, MN. Results of Algal Toxicity Tests with Priority Pollutants. Center for Lake Superior Environmental Stud., Univ. of Wisconsin-Superior, Superior, WI: 12 p.	14312	AF, Plant	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Ruesink, R.G. and L.L. Smith Jr. 1975. The relationship of the 96-hr LC50 to the lethal threshold concentration of hexavalent chromium, phenol, and sodium pentachlorophenate for fathead minnows (*Pimephales promelas* Rafinesque). Trans. Am. Fish. Soc. 104(3): 567-570 (Personal Communication Used as Reference).	837	AF, Tox	
Saltabas, O. and G. Akcin. 1994. Removal of chromium, copper and nickel by water hyacinth (*Eichhornia crassipes*). Toxicol. Environ. Chem. 41: 131-134.	14541	AF, Plant, Tox, Uendp	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Santojanni, A., G. Gorbi and F. Sartore. 1998. Prediction of fecundity in chronic toxicity tests on *Daphnia magna*. Water Res. 32(10): 3146-3156.	19658	AF, UEndp, Tox, Dur	
Sarkar, S.K. 1989. Evaluation of two heavy metals on the oxygen consumption of *Tilapia mossambica* (Peters). Geobios 16(2/3): 108-110.	13389	AF, UEndp, Dur	
Sastry, K.V. and K.M. Sunita. 1982. Effect of cadmium and chromium on the intestinal absorption of glucose in the snakehead fish, *Channa punctatus*. Toxicol. Lett. 10(2/3): 293-296.	15667	AF, UEndp, Tox, Dur, RouExp, NonRes	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Sauvant, M.P., D. Pepin, C.A. Groliere and J. Bohatier. 1995. Effects of organic and inorganic substances on the cell proliferation of L-929 fibroblasts and *Tetrahymena pyriformis* GL protozoa used for toxicological bioassays. Bull. Environ. Contam. Toxicol. 55(2): 171-178.	14980	AF, Ace, Dur	
Sauvant, M.P., D. Pepin, J. Bohatier and C.A. Groliere. 1995. Microplate technique for screening and assessing cytotoxicity of xenobiotics with *Tetrahymena pyriformis*. Ecotoxicol. Environ. Saf. 32(2): 159-165.	16142	AF, Ace, Dur	
Schiffman, R.H. and P.O. Fromm. 1959. Chromium-induced changes in the blood of rainbow trout, *Salmo gairdnerii*. Sewage Ind. Wastes 31: 205-211.	10294	AF, Dur, Tox / UEndp, Dur, Tox	
See, C.L., A.L. Buikema, Jr. and J. Cairns, Jr. 1974. The effects of selected toxicants on survival of *Dugesia tigrina* (Turbellaria). ASB (Assoc. Southeast. Biol.) Bull. 21(2): 82.	8709	AF, Tox	
Shabana, E.F., A.F. Dowidar, I.A. Kobbia and S.A. El Attar. 1986. Studies on the effects of some heavy metals on the biological activities of some phytoplankton species. II. The effects of some metallic ions on the growth criteria and morphology of *Anabaena oryzae* and *Aulosira fertilissima*. Egypt. J. Physiol. Sci. 13(1/2): 55-71.	3385	AF, Plant, UEndp	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Shabana, E.F., I.A. Kobbia, A.E. Dowidar and S.A. El Attar. 1986. Studies on the effects of some heavy metals on the biological activities of some phytoplankton species. III. Effects of Al3+, Cr3+, Pb2+ and Zn2+ on heterocyst frequency, nitrogen and phosphorus metabolism of Anabaena. Egypt. J. Physiol. Sci. 13(1/2): 73-94.	3406	AF, Plant, UEndp, Tox	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Shandilya, S. and V. Banerjee. 1989. Effect of sublethal toxicity of zinc and chromium on peripheral hemogram in the fish *Heteropneustes fossilis*. Environ. Ecol. 7(1):16-23.	2388	AF, UEndp, NonRes, Dur	
Sinha, S., U.N. Rai, R.D. Tripathi and P. Chandra. 1993. Chromium and manganese uptake by *Hydrilla verticillata* (l.f.) Royle: Amelioration of chromium toxicity by manganese. J. Environ. Sci. Health A28(7): 1545-1552.	13288	AF, Plant, UEndp, Tox	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Slabbert, J.L. and J.P. Maree. 1986. Evaluation of interactive toxic effects of chemicals in water using a *Tetrahymena pyriformis* toxicity screening test. Water S.A. 12(2): 57-62.	12836	AF, Ace, UEndp, Dur	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Smissaert, H.R., D.A. Van Bruggen and A.M. Thiadens. 1975. Pitfalls in experiment on a possible toxic effect of chromium III, with special reference to the acetylcholinesterase of the gill of the rainbow. In: J.H. Koeman and J.J.T.W.A. Strik (Eds.), Sublethal Effects of Toxic Chemicals on Aquatic Animals, Elsevier Sci. Publ., Amsterdam, NY: 93-102.	15543	AF, UEndp, Dur	
Snell, T.W. 1991. New Rotifer Bioassays for Aquatic Toxicology. Final Report, U.S. Army Medical Research and Development Command, Ft. Detrick, Frederick, MD: 29 p. (U.S. NTIS AD-A258002).	17689	AF, UEndp, Tox	
Snell, T.W. and B.D. Moffat. 1992. A 2-d life cycle test with the rotifer *Brachionus calyciflorus*. Environ. Toxicol. Chem. 11(9): 1249-1257.	3963	AF, Dur, Tox	
Sornaraj, R., P. Baskaran and S. Thanalakshmi. 1995. Effects of heavy metals on some physiological responses of air-breathing fish *Channa punctatus* (Bloch). Environ. Ecol. 13(1): 202-207.	17380	AF, Tox	
Sornaraj, R., S. Thanalashmi and P. Baskaran. 1995. Influence of heavy metals on biochemical responses of the freshwater air-breathing fish *Channa punctatus* (Bloch). J. Ecotoxicol. Environ. Monit. 5(1): 19-27.	14012	AF, NonRes, UEndp, Dur	
Sprague, J.B. and W.J. Logan. 1979. Separate and joint toxicity to rainbow trout of substances used in drilling fluids for oil exploration. Environ. Pollut. 19(4): 269-281 (Author Communication Used).	869	AF, Tox	
Sridevi, B., K.V. Reddy and S.L.N. Reddy. 1998. Effect of trivalent and hexavalent chromium on antioxidant enzyme activities and lipid peroxidation in a freshwater field crab, *Barytelphusa guerini*. Bull. Environ. Contam. Toxicol. 61(3): 384-390.	19810	AF, Dur	
Stanley, R.A. 1974. Toxicity of heavy metals and salts to Eurasian watermilfoil (*Myriophyllum spicatum* L.). Arch. Environ. Contam. Toxicol. 2(4): 331-341.	2262	AF, Plant, Tox	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Stary, J. and K. Kratzer. 1982. The cumulation of toxic metals on alga. J. Environ. Anal. Chem. 12: 65-71.	14286	AF, Plant, UEndp, Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Stary, J., B. Havlik, K. Kratzer, J. Prasilova and J. Hanusova. 1983. Cumulation of zinc, cadmium and mercury on the alga *Scenedesmus obliquus*. Acta Hydrochim. Hydrobiol. 11(4): 401-409.	14088	AF, Plant, UEndp, Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Stary, J., K. Kratzer, J. Prasilova and T. Vrbska. 1982. The cumulation of chromium and arsenic species in fish (*Poecilia reticulata*). Int. J. Environ. Anal. Chem. 12: 253-257.	14539	AF, Plant, UEndp, Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Tatara, C.P., M.C. Newman, J.T. McCloskey and P.L. Williams. 1998. Use of ion characteristics to predict relative toxicity of mono-, di- and trivalent metal ions: *Caenorhabditis elegans*. Aquat. Toxicol. 42: 255-269.	5072	AF, Dur	
Tomasik, P., C.H.D. Magadza, S. Mhizha and A. Chirume. 1995. The metal-metal interactions in biological systems. Part III. *Daphnia magna*. Water Air Soil Pollut. 82: 695-711.	45194	AF, UEndp, RouExp, Dur	
Tomasik, P., C.M. Magadza, S. Mhizha, A. Chirume, M.F. Zaranyika and S. Muchiriri. 1995. Metal-metal interactions in biological systems. Part IV. Freshwater snail *Bulinus globosus*. Water Air Soil Pollut. 83(1/2): 123-145.	16369	AF, UEndp, NoConc	
Vareille-Morel, C. and C. Chaisemartin. 1982. Natural tolerance and acclimation of different populations of *Austropotamobius pallipes* (Le.) to heavy metals (chromium and lead). Acta Oecol.Oecol.Appl. 3(1): 105-122 (FRE) (ENG ABS).	15732	NonRes	
Venugopal, N.B.R.K. and S.L.N. Reddy. 1992. Nephrotoxic and hepatotoxic effects of trivalent and hexavalent chromium in a teleost fish *Anabas scandens*: Enzymological and biochemical changes. Ecotoxicol. Environ. Saf. 24(3): 287-293.	6572	AF, UEndp, Dur	
Venugopal, N.B.R.K. and S.L.N. Reddy. 1992. Effect of trivalent and hexavalent chromium on renal and hepatic tissue glycogen metabolism of a fresh water teleost *Anabas scandens*. Environ. Monit. Assess. 21(2): 133-140.	7399	AF, UEndp, Dur	
Venugopal, N.B.R.K. and S.L.N. Reddy. 1993. *In vivo* effects of trivalent and hexavalent chromium on renal and hepatic ATPases of a freshwater teleost *Anabas scandens.* Environ. Monit. Assess. 28(2): 131-136.	10731	AF, Dur	
Verma, N., S. Batta and R. Rehal. 1995. Studies on some cyanobacteria for the selection of bioindicators and bioscavengers of chromium metal ions for industrial waste waters. Int. J. Environ. Stud. 47(3/4): 211-215.	19599	AF, UEndp, Tox, Bact, Dur	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Verma, S.R., M. Jain and R.C. Dalela. 1982. A laboratory study to assess separate and in-combination effects of zinc, chromium and nickel to the gish *Mystus vittatus*. Acta Hydrochim. Hydrobiol. 10(1): 23-29.	15793	AF, Tox	
Vijayram, K. and P. Geraldine. 1996. Regulation of essential heavy metals (Cu, Cr, and Zn) by the freshwater prawn *Macrobrachium malcolmsonii* (Milne Edwards). Bull. Environ. Contam. Toxicol. 56(2): 335-342.	16442	AF, UEndp, Tox, Dur	
Vincent, S. and T. Ambrose. 1994. Uptake of heavy metals cadmium and chromium in tissues of the Indian major carp, *Catla catla* (Ham.). Indian J. Environ. Health 36(3): 200-204.	19450	AF, UEndp, Tox, Dur	
Vymazal, J. 1990. Uptake of lead, chromium, cadmium and cobalt by *Cladophora glomerata*. Bull. Environ. Contam. Toxicol. 44(2): 468-472.	2191	AF, Plant, UEndp, Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Vymazal, J. 1990. Uptake of heavy metals by *Cladophora glomerata*. Acta Hydrochim. Hydrobiol. 18(6): 657-665.	45131	AF, Plant, UEndp, Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Vymazal, J. 1995. Influence of pH on heavy metals uptake by *Cladophora glomerata*. Pol. Arch. Hydrobiol. 42(3): 231-237.	45130	AF, Plant, UEndp, Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Wang, W. 1986. Toxicity tests of aquatic pollutants by using common duckweed. Environ. Pollut. Ser. B Chem. Phys. 11(1): 1-14.	11789	AF, Plant, Tox	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Winner, R.W. 1976. Toxicity of Copper to Daphnids in Reconstituted and Natural Waters. EPA-600/3-76-051, U.S. EPA, Duluth, MN: 68 p.(U.S. NTIS PB-252915) (Publ in Part As 8477 and 8478).	8476	AF, Tox	
Wolmarans, C.T., E. Yssel and V.L. Hamilton-Attwell. 1988. Toxic effects of chromium on *Schistosoma haematobium miracidia*. Bull. Environ. Contam. Toxicol. 41(6): 928-935.	8767	AF, UEndp, Dur	
Wooldridge, C.R. and D.P. Wooldridge. 1969. Internal damage in an aquatic beetle exposed to sublethal concentrations of inorganic ions. Ann. Entomol. Soc. Am. 62(4): 921-933.	2868	AF, UEndp, Dur	

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated the studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

3) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[82], EPA is providing a transparent rationale as to why they were not utilized (see below).
4) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable.

<u>General QA/QC failure because non-resident species in Oregon</u>

Tests with the following several species were used in the EPA BE of OR WQS for chromium III in freshwater, but were not considered in the CWA review and approval/disapproval action of the standards because these species do not have a breeding wild population in Oregon's waters:

Ephemerella	*subvaria*	*Mayfly*	Warnick and Bell 1969
Poecilia	*reticulata*	*Guppy*	Pickering and Henderson 1964

<u>Other Acute tests failing QA/QC by species</u>

***Daphnia pulex* - Cladoceran**

The following test was included in EPA's BE of the OR WQS for chromium III in freshwater, but was not used in this CWA review and approval/disapproval action of these standards because it is a 96-hr test, and the 48-hr test for the same species is the preferred data according to the 1985 Guidelines. Also, note that the 96-h LC50 from this test, when normalized to a hardness of 100 mg/L as $CaCO_3$ and expressed on a dissolved basis, was over an order of magnitude lower than the acute values for all other species, including other cladocerans. Data from the 48-hr test in this study was used.

[82] U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

Stackhouse, R.A. and W.H. Benson. 1989. The effect of humic acid on the toxicity and bioavailability of trivalent chromium. Ecotoxicol. Environ. Saf. 17(1): 105-111.

<u>Other Chronic tests failing QA/QC by species</u>

Daphnia magna - Cladoceran

The following test was included in EPA's BE of the OR WQS for chromium III in freshwater, but was not used in this CWA review and approval/disapproval action of these standards because no LOEC was given in the paper, i.e., NOEC is a greater than value, and therefore, a chronic value could not be determined for the study:

Kuhn, R., M. Pattard, K.-D. Pernak and A. Winter. 1989. Results of the harmful effects of water pollutants to *Daphnia magna* in the 21 day reproduction test. Wat. Res. 23(4): 501-510.

Appendix E Chromium VI (freshwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Anderson, 1946.	2130	UEndp, Dur	No Info
Bringmann, G. and R. Kuhn. 1960. The Water-Toxicological Detection of Insecticides (Zum Wasser-Toxikologischen Nachweis von Insektiziden). Gesund.Ing. 8:243-244 (GER).	58990	Det	
Khangarot, B.S., P.K. Ray and H. Chandra. 1987. Daphnia magna as a Model to Assess Heavy Metal Toxicity: Comparative Assessment with Mouse System. Acta Hydrochim.Hydrobiol. 15(4):427-432.	12575	Det	
Merlin, G., P. Eulaffroy and G. Blake. 1993. Use of Fluorescence Induction Kinetics of Lemna minor as a Tool for Chemical Stress Evaluation. Sci.Total Environ.(Suppl.) :761-772.	4334	Plant	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Wang, W. 1986. Toxicity Tests of Aquatic Pollutants by Using Common Duckweed. Environ.Pollut.Ser.B Chem.Phys. 11(1):1-14.	11789	Plant	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Wang, W. 1987. Chromate Ion As a Reference Toxicant for Aquatic Phytotoxicity Tests. Environ.Toxicol.Chem. 6(12):953-960.	12693	Plant	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS

Note: Also see Chromium III

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

3) For the studies that were not utilized, but the most representative GMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC, EPA is providing a transparent rationale as to why they were not utilized (see below).
4) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix E).

General QA/QC failure because non-resident species in Oregon

Tests with the following several species were used in the EPA BE of OR WQS for chromium VI in freshwater, but were not considered in the CWA review and approval/disapproval action of the standards because these species do not have a breeding wild population in Oregon's waters:

Gammarus	*pseudolimnaeus*	Amphipod	Call et al. 1983
Daphnia	*obtusa*	Cladoceran	Rossini and Ronco 1996; Coniglio and Baudo 1989

Other Acute tests failing QA/QC by species

Daphnia pulex* - *Cladoceran

The following tests were included in EPA's BE of the OR WQS for chromium VI in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because the tests were not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for these species.

Mount, D.I. and T.J. Norberg. 1984. A seven-day life-cycle cladoceran toxicity test. Environ. Toxicol. Chem. 3: 425.
One LC50 value from S,U test of 47.14 µg/L.

Cairns, J. Jr., A.L. Buikema, A.G. Heath and B.C. Parker. 1978. Effects of Temperature on Aquatic Organism Sensitivity to Selected Chemicals. Va. Water Resour. Res. Center Bull. 106, OWRT Proj. B-084-VA, Va. Polytechnic Inst. State Univ., Blacksburg, VA: 88 p.
One LC50 value from S,U test of 392.80 µg/L.

Dorn, P.B., J.H. Rodgers Jr., K.M. Jop, J.C. Raia and K.L. Dickson. 1987. Hexavalent chromium as a reference toxicant in effluent toxicity tests. Environ. Toxicol. Chem. 6(6): 435-444.
Eighteen LC50 values from static tests ranging from 19.64 to 166.94 µg/L.

Elnabarawy, M.T., A.N. Welter and R.R. Robideau. 1986. Relative sensitivity of three daphnid species to selected organic and inorganic chemicals. Environ. Toxicol. Chem. 5(4): 393-398.
One LC50 value from S,U test of 119.80 µg/L.

Jop, K.M., A.M. Askew, D.J. Texeira and J. MacGregor. 1993. Quality Control in Aquatic Toxicity Testing Programs: Evaluation of Copper and Hexavalent Chromium as Reference Toxicants. Environ. Toxicol. Risk Assess., ASTM STP 1179, W.G. Landis, J.S. Hughes and M.A. Lewis (Eds.), Amer. Soc. for Testing and Materials, Philadelphia, pp. 397-404.
One LC50 value from S,M test of 183.63 µg/L.

Jop, K.M., J.H. Rodgers Jr., E.E. Price and K.L. Dickson. 1986. Renewal device for test solutions in daphnia toxicity tests. Bull. Environ. Contam. Toxicol. 36: 95-100.
Two LC50 values from static and renewal tests, both with values of 216.04 µg/L.

Jop, K.M., J.H. Rodgers Jr., P.B. Dorn and K.L. Dickson. 1986. Use of hexavalent chromium as a reference toxicant in aquatic toxicity tests. In: T.M. Poston and R. Purdy (Eds.), Aquatic Toxicology and Environmental Fate, 9th Volume, ASTM STP 921, Philadelphia, PA: 390-403.
One LC50 value from a static test of 108.02 µg/L.

Jop, K.M., T.F. Parkerton, J.H. Rodgers Jr., K.L. Dickson and P.B. Dorn. 1987. Comparative toxicity and speciation of two hexavalent chromium salts in acute toxicity tests. Environ. Toxicol. Chem. 6(9): 697-703.
Two LC50 values from static tests, both with values of 216.04 µg/L.

Jop, K.M., R.B. Foster and A.M. Askew. 1991. Factors affecting toxicity identification evaluation: The role of source water used in industrial processes. In: M.A. Mayes and M.G. Barron (Eds.), Aquatic Toxicology and Risk Assessment, 14th Volume, ASTM STP 1124, Philadelphia, PA: 84-93.
One LC50 value from a static test of 216.04 µg/L.

Stackhouse, R.A. and W.H. Benson. 1988. The influence of humic acid on the toxicity and bioavailability of selected trace metals. Aquat. Toxicol. 13(2): 99-108.

One LC50 value from a static test of 356.07 µg/L.

Daphnia magna - Cladoceran

The following tests were included in EPA's BE of the OR WQS for chromium VI in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because the tests were not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for these species.

Anderson, B.G. 1946. The toxicity thresholds of various substances found in industrial wastes as determined by the use of *Daphnia magna*. Sew. Works J. 16: 1156.
Two LC50 values from S,U tests ranging from <103 to <123 µg/L.

Baird, D.J., I. Barber, M. Bradley, A.M.V.M. Soares and P. Calow. 1991. A comparative study of genotype sensitivity to acute toxic stress using clones of *Daphnia magna* Straus. Ecotoxicol. Environ. Saf. 21(3): 257-265.
Six LC50 values from static tests ranging from 98.56 to 283.11 µg/L.

Berglind, R. and G. Dave. 1984. Acute toxicity of chromate, DDT, PCP, TPBS, and zinc to *Daphnia magna* cultured in hard and soft water. Bull. Environ. Contam. Toxicol. 33(1): 63-68.
Two LC50 values from static tests ranging from 265.14 to 314.24 µg/L.

Cairns, J. Jr., A.L. Buikema, A.G. Heath and B.C. Parker. 1978. Effects of Temperature on Aquatic Organism Sensitivity to Selected Chemicals. Va. Water Resour. Res. Center Bull. 106, OWRT Proj. B-084-VA, Va. Polytechnic Inst. State Univ., Blacksburg, VA: 88 p.
Two LC50 values from static tests ranging from 549.92 to 883.80 µg/L.

Call, D.J., L.T. Brooke, N. Ahmad and D.D. Vaishnav. 1981. Aquatic Pollutant Hazard Assessments and Development of a Hazard Prediction Technology by Quantitative Structure-activity Relationships. Second Quarterly Report to EPA. Center for Lake Superior Environmental Studies, University of Wisconsin-Superior, Superior, WI: 74 p.
Twelve LC50 values from S,M tests ranging from 15.02 to 208.18 µg/L.

Cerejeira, M.J., T. Pereira and A. Silva-Fernandes. 1998. Use of new microbiotests with *Daphnia magna* and *Selenstrum capricornutum* immobilized forms. Chemosphere 37(14/15): 2949-2955.
One LC50 value from an unknown test of 638.30 µg/L.

Crisinel, A., L. Delaunay, D. Rossel, J. Tarradellas, H. Meyer, H. Saiah, P. Vogel, C. Delisle and C. Blaise. 1994. Cyst-based ecotoxicological tests using anostracans: Comparison of two species of *Streptocephalus*. Environ. Toxicol. Water Qual. 9(4): 317-326.
One LC50 value from an unknown test of 1031.10 µg/L.

Diamantino, R.C., L. Gilhermino, E. Almeida and A.M.V.M. Soares. 2000. Toxicity of sodium molybdate and sodium dichromate to *Daphnia magna* Straus evaluated in acute, chronic, and acetylcholinesterase inhibition tests. Ecotoxicol. Environ. Saf. 45: 253-259.
One LC50 value from a S,U test of 284.78 µg/L.

Dowden, B.F. and H.J. Bennett. 1965. Toxicity of selected chemicals to certain animals. J. Water Pollut. Control Fed. 37: 1308-1316.
One LC50 value from a S,U test of 138.46 µg/L.

Elnabarawy, M.T., A.N. Welter and R.R. Robideau. 1986. Relative sensitivity of three daphnid species to selected organic and inorganic chemicals. Environ. Toxicol. Chem. 5(4): 393-358.
One LC50 value from a static test of 109.98 µg/L.

Enserink, L., W. Luttmer and H. Maas-Diepeveen. 1990. Reproductive Strategy of Daphnia magna Affects the Sensitivity of Its Progeny in Acute Toxicity Tests. Aquat. Toxicol. 17(1):15-26.
One LC50 value from a static test of 1276.60 µg/L.

Fargasova, A. 1994. Comparative toxicity of five metals on various biological subjects. Bull. Environ. Contam. Toxicol. 53(2): 317-324.
Two LC50 values from static tests ranging from 157.12 to 353.52 µg/L.

Fargasova, A. 1994. Toxicity of metals on *Daphnia magna* and *Tubifex tubifex*. Ecotoxicol. Environ. Saf. 27(2): 210-213.
Two LC50 values from unknown tests ranging from 159.08 to 357.45 µg/L.

Guilhermino, L., T. Diamantino, M.C. Silva and A.M.V.M. Soares. 2000. Acute toxicity test with *Daphnia magna*: An alternative to mammals in the prescreening of chemical toxicity? Ecotoxicol. Environ. Saf. 46(3): 357-362.
One LC50 value from an unknown test of 764.00 µg/L.

Guilhermino, L., T.C. Diamantino, R. Ribeiro, F. Goncalves and A.M.V.M. Soares. 1997. Suitability of test media containing EDTA for the evaluation of acute metal toxicity to *Daphnia magna* Straus. Ecotoxicol. Environ. Saf. 38(3): 292-295.
Two LC50 values from static tests ranging from 183.63 to 224.98 µg/L.

Hermens, J., H. Canton, N. Steyger and R. Wegman. 1984. Joint effects of a mixture of 14 chemicals on mortality and inhibition of reproduction of *Daphnia magna*. Aquat. Toxicol. 5(4): 315-322.
One LC50 value from a static test of 451.72 µg/L.

Janssen, C.R. and G. Persoone. 1993. Rapid toxicity screening tests for aquatic biota. 1. Methodology and experiments with *Daphnia magna*. Environ. Toxicol. Chem. 12: 711-717.
One LC50 value from a static test of 157.12 µg/L.

Kazlauskiene, N., A. Burba and G. Svecevicius. 1994. Acute toxicity of five galvanic heavy metals to hydrobionts. Ekologija 1: 33-36.
One LC50 value from a renewal test of 147.30 µg/L.

Kim, S.D., K.S. Park and M.B. Gu. 2002. Toxicity of hexavalent chromium to *Daphnia magna*: Influence of reduction reaction by ferrous iron. J. Hazard. Mat. A93(2): 155-164.
One LC50 value from a S,U test of 5361.32 µg/L.

Office of Pesticide Programs. 2000. Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB)). Environmental Fate and Effects Division, U.S. EPA, Washington, D.C.
One LC50 value from a static test of 746.32 µg/L.

Oikari, A., J. Kukkonen and V. Virtanen. 1992. Acute toxicity of chemicals to D*aphnia magna* in humic waters. Sci. Total Environ. 117/118: 367-377.
One LC50 value from a static test of 19.64 µg/L.

Stephenson, R.R. and S.A. Watts. 1984. Chronic toxicity tests with *Daphnia magna*: The effects of different food and temperature regimes on survival, reproduction and growth. Environ. Pollut. Ser. A Ecol. Biol. 36(2): 95-107.
Ten LC50 values from static tests ranging from 34.37 to 117.84 µg/L.

Trabalka, J.R. and C.W. Gehrs. 1977. An observation on the toxicity of hexavalent chromium to *Daphnia magna*. Toxicol. Letters 1: 131.
One LC50 value from a S,M test of 49.10 µg/L.

White, B. 1979. Report of two toxicity evaluations conducted using hexavalent chromium. Michigan Department of Natural Resources.
Two LC50 values from S,M tests ranging from 154.17 to 171.85 µg/L.

Ceriodaphnia reticulata - Cladoceran

The following tests were included in EPA's BE of the OR WQS for chromium VI in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because the tests were not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for these species.

Elnabarawy, M.T., A.N. Welter and R.R. Robideau. 1986. Relative sensitivity of three daphnid species to selected organic and inorganic chemicals. Environ. Toxicol. Chem. 5(4): 393-358.
One LC50 value from a S,U test of 191.49 µg/L.

Simocephalus vetulus - Cladoceran

The following tests were included in EPA's BE of the OR WQS for chromium VI in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because the tests were not based on the preferred flow-through measured test conditions when other tests with the species were.

Mount, D.I. and T.J. Norberg. 1984. A seven-day life-cycle cladoceran toxicity test. Environ. Toxicol. Chem. 3: 425.
One LC50 value from a S,U test of 49.10 µg/L.

Gammarus pseudolimnaeus - Cladoceran

The following tests were included in EPA's BE of the OR WQS for chromium VI in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because the tests were not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for these species.

Call, D.J., L.T. Brooke, N. Ahmad and D.D. Vaishnav. 1981. Aquatic Pollutant Hazard Assessments and Development of a Hazard Prediction Technology by Quantitative Structure-activity Relationships. Second Quarterly Report to EPA. Center for Lake Superior Environmental Studies, University of Wisconsin-Superior, Superior, WI: 74 p.
One LC50 value from a S,M test of 99.18 µg/L. Some data from this study was used for this species.

Call, D.J., L.T. Brooke, N. Ahmad and J.E. Richter. 1983. Toxicity and metabolism studies with EPA priority pollutants and related chemicals in freshwater organisms. PB83-263665. National Technical Information Service, Springfield, VA.
One LC50 value from a S,U test of 92.41 µg/L. Some data from this study was used for this species.

<u>Other Chronic tests failing QA/QC by species</u>

Daphnia magna - Cladoceran

Gorbi, G., M.G. Corradi, M. Invidia, L. Rivara and M. Bassi. 2002. Is Cr(VI) toxicity to *Daphnia magna* modified by food availability or algal exudate? The hypothesis of a specific chromium/algae/exudates interaction. Water Res. 36(8): 1917-1926.
The concentrations in this chronic test were unmeasured. Unmeasured chronic tests are considered "other" data and relegated to Table 6 per the 1985 Guidelines.

Kuhn, R., M. Pattard, K. Pernak and A. Winter. 1989. Results of the harmful effects of water pollutants to *Daphnia magna* in the 21 day reproduction test. Water Res. 23(4): 501-510 (OECDG Data File).
This test did not report a corresponding LOEC with the NOEC. Furthermore, many details were missing in this report.

Munzinger, A. and F. Monicelli. 1991. A comparison of the sensitivity of three *Daphnia magna* populations under chronic heavy metal stress. Ecotoxicol. Environ. Saf. 22: 24-31.
Effects occurred at all concentrations tested. The value used in the BE is an LOEC indicated with an effect occurring less than "<" 4.81 µg/L. Other tests were available and provided definitive chronic values for the species. Interestingly, this value corresponds with the SMCV calculated for *Daphnia magna* from those definitive tests.

Ceriodaphnia dubia - Cladoceran

DeGraeve, G.M., J.D. Cooney, B.H. Marsh, T.L. Pollock and N.G. Reichenbach. 1992. Variability in the performance of the 7-d *Ceriodaphnia dubia* survival and reproduction test: An intra- and interlaboratory study. Environ. Toxicol. Chem. 11(6): 851-866.

This study was rejected because a corresponding LOEC cannot be determined from the article as published.

Appendix F Dieldrin (freshwater)

Studies Not Pertinent to this Determination

(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Adema, D.M.M. 1978. Daphnia magna as a Test Animal in Acute and Chronic Toxicity Tests. Hydrobiologia 59(2):125-134.	2018	See comment	LC50 value is a greater than highest concentration tested, i.e., > 200 ug/L; other more appropriate data used for the species.
Allan, J.D., and R.E. Daniels. 1980. Sublethal Effects of Pollutants: Test of the Usefulness of Life Table for Evaluating the Impact of Chronic Toxicity. Tech.Rep.No.57, Water Resour.Res.Cen., University of Maryland, College Park, MD:69 p.(U.S.NTIS PB80-216674).	5582	Con	
Argyle, MR.., G.C. Williams, and C.B. Daniel. 1975. Dieldrin in the Diet of Channel Catfish (Ictalurus punctatus): Uptake and Effect on Growth. J.Fish.Res.Board Can. 32(11):2197-2204.	15795	UEndp, Dur, RouExp	
Batterton, J.C., G.M. Boush, and F. Matsumura. 1971. Growth Response of Blue-Green Algae to Aldrin, Dieldrin Endrin and Their Metabolites. Bull.Environ.Contam.Toxicol. 6(6):589-594.	9282	Plant, UEndp, Dur,	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Bedford, J.W., and M.J. Zabik. 1973. Bioactive Compounds in the Aquatic Environment: Uptake and Loss of DDT and Dieldrin by Freshwater Mussels. Arch.Environ.Contam.Toxicol. 1(2):97-111.	2073	UEndp	
Benson, B., and G.M. Boush. 1983. Effect of Pesticides and PCBs on Budding Rates of Green Hydra. Bull.Environ.Contam.Toxicol. 30(3):344-350.	15737	Plant, UEndp	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Bhatnagar, P., S. Kumar, and R. Lal. 1988. Uptake and Bioconcentration of Dieldrin, Dimethoate, and Permethrin by Tetrahymena pyriformis. Water Air Soil Pollut. 40(3/4):345-349.	4707	UEndp, Dur	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Boryslawskyj, M., A.C. Garrood, J.T. Pearson, and D. Woodhead. 1987. Rates of Accumulation of Dieldrin by a Freshwater Filter Feeder: Sphaerium corneum. Environ.Pollut. 43(1):3-13.	12248	UEndp, Dur	
Boryslawskyj, M., T. Garrood, M. Stanger, T. Pearson, and D. Woodhead. 1988. Role of Lipid/Water Partitioning and Membrane Composition in the Uptake of Organochlorine Pesticides Into a Freshwater Mussel. Mar.Environ.Res. 24(1-4):57-61.	13095	UEndp, Dur	
Bowman, M.C., W.L. Oller, T. Cairns, A.B. Gosnell, and K.H. Oliver. 1981. Stressed Bioassay Systems for Rapid Screening of Pesticide Residues. Part I: Evaluation of Bioassay Systems. Arch.Environ.Contam.Toxicol. 10:9-24.	2192	Dur	
Boyd, J.E.. 1957. The Use of Daphnia magna in the Microbioassay of Insecticides. Ph.D.Thesis, Penn.State University, University Park, PA :194.	14647	UEndp, Dur	
Brockway, D.L.. 1972. The Uptake, Storage, and Release of Dieldrin and Some Effects of its Release in the Fish, Cichlasoma bimaculatum (Linnaeus). Ph.D.Thesis, University of Michigan, Ann Arbor, MI:104 p; Diss.Abstr.Int.B Sci.Eng.33(9):4323-4324 (1973).	9050	UEndp, Con	
Bulkley, R.V., L.R. Shannon, and R.L. Kellogg. 1974. Contamination of Channel Catfish with Dieldrin from Agricultural Runoff. Proj.No.A-042-IA, Iowa State Water Res.Inst., Iowa State University, Ames, IA :144 p..	16211	UEndp, Dur	
Burchfield, H.P., and E.E. Storrs. 1954. Kinetics of Insecticidal Action Based on the Photomigration of Larvae of Aedes aegypti (L.). Contrib.Boyce Thompson Inst. 17:439-452.	2929	UEndp, Dur, Con	
Burnett, K.M., and W.J. Liss. 1990. Multi-Steady-State Toxicant Fate and Effect in Laboratory Aquatic Ecosystems. Environ.Toxicol.Chem. 9(3):637-647.	3135	UEndp, Con	
Cairns, J.Jr.. 1968. The Effects of Dieldrin on Diatoms. Mosq.News 28:177-179.	14723	Plant, Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Cairns, J.Jr., and J.J. Loos. 1966. Changes in Guppy Populations Resulting From Exposure to	2429	UEndp, Con	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Dieldrin. Prog.Fish-Cult. 28(4):220-226.			
Cairns, J.Jr., N.R. Foster, and J.J. Loos. 1967. Effects of Sublethal Concentrations of Dieldrin on Laboratory Populations of Guppies, Poecilia reticulata Peters. Proc.Acad.Nat.Sci.Philadelphia 119:75-91.	7386	UEndp, Con	
Christoffers, D., and D.E.W. Ernst. 1983. The In-Vivo Fluorescence of Chlorella fusca as a Biological Test for the Inhibition of Photosynthesis. Toxicol.Environ.Chem. 7:61-71.	45160	Plant, UEndp, Dur,	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Clegg, T.J., and J.L. Koevenig. 1974. The Effect of Four Chlorinated Hydrocarbon Pesticides and One Organophosphate Pesticide on ATP Levels in Three Species of Photosynthesizing Freshwater Algae. Bot.Gaz. 135(4):368-372.	17261	Plant, UEndp, Dur,	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Clemens, H.P., and K.E. Sneed. 1959. Lethal Doses of Several Commercial Chemicals for Fingerling Channel Catfish. U.S.Fish Wildl.Serv.Sci.Rep.Fish.No.316, U.S.D.I., Washington, D.C. :10 p..	934	Pur, Con	
Crosby, D.G., R.K. Tucker, and N. Aharonson. 1966. The Detection of Acute Toxicity with Daphnia magna. Food Cosmet.Toxicol. 4:503-514.	7984	Dur, Con	
Dhanaraj, P.S., S. Kumar, and R. Lal. 1989. Bioconcentration and Metabolism of Aldrin and Phorate by the Blue-Green Algae Anabaena (ARM 310) and Aulosira fertilissima (ARM 68). Agric.Ecosyst.Environ. 25(2-3):187-193.	9990	Plant, UEndp, Dur, Con	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Diamond, J.M., M.J. Parson, and D. Gruber. 1990. Rapid Detection of Sublethal Toxicity Using Fish Ventilatory Behavior. Environ.Toxicol.Chem. 9(1):3-11.	3190	UEndp, Dur	
Douglas, M.T., D.O. Chanter, I.B. Pell, and G.M. Burney. 1986. A Proposal for the Reduction of Animal Numbers Required for the Acute Toxicityto Fish Test (LC50 Determination). Aquat.Toxicol. 8(4):243-249.	12210	Con	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Estenik, J.F., and W.J. Collins. 1979. In Vivo and In Vitro Studies of Mixed-Function Oxidase in an Aquatic Insect, Chironomus riparius. In: M.A.Q.Khan, J.J.Lech, and J.J.Menn (Eds.), Pesticide and Xenobiotic Metabolism in Aquatic Organisms, ACS (Am.Chem.Soc.) Symp.Ser.99 :349-370 (Author Communication Used).	6830	UEndp, Dur, Con	
Ferguson, D.E., D.D. Culley, and W.D. Cotton. 1965. Tolerances of Two Populations of Fresh Water Shrimp to Five Chlorinated Hydrocarbon Insecticides. J.Miss.Acad.Sci. 11:235-237.	8063	Dur	
Frear, D.E.H., and J.E. Boyd. 1967. Use of Daphnia magna for the Microbioassay of Pesticides. I. Development of Standardized Techniques for Rearing Daphnia and Preparation of Dosage-M. J.Econ.Entomol. 60(5):1228-1236.	2820	Dur, Con	
Frederick, L.L.. 1975. Comparative Uptake of a Polychlorinated Biphenyl and Dieldrin by the White Sucker (Catostomus commersoni). J.Fish.Res.Board Can. 32(10):1705-1709.	2294	UEndp, Con	
Gauna, L., A. Caballero de Castro, M. Chifflet de Llamas, and A.M. Pechen de D'Angelo. 1991. Effects of Dieldrin Treatment on Physiological and Biochemical Aspects of the Toad Embryonic Development. Bull.Environ.Contam.Toxicol. 46:633-640.	2638	UEndp, Con	
Georgacakis, E., and M.A.Q. Khan. 1971. Toxicity of the Photoisomers of Cyclodiene Insecticides to Freshwater Animals. C.R.Hebd.Seances Acad.Sci.Ser.D 233(5315):120-121.	9334	Dur, Con	
Gilroy, D.J., H.M. Carpenter, L.K. Siddens, and L.R. Curtis. 1993. Chronic Dieldrin Exposure Increases Hepatic Disposition and Biliary Excretion of [14C]Dieldrin in Rainbow Trout. Fundam.Appl.Toxicol. 20(3):295-301.	13609	UEndp, RouExp	
Glooschenko, W.A.. 1971. The Effect of DDT and Dieldrin upon 14C Uptake by In Situ Phytoplankton in Lakes Erie and Ontario. In: Proc.14th Conf.Int.Assoc.Great Lakes Res., Ann Arbor, MI :219-223.	9337	Plant, UEndp, Dur, Con	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Golow, A.A., and K.S. Aborah. 1992. Acute Toxicity of Wood Tar and Dieldrin to Lebistes reticulatus (PL). Bull.Environ.Contam.Toxicol. 48(3):463-466.	5007	Dur, Con	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Golow, A.A., and T.A. Godzi. 1994. Acute Toxicity of Deltamethrin and Dieldrin to Oreochromis niloticus (LIN). Bull.Environ.Contam.Toxicol. 52(3):351-354.	13799	Pur	
Grant, B.F., and P.M. Mehrle. 1970. Pesticide Effects on Fish Endocrine Function. In: Resour.Publ.No.88, Prog.Sport Fish.Res.1969, Div.Fish.Res., Bur.Sport Fish.Wildl., U.S.D.I., Washington, D.C. :13-15.	17208	UEndp, RouExp	
Grzenda, A.R., W.J. Taylor, and D.F. Paris. 1971. The Uptake and Distribution of Chlorinated Residues by Goldfish (Carassius auratus) Fed a 14C-Dieldrin Contaminated Diet. Trans.Am.Fish.Soc. 100(2):215-221.	9341	UEndp, Dur, RouExp, Con	
Grzenda, A.R., W.J. Taylor, and D.F. Paris. 1972. The Elimination and Turnover of 14C-Dieldrin by Different Goldfish Tissues. Trans.Am.Fish.Soc. 101(4):686-690.	9093	UEndp, Dur,Con, RouExp	
Hashimoto, Y., and J. Fukami. 1969. Toxicity of Orally and Topically Applied Pesticide Ingredients to Carp, Cyprinus carpio Linne. Sci.Pest Control /Botyu-Kagaku 34(2):63-66.	9038	Dur,Con, RouExp	
Hendricks, J.D., T.P. Putnam, and R.O. Sinnhuber. 1979. Effect of Dietary Dieldrin on Aflatoxin B1 Carcinogenesis in Rainbow Trout (Salmo gairdneri). J.Environ.Pathol.Toxicol. 2(3):719-728.	15774	UEndp, RouExp	
Hogan, R.L., and E.W. Roelofs. 1971. Concentrations of Dieldrin in the Blood and Brain of the Green Sunfish, Lepomis cyanellus, at Death. J.Fish.Res.Board Can. 28(4):610-612.	9354	UEndp, Dur, Con	
Hoke, R.A., P.A. Kosian, G.T. Ankley, A.M. Cotter, F.M. Vandermeiden, G.L. Phipps, and E.J. Durhan. 1995. Check Studies with Hyalella azteca and Chironomus tentans in Support of the Development of Sediment Quality Criterion for Dieldrin. Environ.Toxicol.Chem. 14(3):435-443.	14207	UEndp, Dur	
Holden, A.V.. 1966. Organochlorine Insecticide Residues in Salmonid Fish. J.Appl.Ecol. 3:45-53.	4977	UEndp, Dur	
Javaid, M.Y., and A. Waiz. 1972. Acute Toxicity of Five Chlorinated Hydrocarbon Insecticides to the Fish, Channa punctatuts. Pak.J.Sci.Ind.Res. 15(4-5):291-293.	8371	Con	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Jensen, L.D., and A.R. Gaufin. 1966. Acute and Long-Term Effects of Organic Insecticides on Two Species of Stonefly Naiads. J.Water Pollut.Control.Fed. 38(8):1273-1286.	604	Dur	
Jeyasingam, D.N.T., B. Thayumanavan, and S. Krishnaswamy. 1978. The Relative Toxicities of Insecticides on Aquatic Insect Eretes sticticus (Linn.) (Coleoptera: Dytiscidae). J.Madurai Univ. 7(1):85-87.	5182	Dur	
Kader, H.A., B. Thayumanavan, and S. Krishnaswamy. 1976. The Relative Toxicities of Ten Biocides on Spicodiaptomus chelospinus Rajendran (1973) [Copepoda: Calanoida]. Comp.Physiol.Ecol. 1(3):78-82.	5264	Dur	
Kanazawa, J.. 1980. Prediction of Biological Concentration Potential of Pesticides in Aquatic Organisms. Rev.Plant Prot.Res. 13:27-36.	59925	UEndp, Dur	
Kanazawa, J.. 1981. Measurement of the Bioconcentration Factors of Pesticides by Freshwater Fish and Their Correlation with Physicochemical Properties or Acute Toxicities. Pestic.Sci. 12(4):417-424.	15599	UEndp, Dur	
Kanazawa, J.. 1981. Bioconcentration Potential of Pesticides by Aquatic Organisms. Jpn.Pestic.Inf. 39:12-16.	12534	UEndp, Dur	
Kanazawa, J.. 1983. A Method of Predicting the Bioconcentration Potential of Pesticides by Using Fish. Jarq (Jpn.Agric.Res.Q.) 17(3):173-179.	10750	UEndp, Dur, Con	
Karnak, R.E., and W.J. Collins. 1974. The Susceptibility to Selected Insecticides and Acetylcholinesterase Activity in a Laboratory Colony of Midge Larvae, Chironomus tentans. Bull.Environ.Contam.Toxicol. 12(1):62-69.	6267	Dur	
Kawatski, J.A., and J.C. Schmulbach. 1971. Toxicities of Aldrin and Dieldrin to the Freshwater Ostracod Chlamydotheca arcuata. J.Econ.Entomol. 64(5):1082-1085.	9366	Dur	
Kimura, T., and H.L. Keegan. 1966. Toxicity of Some Insecticides and Molluscicides for the Asian Blood Sucking Leech, Hirudo nipponia Whitman. Am.J.Trop.Med.Hyg. 15(1):113-115.	2890	Dur, Con	
Kuwabara, K., A. Nakamura, and T. Kashimoto. 1980. Effect of Petroleum Oil, Pesticides, PCBs and Other Environmental Contaminants on the Hatchability of Artemia salina Dry Eggs. Bull.Environ.Contam.Toxicol. 25(1):69-74.	6548	UEndp, Dur	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
LaBrecque, G.C., J.R. Noe, and J.B. Gahan. 1956. Effectiveness of Insecticides on Granular Clay Carriers Against Mosquito Larvae. Mosq.News 16:1-3.	2808	UEndp, Dur, Pur	1% solution
Lamai, S.L., G.F. Warner, and C.H. Walker. 1999. Effects of Dieldrin on Life Stages of the African Catfish, Clarias gariepinus (Burchell). Ecotoxicol.Environ.Saf. 42(1):22-29.	20063	NonRes / NonRes, UEndp	
Lichtenstein, E.P., K.R. Schulz, R.F. Skrentny, and Y. Tsukano. 1966. Toxicity and Fate of Insecticide Residues in Water. Arch.Environ.Health 12:199-212.	8020	UEndp, Dur	
Liong, P.C., W.P. Hamzah, and V. Murugan. 1988. Toxicity of Some Pesticides Towards Freshwater Fishes. Fish.Bull.Dep.Fish.(Malays.) No .57:13.	3296	Pur	
Lohner, T.W., and W.J. Collins. 1987. Determination of Uptake Rate Constants for Six Organochlorines in Midge Larvae. Environ.Toxicol.Chem. 6(2):137-146.	12298	UEndp, Dur, Con	
Lorio, W.J., J.H. Jenkins, and M.T. Huish. 1976. Deposition of Dieldrin in Four Components of Two Artificial Aquatic Systems and a Farm Pond. Trans.Am.Fish.Soc. 105(6):695-699.	9009	Plant UEndp, Dur / UEndp, Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Lunn, C.R., D.P. Toews, and D.J. Pree. 1976. Effects of Three Pesticides on Respiration, Coughing, and Heart Rates of Rainbow Trout (Salmo gairdneri Richardson). Can.J.Zool. 54(2):214-219.	7846	UEndp, Dur / UEndp, Dur, Con	
Lydy, M.J., K.A. Bruner, D.M. Fry, and S.W. Fisher. 1990. Effects of Sediment and the Route of Exposure on the Toxicity and Accumulation of Neutral Lipophilic and Moderately Water-Soluble Metabolizable Compounds in the Midge, Chironomus riparius. In: W.G.Landis and W.H.Van der Schalie (Eds.), Aquatic Toxicology and Risk Assessment, 13th Volume, ASTM STP 1096, Philadelphia, PA :140-164.	18935	Dur	
Macek, K.J., C.R. Rodgers, D.L. Stalling, and S. Korn. 1970. The Uptake, Distribution and Elimination of Dietary 14C-DDT and 14C-Dieldrin in Rainbow Trout. Trans.Am.Fish.Soc. 99(4):689-695.	9623	UEndp, RouExp	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
MacPhee, C., and R. Ruelle. 1969. Lethal Effects of 1888 Chemicals upon Four Species of Fish From Western North America. Univ.of Idaho Forest, Wildl.Range Exp.Station Bull.No.3, Moscow, ID :112 p..	15148	UEndp, Dur, Con	
Malone, C.R., and B.G. Blaylock. 1970. Toxicity of Insecticide Formulations to Carp Embryos Reared In Vitro. J.Wildl.Manage. 34(2):460-463.	9629	UEndp	
Matsuo, K., and T. Tamura. 1970. Laboratory Experiments on the Effect of Insecticides Against Blackfly Larvae (Diptera: Simuliidae) and Fishes. Sci.Pest Control/Botyu-Kagaku 35(4):125-130.	9634	UEndp, Dur, Pur	
Mayhew, J.. 1955. Toxicity of Seven Different Insecticides to Rainbow Trout Salmo gairdnerii (Richardson). Proc.Iowa J.Acad.Sci. 62:599-606.	6461	UEndp, Dur, Pur	
Mehrle, P.M., and M.E. Declue. 1972. Phenylalanine Metabolism Altered by Dietary Dieldrin. Nature (London) 238(5365):462-463.	9140	UEndp, RouExp, Con	
Mehrle, P.M., F.L. Mayer, and W.W. Johnson. 1977. Diet Quality in Fish Toxicology: Effects on Acute and Chronic Toxicity. In: F.L.Mayer and J.L.Hamelink (Eds.), Aquatic Toxicology and Hazard Evaluation, 1st Symposium, ASTM STP 634, Philadelphia, PA :269-280 (Publ in Part As 6797).	7574	UEndp, RouExp	
Metcalf, R.L., I.P. Kapoor, P.Y. Lu, C.K. Schuth, and P. Sherman. 1973. Model Ecosystem Studies of the Environmental Fate of Six Organochlorine Pesticides. Environ.Health Perspect. 4:35-44.	740	UEndp, Con	
Mitsuhashi, J., T.D.C. Grace, and D.F. Waterhouse. 1970. Effects of Insecticides on Cultures of Insect Cells. Entomol.Exp.Appl. 13:327-341.	2797	UEndp, Dur, Con	
Morgan, W.S.G.. 1975. Monitoring Pesticides by Means of Changes in Electric Potential Caused by Fish Opercular Rhythms. Prog.Water Technol.7(2):33-40 (Author Communication Used).	8151	UEndp, Dur, Con	
Mulla, M.S., R.L. Metcalf, and G. Kats. 1964. Evaluation of New Mosquito Larvicides, with Notes on Resistant Strains. Mosq.News 24(3):312-319.	4431	Dur	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Naqvi, S.M., and D.E. Ferguson. 1968. Pesticide Tolerances of Selected Freshwater Invertebrates. J.Miss.Acad.Sci. 14:121-127.	2093	UEndp, Dur, Con	
Naqvi, S.M.Z.. 1973. Toxicity of Twenty-Three Insecticides to a Tubificid Worm Branchiura sowerbyi From the Mississippi Delta. J.Econ.Entomol. 66(1):70-74.	2798	UEndp, Dur, Con	
Nebeker, A.V., and A.R. Gaufin. 1964. Bioassays to Determine Pesticide Toxicity to the Amphipod Crustacean, Gammarus lacustris. Proc.Utah Acad.Sci. 4(1):64-67.	2094	Con	
Novak, A., B.S. Walters, and D.R.M. Passino. 1980. Toxicity of Contaminants to Invertebrate Food Organisms. Prog.Fish.Res.1980, Great Lakes Fish.Lab., U.S.Fish Wildl.Serv., Ann Arbor, M I:2.	2210	Con	
Office of Pesticide Programs. 2000. Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB)). Environmental Fate and Effects Division, U.S.EPA, Washington, D.C..	344	Dur / UEndp, Dur Con	
Perschbacher, P.W., and J. Sarkar. 1989. Toxicity of Selected Pesticides to the Snakehead, Channa punctata. Asian Fish.Sci. 2(2):249-254.	158	UEndp, Dur, Con	
Phipps, G.L., V.R. Mattson, and G.T. Ankley. 1995. Relative Sensitivity of Three Freshwater Benthic Macroinvertebrates to Ten Contaminants. Arch.Environ.Contam.Toxicol. 28(3):281-286.	14907	Dur	
Rao, T.S., M.S. Rao, and S.B.S. Prasad. 1975. Median Tolerance Limits of Some Chemicals to the Fresh Water Fish "Cyprinus carpio". Indian J.Environ.Health 17(2):140-146.	2077	Pur	
Reinert, R.E., L.J. Stone, and H.L. Bergman. 1974. Dieldrin and DDT: Accumulation From Water and Food by Lake Trout (Salvelinus namaycush) in the Laboratory. Proc.17th Conf.Great Lakes Res .:52-58.	2049	UEndp	
Rettich, F.. 1977. The Susceptibility of Mosquito Larvae to Eighteen Insecticides in Czechoslovakia. Mosq.News 37(2):252-257.	2914	Dur, Con	
Rongsriyam, Y., S. Prownebon, and S. Hirakoso. 1968. Effects of Insecticides on the Feeding Activity of the Guppy, a Mosquito-Eating Fish, in Thailand. Bull.W.H.O. 39:977-980.	3663	Dur, Con	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Sanders, H.O., and O.B. Cope. 1968. The Relative Toxicities of Several Pesticides to Naiads of Three Species of Stoneflies. Limnol.Oceanogr. 13(1):112-117 (Author Communication Used) (Publ in Part As 6797).	889	Dur, Con	
Santerre, C.R., V.S. Blazer, N. Khanna, R.E. Reinert, and F.T. Barrows. 1997. Absorption of Dietary Dieldrin by Striped Bass. Bull.Environ.Contam.Toxicol. 58(2):334-340.	17906	UEndp, RouExp	
Schmulbach, J.C.. 1969. Effects of Chlorinated Hydrocarbon Insecticides on the Freshwater Seed Shrimp. South Dakota University, Vermillion, SD:60 p.(U.S.NTIS PB-188796).	6049	UEndp, Dur, Con	
Schoettger, R.A.. 1970. Fish-Pesticide Research Laboratory: Progress in Sport Fishery Research. U.S.Dep.Interior, Bur.Sport Fish.Wildl.Res., Publ. 106:2-40 (Publ in Part As 6797).	6615	NonRes; Form	Acute data for Korean shrimp was used in Table 1 of the ALC document, but no mention was made of the acute data provided for Oncorhynchus tshawyscha
Shannon, L.R.. 1977. Accumulation and Elimination of Dieldrin in Muscle Tissue of Channel Catfish. Bull.Environ.Contam.Toxicol. 17(6):637-644.	16450	UEndp, Dur, RouExp	
Shannon, L.R.. 1977. Equilibrium Between Uptake and Elimination of Dieldrin by Channel Catfish, Ictalurus punctatus. Bull.Environ.Contam.Toxicol. 17(3):278-284.	16451	UEndp, Dur	
Shim, J.C., and L.S. Self. 1973. Toxicity of Agricultural Chemicals to Larvivorous Fish in Korean Rice Fields. Trop.Med. 15(3):123-130.	8977	Dur, Con	
Silbergeld, E.K. 1973. Dieldrin. Effects of Chronic Sublethal Exposure on Adaptation to Thermal Stress in Freshwater Fish. Environ.Sci.Technol. 7(9):846-849.	8983	UEndp, Dur, Con	
Statham, C.N., and J.J. Lech. 1975. Potentiation of the Acute Toxicity of Several Pesticides and Herbicides in Trout by Carbaryl. Toxicol.Appl.Pharmacol. 34(1):83-87.	5550	UEndp, Dur, Con	
Tsuji, S., Y. Tonogai, Y. Ito, and S. Kanoh. 1986. The Influence of Rearing Temperatures on the Toxicity of Various Environmental Pollutants for Killifish (Oryzias latipes). J.Hyg.Chem./Eisei Kagaku 32(1):46-53 (JPN) (ENG ABS).	12497	Dur, Con	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Van Jaarsveld, J.H.. 1970. Laboratory Study on the Toxicity of Dieldrin to Fresh Water Invertebrates. Phytophylactica 2:269-274.	9712	Dur, Con, Pur	
Vance, B.D., and W. Drummond. 1969. Biological Concentration of Pesticides by Algae. J.Am.Water Words Assoc. 61:360-362.	4967	Plant, UEndp	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Wade, R.A. 1969. Ecology of Juvenile Tarpon and Effects of Dieldrin on Two Associated Species. Tech.Pap.No.41, Sport Fish Wildl., Fish Wildl.Serv., U.S.D.I., Washington, D.C .:85.	16215	Dur	
Warren, C.E. 1972. Effects of Dieldrin on the Longevity, Reproduction and Growth of Aquatic Animals in Laboratory Ecosystems. Oregon State Univ.Environ.Health Sci.Cen .:181-185.	9270	UEndp, RouExp, Con	
Whitten, B.K., and C.J. Goodnight. 1966. Toxicity of Some Common Insecticides to Tubificids. J.Water Pollut.Control Fed. 38(2):227-235.	8046	Con, Pur	
Woltering, D.M. 1983. Environmental Influence on the Response of Aquatic Laboratory Ecosystems to a Toxicant. In: W.E.Bishop, R.D.Cardwell, and B.B.Heidolph (Eds.), Aquatic Toxicology and Hazard Assessment, 6th Symposium, ASTM STP 802, Philadelphia, PA :153-170.	10186	UEndp	

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

3) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[83], EPA is providing a transparent rationale as to why they were not utilized (see below).
4) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix F).

General QA/QC failure because non-resident species in Oregon

The test with the following species was used in the EPA BE of OR WQS for dieldrin in freshwater, but was not considered in the CWA review and approval/disapproval action of the standards because this species does not have a breeding wild population in Oregon's waters:

Claassenia	*sabulosa*	Stonefly	Mayer and Ellersieck 1986

Other Acute tests failing QA/QC by species

Oncorhynchus mykiss – Rainbow Trout

The following tests were included in EPA's BE of the OR WQS for dieldrin in freshwater, but were not used for determining the most representative SMAV in this CWA review and approval/disapproval action of these standards because the tests were not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for these species which was utilized.

Mayer, F.L.J., and M.R. Ellersieck. 1986. Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals. Resour. Publ. No. 160, U.S. Dep. Interior, Fish Wildl. Serv., Washington, DC: 505 p. (USGS Data File).

[83] U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

Three LC50 values from static tests ranging from 1.2 ug/L to 2.3 ug/L.

Van Leeuwen, C.J., P.S. Griffioen, W.H.A. Vergouw and J.L. Maas-Diepeveen. 1985. Differences in susceptibility of early life stages of rainbow trout (*Salmo gairdneri*) to environmental pollutants. Aq. Toxicol. 7: 59-78.
One LC50 value from a static or renewal test of 3 µg/L.

Katz, M. 1961. Acute toxicity of some organic insecticides to three species of salmonids and to the threespine stickleback. Trans. Am. Fish. Soc. 90(3): 264-268.
One LC50 value from S,U test of 9.9 µg/L.

Macek, K.J., C. Hutchinson and O.B. Cope. 1969. The effects of temperature on the susceptibility of bluegills and rainbow trout to selected pesticides. Bull. Environ. Contam. Toxicol. 4: 175-183.
Three LC50 values from S,U tests ranging from 1.1 µg/L to 2.4 µg/L.

Pteronarcys californicus – Stonefly

The following test was included in EPA's BE of the OR WQS for dieldrin in freshwater, but was not used for determining the most representative SMAV in this CWA review and approval of these standards because the value was deemed an outlier and unacceptable to use for calculating the SMAV for the species as per 1995 GLI method:

Jensen, L.D. and A.R. Gaufin. 1964. Effects of ten organic insecticides on two species of stonefly naiads. Trans. Am. Fish. Soc. 93(1): 27-34.
P. californicus test was a S,U test using 100% dieldrin which resulted in an LC50 of 39 ug/L.

Appendix G Endrin (freshwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Argyle, R.L., G.C. Williams, and H.K. Dupree. 1973. Endrin Uptake and Release by Fingerling Channel Catfish (Ictalurus punctatus). J.Fish.Res.Board Can. 30(11):1743-1744.	8291	Insuff. Control, Endpoint (ACC)	
Batterton, et al. 1971.		Non-NA, Details, Endpoint (ICxx)	
Bennett, R.O., and R.E. Wolke. 1987. The Effect of Sublethal Endrin Exposure on Rainbow Trout, Salmo gairdneri Richardson. II. The Effect of Altering Serum Cortisol Concentrations on the. J.Fish Biol. 31(3):387-394.	235	Insuff. Control, Endpoint (PHY)	
Bennett, R.O., and R.E. Wolke. 1987. The Effect of Sublethal Endrin Exposure on Rainbow Trout, Salmo gairdneri Richardson. I. Evaluation of Serum Cortisol Concentrations and Immune. J.Fish Biol. 31(3):375-385.	562	Insuff. Control, Endpoint (PHY)	
Bennett, R.O., and R.E. Wolke. 1988. The Effect of Sublethal Endrin Exposure on the Immune Response of Rainbow Trout, Salmo gairdneri. Mar.Environ.Res.24(1-4):351 (ABS).	13092	Endpoint (ACC)	
Bennett, W.N., and J.W. Day Jr.. 1970. Absorption of Endrin by the Bluegill Sunfish, Lepomis macrochirus. Pestic.Monit.J. 3(4):201-203.	9495	Dur, Insuff. Control	
Bonner, J.C., and J.D. Yarbrough. 1988. Vertebrate Cyclodiene Insecticide Resistance: Role of gamma-Aminobutyric Acid and Diazepam Binding Sites. Arch.Toxicol. 62(4):311-315.	5121	Dur, Insuff. Control	
Boyd, C.E., and D.E. Ferguson. 1964. Susceptibility and Resistance of Mosquito Fish to Several Insecticides. J.Econ.Entomol. 57(4):430-431.	10332	Dur	
Boyd, J.E.. 1957. The Use of Daphnia magna in the Microbioassay of Insecticides. Ph.D.Thesis, Penn.State University, University Park, PA :194.	14647	Dur	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Crosby, D.G., R.K. Tucker, and N. Aharonson. 1966. The Detection of Acute Toxicity with Daphnia magna. Food Cosmet.Toxicol. 4:503-514.	7984	Dur, Insuff. Control	
Dalela, R.C., S.R. Verma, and M.C. Bhatnagar. 1978. Biocides in Relation to Water Pollution. Part I: Bioassay Studies on the Effects of a Few Biocides on Fresh Water Fish, Channa gachua. Acta Hydrochim.Hydrobiol. 6(1):15-25 (Author Communication Used).	5736	Non-NA, Dur, Purity	20 Emulsified Concentration
Denison, M.S., J.E. Chambers, and J.D. Yarbrough. 1985. Short-Term Interactions between DDT and Endrin Accumulation and Elimination in Mosquitofish (Gambusia affinis). Arch.Environ.Contam.Toxicol. 14(3):315-320.	10811	Dur, Insuff. Control, Endpoint (ACC)	
Devillers, J., T. Meunier, and P. Chambon. 1985. Advantage of the Dosage-Action-Time Relation in Ecotoxicology for the Test of the Various Chemical Species of Toxics. Tech.Sci.Munic. 80:329-334 (FRE) (ENG ABS).	17456	Dur	
El Refai, A., F.A. Fahmy, M.F.A. Abdel-Lateef, and A.K.E. Imam. 1976. Toxicity of Three Insecticides to Two Species of Fish. Int.Pest Control 18(6):4-8.	6090	Dur, Purity	19.5% Emulsified Concentration
Eller, L.L.. 1971. Histopathologic Lesions in Cutthroat Trout (Salmo clarki) Exposed Chronically to the Insecticide Endrin. Am.J.Pathol. 64(2):321-336.	9317	Dur, Insuff. Control, Endpoint (HIS)	
Fabacher, D.L.. 1976. Toxicity of Endrin and an Endrin-Methyl Parathion Formulation to Largemouth Bass Fingerlings. Bull.Environ.Contam.Toxicol. 16(3):376-378.	6207	Dur, Insuff. Control, Unknown Endpoint	
Fabacher, D.L., and H. Chambers. 1971. A Possible Mechanism of Insecticide Resistance in Mosquitofish. Bull.Environ.Contam.Toxicol. 6(4):372-376.	15104	Dur, Insuff. Control, Endpoint (PHY)	
Ferguson, D.E., and C.R. Bingham. 1966. Endrin Resistance in the Yellow Bullhead, Ictalurus natalis. Trans.Am.Fish.Soc. 95(3):325-326.	4388	Dur, Insuff. Control	
Ferguson, D.E., and C.R. Bingham. 1966. The Effects of Combinations of Insecticides on Susceptible and Resistant Mosquito Fish. Bull.Environ.Contam.Toxicol. 1(3):97-103.	10340	Dur, Insuff. Control, Unknown Endpoint	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Ferguson, D.E., D.D. Culley, and W.D. Cotton. 1965. Tolerances of Two Populations of Fresh Water Shrimp to Five Chlorinated Hydrocarbon Insecticides. J.Miss.Acad.Sci. 11:235-237.	8063	Dur	
Ferguson, D.E., D.D. Culley, W.D. Cotton, and R.P. Dodds. 1964. Resistance to Chlorinated Hydrocarbon Insecticides in Three Species of Freshwater Fish. Bioscience 14(1):43-44.	10341	Dur	
Ferguson, D.E., J.L. Ludke, and G.G. Murphy. 1966. Dynamics of Endrin Uptake and Release by Resistant and Susceptible Strains of Mosquitofish. Trans.Am.Fish.Soc. 95(4):335-344.	4389	Dur, Insuff. Control, Endpoint (ACC, Lethal, Unknown)	
Finley, M.T., D.E. Ferguson, and J.L. Ludke. 1970. Possible Selective Mechanisms in the Development of Insecticide-Resistant Fish. Pestic.Monit.J. 3(4):212-218.	9556	Species, Dur, Endpoint (Lethal, No Effect), Dietary Exp	
Frear, D.E.H., and J.E. Boyd. 1967. Use of Daphnia magna for the Microbioassay of Pesticides. I. Development of Standardized Techniques for Rearing Daphnia and Preparation of Dosage-M. J.Econ.Entomol. 60(5):1228-1236.	2820	Dur, Insuff. Control	
Georgacakis, E., and M.A.Q. Khan. 1971. Toxicity of the Photoisomers of Cyclodiene Insecticides to Freshwater Animals. C.R.Hebd.Seances Acad.Sci.Ser.D 233(5315):120-121.	9334	Dur, Insuff. Control	
Ghazaly, K.S. 1991. Physiological Alterations in Claria lazera Induced by Two Different Pollutants.' Water Air Soil Pollut. 60(1/2):181-187.	3997	Non-NA	
Grant, B.F., and P.M. Mehrle. 1970. Pesticide Effects on Fish Endocrine Function. In: Resour.Publ.No.88, Prog.Sport Fish.Res.1969, Div.Fish.Res., Bur.Sport Fish.Wildl., U.S.D.I., Washington, D.C. :13-15.	17208	Dur, Endpoint (Lethal)	
Hansen, D.J., E. Matthews, S.L. Nall, and D.P. Dumas. 1972. Avoidance of Pesticides by Untrained Mosquitofish, Gambusia affinis. Bull.Environ.Contam.Toxicol. 8(1):46-51.	5147	Dur, Insuff. Control	
Hashimoto, Y., and J. Fukami. 1969. Toxicity of Orally and Topically Applied Pesticide Ingredients to Carp, Cyprinus carpio Linne. Sci.Pest Control /Botyu-Kagaku 34(2):63-66.	9038	Dur, Insuff. Control, Endpoint (LD50), Dietary Exp	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Henderson, C., Q.H. Pickering, and C.M. Tarzwell. 1960. The Toxicity of Organic Phosphorus and Chlorinated Hydrocarbon Insecticides to Fish. In: C.M.Tarzwell (Ed.), Biological Problems in WAter Pollution, Trans.2nd Seminar, April 20-24, 1959, Tech.Rep.W60-3, U.S.Public Health Service, R.A.Taft Sanitary Engineering Center, Cincinnati, OH :76-88.	936	Insuff. Control	
Hermanutz, R.O., J.G. Eaton, and L.H. Mueller. 1985. Toxicity of Endrin and Malathion Mixtures to Flagfish (Jordanella floridae). Arch.Environ.Contam.Toxicol. 14:307-314.	10687	96 h LC50 = 0.85 ug/L	This study appears to provide an appropriate 96 h LC50 for J. floridae, but the paper should be secured to ensure acceptability. Species is relatively insensitive to acute endrin exposure.
Javaid, M.Y., and A. Waiz. 1972. Acute Toxicity of Five Chlorinated Hydrocarbon Insecticides to the Fish, Channa punctatuts.' Pak.J.Sci.Ind.Res. 15(4-5):291-293.	8371	Non-NA	
Joshi, H.C., D. Kapoor, R.S. Panwar, and R.A. Gupta. 1975. Toxicity of Some Insecticides to Chironomid Larvae. Indian J.Environ.Health 17(3):238-241.	7954	Species, Dur, Purity	20 Emulsified Concentration
Khangarot, B.S., A. Sehgal, and M.K. Bhasin. 1985. Man and Biosphere-Studies on the Sikkim Himalayas. Part 6: Toxicity of Selected Pesticides to Frog Tadpole Rana hexadactyla (Lesson). Acta Hydrochim.Hydrobiol. 13(3):391-394.	11521	Dur, Purity	20 Emulsified Concentration
Khudairi, S.Y.A.D., and E. Ruber. 1974. Survival and Reproduction of Ostracods As Affected by Pesticides and Temperature. J.Econ.Entomol. 67(1):22-24.	8599	Dur, Insuff. Control	
Kulkarni, K.M., and S.V. Kamath. 1980. The Metabolic Response of Paratelphusa jacquemontii to Some Pollutants. Geobios (Jodhpur) 7(2):70-73 (Author Communication Used).	5036	Dur, Endpoint (PHY)	
LaBrecque, G.C., J.R. Noe, and J.B. Gahan. 1956. Effectiveness of Insecticides on Granular Clay Carriers Against Mosquito Larvae. Mosq.News 16:1-3.	2808	Dur, Purity, Unknown Endpoint	
Lincer, J.L., J.M. Solon, and J.H. Nair Iii. 1970. DDT and Endrin Fish Toxicity Under Static Versus Dynamic Bioassay Conditions. Trans.Am.Fish.Soc. 99(1):13-19.	9615	Dur, Insuff. Control	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Ludke, J.L., D.E. Ferguson, and W.D. Burke. 1968. Some Endrin Relationships in Resistant and Susceptible Populations of Golden Shiners, Notemigonus crysoleucas. Trans.Am.Fish.Soc. 97:260-263.	5458	Dur, Endpoint (ACC)	
Macek, K.J., C. Hutchinson, and O.B. Cope. 1969. The Effects of Temperature on the Susceptibility of Bluegills and Rainbow Trout to Selected Pesticides. Bull.Environ.Contam.Toxicol. 4(3):174-183 (Publ in Part As 6797).	2085	Dur, Insuff. Control	
MacPhee, C., and R. Ruelle. 1969. Lethal Effects of 1888 Chemicals upon Four Species of Fish From Western North America. Univ.of Idaho Forest, Wildl.Range Exp.Station Bull.No.3, Moscow, ID :112 p.	15148	Dur, Insuff. Control, Unknown Endpoint	
Malone, C.R., and B.G. Blaylock. 1970. Toxicity of Insecticide Formulations to Carp Embryos Reared In Vitro. J.Wildl.Manage. 34(2):460-463.	9629	Dur, Endpoint (Lethal)	
Mane, U.H., M.S. Kachole, and S.S. Pawar. 1979. Effect of Pesticides and Narcotants on Bivalve Molluscs. Malacologia 18:347-360.	8286	Dur, Endpoint (HIS)	
McCorkle, F.M., J.E. Chambers, and J.D. Yarbrough. 1977. Acute Toxicities of Selected Herbicides to Fingerling Channel Catfish, Ictalurus punctatus. Bull.Environ.Contam.Toxicol. 18(3):267-270.	858	Insuff. Control	
McKim, J.M., and H.M. Goeden. 1982. A Direct Measure of the Uptake Efficiency of a Xenobiotic Chemical Across the Gills of Brook Trout (Salvelinus fontinalis) Under Normoxic and. Comp.Biochem.Physiol.C 72(1):65-74.	15606	Dur, Insuff. Control, Endpoint (PHY)	
Metcalf, R.L., I.P. Kapoor, P.Y. Lu, C.K. Schuth, and P. Sherman. 1973. Model Ecosystem Studies of the Environmental Fate of Six Organochlorine Pesticides. Environ.Health Perspect. 4:35-44.	740	Dur, Insuff. Control, Endpoint (ACC)	
Naqvi, S.M., and D.E. Ferguson. 1970. Levels of Insecticide Resistance in Fresh-Water Shrimp, Palaemonetes kadiakensis. Trans.Am.Fish.Soc. 99(4):696-699.	2665	Dur, Insuff. Control	
Naqvi, S.M.Z.. 1973. Toxicity of Twenty-Three Insecticides to a Tubificid Worm Branchiura sowerbyi From the Mississippi Delta. J.Econ.Entomol. 66(1):70-74.	2798	Dur, Insuff. Control, Endpoint (Lethal, Unknown)	

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Panwar, R.S., D. Kapoor, H.C. Joshi, and R.A. Gupta. 1976. Toxicity of Some Insecticides to the Weed Fish, Trichogaster fasciatus (Bloch and Schneider). J.Inl.Fish.Soc.India 8:129-130.	7881	Dur, Purity	20 Emulsified Concentration
Panwar, R.S., R.A. Gupta, H.C. Joshi, and D. Kapoor. 1982. Toxicity of Some Chlorinated Hydrocarbon and Organophosphorus Insecticides to Gastropod, Viviparus bengalensis Swainson. J.Environ.Biol. 3(1):31-36.	14311	Dur, Purity	20 Emulsified Concentration
Rao, T.S., S. Dutt, and K. Mangaiah. 1967. TLM Values of Some Modern Pesticides to the Freshwater Fish - Puntius puckelli. Environ.Health (Nagpur) 9:103-109.	6722	Dur, Purity	20 Emulsified Concentration
Rosato, P., and D.E. Ferguson. 1968. The Toxicity of Endrin-Resistant Mosquito Fish to Eleven Species of Vertebrates. Bioscience 18(8):783-784.	18492	Dur, Endpoint (ACC, Lethal, Unknown), Dietary Exp	
Roy, D., S.A.K. Nasar, and O.P. Dandotia. 1978. Effect of Tafdrin on Colisa fasciatus (Bloch) (Perciformes: Osphronemidae). Bangladesh J.Zool. :147-148.	271	Dur	
Sanders, H.O.. 1969. Toxicity of Pesticides to the Crustacean Gammarus lacustris. Tech.Pap.No.25, Bur.Sports Fish.Wildl., Fish Wildl.Serv., U.S.D.I., Washington, D.C. :18 p. (Author Communication Used)(Used with Reference 732) (Publ in Part As 6797).	885	Dur, Insuff. Control	
Sastry, K.V., and S.K. Sharma. 1978. Endrin Toxicity on Liver of Channa punctatus (Bloch). Indian J.Exp.Biol. 16(3):372-373.	8438	Non-NA, Insuff. Control	
Sharma, S.K., L.D. Chaturvedi, and K.V. Sastry. 1979. Acute Endrin Toxicity on Oxidases of Ophiocephalus punctatus (Bloch). Bull.Environ.Contam.Toxicol. 23(1/2):153-157.	469	Non-NA, Insuff. Control	
Singh, H., and T.P. Singh. 1980. Short-Term Effect of 2 Pesticides on the Survival, Ovarian 32P Uptake and Gonadotrophic Potency in a Freshwater Catfish, Heteropneustes fossilis (Bloch).' J.Endocrinol. 85:193-199.	470	Non-NA	
Singh, H., and T.P. Singh. 1980. Effect of Two Pesticides on Total Lipid and Cholesterol Contents of Ovary, Liver and Blood Serum During Different Phases of the Annual Reproductive C. Environ.Pollut.Ser.A Ecol.Biol. 23(1):9-18.	6646	Non-NA, Purity, Endpoint (PHY)	20 Emulsified Concentration

Citation	ECOTOX EcoRef#	Rejection Code(s)	Comment
Singh, H., and T.P. Singh. 1980. Short-Term Effect of Two Pesticides on Lipid and Cholesterol Content of Liver, Ovary and Blood Serum During the Pre-Spawning Phase in the Freshwater. Environ.Pollut.Ser.A Ecol.Biol. 22(2):85-90.	6647	Non-NA, Endpoint (PHY)	
Sudershan, P., and M.A.Q. Khan. 1980. Metabolic Fate of (14C)Endrin in Bluegill Fish. Pestic.Biochem.Physiol. 14(1):5-12.	9904	Dur, Insuff. Control, Endpoint (ACC)	
Toor, H.S., K. Mehta, and S. Chhina. 1973. Toxicity of Insecticides (Commercial Formulations) to the Exotic Fish, Common Carp Cyprinus carpio communis Linnaeus. J.Res.Punjab.Agric.Univ. 10(3):341-345.	8737	Dur, Purity, Unsatis. Control, Unknown Endpoint	20 Emulsified Concentration
Wells, M.R., and J.D. Yarbrough. 1972. Vertebrate Insecticide Resistance: In Vivo and In Vitro Endrin Binding to Cellular Fractions From Brain and Liver Tissues of Gambusia. J.Agric.Food Chem. 20(1):14-16.	9220	Dur, Insuff. Control, Endpoint (ACC)	
Yarbrough, J.D., R.T. Roush, J.C. Bonner, and D.A. Wise. 1986. Monogenic Inheritance of Cyclodiene Insecticide Resistance in Mosquitofish, Gambusia affinis. Experientia (Basel) 42(7):851-853.	12987	Dur, Insuff. Control	

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

3) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[84], EPA is providing a transparent rationale as to why they were not utilized (see below).
4) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix G).

[84] U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

General QA/QC failure because non-resident species in Oregon

All data considered in this CWA review and approval/disapproval action of OR WQS for endrin below the chronic criterion or related to the four most sensitive genera were from species that are known or expected to have a breeding wild population in Oregon's waters.

Other Acute tests failing QA/QC by species

Lepomis macrochirus – bluegill

Katz, M. and G.G. Chadwick. 1961. Toxicity of endrin to some Pacific Northwest fishes. Trans. Am. Fish. Soc. 90: 394-397.
This study was deemed unacceptable by the 1995 GLI

The following tests were not used for determining the most representative SMAV in this CWA review and approval/disapproval action of these standards because the tests were not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for these species.

Sanders, H.O. 1972. Toxicity of some Insecticides to Four Species of Malacostracan Crustaceans. U.S. Dep. Inter. Bur. Sport Fish. and Wildl. Tech. Paper 66.
One LC50 value from S,U test of 0.61 ug/L

Henderson, C., Q.H. Pickering and C.M. Tarzwell. 1959. Relative toxicity of ten chlorinated hydrocarbon insecticides to four species of fish. Trans. Am. Fish. Sot. 88: 23-32.
One LC50 value from S,U test of 0.66 ug/L

Macek, K.J., C. Hutchinson and O.B. Cope. 1969. Effects of temperature on the susceptibility of bluegills and rainbow trout to selected pesticides. Bull. Environ. Contam. Toxicol. 4: 174-183.
Three LC50 values from S,U tests ranging from 0.37 to 0.61 ug/L

Pteronarcys californica – stonefly

Jensen, L.D. and A.R. Gaufin. 1966. Acute and long-term effects of organic insecticides on two species of stonefly naiads. J. Water Pollut. Control Fed. 38: 1273-1286.
This study was deemed unacceptable by the 1995 GLI

<u>Other Chronic tests failing QA/QC by species</u>

Pteronarcys californica – stonefly

Anderson, R.L., and D.L. De Foe. 1980. Toxicity and Bioaccumulation of Endrin and Methoxychlor in Aquatic Invertebrates and Fish. Environ.Pollut.Ser.A Ecol.Biol. 22(2):111-121 (Author Communication Used for ECOTOX entries)
Anderson and DeFoe (1980) reported results of 4 and 28-day exposures of a caddisfly (*Brachycentrus americanus*), a stonefly (*Pteronarcys dorsata*), and the bullhead (*Ictalurus melas*, which is now the black bullhead, *Ameiurus melas*) to endrin. For the black bullhead the 96-hr LC50 is 0.45 µg/L and the 28-day LC50 is 0.10 µg/L. A 96-hr LC50 is not reported for the stonefly, but the 28-day LC50 is 0.07 µg/L. For the caddisfly the 96-hr LC50 is 0.34 µg/L and the 28-day LC50 is reported to be >0.034 µg/L. The 96-h LC50s for these tests were not acceptable for SMAV calculation because they were fed tests. The 28-d LC50s were not acceptable to calculate the SMCV because: 1) the point estimate (50% mortality), although long term, is not considered sublethal, and 2) the test with bullhead was not an acceptable ELS test and the tests with the caddisfly and stonefly were not the full life-cycle tests required for invertebtrates.

Oncorhynchus clarki – cutthroat trout

Post, G., and T.R. Schroeder. 1971. Toxicity of Four Insecticides to Four Salmonid Species. Bull.Environ.Contam.Toxicol. 6(2):144-155.
This study did not provide sufficient information concerning the concentration of dissolved oxygen (DO) in the test chambers during the tests. The study states that the concentration of DO in the incoming water supply ranged from 5.9 to 6.0 mg/L and that temperature ranged from 13.6 to 14.6 °C. Thus the DO was initially at 57 to 59% saturation in the incoming water supply. The test temperature was 12.9 °C, which would mean that the DO could be no higher than 56 to 57% saturation. Section 11.2.1 of the American Society for Testing and Materials (ASTM) Standard E729 says that the concentration of DO must be at least 60% during the first 48 hr of a static test and must be at least 40% after 48 hr in a static test; this section also says that DO must be at least 60% at all times during renewal and flow-through tests. Forty percent was allowed after 48 hr in static tests for practical reasons; sixty percent is the preferred minimum. The maximum DO saturation in the test solutions of the Post and Schroeder study was 57 to 59% saturation, based on the concentration of DO in the incoming water, which most likely dropped immediately to no higher than 56 to 57% saturation based on the temperature of the test. In addition, the test solutions also contained fish and acetone, which could use up some DO, so the actual DO saturation most likely continued to fall during the duration of the test. Regarding the tests on malathion, page 147 of Post and Schroeder states “Therefore, the ten experimental fish could be held in the same jar without causing serioous depletion of dissolved oxygen.” This acknowledges depletion of DO during these tests, which is normal in toxicity tests, however

Post and Schroeder gave no indication of what is meant by "serious depletion". Thus there is very strong evidence that the concentration of DO during the toxicity tests was below 60% and might have been substantially below 60% due to the biological oxygen demand of acetone and due to the uptake of oxygen by the test organisms.

In addition, Section 9.2.3 of ASTM Standard E729 says that any organic solvent used should be reagent-grade or better and its concentration in the test solution must not exceed 0.5 mL/L. Post and Schroeder says that acetone was used, but does not give the purity of the acetone or identify how much acetone was used. Also, Section 9.1 of ASTM Standard E729 states that the test material should be reagent-grade or better. Post and Schroeder states that the endrin used in these tests was technical grade and consisted of 95% active ingredient and 5% inert ingredient. The study did not identify the remaining 5% inert ingredients.

Appendix H Lead (freshwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Abbasi, S.A., and R. Soni. 1986. An Examination of Environmentally Safe Levels of Zinc (II), Cadmium (II) and Lead (II) with Reference to Impact on Channelfish Nuria denricus. Environ.Pollut.Ser.A Ecol.Biol. 40(1):37-51.	11078	Con, Dur, AF	
Abdelhamid, A.M., and S.A. El Ayouty. 1991. Effect on Catfish (Clarias lazera) Composition of Ingestion Rearing Water Contaminated with Lead or Aluminum Compounds. Arch.Anim.Nutr. 41(7/8):757-763.	5453	UEndp, Eff, AF	
Adams, E.S.. 1975. Effects of Lead and Hydrocarbons From Snowmobile Exhaust on Brook Trout (Salvelinus fontinalis). Trans.Am.Fish.Soc. 104(2):363-373.	15675	UEndp, Eff, AF, Field	
Akcin, G., O. Saltabas, and H. Afsar. 1994. Removal of Lead by Water Hyacinth (Eichhornia crassipes). J.Environ.Sci.Health A29(10):2177-2183.	14548	UEndp, Dur	
Al Akel, A.S. 1994. Changes in Behaviour, Tissue Glycogen and Blood Chemistry of Freshwater Carp, Cyprinus carpio in Relation to Toxicity of Lead. Z.Angew.Zool. 80(1):87-96.	45064	UEndp	
Alam, M.K., and O.E. Maughan. 1992. The Effect of Malathion, Diazinon, and Various Concentrations of Zinc, Copper, Nickel, Lead, Iron, and Mercury on Fish. Biol.Trace Elem.Res. 34(3):225-236.	7085	AF, UEndp, Eff	
Alam, M.K., and O.E. Maughan. 1995. Acute Toxicity of Heavy Metals to Common Carp (Cyprinus carpio). J.Environ.Sci.Health Part A 30(8):1807-1816.	45566	AF, UEndp	
Allen, P. 1993. Effects of Acute Exposure to Cadmium (II) Chloride and Lead (II) Chloride on the Haematological Profile of Oreochromis aureus (Steindachner). Comp.Biochem.Physiol.C 105(2):213-217.	8038	UEndp, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Allen, P. 1993. Changes in Tissue GSH Concentrations as Indicators of Acute Cadmium or Lead Toxicity. Fresenius Environ.Bull. 2(10):582-587.	16833	UEndp, Dur	
Allen, P. 1994. Accumulation Profiles of Lead and the Influence of Cadmium and Mercury in Oreochromis aureus (Steindachner) During Chronic Exposure. Toxicol.Environ.Chem. 44(1/2):101-112.	16057	UEndp, Eff	
Allen, P.. 1995. Accumulation Profiles of Lead and Cadmium in the Edible Tissues of Oreochromis aureus During Acute Exposure. J.Fish Biol. 47(4):559-568.	16322	UEndp, Eff, Dur	
Allen, P.. 1995. Changes in Tissue Glutathione Levels in the Cichlid Oreochromis aureus (Steindachner) Following Long Term Exposure to Mercury, Cadmium and Lead. Toxicol.Environ.Chem. 49:1-12.	18881	UEndp, Eff	
Allen, P.. 1995. Soft-Tissue Accumulation of Lead in the Blue Tilapia, Oreochromis aureus (Steindachner), and the Modifying Effects of Cadmium and Mercury. Biol.Trace Elem.Res. 50(3):193-208.	45059	UEndp, Eff	
Anderson, B.G. 1948. The Apparent Thresholds of Toxicity to Daphnia magna for Chlorides of Various Metals when Added to Lake Erie Water. Trans.Am.Fish.Soc. 78:96-113.	2054	Dur, AF	
Anderson, B.G. 1948.		Det	No Information - Might be same as above
Anderson, B.G., T.F. Andrews, D.C. Chandler, and W.J. Jahoda. 1948. The Evaluation of Aquatic Invertebrates as Assay Organisms for the Determination of the Toxicity of Industrial Wastes. Am.Pet.Inst.Proj.Final Rep.No.51, The Ohio State University, Columbus, OH.	60644	AF	
Anderson, M.B., J.E. Preslan, L. Jolibois, and J.E. Bollinger. 1997. Bioaccumulation of Lead Nitrate in Red Swamp Crayfish (Procambarus clarkii). J.Hazard.Mater. 54(1-2):15-29.	19697	UEndp, AF	
Anderson, R.L., C.T. Walbridge, and J.T. Fiandt. 1980. Survival and Growth of Tanytarsus dissimilis (Chironomidae) Exposed to Copper, Cadmium, Zinc, and Lead. Arch.Environ.Contam.Toxicol. 9(3):329-335 (Author Communication Used).	5249	Dur, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Anderson, R.V.. 1978. The Effects of Lead on Oxygen Uptake in the Crayfish, Orconectes virilis (Hagen). Bull.Environ.Contam.Toxicol. 20(3):394-400.	15449	UEndp, AF	
Applegate, V.C., J.H. Howell, A.E. Hall Jr., and M.A. Smith. 1957. Toxicity of 4,346 Chemicals to Larval Lampreys and Fishes. Spec.Sci.Rep.Fish.No.207, Fish Wildl.Serv., U.S.D.I., Washington, D.C. :157.	638	UEndp, Con, AF	
Arambasic, M.B., S. Bjelic, and G. Subakov. 1995. Acute Toxicity of Heavy Metals (Copper, Lead, Zinc), Phenol and Sodium on Allium cepa L., Lepidium sativum L. and Daphnia magna St.: Comparative. Water Res. 29(2):497-503.	13712	AF	
Arias, G.S., L. Martinez-Tabche, and I. Galar. 1991. Effects of Paraquat and Lead on Fish Oreochromis hornorum. Bull.Environ.Contam.Toxicol. 46(2):237-241.	94	NonRes	
Ariyoshi, T., S. Shiiba, H. Hasegawa, and K. Arizono. 1990. Profile of Metal-Binding Proteins and Heme Oxygenase in Red Carp Treated With Heavy Metals, Pesticides and Surfactants. Bull.Environ.Contam.Toxicol. 44(4):643-649.	3167	UEndp, Dur, RouExp, AF	
Arshaduddin, M., R. Yasmeen, M. Masood Hussain, and M.A. Khan. 1989. Effect of Two Heavy Metals (Lead and Cadmium) on Growth in the Rotifer Asplanchna intermedia. Pollut.Res. 8(3):129-128.	45163	UEndp, Dur, AF	
Audesirk, G., and T. Audesirk. 1984. Chronic Lead Exposure Reduces Junctional Resistance at an Electrical Synapse. Neurotoxicology 5(4):1-8.	45161	UEndp, AF	
Ay, O., M. Kalay, L. Tamer, and M. Canli. 1999. Copper and Lead Accumulation in Tissues of a Freshwater Fish Tilapia zillii and Its Effects on the Branchial Na,K-ATPase Activity. Bull.Environ.Contam.Toxicol. 62(2):160-168.	20035	UEndp, Dur	
Back, H.. 1983. Interactions, Uptake and Distribution of Barium, Cadmium, Lead and Zinc in Tubificid Worms (Annelida, Oligochaeta). In: 4th Int.Conf.on Heavy Metals in the Environment, Heidelberg, Vol.1, Sept.1983, CEP Consultants Ltd., Edinburgh, U.K. :370-371.	11865	UEndp, AF	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Back, H.. 1990. Epidermal Uptake of Pb, Cd, and Zn in Tubificid Worms. Oecologia 85(2):226-232.	20568	UEndp, AF	
Bailey, H.C., and D.H.W. Liu. 1980. Lumbriculus variegatus, a Benthic Oligochaete, As a Bioassay Organism. In: J.C.Eaton, P.R.Parrish, and A.C.Hendricks (Eds.), Aquatic Toxicology and Hazard Assessment, 3rd Symposium, ASTM STP 707, Philadelphia, PA :205-215.	6502	96 h LC50 approx. 6590 ug/L dissolved lead normalized to 100 mg/L as CaCO3 hardness. Test was static, unmeasured.	This study appears to provide an appropriate 96 h LC50 for L. variegatus, but the paper should be secured to ensure acceptability. Species is relatively insensitive to acute lead exposure. Note: Additional LC50 does not affect SMAV/2 because other flow-through measured data available for species.
Bascombe, A.D., J.B. Ellis, D.M. Revitt, and R.B.E. Shutes. 1990. The Development of Ecotoxicological Criteria in Urban Catchments. Water Sci.Technol. 22(10/11):173-179.	19322	NonRes	
Baudouin, M.F., and P. Scoppa. 1974. Acute Toxicity of Various Metals to Freshwater Zooplankton. Bull.Environ.Contam.Toxicol. 12(6):745-751.	5339	AF, Dur	
Belabed, W., N. Kestali, S. Semsari, and A. Gaid. 1994. Toxicity Study of Some Heavy Metals with Daphnia Test. Tech.Sci.Methodes 6:331-336(FRE)(ENG ABS).	16801	AF, Dur	
Bell, C.E., L.A. Baldwin, P.T. Kostecki, and E.J. Calabrese. 1993. Comparative Response of Rainbow Trout and Rat to the Liver Mitogen, Lead. Ecotoxicol.Environ.Saf. 26(3):280-284.	13277	UEndp, RouExp, AF	
Bender, J.A., E.R. Archibold, V. Ibeanusi, and J.P. Gould. 1989. Lead Removal from Contaminated Water by a Mixed Microbial Ecosystem. Water Sci.Technol. 21(12):1661-1664.	13412	UEndp, Eff, AF	
Bengeri, K.V., and H.S. Patil. 1984. Acute Toxicity of Lead Nitrate and Lead Acetate to a Fresh Water Fish Barbus aurilus and Their Effect on Oxygen Uptake. Bull.Pure Appl.Sci.3 A(1):9-13.	11579	AF	
Bengeri, K.V., and H.S. Patil. 1986. Lead Induced Histological Changes in the Liver of Puntius arulius. J.Anim.Morphol.Physiol. 33(1/2):147-150.	14545	UEndp, Dur, AF	
Bengeri, K.V., and H.S. Patil. 1987. Histopathological Changes in the Gill of Puntius arulius Induced by Lead. J.Anim.Morphol.Physiol. 34(1-2):113-116.	9972	UEndp, AF	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Benyahia, M., C. Crochard, and J.C. Pihan. 1988. Toxicity, Uptake and Release of Lead by Dreissena polymorpha. Effects of EDTA and Phosphates. Haliotis 18:239-249 (FRE) (ENG ABS).	4036	UEndp, Con	
Berglind, R.. 1986. Combined and Separate Effects of Cadmium, Lead and Zinc on Ala-D Activity, Growth and Hemoglobin Content in Daphnia magna. Environ.Toxicol.Chem. 5:989-995.	12155	UEndp, Dur	
Berglind, R., G. Dave, and M.L. Sjobeck. 1985. The Effects of Lead on Delta-Aminolevulinic Acid Dehydratase Activity, Growth, Hemoglobin Content, and Reproduction in Daphnia magna. Ecotoxicol.Environ.Saf. 9(2):216-229.	10906	UEndp, Dur, Con, AF	
Beritic, T., J. Zibar-Sikic, D. Prpic-Majic, and M. Tudor. 1980. Some Morphological and Biochemical Hematological Parameters of Abnormal Lead Absoprtion in Fish. In: M.Branica, Z.Konrad (Eds.), Lead Mar.Environ., Pergamon Press, Oxford, England :263-269.	9749	UEndp, Con, AF	
Biegert, E.K., and V. Valkovic. 1980. Acute Toxicity and Accumulation of Heavy Metals in Aquatic Animals. Period.Biol. 82:25-31(Author Communication Used).	5302	UEndp, LT, Dur	
Biesinger, K.E., and G.M. Christensen. 1972. Effects of Various Metals on Survival, Growth, Reproduction and Metabolism of Daphnia magna. J.Fish Res.Board Can. 29:1691-1700.	2022	Con, Dur	
Bilgrami, K.S., and S. Kumar. 1997. Effects of Copper, Lead and Zinc on Phytoplankton Growth. Biol.Plant. 39(2):315-317.	45158	UEndp, AF	
Biondi, C., E. Fabbri, M.E. Ferretti, D. Sonetti, and A.M. Bolognani Fantin. 1989. Effects of Lead Exposure on cAMP and Correlated Enzymes in Viviparus ater (Mollusca Gastropoda) Nervous System. Comp.Biochem.Physiol.C 94(1):327-333.	3058	UEndp, Dur, AF	
Birge, W.J.. 1978. Aquatic Toxicology of Trace Elements of Coal and Fly Ash. In: J.H.Thorp and J.W.Gibbons (Eds.), Dep.Energy Symp.Ser., Energy and Environmental Stress in Aquatic Systems, Augusta, GA 48:219-240.	5305	Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson. 1980. Aquatic Toxicity Tests on Inorganic Elements Occurring in Oil Shale. In: C.Gale (Ed.), EPA-600/9-80-022, Oil Shale Symposium: Sampling, Analysis and Quality Assurance, March 1979, U.S.EPA, Cincinnati, OH :519-534 (U.S.NTIS PB80-221435).	11838	Dur	
Birge, W.J., J.A. Black, and A.G. Westerman. 1979. Evaluation of Aquatic Pollutants Using Fish and Amphibian Eggs as Bioassay Organisms. In: S.W.Nielsen, G.Migaki, and D.G.Scarpelli (Eds.), Symp.Animals Monitors Environ.Pollut., 1977, Storrs, CT 12:108-118.	4943	Dur	
Birge, W.J., J.E. Hudson, J.A. Black, and A.G. Westerman. 1978. Embryo-Larval Bioassays on Inorganic Coal Elements and in Situ Biomonitoring of Coal-Waste Effluents. In: Symp.U.S.Fish Wildl.Serv., Surface Mining Fish Wildl.Needs in Eastern U.S., W.VA :97-104.	6199	Dur	
Black, M.C., J.R. Ferrell, R.C. Horning, and L.K. Martin Jr.. 1996. DNA Strand Breakage in Freshwater Mussels (Anodonta grandis) Exposed to Lead in the Laboratory and Field. Environ.Toxicol.Chem. 15(5):802-808.	16859	UEndp, AF	
Bleeker, E.A.J., M.H.S. Kraak, and C. Davids. 1992. Ecotoxicity of Lead to the Zebra Mussel Dreissena polymorpha, Pallas. Hydrobiol.Bull. 25(3):233-236.	6741	AF, Eff, Dur	
Bodar, C.W.M., A.V.D. Zee, P.A. Voogt, H. Wynne, and D.I. Zandee. 1989. Toxicity of Heavy Metals to Early Life Stages of Daphnia magna. Ecotoxicol.Environ.Saf. 17(3):333-338.	3854	UEndp, Con, AF	
Bogaerts, P., J. Senaud, and J. Bohatier. 1998. Bioassay Technique Using Nonspecific Esterase Activities of Tetrahymena pyriformis for Screening and Assessing Cytotoxicity of Xenobiotics. Environ.Toxicol.Chem. 17(8):1600-1605.	18353	Ace, UEndp, Dur, AF	
Bolognani Fantin, A.M., A. Franchini, P. Trevisan, and A. Pederzoli. 1992. Histomorphological and Cytochemical Changes Inducedin the Liver of Goldfish Carassius carassius var. auratus by Short-Term Exposure to Lead. Acta Histochem. 92(2):228-235.	8988	UEndp, Con, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Bolognani Fantin, A.M., and B. Rebecchi. 1993. Preliminary Data on Adenylate Energy Charge Variation in Carassius carassius var. auratus Submitted to Lead Intoxication. Sci.Total Environ.(Suppl .):907-912.	4381	UEndp, Dur, AF	
Borgmann, U.. 1980. Interactive Effects of Metals in Mixtures on Biomass Production Kinetics of Freshwater Copepods. Can.J.Fish.Aquat.Sci. 37(8):1295-1302.	9757	NonRes, UEndp, Con	
Borgmann, U., and W.P. Norwood. 1999. Assessing the Toxicity of Lead in Sediments to Hyalella azteca: The Significance of Bioaccumulation and Dissolved Metal. Can.J.Fish.Aquat.Sci. 56(8):1494-1503.	20650	UEndp	
Borgmann, U., R. Cove, and C. Loveridge. 1980. Effects of Metals on the Biomass Production Kinetics of Freshwater Copepods. Can.J.Fish.Aquat.Sci. 37(4):567-575.	9758	NonRes, UEndp, Con	
Borgmann, U., W.P. Norwood, and C. Clarke. 1993. Accumulation, Regulation and Toxicity of Copper, Zinc, Lead and Mercury in Hyalella azteca. Hydrobiologia 259:79-89.	9248	UEndp	
Boutet, C., and C. Chaisemartin. 1973. Specific Toxic Properties of Metallic Salts in Austropotamobius pallipes pallipes and Orconectes limosus. C.R.Soc.Biol.(Paris) 167(12):1933-1938 (FRE) (ENG TRANSL).	5421	Con, Dur, AF	
Brady, D., B. Letebele, J.R. Duncan, and P.D. Rose. 1994. Bioaccumulation of Metals by Scenedesmus, Selenastrum and Chlorella Algae. Water S.A. 20(3):213-218.	45157	UEndp, Dur, AF	
Bresch, H.. 1982. Investigation of the Long-Term Action of Xenobiotics on Fish with Special Regard to Reproduction. Ecotoxicol.Environ.Saf. 6(1):102-112.	10392	Con, AF	
Bringmann, G.. 1975. Determination of the Biologically Harmful Effect of Water Pollutants by Means of the Retardation of Cell Proliferation of the Blue Algae Microcystis. Gesund.Ing. 96(9):238-241 (GER) (ENG TRANSL).	10116	UEndp, Dur, AF	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Bringmann, G., and R. Kuhn. 1959. Water Toxicological Studies with Protozoa as Test Organisms. TR-80-0058, Literature Research Company:13 p.; Gesund.-Ing.80:239-242 (GER); Chem.Abstr. 53:22630D-(GER)(ENG TRANSL).	2394	Ace, UEndp	
Bringmann, G., and R. Kuhn. 1977. The Effects of Water Pollutants on Daphnia magna. Wasser-Abwasser-Forsch. 10(5):161-166(ENG TRANSL)(OECDG Data File)(GER)(ENG ABS).	5718	Con, Dur	
Bringmann, G., and R. Kuhn. 1978. Investigation of Biological Harmful Effects of Chemical Substances Which are Classified as Dangerous for Water on Protozoa. Z.Wasser-Abwasser-Forsch.11(6):210-215, TR-80-0307, Literature Research Company :13 p. (ENG TRANSL) (OECDG Data File).	6601	UEndp, Dur, AF	
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Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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Goettl, J.P.J., and P.H. Davies. 1976. Water Pollution Studies. Job Progress Report, Federal Aid Project F-33-R-11, DNR, Boulder, C O:58.	10208	UEndp, AF	
Goettl, J.P.J., J.R. Sinley, and P.H. Davies. 1972. Laboratory Studies: Water Pollution Studies. In: L.E.Yeager and D.T.Weber (Eds.), Colorado Fish.Res.Rev.No.7, Div.Game Fish Parks, Ft.Collins, CO :36-49.	2122	Con, AF, Dur	
Goettl, J.P.J., J.R. Sinley, and P.H. Davies. 1974. Water Pollution Studies. Job Progress Report, Federal Aid Project F-33-R-9, DNR, Boulder, CO :96 p..	285	Secondary	Same data used from a different study reported by the authors in a subsequent peer-reviewed article
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Hiraoka, Y., S. Ishizawa, T. Kamada, and H. Okuda. 1985. Acute Toxicity of 14 Different Kinds of Metals Affecting Medaka Fry. Hiroshima J.Med.Sci. 34(3):327-330.	12151	UEndp, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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Rao, T.S., M.S. Rao, and S.B.S. Prasad. 1975. Median Tolerance Limits of Some Chemicals to the Fresh Water Fish "Cyprinus carpio". Indian J.Environ.Health 17(2):140-146.	2077	96 h LC50 approx. 182 ug/L dissolved lead normalized to 100 mg/L as CaCO3 hardness. Test was static, unmeasured.	This study appears to provide appropriate 96 h LC50s for C. carpio, but the paper should be secured to ensure acceptability. Species is somewhat sensitive to acute lead exposure; this LC50 was relegated to Table 6 in the 2008 draft update of the lead ALC
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Rao, V.N.R., and S.K. Subramanian. 1982. Metal Toxicity Tests on Growth of Some Diatoms. Acta Bot.Indica 10:274-281.	14425	UEndp, AF	
Rathore, H.S., H. Swarup, S.V.R. Rao, and L.P. Mall. 1978. A Short Note on the Pollution Ecology of Chironomus tentans (Diptera) Larvae in a River. Natl.Acad.Sci.Lett.(India) 1(6):235-236.	2967	UEndp, Con, AF	
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Roldan, B.M., and R.R. Shivers. 1987. The Uptake and Storage of Iron and Lead in Cells of the Crayfish (Orconectes propinquus) Hepatopancreas and Antennal Gland. Comp.Biochem.Physiol.C 86(1):201-214.	370	UEndp, AF	
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Rubio, R., P. Tineo, A. Torreblanca, J. Del Ramo, and J.D. Mayans. 1991. Histological and Electron Microscopical Observations on the Effects of Lead on Gills and Midgut Gland of Procambarus clarkii. Toxicol.Environ.Chem. 31/32:347-352.	9839	UEndp, AF	
Ruby, S.M., P. Jaroslawski, and R. Hull. 1993. Lead and Cyanide Toxicity in Sexually Maturing Rainbow Trout, Oncorhynchus mykiss During Spermatogenesis. Aquat.Toxicol. 26(3/4):225-238.	8194	UEndp	
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Sastry, K.V., and P.K. Gupta. 1978. Alterations in the Activity of Some Digestive Enzymes of Channa punctatus, Exposed to Lead Nitrate. Bull.Environ.Contam.Toxicol. 19(5):549-555.	7160	UEndp, AF, NonRes	
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Sastry, K.V., and P.K. Gupta. 1979. Enzyme Alterations in the Digestive System of Heteropneustes fossilis Induced by Lead Nitrate. Toxicol.Lett. 3(3):145-150.	7242	UEndp, NonRes	

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Sauvant, M.P., D. Pepin, J. Bohatier, and C.A. Groliere. 1995. Microplate Technique for Screening and Assessing Cytotoxicity of Xenobiotics with Tetrahymena pyriformis. Ecotoxicol.Environ.Saf. 32(2):159-165.	16142	Dur, AF, Ace	
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Shaffi, S.A., and S. Jeelani. 1985. Biochemical Compartmentation of Fish Tissues, Heavy Metal Toxicity on Tissue Non-Specific Phosphomonoesterases in Three Fishes. Symp.Biol.Hung. 29:367-386.	17375	UEndp, AF	
Shakoori, A.R., K.A. Mujeeb, M.J. Iqbal, and S.S. Ali. 1992. Biochemical Changes Following Lead Exposure in the Liver and Muscle of a Fresh Water Fish, Cirrhina mrigala. Proc.Pak.Congr.Zool. 12:435-444.	4166	UEndp, Con, AF	
Sharma, M.S., and C.S. Selvaraj. 1994. Zinc, Lead and Cadmium Toxicity to Selected Freshwater Zooplankters. Pollut.Res. 13(2):191-201.	45139	96 h LC50 approx. 6320 ug/L dissolved lead normalized to 100 mg/L as CaCO3 hardness. Test was static, measured.	This study appears to provide appropriate 96 h LC50s for C. reticulata, but the paper should be secured to ensure acceptability. Species is relatively insensitive to acute lead exposure; this LC50 was relegated to Table 6 in the 2008 draft update of the lead ALC
Sharma, R.K., A. Qureshi, and N.A. Qureshi. 1985. Toxic Effect of Lead on Kidney of a Fresh Water Catfish, Clarias batrachus (Linn.). Ind.J.Zool. 13(2):47-50.	13983	UEndp, AF	
Shutes, B., B. Ellis, M. Revitt, and A. Bascombe. 1993. The Use of Freshwater Invertebrates for the Assessment of Metal Pollution in Urban Receiving Waters. In: R.Dallinger and P.S.Rainbow (Eds.), Proc.1st SETAC Env.Conf.: Ecotoxicology of Metals in Intertebrates, Lewis Publ., Boca Raton, FL :201-222.	8859	Field, UEndp, AF	
Sicko-Goad, L.. 1982. A Morphometric Analysis of Algal Response to Low Dose, Short-Term Heavy Metal Exposure. Protoplasma 110(2):75-86.	15576	UEndp, Con, AF	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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Singhal, K.C.. 1994. Biochemical and Enzymatic Alterations Due to Chronic Lead Exposure in the Freshwater Catfish, Heteropneustes fossilis. J.Environ.Biol. 15(3):185-191.	4448	NonRes, UEndp	
Sivakumari, K., M. Ramesh, R. Manavalaramanujam, M.K. Kanagaraj, and R. Manonmani. 1995. Uptake of Lead Nitrate by Cyprinus carpio: Modified by pH. Pollut.Res. 14(3):299-303.	45122	UEndp, AF	
Slabbert, J.L., and J.P. Maree. 1986. Evaluation of Interactive Toxic Effects of Chemicals in Water Using a Tetrahymena pyriformis Toxicity Screening Test. Water S.A. 12(2):57-62.	12836	UEndp, Dur, AF	
Slabbert, J.L., and W.S.G. Morgan. 1982. A Bioassay Technique Using Tetrahymena pyriformis for the Rapid Assessment of Toxicants in Water. Water Res. 16(5):517-523.	11048	UEndp, Dur, AF	
Slowik, J., and M. Pawlaczyk-Szpilowa. 1979. Interaction between Scenedesmus obliquus and the Heavy Metals Copper and Lead. Acta Hydrochim.Hydrobiol. 7(5):503-509.	10072	UEndp, AF	
Snell, T.W.. 1991. New Rotifer Bioassays for Aquatic Toxicology. Final Report, U.S.Army Medical Research and Development Command, Ft.Detrick, Frederick, MD :29 p.(U.S.NTIS AD-A258002).	17689	Dur, AF	
Snell, T.W., B.D. Moffat, C. Janssen, and G. Persoone. 1991. Acute Toxicity Tests Using Rotifers IV. Effects of Cyst Age, Temperature, and Salinity on the Sensitivity of Barachionus calyciflorus. Ecotoxicol.Environ.Saf. 21(3):308-317 (OECDG Data File).	9385	Dur, AF	
Sobotka, J.M., and R.G. Rahwan. 1995. Teratogenesis Induced by Short- and Long-Term Exposure of Xenopus laevis Progeny to Lead. J.Toxicol.Environ.Health 44(4):469-484.	45121	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Sola, F., A. Masoni, and J. Isaia. 1994. Effects of Lead Loads on Branchial Osmoregulatory Mechanisms in the Rainbow Trout Oncorhynchus mykiss. J.Appl.Toxicol. 14(5):343-349.	14449	UEndp, AF, LT	
Sordyl, H.. 1990. Influence of Exposure Time and H+ Concentration of the Water on the Effects of Sublethal Pb2+ Loads on Blood Parameters of the Rainbow Trout (Salmo gairdneri). Zool.Jahrb.Abt.Allg.Zool.Physiol.Tiere 94:141-152.	45128	UEndp, AF	
Soundrapandian, S., and K. Venkataraman. 1990. Effect of Heavy Metal Salts on the Life History of Daphnia similis Claus (Crustacea: Cladocera). Proc.Indian Acad.Sci.Anim.Sci. 99(5):411-418.	3945	Eff, Con, AF	
Spieler, R.E., A.C. Russo, and D.N. Weber. 1995. Waterborne Lead Affects Circadian Variations of Brain Neurotransmitters in Fathead Minnows. Bull.Environ.Contam.Toxicol. 55(3):412-418.	14983	UEndp, AF	
Spieler, R.E., and D.N. Weber. 1991. Effects of Waterborne Lead on Circulating Thyroid Hormones and Cortisol in Rainbow Trout. Med.Sci.Res. 19(15):477.	9513	UEndp, AF	
Srivastav, R.K., S.K. Gupta, K.D.P. Nigam, and P. Vasudevan. 1994. Use of Aquatic Plants for the Removal of Heavy Metals from Wastewater. Int.J.Environ.Stud. 45(1):43-50.	16762	Eff, AF	
Srivastava, A.K.. 1987. Changes Induced by Lead in Fish Testis. J.Environ.Biol. 8(4):329-332.	12649	UEndp, Con	
Srivastava, A.K., and S. Mishra. 1979. Blood Dyscrasia in a Teleost, Colisa fasciatus After Acute Exposure to Sublethal Concentrations of Lead. J.Fish Biol. 14(2):199-203.	5640	Con	
Stallwitz, E., and D.P. Hader. 1993. Motility and Phototatic Orientation of the Flagellate Euglena gracilis Impaired by Heavy Metal Ions. J.Photochem.Photobiol. B:Biol-74.	7299	UEndp, Con	
Stallwitz, E., and D.P. Hader. 1994. Effects of Heavy Metals on Motility and Gravitactic Orientation of the Flagellate, Euglena gracilis. Eur.J.Protistol. 30:18-24.	45123	UEndp, Dur, AF	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Starodub, M.E., P.T.S. Wong, and C.I. Mayfield. 1987. Short Term and Long Term Studies on Individual and Combined Toxicities of Copper, Zinc and Lead to Scenedesmus quadricauda. Sci.Total Environ. 63:101-110.	12380	Dur, AF	
Starodub, M.E., P.T.S. Wong, C.I. Mayfield, and Y.K. Chau. 1987. Influence of Complexation and pH on Individual and Combined Heavy Metal Toxicity to a Freshwater Green Alga. Can.J.Fish.Aquat.Sci. 44:1173-1180.	12817	Dur, AF	
Stauber, J.L., and T.M. Florence. 1987. Mechanism of Toxicity of Ionic Copper and Copper Complexes to Algae. Mar.Biol. 94(4):511-519.	12971	UEndp, AF	
Steele, C.W., S. Strickler-Shaw, and D.H. Taylor. 1989. Behavior of Tadpoles of the Bullfrog, Rana catesbeiana, in Response to Sublethal Lead Exposure. Aquat.Toxicol. 14(4):331-344.	3976	UEndp, AF	
Steele, C.W., S. Strickler-Shaw, and D.H. Taylor. 1991. Failure of Bufo americanus Tadpoles to Avoid Lead-Enriched Water. J.Herpetol. 25(2):241-243.	3635	UEndp, AF	
Stouthart, et al. 1994.		Det	No Information - Might be same as below
Stouthart, J.H.X., F.A.T. Spanings, R.A.C. Lock, and S.E. Wendelaar Bonga. 1994. Effects of Low Water pH on Lead Toxicity to Early Life Stages of the Common Carp (Cyprinus carpio). Aquat.Toxicol. 30(2):137-151.	16689	UEndp, AF	
Stoyanova, D.P., and E.S. Tchakalova. 1993. The Effect of Lead and Copper on the Photosynthetic Apparatus in Elodea canadensis Rich. Photosynthetica 28(1):63-74.	45125	UEndp, AF	
Strickler-Shaw, S., and D.H. Taylor. 1990. Sublethal Exposure of Lead Inhibits Acquisition and Retention of Discriminate Avoidance Learning in Green Frog (Rana clamitans) Tadpoles. Environ.Toxicol.Chem. 9(1):47-52.	3189	UEndp, AF	
Strickler-Shaw, S., and D.H. Taylor. 1991. Lead Inhibits Acquisition and Retention Learning in Bullfrog Tadpoles. Neurotoxicol.Teratol. 13:167-173.	45126	UEndp, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Sultana, R., V.U. Devi, and M.N. Prasad. 1991. Effect of Heavy Metals on the Respiration of the Catfish, Mystus gulio. J.Ecotoxicol.Environ.Monit. 1(3):234-237.	4421	UEndp, AF	
Summerfelt, R.C., and W.M. Lewis. 1967. Repulsion of Green Sunfish by Certain Chemicals. J.Water Pollut.Control Fed.39(12):2030-2038 (Author Communication Used).	2423	UEndp, AF	
Swinehart, J.H.. 1990. The Effects of Humic Substances on the Interactions of Metal Ions wiht Organisms and Liposomes. Final Tech.Rep., Dep.of Chem., Univ.California, Davis, CA :103.	17696	UEndp, Dur, AF	
Swinehart, J.H.. 1992. The Effects of Humic Substances on the Interactions of Metal Ions with Organisms and Liposomes. Final Tech.Rep.U.S.G.S.G-1625, Dep.of Chemistry, Univ.of California, Davis, CA :103.	18060	UEndp, Dur, AF	
Tabche, L.M., C.M. Martinez, and E. Sanchez-Hidalgo. 1990. Comparative Study of Toxic Lead Effect on Gill and Haemoglobin of Tilapia Fish. J.Appl.Toxicol. 10(3):193-195.	172	Con, AF	
Tang, Y., and E.T. Garside. 1987. Preexposure and Subsequent Resistance to Lead in Yearling Brook Trout, Salvelinus fontinalis. Can.J.Fish.Aquat.Sci. 44(5):1089-1091.	12973	AF	
Tao, S., C. Liu, R. Dawson, J. Cao, and B. Li. 1999. Uptake of Particulate Lead via the Gills of Fish (Carassius auratus). Arch.Environ.Contam.Toxicol. 37(3):352-357.	20577	UEndp, AF	
Tarzwell, C.M., and C. Henderson. 1960. Toxicity of Less Common Metals to Fishes. Ind.Wastes 5:12.	2042	Con	
Tatara, C.P., M.C. Newman, J.T. McCloskey, and P.L. Williams. 1997. Predicting Relative Metal Toxicity with Ion Characteristics: Caenorhabditis elegans LC50. Aquat.Toxicol. 39(3/4):279-290.	18605	Dur, AF	
Tatara, C.P., M.C. Newman, J.T. McCloskey, and P.L. Williams. 1998. Use of Ion Characteristics to Predict Relative Toxicity of Mono-, Di- and Trivalent Metal Ions: Caenorhabditis elegans. Aquat.Toxicol. 42:255-269.	5072	Dur, AF	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Tatem, H.E.. 1986. Bioaccumulation of Polychlorinated Biphenyls and Metals From Contaminated Sediment by Freshwater Prawns, Macrobrachium rosenbergii and Clams,. Arch.Environ.Contam.Toxicol. 15(2):171-183.	12002	UEndp, Dur, AF	
Tewari, H., T.S. Gill, and J. Pant. 1987. Impact of Chronic Lead Poisoning on the Hematological and Biochemical Profiles of a Fish, Barbus conchonius (Ham). Bull.Environ.Contam.Toxicol. 38(5):748-752.	12599	UEndp, AF	
Thomas, A.. 1915. Effects of Certain Metallic Salts upon Fishes. Trans.Am.Fish.Soc. 44:120-124.	2865	UEndp, Dur, AF	
Tiedemann, G., M. Kublbeck, and J. Rosmanith. 1984. Interaction of Cadmium and Lead in Fish. (Die Gegenseitige Beeinflussung Von Cadmium Und Blei Im Fischorganismus). Wiss.Umwelt 3:145-154 (Ger) (Eng Abs).	11828	UEndp, Con, AF	
Timmermans, K.R., W. Peeters, and M. Tonkes. 1992. Cadmium, Zinc, Lead and Copper in Chironomus riparius (Meigen) Larvae (Diptera, Chironomidae): Uptake and Effects. Hydrobiologia 241(2):119-134.	6029	Con, AF	
Tomasik, P., C.M. Magadza, S. Mhizha, A. Chirume, M.F. Zaranyika, and S. Muchiriri. 1995. Metal-Metal Interactions in Biological Systems. Part IV. Freshwater Snail Bulinus globosus. Water Air Soil Pollut. 83(1/2):123-145.	16369	UEndp, Dur	
Torreblanca et al. 1977.		Det	No Information
Torreblanca, A., J. Del Ramo, and J. Diaz-Mayans. 1989. Gill ATPase Activity in Procambarus clarkii as an Indicator of Heavy Metal Pollution. Bull.Environ.Contam.Toxicol. 42(6):829-834.	3407	UEndp	
Torreblanca, A., J. Del Ramo, J.A. Arnau, and J. Diaz-Mayans. 1989. Cadmium, Mercury, and Lead Effects on Gill Tissue of Freshwater Crayfish Procambarus clarkii (Girard). Biol.Trace Elem.Res. 21:343-347.	2695	UEndp, AF	
Truscott, R., C.R. McCrohan, S.E.R. Bailey, and K.N. White. 1995. Effect of Aluminium and Lead on Activity in the Freshwater Pond Snail Lymnaea stagnalis. Can.J.Fish.Aquat.Sci. 52(8):1623-1629.	16187	UEndp, AF	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Tsuji, S., Y. Tonogai, Y. Ito, and S. Kanoh. 1986. The Influence of Rearing Temperatures on the Toxicity of Various Environmental Pollutants for Killifish (Oryzias latipes). J.Hyg.Chem./Eisei Kagaku 32(1):46-53 (JPN) (ENG ABS).	12497	Dur, Con, AF	
Tulasi, S.J., and J.V.R. Rao. 1988. Acid-Base Balance and Blood Gas Changes in the Fresh Water Field Crab, Barytelphusa guerini, on Exposure to Organic and Inorganic Lead. Bull.Environ.Contam.Toxicol. 40(2):198-203.	2416	UEndp, AF	
Tulasi, S.J., and J.V.R. Rao. 1988. Effects of Lead on Copper Content of Fresh Water Crab Barytelphusa guerini (H. Miline Edwards). Indian J.Exp.Biol. 26(4):323-324.	13131	UEndp, AF	
Tulasi, S.J., P.U.M. Reddy, and J.V. Ramana Rao. 1989. Effects of Lead on the Spawning Potential of the Fresh Water Fish, Anabas testudineus. Bull.Environ.Contam.Toxicol. 43(6):858-863.	2551	UEndp, AF	
Tulasi, S.J., P.U.M. Reddy, and J.V.R. Rao. 1992. Accumulation of Lead and Effects on Total Lipids and Lipid Derivatives in the Freshwater Fish Anabas testudineus (Bloch). Ecotoxicol.Environ.Saf. 23:33-38.	3905	UEndp, AF	
Tulasi, S.J., R. Yasmeen, and J.V. Ramana Rao. 1988. Physiological Responses of the Fresh Water Crab, Barytelphusa guerini During Lead Nitrate Toxicity. Comp.Physiol.Ecol. 13(1):9-12.	3829	UEndp, AF	
Tulasi, S.J., R. Yasmeen, and J.V.R. Rao. 1990. Ionic Balance in the Haemolymph of the Freshwater Crab, Barytelphusa guerini (H. Miline Edwards) Exposed to Sublethal Concentrations of Lead Acetate. J.Environ.Biol. 11(2):163-168.	3145	UEndp, AF	
Tulasi, S.J., R. Yasmeen, and J.V.R. Rao. 1992. Biochemical Changes in the Haemolymph of the Freshwater Field Crab, Barytelphusa guerini on Exposure to Organic and Inorganic Lead. J.Environ.Biol. 13(3):261-271.	10983	UEndp, AF	
Tulasi, S.J., R. Yasmeen, C.P. Reddy, and J.V.R. Rao. 1987. Lead Uptake and Lead Loss in the Fresh Water Field Crab, Barytelphusa guerini, on Exposure to Organic and Inorganic Lead. Bull.Environ.Contam.Toxicol. 39(1):63-68.	12603	UEndp, Con, AF	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Turnbull, H., J.G. Demann, and R.F. Weston. 1954. Toxicity of Various Refinery Materials to Fresh Water Fish. Ind.Eng.Chem. 46(2):324-333.	922	Dur, AF	
Twagilimana, L., J. Bohatier, C.A. Groliere, F. Bonnemoy, and D. Sargos. 1998. A New Low-Cost Microbiotest with the Protozoan Spirostomum teres: Culture Conditions and Assessment of Sensitivity of the Ciliate to 14 Pure Chemicals. Ecotoxicol.Environ.Saf. 41(3):231-244.	20057	Ace, Dur, AF	
Van der Werff, M., and M.J. Pruyt. 1982. Long-Term Effects of Heavy Metals on Aquatic Plants. Chemosphere 11(8):727-739.	14480	UEndp, AF	
Varanasi, U., and D.J. Gmur. 1978. Influence of Water-Borne and Dietary Calcium on Uptake and Retention of Lead by Coho Salmon (Oncorhynchus kisutch). Toxicol.Appl.Pharmacol. 46(1):65-75.	15414	Eff, Con	
Vareille-Morel, C., and C. Chaisemartin. 1982. Natural Tolerance and Acclimation of Different Populations of Austropotamobius pallipes (Le.) to Heavy Metals (Chromium and Lead). Acta Oecol.Oecol.Appl. 3(1):105-122 (FRE) (ENG ABS).	15732	Con, AF	
Vazquez, M.D., J. Lopez, and A. Carballeira. 1999. Uptake of Heavy Metals to the Extracellular and Intracellular Compartments in Three Species of Aquatic Bryophyte. Ecotoxicol.Environ.Saf. 44(1):12-24.	20585	UEndp, AF	
Verrengia Guerrero, N.R., M.N. Mozzarelli, H. Giancarlo, D. Nahabedian, and E. Wider. 1997. Biomphalaria glabrata: Relevance of Albino Organisms as a Useful Tool for Environmental Lead Monitoring. Bull.Environ.Contam.Toxicol. 59(5):822-827.	18463	UEndp, AF	
Victor, B.. 1994. Gill Tissue Pathogenicity and Hemocyte Behavior in the Crab Paratelphusa hydrodromous Exposed to Lead Chloride. J.Environ.Sci.Health 29 A(5):1011-1034.	19565	NonRes	
Vijayamadhavan, K.T., and T. Iwai. 1975. Histochemical Observations on the Permeation of Heavy Metals Into Taste Buds of Goldfish. Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 41(6):631-639.	15445	UEndp, Dur, Con, AF	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Vymazal, J.. 1990. Uptake of Lead, Chromium, Cadmium and Cobalt by Cladophora glomerata. Bull.Environ.Contam.Toxicol. 44(2):468-472.	2191	UEndp, AF	
Vymazal, J.. 1990. Uptake of Heavy Metals by Cladophora glomerata. Acta Hydrochim.Hydrobiol. 18(6):657-665.	45131	UEndp, AF	
Vymazal, J.. 1995. Influence of pH on Heavy Metals Uptake by Cladophora glomerata. Pol.Arch.Hydrobiol. 42(3):231-237.	45130	UEndp, AF	
Waldegger, S., F. Schmidt, T. Herzer, E. Gulbins, A. Schuster, J. Biber, D. Markovich, H. Murer, A.E. Busch, and F. Lang. 1995. Heavy Metal Mediated Inhibition of rBAT-Induced Amino Acid Transport. Kidney Intl. 47(6):1677-1681.	45834	UEndp, AF	
Wallen, I.E., W.C. Greer, and R. Lasater. 1957. Toxicity to Gambusia affinis of Certain Pure Chemicals in Turbid Waters. Sewage Ind.Wastes 29(6):695-711.	508	Con, AF	
Wallen, I.E., W.C. Greer, and R. Lasater. 1957.		Det	No Information - Might be same as above
Wang, T.C., J.C. Weissman, G. Ramesh, R. Varadarajan, and J.R. Benemann. 1996. Parameters for Removal of Toxic Heavy Metals by Water Milfoil (Myriophyllum spicatum). Bull.Environ.Contam.Toxicol. 57(5):779-786.	20408	UEndp, AF	
Wang, W. 1994. Rice Seed Toxicity Tests for Organic and Inorganic Substances. Environ.Monit.Assess. 29:101-107.	45060	AF	
Weber, D.N.. 1991. Physiological and Behavioral Effects of Waterborne Lead on Fathead Minnows (Pimephales promelas). Diss.Abstr.Int.B Sci.Eng.52(10):5073-5074 (1992) / Ph.D.Thesis, University of Wisconsin, Milwaukee, WI :157 p..	7168	UEndp, Con, AF	
Weber, D.N.. 1993. Exposure to Sublethal Levels of Waterborne Lead Alters Reproductive Behavior Patterns in Fathead Minnows (Pimephales promelas). Neurotoxicology 14(2/3):347-358.	9543	UEndp, AF	
Weber, D.N.. 1996. Lead-Induced Metabolic Imbalances And Feeding Alterations In Juvenile Fathead Minnows (Pimephales promelas). Environ.Toxicol.Water Qual. 11(1):45-51.	19673	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Weber, D.N., A. Russo, D.B. Seale, and R.E. Spieler. 1989. Waterborne Lead Affects Feeding Abilities and Neurotransmitter Levels of Juvenile Fathead Minnows (Pimephales promelas). Aquat.Toxicol.21:71-80 (1991) / Am.Zool. 29(4):38A (ABS).	5276	UEndp, AF	
Weber, D.N., W.M. Dingel, J.J. Panos, and R.E. Steinpreis. 1997. Alterations in Neurobehavioral Responses in Fishes Exposed to Lead and Lead-Chelating Agents. Am.Zool. 37:354-362.	45129	UEndp, AF	
Wehrheim, B., and M. Wettern. 1994. Comparative Studies of the Heavy Metal Uptake of Whole Cells and Different Types of Cell Walls from Chlorella fusca. Biotechnol.Tech. 8(4):227-232.	16139	UEndp, AF	
Wehrheim, B., and M. Wettern. 1994. Influence of the External REDOX State on Heavy Metal Adsorption by Whole Cells and Isolated Cell Walls of Chlorella fusca. Biotechnol.Tech. 8:221-226.	45132	UEndp, AF	
Weir, P.A., and C.H. Hine. 1970. Effects of Various Metals on Behavior of Conditioned Goldfish. Arch.Environ.Health 20(1):45-51.	908	Con, AF, UEndp	
Weis, J.S., and P. Weis. 1977. Effects of Heavy Metals on Development of the Killifish, Fundulus heterclitus. J.Fish Biol. 11(1):49-54.	45298	UEndp, AF	
Wetzel, A., T. Alexander, S. Brandt, R. Haas, and D. Werner. 1994. Reduction by Fluoranthene of Copper and Lead Accumulation in Triticum aestivum L. Bull.Environ.Contam.Toxicol. 53(6):856-862.	13737	UEndp, AF	
Whitley, L.S.. 1968. The Resistance of Tubificid Worms to Three Common Pollutants. Hydrobiologia 32(1/2):193-205 (Author Communication Used).	15507	Con, Dur, AF	
Williams, P.L., and D.B. Dusenbery. 1990. Aquatic Toxicity Testing Using the Nematode, Caenorhabditis elegans. Environ.Toxicol.Chem. 9(10):1285-1290.	3437	AF, Dur	
Wong, P.T.S., Y.K. Chau, J.L. Yaromich, and O. Kramar. 1987. Bioaccumulation and Metabolism of Tri- and Dialkyllead Compounds by a Freshwater Alga. Can.J.Fish.Aquat.Sci.44:1257-1260 / In: J.S.S.Lakshminarayana (Ed.), Proc.13th Annual Aquatic Toxicity Workshop, Nov.12-14, 1986, Moncton, New Brunswick, Can.Tech.Rep.Fish.Aquat.Sci.No.1575 :37-38 (ABS).	12819	Eff, Con, AF	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Woodward, D.F., J.N. Goldstein, A.M. Farag, and W.G. Brumbaugh. 1997. Cutthroat Trout Avoidance of Metals and Conditions Characteristic of a Mining Waste Site: Coeur d'Alene River, Idaho. Trans.Am.Fish.Soc. 126:699-706.	45186	UEndp, Dur	
Yoshitomi, T., C. Nakayasu, S. Hasegawa, A. Iida, and N. Okamoto. 1998. Site-Specific Lead Distribution in Scales of Lead-Administered Carp (Cyprinus carpio) by Non-Destructive SR-XRF Analysis. Chemosphere 36(10):2305-2310.	18974	UEndp, AF	
Ziegenfuss, P.S., W.J. Renaudette, and W.J. Adams. 1986. Methodology for Assessing the Acute Toxicity of Chemicals Sorbed to Sediments: Testing the Equilibrium Partitioning Theory. In: T.M.Poston and R.Purdy (Eds.), Aquatic Toxicology and Environmental Fate, 9th Volume, ASTM STP 921, Philadelphia, PA :479-493.	7884	Con, AF	
Zimmermann, S., B. Sures, and H. Taraschewski. 1999. Experimental Studies on Lead Accumulation in the Eel-Specific Endoparasites Anguillicola crassus (Nematoda) and Paratenuisentis ambiguus (Acanthocephala) as Compared with Their Host, Anguilla anguilla. Arch.Environ.Contam.Toxicol. 37(2):190-195.	20449	UEndp,Af	

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

3) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[85], EPA is providing a transparent rationale as to why they were not utilized (see below).

[85] U.S. EPA. 1984. Ambient Water Quality Criteria Documents for Lead. EPA-440/5-84-027.

4) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix H).

General QA/QC failure because non-resident species in Oregon

The test with the following species was used in the EPA BE of OR WQS for lead in freshwater, but was not considered in the CWA review and approval/disapproval action of the standards because this species does not have a breeding wild population in Oregon's waters:

Gammarus	*pseudolimnaeus*	Scud	Spehar et al. 1978; Call et al. 1983

Other Acute tests failing QA/QC by species

Oncorhynchus mykiss – Rainbow Trout

The following tests were included in EPA's BE of the OR WQS for lead in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because the tests were not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for these species.

Buhl, K.J. and S.J. Hamilton. 1990. Comparative toxicity of inorganic contaminants released by placer mining to early life stages of salmonids. Ecotoxicol. Environ. Saf. 20(3): 325-342.
Two LC50 values from S,U tests ranging from 4871 µg/L to 85954 µg/L.

Goettl, J.P.Jr., P.H. Davies and J.R. Sinley. 1976. Water Pollution Studies. In: D.B. Cope (Ed.), Colorado Fish. Res. Rev. 1972-1975, DOW-R-R-F72-75, Colorado Div. of Wildl., Boulder, CO: 68-75.
Two LC50 values from D,U tests ranging from 57931 µg/L to 77224 µg/L.

Davies, P.H., J.P. Goettl, Jr., J.R. Sinley and N.F. Smith. 1976. Acute and chronic toxicity of lead to rainbow trout (*Oncorhynchus mykiss*) in hard and soft water. Water Res. 10: 199-206.
Two LC50 values from S,U tests ranging from 57931 µg/L to 77224 µg/L.

Goettl, J.P., et al. 1972. Laboratory water pollution studies. Colorado Fisheries Research Review.
Two LC50 values from S,U tests ranging from 57931 µg/L to 77224 µg/L.

Davies, P.H. and W.E. Everhart. 1973. Effects of chemical variations in aquatic environments: Lead toxicity to rainbow trout and testing application factor concept. EPA-R3-73-011C. National Technical Information Service, Springfield, VA.
Two LC50 values from S,U tests ranging from 57931 µg/L to 77224 µg/L.

Oncorhynchus kisutch – Coho salmon

Buhl, K.J. and S.J. Hamilton. 1990. Comparative toxicity of inorganic contaminants released by placer mining to early life stages of salmonids. Ecotoxicol. Environ. Saf. 20(3): 325-342.
One value, a 24-hr test, was an inappropriate test duration and was not used. Other values from this study were used for this species.

Daphnia magna – Cladoceran

The following tests were included in EPA's BE of the OR WQS for lead in freshwater, but was not used in this CWA review and approval/disapproval action of these standards because the tests were conducted in river water:

Bringmann, G. and R. Kuhn. 1959a. The toxic effects of waste water on aquatic bacteria, algae, and small crustaceans. Gesundheints-Ing. 80: 115.

Bringmann, G. and R. Kuhn. 1959b. Water toxicology studies with protozoans as test organisms. Gesundheits-Ing. 80: 239.

Daphnia pulex – Cladoceran

The following test was included in EPA's BE of the OR WQS for lead in freshwater, but was not used in this CWA review and approval/disapproval action of these standards because the value was deemed an outlier and unacceptable to use for calculating the SMAV for the species:

Mount, D.I. and T.J. Norberg. 1984. A seven-day life-cycle cladoceran toxicity test. Environ. Toxicol. Chem. 3(3):425-434 (Author Communication Used).

<u>Other Chronic tests failing QA/QC by species</u>

Oncorhynchus mykiss – Rainbow Trout

The following tests were included in EPA's BE of the OR WQS for lead in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because they are duplicate data for another test already used:

Davies, P.H., J.P. Goettl, Jr., J.R. Sinley and N.F. Smith. 1976. Acute and chronic toxicity of lead to rainbow trout (*Oncorhynchus mykiss*) in hard and soft water. Water Res. 10: 199-206.

Davies, P.H. and W.E. Everhart. 1973. Effects of chemical variations in aquatic environments: Lead toxicity to rainbow trout and testing application factor concept. EPA-R3-73-011C. National Technical Information Service, Springfield, VA.

Appendix I Lindane (freshwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Almar, M.M., M.M.D. Ferrando, V. Alarcon, C. Soler, and E. Andreu. 1988. Influence of Temperature on Several Pesticides Toxicity to Melanopsis Dufouri Under Laboratory Conditions. J.Environ.Biol. 9(2):183-190.	12863	Con	
Andreu-Moliner, E.S., M.M. Almar, I. Legarra, and A. Nunez. 1986. Toxicity of Some Ricefield Pesticides to the Crayfish P. clarkii, Under Laboratory and Field Conditions in Lake Albufera (Spain). J.Environ.Sci.Health B21(6):529-537.	12517	UEndp, Con	
Bakthavathsalam, R.. 1986. Effect of Lindane and Carbofuran on the Survival Times and Total Evaporative Water Loss of the Fish Anabas testudineus at Submerged Condition and. Environ.Ecol. 4(4):533-535.	12777	UEndp, Dur	
Bakthavathsalam, R.. 1988. Toxicity of Lindane to Some Air-Breathing Fishes. Environ.Ecol. 6(1):222-224.	13192	Con, Dur	
Bakthavathsalam, R., and C. Rajaretnam. 1990. Effects of Lindane and Atropine Sulphate on the Digestive Tissues of Anabas testudineus (Bloch). Indian J.Environ.Health 32(3):284-288.	7231	UEndp, Dur	
Bakthavathsalam, R., and Y.S. Reddy. 1983. Intoxication Effects of Lindane (gamma-BHC) on the Carbohydrate Metabolism in the Climbing Perch, Anabas testudineus (Bloch). Pestic.Biochem.Physiol. 20(3):340-346.	10680	UEndp, Dur	
Bakthavathsalam, R., and Y.S. Reddy. 1983. Changes in Bimodal Oxygen Uptake of an Obligate Air Breather Anabas testudineus (Bloch) Exposed to Lindane. Water Res. 17(10):1221-1226.	11361	UEndp, Dur	
Bakthavathsalam, R., U. Balasubramanian, and G. Ravikumar. 1987. Time-Dependent Effects of Lindane (gamma-BHC) on the Bimodal Oxygen Consumption of Anabas testudineus (Bloch). Pestic.Biochem.Physiol. 28(3):318-324.	2410	UEndp, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Basha, S.M., K.S.P. Rao, K.R.S. Rao, and K.V.R. Rao. 1983. Differential Toxicity of Malathion, BHC, and Carbaryl to the Freshwater Fish, Tilapia mossambica (Peters). Bull.Environ.Contam.Toxicol. 31(5):543-546.	10055	Dur, Con	
Bhatia, H.L.. 1971. Toxicity of Some Pesticides to Puntius ticto (Hamilton). Sci.Cult. 37(3):160-161.	962	Con	
Biagianti-Risbourg, S., C. Pairault, G. Vernet, and H. Boulekbache. 1996. Effect of Lindane on the Ultrastructure of the Liver of the Rainbow Trout, Oncorhynchus mykiss, Sac-Fry. Chemosphere 33(10):2065-2079.	17478	UEndp	
Bitton, G., K. Rhodes, and B. Koopman. 1996. CerioFAST: An Acute Toxicity Test Based on Ceriodaphnia dubia Feeding Behavior. Environ.Toxicol.Chem. 15(2):123-125.	17097	Dur	
Blockwell, S.J., D. Pascoe, and E.J. Taylor. 1996. Effects of Lindane on the Growth of the Freshwater Amphipod Gammarus pulex (L.). Chemosphere 32(9):1795-1803.	16881	UEndp	
Blockwell, S.J., E.J. Taylor, I. Jones, and D. Pascoe. 1998. The Influence of Fresh Water Pollutants and Interaction with Asellus aquaticus (L.) on the Feeding Activity of Gammarus pulex (L.). Arch.Environ.Contam.Toxicol. 34(1):41-47.	19003	UEndp	
Blockwell, S.J., S.J. Maund, and D. Pascoe. 1999. Effects of the Organochlorine Insecticide Lindane (gamma-C6H6Cl6) on the Population Responses of the Freshwater Amphipod Hyalella azteca. Environ.Toxicol.Chem. 18(6):1264-1269.	47629	UEndp	
Bogaerts, P., J. Senaud, and J. Bohatier. 1998. Bioassay Technique Using Nonspecific Esterase Activities of Tetrahymena pyriformis for Screening and Assessing Cytotoxicity of Xenobiotics. Environ.Toxicol.Chem. 17(8):1600-1605.	18353	Ace, UEndp, Dur	
Boulekbache, H., and C. Spiess. 1974. Effects of Lindane on Trout Fry (Salmo irideus Gibb.) Changes in Glycolytic Enzymes. Bull.Soc.Zool.Fr. 99(1):79-85 (FRE) (ENG ABS).	8495	UEndp, Con	
Boyd, C.E., and D.E. Ferguson. 1964. Susceptibility and Resistance of Mosquito Fish to Several Insecticides. J.Econ.Entomol. 57(4):430-431.	10332	Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Burchfield, H.P., and E.E. Storrs. 1954. Kinetics of Insecticidal Action Based on the Photomigration of Larvae of Aedes aegypti (L.). Contrib.Boyce Thompson Inst. 17:439-452.	2929	Dur, Con	
Butte, W., K. Fox, and G.P. Zauke. 1991. Kinetics of Bioaccumulation and Clearance of Isomeric Hexachlorocyclohexanes. Sci.Total Environ. 109/110:377-382.	8009	Eff, Con	
Call, D.J., L.T. Brooke, N. Ahmad, and D.D. Vaishnav. 1981. Aquatic Pollutant Hazard Assessments and Development of a Hazard Prediction Technology by Quantitative Structure-Activity Relationships. Second Quarterly Report, U.S.EPA Cooperative Agreement No.CR 809234-01-0, Center for Lake Superior Environmental Studies, University of Wisconsin, Superior, WI:74 p.(Publ in Part As 12448).	3690	Con	
Canyurt, M.A.. 1983. Toxic Effects of Lindane and Parathion Methyl on Three Fresh Water Fish Species. Bull.Cent.Etud.Rech.Sci.Biarritz 14(3/4):257-262 (FRE) (ENG ABS).	11840	Dur, Con	
Caquet, T., E. Thybaud, S. Le Bras, O. Jonot, and F. Ramade. 1992. Fate and Biological Effects of Lindane and Deltamethrin in Freshwater Mesocosms. Aquat.Toxicol. 23(3/4):261-278.	6170	UEndp, Eff, Dur	
Cebrian, C., E. Andreu-Moliner, and M. Gamon. 1993. The Effect of Time, Concentration and Temperature on Bioaccumulation in the Gill of Crayfish Procambarus clarkii Induced by Organochlorine Pesticides, Lindane and Endosulfan. Comp.Biochem.Physiol.C 104(3):445-451.	6888	UEndp, Con	
Chabert, D., and N. Vicente. 1978. Contamination of Mediterranean Molluscs by an Organochlorine Biocide: Lindane (Contamination de Mollusques Mediterraneens par un Biocide Organochlore: Le Lindane). Rev.Int.Oceanogr.Med. 49:45-48 (FRE)(ENG ABS).	5161	Eff, Dur	
Chen, P.S., Y.N. Lin, and C.L. Chung. 1971. Laboratory Studies on the Susceptibility of Mosquito-Eating Fish, Lebistes reticulatus and the Larvae of Culex pipiens fatigans to Insecticides. Tai-Wan I.Hsueh Hui Tsa Chih 70(1):28-35.	9297	Dur, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Christoffers, D., and D.E.W. Ernst. 1983. The In-Vivo Fluorescence of Chlorella fusca as a Biological Test for the Inhibition of Photosynthesis. Toxicol.Environ.Chem. 7:61-71.	45160	UEndp, Dur	
Clemens, H.P., and K.E. Sneed. 1959. Lethal Doses of Several Commercial Chemicals for Fingerling Channel Catfish. U.S.Fish Wildl.Serv.Sci.Rep.Fish.No.316, U.S.D.I., Washington, D.C. :10 p..	934	Con, Dur, Pur	
Cossarini-Dunier, M.. 1987. Effects of the Pesticides Atrazine and Lindane and of Manganese Ions on Cellular Immunity of Carp, Cyprinus carpio. J.Fish Biol.31(Suppl. A):67-73.	6236	Dur	
Cossarini-Dunier, M., G. Monod, A. Demael, and D. Lepot. 1987. Effect of gamma-Hexachlorocyclohexane (Lindane) on Carp (Cyprinus carpio). I. Effect of Chronic Intoxication on Humoral Immunity in Relation to. Ecotoxicol.Environ.Saf. 13(3):339-345.	12657	UEndp, Con	
Crosby, D.G., R.K. Tucker, and N. Aharonson. 1966. The Detection of Acute Toxicity with Daphnia magna. Food Cosmet.Toxicol. 4:503-514.	7984	Con, Dur	
De Coen, W.M., M.L. Vangheluwe, and C.R. Janssen. 1998. The Use of Biomarkers in Daphnia magna Toxicity Testing. III. Rapid Toxicity Testing of Pure Chemicals and Sediment Pore Waters Using Ingestion and. Chemosphere 37(13):2677-2694.	2919	Dur	
Demael, A., D. Lepot, M. Cossarini-Dunier, and G. Monod. 1987. Effect of gamma-Hexachlorocyclohexane (Lindane) on Carp (Cyprinus carpio). II. Effects of Chronic Intoxication on Blood, Liver Enzymes, and. Ecotoxicol.Environ.Saf. 13(3):346-351.	12659	UEndp	
Deneer, J.W., W. Seinen, and J.L.M. Hermens. 1988. Growth of Daphnia magna Exposed to Mixtures of Chemicals with Diverse Modes of Action. Ecotoxicol.Environ.Saf. 15(1):72-77.	12872	Con, Dur	
Devillers, J., T. Meunier, and P. Chambon. 1985. Advantage of the Dosage-Action-Time Relation in Ecotoxicology for the Test of the Various Chemical Species of Toxics. Tech.Sci.Munic. 80:329-334 (FRE) (ENG ABS).	17456	Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Dunier, M., A.K. Siwicki, J. Scholtens, S.D. Molin, C. Vergnet, and M. Studnicka. 1994. Effects of Lindane Exposure on Rainbow Trout (Oncorhynchus mykiss) Immunity. Ecotoxicol.Environ.Saf. 27(3):324-334.	4188	UEndp, Con	
Ensenbach, U., and R. Nagel. 1991. Toxicokinetics of Xenobiotics in Zebrafish - Comparison Between Tap and River Water. Comp.Biochem.Physiol.C 100(1/2):49-53.	3964	Eff, Con, Dur	
Ensenbach, U., and R. Nagel. 1995. Toxicity of Complex Chemical Mixtures: Acute and Long-Term Effects on Different Life Stages of Zebrafish (Brachydanio rerio). Ecotoxicol.Environ.Saf. 30(2):151-157.	15345	UEndp, Dur	
Estenik, J.F., and W.J. Collins. 1979. In Vivo and In Vitro Studies of Mixed-Function Oxidase in an Aquatic Insect, Chironomus riparius. In: M.A.Q.Khan, J.J.Lech, and J.J.Menn (Eds.), Pesticide and Xenobiotic Metabolism in Aquatic Organisms, ACS (Am.Chem.Soc.) Symp.Ser.99 :349-370 (Author Communication Used).	6830	Dur	
Ferrando, M.D., and E. Andreu-Moliner. 1991. Effects of Lindane on Fish Carbohydrate Metabolism. Ecotoxicol.Environ.Saf. 22:17-23.	5214	UEndp	
Ferrando, M.D., C.R. Janssen, E. Andreu, and G. Persoone. 1993. Ecotoxicological Studies with the Freshwater Rotifer Brachionus calyciflorus. II. An Assessment of the Chronic Toxicity of Lindane and 3,4-Dichloroaniline Using Life Tables. Hydrobiologia 255/256:33-40.	6855	UEndp, Dur	
Ferrando, M.D., C.R. Janssen, E. Andreu, and G. Persoone. 1993. Ecotoxicological Studies with the Freshwater Rotifer Brachionus calyciflorus III. The Effects of Chemicals on the Feeding Behavior. Ecotoxicol.Environ.Saf. 26(1):1-9 (OECDG Data File).	8272	Dur	
Fisher, S.W.. 1985. Effects of pH on the Toxicity and Uptake of [14C] Lindane in the Midge, Chironomus riparius. Ecotoxicol.Environ.Saf. 10(2):202-208.	11202	Con, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Fisher, S.W., and R.W. Wadleigh. 1985. Effects of Temperature on the Acute Toxicity and Uptake of Lindane by Chironomus riparius (Meigen) (Diptera: Chironomidae). J.Econ.Entomol. 78(6):1222-1226.	10897	Con, Dur	
Fliedner, A., and W. Klein. 1996. Effects of Lindane on the Planktonic Community in Freshwater Microcosms. Ecotoxicol.Environ.Saf. 33(3):228-235.	17083	UEndp, Dur	
Frear, D.E.H., and J.E. Boyd. 1967. Use of Daphnia magna for the Microbioassay of Pesticides. I. Development of Standardized Techniques for Rearing Daphnia and Preparation of Dosage-M. J.Econ.Entomol. 60(5):1228-1236.	2820	Con, Dur	
Geyer, H., G. Politzki, and D. Freitag. 1984. Prediction of Ecotoxicological Behaviour of Chemicals: Relationship Between N-Octanol/Water Partition Coefficient and Bioaccumulation of Organic Chemicals by Alga Chlorella. Chemosphere 13(2):269-284.	11297	Eff	
Ginsburg, J.M.. 1947. Tests with New Toxicants, in Comparison with DDT, on Mosquito Larvae and Fish. Proc.N.J.Mosq.Exterm.Assoc. 34:132-135.	10331	UEndp	
Gliwicz, M.Z., and A. Sieniawska. 1986. Filtering Activity of Daphnia in Low Concentrations of a Pesticide. Limnol.Oceanogr. 31(5):1132-1138.	12056	Con, Dur	
Gopal, K., and R.C. Dalela. 1997. Pathological Impact of Endosulfan and Lindane on Chironomus Larvae (Chironomidae). J.Environ.Biol. 18(4):429-434.	19029	UEndp	
Gopal, K., M.D. Ram, M. Anand, and P.K. Ray. 1989. Toxicity and Fate of Lindane in Fresh Water Fish Channa punctatus. Environ.Ecol. 7(3):571-576.	3055	NonRes, Con	
Gorge, G., and R. Nagel. 1990. Kinetics and Metabolism of 14C-Lindane and 14C-Atrazine in Early Life Stages of Zebrafish (Brachydanio rerio). Chemosphere 21(9):1125-1137.	246	Eff, Dur	
Gouda, R.K., N.K. Tripathy, and C.C. Das. 1981. Toxicity of Dimecron, Sevin and Lindex to Anabas scandens and Heteropneustes fossilis. Comp.Physiol.Ecol. 6(3):170-172.	15652	Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Gupta, P.K., V.S. Mujumdar, and P.S. Rao. 1984. Studies on the Toxicity of Some Insecticides to a Freshwater Teleost Lebistes reticulatus. Acta Hydrochim.Hydrobiol. 12(6):629-636.	10646	Tox, Dur	20 Emulsified Concentration
Gurure, R.M.. 1987. Influence of Two Organochloride Pesticides, Thiodan and Lindane on Survival of Fingerlings of Oreochromis niloticus (Linnaeus) and Tilapia zillii. United Nations Development Programme /Food and Agriculture Organization /Nigerian Institute for Oceanography and Marine Research, Port Harcourt, Nigeria.ARAC/W P/6/87:14p.	3409	Con, Dur	
Hashimoto, Y., and J. Fukami. 1969. Toxicity of Orally and Topically Applied Pesticide Ingredients to Carp, Cyprinus carpio Linne. Sci.Pest Control /Botyu-Kagaku 34(2):63-66.	9038	Con, Dur	
Hazarika, R., and M. Das. 1998. Toxicological Impact on BHC on the Ovary of the Air-Breathing Catfish Heteropneustes fossilis (Bloch). Bull.Environ.Contam.Toxicol. 60:16-21.	18966	NonRes, UEndp	
Henderson, C., Q.H. Pickering, and C.M. Tarzwell. 1960. The Toxicity of Organic Phosphorus and Chlorinated Hydrocarbon Insecticides to Fish. In: C.M.Tarzwell (Ed.), Biological Problems in WAter Pollution, Trans.2nd Seminar, April 20-24, 1959, Tech.Rep.W60-3, U.S.Public Health Service, R.A.Taft Sanitary Engineering Center, Cincinnati, OH :76-88.	936	Con	
Hermens, J., H. Canton, N. Steyger, and R. Wegman. 1984. Joint Effects of a Mixture of 14 Chemicals on Mortality and Inhibition of Reproduction of Daphnia magna. Aquat.Toxicol. 5(4):315-322.	5675	Con, Dur	
Hirose, K.. 1975. Reproduction in Medaka, Oryzias latipes, Exposed to Sublethal Concentrations of gamma-Benzenehexachloride (BHC). Bull.Tokai Reg.Fish.Res.Lab. 81:139-149.	65148	UEndp	
Holland, G.A., J.E. Lasater, E.D. Neumann, and W.E. Eldridge. 1960. Toxic Effects of Organic and Inorganic Pollutants on Young Salmon and Trout. Res.Bull.No.5, State of Washington Dept.Fish., Seattle, W A:263.	14397	UEndp, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Hooftman, R.N., D.M.M. Adema, and J. Kauffman-Van Bommel. 1989. Developing a Set of Test Methods for the Toxicological Analysis of the Pollution Degree of Waterbottoms. Rep.No.16105, Netherlands Organization for Applied Scientific Research:68 p.(DUT).	5356	NonRes, Dur	
Hori, H., M. Tateishi, K. Takayanagi, and H. Yamada. 1996. Applicability of Artificial Seawater as a Rearing Seawater for Toxicity Tests of Hazardous Chemicals by Marine Fish Species. Nippon Suisan Gakkaishi /Bull.Jpn.Soc.Sci.Fish.(4):614-622 (JPN) (ENG ABS).	16999	NonRes, Eff	
Jabbar Khan, M.A.. 1975. Susceptibility of Some Important Fresh Water Fauna (Chordates) to Synthetic Insecticides and Indigenous Vegetable Oils Used As Mosquito Larvicide. Agric.Pak. 26(3):393-400.	7951	UEndp, Dur	
Janssen, C.. 1992. The Use of Sublethal Criteria for Toxicity Tests with the Freshwater Rotifer Brachionus calyciflorus (Pallas). Ph.D.Thesis, University of Gent, Belgium:157 p.(Publ in Part As 4748, 6851, 8272, 16572).	18654	UEndp	
Janssen, C.R., E.Q. Espiritu, and G. Persoone. 1993. Evaluation of the New "Enzymatic Inhibition" Criterion for Rapid Toxicity Testing with Daphnia magna. In: A.Soares and P.Calow (Eds.), Progress in Standardization of Aquatic Toxicity Tests, Lewis Publ. :71-81.	16601	48 h EC50 = 1990 ug/L. Test was static, unmeasured.	This study appears to provide an appropriate 48 h EC50 for C. dubia, but the paper should be secured to ensure acceptability. Species is insensitive to acute lindane exposure.
Janssen, C.R., G. Persoone, and T.W. Snell. 1994. Cyst-Based Toxicity Tests. VIII. Short-Chronic Toxicity Tests with the Freshwater Rotifer Brachionus calyciflorus. Aquat.Toxicol. 28(3/4):243-258.	16572	UEndp	
Jeyasingam, D.N.T., B. Thayumanavan, and S. Krishnaswamy. 1978. The Relative Toxicities of Insecticides on Aquatic Insect Eretes sticticus (Linn.) (Coleoptera: Dytiscidae). J.Madurai Univ. 7(1):85-87.	5182	Dur	
Jones, R.O.. 1962. Tolerance of the Fry of Common Warm-Water Fishes to Some Chemicals Employed in Fish Culture. Proc.Annu.Conf.Southeast.Assoc.Game Fish Comm. 16:436-445.	10014	UEndp, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Joshi, A.G., and M.S. Rege. 1980. Acute Toxicity of Some Pesticides and a Few Inorganic Salts to the Mosquito Fish Gambusia affinis (Baird and Girard). Indian J.Exp.Biol. 18:435-437.	568	96 h LC50 = 1350 ug/L. Test was static, measured.	This study appears to provide an appropriate 96 h LC50 for Gambusia affinis, but the paper should be secured to ensure acceptability. Species is insensitive to acute lindane exposure.
Joshi, H.C., D. Kapoor, R.S. Panwar, and R.A. Gupta. 1975. Toxicity of Some Insecticides to Chironomid Larvae. Indian J.Environ.Health 17(3):238-241.	7954	No Org, Dur, Pur	20 Emulsified Concentration
Juarez, A., and J.A. Guzman. 1984. Chronic Effect of Five Organochlorine Insecticides on Larvae of Bufo arenarum (H.). Comun.Biol. 2(4):411-415.	18322	UEndp	
Kader, H.A., B. Thayumanavan, and S. Krishnaswamy. 1976. The Relative Toxicities of Ten Biocides on Spicodiaptomus chelospinus Rajendran (1973) [Copepoda: Calanoida]. Comp.Physiol.Ecol. 1(3):78-82.	5264	NonRes, Dur	
Kalafatic, M., D. Znidaric, A. Lui, and M. Wrischer. 1991. Effect of Insecticides (Dimiline WP 25, Torak EC 24 and Gamacide 20) on Hydra (Hydra vulgaris Pallas). Int.J.Dev.Biol. 35(3):335-340.	9587	UEndp, Dur	
Kanazawa, J.. 1980. Prediction of Biological Concentration Potential of Pesticides in Aquatic Organisms. Rev.Plant Prot.Res. 13:27-36.	59925	Eff	
Kanazawa, J.. 1981. Bioconcentration Potential of Pesticides by Aquatic Organisms. Jpn.Pestic.Inf. 39:12-16.	12534	Eff	
Kanazawa, J.. 1981. Measurement of the Bioconcentration Factors of Pesticides by Freshwater Fish and Their Correlation with Physicochemical Properties or Acute Toxicities. Pestic.Sci. 12(4):417-424.	15599	Eff	
Kanazawa, J.. 1983. A Method of Predicting the Bioconcentration Potential of Pesticides by Using Fish. Jarq (Jpn.Agric.Res.Q.) 17(3):173-179.	10750	Eff, Con	
Kaushik, B.D., and G.S. Venkataraman. 1983. Response of Cyanobacterial Nitrogen Fixation to Insecticides. Curr.Sci. 52(7):321-323.	11601	UEndp, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Khangarot, B.S., A. Sehgal, and M.K. Bhasin. 1985. Man and Biosphere-Studies on the Sikkim Himalayas. Part 6: Toxicity of Selected Pesticides to Frog Tadpole Rana hexadactyla (Lesson). Acta Hydrochim.Hydrobiol. 13(3):391-394.	11521	NonRes	
Khillare, Y.K., and S.B. Wagh. 1988. Toxicity of an Organochlorine Insecticide "Lindene" to Fresh Water Fish Barbus stigma. J.Adv.Zool. 9(2):83-86.	3245	NonRes, Con	
Kimura, T., and H.L. Keegan. 1966. Toxicity of Some Insecticides and Molluscicides for the Asian Blood Sucking Leech, Hirudo nipponia Whitman. Am.J.Trop.Med.Hyg. 15(1):113-115.	2890	NonRes, Dur, Con	
Kok, L.T.. 1972. Toxicity of Insecticides Used for Asiatic Rice Borer Control to Tropical Fish in Rice Paddies. In: The Careless Technol.: Conf.on the Ecological Aspects of Int.Development :498.	9114	UEndp, Dur	
Krishnakumari, M.K.. 1977. Sensitivity of the Alga Scenedesmus acutus to Some Pesticides. Life Sci. 20:1525-1532.	2246	UEndp	
La Rocca, C., A. Di Domenico, and L. Vittozzi. 1991. Chemiobiokinetic Study in Freshwater Fish Exposed to Lindane: Uptake and Excretion Phase Rate Constants and Bioconcentration Factors. Int.J.Environ.Health Res. 1(2):103-116.	6919	Eff	
LaBrecque, G.C., J.R. Noe, and J.B. Gahan. 1956. Effectiveness of Insecticides on Granular Clay Carriers Against Mosquito Larvae. Mosq.News 16:1-3.	2808	UEndp, Dur, Pur	
Lakota, S., A. Raszka, J. Roszkowski, S. Hlond, and F. Kozlowski. 1983. Toxic Effects of DDT, Lindane, and Toxaphene on the Fry of the Carp, Cyprinus carpio, as Revealed by an Acute Test. Folia Biol.(Krakow) 31(1):94-99.	10842	UEndp, Dur	
Lal, B., and T.P. Singh. 1987. Impact of Pesticides on Lipid Metabolism in the Freshwater Catfish, Clarias batrachus, during the Vitellogenic Phase of its Annual Reproductive Cycle. Ecotoxicol.Environ.Saf. 13(1):13-23.	12341	UEndp	
Lansing, M.B., W.S. Gardner, and B.J. Eadie. 1993. Catecholamines as Potential Sub-Lethal Stress Indicators in Great Lakes Macrobenthic Invertebrates. J.Gt.Lakes Res. 19(3):569-581.	4997	Eff, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Larsen, J.. 1996. Pilot Ringtest on Five Test Substances Employing Optimized Test Protocols with the Protozoan Tetrahymena pyriformis. In: W.Pauli and S.Berger (Eds.), Rep.No.UBA-FB 96-039, Proc.International Workshop on a Protozoan Test Protocol with Tetrahymena in Aquatic Toxicity Testing, Umweltbundesamt :67-104.	12482	Ace, Dur	
Lay, J.P., A. Muller, L. Peichl, R. Lang, and F. Korte. 1987. Effects of gamma-BHC (Lindane) on Zooplankton Under Outdoor Conditions. Chemosphere 16(7):1527-1538.	12670	UEndp, No Org	
Le Bras, S., T. Caquet, E. Thybaud, and O. Jonot. 1992. Ponderal Growth of Asellus aquaticus L. Under Laboratory Conditions and in Experimental Mesocosms, Consequences of Lindane Contamination. J.Water Sci./Rev.Sci.Eau.5(3):431-443 (Fre) (Eng Abs).	7541	UEndp, Dur	
Lichtenstein, E.P., K.R. Schulz, R.F. Skrentny, and Y. Tsukano. 1966. Toxicity and Fate of Insecticide Residues in Water. Arch.Environ.Health 12:199-212.	8020	UEndp	
Lilius, H., B. Isomaa, and T. Holmstrom. 1994. A Comparison of the Toxicity of 50 Reference Chemicals to Freshly Isolated Rainbow Trout Hepatocytes and Daphnia magna. Aquat.Toxicol. 30:47-60.	16756	Dur	
Liong, P.C., W.P. Hamzah, and V. Murugan. 1988. Toxicity of Some Pesticides Towards Freshwater Fishes. Fish.Bull.Dep.Fish.(Malays.) No .57:13.	3296	Pur, Dur	
Lohner, T.W., and W.J. Collins. 1987. Determination of Uptake Rate Constants for Six Organochlorines in Midge Larvae. Environ.Toxicol.Chem. 6(2):137-146.	12298	UEndp, Con	
Lombardo, R.J., L. Ferrari, and J.H. Vinuesa. 1991. Effects of Lindane and Acetone on the Development of Larvae of the Southern King Crab (Lithodes antarcticus Jaquinot). Bull.Environ.Contam.Toxicol. 46(2):185-192.	136	NonRes	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Lydy, M.J., K.A. Bruner, D.M. Fry, and S.W. Fisher. 1990. Effects of Sediment and the Route of Exposure on the Toxicity and Accumulation of Neutral Lipophilic and Moderately Water-Soluble Metabolizable Compounds in the Midge, Chironomus riparius. In: W.G.Landis and W.H.Van der Schalie (Eds.), Aquatic Toxicology and Risk Assessment, 13th Volume, ASTM STP 1096, Philadelphia, PA :140-164.	18935	Dur	
MacPhee, C., and R. Ruelle. 1969. Lethal Effects of 1888 Chemicals upon Four Species of Fish From Western North America. Univ.of Idaho Forest, Wildl.Range Exp.Station Bull.No.3, Moscow, ID :112 p..	15148	UEndp, Con	
Maheshwari, U.K., B.C. Das, S. Paul, S.K. Chouhan, and A.K. Yadav. 1988. Bioassay Studies of Some Commercial Organic Pesticides to an Exotic Carp Fry, Hypophthalmichthys molitrix (C. & V). J.Environ.Biol. 9(4):377-380.	580	Dur, Con	
Mailhot, H.. 1987. Prediction of Algal Bioaccumulation and Uptake Rate of Nine Organic Compounds by Ten Physicochemical Properties. Environ.Sci.Technol. 21(10):1009-1013.	12891	Eff, Dur, Con	
Malbouisson, J.F.C., T.W.K. Young, and A.W. Bark. 1995. Use of Feeding Rate and Re-Pairing of Precopulatory Gammarus pulex to Assess Toxicity of gamma-Hexachlorocyclohexane (Lindane). Chemosphere 30(8):1573-1583.	16036	UEndp	
Marcelle, C., and J.P. Thome. 1983. Acute Toxicity and Bioaccumulation of Lindane in Gudgeon, Gobio gobio (L.). Bull.Environ.Contam.Toxicol. 31(4):453-458.	10088	NonRes, Eff	
Marcelle, C., and J.P. Thome. 1984. Relative Importance of Dietary and Environmental Sources of Lindane in Fish. Bull.Environ.Contam.Toxicol. 33(4):423-429.	10753	UEndp, Con	
Marchal-Segault, D., and F. Ramade. 1981. The Effects of Lindane, an Insecticide, on Hatching and Postembryonic Development of Xenopus laevis (Daudin) Anuran Amphibian. Environ.Res. 24:250-258.	18482	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Mathur, R., and D.M. Saxena. 1986. Effect of Hexachlorocyclohexane (HCH) Isomers on Growth of, and Their Accumulation in, the Blue-Green Alga, Anabaena sp. (ARM 310). J.Environ.Biol. 7(1):239-251.	12632	Con, UEndp, Eff	
Mathur, R., and D.M. Saxena. 1987. Bioconcentration of HCH Isomers by the Ciliate Protozoan, Tetrahymena pyriformis Under Laboratory Conditions. Water Air Soil Pollut. 32(3-4):323-327.	12801	Ace, Eff, Con	
Matsuo, K., and T. Tamura. 1970. Laboratory Experiments on the Effect of Insecticides Against Blackfly Larvae (Diptera: Simuliidae) and Fishes. Sci.Pest Control/Botyu-Kagaku 35(4):125-130.	9634	UEndp	
Maund, S.J., A. Peither, E.J. Taylor, I. Juttner, R. Beyerle-Pfnur, J.P. Lay, and D. Pascoe. 1992. Toxicity of Lindane to Freshwater Insect Larvae in Compartments of an Experimental Pond. Ecotoxicol.Environ.Saf. 23:76-88 (OECDG Data File).	3908	NonRes, Con	
McLeay, D.J.. 1976. A Rapid Method for Measuring the Acute Toxicity of Pulpmill Effluents and Other Toxicants to Salmonid Fish at Ambient Room Temperature. J.Fish.Res.Board Can. 33(6):1303-1311.	2112	Con	
Meliyan, R.I.. 1991. Effect of Pesticides on Reproductive Function of the Freshwater Amphipod Gammarus kischineffensis. Hydrobiol.J.27(6):33-36 / Gidrobiol.Zh. 27(3):107-111 (RUS).	7457	UEndp	
Metcalf, R.L., I.P. Kapoor, P.Y. Lu, C.K. Schuth, and P. Sherman. 1973. Model Ecosystem Studies of the Environmental Fate of Six Organochlorine Pesticides. Environ.Health Perspect. 4:35-44.	740	Eff, Con	
Minchew, C.D., and D.E. Ferguson. 1970. Toxicities of Six Insecticides to Resistant and Susceptible Green Sunfish and Golden Shiners in Static Bioassays. J.Miss.Acad.Sci. 15:29-32.	9645	Dur, Con	
Mitsuhashi, J., T.D.C. Grace, and D.F. Waterhouse. 1970. Effects of Insecticides on Cultures of Insect Cells. Entomol.Exp.Appl. 13:327-341.	2797	UEndp, Con	
Moss, J.L.. 1978. Toxicity of Selected Chemicals to the Fairy Shrimp, Streptocephalus seali, Under Laboratory and Field Conditions. Prog.Fish-Cult. 40(4):158-160.	6248	UEndp, Pur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Mostafa, I.Y., A.E. El Arab, and S.M.A. Zayed. 1987. Fate of 14C-Lindane in a Rice-Fish Model Ecosystem. J.Environ.Sci.Health B22(2):235-243.	4471	UEndp	
Mourad, M.H.. 1990. Effects of Lindane on the Electrocardiogram of Eel, Anguilla anguilla L. Acta Ichthyol.Piscatoria 20(2):77-84.	11325	UEndp, Con	
Mourad, M.H.. 1991. Cardiovascular and Respiratory Changes in Eel, Anguilla anguilla L. During Exposure to Lethal Doses of Lindane at Different Water Temperatures. Acta Ichthyol.Piscatoria 21(1):73-79.	6662	UEndp	
Murthy, B.N., K.S. Prasad, C. Madhu, and K.V.R. Rao. 1986. Toxicity of Lindane to Freshwater Fish Tilapia mossambica. C.A.Sel.-Environ.Pollut.4:106-45416P (1987) / Environ.Ecol. 4(1):20-23.	12786	Dur, Con	
Naqvi, S.M.Z.. 1973. Toxicity of Twenty-Three Insecticides to a Tubificid Worm Branchiura sowerbyi From the Mississippi Delta. J.Econ.Entomol. 66(1):70-74.	2798	UEndp, Con	
Neugebaur-Buchler, K.E., F.J. Zieris, and W. Huber. 1991. Reactions of an Experimental Outdoor Pond to Lindane Application. Z.Wasser-Abwasser-Forsch. 24(2):81-92.	3806	No Org, UEndp	
Nishiuchi, Y., and Y. Hashimoto. 1969. Toxicity of Pesticides to Some Fresh Water Organisms. Rev.Plant Protec.Res. 2:137-139.	2682	Con, Dur	
Oikari, A., J. Kukkonen, and V. Virtanen. 1992. Acute Toxicity of Chemicals to Daphnia magna in Humic Waters. Sci.Total Environ. 117/118:367-377.	5679	Dur, Con	
Oliver, B.G., and A.J. Niimi. 1985. Bioconcentration Factors of Some Halogenated Organics for Rainbow Trout: Limitations in Their Use for Prediction of Environmental Residues. Environ.Sci.Technol. 19(9):842-849.	14353	Eff	
Panwar, R.S., D. Kapoor, H.C. Joshi, and R.A. Gupta. 1976. Toxicity of Some Insecticides to the Weed Fish, Trichogaster fasciatus (Bloch and Schneider). J.Inl.Fish.Soc.India 8:129-130.	7881	Con, Pur	20 Emulsified Concentration

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Panwar, R.S., R.A. Gupta, H.C. Joshi, and D. Kapoor. 1982. Toxicity of Some Chlorinated Hydrocarbon and Organophosphorus Insecticides to Gastropod, Viviparus bengalensis Swainson. J.Environ.Biol. 3(1):31-36.	14311	Pur, Dur	20 Emulsified Concentration
Pawar, K.R., and M. Katdare. 1983. Acute Toxicity of Sumithion, BHC and Furadan to Some Selected Fresh Water Organisms. Biovigyanam 9:67-72.	10265	Con	
Pawar, K.R., and M. Katdare. 1984. Effect of Sublethal and Lethal Concentrations of Fenitrothion, BHC and Carbofuran on Behaviour and Oxygen Consumption of the Freshwater Prawn. Arch.Hydrobiol. 99(3):398-403.	11445	UEndp, Dur	
Persoone, G., and G. Uyttersprot. 1975. The Influence of Inorganic and Organic Pollutants on the Rate of Reproduction of a Marine Hypotrichous Ciliate: Euplotes vannus Muller. Rev.Int.Oceanogr.Med. 37-38:125-151.	5922	UEndp, Ace	
Peterson, R.H.. 1976. Temperature Selection of Juvenile Atlantic Salmon (Salmo salar) as Influenced by Various Toxic Substances. J.Fish.Res.Board Can. 33(8):1722-1730.	5160	UEndp, Dur	
Ramachandran, S., N. Rajendran, R. Nandakumar, and V.K. Venugopalan. 1984. Effect of Pesticides on Photosynthesis and Respiration of Marine Macrophytes. Aquat.Bot. 19:395-399.	10569	NonRes, Dur, Con	
Ramalingam, R., and Y.S. Reddy. 1982. Kinetics of Dose-Response Relationship in the Bimodal Respiration of Colisa lalia (Hamilton-Buchanan) Exposed to Lindane (gamma-BHC). Water Res. 16(1):1-5.	15332	NonRes, Con	
Rao, K.J., C. Madhu, V.A. Rao, and K. Ramamurthy. 1984. Hyperglycemia Induced by Insecticides in Oreochromis mossambicus (Trewavas). J.Curr.Biosci. 1(3):115-116.	2603	Dur, Con	
Rao, P.S.B.. 1985. Lindane Induced Respiratory Changes in Juveniles of an Estuarine Fish Therapon jarbua. Mahasagar Bull.Natl.Inst.Oceanogr. 18(3):413-416.	14189	NonRes, UEndp	
Rao, T.S., S. Dutt, and K. Mangaiah. 1967. TLM Values of Some Modern Pesticides to the Freshwater Fish - Puntius puckelli. Environ.Health (Nagpur) 9:103-109.	6722	NonRes, Pur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Reddy, M.S., and K.V.R. Rao. 1989. Effects of Phosphamidon and Lindane on the Limb Regeneration of Penaeid Prawn, Penaeus monodon. Bull.Environ.Contam.Toxicol. 42(1):154-158.	2983	NonRes, UEndp	
Reddy, M.S., and K.V.R. Rao. 1992. Toxicity of Selected Insecticides to the Penaeid Prawn, Metapenaeus monoceros (Fabricius). Bull.Environ.Contam.Toxicol. 48(4):622-629.	14969	NonRes	
Reddy, M.S., Y. Venkateswarlu, P. Surendranath, and K.V.R. Rao. 1986. Phosphamidon and Lindane Induced Changes in the Hemolymph Biochemistry of a Penaeid Prawn, Metapenaeus monoceros (Fabricius). Natl.Acad.Sci.Lett.(India) 9(5):155-157.	2393	Dur, Con	
Rongsriyam, Y., S. Prownebon, and S. Hirakoso. 1968. Effects of Insecticides on the Feeding Activity of the Guppy, a Mosquito-Eating Fish, in Thailand. Bull.W.H.O. 39:977-980.	3663	Con, Dur	
Rozados, M.V., M.D. Andres, and M.A. Aldegunde. 1991. Preliminary Studies on the Acute Effect of Lindane (gamma-HCH) on Brain Serotoninergic System in Rainbow Trout Oncorhynchus mykiss. Aquat.Toxicol. 19(1):33-40.	3554	UEndp, Dur	
Salanki, J., and I. Varanka. 1978. Effect of Some Insecticides on the Periodic Activity of the Fresh-Water Mussel (Anodonta cygnea L.). Acta Biol.Acad.Sci.Hung. 29(2):173-180.	7158	Dur, Pur	
Sanders, H.O., and O.B. Cope. 1968. The Relative Toxicities of Several Pesticides to Naiads of Three Species of Stoneflies. Limnol.Oceanogr. 13(1):112-117 (Author Communication Used) (Publ in Part As 6797).	889	Dur, Con	
Schulz, R., and M. Liess. 1995. Chronic Effects of Low Insecticide Concentrations on Freshwater Caddisfly Larvae. Hydrobiologia 299(2):103-113.	16023	NonRes, UEndp, Dur	
Seuge, J., and R. Bluzat. 1979. Chronic Toxicity to Carbaryl and Lindane to the Freshwater Mollusc Lymnea stagnalis L. Water Res. 13(3):285-293 (FRE) (ENG ABS).	6775	UEndp, Con	
Seuge, J., and R. Bluzat. 1983. Chronic Toxicity of Three Insecticides (Carbaryl, Fenthion and Lindane) in the Freshwater Snail Lymnaea stagnalis. Hydrobiologia 106(1):65-72.	11221	UEndp, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Shafiei, T.M., and H.H. Costa. 1990. The Susceptibility and Resistance of Fry and Fingerlings of Oreochromis mossambicus Peters to Some Pesticides Commonly used in Sri Lanka. J.Appl.Ichthyol./Z.Angew.Ichthyol. 6(2):73-80.	9253	Con, Dur	
Sherstneva, L.A.. 1978. Effect of Some Pesticides on the Fresh Water Crustaceans. Rybn.Khoz.(2):33-35 (RUS).	7170	UEndp, Con	
Shim, J.C., and L.S. Self. 1973. Toxicity of Agricultural Chemicals to Larvivorous Fish in Korean Rice Fields. Trop.Med. 15(3):123-130.	8977	Dur, Con	
Singh, P.B., and D.E. Kime. 1994. In Vivo Incorporation of [1-14C]Acetic Acid into Liver Lipids of Goldfish, Carassius auratus, During gamma-Hexachlorocyclohexane Exposure. Aquat.Toxicol. 30(3):237-248.	17568	UEndp	
Singh, P.B., and T.P. Singh. 1992. Impact of Malathion and gamma-BHC on Steroidogenesis in the Freshwater Catfish, Heteropmeustes fossilis. Aquat.Toxicol. 22:69-80.	5064	NonRes	
Singh, P.B., D.E. Kime, and T.P. Singh. 1993. Modulatory Actions of Mystus Gonadotropin on gamma-BHC-Induced Histological Changes, Cholesterol, and Sex Steroid Levels in Heteropneustes fossilis. Ecotoxicol.Environ.Saf. 25:141-153.	6653	NonRes, UEndp	
Singh, P.B., D.E. Kime, P. Epler, and J. Chyb. 1994. Impact of gamma-Hexachlorocyclohexane Exposure on Plasma Gonadotropin Levels and In Vitro Stimulation of Gonadal Steroid Production by Carp Hypophyseal Homogenate in Carassius auratus. J.Fish Biol. 44(2):195-204.	65305	UEndp	
Singh, S., and S. Sahai. 1984. Histopathological Changes in the Gills of Rasbora daniconius Induced by gamma-BHC. J.Environ.Biol. 5(2):65-69.	10793	UEndp, Con	
Singh, S., and T.P. Singh. 1987. Evaluation of Toxicity Limit and Sex Hormone Production in Response to Cythion and BHC in the Vitellogenic Catfish Clarias batrachus. Environ.Res. 42(2):482-488.	12689	Con	
Sugiura, K.. 1992. A Multispecies Laboratory Microcosm for Screening Ecotoxicological Impacts of Chemicals. Environ.Toxicol.Chem. 11:1217-1226.	3972	UEndp, No Org	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Taylor, E.J., J.E. Morrison, S.J. Blockwell, A. Tarr, and D. Pascoe. 1995. Effects of Lindane on the Predator-Prey Interaction Between Hydra oligactis Pallas and Daphnia magna Strauss. Arch.Environ.Contam.Toxicol. 29(3):291-296.	14928	UEndp	
Taylor, E.J., S.J. Blockwell, S.J. Maund, and D. Pascoe. 1993. Effects of Lindane on the Life-Cycle of a Freshwater Macroinvertebrate Chironomus riparius Meigen (Insecta: Diptera). Arch.Environ.Contam.Toxicol. 24(2):145-150.	6689	NonRes, UEndp, LT	
Thybaud, E.. 1990. Toxicite Aigue et Bioconcentration du Lindane et de la Deltamethrine par les Tetards de Rana temporaria et les Gambusies (Gambusia affinis). Hydrobiologia 190(2):137-145 (FRE) (ENG ABS).	761	UEndp	
Thybaud, E., and S. Le Bras. 1988. Absorption and Elimination of Lindane by Asellus aquaticus (Crustacea, Isopoda). Bull.Environ.Contam.Toxicol. 40(5):731-735.	6052	Eff, Con	
Thybaud, E., and T. Caquet. 1991. Uptake and Elimination of Lindane by Lymnaea-palustris (Mollusca: Gastropoda): A Pharmacokinetic Approach. Ecotoxicol.Environ.Saf. 21(3):365-376.	9318	Eff, Con	
Tidou, A.S., J.C. Moreteau, and F. Ramade. 1992. Effects of Lindane and Deltamethrin on Zooplankton Communities of Experimental Ponds. Hydrobiologia 232(2):157-168.	6042	UEndp, No Org	
Tsuji, S., Y. Tonogai, Y. Ito, and S. Kanoh. 1986. The Influence of Rearing Temperatures on the Toxicity of Various Environmental Pollutants for Killifish (Oryzias latipes). J.Hyg.Chem./Eisei Kagaku 32(1):46-53 (JPN) (ENG ABS).	12497	Con, Dur	
Twagilimana, L., J. Bohatier, C.A. Groliere, F. Bonnemoy, and D. Sargos. 1998. A New Low-Cost Microbiotest with the Protozoan Spirostomum teres: Culture Conditions and Assessment of Sensitivity of the Ciliate to 14 Pure Chemicals. Ecotoxicol.Environ.Saf. 41(3):231-244.	20057	Ace, Dur	
Udoidiong, O.M., and P.M. Akpan. 1991. Toxicity of Cadmium, Lead and Lindane to Egeria radiata Lamarck (Lamellibranchia, Donacidae). Rev.Hydrobiol.Trop. 24(2):111-117.	8515	NonRes, Pur	Emulsified Concentration

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Varanka, I.. 1977. The Effect of Some Pesticides on the Rhythmic Activity of Adductor Muscle of Fresh-Water Mussel Larvae. Acta Biol.Acad.Sci.Hung. 28(3):317-332.	6065	Dur, Con	
Varanka, I.. 1979. Effect of Some Pesticides on the Rhythmic Adductor Muscle Activity of Fresh-Water Mussel Larvae. Symp.Biol.Hung. 19:177-196.	7285	Dur, Con	
Veith, G.D., D.L. De Foe, and B.V. Bergstedt. 1979. Measuring and Estimating the Bioconcentration Factor of Chemicals in Fish. J.Fish.Res.Board Can. 36(9):1040-1048 (April 14, 1980 G.D.Veith Memo to C.E.Stephan, U.S.EPA, Duluth, MN) (Feb.7, 1980 D.L.Defoe Memo to W.A.Brungs, U.S.EPA, Duluth, MN) (Author Communication Used) (OECDG Data File).	616	Eff, Con	
Verma, S.R., I.P. Tonk, A.K. Gupta, and M. Saxena. 1984. Evaluation of an Application Factor for Determining the Safe Concentration of Agricultural and Industrial Chemicals. Water Res. 18(1):111-115.	10575	Con, Pur	20 Emulsified Concentration
Verma, S.R., S.K. Bansal, A.K. Gupta, N. Pal, A.K. Tyagi, M.C. Bhatnagar, V. Kumar, and R.C. Dalela. 1982. Bioassay Trials with Twenty Three Pesticides to a Fresh Water Teleost, Saccobranchus fossilis. Water Res. 16(5):525-529.	15179	NonRes, Pur	20 Emulsified Concentration
Verma, S.R., S.P. Gupta, and M.P. Tyagi. 1975. Studies on the Toxicity of Lindane on Colisa fasciatus (Part I: TLM Measurements and Histopathological Changes in Certain Tissues). Gegenbaurs Morphol.Jahrb. 121(1):38-54.	8463	Con, Pur	
Vigano, L., S. Galassi, and M. Gatto. 1992. Factors Affecting the Bioconcentration of Hexachlorocyclohexanes in Early Life Stages of Oncorhynchus mykiss. Environ.Toxicol.Chem. 11(4):535-540.	5884	Eff, Con	
Virtanen, V., J. Kukkonen, and A. Oikari. 1989. Acute Toxicity of Organic Chemicals to Daphnia magna in Humic Waters. In: A.Oikari (Ed.), Nordic Symposium on Organic Environmental Chemicals, University of Joensuu, Finland 29:84-86.	16674	48 h LC50 = 1790 ug/L. Test was static, unmeasured.	This study appears to provide an appropriate 48 h LC50 for D. magna, but the paper should be secured to ensure acceptability. Species is insensitive to acute lindane exposure.
Vranken, G., R. Vandergaeghen, and C. Heip. 1991. Effects of Pollutants on Life-History Parameters of the Marine Nematode Monhystera disjuncta. ICES J Mar Sci 48:325-334.	7215	Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Wellborn, T.L.J.. 1971. Toxicity of Some Compounds to Striped Bass Fingerlings. Prog.Fish-Cult. 33(1):32-36.	966	Con	
Whitten, B.K., and C.J. Goodnight. 1966. Toxicity of Some Common Insecticides to Tubificids. J.Water Pollut.Control Fed. 38(2):227-235.	8046	Con, No Org	
Wiger, R.. 1985. Variability of Lindane Toxicity in Tetrahymena pyriformis with Special Reference to Liposomal Lindane and the Surfactant Tween 80. Bull.Environ.Contam.Toxicol. 35(4):452-459.	11665	Ace, Dur	
Zambriborshch, F.C., and B. Lai. 1978. Effect of Hexachloran on Oxygen Consumption of Neogobius melanostomus and Neogobius fluviatilis. Sov.J.Mar.Biol. 4(1):526-529.	7225	NonRes, Pur	
Zambriborshch, F.S., and B. Lai. 1976. The Effect of Hexachloran on the Variability of Macropodus opercularis. Gidrobiol.Zh. 12(1):118-121 (RUS).	5874	Dur	
Zambriborshch, F.S., and B. Lay. 1976. The Effect of Hexachlorane (Hexachlorocyclohexane [HCCH]) and Chlorophos on Underyearlings of the Leaping Gray Mullet Mugil saliens. J.Ichthyol.16(5):841-847; Vopr.Ikhtiol.16(5):3930 (RUS).	7418	NonRes, Con, Pur	
Zayapragassarazan, A., and V. Anandan. 1996. Effect of gamma-HCH on the Protein Profiles of Selected Tissues of the Air-Breathing Fish Anabas testudineus (Bloch). Environ.Ecol. 14(1):55-59.	18184	NonRes	
Zou, E., and M. Fingerman. 1997. Effects of Estrogenic Xenobiotics on Molting of the Water Flea, Daphnia magna. Ecotoxicol.Environ.Saf. 38(3):281-285.	18976	Dur	
	2456	UEndp, Dur, Con, Pur	Ref # only given

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

3) For the studies that were not utilized, but the most representative SMAV/2 fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent

national ambient water quality criteria dataset used to derive the CMC[86], EPA is providing a transparent rationale as to why they were not utilized (see below).

4) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix I).

General QA/QC failure because non-resident species in Oregon

The test with the following species was used in the EPA BE of OR WQS for lindane in freshwater, but was not considered in the CWA review and approval/disapproval action of the standards because this species does not have a breeding wild population in Oregon's waters:

Asellus	*brevicaudus*	Aquatic sowbug	Mayer and Ellersieck 1986
Clarias	*batrachus*	Walking catfish	Kudesia and Bali 1984

Other Acute tests failing QA/QC by species

Clarias batrachus* – *Walking catfish

The following tests were included in EPA's BE of the OR WQS for lindane in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because the purity of the chemical was too low:

Kudesia, V.P. and N.P. Bali. 1984. Study of pesticides in Kalinadi River and evaluation of toxicity of some pesticides on fish *Clarias batrachus*. Acta Ciencia Indica 10(4): 245-254.
Purity was 68.38%. This also uses a non-resident species. This was the only study for this species, and the SMAV/2 would have fallen below the CMC had this study been used.

[86] U.S. EPA. 1980. Ambient Water Quality Criteria for Hexachlorocyclohexane. EPA-440/5-80-054.

Appendix J Nickel (freshwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Abraham, T.J., K.Y.M. Salih, and J. Chacko. 1986. Effects of Heavy Metals on the Filtration Rate of Bivalve Villorita cyprinoides (Hanley) Var. Cochinensis. Indian J.Mar.Sci. 15(3):195-196.	12315	Con, AF	
Agrawal, S.J., A.K. Srivastava, and H.S. Chaudhry. 1979. Haematological Effects of Nickel Toxicity on a Fresh Water Teleost, Colisa fasciatus. Acta Pharmacol.Toxicol. 45(3):215-217.	15705	Con, UEndp	
Alam, M.K., and O.E. Maughan. 1992. The Effect of Malathion, Diazinon, and Various Concentrations of Zinc, Copper, Nickel, Lead, Iron, and Mercury on Fish. Biol.Trace Elem.Res. 34(3):225-236.	7085	AF	
Alam, M.K., and O.E. Maughan. 1995. Acute Toxicity of Heavy Metals to Common Carp (Cyprinus carpio). J.Environ.Sci.Health Part A 30(8):1807-1816.	45566	AF, UEndp	Better data used in CORE
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Alkahem, H.F.. 1994. The Toxicity of Nickel and the Effects of Sublethal Levels on Haematological Parameters and Behaviour of the Fish, Oreochromis niloticus. J.Univ.Kuwait Sci. 21(2):243-251.	16861	AF	
Alkahem, H.F.. 1995. Effects of Nickel on Carbohydrate Metabolism of Oreochromis niloticus. Dirasat (Pure Appl.Sci.) 22 B(1):83-88.	20533	AF	
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Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Anderson, D.R.. 1981. The Combined Effects of Nickel, Chlorine and Temperature on the Mortality of Rainbow Trout, Salmo gairdneri. Ph.D.Thesis, University of Washington, Seattle, WA :202.	3710	96 h LC50 approx. 25700 ug/L dissolved nickel normalized to 100 mg/L as CaCO3 hardness. Test was flow-through, measured.	This study appears to provide an appropriate 96 h LC50 for Oncorhynchus mykiss, but the paper should be secured to ensure acceptability. Species is relatively insensitive to acute nickel exposure
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Angadi, S.B., and P. Mathad. 1994. Effect of Chromium and Nickel on Scenedesmus quadricauda (Turp.) de Breb. Phykos 33(1/2):99-103.	17433	UEndp, AF	
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Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson. 1980. Aquatic Toxicity Tests on Inorganic Elements Occurring in Oil Shale. In: C.Gale (Ed.), EPA-600/9-80-022, Oil Shale Symposium: Sampling, Analysis and Quality Assurance, March 1979, U.S.EPA, Cincinnati, OH :519-534 (U.S.NTIS PB80-221435).	11838	Dur	
Birge, W.J., J.A. Black, and A.G. Westerman. 1979. Evaluation of Aquatic Pollutants Using Fish and Amphibian Eggs as Bioassay Organisms. In: S.W.Nielsen, G.Migaki, and D.G.Scarpelli (Eds.), Symp.Animals Monitors Environ.Pollut., 1977, Storrs, CT 12:108-118.	4943	Dur	
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Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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Bringmann, G., and R. Kuhn. 1978. Investigation of Biological Harmful Effects of Chemical Substances Which are Classified as Dangerous for Water on Protozoa. Z.Wasser-Abwasser-Forsch.11(6):210-215, TR-80-0307, Literature Research Company :13 p. (ENG TRANSL) (OECDG Data File).	6601	UEndp, AF	
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Gottofrey, J., K. Borg, S. Jasim, and H. Tjaelve. 1988. Effect of Potassium Ethylxanthate and Sodium Diethyldithiocarbamate on the Accumulation and Disposition of Nickel in the Brown Trout (Salmo. Pharmacol.Toxicol. 63:46-51.	13087	UEndp, Con, AF	
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Gupta, P.K., B.S. Khangarot, and V.S. Durve. 1981. Studies on the Acute Toxicity of Some Heavy Metals to an Indian Freshwater Pond Snail Viviparus bengalensis L. Arch.Hydrobiol. 91(2):259-264 (Publ in Part as 15716).	15745	Con	
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Khangarot, B.S., and P.K. Ray. 1988. Sensitivity of Freshwater Pulmonate Snails, Lymnaea luteola L., to Heavy Metals. Bull.Environ.Contam.Toxicol. 41(2):208-213.	12943	NonRes, Con	
Khangarot, B.S., S. Mathur, and V.S. Durve. 1982. Comparative Toxicity of Heavy Metals and Interaction of Metals on a Freshwater Pulmonate Snail Lymnaea acuminata (Lamarck). Acta Hydrochim.Hydrobiol. 10(4):367-375.	11099	NonRes, Con	
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O'Neill, J.G.. 1981. The Humoral Immune Response of Salmo trutta L. and Cyprinus carpio L. Exposed to Heavy Metals. J.Fish Biol. 19(3):297-306.	15193	UEndp, Con	
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Rai, L.C., and M. Raizada. 1985. Effect of Nickel and Silver Ions on Survival, Growth, Carbon Fixation and Nitrogenase Activity in Nostoc muscorum: Regulation of Toxicity by EDTA and. J.Gen.Appl.Microbiol. 31(4):329-337.	13292	UEndp, AF	
Rao, T.S., M.S. Rao, and S.B.S. Prasad. 1975. Median Tolerance Limits of Some Chemicals to the Fresh Water Fish "Cyprinus carpio". Indian J.Environ.Health 17(2):140-146.	2077	96 h LC50 approx. 14500 ug/L dissolved nickel normalized to 100 mg/L as CaCO3 hardness. Test was renewal, measured.	This study appears to provide an appropriate 96 h LC50 for C. carpio, but the paper should be secured to ensure acceptability. Species is relatively insensitive to acute nickel exposure
Ray, D., and S.K. Banerjee. 1998. Hematological and Histopathological Changes in Clarias batrachus (Linn) Exposed to Nickel and Vanadium. Environ.Ecol. 16(1):151-156.	19046	UEndp, AF	
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Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Sauser, K.R., J.K. Liu, and T.Y. Wong. 1997. Identification of a Copper-Sensitive Ascorbate Peroxidase in the Unicellular Green Alga Selenastrum capricornutum. Biometals 10(3):163-168.	19840	UEndp, AF	
Saxena, O.P., and A. Parashari. 1983. Comparative Study of the Toxicity of Six Heavy Metals to Channa punctatus. J.Environ.Biol. 4(2):91-94.	10762	NonRes	
Schweiger, G.. 1957. The Toxic Action of Heavy Metals Salts on Fish and Organisms on Which Fish Feed. Arch.Fischereiwiss. 8:54-78.	725	UEndp, Con, AF	
Shcherban, E.P.. 1977. Toxicity of Some Heavy Metals for Daphnia magna Strauss, As a Function of Temperature. Hydrobiol J.13(4):75-80 / Gidrobiol.Zh. 13(4):86-91 (RUS).	5924	UEndp, Con, AF	
Snell, T.W., B.D. Moffat, C. Janssen, and G. Persoone. 1991. Acute Toxicity Tests Using Rotifers IV. Effects of Cyst Age, Temperature, and Salinity on the Sensitivity of Barachionus calyciflorus. Ecotoxicol.Environ.Saf. 21(3):308-317 (OECDG Data File).	9385	Dur, AF	
Sornaraj, R., P. Baskaran, and S. Thanalakshmi. 1995. Effects of Heavy Metals on Some Physiological Responses of Air-Breathing Fish Channa punctatus (Bloch). Environ.Ecol. 13(1):202-207.	17380	AF	
Sreedevi, P., A. Suresh, B. Sivaramakrishna, B. Prabhavathi, and K. Radhakrishnaiah. 1992. Bioaccumulation of Nickel in the Organs of the Freshwater Fish, Cyprinus carpio, and the Freshwater Mussel, Lamellidens marginalis, Under Lethal and Sublethal Nickel Stress. Chemosphere 24(1):29-36.	3880	UEndp, Dur, AF	
Sreedevi, P., B. Sivaramakrishna, A. Suresh, and K. Radhakrishnaiah. 1992. Effect of Nickel on Some Aspects of Protein Metabolism in the Gill and Kidney of the Freshwater Fish, Cyprinus carpio L. Environ.Pollut. 77(1):59-63.	5829	UEndp, Dur, AF	
Srivastav, R.K., S.K. Gupta, K.D.P. Nigam, and P. Vasudevan. 1994. Treatement of Chromium and Nickel in Wastewater by Using Aquatic Plants. Water Res. 28(7):1631-1638.	4438	Eff, AF, UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Stauber, J.L., and T.M. Florence. 1987. Mechanism of Toxicity of Ionic Copper and Copper Complexes to Algae. Mar.Biol. 94(4):511-519.	12971	UEndp, AF	
Stratton, G.W., and C.T. Corke. 1979. The Effect of Mercuric, Cadmium, and Nickel Ion Combinations on a Blue-Green Alga. Chemosphere 8(10):731-740.	15822	UEndp, AF	
Stuijfzand, S.C., M.H.S. Kraak, Y.A. Wink, and C. Davids. 1995. Short-Term Effects of Nickel on the Filtration Rate of the Zebra Mussel Dreissena polymorpha. Bull.Environ.Contam.Toxicol. 54(3):376-381.	14958	UEndp, Dur	
Sunderman, F.WilliamJr. 1992. Embryotoxicity and Teratogenicity of Ni2+ and Co2+ in Xenopus laevis. Science and Technology Letters :467-474.	7578	AF	
Suzuki, K.. 1959. The Toxic Influence of Heavy Metal Salts upon Mosquito Larvae. Hokkaido Univ.J.Fac.Sci.Ser. 6(14):196-209.	2701	AF, LT	
Tarzwell, C.M., and C. Henderson. 1960. Toxicity of Less Common Metals to Fishes. Ind.Wastes 5:12.	2042	Con	
Tatara, C.P., M.C. Newman, J.T. McCloskey, and P.L. Williams. 1997. Predicting Relative Metal Toxicity with Ion Characteristics: Caenorhabditis elegans LC50. Aquat.Toxicol. 39(3/4):279-290.	18605	Dur, AF	
Tatara, C.P., M.C. Newman, J.T. McCloskey, and P.L. Williams. 1998. Use of Ion Characteristics to Predict Relative Toxicity of Mono-, Di- and Trivalent Metal Ions: Caenorhabditis elegans. Aquat.Toxicol. 42:255-269.	5072	Dur, AF	
Thatheyus, A.J.. 1992. Behavioral Alterations Induced by Nickel and Chromium in Common Carp Cyprinus carpio Var communis (Linn). Environ.Ecol. 10(4):911-913.	8279	Con, AF	
Thomas, A.. 1915. Effects of Certain Metallic Salts upon Fishes. Trans.Am.Fish.Soc. 44:120-124.	2865	UEndp, AF	
Tjalve, H., J. Gottofrey, and K. Borg. 1988. Bioaccumulation, Distribution and Retention of 63Ni2+ in the Brown Trout (Salmo trutta). Water Res. 22(9):1129-1136.	13242	Eff, Con, AF	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Van Hoof, F., and J.P. Nauwelaers. 1984. Distribution of Nickel in the Roach (Rutilus rutilus L.) After Exposure to Lethal and Sublethal Concentrations. Chemosphere 13(9):1053-1058.	10671	UEndp, Dur, AF	
Vazquez, M.D., J. Lopez, and A. Carballeira. 1999. Uptake of Heavy Metals to the Extracellular and Intracellular Compartments in Three Species of Aquatic Bryophyte. Ecotoxicol.Environ.Saf. 44(1):12-24.	20585	UEndp, Dur, AF	
Verma, S.R., M. Jain, and R.C. Dalela. 1982. A Laboratory Study to Assess Separate and In-Combination Effects of Zinc, Chromium and Nickel to the Fish Mystus vittatus. Acta Hydrochim.Hydrobiol. 10(1):23-29.	15793	Con, AF	
Vymazal, J.. 1990. Uptake of Heavy Metals by Cladophora glomerata. Acta Hydrochim.Hydrobiol. 18(6):657-665.	45131	UEndp, AF	
Vymazal, J.. 1995. Influence of pH on Heavy Metals Uptake by Cladophora glomerata. Pol.Arch.Hydrobiol. 42(3):231-237.	45130	UEndp, AF	
Wang, T.C., J.C. Weissman, G. Ramesh, R. Varadarajan, and J.R. Benemann. 1996. Parameters for Removal of Toxic Heavy Metals by Water Milfoil (Myriophyllum spicatum). Bull.Environ.Contam.Toxicol. 57(5):779-786.	20408	UEndp, Dur, AF	
Wang, W.. 1987. Toxicity of Nickel to Common Duckweed (Lemna minor). Environ.Toxicol.Chem. 6(12):961-967.	12694	Con, AF	
Wang, W.. 1994. Rice Seed Toxicity Tests for Organic and Inorganic Substances. Environ.Monit.Assess. 29:101-107.	45060	AF, Dur	
Williams, P.L., and D.B. Dusenbery. 1990. Aquatic Toxicity Testing Using the Nematode, Caenorhabditis elegans. Environ.Toxicol.Chem. 9(10):1285-1290.	3437	AF	
Wong, P.K., and C.K. Wong. 1990. Toxicity of Nickel and Nickel Electroplating Water to Chlorella pyrenoidosa. Bull.Environ.Contam.Toxicol. 45(5):752-759.	3493	Dur, AF	
Wong, C.K.. 1992. Effects of Chromium, Copper, Nickel, and Zinc on Survival and Feeding of the Cladoceran Moina macrocopa. Bull.Environ.Contam.Toxicol. 49:593-599.	45188	UEndp, AF	Better data used in CORE

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Wong, C.K.. 1993. Effects of Chromium, Copper, Nickel, and Zinc on Longevity and Reproduction of the Cladoceran Moina macrocopa. Bull.Environ.Contam.Toxicol. 50:633-639.	6973	LT, Dur, AF	
Wooldridge, C.R., and D.P. Wooldridge. 1969. Internal Damage in an Aquatic Beetle Exposed to Sublethal Concentrations of Inorganic Ions. Ann.Entomol.Soc.Am. 62(4):921-933.	2868	UEndp, AF	
Zia, S., and M.A. Alikhan. 1989. A Laboratory Study of the Copper and Nickel Uptake and Regulation in a Copper - Tolerant Decapod, Cambarus bartoni (Fabricius) (Decapoda, Crustacea). Arch.Int.Physiol.Biochim. 97:211-219.	20705	UEndp, AF	

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

3) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[87], EPA is providing a transparent rationale as to why they were not utilized (see below).
4) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix J).

General QA/QC failure because non-resident species in Oregon

The test with the following species was used in the EPA BE of OR WQS for nickel in freshwater, but was not considered in the CWA review and approval/disapproval action of the standards because these species do not have a breeding wild population in Oregon's waters:

Anodonta	*imbecillis*	Mussel	Keller and Zam 1991
Moina	*macrocopa*	Cladoceran	Pokethitiyook et al. 1987

[87] U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

Ambloplites	*rupestris*	Rock bass	Lind et al. 1978
Ephemerella	*subvaria*	Mayfly	Warnick and Bell 1969

<u>Other Acute tests failing QA/QC by species</u>

Daphnia magna – cladoceran

Khangarot, B.S., P.K. Ray, and H. Chandra. 1987. *Daphnia magna* as a model to assess heavy metal toxicity: Comparative assessment with mouse system. Acta Hydrochim. Hydrobiol. 15(4): 427-432.
Test temperature (15ºC) was below ASTM recommendations for the species (20ºC) and life stage was not provided (should be neonate <24 h).

Anderson, B.G. 1948. The apparent threshold to toxicity to *Daphnia magna* for chlorides of various metals when added to lake Erie water. Trans. Am. Fish. Soc. 78: 96-113.
This study had no hardness recorded in the 1986 ALC. In addition, it is a greater than value.

The following tests were included in EPA's BE of the OR WQS for nickel in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because the species were determined to be non-North American residents. Were they Oregon residents, the SMAVs/2 would have fallen below the CMC:

Lymnaea luteola– pond snail

Khangarot, B.S. and P.K. Ray. 1988. Sensitivity of freshwater pulmonate snails, *Lymnaea luteola* L., to heavy metals. Bull. Environ. Contam. Toxicol. 41(2): 208-213.

Lymnaea acuminata– pond snail

Khangarot, B.S., S. Mathur and V.S. Durve. 1982. Comparative toxicity of heavy metals and interaction of metals on a freshwater pulmonate snail *Lymnaea acuminata* (Lamarck). Acta Hydrochim. Hydrobiol. 10(4): 367-375.

<u>Other Chronic tests failing QA/QC by species</u>

Daphnia magna - cladoceran

Lazareva, L.P. 1985. Changes in biological characteristics of *Daphnia magna* from chronic action of copper and nickel at low concentrations. Hydrobiol. J. 21(5): 59-62.
No hardness; Unacceptable effects at all concentrations tested.

Appendix K Pentachlorophenol (freshwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Aben, W.J.M., N.W.H. Houx, and M. Leistra. 1992. Toxicity of Pentachlorophenol and Chlorpyrifos in Soil and in Solution to a Nematode and a Plant Species. Rep.No.59, U.S.Dep.of Commerce, Agric.Res.Dept.Winand Staring Center for Integrated Land, Soil and Water Res., Wageningen, Netherlands (U.S.NTIS PB93-221216) :39 p.	44356	AF, Form	
Adema, D.M.M. 1978. Daphnia magna as a Test Animal in Acute and Chronic Toxicity Tests. Hydrobiologia 59(2):125-134.	2018	AF, Dur	Table 6 in WQC document
Agrawal, H.P. 1987. Evaluation of the Toxicity of Phenol and Sodium Pentachlorophenate to the Snail Indoplanorbis exustus (Deshayes). J.Anim.Morphol.Physiol. 34(1-2):107-112.	9973	AF, Dur, Form	
Alabaster, J.S. 1969. Survival of Fish in 164 Herbicides, Insecticides, Fungicides, Wetting Agents and Miscellaneous Substances. Int.Pest Control 11(2):29-35 (Author Communication Used).	542	AF, Dur	
Alexander, D.G., and R.M.V. Clarke. 1978. The Selection and Limitations of Phenol As a Reference Toxicant to Detect Differences in Sensitivity Among Groups of Rainbow Trout (Salmo gairdneri). Water Res. 12(12):1085-1090.	6262	Uendp, Dur	
Bali, H.S., S. Singh, and D.P. Singh. 1984. Trial of Some Molluscicides on Snails Melanoides tuberculatus and Vivipara bengalensis in Laboratory. Indian J.Anim.Sci. 54(4):401-403.	10207	AF, Dur	
Basack, S.B., M.L. Oneto, N.R. Verrengia Guerrero, and E.M. Kesten. 1997. Accumulation and Elimination of Pentachlorophenol in the Freshwater Bivalve Corbicula fluminea. Bull.Environ.Contam.Toxicol. 58(3):497-503.	18004	Form	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Belliyappa, G., and S.R. Reddy. 1986. Growth and Conversion Efficiency of the Catfish Heteropneustes fossilis (Bloch) Exposed to Sub-Lethal Concentrations of Sodium Pentachlorophenate. Pol.Arch.Hydrobiol. 33(1):115-120.	12702	AF, Con, Form	
Bennett, W.R., and A.P. Farrell. 1998. Acute Toxicity Testing with Juvenile White Sturgeon (Acipenser transmontanus). Water Qual.Res.J.Can. 33(1):95-110.	20400	Uendp, Dur, Form	
Berglind, R., and G. Dave. 1984. Acute Toxicity of Chromate, DDT, PCP, TPBS, and Zinc to Daphnia magna Cultured in Hard and Soft Water. Bull.Environ.Contam.Toxicol. 33(1):63-68.	10871	Dur, Con	Not in WQC Doc
Bierkens, J., J. Maes, and F. Vander Plaetse. 1998. Dose-Dependent Induction of Heat Shock Protein 70 Synthesis in Raphidocelis subcapitata Following Exposure to Different Classes of Environmental. Environ.Pollut. 101:91-97.	19649	Plant, UEndp, AF	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Bitton, G., K. Rhodes, and B. Koopman. 1996. CerioFAST: An Acute Toxicity Test Based on Ceriodaphnia dubia Feeding Behavior. Environ.Toxicol.Chem. 15(2):123-125.	17097	AF, Dur	
Bitton, G., K. Rhodes, B. Koopman, and M. Cornejo. 1995. Short-Term Toxicity Assay Based on Daphnid Feeding Behavior. Water Environ.Res. 67(3):290-293.	19602	AF, Form	
Blackman, G.E., M.H. Parke, and G. Garton. 1955. The Physiological Activity of Substituted Phenols. I. Relationships between Chemical Structure and Physiological Activity. Arch.Biochem.Biophys. 54:45-54.	2231	Plant, Con	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Bogaerts, P., J. Senaud, and J. Bohatier. 1998. Bioassay Technique Using Nonspecific Esterase Activities of Tetrahymena pyriformis for Screening and Assessing Cytotoxicity of Xenobiotics. Environ.Toxicol.Chem. 17(8):1600-1605.	18353	AF, UEndp, Dur	
Borgmann, U., and K.M. Ralph. 1986. Effects of Cadmium, 2,4-Dichlorophenol, and Pentachlorophenol on Feeding, Growth, and Particle-Size-Conversion Efficiency of White. Arch.Environ.Contam.Toxicol. 15(5):473-480.	11938	UEndp, Con, AF	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Borgmann, U., K.M. Ralph, and W.P. Norwood. 1989. Toxicity Test Procedures for Hyalella azteca, and Chronic Toxicity of Cadmium and Pentachlorophenol to H. azteca, Gammarus fasciatus, and Daphnia magna. Arch.Environ.Contam.Toxicol. 18(5):756-764.	772	UEndp	
Bresch, H.. 1982. Investigation of the Long-Term Action of Xenobiotics on Fish with Special Regard to Reproduction. Ecotoxicol.Environ.Saf. 6(1):102-112.	10392	Con	
Brockway, D.L.. 1963. Some Effects of Sub-Lethal Levels of Pentachlorophenol and Cyanide on the Physiology and Behavior of a Cichlid Fish Cichlasoma bimaculatum (Linnaeus). M.S.Thesis, Oregon State University, Corvalis, O R:56.	5591	Dur	
Canton, J.H., and D.M.M. Adema. 1978. Reproducibility of Short-Term and Reproduction Toxicity Experiments with Daphnia magna and Comparison of the Sensitivity of Daphnia magna with Daphnia pulex and Daphnia cucullata in Short-Term Experiments. Hydrobiologia 59(2):135-140 (Used Reference 2018).	2017	AF, Con	In current WQC Doc, but no pH value given
Carlson, R.W.. 1990. Ventilatory Patterns of Bluegill (Lepomis macrochirus) Exposed to Organic Chemicals with Different Mechanisms of Toxic Action. Comp.Biochem.Physiol.C 95(2):181-196.	3461	UEndp, AF	
Castren, M., and A. Oikari. 1987. Changes of the Liver UDP-Glucuronosyltransferase Activity in Trout (Salmo gairdneri Rich.) Acutely Exposed to Selected Aquatic Toxicants. Comp.Biochem.Physiol.C 86(2):357-360.	12208	UEndp, Con, AF	
Centeno, M.D., L. Brendonck, and G. Persoone. 1993. Cyst-Based Toxicity Tests. III. Development and Standardization of an Acute Toxicity Test with the Freshwater Anostracan Crustacean Streptocephalus. In: A.M.V.M.Soares and P.Calow (Eds.), Progress in Standardization of Aquatic Toxicity Tests, Lewis Publishers :37-55.	14250	Dur	
Centeno, M.D.F., G. Persoone, and M.P. Goyvaerts. 1995. Cyst-Based Toxicity Tests. IX. The Potential of Thamnocephalus platyurus as Test Species in Comparison with Streptocephalus proboscideus (Crustacea. Environ.Toxicol.Water Qual. 10(4):275-282.	14017	AF, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Centeno, M.D.F., L. Brendonck, and G. Persoone. 1993. Influence of Production, Processing, and Storage Conditions of Resting Eggs of Streptocephalus proboscideus (Crustacea: Branchiopoda: Anostraca) on. Bull.Environ.Contam.Toxicol. 51(6):927-934.	8130	AF, Dur	
Chapman, G.A.. 1969. Toxicity of Pentachlorophenol to Trout Alevins. Ph.D.Thesis, Oregon State University, Corvallis, OR :87 p..	151	Dur	
Chapman, G.A., and D.L. Shumway. 1978. Effects of Sodium Pentachlorophenate on Survival and Energy Metabolism of Embryonic and Larval Steelhead Trout. In: K.R.Rao (Ed.), Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology, Plenum Press, New York, NY :285-299.	15219	AF, Dur, Con	
Chapman, P.M., M.A. Farrell, and R.O. Brinkhurst. 1982. Effects of Species Interactions on the Survival and Respiration of Limnodrilus hoffmeisteri and Tubifex tubifex (Oligochaeta, Tubificidae) Exposed to. Water Res. 16(9):1405-1408.	15207	See comment	Table 6 because tests included sediment
Charoy, C., and C.R. Janssen. 1999. The Swimming Behaviour of Brachionus calyciflorus (Rotifer) Under Toxic Stress. II. Comparative Sensitivity of Various Behavioural Criteria. Chemosphere 38(14):3247-3260.	20070	UEndp, Dur	
Chowdary, V.D., P.V. Rao, and R. Narayanan. 1979. Effect of Copper Sulfate and Sodium Pentachlorophenate on Adenine and Andenosine Phosphates in Lymnaea luteola (Mollusca: Gastropoda). Bull.Environ.Contam.Toxicol. 23(4-5):615-619.	6804	AF, Dur, Con	
Christoffers, D., and D.E.W. Ernst. 1983. The In-Vivo Fluorescence of Chlorella fusca as a Biological Test for the Inhibition of Photosynthesis. Toxicol.Environ.Chem. 7:61-71.	45160	Plant, AF, UEndp	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Clemens, H.P., and K.E. Sneed. 1959. Lethal Doses of Several Commercial Chemicals for Fingerling Channel Catfish. U.S.Fish Wildl.Serv.Sci.Rep.Fish.No.316, U.S.D.I., Washington, D.C. :10 p..	934	AF, Dur, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Cleveland, L., D.R. Buckler, F.L. Mayer, and D.R. Branson. 1982. Toxicity of Three Preparations of Pentachlorophenol to Fathead Minnows-a Comparative Study. Environ.Toxicol.Chem. 1(3):205-212.	15155	UEndp	Table 6 in WQC document
Crandall, C.A., and C.J. Goodnight. 1959. The Effect of Various Factors on the Toxicity of Sodium Pentachlorophenate to Fish. Limnol.Oceanogr. 4:53-56.	8057	UEndp, Dur	
Crandall, C.A., and C.J. Goodnight. 1962. Effects of Sublethal Concentrations of Several Toxicants on Growth of the Common Guppy, Lebistes reticulatus. Limnol.Oceanogr. 7(2):233-239.	13950	UEndp, Dur	
Crandall, C.A., and C.J. Goodnight. 1963. The Effects of Sublethal Concentrations of Several Toxicants to the Common Guppy, Lebistes reticulatus. Trans.Am.Microsc.Soc. 82:59-73.	13951	UEndp, Dur	
Cravedi, J.P., C. Gillet, and G. Monod. 1995. In Vivo Metabolism of Pentachlorophenol and Aniline in Arctic Charr (Salvelinus alpinus L.) Larvae. Bull.Environ.Contam.Toxicol. 54(5):711-716.	17842	UEndp, Dur, Con	
Cressman III, C.P., and P.L. Williams. 1997. Reference Toxicants for Toxicity Testing Using Caenorhabditis elegans in Aquatic Media. In: F.J.Dwyer, T.R.Doane, and M.L.Hinman (Eds.), Environmental Toxicology and Risk Assessment: Modeling and Risk Assessment, 6th Volume, ASTM STP 1317, Philadelphia, PA :518-532.	19999	UEndp, Dur	
Dalela, R.C., S. Rani, S. Rani, and S.R. Verma. 1980. Influence of pH on the Toxicity of Phenol and its Two Derivatives Pentachlorophenol and Dinitrophenol to Some Fresh Water Teleosts. Acta Hydrochim.Hydrobiol. 8(6):623-629.	6432	Dur	
De Coen, W.M., M.L. Vangheluwe, and C.R. Janssen. 1998. The Use of Biomarkers in Daphnia magna Toxicity Testing. III. Rapid Toxicity Testing of Pure Chemicals and Sediment Pore Waters Using Ingestion and. Chemosphere 37(13):2677-2694.	2919	AF, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Devillers, J., T. Meunier, and P. Chambon. 1985. Advantage of the Dosage-Action-Time Relation in Ecotoxicology for the Test of the Various Chemical Species of Toxics. Tech.Sci.Munic. 80:329-334 (FRE) (ENG ABS).	17456	Dur	
Donkin, S.G., and P.L. Williams. 1995. Influence of Developmental Stage, Salts and Food Presence on Various End Points Using Caenorhabditis elegans for Aquatic Toxicity Testing. Environ.Toxicol.Chem. 14(12):2139-2147.	16377	Dur	
Douglas, M.T., D.O. Chanter, I.B. Pell, and G.M. Burney. 1986. A Proposal for the Reduction of Animal Numbers Required for the Acute Toxicityto Fish Test (LC50 Determination). Aquat.Toxicol. 8(4):243-249.	12210	AF, Con	
Feind, D., F.J. Zieris, and W. Huber. 1988. Effects of Sodium Pentachlorophenate on the Ecology of a Freshwater Model Ecosystem. Environ.Pollut. 50:211-223.	12876	AF, UEndp, Dur	
Ferrando, M.D., C.R. Janssen, E. Andreu, and G. Persoone. 1993. Ecotoxicological Studies with the Freshwater Rotifer Brachionus calyciflorus III. The Effects of Chemicals on the Feeding Behavior. Ecotoxicol.Environ.Saf. 26(1):1-9 (OECDG Data File).	8272	AF, UEndp, Dur	
Fisher, S.W.. 1986. Effects of Temperature on the Acute Toxicity of PCP in the Midge Chironomus riparius Meigen. Bull.Environ.Contam.Toxicol. 36(5):744-748.	12137	UEndp, Dur, Con	Table 6 in WQC Doc - Dur 24 h
Fisher, S.W., and R.W. Wadleigh. 1986. Effects of pH on the Acute Toxicity and Uptake of [14C]Pentachlorophenol in the Midge, Chironomus riparius. Ecotoxicol.Environ.Saf. 11(1):1-8.	11708	Dur, Con	Table 6 in WQC Doc - Dur 24 h
Flerov, B.A.. 1979. Comparative Study of the Avoidance of Toxic Substances in Some Aquatic Animals. Tr.Inst.Biol.Vnutr.Vod Akad.Nauk SSSR 38:81-87 (RUS) (ENG ABS).	6837	AF, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Fort, D.J., and E.L. Stover. 1997. Development of Short-Term, Whole-Embryo Assays to Evaluate Detrimental Effects on Amphibian Limb Development and Metamorphosis Using Xenopus laevis. In: F.J.Dwyer, T.R.Doane, and M.L.Hinman (Eds.), Environmental Toxicology and Risk Assessment: Modeling and Risk Assessment, 6th Volume, ASTM STP 1317, Philadelphia, PA :376-390.	19965	UEndp	
Freitag, D., H. Geyer, A. Kraus, R. Viswanathan, D. Kotzias, A. Attar, W. Klein, and F. Korte. 1982. Ecotoxicological Profile Analysis VII. Screening Chemicals for Their Environmental Behavior by Comparative Evaluation. Ecotoxicol.Environ.Saf. 6:60-81.	3781	AF, UEndp, Dur	
Geyer, H., G. Politzki, and D. Freitag. 1984. Prediction of Ecotoxicological Behaviour of Chemicals: Relationship Between N-Octanol/Water Partition Coefficient and Bioaccumulation of Organic Chemicals by Alga Chlorella. Chemosphere 13(2):269-284.	11297	Plant, AF, UEndp, Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Geyer, H., I. Scheunert, and F. Korte. 1985. The Effects of Organic Environmental Chemicals on the Growth of the Alga Scenedesmus subspicatus: A Contribution to Environmental Biology. Chemosphere 14(9):1355-1369.	11677	Plant, UEndp, AF	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
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Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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Pierce, R.H.J.. 1978. Fate and Impact of Pentachlorophenol in a Freshwater Ecosystem. EPA 600/3-78-063, U.S.EPA, Athens, GA :74 p..	14319	AF, UEndp, Dur	Provided with Pruitt et al. 1977 in Table 1 of WQC doc
Pignatello, J.J., M.M. Martinson, J.G. Steiert, R.E. Carlson, and R.L. Crawford. 1983. Biodegradation and Photolysis of Pentachlorophenol in Artificial Freshwater Streams. Appl.Environ.Microbiol. 46(5):1024-1031.	67599	AF, UEndp, Form	
Preston, B.L., T.W. Snell, and R. Kneisel. 1999. UV-B Exposure Increases Acute Toxicity of Pentachlorophenol and Mercury to the Rotifer Brachionus calyciflorus. Environ.Pollut. 106(1):23-31.	20344	AF, Dur, Form	
Preston, B.L., T.W. Snell, T.L. Robertson, and B.J. Dingmann. 2000. Use of Freshwater Rotifer Brachionus calyciflorus in Screening Assay for Potential Endocrine Disruptors. Environ.Toxicol.Chem. 19(12):2923-2928.	60076	AF, Dur	
Randall, T.L., and P.V. Knopp. 1980. Detoxification of Specific Organic Substances by Wet Oxidation. J.Water Pollut.Control Fed. 52(8):2117-2130.	2193	Con	
Rao, P.S., V.S. Durve, B.S. Khangarot, and S.S. Shekhawat. 1983. Acute Toxicity of Phenol, Pentachlorophenol and Sodium Pentachlorophenate to a Freshwater Ostracod Cypris subglobosa (Sowerby). Acta Hydrochim.Hydrobiol. 11(4):457-465.	11517	NonRes	
Samis, A.J.W., P.W. Colgan, and P.H. Johansen. 1991. A Comparison of the Effects of Subchronic and Acute Spill-Mimicking Pentachlorophenol Exposures on Growth of Bluegill Sunfish (Lepomis macrochirus). Aquat.Toxicol. 19(3):231-240.	3611	UEndp, Dur	
Samis, A.J.W., P.W. Colgan, and P.H. Johansen. 1993. Pentachlorophenol and Reduced Food Intake of Bluegill. Trans.Am.Fish.Soc. 122(6):1156-1160.	4247	UEndp, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Samis, A.J.W., P.W. Colgan, and P.H. Johansen. 1994. Recovery from the Effects of Subchronic Pentachlorophenol Exposure on the Growth of Juvenile Bluegill Sunfish (Lepomis macrochirus). Can.J.Zool. 72(11):1973-1977.	16812	AF, UEndp, Dur	
Sembiring, S.B., G. Merlin, and G. Blake. 1994. The Effect of Pentachlorophenol (PCP) on Lemna minor. In: B.Widianarko, K.Vink, and N.M.Van Straalen (Eds.), Environmental Toxicology in South East Asian, VU University Press, Amsterdam, Netherlands :113-118.	20176	AF, UEndp, Dur, Form	
Servizi, J.A., R.W. Gordon, and J.H. Carey. 1988. Bioconcentration of Chlorophenols by Early Life Stages of Fraser River Pink and Chinook Salmon (Oncorhynchus gorbuscha, O. tshawytscha). Water Pollut.Res.J.Can. 23(1):88-99.	3786	UEndp, Dur	
Sharma, H.A., J.T. Barber, H.E. Ensley, and M.A. Polito. 1997. A Comparison of the Toxicity and Metabolism of Phenol and Chlorinated Phenols by Lemna gibba, with Special Reference to 2,4,5-Trichlorophenol. Environ.Toxicol.Chem. 16(2):346-350.	17665	Plant, AF	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Shedd, T.R., M.W. Widder, M.W. Toussaint, M.C. Sunkel, and E. Hull. 1999. Evaluation of the Annual Killifish Nothobranchius guentheri as a Tool for Rapid Acute Toxicity Screening. Environ.Toxicol.Chem. 18(10):2258-2261.	20487	Dur	
Shigeoka, T., T. Yamagata, T. Minoda, and F. Yamauchi. 1988. Acute Toxicity and Hatching Inhibition of Chlorophenols to Japanese Medaka, Oryzias latipes and Structure-Activity Relationships. J.Hyg.Chem./Eisei Kagaku 34(4):343-349 (JPN) (ENG ABS).	753	Plant, AF, Dur, Con	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Shigeoka, T., Y. Sato, Y. Takeda, K. Yoshida, and F. Yamauchi. 1988. Acute Toxicity of Chlorophenols to Green Algae, Selenastrum capricornutum and Chlorella vulgaris, and Quantitative Structure-Activity Relationships. Environ.Toxicol.Chem. 7(10):847-854.	13171	Plant, AF, Dur, Con	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Shim, J.C., and L.S. Self. 1973. Toxicity of Agricultural Chemicals to Larvivorous Fish in Korean Rice Fields. Trop.Med. 15(3):123-130.	8977	AF, Dur, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Shumway, D.L., and J.R. Palensky. 1973. Impairment of the Flavor of Fish by Water Pollutants. EPA-R3-73-010, U.S.EPA, Washington, D.C. :80 p.	6573	Dur	
Slabbert, J.L., and W.S.G. Morgan. 1982. A Bioassay Technique Using Tetrahymena pyriformis for the Rapid Assessment of Toxicants in Water. Water Res. 16(5):517-523.	11048	AF, UEndp, Dur	
Slooff, W. 1978. Biological Monitoring Based on Fish Respiration for Continuous Water Quality Control. In: O.Hutzinger, I.H.Van Lelyveld and B.C.Zoeteman (Eds.), Aquatic Pollutants: Transformation and Biological Effects, Pergamon Press, NY :501-506.	17278	Dur, Con	
Slooff, W. 1979. Detection Limits of a Biological Monitoring System Based on Fish Respiration. Bull.Environ.Contam.Toxicol. 23(4-5):517-523.	5938	Dur	
Slooff, W.. 1983. Benthic Macroinvertebrates and Water Quality Assessment: Some Toxicological Considerations. Aquat.Toxicol. 4:73-82.	15788	AF, Dur - 48 h	Table 6 in WQC Doc
Slooff, W., and R. Baerselman. 1980. Comparison of the Usefulness of the Mexican Axolotl (Ambystoma mexicanum) and the Clawed Toad (Xenopus laevis) in Toxicological Bioassays. Bull.Environ.Contam.Toxicol. 24(3):439-443.	9740	AF, UEndp, Con	Table 6 in WQC Doc
Smith, A.D., A. Bharath, C. Mallard, D. Orr, K. Smith, J.A. Sutton, J. Vukmanich, L.S. McCarty, and G.W. Ozburn. 1991. The Acute and Chronic Toxicity of Ten Clorinated Organic Compounds to the American Flagfish (Jordanella floridae). Arch.Environ.Contam.Toxicol. 20(1):94-102.	140	AF, Con	
Smith, A.D., A. Bharath, C. Mallard, D. Orr, L.S. McCarty, and G.W. Ozburn. 1990. Bioconcentration Kinetics of Some Chlorinated Benzenes and Chlorinated Phenols in American Flagfish, Jordanella floridae (Goode and Bean). Chemosphere 20(3-4):379-386.	3116	AF, UEndp	
Smith, P.D., D.L. Brockway, and F.E. Stancil Jr.. 1987. Effects of Hardness, Alkalinity and pH on the Toxicity of Pentachlorophenol to Selenastrum capricornutum (Printz). Environ.Toxicol.Chem. 6(11):891-900.	12735	Plant, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Snell, T.W.. 1991. New Rotifer Bioassays for Aquatic Toxicology. Final Report, U.S.Army Medical Research and Development Command, Ft.Detrick, Frederick, MD :29 p.(U.S.NTIS AD-A258002).	17689	AF, Dur	
Snell, T.W., and B.D. Moffat. 1992. A 2-D Life Cycle Test with the Rotifer Brachionus calyciflorus. Environ.Toxicol.Chem. 11(9):1249-1257.	3963	AF, Dur, Form	
Snell, T.W., and M.J. Carmona. 1995. Comparative Toxicant Sensitivity of Sexual and Asexual Reproduction in the Rotifer Brachionus calyciflorus. Environ.Toxicol.Chem. 14(3):415-420.	14212	AF, Dur	
Snell, T.W., B.D. Moffat, C. Janssen, and G. Persoone. 1991. Acute Toxicity Tests Using Rotifers IV. Effects of Cyst Age, Temperature, and Salinity on the Sensitivity of Barachionus calyciflorus. Ecotoxicol.Environ.Saf. 21(3):308-317 (OECDG Data File).	9385	AF, Dur, Form	
Statham, C.N., and J.J. Lech. 1975. Potentiation of the Acute Toxicity of Several Pesticides and Herbicides in Trout by Carbaryl. Toxicol.Appl.Pharmacol. 34(1):83-87.	5550	UEndp, Dur, Con	
Stehly, G.R., and W.L. Hayton. 1988. Detection of Pentachlorophenol and its Glucuronide and Sulfate Conjugates in Fish Bile and Exposure Water. J.Environ.Sci.Health B23(4):355-366.	13262	UEndp, Dur, Con, Form	
Stehly, G.R., and W.L. Hayton. 1989. Disposition of Pentachlorophenol in Rainbow Trout (Salmo gairdneri): Effect of Inhibition of Metabolism. Aquat.Toxicol. 14(2):131-148.	386	UEndp, Form	
Stehly, G.R., and W.L. Hayton. 1990. Effect of pH on the Accumulation Kinetics of Pentachlorophenol in Goldfish. Arch.Environ.Contam.Toxicol. 19(3):464-470.	3179	UEndp, Con, Form	
Steinberg, C.E.W., Y. Xu, S.K. Lee, D. Freitag, and A. Kettrup. 1993. Effect of Dissolved Humic Material (DHM) on Bioavailability of Some Organic Xenobiotics to Daphnia magna. Chem.Spec.Bioavail. 5(1):1-9.	13435	AF, UEndp, Dur, Form	
Stephenson, G.L., N.K. Kaushik, and K.R. Solomon. 1991. Acute Toxicity of Pure Pentachlorophenol and a Technical Formulation to Three Species of Daphnia. Arch.Environ.Contam.Toxicol. 20(1):73-80.	174	AF, Dur, Form	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Stephenson, G.L., N.K. Kaushik, and K.R. Solomon. 1991. Chronic Toxicity of a Pure and Technical Grade Pentachlorophenol to Daphnia magna. Arch.Environ.Contam.Toxicol. 21:388-394.	5031	Uendp, Dur, Form	
Surtikanti, H.K.. 1994. The Influence of Food (Algae) Concentration on the NaPCP Toxicity for Brachionus calyciflorus Based on Its Life Table. In: B.Widianarko, K.Vink, and N.M.Van Straalen (Eds.), Environmental Toxicology in South East Asia, VU University Press, Amsterdam, Netherlands :106-111.	20175	AF, UEndp, Form	
Tachikawa, M., A. Hasegawa, R. Sawamura, A. Takeda, S. Okada, and M. Nara. 1987. Difference between Fresh- and Seawater Fishes in the Accumulation and Effect of Environmental Chemical Pollutants. I. Intakes of Chlordane. J.Hyg.Chem./Eisei Kagaku 33(2):98-105 (JPN) (ENG ABS).	12737	UEndp, Dur, Con, Form	
Tachikawa, M., and R. Sawamura. 1994. The Effects of Salinity on Pentachlorophenol Accumulation and Elimination by Killifish (Oryzias latipes). Arch.Environ.Contam.Toxicol. 26(3):304-308.	13665	Uendp, Dur, Form	
Tomizawa, C., and H. Kazano. 1979. Environmental Fate of Rice Paddy Pesticides in a Model Ecosystem. J.Environ.Sci.Health Part B 14(2):121-152.	6553	Plant, AF, UEndp	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Twagilimana, L., J. Bohatier, C.A. Groliere, F. Bonnemoy, and D. Sargos. 1998. A New Low-Cost Microbiotest with the Protozoan Spirostomum teres: Culture Conditions and Assessment of Sensitivity of the Ciliate to 14 Pure Chemicals. Ecotoxicol.Environ.Saf. 41(3):231-244.	20057	Dur	
Vallejo-Freire, A., O. Fonseca Ribeiro, and I. Fonseca Ribeiro. 1954. Quaternary Ammonium Compounds As Molluscacides. Science 119(3093):470-472.	2545	AF, UEndp, Dur, Con	
Van den Heuvel, M.R., L.S. McCarty, R.P. Lanno, B.E. Hickie, and D.G. Dixon. 1991. Effect of Total Body Lipid on the Toxicity and Toxicokinetics of Pentachlorophenol in Rainbow Trout (Oncorhychus mykiss). Aquat.Toxicol. 20(4):235-252.	2334	UEndp, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Van Leeuwen, C.J., G. Niebeek, and M. Rijkeboer. 1988. Effects of Chemical Stress on the Population Dynamics of Daphnia magna: A Comparison of Two Test Procedures. Ecotoxicol.Environ.Saf.14(1):1-11 (1987) / Aquat.Toxicol. 11(3/4):421-422 (ABS).	12690	AF, Dur, Con	
Van Leeuwen, C.J., P.S. Griffioen, W.H.A. Vergouw, and J.L. Maas-Diepeveen. 1985. Differences in Susceptibility of Early Life Stages of Rainbow Trout (Salmo gairdneri) to Environmental Pollutants. Aquat.Toxicol. 7(1-2):59-78.	11519	AF, Con, Form	In Table 1 of WQC doc with pH, but no pH reported in ECOTOX
Veith, G.D., D.L. De Foe, and B.V. Bergstedt. 1979. Measuring and Estimating the Bioconcentration Factor of Chemicals in Fish. J.Fish.Res.Board Can. 36(9):1040-1048 (April 14, 1980 G.D.Veith Memo to C.E.Stephan, U.S.EPA, Duluth, MN) (Feb.7, 1980 D.L.Defoe Memo to W.A.Brungs, U.S.EPA, Duluth, MN) (Author Communication Used) (OECDG Data File).	616	UEndp, Con	
Venegas, W., I. Hermosilla, L. Quevedo, and G. Montoya. 1993. Genotoxic and Teratogenic Effect of Pentachlorophenol, Pollutant Present in Continental Water Bodies in the South of Chile. Bull.Environ.Contam.Toxicol. 51:107-114.	6827	AF, UEndp, Dur	
Verma, S.R., I.P. Tonk, A.K. Gupta, and M. Saxena. 1984. Evaluation of an Application Factor for Determining the Safe Concentration of Agricultural and Industrial Chemicals. Water Res. 18(1):111-115.	10575	Con	
Verma, S.R., S. Rani, A.K. Tyagi, and R.C. Dalela. 1980. Evaluation of Acute Toxicity of Phenol and its Chloro- and Nitro-Derivatives to Certain Teleosts. Water Air Soil Pollut. 14:95-102.	5266	Con	
Verma, S.R., S. Rani, and R.C. Dalela. 1981. Synergism, Antagonism, and Additivity of Phenol, Pentachlorophenol, and Dinitrophenol to a Fish (Notopterus notopterus). Arch.Environ.Contam.Toxicol. 10(3):365-370.	15670	Con, NonRes	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Versteeg, D.J.. 1990. Comparison of Short- and Long-Term Toxicity Test Results for the Green Alga, Selenastrum capricornutum. In: W.Wang, J.W.Gorsuch, and W.R.Lower (Eds.), Plants for Toxicity Assessment, ASTM STP 1091, Philadelphia, PA :40-48.	17639	Plant, Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Whitley, L.S. 1968. The Resistance of Tubificid Worms to Three Common Pollutants. Hydrobiologia 32(1/2):193-205 (Author Communication Used).	15507	Dur - 24 h, Con	Table 6 in WQC doc
Winner, R.W. 1988. Evaluation of the Relative Sensitivities of 7-D Daphnia magna and Ceriodaphnia dubia Toxicity Tests for Cadmium and Sodium Pentachlorophenate. Environ.Toxicol.Chem. 7(2):153-159.	2443	AF, UEndp, Dur, Form	
Yount, J.D., and J.E. Richter. 1986. Effects of Pentachlorophenol on Periphyton Communities in Outdoor Experimental Streams. Arch.Environ.Contam.Toxicol. 15(1):51-60.	12104	Plant, AF, Uendp, Form	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Zischke, J.A., J.W. Arthur, R.O. Hermanutz, S.F. Hedtke, and J.C. Helgen. 1985. Effects of Pentachlorophenol on Invertebrates and Fish in Outdoor Experimental Channels. Aquat.Toxicol. 7(1-2):37-58.	2652	UEndp, Field, NoOrg	
Whitley, L.S. 1968. The Resistance of Tubificid Worms to Three Common Pollutants. Hydrobiologia 32(1/2):193-205 (Author Communication Used).	15507	Dur	Table 6
Winner, R.W. 1988. Evaluation of the Relative Sensitivities of 7-D Daphnia magna and Ceriodaphnia dubia Toxicity Tests for Cadmium and Sodium Pentachlorophenate. Environ.Toxicol.Chem. 7(2):153-159.	2443	Form, Dur, Unknown Endpoint, Chronic Renewal and Unmeasured, No pH	
Yount, J.D., and J.E. Richter. 1986. Effects of Pentachlorophenol on Periphyton Communities in Outdoor Experimental Streams. Arch.Environ.Contam.Toxicol. 15(1):51-60.	12104	Form, Species, Field, Unknown Endpoint, No pH	
Zischke, J.A., J.W. Arthur, R.O. Hermanutz, S.F. Hedtke, and J.C. Helgen. 1985. Effects of Pentachlorophenol on Invertebrates and Fish in Outdoor Experimental Channels. Aquat.Toxicol. 7(1-2):37-58.	2652	Species, Field, Dur, Unknown Endpoint, Endpoint (Lethal)	Not in WQC Doc

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

1. For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[88], EPA is providing a transparent rationale as to why they were not utilized (see below).
2. For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix K).

General QA/QC failure because non-resident species in Oregon

Tests with the following several species were used in the EPA BE of OR WQS for pentachlorophenol in freshwater, but were not considered in the CWA review and approval/disapproval action of the standards because these species do not have a breeding wild population in Oregon's waters:

Ceriodaphnia	*reticulata*	Cladoceran	Hedtke et al. 1986
Oncorhynchus	*clarki (stomias)*	Greenback cutthroat trout	Sappington et al. 2001
Oncorhynchus	*gilae*	Apache trout	Sappington et al. 2001

Other Acute tests failing QA/QC by species

Oncorhynchus clarki - Cutthroat Trout

Mayer, F.L.J. and M.R. Ellersieck. 1986. Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals. Resour. Publ. No. 160, U.S. Dep. Interior, Fish Wildl. Serv., Washington, DC: 505 p. (USGS Data File).

[88] U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

The LC50s from this extensive aquatic toxicity data compendium were included in EPA's BE of the OR WQS for pentachlorophenol in freshwater, but were not used for determining the most representative SMAV in this CWA review and approval of these standards because the values included in EPA's ECOTOX database that were used for the BE were erroneous when checked against the original source. No 96-h LC50 is provided, only a lower bound of 10 ug/L and an upper bound of 100 ug/L about some unspecified 96-h LC50. Also, the same test data appears to be entered for the commercial formulation of pentachlorphenol - Dowicide EC-7 (88% purity) and NaPCP (see pages 374 and 375 in the compendium). The lower bound value of 10 ug/L for three forms of pentachlorophenol (technical, Dowicide and NaPCP) was recorded as the mean 96 h LC50 in ECOTOX.

Ictalurus punctatus – Channel catfish

Phipps, G.L. and G.W. Holcombe. 1985. A method for aquatic multiple species toxicant testing: Acute toxicity of 10 chemicals to 5 vertebrates and 2 invertebrates. Environ. Pollut. Ser. A Ecol. Biol. 38(2): 141-157 (Author Communication Used) (OECDG Data File).
An LC50 included in EPA's BE of the OR WQS for pentachlorophenol in freshwater was not used for determining the most representative SMAV in this CWA review and approval of these standards because it was a less than value and two other LC50s from the same study were available for use, as per the 1986 ALC document.

Mayer, F.L.J. and M.R. Ellersieck. 1986. Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals. Resour. Publ. No. 160, U.S. Dep. Interior, Fish Wildl. Serv., Washington, DC: 505 p. (USGS Data File).
Four LC50s from S and F tests where it was unknown whether they were measured or not with original values ranging from 66 to 200 ug/L.

Johnson, W.W. and M.T. Finley. 1980. Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates. Resource Publ. 137. U.S. Fish and Wildlife Service, Washington, DC.: 58 p.
Two LC50 values from S,U tests ranging from 64.01 to 65.28 ug/L.

Oncorhynchus kisutch - Coho salmon

Davis, J.C. and R.A.W. Hoos. 1975. Use of sodium pentachlorophenate and dehydroabietic acid as reference toxicants for salmonid bioassays. J. Fish. Res. Board Can. 32(3): 411-416.

One of the two LC50s reported in ECOTOX and included in the BE from this study was not used because it was estimated using the nomographic method and an LC50 calculated using log-probit was provided for the same test.

Oncorhynchus nerka - Sockeye salmon

Davis, J.C. and R.A.W. Hoos. 1975. Use of sodium pentachlorophenate and dehydroabietic acid as reference toxicants for salmonid bioassays. J. Fish. Res. Board Can. 32(3): 411-416.
One of the two LC50s reported in ECOTOX and included in the BE from this study was not used because it was estimated using the nomographic method and an LC50 calculated using log-probit was provided for the same test.

Oncorhynchus mykiss – Rainbow Trout

The following tests were included in EPA's BE of the OR WQS for pentachlorophenol in freshwater, but were not used for determining the most representative SMAV in this CWA review and approval/disapproval action of these standards because the tests were not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for these species.

Bentley, R.E., T. Heitmuller, B.H. Sleight III and P.R. Parrish. 1975. Acute Toxicity of Pentachlorophenol to Bluegill (*Lepomis macrochirus*), Rainbow Trout (*Salmo gairdneri*), and Pink Shrimp (*Penaeus duorarum*). U.S. EPA, Criteria Branch, WA-6-99-1414-B, Washington, D.C: 13.
Two LC50 values from S,U tests ranging from 75 to 92 µg/L.

Brooke, L.T., D.J. Call, D.E. Hammermeister, A. Hoffman and C.E. Northcott. Manuscript. Acute Toxicities of Five Chemicals in Different Natural Waters. Center for Lake Superior Environmental Studies, University of Wisconsin-Superior, Superior, WI.
One LC50 value from S,M test of 47.2 µg/L

Davis, J.C. and R.A.W. Hoos. 1975. Use of sodium pentachlorophenate and dehydroabietic acid as reference toxicants for salmonid bioassays. J. Fish. Res. Board Can. 32(3): 411-416.
Eleven LC50 values from S,U tests ranging from 44 to 106 µg/L.

Dominguez, S.E. and G.A. Chapman. 1984. Effect of pentachlorophenol on the growth and mortality of embryonic and juvenile steelhead trout. Arch. Environ. Contam. Toxicol. 13: 739-743.

One LC50 value from F,U test of 66 µg/L

Johnson, W.W. and M.T. Finley. 1980. Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates. Resource Publ. 137. U.S. Fish and Wildlife Service, Washington, DC.: 58 p.
Two LC50 values from S,U tests ranging from 45.72 to 49.92 µg/L.

Kennedy, C.J. 1990. Toxicokinetic Studies of Chlorinated Phenols and Polycyclic Aromatic Hydrocarbons in Rainbow Trout (*Oncorhynchus mykiss*). Ph.D. Thesis, Simon Fraser University, Canada: 188 p.; Diss. Abstr. Int. B Sci. Eng. 53(1): 18
One LC50 value from a renewal test of 153 µg/L

Mayer, F.L.J. and M.R. Ellersieck. 1986. Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals. Resour. Publ. No. 160, U.S. Dep. Interior, Fish Wildl. Serv., Washington, DC: 505 p. (USGS Data File).
Ten LC50 values from S and F tests where it was unknown whether they were measured or not with original values ranging from 34 to 300 µg/L.

Sappington, L.C., F.L. Mayer, F.J. Dwyer, D.R. Buckler, J.R. Jones and M.R. Ellersieck. 2001. Contaminant sensitivity of threatened and endangered fishes compared to standard surrogate species. Environ. Toxicol. Chem. 20(12): 2869-2876.
One LC50 value from S,M test of 160 µg/L

Van Leeuwen, C.J., P.S. Griffioen, W.H.A. Vergouw and J.L. Maas-Diepeveen. 1985. Differences in susceptibility of early life stages of rainbow trout (*Salmo gairdneri*) to environmental pollutants. Aquat. Toxicol. 7: 59-78.
Six LC50 values from S,U tests ranging from 18 to 3000 µg/L.

Vigers, G.A. and A.W. Maynard. 1977. The residual oxygen bioassay: A rapid procedure to predict effluent toxicity to rainbow trout. Water Res. 11(4): 343-346.
One LC50 value from S,U test of 83 µg/L.

Appendix L Silver (freshwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Anderson, B.G.. 1948. The Apparent Thresholds of Toxicity to Daphnia magna for Chlorides of Various Metals when Added to Lake Erie Water. Trans.Am.Fish.Soc. 78:96-113.	2054	AF, UEndp, Dur	
Barera, Y., and W.J. Adams. 1983. Resolving Some Practical Questions About Daphnia Acute Toxicity Tests. In: W.E.Bishop (Ed.), Aquatic Toxicology and Hazard Assessment, 6th Symposium, ASTM STP 802, Philadelphia, PA :509-518.	14533	UEndp	
Baudin, J.P., and J. Garnier-Laplace. 1994. Accumulation, Release, and Tissue Distribution of 110mAg from Natural Food (Gammarus pulex) by the Common Carp, Cyprinus carpio L. Arch.Environ.Contam.Toxicol. 27(4):459-465.	13680	AF, UEndp, RouExp, Dur	
Baudin, J.P., J. Garnier-Laplace, and A. Lambrechts. 1994. Uptake from Water, Depuration and Tissue Distribution of 110mAg in a Freshwater Fish, Cyprinus carpio L. Water Air Soil Pollut. 72(1-4):129-141.	14183	AF, UEndp, Dur	
Berthet, B., J.C. Amiard, C. Amiard-Triquet, M. Martoja, and A.Y. Jeantet. 1992. Bioaccumulation, Toxicity and Physico-Chemical Speciation of Silver in Bivalve Molluscs: Ecotoxicological and Health Consequences. Sci.Total Environ. 125:97-122.	6930	AF, UEndp, Dur	
Birge, W.J., and J.A. Zuiderveen. 1996. The Comparative Toxicity of Silver to Aquatic Biota. In: A.W.Andren and T.W.Bober (Eds.), 3rd Int.Conf.Proc.Transport, Fate and Effects of Silver in the Environment, Aug.6-9, 1995, Washington, D.C. :79-87.	20262	Dur	
Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson. 1980. Aquatic Toxicity Tests on Inorganic Elements Occurring in Oil Shale. In: C.Gale (Ed.), EPA-600/9-80-022, Oil Shale Symposium: Sampling, Analysis and Quality Assurance, March 1979, U.S.EPA, Cincinnati, OH :519-534 (U.S.NTIS PB80-221435).	11838	Dur, Lifestage	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Birge, W.J., J.A. Black, and A.G. Westerman. 1979. Evaluation of Aquatic Pollutants Using Fish and Amphibian Eggs as Bioassay Organisms. In: S.W.Nielsen, G.Migaki, and D.G.Scarpelli (Eds.), Symp.Animals Monitors Environ.Pollut., 1977, Storrs, CT 12:108-118.	4943	Dur, Lifestage	
Birge, W.J., J.E. Hudson, J.A. Black, and A.G. Westerman. 1978. Embryo-Larval Bioassays on Inorganic Coal Elements and In Situ Biomonitoring of Coal-Waste Effluents. In: Symp., U.S.Fish Wildl.Serv., Dec.3-6, 1978, Surface Mining Fish Wildl.needs in Eastern U.S., WV :97-104.	6199	Dur, Lifestage	
Birge, W.J.. 1978. Aquatic Toxicology of Trace Elements of Coal and Fly Ash. In: J.H.Thorp and J.W.Gibbons (Eds.), Dep.Energy Symp.Ser., Energy and Environmental Stress in Aquatic Systems, Augusta, GA 48:219-240.	5305	Dur, Lifestage	
Bitton, G., K. Rhodes, and B. Koopman. 1996. CerioFAST: An Acute Toxicity Test Based on Ceriodaphnia dubia Feeding Behavior. Environ.Toxicol.Chem. 15(2):123-125.	17097	AF, UEndp, Dur	
Bringmann, G., and R. Kuhn. 1959. Comparative Water-Toxicological Investigations on Bacteria, Algae, and Daphnia. Gesundheitsingenieur 80(4):115-120.	61194	Plant, UEndp	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Bringmann, G., and R. Kuhn. 1959. The Toxic Effects of Waste Water on Aquatic Bacteria, Algae, and Small Crustaceans. Tr-Ts-0002 53:17390G / Gesund.Ing. 80:115-120 (GER)(ENG TRANSL).	607	AF, UEndp	
Bringmann, G., and R. Kuhn. 1959. Water Toxicological Studies with Protozoa as Test Organisms. TR-80-0058, Literature Research Company:13 p./ Gesund.-Ing.80:239-242 (GER) / Chem.Abstr. 53:22630D-(GER)(ENG TRANSL).	2394	UEndp, Dur, Eff	
Bringmann, G., and R. Kuhn. 1977. The Effects of Water Pollutants on Daphnia magna (Befunde der Schadwirkung Wassergefahrdender Stoffe Gegen Daphnia magna). Z.Wasser-Abwasser-Forsch. 10(5):161-166(ENG TRANSL)(OECDG Data File)(GER)(ENG ABS).	5718	Dur, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Bringmann, G., and R. Kuhn. 1978. Investigation of Biological Harmful Effects of Chemical Substances Which are Classified as Dangerous for Water on Protozoa. Z.Wasser-Abwasser-Forsch.11(6):210-215, TR-80-0307, Literature Research Company :13 p. (ENG TRANSL) (OECDG Data File).	6601	AF, UEndp, Dur	
Brown, B.T., and B.M. Rattigan. 1979. Toxicity of Soluble Copper and Other Metal Ions to Elodea canadensis. Environ.Pollut. 20(4):303-314.	2255	Plant, UEndp, AF, Con	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Buikema, A.L.Jr., J. Cairns Jr., and G.W. Sullivan. 1974. Evaluation of Philodina acuticornis (Rotifera) as Bioassay Organisms for Heavy Metals. Water Resour.Bull. 10(4):648-661.	2019	UEndp, Dur	
Coleman, R.L., and J.E. Cearley. 1974. Silver Toxicity and Accumulation in Largemouth Bass and Bluegill. Bull.Environ.Contam.Toxicol. 12(1):53-61.	8517	UEndp, Dur, Con	
Cosson, R.P.. 1994. Heavy Metal Intracellular Balance and Relationship with Metallothionein Induction in the Liver of Carp After Contamination by Silver, Cadmium and. Biometals 7(1):9-19.	4994	UEndp, Dur	
Davies, P.H.Jr.. 1978. Evaluation of the Potential Impacts of Silver and/or Silver Iodide on Rainbow Trout in Laboratory and High Mountain Lake Environments. Environ.Impacts Artif.Ice Nucleating Agents :149-161.	7303	UEndp, Con	
Diamond, J.M., D.E. Koplish, J. Mcmahon III, and R. Rost. 1997. Evaluation of the Water-Effect Ratio Procedure for Metals in a Riverine System. Environ.Toxicol.Chem. 16(3):509-520.	17591	Lifestage	
Diamond, J.M., E.L. Winchester, D.G. Mackler, and D. Gruber. 1992. Use of the Mayfly Stenonema modestum (Heptageniidae) in Subacute Toxicity Assessments. Environ.Toxicol.Chem. 11(3):415-425.	16355	Eff	
Fitzgerald, G.P.. 1967. The Algistatic Properties of Silver. Water Sewage Works Chicago 114:185-188.	17270	Plant, AF, UEndp	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Galvez, F., and C.M. Wood. 1997. The Relative Importance of Water Hardness and Chloride Levels in Modifying the Acute Toxicity of Silver to Rainbow Trout (Oncorhynchus mykiss). Environ.Toxicol.Chem. 16(11):2363-2368.	18133	UEndp, Dur	
Galvez, F., C. Hogstrand, and C.M. Wood. 1998. Physiological Responses of Juvenile Rainbow Trout to Chronic Low Level Exposure of Waterborne Silver. Comp.Biochem.Physiol.C 119(2):131-137.	19141	UEndp, Eff	
Garnier, J., and J.P. Baudin. 1989. Accumulation and Depuration of 110mAg by a Planktonic Alga, Scenedesmus obliquus. Water Air Soil Pollut. 45(3/4):287-299.	3155	Plant, AF, Con, UEndp	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Garnier, J., and J.P. Baudin. 1990. Retention of Ingested Ag110m by a Freshwater Fish, Salmo trutta L. Water Air Soil Pollut.50 3/4:409-421.	3255	AF, UEndp, Dur, Con	
Garnier, J., J.P. Baudin, and L. Foulquier. 1990. Accumulation from Water and Depuration of 110mAg by a Freshwater Fish, Salmo trutta L. Water Res. 24(11):1407-1414.	3487	AF, UEndp, Dur	
Ghosh, T.K., J.P. Kotangale, and K.P. Krishnamoorthi. 1990. Toxicity of Selective Metals to Freshwater Algae, Ciliated Protozoa and Planktonic Crustaceans. Environ.Ecol. 8(1B):356-360.	3432	Plant, Dur, Con	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Goettl, J.P.J., and P.H. Davies. 1976. Water Pollution Studies. Job Progress Report, Federal Aid Project F-33-R-11, DNR, Boulder, CO :58.	10208	Con	
Goettl, J.P.Jr., and P.H. Davies. 1975. Water Pollution Studies. Job Prog.Rep., Fed.Aid Proj.F-33-R-10, Jan 1-Dec 31, 1974, Colorado :29 p.	20720	UEndp, Eff	
Goettl, J.P.Jr., P.H. Davies, and J.R. Sinley. 1976. Water Pollution Studies. In: D.B.Cope (Ed.), Colorado Fish.Res.Rev.1972-1975, DOW-R-R-F72-75, Colorado Div.of Wildl., Boulder, CO :68-75.	14367	Nom, UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Grosell, M., C. Hogstrand, C.M. Wood, and H.J.M. Hansen. 2000. A Nose-to-Nose Comparison of the Physiological Effects of Exposure to Ionic Silver Versus Silver Chloride in the European Eel (Anguilla anguilla) and the Rainbow Trout (Oncorhynchus mykiss). Aquat.Toxicol. 48(2/3):327-342.	49762	AF, UEndp, Dur, NonRes	
Hale, J.G.. 1977. Toxicity of Metal Mining Wastes. Bull.Environ.Contam.Toxicol. 17(1):66-73.	861	AF	
Hamilton, S.J., and K.J. Buhl. 1990. Safety Assessment of Selected Inorganic Elements to Fry of Chinook Salmon (Oncorhynchus tshawytscha). Ecotoxicol.Environ.Saf. 20(3):307-324.	3526	AF, UEndp, Con	
Haung, Y., L. Mo, J. Ma, L. Liu, W. Lin, and L. Lu. 1988. Effects of Heavy Metal Ions on Cough Response of Mud Carp. Acta Sci.Circumstant.(Huanjing Kexue Xuebao) 8(2):216-222 (CHI) (ENG ABS).	3476	AF, UEndp, Dur	
Hiraoka, Y., S. Ishizawa, T. Kamada, and H. Okuda. 1985. Acute Toxicity of 14 Different Kinds of Metals Affecting Medaka Fry. Hiroshima J.Med.Sci. 34(3):327-330.	12151	UEndp, Dur	
Huang, Y., L. Mo, J. Ma, M. Wu, and M. Chen. 1987. The Effects of Heavy Metal Ions (Cu2+, Hg2+, Ag+) on the Respiratory Movements in Carp and Crucian Carp. Acta Sci.Nat.Univ.Sunyatseni 4:80-85 (CHI) (ENG ABS).	9956	AF, UEndp, Dur, Con	
Janes, N., and R.C. Playle. 1995. Modeling Silver Binding to Gills of Rainbow Trout (Oncorhynchus mykiss). Environ.Toxicol.Chem. 14(11):1847-1858.	16381	UEndp, Dur	
Jones, J.R.E.. 1939. The Relation Between the Electrolytic Solution Pressures of the Metals and Their Toxicity to the Stickleback (Gasterosteus aculeatus L.). J.Exp.Biol. 16(4):425-437.	2851	AF, UEndp, Dur, Con	
Jones, J.R.E.. 1940. A Further Study of the Relation Between Toxicity and Solution Pressure, with Polycelis nigra as Test Animal. J.Exp.Biol. 17:408-415.	10012	AF, UEndp, Dur, Con	
Khangarot, B.S., and P.K. Ray. 1987. Sensitivity of Toad Tadpoles, Bufo melanostictus (Schneider), to Heavy Metals. Bull.Environ.Contam.Toxicol. 38(3):523-527.	12339	NonRes, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Khangarot, B.S., A. Sehgal, and M.K. Bhasin. 1985. "Man and Biosphere" - Studies on the Sikkim Himalayas. Part 5: Acute Toxicity of Selected Heavy Metals on the Tadpoles of Rana hexadactyla. Acta Hydrochim.Hydrobiol. 13(2):259-263.	11438	Con	
Khangarot, B.S., and P.K. Ray. 1988. Sensitivity of Freshwater Pulmonate Snails, Lymnaea luteola L., to Heavy Metals. Bull.Environ.Contam.Toxicol. 41(2):208-213.	12943	Con	
Khangarot, B.S., P.K. Ray, and H. Chandra. 1987. Daphnia magna as a Model to Assess Heavy Metal Toxicity: Comparative Assessment with Mouse System. Acta Hydrochim.Hydrobiol. 15(4):427-432.	12575	Dur	
Klaine, S.J., T.W. La Point, G.P. Cobb, B.L. Forsythe II, T.P. Bills, M.D. Wenholz, and R.D.Jeffers.. 1996. Influence of Water Quality Parameters on Silver Toxicity: Preliminary Result. In: A.W.Andren and T.W.Bober (Eds.), 3rd Int.Conf.Proc.Transport, Fate and Effects of Silver in the Environment, Aug.6-9, 1995, Washington, D.C. :65-77.	20261	Con	
McGeer, J.C., and C.M. Wood. 1998. Protective Effects of Water Cl- on Physiological Responses to Waterborne Silver in Rainbow Trout. Can.J.Fish.Aquat.Sci. 55(11):2447-2454.	52067	AF, UEndp, Dur	
Morgan, I.J., R.P. Henry, and C.M. Wood. 1997. The Mechanism of Acute Silver Nitrate Toxicity in Freshwater Rainbow Trout (Oncorhynchus mykiss) is Inhibition of Gill Na+ and Cl- Transport. Aquat.Toxicol. 38:145-163.	18359	AF, UEndp, Dur	
Nalecz-Jawecki, G., and J. Sawicki. 1998. Toxicity of Inorganic Compounds in the Spirotox Test: A Miniaturized Version of the Spirostomum ambiguum Test. Arch.Environ.Contam.Toxicol. 34(1):1-5.	18997	Ace	
Nasu, Y., and M. Kugimoto. 1981. Lemna (Duckweed) as an Indicator of Water Pollution I. The Sensitivity of Lemna paucicostata to Heavy Metals. Arch.Environ.Contam.Toxicol. 10(2):159-169.	9489	Plant, AF, UEndp, Con	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Nasu, Y., K. Hirabayashi, and M. Kugimoto. 1988. The Toxicity of Some Water Pollutants for Lemnaceae (Duckweed) Plant. Proc.ICMR Semin. 8:485-491.	9057	Plant, AF, UEndp	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Nehring, R.B.. 1976. Aquatic Insects as Biological Monitors of Heavy Metal Pollution. Bull.Environ.Contam.Toxicol. 15(2):147-154.	10198	AF, UEndp, Dur	
Nishiuchi, Y.. 1979. Toxicity of Pesticides to Animals in Freshwater. LXII. The Aquiculture (Suisan Zoshoku) 27(2):119-124 (JPN).	6956	AF	
Norberg-King, T.J.. 1987. An Evaluation of the Fathead Minnow Seven-Day Subchronic Test for Estimating Chronic Toxicity. M.S.Thesis, University of Wyoming, Laramie, WY :80 p..	17878	AF, UEndp	
Norberg-King, T.J.. 1989. An Evaluation of the Fathead Minnow Seven-Day Subchronic Test For Estimating Chronic Toxicity. Environ.Toxicol.Chem. 8(11):1075-1089.	5313	AF, Con	
Office of Pesticide Programs. 2000. Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB)). Environmental Fate and Effects Division, U.S.EPA, Washington, D.C..	344	AF	
Patil, H.S., and M.B. Kaliwal. 1986. Relative Sensitivity of a Freshwater Prawn Macrobrachium hendersodyanum to Heavy Metals. Environ.Ecol. 4(2):286-288.	12787	AF, Con	
Rai, L.C., and M. Raizada. 1985. Effect of Nickel and Silver Ions on Survival, Growth, Carbon Fixation and Nitrogenase Activity in Nostoc muscorum: Regulation of Toxicity by EDTA and. J.Gen.Appl.Microbiol. 31(4):329-337.	13292	Plant, AF, UEndp	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Rao, T.S., M.S. Rao, and S.B.S.K. Prasad. 1975. Median Tolerance Limits of Some Chemicals to the Fresh Water Fish "Cyprinus carpio". Indian J.Environ.Health 17(2):140-146.	2077	See Comment	The test data provided in ECOTOX for this study appears to be useful. The hardness normalized dissolved LC50 for 96 h R,M test would be 1.72 ug/L, making the most representative species SMAV approximately 0.86 ug/L, which falls well below the CMC of 3.2 ug/L. This datum has been incorporated in the evaluation.

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Rombough, P.J.. 1985. The Influence of the Zona radiata on the Toxicities of Zinc, Lead, Mercury, Copper and Silver Ions to Embryos of Steelhead Trout Salmo gairdneri. Comp.Biochem.Physiol.C 82(1):115-117.	11219	AF, UEndp, Con	
Shivaraj, K.M., and H.S. Patil. 1988. Toxicity of Silver Chloride to a Fresh Water Fish Lepidocephalichthyes guntea. Environ.Ecol. 6(3):713-716.	806	AF, Dur, Con	
Snell, T.W., B.D. Moffat, C. Janssen, and G. Persoone. 1991. Acute Toxicity Tests Using Rotifers IV. Effects of Cyst Age, Temperature, and Salinity on the Sensitivity of Brachionus calyciflorus. Ecotoxicol.Environ.Saf. 21(3):308-317 (OECDG Data File).	9385	AF, Dur	
Snell, T.W.. 1991. New Rotifer Bioassays for Aquatic Toxicology. Final Report, U.S.Army Medical Research and Development Command, Ft.Detrick, Frederick, MD :29 p.(U.S.NTIS AD-A258002).	17689	AF, Dur	
Stangenberg, M.. 1975. The Influence of the Chemical Composition of Water on the Pike Perch (Lucioperca lucioperca L.) Fry from the Lake Gopio. Limnologica 9(3):421-426.	2700	AF, UEndp,Dur	
Suzuki, K.. 1959. The Toxic Influence of Heavy Metal Salts upon Mosquito Larvae. Hokkaido Univ.J.Fac.Sci.Ser. 6(14):196-209.	2701	AF, UEndp, Eff, Dur	
Tsuji, S., Y. Tonogai, Y. Ito, and S. Kanoh. 1986. The Influence of Rearing Temperatures on the Toxicity of Various Environmental Pollutants for Killifish (Oryzias latipes). J.Hyg.Chem.(Eisei Kagaku) 32(1):46-53 (JPN) (ENG ABS).	12497	AF, Dur, Con	
Turbak, S.C., S.B. Olson, and G.A. McFeters. 1986. Comparison of Algal Assay Systems for Detecting Waterborne Herbicides and Metals. Water Res. 20(1):91-96.	11780	Plant, AF, Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Wang, W.. 1994. Rice Seed Toxicity Tests for Organic and Inorganic Substances. Environ.Monit.Assess. 29:101-107.	45060	Plant, AF, Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Webb, N.A., and C.M. Wood. 1998. Physiological Analysis of the Stress Response Associated with Acute Silver Nitrate Exposure in Freshwater Rainbow Trout (Oncorhynchus	18939	UEndp, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
mykiss). Environ.Toxicol.Chem. 17(4):579-588.			
Williams, P.L., and D.B. Dusenbery. 1990. Aquatic Toxicity Testing Using the Nematode, Caenorhabditis elegans. Environ.Toxicol.Chem. 9(10):1285-1290.	3437	AF	
Wilson, W.B., and L.R. Freeburg. 1980. Toxicity of Metals to Marine Phytoplankton Cultures. EPA-600/3-80-025, U.S.EPA, Narragansett, RI :110 p.(U.S.NTIS PB80-182843).	5557	Plant, AF, Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Wood, C.M., C. Hogstrand, F. Galvez, and R.S. Munger. 1996. The Physiology of Waterborne Silver Toxicity in Freshwater Rainbow Trout (Oncorhynchus mykiss) 1. The Effects of Ionic Ag+. Aquat.Toxicol. 35(2):93-109.	18582	UEndp, Eff, Dur	
Ziegenfuss, P.S., W.J. Renaudette, and W.J. Adams. 1986. Methodology for Assessing the Acute Toxicity of Chemicals Sorbed to Sediments: Testing the Equilibrium Partitioning Theory. In: T.M.Poston and R.Purdy (Eds.), Aquatic Toxicology and Environmental Fate, 9th Volume, ASTM STP 921, Philadelphia, PA :479-493.	7884	AF, Dur, Con	
Zuiderveen, J.A., and W.J. Birge. 1996. Interaction of Silver and Metal Chelators on Ceriodaphnia dubia Survival and Reproduction. In: A.W.Andren and T.W.Bober (Eds.), 3rd Int.Conf.Proc.Transport, Fate and Effects of Silver in the Environment, Aug.6-9, 1995, Washington, D.C. :135-142.	20264	AF, UEndp, Dur	

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

1 For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most

sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[89], EPA is providing a transparent rationale as to why they were not utilized (see below).

2 For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix L).

<u>General QA/QC failure because non-resident species in Oregon</u>

Tests with the following several species were used in the EPA BE of OR WQS for silver in freshwater, but were not considered in the CWA review and approval/disapproval action of the standards because these species do not have a breeding wild population in Oregon's waters:

Poecilia	*reticulata*	*Guppy*	Khangarot and Ray 1988
Gammarus	*pseudolimnaeus*	*Scud*	Lima et al. 1982
Jordanella	*floridae*	*Flagfish*	Lima et al. 1982

<u>Other Acute tests failing QA/QC by species</u>

***Daphnia magna* - Cladoceran**

The following test was included in EPA's BE of the OR WQS and the 1980 ALC document for silver in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because the tests were not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for this species.

Nebeker, A.V., C.K. McAuliffe, R. Mshar and D.G. Stevens. 1983. Toxicity of silver to steelhead and rainbow trout, fathead minnows and *Daphnia magna*. Environ. Toxicol. Chem. 2: 95-104.
Two LC50 values from S,M tests ranging from 2.58 to 4.94 µg/L.

Chapman, G.A. 1980. Memorandum to Q. Pickering (Newtown Fish Toxicology Station, July 14).

[89] U.S. EPA. 1980. Ambient Water Quality Criteria Documents for Silver. Unpublished document authored by W. A. Brungs and D.J. Hansen, U.S. EPA ERL-Narragansett and Gulf Breeze, respectively.

One LC50 value from S,M test of 0.75 µg/L.

Elnabarawy, M.T., A.N. Welter and R.R. Robideau. 1986. Relative sensitivity of three daphnid species to selected organic and inorganic chemicals. Environ. Toxicol. Chem. 5: 393-398.
One LC50 value from S,U test of 0.28 µg/L.

Khangarot, B.S. and P.K. Ray. 1989. Investigation of correlation between physicochemical properties of metals and their toxicity to the water flea *Daphnia magna* Straus. Ecotoxicol. Environ. Saf. 18: 109-120.
One LC50 value from S,U test of 1.89 µg/L.

Lemke, A.E. 1981. Interlaboratory Comparison Acute Testing Set. EPA 600/3-81-005 or PB81-160772. National Technical Information Service, Springfield, VA.
Ten LC50 values from static tests ranging from 1.17 to 20.77 µg/L.

Erickson, R.J., L.T. Brooke, M.C. Kahl, F. Vande Venter. S.L. Harting, T.P. Markee and R.L. Spehar. 1998. Effects of laboratory test conditions on the toxicity of silver to aquatic organisms. Environ. Toxicol. Chem. 17: 572-578.
One LC50 value from S,M test of 1.74 µg/L.

LeBlanc, G.A. 1980. Acute toxicity of priority pollutants to water flea (*Daphnia magna*). Bull. Environ. Contam. Toxicol. 24: 684-691.
One LC50 value from S,M test of 2.24 µg/L.

Karen, D.J., D.R. Ownby, B.L. Forsythe, T.P. Bills, T.W. La Point, G.B. Cobb and S.J. Klaine. 1999. Influence of water quality on silver toxicity to rainbow trout (*O. mykiss*), fathead minnows (*P. promelas*), and the waterflea (*D. magna*). Environ. Toxicol. Chem. 18(1): 63-70.
Twenty-four LC50 values from static tests ranging from 0.15 to 2.77 µg/L.

Pimephales promelas – Fathead minnow

The following test was included in EPA's BE of the OR WQS and the 1980 ALC document for silver in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because the tests were not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for this species.

Nebeker, A.V., C.K. McAuliffe, R. Mshar and D.G. Stevens. 1983. Toxicity of silver to steelhead and rainbow trout, fathead minnows and *Daphnia magna*. Environ. Toxicol. Chem. 2: 95-104.
One LC50 value from S,M test of 42.20 µg/L.

Bury, N.R., F. Galvez and C.M. Wood. 1999a. Effects of chloride, calcium and dissolved organic carbon on silver toxicity: Comparison between rainbow trout and fathead minnows. Environ. Toxicol. Chem. (in press).
Seven LC50 values from R,U tests ranging from 2.55 to 1954.53 µg/L.

Holcombe, G.W., G.L. Phipps and J.T. Fiandt. 1983. Toxicity of selected priority pollutants to various aquatic organisms. Ecotoxicol. Environ. Safety 7: 400-409.
One LC50 value from S,M test of 47.35 µg/L.

Erickson, R.J., L.T. Brooke, M.C. Kahl, F. Vande Venter, S.L. Harting, T.P. Markee and R.L. Spehar. 1998. Effects of laboratory test conditions on the toxicity of silver to aquatic organisms. Environ. Toxicol. Chem. 17: 572-578.
Twelve LC50 values from S,M tests ranging from 2.37 to 46.71 µg/L.

Lemke, A.E. 1981. Interlaboratory Comparison Acute Testing Set. EPA 600/3-81-005 or PB81-160772. National Technical Information Service, Springfield, VA.
Ten LC50 values from S,M tests ranging from 12.13 to 91.41 µg/L. Some data used for this species from this study.

Karen, D.J., D.R. Ownby, B.L. Forsythe, T.P. Bills, T.W. La Point, G.B. Cobb and S.J. Klaine. 1999. Influence of water quality on silver toxicity to rainbow trout (*O. mykiss*), fathead minnows (*P. promelas*), and the waterflea (*D. magna*). Environ. Toxicol. Chem. 18(1): 63-70.
Twenty-three LC50 values from S,U tests ranging from 0.71 to 27.22 µg/L.

Forsythe, B.L., II. 1996. Silver in a Freshwater Ecosystem: Acute Toxicity and Trophic Transfer. Ph.D. Thesis. Clemson University, Clemson, SC: 149 pp.
Thirty-two LC50 values from S,M tests ranging from 0.72 to 73.37 µg/L.

The following test was included in EPA's 1980 ALC document for silver in freshwater, but was not used in this CWA review and approval/disapproval action of these standards because some detail was missing and numerous other representative F,M tests were available to calculate the SMAV for the species. The two LC50s reported for fathead minnow from the study were 3.9 and 4.8 µg/L in soft and hard water, respectively.

Goettl, J.P., Jr. and P.H. Davies. 1978. Water Pollution Studies. Job Progress Report. Colorado Division of Wildlife, Department of Natural Resources, Boulder, CO.

The following test was included in EPA's BE of the OR WQS document for silver in freshwater, but was not used in this CWA review and approval/disapproval action of these standards because the same data existed in another study that had been used to calculate the SMAV:

LeBlanc, G.A., J.D. Maston, A.P. Paradice, B.F. Wilson, H.B. Lockhart, Jr. and K.A. Robillard. 1984. The influence of speciation on the toxicity of silver to fathead minnow (*Pimephales promelas*). Environ. Toxicol. Chem. 3: 37-46.

Appendix M Tributyltin (freshwater)

Studies Not Pertinent to this Determination

(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Alabaster, J.S.. 1969. Survival of Fish in 164 Herbicides, Insecticides, Fungicides, Wetting Agents and Miscellaneous Substances. Int. Pest Control 11(2):29-35 (Author Communication Used).	542	Dur, Con	
Avery, S.V., G.A. Codd, and G.M. Gadd. 1993. Biosorption of Tributyltin and Other Organotin Compounds by Cyanobacteria and Microalgae. Appl.Microbiol.Biotechnol. 39(6):812-817.	16761	Dur, UEndp	
Baldwin, I.G., M.M.I. Harman, and D.A. Neville. 1994. Performance Characteristics of a Fish Monitor for Detection of Toxic Substances - I. Laboratory Trails. Water Res. 28(10):2191-2199.	4437	Dur, UEndp	
Bodar, C.W.M., E.G. Van Donselaar, and H.J. Herwig. 1990. Cytopathological Investigations of Digestive Tract and Storage Cells in Daphnia magna Exposed to Cadmium and Tributyltin. Aquat.Toxicol. 17(4):325-338.	3509	Dur, UEndp	
Borgmann, U., Y.K. Chau, P.T.S. Wong, M. Brown, and J. Yaromich. 1996. The Relationship Between Tributyltin (TBT) Accumulation and Toxicity to Hyalella azteca for Use in Identifying TBT Toxicity in the Field. J.Aquat.Ecosyst.Health 5(3):199-206.	7104	Dur	
Boyer, L., and L.R. Sherman. 1990. A Study in the Threshold Toxicity of bis-Tri-n-Butyltin Oxide upon the Comet Goldfish, Carassius auratus. J.Pa.Acad.Sci.63(Suppl.):207 (ABS).	216	Dur, Con, UEndp	
Bruggemann, R., J. Schwaiger, and R.D. Negele. 1995. Applying Hasse Diagram Technique for the Evaluation of Toxicological Fish Tests. Chemosphere 30(9):1767-1780.	16035	Endpoint (HIS)	
Buzinova, N.S., and O.V. Parina. 1984. Action of a Pollutant on Plastic Metabolism of Fish. C.A.Sel.-Environ.Pollut.25(101):2 / In: M.M.Telitchenko (Ed.) Sb.Tr.Vses.Soveshch.Sanit.Gidrobiol.4th 1991:97-102 (RUS).	11008	Dur, Insuff. Control, Endpoint (Lethal)	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Clayton, M.E., R. Steinmann, and K. Fent. 2000. Different Expression Patterns of Heat Shock Proteins hsp 60 and hsp 70 in Zebra Mussels (Dreissena polymorpha) Exposed to Copper and Tributyltin. Aquat.Toxicol. 47(3/4):213-226.	48289	Dur, Endpoint (ACC)	
Das, V.G.K., L.Y. Kuan, K.I. Sudderuddin, C.K. Chang, V. Thomas, C.K. Yap, M.K. Lo, G.C.Ong, W.K.Ng, and Y.Hoi-Sen. 1984. The Toxic Effects of Triorganotin (IV) Compounds on the Culicine Mosquito, Aedes aegypti (L). Toxicology 32(1):57-66.	11009	Dur	
De Vries, H., A.H. Penninks, N.J. Snoeij, and W. Seinen. 1991. Comparative Toxicity of Organotin Compounds to Rainbow Trout (Oncorhynchus mykiss) Yolk Sac Fry. Sci.Total Environ. 103(2/3):229-243.	5674	Dur, Endpoint (LC100, LOEC)	
Dojmi di Delupis, G., and R. Miniero. 1989. Preliminary Studies on the TBTO Effects on Fresh Water Biotic Communities. Riv.Idrobiol. 28(1/2):63-68.	8704	Dur, Unknown Endpoint	
Douglas, M.T., D.O. Chanter, I.B. Pell, and G.M. Burney. 1986. A Proposal for the Reduction of Animal Numbers Required for the Acute Toxicityto Fish Test (LC50 Determination). Aquat.Toxicol. 8(4):243-249.	12210	Insuff. Control	
Fargasova, A.. 1997. The Effects of Organotin Compounds on Growth, Respiration Rate, and Chlorophyll a Content of Scenedesmus quadricauda. Ecotoxicol.Environ.Saf. 37:193-198.	18323	Dur, Endpoint (PHY, Unknown)	
Fargasova, A.. 1998. Comparison of Tributyltin Compound Effects on the Alga Scenedesmus quadricauda and the Benthic Organisms Tubifex tubifex and Chironomus plumosus. Ecotoxicol.Environ.Saf. 41(3):222-230.	20058	Dur, Endpoint (PHY)	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Fargasova, A., and M. Drtil. 1996. Respirometric Toxicity Test: Freshwater Alga Scenedesmus quadricauda Sensitivity to Organotin Compounds. Bull.Environ.Contam.Toxicol. 56(6):993-999.	17429	Dur, Endpoint (PHY)	
Fent, K.. 1991. Bioconcentration and Elimination of Tributyltin Chloride by Embryos and Larvae of Minnows Phoxinus phoxinus. Aquat.Toxicol. 20:147-158.	5319	Non-NA, Dur, Endpoint (ACC)	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Fent, K.. 1992. Embryotoxic Effects of Tributyltin on the Minnow Phoxinus phoxinus. Environ.Pollut. 76(3):187-194.	5845	Non-NA, Dur, Insuff. Control, Endpoint (DVP, Lethal, Unknown)	
Fent, K., and J. Hunn. 1993. Uptake and Elimination of Tributyltin in Fish-Yolk-Sac Larvae. Mar.Environ.Res. 35(1/2):65-71.	4181	Non-NA, Dur, Insuff. Control, Endpoint (ACC)	
Fent, K., and P.W. Looser. 1995. Bioaccumulation and Bioavailability of Tributyltin Chloride: Influence of pH and Humic Acids. Water Res. 29(7):1631-1637.	15019	Non-NA, Dur, Endpoint (ACC)	
Fent, K., and W. Meier. 1992. Tributyltin-Induced Effects on Early Life Stages of Minnows Phoxinus phoxinus. Arch.Environ.Contam.Toxicol. 22(4):428-438.	11253	Dur, Endpoint (HIS, Unknown)	
Geiger, D.L., L.T. Brooke, and D.J. Call. 1990. Acute Toxicities of Organic Chemicals to Fathead Minnows (Pimephales promelas), Vol. 5. Center for Lake Superior Environmental Stud., Univ.of Wisconsin-Superior, Superior, WI I:332 p..	3217	Secondary	Same data used from a different study reported by the authors in a subsequent peer-reviewed article
Grinwis, G.C.M., A. Boonstra, E.J. Van den Brandhof, J.A.M. Dormans, M. Engelsma, and R.V.Kuiper. ... 1998. Short-Term Toxicity of Bis(tri-n-butyltin)Oxide in Flounder (Platichthys flesus): Pathology and Immune Function. Aquat.Toxicol. 42(1):15-36.	19152	Dur, Endpoint (FDB, HIS, IMM, MPH, Unknown)	
Hooftman, R.N., D.M.M. Adema, and J. Kauffman-Van Bommel. 1989. Developing a Set of Test Methods for the Toxicological Analysis of the Pollution Degree of Waterbottoms. Rep.No.16105, Netherlands Organization for Applied Scientific Research:68 p.(DUT).	5356	Non-NA, Dur	
Itow, T., R.E. Loveland, and M.L. Botton. 1998. Developmental Abnormalities in Horseshoe Crab Embryos Caused by Exposure to Heavy Metals. Arch.Environ.Contam.Toxicol. 35(1):33-40.	19470	Endpoint (Lethal)	
Kuhn, R., and M. Pattard. 1990. Results of the Harmful Effects of Water Pollutants to Green Algae (Scenedesmus subspicatus) in the Cell Multiplication Inhibition Test. Water Res. 24(1):31-38 (OECDG Data File).	2997	Dur	
Kuhn, R., M. Pattard, K. Pernak, and A. Winter. 1989. Results of the Harmful Effects of Water Pollutants to Daphnia magna in the 21 Day Reproduction Test. Water Res. 23(4):501-510 (OECDG Data File).	847	Dur, Insuff. Control	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Laughlin, R., and O. Linden. 1982. Sublethal Responses of the Tadpoles of the European Frog Rana temporaria to Two Tributyltin Compounds. Bull.Environ.Contam.Toxicol. 28(4):494-499.	15464	Dur, Unknown Endpoint	
Lewis, J.W., A.N. Kay, and N.S. Hanna. 1995. Responses of Electric Fish (Family Mormyridae) to Inorganic Nutrients and Tributyltin Oxide. Chemosphere 31(7):3753-3769.	16156	Dur, Endpoint (PHY)	
Machado, J., J. Coimbra, and C. Sa. 1989. Shell Thickening in Anodonta cygnea by TBTO Treatments. Comp.Biochem.Physiol.C 92(1):77-80.	796	Dur, Insuff. Control, Unknown Endpoint	
Maguire, R.J., P.T.S. Wong, and J.S. Rhamey. 1984. Accumulation and Metabolism of Tri-N-Butyltin Cation by a Green Alga, Ankistrodesmus falcatus. Can.J.Fish.Aquat.Sci. 41(3):537-540.	10827	Dur, Insuff. Control, Endpoint (ACC)	
Mathijssen-Spiekman, E.A.M., J.H. Canton, and C.J. Roghair. 1989. Research After the Toxicity of TBTO for a Number of Fresh Water Organisms. Rep.No.668118-001, Natl.Inst.Public Health and Environ.Hyg.:48 p.(DUT).	5337	Non-NA, Dur, Endpoint (DVP, HIS, Unknown)	
Meador, J.P.. 1986. An Analysis of Photobehavior of Daphnia magna Exposed to Tributyltin. In: Oceans '86 Conference Records: Science-Engineering-Adventure, Vol.4, Organotin Symp., Washington, DC, Sept.23-25, IEEE Publ.Serv., NY :1213-1218.	12847	Dur	
Nagase, H., T. Hamasaki, T. Sato, H. Kito, Y. Yoshioka, and Y. Ose. 1991. Structure-Activity Relationships for Organotin Compounds on the Red Killifish Oryzias latipes. Appl.Organomet.Chem. 5:91-97.	18537	Non-NA, Dur	
Oberdorster, E., D. Rittschof, and G.A. LeBlanc. 1998. Alteration of [14C]-Testosterone Metabolism After Chronic Exposure of Daphnia magna to Tributyltin. Arch.Environ.Contam.Toxicol. 34(1):21-25.	19000	Endpoint (DVP, No Effect, Unknown)	
Orthuber, G.. 1991. Clinical and Haematological Studies of the Subacute Toxicity of bis (Tri-n-Butyltin) Oxide in Rainbow Trout (Oncorhynchus mykiss). Ph.D.Thesis, Ludwig-Maximilians Univ., Muenchen, Germany:194 p.(GER) (ENG ABS).	17357	Endpoint (PHY, Unknown)	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Parina, O.V., and R.D. Ozrina. 1989. Evaluation of the Toxic Effect of Organotin Compounds in Carp as Related to Their Accumulation and Excretion. Hydrobiol.J. 25(1):72-77.	3186	Dur, Insuff. Control, Endpoint (ACC, Unknown)	
Quick, T., and N.F. Cardarelli. 1977. Environmental Impact of Controlled Release Molluscicides and Their Degradation Products: A Preliminary Report. In: Proc.Int.Controlled Release Pestic.Symp. :90-104.	68590	Dur, Endpoint (LT100, Lethal, Unknown), LT	
Rurangwa, E., A. Biegniewska, E. Slominska, E.F. Skorkowski, and F. Ollevier. 2002. Effect of Tributyltin on Adenylate Content and Enzyme Activities of Teleost Sperm: A Biochemical Approach to Study the Mechanisms of Toxicant Reduced Spermatozoa Motility. Comp.Biochem.Physiol.C 131(3):335-344.	65145	Dur, Endpoint (PHY, Unknown)	
Santos, A.T.Jr., M.J. Santos, B.L. Blas, and E.A. Banez. 1977. Field Trials Using Slow Release Rubber Molluscicide Formulations, MT-1E (BioMet SRM) and CBL-9B. In: R.L.Goulding (Ed.), Proc.-Int.Controlled Release Pestic.Symp., Oregon State Univ., Corvallis, OR :114-123.	68589	Field, Endpoint (Lethal, Unknown)	
Sarojini, R., B. Indira, and R. Nagabhushanam. 1990. Effect of the Lethal and Sublethal Concentrations of Two Antifouling Organometallic Compounds CuSO4 and TBTO on the Eyestalks of Freshwater Prawn. J.Freshw.Biol. 2(1):29-35.	3719	Endpoint (HIS)	
Scadding, S.R.. 1990. Effects of Tributyltin Oxide on the Skeletal Structures of Developing and Regenerating Limbs of the Axolotl Larvae, Ambystoma mexicanum. Bull.Environ.Contam.Toxicol. 45(4):574-581.	68550	Endpoint (DVP, Lethal, No Effect, Unknown)	
Schulte-Oehlmann, U., C. Bettin, P. Fioroni, J. Oehlmann, and E. Stroben. 1995. Marisa cornuarietis (Gastropoda, Prosobranchia): A Potential TBT Bioindicator for Freshwater Environments. Ecotoxicology 4(6):372-384.	18104	Endpoint (ACC, Unknown)	
Schwaiger, J., F. Bucher, H. Ferling, W. Kalbfus, and R.D. Negele. 1992. A Prolonged Toxicity Study on the Effects of Sublethal Concentrations of Bis(Tri-n-Butyltin)Oxide (TBTO): Histopathological and Histochemical. Aquat.Toxicol. 23(1):31-48.	6126	Endpoint (ACC, HIS)	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Snell, T.W., B.D. Moffat, C. Janssen, and G. Persoone. 1991. Acute Toxicity Tests Using Rotifers IV. Effects of Cyst Age, Temperature, and Salinity on the Sensitivity of Barachionus calyciflorus. Ecotoxicol.Environ.Saf. 21(3):308-317 (OECDG Data File).	9385	Dur	
Tas, J.W., A. Keizer, and A. Opperhuizen. 1996. Bioaccumulation and Lethal Body Burden of Four Triorganotin Compounds. Bull.Environ.Contam.Toxicol. 57(1):146-154.	17079	Dur, Endpoint (ACC)	
Triebskorn, R., H.R. Kohler, J. Flemming, T. Braunbeck, R.D. Negele, and H. Rahmann. 1994. Evaluation of bis(Tri-n-Butyltin)Oxide (TBTO) Neurotoxicity in Rainbow Trout (Oncorhynchus mykiss). I. Behaviour, Weight Increase, and Tin Content. Aquat.Toxicol. 30(3):189-197.	17449	Endpoint (ACC, Unknown)	
Triebskorn, R., H.R. Kohler, K.H. Kortje, R.D. Negele, H. Rahmann, and T. Braunbeck. 1994. Evaluation of bis(Tri-n-Butyltin)Oxide (TBTO) Neurotoxicity in Rainbow Trout (Oncorhynchus mykiss). II. Ultrastructural Diagnosis and Tin Localization by Energy Filtering Transmission Electron Microscopy (EFTEM). Aquat.Toxicol. 30(3):199-213.	17448	Endpoint (ACC, HIS)	
Tsuda, T., H. Nakanishi, S. Aoki, and J. Takebayashi. 1988. Bioconcentration and Metabolism of Butyltin Compounds in Carp. Water Res. 22(5):647-651.	12977	Dur, Insuff. Control, Endpoint (ACC)	
Tsuda, T., M. Wada, S. Aoki, and Y. Matsui. 1987. Excretion of Bis(Tri-n-Butyltin)Oxide and Triphenyltin Chloride from Carp. Toxicol.Environ.Chem. 16(1):17-22.	7771	Dur, Insuff. Control, Endpoint (ACC)	
Tsuda, T., S. Aoki, M. Kojima, and H. Harada. 1990. The Influence of pH on the Accumulation of Tri-N-Butyltin Chloride and Triphenyltin Chloride in Carp. Comp.Biochem.Physiol.C 95(2):151-153.	3463	Dur, Insuff. Control, Endpoint (ACC)	
Tsuda, T., S. Aoki, M. Kojima, and H. Harada. 1990. Differences Between Freshwater and Seawater-Acclimated Guppies in the Accumulation and Excretion of Tri-N-Butyltin Chloride and Triphenyltin Chloride. Water Res. 24(11):1373-1376.	3486	Dur, Insuff. Control, Endpoint (ACC)	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Tsuda, T., S. Aoki, M. Kojima, and H. Harada. 1991. Accumulation of Tri-n-Butyltin Chloride and Triphenyltin Chloride by Oral and Via Gill Intake of Goldfish (Carassius auratus). Comp.Biochem.Physiol.C 99(1/2):69-72.	9240	Endpoint (ACC)	
Tsuda, T., S. Aoki, M. Kojima, and T. Fujita. 1992. Accumulation and Excretion of Tri-n-Butyltin Chloride and Triphenyltin Chloride by Willow Shiner. Comp.Biochem.Physiol.C 101(1):67-70.	3999	Insuff. Control, Endpoint (ACC)	
Umezu, T.. 1991. Saponins and Surfactants Increase Water Flux in Fish Gills. Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 57(10):1891-1896.	7136	Non-NA, Dur, Endpoint (PHY)	
Upatham, E.S., M. Koura, M.D. Ahmed, and A.H. Awad. 1980. Laboratory Trials of Controlled Release Molluscicides on Bulinus (Ph.) abyssinicus the Intermediate Host of Schistosoma haematobium in Somalia. In: R.Baker (Ed.), Controlled Release of Bioactive Materials, Academic Press, NY :461-469.	67506	Dur, Endpoint (LT100), LT	
Vighi, M., and D. Calamari. 1985. QSARs for Organotin Compounds on Daphnia magna. Chemosphere 14(11-12):1925-1932.	12391	Dur, Insuff. Control	
Walker, K.E.. 1977. Organotin Contact Studies. In: R.L.Goulding (Ed.), Proc.-Int.Controlled Release Pestic.Symp., Oregon State Univ., Corvallis, OR :124-131.	68588	Dur, Unknown Endpoint	
Wang, W.X., J. Widdows, and D.S. Page. 1992. Effects of Organic Toxicants on the Anoxic Energy Metabolism of the Mussel Mytilus edulis. Mar.Environ.Res. 34(1-4):327-331.	4391	Dur, Insuff. Control, Endpoint (PHY)	
Wester, P.W., and J.H. Canton. 1987. Histopathological Study of Poecilia reticulata (Guppy) After Long-Term Exposure to Bis(Tri-n-Butyltin)oxide (TBTO) and Di-n-Butyltindichloride. Aquat.Toxicol. 10(2-3):143-165.	12607	Nom, Insuff. Control, Endpoint (HIS)	
Wester, P.W., J.H. Canton, A.A.J. Van Iersel, E.I. Krajnc, and H.A.M. Vaessen. 1990. The Toxicity of Bis(Tri-n-Butyltin)Oxide (TBTO) and Di-n-Butyltindichloride (DBTC) in the Small Fish Species Oryzias latipes (Medaka) and Poecilia. Aquat.Toxicol. 16(1):53-72.	3003	Endpoint (ACC, HIS, Unknown)	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Wong, P.T.S., Y.K. Chau, O. Kramar, and G.A. Bengert. 1982. Structure-Toxicity Relationship of Tin Compounds on Algae. Can.J.Fish.Aquat.Sci. 39(3):483-488.	15764	Species, Dur, Insuff. Control, Endpoint (PHY)	

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

3) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[90], EPA is providing a transparent rationale as to why they were not utilized (see below).
4) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable.

<u>General QA/QC failure because non-resident species in Oregon</u>

The tests with the following species were used in the EPA BE of OR WQS for tributyltin in freshwater, but were not considered in the CWA review and approval/disapproval action of the standards because these species do not have a breeding wild population in Oregon's waters:

Hydra	*oligactis*	Hydra	TAI 1989a
Hydra	*littoralis*	Hydra	TAI 1989a; TAI 1989b
Chlorohydra	*viridissima*	Hydra	TAI 1989b
Gammarus	*pseudolimnaeus*	Scud	Brooke et al. 1986

[90] U.S. EPA. 2003. Ambient Water Quality Criteria Document for Tributyltin (TBT) - Final. EPA-822/R-03-031.

Appendix N Zinc (freshwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Abbasi, S.A., and R. Soni. 1986. An Examination of Environmentally Safe Levels of Zinc (II), Cadmium (II) and Lead (II) with Reference to Impact on Channelfish Nuria denricus. Environ.Pollut.Ser.A Ecol.Biol. 40(1):37-51.	11078	AF, Dur, Con	
Abbasi, S.A., P.C. Nipaney, and R. Soni. 1985. Environmental Consequences of the Inhibition in the Hatching of Pupae of Aedesaegypti by Mercury, Zinc and Chromium-the Abnormal Toxicity of Zinc. Int.J.Environ.Stud. 24(2):107-114.	10797	AF, UEndp, Dur	
Abbasi, S.A., P.C. Nipaney, and R. Soni. 1988. Studies on Environmental Management of Mercury (II), Chromium (VI) and Zinc (II) with Respect to the Impact on Some Arthropods and Protozoans -. Int.J.Environ.Stud. 32:181-187.	13255	AF, Dur, Con	
Abel, T.H., and F. Barlocher. 1984. Effects of Cadmium on Aquatic Hyphomycetes. Appl.Environ.Microbiol. 48(2):245-251.	11030	AF, UEndp	
Admiraal, W., H. Blanck, M. Buckert-De Jong, H. Guasch, N. Ivorra, V. Lehmann, B.A.H. Nystrom, M.Paulsson, and S.Sabater. 1999. Short-Term Toxicity of Zinc to Microbenthic Algae and Bacteria in a Metal Polluted Stream. Water Res. 33(9):1989-1996.	20376	Plant, NoOrg, AF, UEndp, Dur	
Agrawal, S.C.. 1984. The Effects of Zinc Sulphate on the Ultraviolet Light Sensitivity of Chlorella vulgaris Beijernick. Curr.Sci. 53(18):989-990.	19907	Plant, AF, UEndp, Dur	
Alam, M.K., and O.E. Maughan. 1992. The Effect of Malathion, Diazinon, and Various Concentrations of Zinc, Copper, Nickel, Lead, Iron, and Mercury on Fish. Biol.Trace Elem.Res. 34(3):225-236.	7085	AF, UEndp, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Alam, M.K., and O.E. Maughan. 1995. Acute Toxicity of Heavy Metals to Common Carp (Cyprinus carpio). J.Environ.Sci.Health Part A 30(8):1807-1816.	45566	AF	
Anderson, B.G.. 1948. The Apparent Thresholds of Toxicity to Daphnia magna for Chlorides of Various Metals when Added to Lake Erie Water. Trans.Am.Fish.Soc. 78:96-113.	2054	AF	
Anderson, P.D., and L.J. Weber. 1975. Toxic Response As a Quantitative Function of Body Size. Toxicol.Appl.Pharmacol. 33(3):471-483.	2137	See comment	Not used in 1987 ALC document
Anderson, R.L., C.T. Walbridge, and J.T. Fiandt. 1980. Survival and Growth of Tanytarsus dissimilis (Chironomidae) Exposed to Copper, Cadmium, Zinc, and Lead. Arch.Environ.Contam.Toxicol. 9(3):329-335 (Author Communication Used).	5249	Con	
Annune, P.A., A.A. Oladimeji, and S. Ebele. 1991. Acute Toxicity of Zinc to the Fingerlings of Clarias lazera Cuvier and Valenciennes and Oreochromis niloticus (Trewavas). J.Aquat.Sci. 6:19-22.	17157	NonRes	
Annune, P.A., and T.T. Iyaniwura. 1993. Accumulation of Two Trace Metals in Tissues of Freshwater Fishes, Oreochromis niloticus and Clarias gariepinus. J.Aquat.Food Product Technol. 2(3):5-18.	16167	AF, UEndp, Dur	
Arambasic, M.B., S. Bjelic, and G. Subakov. 1995. Acute Toxicity of Heavy Metals (Copper, Lead, Zinc), Phenol and Sodium on Allium cepa L., Lepidium sativum L. and Daphnia magna St.: Comparative. Water Res. 29(2):497-503.	13712	AF	
Back, H.. 1983. Interactions, Uptake and Distribution of Barium, Cadmium, Lead and Zinc in Tubificid Worms (Annelida, Oligochaeta). In: 4th Int.Conf.on Heavy Metals in the Environment, Heidelberg, Vol.1, Sept.1983, CEP Consultants Ltd., Edinburgh, U.K. :370-371.	11865	AF, UEndp, Dur	
Back, H.. 1990. Epidermal Uptake of Pb, Cd, and Zn in Tubificid Worms. Oecologia 85(2):226-232.	20568	AF, UEndp, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Baird, D.J., I. Barber, M. Bradley, A.M.V.M. Soares, and P. Calow. 1991. A Comparative Study of Genotype Sensitivity to Acute Toxic Stress Using Clones of Daphnia magna Straus. Ecotoxicol.Environ.Saf. 21(3):257-265.	2493	Con	
Baker, L., and D. Walden. 1984. Acute Toxicity of Copper and Zinc to Three Fish Species from the Alligator Rivers Region. Tech.Memorandum No.8, Supervising Scientist for the Alligator Rivers Region, Australian Gov.Publ.Serv., Canberra, Australi a:27.	4126	NonRes	
Banerjee, V., and K. Kumari. 1988. Effect of Zinc, Mercury and Cadmium on Erythrocyte and Related Parameters in the Fish Anabas testudineus. Environ.Ecol. 6(3):737-739.	803	AF, Dur, Con	
Bantle, J.A., D.J. Fort, and B.L. James. 1989. Identification of Developmental Toxicants Using the Frog Embryo Teratogenesis Assay-Xenopus (FETAX). Hydrobiologia 188/189:577-585.	3122	AF, Con, Eff	
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Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
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Verma, S.R., M. Jain, and R.C. Dalela. 1982. A Laboratory Study to Assess Separate and In-Combination Effects of Zinc, Chromium and Nickel to the Fish Mystus vittatus. Acta Hydrochim.Hydrobiol. 10(1):23-29.	15793	AF, Con	
Vijayamadhavan, K.T., and T. Iwai. 1975. Histochemical Observations on the Permeation of Heavy Metals Into Taste Buds of Goldfish. Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 41(6):631-639.	15445	AF, UEndp, Dur, Con	
Vijayaraman, K., G. John, P. Sivakumar, and R.R. Mohamed. 1999. Uptake and Loss of Heavy Metals by the Freshwater Prawn, Macrobrachium malcolmsonii. J.Environ.Biol. 20(3):217-222.	55226	UEndp	
Vijayram, K., and P. Geraldine. 1996. Regulation of Essential Heavy Metals (Cu, Cr, and Zn) by the Freshwater Prawn Macrobrachium malcolmsonii (Milne Edwards). Bull.Environ.Contam.Toxicol. 56(2):335-342.	16442	UEndp	
Vincent, M.J.D., and B. Penicaut. 1986. Comparative Studies on the Toxicity of Metal Chlorides and of a Synthetic Organic Molluscicide, N-Trityl-Morpholine, upon Two Aquatic Amphipod. Ann.Rech.Vet. 17(4):441-446.	12420	AF, Con	
Vymazal, J.. 1990. Uptake of Heavy Metals by Cladophora glomerata. Acta Hydrochim.Hydrobiol. 18(6):657-665.	45131	Plant, AF, UEndp, Dur	
Vymazal, J.. 1995. Influence of pH on Heavy Metals Uptake by Cladophora glomerata. Pol.Arch.Hydrobiol. 42(3):231-237.	45130	Plant, AF, UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Wagh, S.B., K. Shareef, and S. Shaikh. 1985. Acute Toxicity of Cadmium Sulphate, Zinc Sulphate and Copper Sulphate to Barbus ticto (Ham.): Effect on Oxygen Consumption and Gill Histology. J.Environ.Biol. 6(4):287-293.	11483	Con	
Wagner, G.F., and B.A. McKeown. 1982. Changes in Plasma Insulin and Carbohydrate Metabolism of Zinc-Stressed Rainbow Trout, Salmo gairdneri. Can.J.Zool. 60(9):2079-2084.	11352	UEndp	
Wang, T.C., J.C. Weissman, G. Ramesh, R. Varadarajan, and J.R. Benemann. 1996. Parameters for Removal of Toxic Heavy Metals by Water Milfoil (Myriophyllum spicatum). Bull.Environ.Contam.Toxicol. 57(5):779-786.	20408	Plant, AF, UEndp, Dur	
Wang, W.. 1986. Toxicity Tests of Aquatic Pollutants by Using Common Duckweed. Environ.Pollut.Ser.B Chem.Phys. 11(1):1-14.	11789	Plant, Af, Con	
Wang, W.. 1994. Rice Seed Toxicity Tests for Organic and Inorganic Substances. Environ.Monit.Assess. 29:101-107.	45060	Plant, AF, Dur	
Water Pollution Research Board. 1962. Effects of Pollution on Fish: Toxicity of Mixtures of Zinc Sulphate and Ammonium Chloride. In: Water Pollution Research 1961, Water Pollution Research Board, Dep.of Scientific and Industrial Research, H.M.Stationery Office, London :90-93.	2515	AF, Dur, Con	
Water Pollution Research Board. 1968. Effects of Pollution on Fish: Chronic Toxicity of Ammonia to Rainbow Trout. In: Water Pollution Research 1967, Water Pollution Research Board, Dep.of Scientific and Industrial Research, H.M.Stationery Office, London :56-65.	10185	AF, Dur, Con	
Water Pollution Research Laboratory. 1967. Effects of Pollution on Fish. In: Water Pollution Research 1966, Ministry of Technology, London, England :50-61.	14394	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Watson, T.A., and B.A. McKeown. 1976. The Effect of Sublethal Concentrations of Zinc on Growth and Plasma Glucose Levels in Rainbow Trout, Salmo gairdneri (Richardson). J.Wildl.Dis. 12(2):263-270.	8470	UEndp	
Watson, T.A., and B.A. McKeown. 1976. The Activity of Delta 5-3 beta Hydroxysteriod Dehydrogenase Enzyme in the Interrenal Tissue of Rainbow Trout (Salmo gairdneri Richardson). Bull.Environ.Contam.Toxicol. 16(2):173-181.	15996	UEndp	
Wehr, J.D., M.G. Kelly, and B.A. Whitton. 1987. Factors Affecting Accumulation and Loss of Zinc by the Aquatic Moss Rhynchostegium riparioides (Hedw.) C. Jens. Aquat.Bot. 29:261-274.	15013	Plant, AF, UEndp	
Wekell, J.C., K.D. Shearer, and C.R. Houle. 1983. High Zinc Supplementation of Rainbow Trout Diets. Prog.Fish-Cult. 45(3):144-147.	11257	AF, UEndp, RouExp	
Whitley, L.S.. 1968. The Resistance of Tubificid Worms to Three Common Pollutants. Hydrobiologia 32(1/2):193-205 (Author Communication Used).	15507	AF, Dur, Con, NoOrg	
Williams, P.L., and D.B. Dusenbery. 1990. Aquatic Toxicity Testing Using the Nematode, Caenorhabditis elegans. Environ.Toxicol.Chem. 9(10):1285-1290.	3437	AF, Dur	
Willis, M.. 1988. Experimental Studies of the Effects of Zinc on Ancylus fluviatilis (Mueller) (Mollusca; Gastropoda) From the Afon Crafnant, N. Wales. Arch.Hydrobiol. 112(2):299-316.	13067	AF	
Willis, M.. 1989. Experimental Studies on the Effects of Zinc on Erpobdella octulata (L.) (Annelida: Hirudinea) from the Afon Crafnant, N. Wales. Arch.Hydrobiol. 116(4):449-469.	8529	AF	
Winner, R.W.. 1981. A Comparison of Body Length, Brood Size, and Longevity as Indices of Chronic Copper and Zinc Stresses in Daphnia magna. Environ.Pollut.Ser.A Ecol.Biol. 26:33-37.	3543	AF, UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Winner, R.W., and J.D. Gauss. 1986. Relationship Between Chronic Toxicity and Bioaccumulation of Copper, Cadmium and Zinc As Affected by Water Hardness and Humic Acid. Aquat.Toxicol. 8(3):149-161.	12009	AF, UEndp, Con	
Wolterbeek, H.T., A. Viragh, J.E. Sloof, G. Bolier, B. Van der Veer, and J. De Kok. 1995. On the Uptake and Release of Zinc (65 Zn) in the Growing Alga Selenastrum capricornutum Printz. Environ.Pollut. 88:85-90.	13741	Plant, AF, UEndp	
Wong, C.K.. 1992. Effects of Chromium, Copper, Nickel, and Zinc on Survival and Feeding of the Cladoceran Moina macrocopa. Bull.Environ.Contam.Toxicol. 49:593-599.	45188	AF, UEndp	
Wong, C.K.. 1993. Effects of Chromium, Copper, Nickel, and Zinc on Longevity and Reproduction of the Cladoceran Moina macrocopa. Bull.Environ.Contam.Toxicol. 50:633-639.	6973	AF	
Wong, M.H., K.C. Luk, and K.Y. Choi. 1977. The Effects of Zinc and Copper Salts on Cyprinus carpio and Ctenopharyngodon idellus. Acta Anat. 99(4):450-454.	15701	UEndp, Dur	
Wong, M.H., S.H. Kwan, and F.Y. Tam. 1980. Comparative Toxicity of Manganese and Zinc on Chlorella pyrenoidosa, Chlorella salina and Scenedesmus quadricauda. Microbios Lett. 12(45):37-46.	5872	Plant, Af, Con	
Wong, P.T.S., and Y.K. Chau. 1990. Zinc Toxicity to Freshwater Algae. Toxic.Assess. 5(2):167-177.	180	Plant, AF, Dur, Con	
Woodall, C., N. MacLean, and F. Crossley. 1988. Responses of Trout Fry (Salmo gairdneri) and Xenopus laevis Tadpoles to Cadmium and Zinc. Comp.Biochem.Physiol.C 89(1):93-99.	6074	Dur	
Wooldridge, C.R., and D.P. Wooldridge. 1969. Internal Damage in an Aquatic Beetle Exposed to Sublethal Concentrations of Inorganic Ions. Ann.Entomol.Soc.Am. 62(4):921-933.	2868	AF, UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Wren, M.J., and D. McCarroll. 1990. A Simple and Sensitive Bioassay for the Detection of Toxic Materials Using a Unicellular Green Alga. Environ.Pollut. 64(1):87-91.	3265	Plant, Af, Con	
Xu, Q., and D. Pascoe. 1993. The Bioconcentration of Zinc by Gammarus pulex (L.) and the Application of a Kinetic Model to Determine Bioconcentration Factors. Water Res. 27(11):1683-1688.	9228	UEndp	
Xu, Q., and D. Pascoe. 1993. Autoradiographic Study of Zinc in Gammarus pulex (Amphipoda). In: R.Dallinger and P.S.Rainbow (Eds.), Ecotoxicology of Metals in Invertebrates, Lewis Publ. :187-199.	13826	UEndp	
Xu, Q., and D. Pascoe. 1994. The Importance of Food and Water as Sources of Zinc During Exposure of Gammarus pulex (Amphipoda). Arch.Environ.Contam.Toxicol. 26(4):459-465.	13662	UEndp, RouExp	
Yager, C.M., and H.W. Harry. 1964. The Uptake of Radioactive Zinc, Cadmium and Copper by the Freshwater Snail, Taphius glabratus. Malacologia 1(3):339-353.	14058	AF, UEndp, Dur	
Yang, H.N., and H.C. Chen. 1996. The Influence of Temperature on the Acute Toxicity and Sublethal Effects of Copper, Cadmium and Zinc to Japanese Eel, Anguilla japonica. Acta Zool.Taiwan. 7(1):29-38.	18914	NonRes	
Zia, S., and D.G. McDonald. 1994. Role of the Gills and Gill Chloride Cells in Metal Uptake in the Freshwater-Adapted Rainbow Trout, Oncorhynchus mykiss. Can.J.Fish.Aquat.Sci. 51(11):2482-2492.	17464	AF, UEndp, Dur	
Zitko, V., and W.G. Carson. 1976. A Mechanism of the Effects of Water Hardness on the Lethality of Heavy Metals to Fish. Chemosphere 5(5):299-303.	8483	UEndp, Dur	
Zou, E.. 1997. Effects of Sublethal Exposure to Zinc Chloride on the Reproduction of the Water Flea, Moina irrasa (Cladocera). Bull.Environ.Contam.Toxicol. 58(3):437-441.	18008	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Zou, E., and S. Bu. 1994. Acute Toxicity of Copper, Cadmium, and Zinc to the Water Flea, Moina irrasa (Cladocera). Bull.Environ.Contam.Toxicol. 52(5):742-748.	13762	Dur, NonRes	

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

1. For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[91], EPA is providing a transparent rationale as to why they were not utilized (see below).
2. For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable.

General QA/QC failure because non-resident species in Oregon

The tests with the following species were used in the EPA BE of OR WQS for zinc in freshwater, but were not considered in the CWA review and approval/disapproval action of the standards because these species do not have a breeding wild population in Oregon's waters:

Morone	*americana*	White perch	Rehwoldt et al. 1971; Rehwoldt et al. 1972
Jordanella	*floridae*	Flagfish	Spehar 1976a;b
Agosia	*chrysogaster*	Longfin dace	Lewis 1978

Other Acute tests failing QA/QC by species

Daphnia pulex - Cladoceran

[91] U.S. EPA. 1996. 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. EPA-820-B-96-001.

The following test was included in EPA's BE of the OR WQS for zinc in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because a more sensitive lifestage was available.

Jindal, R., and A. Verma. 1990. Heavy Metal Toxicity to Daphnia pulex. Indian J. Environ. Health 32(3): 289-292.

Daphnia magna - Cladoceran

The following tests were included in EPA's BE of the OR WQS for zinc in freshwater, but were not used used in this CWA review and approval/disapproval action of these standards because the tests were not based on the preferred flow-through measured test conditions; however other flow-through measured test concentrations were available for this species.

Anderson, B.G. 1948. The apparent thresholds of toxicity to Daphnia magna for chlorides of various metals when added to Lake Erie water. Trans. Am. Fish. Soc. 78: 96-113.
One LC50 value from S,U test, also a less than value, of <71.95 µg/L.

Biesinger, K.E. and G.M. Christensen. 1972. Effects of Various Metals on Survival, Growth, Reproduction and Metabolism of Daphnia magna. J. Fish Res. Board Can. 29: 1691-1700.
One LC50 value from S,U test of 191.31 µg/L.

Cairns, J., Jr., A.L. Buikema, A.G. Heath and B.C. Parker. 1978. Effects of Temperature on Aquatic Organism Sensitivity to Selected Chemicals. Va. Water Resour. Res. Center, Bull. 106, Office of Water Res. and Technol., OWRT Project B-084-VA, VA. Polytech. Inst. State Univ., Blacksburg, VA: 1-88.
One LC50 value from S,M test of 538.68 µg/L.

Mount, D.I. and T.J. Norberg. 1984. A Seven-Day Life-Cycle Cladoceran Toxicity Test. Environ. Toxicol. Chem. 3(3): 425-434 (Author Communication Used).
One LC50 value from S,U test of 130.82 µg/L.

Chapman, G.A. , S. Ota and F. Recht. Manuscript. Effects of water hardness on the toxicity of metals to Daphnia magna. Available from: C.E. Stephan, U.S. EPA, Duluth, MN.
Three LC50 values from S,M tests ranging from 362.20 to 550.59 µg/L.

Magliette, R.J., F.G. Doherty, D. McKinney, and E.S. Venkataramani. 1995. Need for Environmental Quality Guidelines Based on Ambient Freshwater Quality Criteria in Natural Waters--Case Study "Zinc." Bull. Environ. Contam. Toxicol. 54(4): 626-632.
Two LC50 values from S,M tests ranging from 488.26 to 692.65 µg/L.

Brata, C., D.J. Baird, and S.J. Markich. 1998. Influence of Genetic and Environmental Factors on the Tolerance of Daphnia magna Straus to Essential and Non-Essential Metals. Aquat. Toxicol. 42(2): 115-137.
Six LC50 values from S,M tests ranging from 358.90 to 1126.07 µg/L.

Khangarot, B.S., P.K. Ray and H. Chandra. 1987. Daphnia magna as a Model to Assess Heavy Metal Toxicity: Comparative Assessment with Mouse System. Acta Hydrochim. Hydrobiol. 15(4): 427-432.
One LC50 value from S,U test of 321.39 µg/L.

Morone saxatilis – Striped bass

The following tests were included in EPA's BE of the OR WQS for zinc in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because the 1987 ALC document deemed the values too high and therefore were outliers for this species.

Rehwoldt, R., G. Bida and B. Nerrie. 1971. Acute Toxicity of Copper, Nickel, and Zinc Ions to Some Hudson River Fish Species. Bull. Environ. Contam. Toxicol. 6(5): 445-448.

Rehwoldt, R., L.W. Menapace, B. Nerrie and D. Allessandrello. 1972. The Effect of Increased Temperature upon the Acute Toxicity of Some Heavy Metal Ions. Bull. Environ. Contam. Toxicol. 8(2): 91-96.

Morone americana – White perch

The following tests were included in EPA's BE of the OR WQS for zinc in freshwater, but were not used in this CWA review and approval of these standards because the 1987 ALC document deemed the values too high and therefore were outliers for this species.

Rehwoldt, R., G. Bida and B. Nerrie. 1971. Acute Toxicity of Copper, Nickel, and Zinc Ions to Some Hudson River Fish Species. Bull. Environ. Contam. Toxicol. 6(5): 445-448.

Rehwoldt, R., L.W. Menapace, B. Nerrie and D. Allessandrello. 1972. The Effect of Increased Temperature upon the Acute Toxicity of Some Heavy Metal Ions. Bull. Environ. Contam. Toxicol. 8(2): 91-96.

<u>Other Chronic tests failing QA/QC by species</u>

Daphnia magna - Cladoceran

The following tests were included in EPA's BE of the OR WQS for zinc in freshwater, but were not used in this CWA review and approval/disapproval action of these standards because the tests were not based on measured test conditions, as per the Guidelines.

Magliette, R.J., F.G. Doherty, D. McKinney, and E.S. Venkataramani. 1995. Need for Environmental Quality Guidelines Based on Ambient Freshwater Quality Criteria in Natural Waters--Case Study "Zinc." Bull. Environ. Contam. Toxicol. 54(4): 626-632.
This was also only a 48-hr chronic test

Paulaskis, J.D. and R.W. Winner. 1988. Effects of Water Hardness and Humic Acid on Zinc Toxicity to Daphnia magna. Toxicology 12: 273-290..

Appendix O Cadmium (Saltwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Abdullah, A.M., and M.P. Ireland. 1986. Cadmium Content, Accumulation and Toxicity in Dog Whelks Collected Around the Welsh Coastline. Mar.Pollut.Bull. 17(12):557-561.	6801	UEndp	
Ahsanullah, M., and A.R. Williams. 1991. Sublethal Effects and Bioaccumulation of Cadmium, Chromium, Copper, and Zinc in the Marine Amphipod Allorchestes compressa. Mar.Biol. 108:59-65.	331	Eff	
Ahsanullah, M., and W. Ying. 1993. Tidal Rhythms and Accumulation of Cadmium from Water and Sediment by Soldier Crabs. Mar.Pollut.Bull. 26(1):20-23.	7147	UEndp, Eff	
Ahsanullah, M., M.C. Mobley, and P. Rankin. 1988. Individual and Combined Effects of Zinc, Cadmium and Copper on the Marine Amphipod Allorchestes compressa. Aust.J.Mar.Freshwater Res. 39(1):33-37.	13187	NonRes	
Alderdice, D.F., H. Rosenthal, and F.P.J. Velsen. 1979. Influence of Salinity and Cadmium on Capsule Strength in Pacific Herring Eggs. Helgol.Wiss.Meeresunters. 32:149-162.	2575	UEndp, Eff, Dur	
Alderdice, D.F., T.R. Rao, and H. Rosenthal. 1979. Osmotic Responses of Eggs and Larvae of the Pacific Herring to Salinity and Cadmium. Helgol.Wiss.Meeresunters. 32(4):508-538.	9352	UEndp, Eff, Dur, Con	
Amiard-Triquet, C., J.C. Amiard, R. Ferrand, A.C. Andersen, and M.P. Dubois. 1986. Disturbance of a Met-Enkephalin-Like Hormone in the Hepatopancreas of Crabs Contaminated by Metals. Ecotoxicol.Environ.Saf. 11(2):198-209.	12111	UEndp, Eff	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Arasu, S.M., and P.S. Reddy. 1994. Alterations in Oxidative Metabolism in the Gill and Muscle of Marine Bivalve Perna viridis During Cadmium and Copper Exposure. Fresenius Environ.Bull. 3(12):721-727.	16831	Dur, AF	Has 48hr LC50 for Perna viridis(an invasive species to North America)
Arnott, G.H., and M. Ahsanullah. 1979. Acute Toxicity of Copper, Cadmium and Zinc to Three Species of Marine Copepod. Aust.J.Mar.Freshwater Res. 30(1):63-71.	5563	Dur, Con	only 24hr
Aunaas, T., S. Einarson, T.E. Southon, and K.E. Zachariassen. 1991. The Effects of Organic and Inorganic Pollutants on Intracellular Phosphate Compounds in Blue Mussels (Mytilus edulis). Comp.Biochem.Physiol.C 100(1/2):89-93.	3968	UEndp, Eff	
Bahner, L.H., and D.R. Nimmo. 1975. Methods to Assess Effects of Combinations of Toxicants, Salinity and Temperature on Estuarine Animals. Trace Subst.Environ.Health 9:169-177.	2839	UEndp, Eff, Dur, Con	
Bailey, H.C., J.L. Miller, M.J. Miller, and B.S. Dhaliwal. 1995. Application of Toxicity Identification Procedures to the Echinoderm Fertilization Assay to Identify Toxicity in a Municipal Effluent. Environ.Toxicol.Chem. 14(12):2181-2186.	16375	Dur	40mi
Bat, L.. 1997. Studies on the Uptake of Copper, Zinc and Cadmium by the Amphipod Corophium volutator (Pallas) in the Laboratory. Turk.J.Mar.Sci. 3(2):93-109.	19858	UEndp, Eff	
Bebianno, M.J., and W.J. Langston. 1992. Cadmium Induction of Metallothionein Synthesis in Mytilus galloprovincialis. Comp.Biochem.Physiol.C 103(1):79-85.	6497	UEndp, Eff	
Bebianno, M.J., and W.J. Langston. 1992. Metallothionein Induction in Littorina littorea (Mollusca: Prosobranchia) on Exposure to Cadmium. J.Mar.Biol.Assoc.U.K. 72(2):329-342.	7153	UEndp, Eff	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Bebianno, M.J., J.A. Nott, and W.J. Langston. 1993. Cadmium Metabolism in the Clam Ruditapes decussata: The Role of Metallothioneins. Aquat.Toxicol. 27(3/4):315-334.	12440	UEndp, Eff, UChron	
Bebianno, M.J., M.A.P. Serafim, and M.F. Rita. 1994. Involvement of Metallothionein in Cadmium Accumulation and Elimination in the Clam Ruditapes decussata. Bull.Environ.Contam.Toxicol. 53(5):726-732.	13747	UEndp, Eff, UChron	
Berail, G., P. Prudent, C. Massiani, and M. Pellegrini. 1992. Isolation of Heavy Metal-Binding Proteins from a Brown Seaweed Cystoseira barbata f. repens Cultivated in Copper or Cadmium Enriched Seawater. In: E.Merian and W.Haerdi (Eds.), Metal Compounds in Environment and Life, 4.Interrelation Between Chemistry and Biology, Science and Technology Letters, Northwood, Middlesex, UK :55-62.	2351	UEndp, Eff	
Bervoets, L., R. Blust, and R. Verheyen. 1995. The Uptake of Cadmium by the Midge Larvae Chironomus riparius as a Function of Salinity. Aquat.Toxicol. 33(3/4):227-243.	16117	UEndp, Eff, Dur	
Birmelin, C., J. Cuzin-Roudy, M. Romeo, M. Gnassia-Barelli, and S. Puiseux-Dao. 1995. The Mysid Siriella armata as a Test Organisms in Toxicology: Effects of Cadmium. Mar.Environ.Res. 39(1-4):317-320.	16897	UEndp, Eff, NonRes	
Bjerregaard, P., and M.H. Depledge. 1994. Cadmium Accumulation in Littorina littorea, Mytilus edulis and Carcinus maenas: The Influence of Salinity and Calcium Ion Concentrations. Mar.Biol. 119(3):385-395.	16407	UEndp, Eff, UChron	
Bjerregaard, P., and T. Vislie. 1985. Effects of Cadmium on Hemolymph Composition in the Shore Crab Carcinus maenas. Mar.Ecol.Prog.Ser. 27(1):135-142.	8043	Dur, UChron, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Bjerregaard, P.. 1982. Accumulation of Cadmium and Selenium and Their Mutual Interaction in the Shore Crab Carcinus maenas (L.). Aquat.Toxicol. 2(2):113-125.	6873	UEndp, Eff, UChron	
Bjerregaard, P.. 1985. Effect of Selenium on Cadmium Uptake in the Shore Crab Carcinus maenas (L.). Aquat.Toxicol. 7(3):177-189.	6944	UEndp, Eff, UChron	
Bjerregaard, P.. 1988. Effect of Selenium on Cadmium Uptake in Selected Benthic Invertebrates. Mar.Ecol.Prog.Ser. 48(1):17-28.	2974	UEndp, Eff, UChron, Con	
Bjerregaard, P.. 1988. Interaction between Selenium and Cadmium in the Hemolymph of the Shore Crab Carcinus maenas (L.). Aquat.Toxicol. 13(1):1-12.	13132	Eff, Dur	
Bjerregaard, P.. 1991. Relationship Between Physiological Condition and Cadmium Accumulation in Carcinus maenas (L.). Comp.Biochem.Physiol.A 99(1/2):75-83.	20017	UEndp, Eff, UChron	
Blasco, J., and J. Puppo. 1999. Effect of Heavy Metals (Cu, Cd and Pb) on Aspartate and Alanine Aminotransferase in Ruditapes phillippinarum (Mollusca: Bivalvia). Comp.Biochem.Physiol.C 122(2):253-263.	20072	Eff, Dur, UChron	
Blust, R., E. Kockelbergh, and M. Baillieul. 1992. Effect of Salinity on the Uptake of Cadmium by the Brine Shrimp Artemia franciscana. Mar.Ecol.Prog.Ser. 84(3):245-254.	7554	UEndp, Eff, Dur	
Blust, R., M. Baillieul, and W. Decleir. 1995. Effect of Total Cadmium and Organic Complexing on the Uptake of Cadmium by the Brine Shrimp, Artemia franciscana. Mar.Biol. 123(1):65-73.	18288	UEndp, Eff, Dur	
Borchardt, T.. 1983. Influence of Food Quantity on the Kinetics of Cadmium Uptake and Loss Via Food and Seawater in Mytilus edulis. Mar.Biol. 76(1):67-76.	11783	UEndp, Eff, Dur, UChron	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Braek, G.S., D. Malnes, and A. Jensen. 1980. Heavy Metal Tolerance of Marine Phytoplankton. IV. Combined Effect of Zinc and Cadmium on Growth and Uptake in Some Marine Diatoms. J.Exp.Mar.Biol.Ecol. 42:39-54.	9761	UEndp, Dur, UChron, Con	
Brand, G.W., G.J. Fabris, and G.H. Arnott. 1986. Reduction of Population Growth in Tisbe holothuriae Humes (Copepoda: Harpacticoida) Exposed to Low Cadmium Concentrations. Aust.J.Mar.Freshwater Res. 37(4):475-479.	12048	UEndp	
Brand, L.E., W.G. Sunda, and R.R.L. Guillard. 1986. Reduction of Marine Phytoplankton Reproduction Rates by Copper and Cadmium. J.Exp.Mar.Biol.Ecol. 96(3):225-250.	12014	UEndp, UChron	
Bresler, V., and V. Yanko. 1995. Acute Toxicity of Heavy Metals for Benthic Epiphytic Foraminifera Pararotalia spinigera (Le Calvez) and Influence of Seaweed-Derived DOC. Environ.Toxicol.Chem. 14(10):1687-1695.	15933	Dur	24hr only
Bressan, M., and R. Brunetti. 1988. The Effects of Nitriloacetic Acid, Cd and Hg on the Marine Algae Dunaliella tertiolecta and Isochrysis galbana. Water Res. 22(5):553-556.	12936	UEndp	
Brinkhuis, B.H., W.F. Penello, and A.C. Churchill. 1980. Cadmium and Manganese Flux in Eelgrass Zostera marina. II. Metal Uptake by Leaf and Root-Rhizome Tissue. Mar.Biol. 58(3):187-196.	6194	Eff, Dur, Con	
Brouwer, M., and T. Brouwer-Hoexum. 1984. Cadmium Accumulation by the Blue Crab, Callinectes sapidus: Involvement of Hemocyanin and Characterization of Cadmium-Binding Proteins. Mar.Environ.Res. 14(1-4):71-88.	14642	UEndp, Eff, Dur	
Brown, B., and M. Ahsanullah. 1971. Effect of Heavy Metals on Mortality and Growth. Mar.Pollut.Bull. 2:182-187.	2467	Dur, UChron, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Brown, C.L., and S.N. Luoma. 1995. Use of the Euryhaline Bivalve Potamocorbula amurensis as a Biosentinel Species to Assess Trace Metal Contamination in San Francisco Bay. Mar.Ecol.Prog.Ser. 124(1-3):129-142.	18036	UEndp, Eff, Dur, UChron	
Burdin, K.S., and K.T. Bird. 1994. Heavy Metal Accumulation by Carrageenan and Agar Producing Algae. Bot.Mar. 37:467-470.	45156	UEndp, Eff, Dur	24hr only
Calabrese, A., F.P. Thurberg, and E. Gould. 1977. Effects of Cadmium, Mercury and Silver on Marine Animals. MFR Paper 1244, Mar Fish Rev 39:5-11.	12206	UEndp, Eff, UChron	
Calabrese, A., F.P. Thurberg, M.A. Dawson, and D.R. Wenzloff. 1975. Sublethal Physiological Stress Induced by Cadmium and Mercury in the Winter Flounder, Pseudopleuronectes americanus. In: J.H.Koeman and J.J.T.W.A.Strik (Eds.), Sublethal Effects of Toxic Chemicals on Aquat.Animals, Elsevier Sci.Publ., Amsterdam, NY :15-21.	15525	UEndp, Eff, UChron, Con	
Calabrese, A., R.S. Collier, and J.E. Miller. 1974. Physiological Response of the Cunner, Tautogolabrus adspersus, to Cadmium. I. Introduction and Experimental Design. Noaa Tech.Rep.Nmfs Ssr F-681:1-3.	6444	UEndp	
Calapaj, G.G.. 1974. Ricerche Di Laboratorio Sull'Inquinamento Chimico Dei Mitili Nota II: Cadmio, Zinco. (Chemical Pollution of Mytilus. II. Cadmium and Zinc). Ig.Mod. 67(2):136-145 (ITA) (ENG ABS).	8508	UEndp, Eff, UChron	
Canli, M., and R.W. Furness. 1993. Toxicity of Heavy Metals Dissolved in Sea Water and Influences of Sex and Size on Metal Accumulation and Tissue Distribution in the Norway Lobster. Mar.Environ.Res. 36(4):217-236.	4563	UEndp, Eff, UChron	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Canli, M., and R.W. Furness. 1995. Mercury and Cadmium Uptake from Seawater and from Food by the Norway Lobster Nephrops norvegicus. Environ.Toxicol.Chem.. 14(5):819-828.	15120	UEndp, Eff, UChron	
Canterford, G.S., A.S. Buchanan, and S.C. Ducker. 1978. Accumulation of Heavy Metals by the Marine Diatom Ditylum brightwellii (West) Grunow. Aust.J.Mar.Freshwater Res. 29(5):613-622.	15455	UEndp, Eff, Dur, UChron, Con	
Carmichael, N.G., and B.A. Fowler. 1981. Cadmium Accumulation and Toxicity in the Kidney of the Bay Scallop Argopecten irradians. Mar.Biol. 65(1):35-43.	15347	UEndp, Eff, Con	
Carr, R.S., and J.M. Neff. 1982. Biochemical Indices of Stress in the Sandworm Neanthes virens (Sars). II. Sublethal Responses to Cadmium. Aquat.Toxicol. 2(5-6):319-333.	6153	Eff, UChron	
Carr, R.S., J.W. Williams, F.I. Saksa, R.L. Buhl, and J.M. Neff. 1985. Bioenergetic Alterations Correlated with Growth, Fecundity and Body Burden of Cadmium for Mysids (Mysidopsis bahia). Environ.Toxicol.Chem. 4(2):181-188.	11581	UEndp, Eff, UChron	
Carvalho, R.A., M.C. Benfield, and P.H. Santschi. 1999. Comparative Bioaccumulation Studies of Colloidally Complexed and Free-Ionic Heavy Metals in Juvenile Brown Shrimp Penaeus aztecus (Crustacea: Decapoda: Penaeidae). Limnol.Oceanogr. 44(2):403-414.	48059	UEndp, Eff, Dur	
Casini, S., and M.H. Depledge. 1997. Influence of Copper, Zinc, and Iron on Cadmium Accumulation in the Talitrid Amphipod, Platorchestia platensis. Bull.Environ.Contam.Toxicol. 59:500-506.	18370	UEndp, Eff, Dur, UChron	
Cattani, O., R. Serra, G. Isani, G. Raggi, P. Cortesi, and E. Carpene. 1996. Correlation Between Metallothionein and Energy Metabolism in Sea Bass, Dicentrarchus labrax, Exposed to Cadmium. Comp.Biochem.Physiol.C 113(2):193-199.	16851	UEndp, Eff, Dur, UChron	

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Chan, H.M., P. Bjerregaard, P.S. Rainbow, and M.H. Depledge. 1992. Uptake of Zinc and Cadmium by Two Populations of Shore Crabs Carcinus maenas at Different Salinities. Mar.Ecol.Prog.Ser. 86(1):91-97.	7546	UEndp, Eff	
Chapman, P.M., M.A. Farrell, and R.O. Brinkhurst. 1982. Relative Tolerances of Selected Aquatic Oligochaetes to Combinations of Pollutants and Environmental Factors. Aquat.Toxicol. 2(1):69-78.	10602	No Code	ECOTOX provides three 96-h LC50s of 125000 - 135000 µg/L for *Monopylephorus cuticulatus* for this study. This value could have been considered for EPA's evaluation of saltwater cadmium, but the species is relatively insensitive to cadmium compared to others. Note, this test was not used in the 2001 cadmium WQC doc. Other LC50s for this and other species were enterted into ECOTOX as approximate values or ranges.
Chelomin, V.P., and N.N. Belcheva. 1992. The Effect of Heavy Metals on Processes of Lipid Peroxidation in Microsomal Membranes from the Hepatopancreas of the Bivalve Mollusc Mizuhopecten. Comp.Biochem.Physiol.C 103(2):419-422.	6730	UEndp, Eff, UChron	
Chelomin, V.P., E.A. Bobkova, O.N. Lukyanova, and N.M. Chekmasova. 1995. Cadmium-Induced Alterations in Essential Trace Element Homoeostasis in the Tissues of Scallop Mizuhopecten yessoensis. Comp.Biochem.Physiol.C 110(3):329-335.	16150	UEndp, Eff, Dur, UChron	
Chen, J.C., and P.C. Liu. 1987. Accumulation of Heavy Metals in the Nauplii of Artemia salina. J.World Aquacult.Soc. 18(2):84-93.	2749	UEndp, Eff, Dur	
Coleman, N., T.F. Mann, M. Mobley, and N. Hickman. 1986. Mytilus edulis planulatus: An "Integrator" of Cadmium Pollution?. Mar.Biol. 92(1):1-5.	2486	UEndp	
Coleman, N.. 1980. The Effect of Emersion on Cadmium Accumulation by Mytilus edulis. Mar.Pollut.Bull. 11(12):359-362.	9254	UEndp, Eff, Dur, Con	
Congiu, A.M., E. Calendi, and G. Ugazio. 1984. Effects of Metal Ions and CCl4 on Sea Urchin Embryo (Paracentrotus lividus). Res.Commun.Chem.Pathol.Pharmacol. 43(2):317-323.	625	UEndp, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Cui, K., Y. Liu, and L. Hou. 1987. Effects of Six Heavy Metals on Hatching Eggs and Survival of Larval of Marine Fish. Oceanol.Limnol.Sin./Haiyang Yu Huzhao 18(2):138-144 (CHI) (ENG ABS).	3222	NonRes	
D'Agostino, A., and C. Finney. 1974. The Effect of Copper and Cadmium on the Development of Tigriopus japonicus. In: F.J.Vernberg and W.B.Vernberg (Eds.), Pollution and Physiology of Mar.Organisms, Academic Press, NY :445-463.	15558	UEndp, Dur, UChron	
Dalla Via, G.J., R. Dallinger, and E. Carpene. 1989. Effects of Cadmium on Murex trunculus from the Adriatic Sea. II. Oxygen Consumption and Acclimation Effects. Arch.Environ.Contam.Toxicol. 18(4):562-567.	2557	UEndp, Eff, Dur, Con	
Darmono, D.. 1990. Uptake of Cadmium and Nickel in Banana Prawn (Penaeus merguiensis de Man). Bull.Environ.Contam.Toxicol. 45(3):320-328.	18787	UEndp, Eff, UChron	
Darmono, G.R.W.D., and R.S.F. Campbell. 1990. The Pathology of Cadmium and Nickel Toxicity in the Banana Shrimp (Penaeus merguiensis de Man). Asian Fish.Sci. 3(3):287-297.	9711	UEndp, Eff, UChron	
Davies, I.M., G. Topping, W.C. Graham, C.R. Falconer, A.D. McIntosh, and D. Saward. 1981. Field and Experimental Studies on Cadmium in the Edible Crab Cancer pagurus. Mar.Biol. 64:291-297.	14333	UEndp, Eff, UChron	
Davies, N.A., M.G. Taylor, and K. Simkiss. 1997. The Influence of Particle Surface Characteristics on Pollutant Metal Uptake by Cells. Environ.Pollut. 96(2):179-184.	18661	UEndp, Eff, Dur	
Dawson, M.A., E. Gould, F.P. Thurberg, and A. Calabrese. 1977. Physiological Response of Juvenile Striped Bass, Morone saxatilis, to Low Levels of Cadmium and Mercury. Chesapeake Sci. 18(4):353-359.	15770	UEndp, Eff, UChron	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Del Ramo, J., A. Torreblanca, M. Martinez, A. Pastor, and J. Diaz-Mayans. 1995. Quantification of Cadmium-Induced Metallothionein in Crustaceans by the Silver-Saturation Method. Mar.Environ.Res. 39(1-4):121-125.	16911	UEndp, Eff	Brine Shrimp
DeLisle, P.F.Jr.. 1994. The Effect of Salinity on Cadmium Toxicity in the Estuarine Mysid Mysidopsis bahia: Roles of Osmoregulation and Calcium. Mar.Environ.Res. 37(1):47-62.	4110	UEndp	
Demuynck, S., and N. Dhainaut-Courtois. 1994. Metal-Protein Binding Patterns in the Polychaete Worm Nereis diversicolor During Short-Term Acute Cadmium Stress. Comp.Biochem.Physiol.C 108(1):59-64.	16755	Eff, Dur	
Den Besten, P.J., E.G. Van Donselaar, H.J. Herwig, D.I. Zandee, and P.A. Voogt. 1991. Effects of Cadmium on Gametogenesis in the Sea Star Asterias rubens L. Aquat.Toxicol. 20:83-94.	5251	Field, UEndp, Eff	
DeNicola, M., N. Cardellicchio, C. Gambardella, S.M. Guarino, and C. Marra. 1993. Effects of Cadmium on Survival, Bioaccumulation, Histopathology, and PGM Polymorphism in the Marine Isopod Idotea baltica. In: R.Dallinger and P.S.Rainbow (Eds.), Ecotoxicology of Metals in Invertebrates, Lewis Publ. :103-116.	13827	UEndp, Eff, Dur, UChron	
Denton, G.R.W., and C. Burdon-Jones. 1981. Influence of Temperature and Salinity on the Uptake, Distribution and Depuration of Mercury, Cadmium and Lead by the Black-Lip Oyster Saccostrea echinata. Mar.Biol. 64:317-326.	14335	UEndp, Eff	
Denton, G.R.W., and C. Burdon-Jones. 1986. Environmental Effects on Toxicity of Heavy Metals to Two Species of Tropical Marine Fish from Northern Australia. Chem.Ecol. 2(3):233-249.	4327	NonRes	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Devi, V.U., and Y.P. Rao. 1989. Cadmium Accumulation in Fiddler Crabs Uca annulipesLatrelle and Uca triangularis (Milne Edwards). Water Air Soil Pollut. 43(3-4):309-321.	891	UEndp, Eff, Dur, UChron, Con	
Devi, V.U., and Y.P. Rao. 1989. Heavy Metal Toxicity to Fiddler Crabs, Uca annulipes Latreille and Uca triangularis (Milne Edwards): Respiration on Exposure to Copper, Mercury,. Bull.Environ.Contam.Toxicol. 43(1):165-172.	2150	UEndp, Eff, Dur	
Devi, V.U.. 1987. Heavy Metal Toxicity to Fiddler Crabs, Uca annulipes latreille and Uca triangularis (Milne Edwards): Tolerance to Copper, Mercury, Cadmium. Bull.Environ.Contam.Toxicol. 39:1020-1027.	2602	NonRes	
Devineau, J., and C.A. Triquet. 1985. Patterns of Bioaccumulation of an Essential Trace Element (Zinc) and a Pollutant Metal (Cadmium) in Larvae of the Prawn Palaemon serratus. Mar.Biol. 86(2):139-143.	10835	UEndp, Eff, Dur, UChron	
Duquesne, S., A.E. Flowers, and J.C. Coll. 1995. Preliminary Evidence for a Metallothionein-Like Heavy Metal-Binding Protein in the Tropical Marine Bivalve Tridacna crocea. Comp.Biochem.Physiol.C 112(1):69-78.	18848	UEndp, Eff, Dur, UChron	
Eertman, R.H.M., W. Zurburg, C.A. Schipper, B. Sandee, and A.C. Smaal. 1996. Effects of PCB 126 and Cadmium on the Anaerobic Metabolism of the Mussel Mytilus edulis L.. Comp.Biochem.Physiol.C 113(2):267-272.	16854	UEndp, Eff, UChron, LT	
Eisler, R., G.E. Zaroogian, and R.J. Hennekey. 1972. Cadmium Uptake by Marine Organisms. J.Fish.Res.Board Can. 29(9):1367-1369.	9100	UEndp, Eff	
Eldon, J., M. Pekkarinen, and R. Kristoffersson. 1980. Effects of Low Concentrations of Heavy Metals on the Bivalve Macoma balthica. Ann.Zool.Fenn. 17:233-242.	17309	UEndp, Eff, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Elliott, N.G., R. Swain, and D.A. Ritz. 1986. Metal Interaction During Accumulation by the Mussel Mytilus edulis planulatus. Mar.Biol. 93(3):395-399.	12054	UEndp, Eff, Dur, UChron	
Emery, V.L.J., D.W. Moore, B.R. Gray, B.M. Duke, A.B. Gibson, R.B. Wright, and J.D. Farrar. 1997. Development of a Chronic Sublethal Sediment Bioassay Using the Estuarine Amphipod Leptocheirus plumulosus (Shoemaker). Environ.Toxicol.Chem. 16(9):1912-1920.	18159	No Code; See note	ECOTOX provides thirteen 96-h LC50s ranging from 20 to 100 µg/L for this study. The saltwater criteria falls within this range/2. Note, this test was not used in the 2001 cadmium WQC doc. No definitive values given.
Emson, S., and M. Crane. 1994. A Comparison of the Toxicity of Cadmium to the Mysid Shrimps Neomysis integer (Leach) and Mysidopsis bahia (Molenock). Water Res. 28(8):1711-1713.	4439	Con	
Engel, D.W.. 1983. The Intracellular Partitioning of Trace Metals in Marine Shellfish. Sci.Total Environ. 28:129-140.	10911	UEndp, Eff, UChron, Con	
Engel, D.W.. 1999. Accumulation and Cytosolic Partitioning of Metals in the American Oyster Crassostrea virginica. Mar.Environ.Res. 47:89-102.	20626	UEndp, Eff, UChron	
Espiritu, E.Q., C.R. Janssen, and G. Persoone. 1995. Cyst-Based Toxicity Tests. VII. Evaluation of the 1-h Enzymatic Inhibition Test (Fluotox) with Artemia nauplii. Environ.Toxicol.Water Qual. 10:25-34.	16031	Dur	Brine Shrimp
Establier, R., and M. Gutierrez. 1980. Cadmium Accumulation From Sea Water on Dicentrarchus labrax and Sparus aurata and its Histopathological Effects. Invest.Pesq.44(1):43-54 (Spa) (Eng Abs).	9794	UEndp, Eff, UChron, Con	
Everaarts, J.M.. 1990. Uptake and Release of Cadmium in Various Organs of the Common Mussel, Mytilus edulis (L.). Bull.Environ.Contam.Toxicol. 45(4):560-567.	3497	UEndp, Eff, UChron	
Fabris, G.J., J.E. Harris, and J.D. Smith. 1982. Uptake of Cadmium by the Seagrass Heterozostera tasmanica from Corio Bay and Western Port, Victoria. Aust.J.Mar.Freshwater Res. 33(5):829-836.	13458	UEndp, Eff, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Faraday, W.E., and A.C. Churchill. 1979. Uptake of Cadmium by the Eelgrass Zostera marina. Mar.Biol. 53(3):293-298.	15650	UEndp, Eff, Dur	
Fernandez, T.V., and N.V. Jones. 1990. Studies on the Toxicity of Zinc and Copper Applied Singly and Jointly to Nereis diversicolor at Different Salinities and Temperatures. Trop.Ecol. 31(1):47-55.	7744	UEndp, Eff, Dur, Con, LT	
Fernandez-Leborans, G., and A. Novillo. 1994. Experimental Approach to Cadmium Effects on a Marine Protozoan Community. Acta Hydrochim.Hydrobiol. 22(1):19-27 (OECDG Data File).	16339	UEndp, Eff, Dur, UChron	
Fernandez-Leborans, G., and Y.O. Herrero. 1999. Toxicity and Bioaccumulation of Cadmium in Marine Protozoa Communities. Ecotoxicol.Environ.Saf. 43(3):292-300.	20428	UEndp, Eff, Dur	
Fisher, N.S., and G.J. Jones. 1981. Heavy Metals and Marine Phytoplankton: Correlation of Toxicity and Sulfhydryl-Binding. J.Phycol. 17(1):108-111.	14681	NonRes, Dur	
Fisher, N.S., M. Bohe, and J.L. Teyssie. 1984. Accumulation and Toxicity of Cd, Zn, Ag, and Hg in Four Marine Phytoplankters. Mar.Ecol.Prog.Ser. 18(3):201-213.	11805	UEndp, Eff	
Forbes, V.E., and M.H. Depledge. 1992. Cadmium Effects on the Carbon and Energy Balance of Mudsnails. Mar.Biol. 113(2):263-269.	6411	UEndp, Eff, Dur, UChron	
Forbes, V.E.. 1991. Response of Hydrobia ventrosa (Montagu) to Environmental Stress: Effects of Salinity Fluctuations and Cadmium Exposure on Growth. Funct.Ecol. 5(5):642-648.	7304	UEndp, UChron	
Forget, J., J.F. Pavillon, M.R. Menasria, and G. Bocquene. 1998. Mortality and LC50 Values for Several Stages of the Marine Copepod Tigriopus brevicornis (Muller) Exposed to the Metals Arsenic and Cadmium and the. Ecotoxicol.Environ.Saf. 40(3):239-244.	19281	NonRes	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Fowler, B.A., N.G. Carmichael, K.S. Squibb, and D.W. Engel. 1981. Factors Affecting Trace Metal Uptake and Toxicity to Estuarine Organisms. II. Cellular Mechanisms. In: J.Vernberg, A.Calabrese, F.P.Thurberg and W.B.Vernberg (Eds.), Biological Monitoring of Marine Pollutants, Academic Press, New York, NY :145-163.	20311	UEndp, Eff, Dur, UChron	
Francesconi, K.A., E.J. Moore, and J.S. Edmonds. 1994. Cadmium Uptake from Seawater and Food by the Western Rock Lobster Panulirus cygnus. Bull.Environ.Contam.Toxicol. 53(2):219-223.	13704	UEndp, Eff, Dur, UChron	
Francesconi, K.A., J. Gailer, J.S. Edmonds, W. Goessler, and K.J. Irgolic. 1999. Uptake of Arsenic-Betaines by the Mussel Mytilus edulis. Comp.Biochem.Physiol.C 122(1):131-137.	19960	UEndp, Eff, Dur, UChron	
Francesconi, K.A.. 1989. Distribution of Cadmium in the Pearl Oyster, Pinctada albina albina (Lamarck), Following Exposure to Cadmium in Seawater. Bull.Environ.Contam.Toxicol. 43(2):321-328.	3322	UEndp, Eff, Dur, UChron	
Frazier, J.M., and S.G. George. 1983. Cadmium Kinetics in Oysters - A Comparative Study of Crassostrea gigas and Ostrea edulis. Mar.Biol. 76(1):55-61.	10716	UEndp, Eff, UChron	
Gajbhiye, S.N., and R. Hirota. 1990. Toxicity of Heavy Metals to Brine Shrimp Artemia. J.Indian Fish.Assoc. 20:43-50.	17792	UEndp, Dur	Brine Shrimp
Gardner, G.R.. 1975. Chemically Induced Lesions in Estuarine or Marine Teleosts. In: W.E.Ribelin and G.Migaki (Eds.), Pathology of Fishes, Univ.of WI Press, Madison, WI :657-693.	15562	UEndp, Eff, UChron	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Gaudy, R., J.P. Guerin, and P. Kerambrun. 1991. Sublethal Effects of Cadmium on Respiratory Metabolism, Nutrition, Excretion and Hydrolase Activity in Leptomysis lingvura (Crustacea: Mysidacea). Mar.Biol. 109(3):493-501.	3802	UEndp, Eff, Dur, Com	
George, S.G., and T.L. Coombs. 1977. The Effects of Chelating Agents on the Uptake and Accumulation of Cadmium by Mytilus edulis. Mar.Biol. 39(3):261-268.	15622	Eff, Con	
George, S.G., P.A. Hodgson, P. Tytler, and K. Todd. 1996. Inducibility of Metallothionein mRNA Expression and Cadmium Tolerance in Larvae of a Marine Teleost, the Turbot (Scophthalmus maximus). Fundam.Appl.Toxicol. 33(1):91-99.	8931	NonRes	
Gil, J.M., J.A. Marigomez, and E. Angulo. 1989. Histopathology of Polysaccharide and Lipid Reserves in Various Tissues of Littorina littorea Exposed to Sublethal Concentrations of Cadmium. Comp.Biochem.Physiol.C 94(2):641-648.	709	UEndp, Eff, UChron	
Giraud, A.S., L.K. Webster, J.G. Fabris, L.C. Collett, and N.D. Yeomans. 1986. Absence of Histopathological Response to Cadmium in Gill and Digestive Diverticula of the Mussel, Mytilus edulis. Bull.Environ.Contam.Toxicol. 36(1):146-149.	11808	UEndp, Eff, UChron	
Gnassia-Barelli, M., M. Romeo, and S. Puiseux-Dao. 1995. Effects of Cadmium and Copper Contamination on Calcium Content of the Bivalve Ruditapes decussatus. Mar.Environ.Res. 39(1-4):325-328.	16894	UEndp, Eff, Dur, UChron	
Gnezdilova, S.M., I.G. Lipina, and N.K. Khristoforova. 1987. Accumulation of Cadmium in the Gonads of Sea Urchins and Its Effect on Gametogenesis and Embryogenesis. Exp.Water Toxicol.(Eksp.Vodn.Toksikol.) 12:68-72 (RUS) / C.A.Select - Environ.Pollut. 110:2329c.	300	UEndp, Dur, UChron	Species(non-NA)????

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Gnezdilova, S.M., I.G. Lipina, and N.K. Khristoforova. 1987. Morphological Changes in the Ovaries of the Sea Urchin Strongylocentrotus intermedius Exposed to Cadmium. Dis.Aquat.Org. 2(2):127-133.	2438	UEndp, Eff, UChron	
Gnezdilova, S.M., I.G. Lipina, V.B. Durkina, I.V. Burovina, and K.Y. Ukhanov. 1988. The Content of Cadmium in the Gonad of the Sea Urchin Strongylocentrotus intermedius and its Effects on Gametes and Offspring. C.A.Sel.-Environ.Pollut.18:109-68396H / Biol.Morya (Vladivost.) 2:46-51 (RUS).	13144	UEndp, Eff, UChron, Con	
Greenwood, J.G., and D.R. Fielder. 1983. Acute Toxicity of Zinc and Cadmium to Zoeae of Three Species of Portunid Crabs (Crustacea: Brachyura). Comp.Biochem.Physiol.C 75(1):141-144.	10063	NonRes, Dur	
Gutierrez-Galindo, E.A.. 1980. Study of the Removal of Cadmium by Mytilus edulis in the Presence of EDTA and Phosphate. Chemosphere 9(7/8):495-500 (FRE) (ENG ABS).	9820	UEndp, Eff, UChron, Con	
Haglund, K., M. Bjorklund, S. Gunnare, A. Sandberg, U. Olander, and M. Pedersen. 1996. New Method for Toxicity Assessment in Marine and Brackish Environments Using the Macroalga Gracilaria tenuistipitata (Gracilariales, Rhodophyta). Hydrobiologia 326/327:317-325.	18453	NonRes	
Hall, L.W.Jr., M.C. Ziegenfuss, R.D. Anderson, and B.L. Lewis. 1994. The Effect of Salinity on the Acute Toxicity of Total Dissolved and Free Cadmium to the Copepod Eurytemora affinis and the Larval Fish Cyprinodon. Chesapeake Bay Program, CBP/TRS 130/94, U.S.EPA, Annapolis, MD :46 p.(U.S.NTIS PB95-179925).	17219		Has Six 96hr LC50's for Sheephead and Copepod

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Hall, L.W.Jr., M.C. Ziegenfuss, R.D. Anderson, and B.L. Lewis. 1995. The Effect of Salinity on the Acute Toxicity of Total and Free Cadmium to a Chesapeake Bay Copepod and Fish. Mar.Pollut.Bull. 30(6):376-384.	18671		Has Six 96hr LC50's for Sheephead and Copepod
Hannan, P.J., and C. Patouillet. 1972. Effects of Pollutants on Growth of Algae. Rep.NRL (Nav.Res.Lab.) Prog.:1-8 (Author Communication Used).	9095	UEndp, Dur	
Hansen, D.J. 1983. Section on Acute Toxicity Tests to be Inserted in the April 1983 Report on Site Specific FAV's. U.S.EPA, Narragansett, RI :7.	3732	No Code; See note	ECOTOX provides a 96-h LC50s of 310 µg/L for this study. This value could have been considered for EPA's evaluation of saltwater cadmium, but the species is relatively insensitive to cadmium compared to others. Note, this test was not used in the 2001 cadmium WQC doc.
Hansen, I.V., J.M. Weeks, and M.H. Depledge. 1995. Accumulation of Copper, Zinc, Cadmium and Chromium by the Marine Sponge Halichondria panicea Pallas and the Implications for Biomonitoring. Mar.Pollut.Bull. 31(1-3):133-138.	18038	UEndp, Eff, Dur, UChron	
Haritonidis, S., H.J. Jager, and H.O. Schwantes. 1983. Accumulation of Cadmium, Zinc, Copper and Lead by Marine Macrophyceae Under Culture Conditions. Angew.Bot. 57(5/6):311-330.	11369	UEndp, Eff, Dur, UChron	
Haritonidis, S.. 1985. Uptake of Cd, Zn, Cu and Pb by Marine Macrophyceae Under Culture Conditions. Mar.Environ.Res. 17(2-4):198-199.	6414	UEndo, Eff, Con	
Hawkins, W.E., L.G. Tate, and T.G. Sarphie. 1980. Acute Effects of Cadmium on the Spot Leiostomus xanthurus (Teleostei): Tissue Distribution and Renal Ultrastructure. J.Toxicol.Environ.Health 6:283-295 (Author Communication Used).	5263	UEndp, Eff, Dur	
Henry, M., W. Huang, C. Cornet, M. Belluau, and J.P. Durbec. 1984. Accidental Contamination by Cadmium of the Mollusc Ruditapes decussatus: Bioaccumulation and Toxicity (LD50, 96H). Oceanol.Acta 7(3):329-325 (1984) (Fre) (Eng Abs).	11394	NonRes	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Hernandez-Pascual, M.D., and L. Tort. 1989. Metabolic Effects After Short-Term Sublethal Cadmium Exposure to Dogfish (Scyliorhinus canicula). Comp.Biochem.Physiol.C 94(1):261-264.	3062	UEndp, Eff	
Hollibaugh, J.T., D.L.R. Seibert, and W.H. Thomas. 1980. A Comparison of the Acute Toxicities of Ten Heavy Metals to Phytoplankton From Saanich Inlet, B.C., Canada. Estuar.Coast.Mar.Sci. 10(1):93-105.	5282	UEndp, Dur, Con	
Hoppenheit, M.. 1977. On the Dynamics of Exploited Populations of Tisbe holothuriae (Copepoda, Harpacticoida). V. The Toxicity of Cadmium: Response to Sub-Lethal. Helgol.Wiss.Meeresunters. 29(4):503-523.	8368	UEndp, UChron, Con	
Hori, H., M. Tateishi, K. Takayanagi, and H. Yamada. 1996. Applicability of Artificial Seawater as a Rearing Seawater for Toxicity Tests of Hazardous Chemicals by Marine Fish Species. Nippon Suisan Gakkaishi /Bull.Jpn.Soc.Sci.Fish.(4):614-622 (JPN) (ENG ABS).	16999	Eff, Dur, Uchron	
Howard, C.L., and C.S. Hacker. 1990. Effects of Salinity, Temperature, and Cadmium on Cadmium-Binding Protein in the Grass Shrimp, Palaemonetes pugio. Arch.Environ.Contam.Toxicol. 19(3):341-347.	3170		ECOTOX provides two 96-h LC50s of 189 µg/L and 2405 µg/L for this study. Combined with the other LC50s for *Palaemonetes pugio*, the SMAV would have been 1283 µg/L. Although this is lower than the species' current SMAV, it is not sensitive relative to other species. Note, this test was not used in the 2001 cadmium WQC doc
Hu, S., C.H. Tang, and M. Wu. 1996. Cadmium Accumulation by Several Seaweeds. Sci.Total Environ. 187:65-71.	18733	UEndp, Eff, Dur	
Hung, Y.W. 1982. Effects of Temperature and Chelating Agents on Cadmium Uptake in the American Oyster. Bull.Environ.Contam.Toxicol. 28:546-551.	14338	UEndp, Eff	
Hutcheson, M., D.C. Miller, and A.Q. White. 1985. Respiratory and Behavioral Responses of the Grass Shrimp Palaemonetes pugio toCadmium and Reduced Dissolved Oxygen. Mar.Biol. 88(1):59-66.	11892	UEndp, Eff, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Hutcheson, M.S.. 1974. The Effect of Temperature and Salinity on Cadmium Uptake by the Blue Crab, Callinectes sapidus. Chesapeake Sci. 15(4):237-241.	8580	UEndp, Eff, Con	
Hutchinson, T.H., and M.J. Manning. 1996. Effect of In Vivo Cadmium Exposure on the Respiratory Burst of Marine Fish (Limanda limanda L.) Phagocytes. Mar.Environ.Res. 41(4):327-342.	20572	UEndp, Eff, NonRes	
Hylland, K., T. Kaland, and T. Andersen. 1994. Subcellular Cd Accumulation and Cd-Binding Proteins in the Netted Dog Whelk, Nassarius reticulatus L. Mar.Environ.Res. 38(3):169-193.	16733	UEndp, Eff, Dur	
Ikuta, K.. 1987. Cadmium Accumulation by a Top Shell Batillus cornutus. Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 53(7):1237-1242.	2628	UEndp, Eff, UChron	
Ikuta, K.. 1987. Concentration Thresholds in Accumulation of Heavy Metals by Haliotis discus and Batillus cornutus. Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 53(9):1673-1678.	2630	UEndp, Eff, UChron	
Ikuta, K.. 1987. Localization of Cadmium in the Viscera and the Muscular Tissues of Carnivorous Gastropods Before and After Exposure. Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 53(12):2275-2278.	5844	UEndp, Eff, Dur	
Ikuta, K.. 1987. Localization of Heavy Metals in the Viscera and the Muscular Tissues of Haliotis discus Exposed to Selected Metal Concentration Gradients. Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 53(12):2269-2274.	3215	UEndp, Eff, UChron	
Itow, T., R.E. Loveland, and M.L. Botton. 1998. Developmental Abnormalities in Horseshoe Crab Embryos Caused by Exposure to Heavy Metals. Arch.Environ.Contam.Toxicol. 35(1):33-40.	19470	UEndp, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Itow, T., T. Igarashi, M.L. Botton, and R.E. Loveland. 1998. Heavy Metals Inhibit Limb Regeneration in Horseshoe Crab Larvae. Arch.Environ.Contam.Toxicol. 35(3):457-463.	20180	UEndp, UChron	
Jackim, E., G. Morrison, and R. Steele. 1977. Effects of Environmental Factors on Radiocadmium Uptake by Four Species of Marine Bivalves. Mar.Biol. 40:303-308.	10416	UEndp, Eff, Dur, UChron	
Jackim, E., J.M. Hamlin, and S. Sonis. 1970. Effects of Metal Poisoning on Five Liver Enzymes in the Killifish (Fundulus heteroclitus) (Auth. communication used). J.Fish.Res.Board Can. 27(2):383-390.	9700	AF	ECOTOX provides one 96-h LC50 of 27,000 µg/L for this study. Combined with the other LC50s for *Fundulus heteroclitus*, the SMAV would have been 22.034 µg/L. This SMAV is higher than the original and is not sensitive relative to other species. Note, this test was not used in the 2001 cadmium WQC doc
Janssen, H.H., and N. Scholz. 1979. Uptake and Cellular Distribution of Cadmium in Mytilus edulis. Mar.Biol. 55(2):133-142.	9836	UEndp, Eff, Con	
Jenkins, K.D., and A.Z. Mason. 1988. Relationships Between Subcellular Distributions of Cadmium and Perturbations in Reproduction in the Polychaete Neanthes arenaceodentata. Aquat.Toxicol. 12(3):229-244.	5037	UEndp, UChron, Con	
Jenkins, K.D., and B.M. Sanders. 1985. Relationships Between Free Cadmium Ion Activity in Sea Water and Cadmium Metabolism, Growth and Reproduction in Polychaetes. Aquat.Sci.Fish.Abstr.16(10):16007-1Q16 (1986) / Mar.Environ.Res. 17(2-4):200.	6478	UEndp, UChron, Con	
Jenkins, K.D., and B.M. Sanders. 1986. Relationships between Free Cadmium Ion Activity in Seawater, Cadmium Accumulation and Subcellular Distribution, and Growth in Polychaetes. Environ.Health Perspect. 65:205-210.	12940	UEndp, UChron	
Jennings, J.R., and P.S. Rainbow. 1979. Studies on the Uptake of Cadmium by the Crab Carcinus maenas in the Laboratory. I. Accumulation From Seawater and a Food Source. Mar.Biol. 50(2):131-139.	15534	UEndp, Eff, Dur, UChron	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Jonczyk, E., K.G. Doe, P.C. Wells, and S.G. Yee. 1991. Technical Evaluation of the Sea Urchin Fertilization Test: Proceedings of a Workshop in Dartmouth, Nova Scotia. In: P.Chapman, F.Bishay, E.Power, K.Hall, L.Harding, D.McLeay, M.Nassichuk and W.Knapp (Eds.), Proc.17th Annual Aquatic Toxicity Workshop, Nov.5-7, 1990, Vol.1, Vancouver, B.C., Can.Tech.Rep.Fish Aquat.Sci.No.1774 :323-330.	8788	Dur	
Juchelka, C.M., and T.W. Snell. 1995. Rapid Toxicity Assessment Using Ingestion Rate of Cladocerans and Ciliates. Arch.Environ.Contam.Toxicol. 28(4):508-512.	14918	Eff, Dur	
Kaland, T., T. Andersen, and K. Hylland. 1993. Accumulation and Subcellular Distribution of Metals in the Marine Gastropod Nassarius reticulatus L. In: R.Dallinger and P.S.Rainbow (Eds.), Ecotoxicology of Metals in Invertebrates, Lewis Publ. :37-53.	13829	UEndp, Eff, Dur	
Karbe, L.. 1972. Marine Hydroids as Test Organisms for Assessing the Toxicity of Water Pollutants. The Effect of Heavy Metals on Colonies of Eirene viridula. Mar.Biol. 12(4):316-328 (GER) (ENG ABS).	15654	UEndp, Eff, UChron, Con	
Karez, C.S., M. Romeo, and M. Gnassia-Barelli. 1988. Uptake of Zn and Cd by Coastal Phytoplankton Species in Culture. In: U.Seeliger, L.D.De Lacerda, and S.R.Patchineelam (Eds.) Metals in Coastal Environments of Latin America, Springer-Verlag New York, Inc., Secaucus, NJ :130-139.	13214	UEndp, Eff, Dur	
Karez, C.S., S. Bonotto, and S. Puiseux-Dao. 1989. Response of the Unicellular Giant Alga Acetabularia acetabulum to Cadmium Toxicity and Accumulation. Toxicol.Environ.Chem. 19(3-4):223-232.	2101	UEndp, UChron, Con	
Karlson, K.. 1994. An Investigation on the Sensitivity to Heavy Metals of the Tiger Shrimp Penaeus monodon, a Commercially Important Tropical Shrimp. Fish.Dev.Ser., Natl.Swed.Board Fish.No. 82:29.	16769	UEndp, Eff, Dur, UChron	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Karlsson-Norrgren, L., P. Runn, C. Haux, and L. Forlin. 1985. Cadmium-Induced Changes in Gill Morphology of Zebrafish, Brachydanio rerio (Hamilton-Buchanan), and Rainbow Trout, Salmo gairdneri Richardson. J.Fish Biol. 27(1):81-95.	11497	UEndp, Eff, UChron	
Kayser, H., and K.R. Sperling. 1980. Cadmium Effects and Accumulation in Cultures of Prorocentrum micans (Dinophyta). Helgol.Wiss.Meeresunters. 33(1/4):89-102.	9841	UEndp, Eff, UChron, Con	
Kerfoot, W.B., and S.A. Jacobs. 1976. Cadmium Accrual in Combined Wastewater Treatment-Aquaculture System. Environ.Sci.Technol. 10(7):662-667.	5265	UEndp, Eff, Dur	
Khan, A., J. Barbieri, S. Khan, and F. Sweeney. 1992. A New Short-Term Mysid Toxicity Test Using Sexual Maturity as an Endpoint. Aquat.Toxicol. 23(2):97-105.	6179	UEndp, Dur	
Kissa, E., M. Moraitou-Apostolopoulou, and V. Kiortsis. 1984. Effects of Four Heavy Metals on Survival and Hatching Rate of Artemia salina (L.). Arch.Hydrobiol. 102(2):255-264.	11259	Dur	Brine Shrimp
Klockner, K.. 1979. Uptake and Accumulation of Cadmium by Ophryotrocha diadema (Polychaeta). Mar.Ecol.Prog.Ser. 1:71-76.	14282	UEndp, Eff, UChron	
Kluytmans, J.H., D.I. Zandee, and E.L. Enserink. 1988. Effects of Cadmium on the Reproduction of Mytilus edulis L. Aquat.Toxicol. 11(3/4):427-428 (ABS).	13012	Eff, UChron, Con	
Kobayashi, N.. 1971. Fertilized Sea Urchin Eggs As an Indicatory Material for Marine Pollution Bioassay, Preliminary Experiments. Mar.Biol.Lab 18(6):379-406.	2963	UEndp, Dur	
Kobayashi, N.. 1990. Marine Pollution Bioassay by Sea Urchin Eggs, an Attempt to Enhance Sensitivity. Publ.Seto Mar.Biol.Lab. 34(4-6):225-237.	9717	UEndp, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Kohler, K., and H.U. Riisgard. 1982. Formation of Metallothioneins in Relation to Accumulation of Cadmium in the Common Mussel Mytilus edulis. Mar.Biol. 66(1):53-58.	10563	UEndp, Eff	
Kohn, N.P., J.Q. Word, D.K. Niyogi, L.T. Ross, T. Dillon, and D.W. Moore. 1994. Acute Toxicity of Ammonia to Four Species of Marine Amphipod. Mar.Environ.Res. 38(1):1-15.	17293	UEndp, Nom, See note	ECOTOX provides one 96-h LC50 of 3121 µg/L for *Grandidierella japonica* and two 96-hr LC50s of 526.8 µg/L and 1908 µg/L for *Rhepoxynius abronius*. Combined with the other LC50s for the species, the SMAV would have been 1905 µg/L for *Grandidierella japonica* and 1003 µg/L for *Rhepoxynius abronius*. This SMAVs are is not sensitive relative to other species. Note, this test was not used in the 2001 cadmium WQC doc
Kozuch, J., and J. Pempkowiak. 1996. Molecular Weight of Humic Acids as a Major Property of the Substances Influencing the Accumulation Rate of Cadmium by a Blue Mussel (Mytilus edulis). Environ.Int. 22(5):585-589.	19499	UEndp, Eff, Dur, UChron	
Krishnaja, A.P., M.S. Rege, and A.G. Joshi. 1987. Toxic Effects of Certain Heavy Metals (Hg, Cd, Pb, As and Se) on the Intertidal Crab Scylla serrata. Mar.Environ.Res. 21(2):109-119.	12413	UEndp, Eff, Dur, Con	
Kumarasamy, P., and A. Karthikeyan. 1999. Effect of Cadmium on Oxygen Consumption and Filtration Rate at Different Salinities in an Estuarine Clam Meretrix casta (Chemnitz). J.Environ.Biol. 20(2):99-102.	20324	UEndp, Eff	
Kuroshima, R., and S. Kimura. 1990. Changes in Toxicity of Cd and Its Accumulation in Girella and Goby with Their Growth. Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 56(3):431-435.	221	NonRes	
Kuroshima, R., S. Kimura, K. Date, and Y. Yamamoto. 1993. Kinetic Analysis of Cadmium Toxicity to Red Sea Bream, Pagrus major. Ecotoxicol.Environ.Saf. 25:300-314.	6751	NonRes	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Kuroshima, R.. 1987. Cadmium Accumulation and its Effect on Calcium Metabolism in the Girella girella punctata during a Long Term Exposure. Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 53(3):445-450.	5774	UEndp, Eff	
Kuroshima, R.. 1992. Cadmium Accumulation in the Mummichog, Fundulus heteroclitus, Adapted to Various Salinities. Bull.Environ.Contam.Toxicol. 49(5):680-685.	5787	UEndp, Eff, Dur	
Kuroshima, R.. 1992. Comparison of Cadmium Accumulation in Tissues Between Carp Cyprinus carpio and Red Sea Bream Pagrus major. Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 58(7):1237-1242.	7830	UEndp, Eff	
Langston, W.J., and M. Zhou. 1986. Evaluation of the Significance of Metal-Binding Proteins in the Gastropod Littorina littorea. Mar.Biol. 92(4):505-515.	12946	UEndp, Dur, Con	
Langston, W.J., and M. Zhou. 1987. Cadmium Accumulation, Distribution and Elimination in the Bivalve Macoma balthica: Neither Metallothionein nor Metallothionein-Like. Mar.Environ.Res. 21(3):225-237.	8587	Eff, UChron	
Larrain, A., A. Riveros, J. Silva, and E. Bay-Schmith. 1999. Toxicity of Metals and Pesticides Using the Sperm Cell Bioassay with the Sea Urchin Arbacia spatuligera. Bull.Environ.Contam.Toxicol. 62(6):749-757.	20469	Dur	
Larsson, A., B.E. Bengtsson, and C. Haux. 1981. Disturbed Ion Balance in Flounder, Platichthys flesus L. Exposed to Sublethal Levels of Cadmium. Aquat.Toxicol. 1(1):19-35.	3639	UEndp, Eff	
Le Dean, L., and J. Devineau. 1985. In Search of Standardisation: A Comparison of Toxicity Bioassays on Two Marine Crustaceans (Paleomon serratus and Tigriopus brevicornis). Rev.Trav.Inst.Peches Marit.Nantes 49(3/4):187-198.	3291	UEndp, Dur, UChron	Has one 45d LC50 for common pink shrimp

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Leborans, G.F., and A. Novillo. 1996. Toxicity and Bioaccumulation of Cadmium in Olisthodiscus luteus (Raphidophyceae). Water Res. 30(1):57-62.	19913	UEndp, Eff	
Lee, H.H., and C.H. Xu. 1984. Differential Response of Marine Organisms to Certain Metal and Agrichemical Pollutants. Bull.Environ.Contam.Toxicol. 33(4):460-467.	10612	UEndo, Dur	
Lee, H.H., and C.H. Xu. 1984. Effects of Metals on Sea Urchin Development: A Rapid Bioassay. Mar.Pollut.Bull. 15(1):18-21.	10086	UEndp, Dur	
Lee, J.G., B.A. Ahner, and F.M.M. Morel. 1996. Export of Cadmium and Phytochelatin by the Marine Diatom Thalassiosira weissflogii. Environ.Sci.Technol. 30(6):1814-1821.	5881	UEndp, Eff, Dur	
LeMaire-Gony, S., and P. LeMaire. 1992. Interactive Effects of Cadmium and Benzo(a)Pyrene on Cellular Structure and Biotransformation Enzymes of the Liver of the European Eel Anguilla anguilla. Aquat.Toxicol. 22(2):145-160.	6148	UEndp, Eff, UChron	
LeMaire-Gony, S., P. LeMaire, and A.L. Pulsford. 1995. Effects of Cadmium and Benzo(a)pyrene on the Immune System, Gill ATPase and EROD Activity of European Sea Bass Dicentrarchus labrax. Aquat.Toxicol. 31(4):297-313.	14878	UEndp, Eff, Dur, UChron	
Lemay, J.A., and D.J. Reish. 1987. The Transfer of Cadmium from the Polychaete, Neanthes arenaceodentata, to the Arrow Goby, Clevelandia ios. In: Malagrino,G.and H.Santoyo (Eds.), Proc.of the 5th Symp.of Marine Biology, 24-26 October 1984, La Paz, B.C.S., Mexico, Autonoma de Baja California Sur, La Paz, B.C.S. :31-37.	4082	Eff, Dur, Uchron	
Lin, W., M.A. Rice, and P.K. Chien. 1992. The Effects of Copper, Cadmium and Zinc on Particle Filtration and Uptake of Glycine in the Pacific Oyster Crassostrea gigas. Comp.Biochem.Physiol.C 103(1):181-187.	6506	UEndp, Eff, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Lipina, I.G., S.M. Gnezdilova, and N.K. Khristoforova. 1987. Cadmium Distribution in Gonads of the Sea Urchin Strongylocentrotus intermedius. Mar.Ecol.Prog.Ser. 36(3):263-266.	8593	UEndp, Eff, Dur, UChron, Con	
Liu, P.C., and J.C. Chen. 1987. Effects of Heavy Metals on the Hatching Rates of Brine Shrimp Artemia salina Cysts. J.World Aquacult.Soc. 18(2):78-83.	4256	UEndp, Dur	Brine Shrimp
Lorenzon, S., M. Francese, and E.A. Ferrero. 2000. Heavy Metal Toxicity and Differential Effects on the Hyperglycemic Stress Response in the Shrimp Palaemon elegans. Arch.Environ.Contam.Toxicol. 39(2):167-176.	51641	NonRes	
Lucu, C., and V. Obersnel. 1986. The Effect of Cadmium on the Spermatozoa and Fertilized Eggs of Sea Urchins. In: Proc.Workshop on Selected Aspects of Exposure to Heavy Metals in the Environment: Monitors, Indicators, and High Risk Groups, Washington, D.C., April 29-30, 1985:69-75 (1987) /In: Papers Presented at FAO/UNEP Meeting Toxicity (ABS).	13385	UEndp, Dur, UChron, Con	
Lucu, C., V. Obersnel, and O. Jelisavcic. 1991. Transport and Toxicity of Metal Pollutants to Marine Organisms. In: Final Report on Research Projects Dealing with Bioaccumulation and Toxicity of Chemical Pollutants, FAO/UNEP, Athens, Greece, MAP Tech.Rep.Ser.No.52 :55-62.	14770	UEndp, Dur, UChron	
Lussier, S.M., and J.A. Cardin. 1985. Results of Acute Toxicity Tests Conducted with Cadmium at ERL, Narragansett. U.S.EPA, Narragansett, RI :5.	14601	UEndp, Dur, See note	ECOTOX provides one 96-h LC50 of 198.8 µg/L for *Acartia clausi* and two 96-hr LC50s of 1641 µg/L and 1071 µg/L for *Eurytemora affinis*. Combined with the other LC50s for the species, the SMAV would have been 168.7 µg/L for *Acartia clausi* and 636.5 µg/L for *Eurytemora affinis*. These SMAVs are not sensitive relative to other species. Note, this test was not used in the 2001 cadmium WQC doc

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Lussier, S.M., W.S. Boothman, S. Poucher, D. Champlin, and A. Helmstetten. 1999. Comparison of Dissolved and Total Metals Concentrations from Acute Tests with Saltwater Organisms. Environ.Toxicol.Chem. 18(5):889-898.	51695	UEndp	
MacDonald, J.M., J.D. Shields, and R.K. Zimmer-Faust. 1988. Acute Toxicities of Eleven Metals to Early Life-History Stages of the Yellow Crab Cancer anthonyi. Mar.Biol. 98(2):201-207.	12861	UEndp	
MacInnes, J.R., and F.P. Thurberg. 1973. Effects of Metals on the Behavior and Oxygen Consumption of the Mud Snail. Mar.Pollut.Bull. 4(12):185-186.	8902	UEndp, Eff	
MacInnes, J.R., F.P. Thurberg, R.A. Greig, and E. Gould. 1977. Long-Term Cadmium Stress in the Cunner, Tautogolabrus adspersus. Fish.Bull. 75(1):199-203.	15496	UEndp, Eff, UChron	
Madhupratap, M., C.T. Achuthankutty, and S.R.S. Nair. 1981. Toxicity of Some Heavy Metals to Copepods Acartia spinicauda and Tortanus forcipatus. Indian J.Mar.Sci. 10:382-383.	15722	Eff, Dur	
Marcaillou-Le Baut, C.. 1988. Development of a Test with Microcrustacea Marine. Oecd-Ircha (Fre).	3520	Dur, UChron	
Marigomez, I., J.M. Gil, and E. Angulo. 1990. Accumulation of Pigment and Lipofuscin Granules in Littorina littorea Exposed to Sublethal Concentrations of Cadmium: A Histochemical Study. Zool.Jb.Anat. 120:127-141.	13306	UEndp, Eff, UChron	
Marigomez, I., M.P. Ireland, and E. Angulo. 1990. Correlation of Cadmium Shell-Weight Index with Environmental Stress Indicators at the Cellular and Organismic Levels in Littorina littorea. Mar.Ecol.Prog.Ser. 67(2):171-176.	3638	UEndp, UChron, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Marigomez, J.A., and M.P. Ireland. 1989. Accumulation, Distribution and Loss of Cadmium in the Marine Prosobranch Littorina littorea (L.). Sci.Total Environ.78(JA N):1-12.	2348	Eff, UChron, Con	
Marigomez, J.A., M.A. Cajaraville, E. Angulo, and J. Moya. 1990. Ultrastructural Alterations in the Renal Epithelium of Cadmium-Treated Littorina littorea (L.). Arch.Environ.Contam.Toxicol. 19(6):863-871.	3504	UEndp, Eff, UChron	
Marigomez, J.A., M.P. Cajaraville, and E. Angulo. 1990. Cellular Cadmium Distribution in the Common Winkle, Littorina littorea (L.) Determined by X-Ray Microprobe Analysis and Histochemistry. Histochemistry 94:191-199.	13304	UEndp, Eff, UChron	
Markham, J.W., B.P. Kremer, and K.R. Sperling. 1980. Cadmium Effects on Growth and Physiology of Ulva lactuca. Helgol.Wiss.Meeresunters. 33(1/4):103-110.	9854	UEndp, Eff	
Martin, D.J., and P.S. Rainbow. 1998. The Kinetics of Zinc and Cadmium in the Haemolymph of the Shore Crab Carcinus maenas (L.). Aquat.Toxicol. 40(2/3):203-231.	18954	UEndp, Eff, Dur, UChron	
Mason, A.Z., and K.D. Jenkins. 1990. Effects of Feeding on Zinc and Cadmium Accumulation by the Polychaete Neanthes arenaceodentata. Chem.Spec.Bioavail. 2:33-47.	11304	UEndp, Eff, Con	
Mazon, L.I., G. Gonzalez, A. Vicario, A. Estomba, and A. Aguirre. 1998. Inhibition of Esterases in the Marine Gastropod Littorina littorea Exposed to Cadmium. Ecotoxicol.Environ.Saf. 41(3):284-287.	20054	UEndp, Dur, UChron	
McClurg, T.P.. 1984. Effects of Fluoride, Cadmium and Mercury on the Estuarine Prawn Penaeus indicus. Water S.A. 10(1):40-45.	11646	UEndp, Con	
McLeese, D.W., and S. Ray. 1984. Uptake and Excretion of Cadmium, CdEDTA, and Zinc by Macoma balthica. Bull.Environ.Contam.Toxicol. 32(1):85-92.	10090	UEndp, Eff, Dur, UChron	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
McLeese, D.W., and S. Ray. 1986. Toxicity of CdCl2, CdEDTA, CuCl2, and CuEDTA to Marine Invertebrates. Bull.Environ.Contam.Toxicol. 36(5):749-755.	12305	Con	
Michibata, H.. 1981. Effect of Water Hardness on the Toxicity of Cadmium to the Egg of the Teleost Oryzias latipes. Bull.Environ.Contam.Toxicol. 27(2):187-192.	15399	NonRes	
Middaugh, D.P., and J.M. Dean. 1977. Comparative Sensitivity of Eggs, Larvae and Adults of the Estuarine Teleost, Fundulus heteroclitus and Menidia menidia to Cadmium. Bull.Environ.Contam.Toxicol. 17(6):645-652.	8334	Dur, Con	
Middaugh, D.P., W.R. Davis, and R.L. Yoakum. 1975. The Response of Larval Fish, Leiostomus xanthurus, to Environmental Stress Following Sublethal Cadmium Exposure. Mar.Sci. 19:13-19.	15632	UEndp, Eff, Dur	
Mirkes, D.Z., W.B. Vernberg, and P.J. Decoursey. 1978. Effects of Cadmium and Mercury on the Behavioral Responses and Development of Eurypanopeus depressus Larvae. Mar.Biol. 47(2):143-147.	15657	UEndp, Eff, Dur, UChron	
Mizrahi, L., and Y. Achituv. 1994. Effects of Cd, Hg and Zn on the Metabolism of the Gastropod Nassarius gibbolosa. In: Final Reports on Research Projects Dealing with Toxicity of Pollutants on Marine Organisms, UNEP, Athens, Greece, MAP Tech.Rep.Ser.No.79 :79-89.	17414	UEndp, Eff	
Mizrahi, L., L. Newberger-Cywiak, and Y. Achituv. 1993. Effect of Heavy Metals Ions on Enzyme Activity, Mortality and Behaviour of the Mediterranean White Mussel Donax trunculus. In: Final Reports on Research Projects (Activity G), UNEP, Athens, Greece, MAP Tech.Rep.Ser.No.48 :73-88.	4276	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Moller, V., V.E. Forbes, and M.H. Depledge. 1996. Population Responses to Acute and Chronic Cadmium Exposure in Sexual and Asexual Estuarine Gastropods. Ecotoxicology 5:313-326.	18831	UEndp, UChron	
Moraitou-Apostolopoulou, M., and G. Verriopoulos. 1982. Individual and Combined Toxicity of Three Heavy Metals, Cu, Cd, and Cr, for the Marine Copepod Tisbe holothuriae. Hydrobiologia 87(1):83-87.	15726	Dur, Con	
Moraitou-Apostolopoulou, M., G. Verriopoulos, and P. Palla. 1979. Temperature and Adaptation to Pollution As Factors Influencing the Acute Toxicity of Cd to the Planktonic Copepod Acartia clausi. Tethys 9(2):97-101.	8404	Eff, Dur, Con	
Motohashi, K., and T. Tsuchida. 1974. Uptake of Cadium by Pure Cultured Diatom, Skeletonema costatum. Bull.Plankton Soc.Jpn. 21(1):55-59.	8652	UEndp, Eff, Dur, UChron, Con	
Mowdy, D.E.. 1981. Elimination of Laboratory-Acquired Cadmium by the Oyster Crassostrea virginica in the Natural Environment. Bull.Environ.Contam.Toxicol. 26(3):345-351.	9486	UEndp, Eff, Dur, UChron, Con	
Murugadas, T.L., S.M. Phang, and S.L. Tong. 1995. Heavy Metal Accumulation Patterns in Selected Seaweed Species of Malaysia. Asia Pacific J.Mol.Biol.Biotechnol. 3(4):290-310.	19239	UEndp, Eff, Dur	
Myint, U.M., and P.A. Tyler. 1982. Effects of Temperature, Nutritive and Metal Stressors on the Reproductive Biology of Mytilus edulis. Mar.Biol. 67(2):209-223.	12950	UEndp, UChron, Con	
Nacci, D., E. Jackim, and R. Walsh. 1986. Comparative Evaluation of Three Rapid Marine Toxicity Tests: Sea Urchin Early Embryo Growth Test, Sea Urchin Sperm Cell Toxicity Test and Microtox. Environ.Toxicol.Chem. 5:521-525.	17742	Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Narayanan, K.R., P.S. Lyla, and S.A. Khan. 1999. Pattern of Depuration of Accumulated Heavy Metals in the Mud Crab, Scylla serrata (Forskal). J.Environ.Biol. 20(3):213-216.	52573	NonRes	
Nassiri, Y., J.L. Mansot, J. Wery, T. Ginsburger-Vogel, and J.C. Amiard. 1997. Ultrastructural and Electron Energy Loss Spectroscopy Studies of Sequestration Mechanisms of Cd and Cu in the Marine Diatom Skeletonema costatum. Arch.Environ.Contam.Toxicol. 33(2):147-155.	18422	UEndp, Eff	Has a 96hr IC50 for a diatom (found in NA)
Nassiri, Y., T. Ginsburger-Vogel, J.L. Mansot, and J. Wery. 1996. Effects of Heavy Metals on Tetraselmis suecica: Ultrastructural and Energy-Dispersive X-Ray Spectroscopic Studies. Biol.Cell 86(2/3):151-160.	19512	NonRes, UEndp, Eff	
Nasu, Y., and M. Kugimoto. 1981. Lemna (Duckweed) As an Indicator of Water Pollution I. The Sensitivity of Lemna paucicostata to Heavy Metals. Arch.Environ.Contam.Toxicol. 10(2):159-169.	9489	UEndp, Con	
Negilski, D.S.. 1976. Acute Toxicity of Zinc, Cadmium and Chromium to the Marine Fishes, Yellow-Eye Mullet (Aldrichetta forsteri C. and V.) and Small-Mouthed Hardyhead. Aust.J.Mar.Freshwater Res. 27(1):137-149.	6225	NonRes	
Nicola Giudici, M., and S.M. Guarino. 1989. Effects of Chronic Exposure to Cadmium or Copper on Idothea baltica (Crustacea, Isopoda). Mar.Pollut.Bull. 20(2):69-73.	9979	UEndp, UChron, Con	
Nicola Giudici, M., L. Migliore, S.M. Guarino, and C. Gambardella. 1987. Acute and Long-Term Toxicity of Cadmium to Idothea baltica (Crustacea, Isopoda). Mar.Pollut.Bull. 18(8):454-458.	2494	UEndp, LT, Dur, UChron	
Nielsen, G., and P. Bjerregaard. 1991. Interaction Between Accumulation of Cadmium and Selenium in the Tissues of Turbot Scophthalmus maximus. Aquat.Toxicol. 20:253-266.	5044	UEndp, Eff, UChron	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Nimmo et al. . 1977b. Effects of Cadmium on the Shrimps, Penaeus duorarum, Palaemonetes pugio, and Palaemonetes vulgaris. In: F.J. Vernberg, et al. (eds.), Physiological Responses of marine Biota to Pollutants.. Academic Press, New York. P. 131..		Eff, UChron	
Nimmo, D.W.R., and L.H. Bahner. 1977. Metals, Pesticides and PCBs: Toxicities to Shrimp Singly and in Combination. In: M.W.Wiley (Ed.), Estuarine Processes, Vol.1, Uses, Stresses, and Adaption to the Estuary.Academic Press, New York, NY :523-532.	17458	UEndp, Eff, Dur	Has a 30d LC50 for northern pink shrimp
Nolan, C.V., and E.J. Duke. 1983. Cadmium Accumulation and Toxicity in Mytilus edulis: Involvement of Metallothioneins and Heavy-Molecular Weight Protein. Aquat.Toxicol. 4(2):153-163.	11276	UEndp, Eff, Dur, Con	
Nott, J.A., and W.J. Langston. 1993. Effects of Cadmium and Zinc on the Composition of Phosphate Granules in the Marine Snail Littorina littorea. Aquat.Toxicol. 25:43-54.	7025	UEndp, Eff, Dur, UChron	
Nugegoda, D., and P.S. Rainbow. 1995. The Uptake and Dissolved Zinc and Cadmium by the Decapod Crustacean Palaemon elegans. Mar.Pollut.Bull. 31(4-12):460-463.	17692	UEndp, Eff	
Oakley, S.M., K.J. Williamson, and P.O. Nelson. 1983. Accumulation of Cadmium by Abarenicola pacifica. Sci.Total Environ. 28:105-118.	14540	UEndp, Eff, Dur	
Odzak, N., D. Martincic, T. Zvonaric, and M. Branica. 1994. Bioaccumulation Rate of Cd and Pb in Mytilus galloprovincialis Foot and Gills. Mar.Chem. 46(1/2):119-131.	16644	UEndp, Eff	
O'Hara, J.. 1973. Cadmium Uptake by Fiddler Crabs Exposed to Temperature and Salinity Stress. J.Fish.Res.Board Can. 30(6):846-848.	8938	UEndp,E ff, Dur, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Okamoto, O.K., L. Shao, J.W. Hastings, and P. Colepicolo. 1999. Acute and Chronic Effects of Toxic Metals on Viability, Encystment and Bioluminescence in the Dinoflagellate Gonyaulax polyedra. Comp.Biochem.Physiol.C 123(1):75-83.	20347	UEndp, Eff	
Olesen, T.M.E., and J.M. Weeks. 1994. Accumulation of Cd by the Marine Sponge Halichondria panica Pallas: Effects upon Filtration Rate and Its Relevance for Biomonitoring. Bull.Environ.Contam.Toxicol. 52(5):722-728.	13759	UEndp, Eff, Dur, UChron	
Olsson, P.E., A. Larsson, and C. Haux. 1996. Influence of Seasonal Changes in Water Temperature on Cadmium Inducibility of Hepatic and Renal Metallothionein in Rainbow Trout. Mar.Environ.Res. 42(1-4):41-44.	18358	UEndp, Eff, UChron	
Overnell, J.. 1976. Inhibition of Marine Algal Photosynthesis by Heavy Metals. Mar.Biol.(Berl.) 38(4):335-342.	15868	UEndp, Eff, Dur	
Pagano, G., A. Esposito, and G.G. Giordano. 1982. Fertilization and Larval Development in Sea Urchins Following Exposure of Gametes and Embryos to Cadmium. Arch.Environ.Contam.Toxicol. 11(1):47-55.	15403	UEndp, Dur, Con	
Pagano, G., M. Cipollaro, G. Corsale, A. Esposito, E. Ragucci, G.G. Giordano, and N.M. Trieff. 1986. The Sea Urchin: Bioassay for the Assessment of Damage from Environmental Contaminants. In: J.Cairns,Jr.(Ed.), Community Toxicity Testing, ASTM STP 920, Philadelphia, PA :66-92.	18937	UEndp, Dur	
Papathanassiou, E., and P.E. King. 1983. Ultrastructural Studies on the Gills of Palaemon serratus (Pennant) in Relation to Cadmium Accumulation. Aquat.Toxicol. 3(4):273-284.	10098	UEndp, Eff, Dur, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Papathanassiou, E.. 1983. Effects of Cadmium and Mercury Ions on Respiration and Survival of the Common Prawn Palaemon serratus (Pennant). Rev.Int.Oceanogr.Med. 72:21-35.	13970	UEndp, LT, Dur	
Park, J.S., and H.G. Kim. 1978. Bioassays on Marine Organisms: Acute Toxicity Test of Mercury, Cadmium and Copper to Arkshell, Anadara broughtonii, From Jin-Dong Bay, and to Oyster,. J.Oceanol.Soc.Korea 13(1):35-43.	8418	NonRes	
Park, J.S., and H.G. Kim. 1979. Bioassays on Marine Organisms. III. Acute Toxicity Test of Mercury, Copper and Cadmium to Yellowtail, Seriola quinqueradiata and Rock Bream,. Bull.Korean Fish.Soc.(Han'Guk Susan Halchoiji) 12(2):119-123 (Used 8419 for Ref).	8420	Dur, Con	
Parker, J.G.. 1984. The Effects of Selected Chemicals and Water Quality on the Marine Polychaete Ophryotrocha diadema. Water Res. 18(7):865-868.	10890	Dur, Con	
Patel, B., and K. Anthony. 1991. Uptake of Cadmium in Tropical Marine Lamellibranchs, and Effects on Physiological Behaviour. Mar.Biol. 108:457-470.	340	UEndp, Eff, Con	
Pavicic, J., B. Raspor, and M. Branica. 1992. Metal Binding Proteins of Mytilus galloprovincialis, Similar to Metallothioneins, as a Potential Indicator of Metal Pollution. In: G.P.Gabrielides (Ed.), Proc.of the FAO/UNEP/IOC Workshop on the Biological Effects of Pollutants on Marine Organisms, Malta, 10-14 Sept., 1991, UNEP, Athens, Greece, MAP Tech.Rep.Ser.No.69 :217-234.	13629	UEndp, Eff, Dur, UChron, Con	
Pavicic, J., M. Skreblin, I. Kregar, M. Tusek-Znidaric, and P. Stegnar. 1994. Embryo-Larval Tolerance of Mytilus galloprovincialis, Exposed to the Elevated Sea Water Metal Concentrations-I. Toxic Effects of Cd, Zn and Hg in. Comp.Biochem.Physiol.C 107(2):249-257.	4073	UEndp, Eff, Dur, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Pempkowiak, J., J. Kozuch, and T. Southon. 1994. The Influence of Structural Features of Marine Humic Substances on the Accumulation Rates of Cadmium by a Blue Mussel Mytilus edulis. Environ.Int. 20(3):391-395.	18708	UEndp, Eff, UChron	
Pereira, J.J., R. Mercaldo-Allen, C. Kuropat, D. Luedke, and G. Sennefelder. 1993. Effect of Cadmium Accumulation on Serum Vitellogenin Levels and Hepatosomatic and Gonadosomatic Indices of Winter Flounder (Pleuronectes americanus). Arch.Environ.Contam.Toxicol. 24:427-431.	6769	UEndp, Eff	
Persoone, G., and G. Uyttersprot. 1975. The Influence of Inorganic and Organic Pollutants on the Rate of Reproduction of a Marine Hypotrichous Ciliate: Euplotes vannus Muller. Rev.Int.Oceanogr.Med. 37-38:125-151.	5922	UEndp, Dur	
Pesch, C.E., D.J. Hansen, W.S. Boothman, W.J. Berry, and J.D. Mahony. 1995. The Role of Acid-Volatile Sulfide and Interstitial Water Metal Concentrations in Determining Bioavailability of Cadmium and Nickel from Contaminated. Environ.Toxicol.Chem. 14(1):129-141.	18028	UEndp, Eff, Dur, UChron	
Pesch, C.E., P.S. Schauer, and M.A. Balboni. 1986. Effect of Diet on Copper Toxicity to Neanthes arenaceodentata (Annelida: Polychaeta). In: T.M.Poston and R.Purdy (Eds.), Aquatic Toxicology and Environmental Fate, 9th Volume, ASTM STP 921, Philadelphia, PA :369-383.	7835	Dur, Con, See note	ECOTOX provides six well-defined 96-h LC50s ranging from 85.48 µg/L to 309.1 µg/L for this study. Combined with the other LC50s for *Nereis arenaceodentata*, the SMAV would have been 725.2 µg/L. This SMAV is significantly lower than the original but is not sensitive relative to other species. Three F,M 96-hr LC50s were greater than values and were not used. Note, this test was not used in the 2001 cadmium WQC doc
Pesch, G.G., and N.E. Stewart. 1980. Cadmium Toxicity to Three Species of Estuarine Invertebrates. Mar.Environ.Res. 3(2):145-156.	5332	UEndp, LT, Eff, Dur	
Peterson, S.M., and J.L. Stauber. 1996. New Algal Enzyme Bioassay for the Rapid Assessment of Aquatic Toxicity. Bull.Environ.Toxicol.Chem. 56(5):750-757.	19926	Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Phelps, H.L.. 1979. Cadmium Sorption in Estuarine Mud-Type Sediment and the Accumulation of Cadmium in the Soft-Shell Clam, Mya arenaria. Estuaries 2(1):40-44.	14331	UEndp, Eff, Dur	
Phillips, D.J.H.. 1976. The Common Mussel Mytilus edulis As an Indicator of Pollution by Zinc, Cadmium, Lead and Copper. I. Effects of Environmental Variables on Uptake of. Mar.Biol. 38(1):59-69.	15633	UEndp, Eff, Dur	
Phinney, J.T., and K.W. .Bruland. 1994. Uptake of Lipophilic Organic Cu, Cd, and Pb Complexes in the Coastal Diatom Thalassiosira weissflogii. Environ.Sci.Technol. 28(11):1781-1790.	45097	UEndp, Eff, Dur	
Pietilainen, K.. 1976. Synergistic and Antagonistic Effects of Lead and Cadmium on Aquatic Primary Production. Proc Int Conf on Heavy Metals in the Environment, Volume II, Toronto, Canada (1975) Part 2:861-873.	8184	UEndp, Eff, Con	
Powell, M.I., and K.N. White. 1989. Influence of the Heavy Metals Copper and Cadmium on the Behaviour of Semibalanus balanoides and Balanus crenatus. Mar.Behav.Physiol. 14(2):115-127.	5438	Dur, Con	
Pragatheeswaran, V., B. Loganathan, R. Natarajan, and V.K. Venugopalan. 1989. Cadmium Induced Malformation in Eyes of Ambassis commersoni Cuvier. Bull.Environ.Contam.Toxicol. 43(5):755-760.	3820	UEndp, Dur, Con	
Prakash, N.T., and K.S.J. Rao. 1995. Modulations in Antioxidant Enzymes in Different Tissues of Marine Bivalve Perna viridis During Heavy Metal Exposure. Mol.Cell.Biochem. 146(2):107-113.	17902	UEndp, Eff	
Prevot, P., and M.O. Soyer-Gobillard. 1986. Combined Action of Cadmium and Selenium on Two Marine Dinoflagellates in Culture, Prorocentrum micans Ehrbg. and Crypthecodinium cohnii Biecheler. J.Protozool. 33(1):42-47.	12548	UEndp, Dur, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Price, R.K.J., and R.F. Uglow. 1980. Cardiac and Ventilatory Responses of Crangon crangon to Cadmium, Copper and Zinc. Helgol.Wiss.Meeresunters. 33(1/4):59-67.	9879	UEndp, Eff, Dur, Con	
Pringle, B.H., et al.. 1968. Trace metal accumulation by estuarine mollusks.. Am. Soc. Civil Eng., J. Sanit. Eng. Div. 94: 455..		Eff, UChron	
Pruell, R.J., and F.R. Engelhardt. 1980. Liver Cadmium Uptake, Catalase Inhibition and Cadmium Thionein Production in the Killifish (Fundulus heteroclitus) Induced by Experimental. Mar.Environ.Res. 3(2):101-111.	9880	UEndp, Eff, Con	
Rabsch, U., and M. Elbraechter. 1980. Cadmium and Zinc Uptake, Growth, and Primary Production in Coscinodiscus granii Cultures Containing Low Levels of Cells and Dissolved Organic Carbon. Helgol.Wiss.Meeresunters. 33(1/4):79-88.	9881	UEndp	
Rainbow, P.S., and S.L. White. 1989. Comparative Strategies of Heavy Metal Accumulation by Crustaceans: Zinc, Copper and Cadmium in a Decapod, an Amphipod and a Barnacle. Hydrobiologia 174(3):245-262.	18778	UEndp, Eff	
Rainbow, P.S., I. Malik, and P. O'Brien. 1993. Physicochemical and Physiological Effects on the Uptake of Dissolved Zinc and Cadmium by the Amphipod Crustacean Orchestia gammarellus. Aquat.Toxicol. 25:15-30.	7010	UEndp, Eff	
Rainbow, P.S.. 1985. Accumulation of Zn, Cu and Cd by Crabs and Barnacles. Estuar.Coast.Shelf Sci. 21(5):669-686.	9713	UEndp, Eff	
Ralph, P.J., and M.D. Burchett. 1998. Photosynthetic Response of Halophila ovalis to Heavy Metal Stress. Environ.Pollut. 103(1):91-101.	19866	UEndp, Eff	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Raspor, B., J. Pavicic, and M. Branica. 1989. Cadmium-Induced Proteins from Mytilus galloprovincialis - Polarographic Characterization and Study of Their Interaction with Cadmium. Mar.Chem. 28(1-3):199-214.	4041	UEndp, Eff, Con	
Ray, S., D.W. McLeese, B.A. Waiwood, and D. Pezzack. 1980. The Disposition of Cadmium and Zinc in Pandalus montagui. Arch.Environ.Contam.Toxicol. 9(6):675-681.	9857	Eff, Dur, Con	
Rebhun, S., and A. Ben Amotz. 1984. The Distribution of Cadmium between the Marine Alga Chlorella stigmatophora and Sea Water Medium. Water Res. 18(2):173-178.	10169	UEndp, Eff	
Reddy, P.S., and M. Fingerman. 1995. Effect of Cadmium Chloride on Physiological Color Changes of the Fiddler Crab, Uca pugilator. Ecotoxicol.Environ.Saf. 31(1):69-75.	15248	UEndp, Eff, Dur	
Reddy, P.S., L.K. Nguyen, P. Obih, and M. Fingerman. 1997. Effect of Cadmium Chloride on the Distal Retinal Pigment Cells of the Fiddler Crab, Uca pugilator. Bull.Environ.Contam.Toxicol. 58(3):504-510.	18003	UEndp, Eff	
Regoli, F., E. Orlando, M. Mauri, M. Nigro, and G.A. Cognetti. 1991. Heavy Metal Accumulation and Calcium Content in the Bivalve Donacilla cornea. Mar.Ecol.Prog.Ser. 74(2/3):219-224.	8705	UEndp, Eff, Dur	
Reish, D.J., and R.S. Carr. 1978. The Effect of Heavy Metals on the Survival, Reproduction, Development and Life Cycles for Two Species of Polychaetous Annelids. Mar.Pollut.Bull. 9(1):24-27.	8428	UEndp, UChron	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Reish, D.J., and T.V. Gerlinger. 1984. The Effects of Cadmium, Lead, and Zinc on Survival and Reproduction in the Polychaetous annelid Neanthes arenaceodentata (F.Nereididae). In: P.A.Hutchings (Ed.), Proc.of the First Int.Polychaete Conf., Sydney, Aust., July 1983, The Linnean Society of New South Wales, Australia :383-389.	4007	Con, UChron	
Reish, D.J., C.E. Pesch, J.H. Gentile, G. Bellan, and D. Bellan-Santini. 1978. Interlaboratory Calibration Experiments Using the Polychaetous Annelid Capitella capitata. Mar.Environ.Res. 1(2):109-118.	5934	Eff, UChron	
Relexens, J.C.. 1989. Ecotoxicology in a Miniaturized Sediment Environment (EMISEM) - Final Report. Effects of Pollutants on the Physiology Respiratory of Meiofauna. Oecd-Ircha (Fre).	3516	UEndp, Eff	
Riisgard, H.U., E. Bjornestad, and F. Mohlenberg. 1987. Accumulation of Cadmium in the Mussel Mytilus edulis: Kinetics and Importance of Uptake Via Food and Sea Water. Mar.Biol. 96(3):349-353.	12907	UEndp, Eff	
Rijstenbil, J.W., A. Sandee, J. Van Drie, and J.A. Wijnholds. 1994. Interaction of Toxic Trace Metals and Mechanisms of Detoxification in the Planktonic Diatoms Ditylum brightwellii and Thalassiosira pseudonana. FEMS (Fed.Eur.Microbiol.Soc.) Microbiol.Rev. 14:387-396.	14606	UEndp, Eff, Dur	
Ringwood, A.H.. 1989. Accumulation of Cadmium by Larvae and Adults of an Hawaiian Bivalve, Isognomon californicum, During Chronic Exposure. Mar.Biol. 102(4):499-504.	3268	Eff, UChron, Con	
Ringwood, A.H.. 1992. Comparative Sensitivity of Gametes and Early Developmental Stages of a Sea Urchin Species (Echinometra mathaei) and a Bivalve Species (Isognomon. Arch.Environ.Contam.Toxicol. 22:288-295.	3886	Dur, Eff	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Ringwood, A.H.. 1992. Effects of Chronic Cadmium Exposures on Growth of Larvae of an Hawaiian Bivalve, Isognomon californicum. Mar.Ecol.Prog.Ser. 83(1):63-70.	7634	UEndp, Dur	
Ringwood, A.H.. 1993. Age-Specific Differences in Cadmium Sensitivity and Bioaccumulation in Bivalve Molluscs. Mar.Environ.Res. 35(1/2):35-39.	4364	Con, Dur	
Ritterhoff, J., and G.P. Zauke. 1997. Bioaccumulation of Trace Metals in Greenland Sea Copepod and Amphipod Collectives on Board Ship: Verification of Toxicokinetic Model Parameters. Aquat.Toxicol. 40(1):63-78.	18598	UEndp, Eff	
Ritterhoff, J., G.P. Zauke, and R. Dallinger. 1996. Calibration of the Estuarine Amphipods, Gammarus zaddachi Sexton (1912), as Biomonitors: Toxicokinetics of Cadmium and Possible Role of Inducible. Aquat.Toxicol. 34(4):351-369.	17081	Eff, Dur, UChron	
Roberts, M.H.J., J.E. Warinner, C.F. Tsai, D. Wright, and L.E. Cronin. 1982. Comparison of Estuarine Species Sensitivities to Three Toxicants. Arch.Environ.Contam.Toxicol. 11(6):681-692.	10443	Con, Eff, Dur	
Roberts, R.O., and S.G. Berk. 1990. Development of a Protozoan Chemoattraction Bioassay for Evaluating Toxicity of Aquatic Pollutants. Toxic.Assess. 5:279-292.	9812	Dur	only 24hr. Has 24hr LC50 for a ciliate
Roed, K.H.. 1979. The Effects of Interacting Salinity, Cadmium, and Mercury on Population Growth of an Archiannelid, Dinophilus gyrociliatus. Sarsia 64(4):245-252.	8434	UEndp, Eff, Con	
Roed, K.H.. 1980. Effects of Salinity and Cadmium Interaction on Reproduction and Growth During Three Successive Generations of Ophryotrocha labronica (Polychaeta). Helgol.Wiss.Meeresunters. 33(1/4):47-58.	9887	Eff, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Roesijadi, G., and P.L. Klerks. 1989. Kinetic Analysis of Cadmium Binding to Metallothionein and Other Intracellular Ligands in Oyster Gills. J.Exp.Zool. 251(1):1-12.	3514	UEndp, Dur	
Roesijadi, G., K.M. Hansen, and M.E. Unger. 1996. Cadmium-Induced Metallothionein Expression During Embryonic And Early Larval Development Of The Mollusc Crassostrea Virginica. Toxicol.Appl.Pharmacol. 140(2):356-363.	19745	UEndp, Eff	
Roman, G., A. Rudolph, and R. Ahumada. 1994. Seasonal Studies on Cadmium Toxicity in Choromytilus chorus (Molina 1782). Soc.Biol.Concepcion 65:23-30 (SPA) (ENG ABS).	19344	NonRes	
Rosenberg, R., and J.D. Costlow Jr.. 1976. Synergistic Effects of Cadmium and Salinity Combined with Constant and Cycling Temperatures on the Larval Development of Two Estuarine Crab. Mar.Biol. 38(4):291-303.	15637	UEndp, UChron	
Sarasquete, M.C., M.L. Gonzales de Canales, and S. Gimeno. 1992. Comparative Histopathological Alterations in the Diestive Gland of Marine Bivalves Exposed to Cu and Cd. Eur.J.Histochem. 36(2):223-232.	9518	UEndp, Eff	
Sathya, K.S., and K.P. Balakrishnan. 1988. Physiology of Phytoplankton in Relation to Metal Concentration. Water Air Soil Pollut. 38(3-4):283-297.	12966	UEndp, Eff	
Sauer, G.R.. 1987. The Effect of Cadmium and Zinc on Calcium Uptake and Scale Regeneration in Fundulus heteroclitus. In: W.A.Vernberg, A.Calabrese, F.P.Thurberg, and F.J.Vernberg (Eds.), Pollution of Estuarine Organisms, Univ.of SC Press, Columbia, SC :373-399.	4904	UEndp, Eff	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Schlekat, C.E., B.L. Mcgee, and E. Reinharz. 1992. Testing Sediment Toxicity in Chesapeake Bay with the Amphipod Leptocheirus plumulosus: An Evaluation. Environ.Toxicol.Chem. 11(2):225-236.	3911	See note	ECOTOX provides one 96-h LC50 of 298.2 µg/L for this study. Combined with the other LC50s for *Leptocheirus plumulosus,* the SMAV would have been 495.6 µg/L. This SMAV is not sensitive relative to other species. A 96-hr LC50 for *Hyalella azteca* of 188.9 µg/L, however, this species was not used in the analysis. Note, this test was not used in the 2001 cadmium WQC doc
Scholz, N.. 1980. Accumulation, Loss and Molecular Distribution of Cadmium in Mytilus edulis. Helgol.Wiss.Meeresunters. 33(1/4):68-78.	9894	UEndp, Eff, Con	
Schroder, H.C., H.M.A. Hassanein, S. Lauenroth, C. Koziol, T.A.A. Mohamed, M. Lacorn, and H. Steinhart. 1999. Induction of DNA Strand Breaks and Expression of HSP70 and GRP78 Homolog by Cadmium in the Marine Sponge Suberites domuncula. Arch.Environ.Contam.Toxicol. 36(1):47-55.	20048	UEndp, Eff	
Scott-Fordsmand, J.J., and M.H. Depledge. 1993. The Influence of Starvation and Copper Exposure on the Composition of the Dorsal Carapace and Distribution of Trace Metals in the Shore Crab (Carcinus. Comp.Biochem.Physiol.C 106(2):537-543.	13334	UEndp, UChron	
Selvakumar, S., and T.M. Haridasan. 2000. Toxic Effects of Heavy Metals Copper, Zinc, Cadmium and Mercury on the Zoeal Development of Sesarminid Crab Nanosesarma (Beanium) batavicum. J.Environ.Biol. 21(2):101-104.	54052	UEndp, UChron	
Selvakumar, S., S.A. Khan, and A.K. Kumaraguru. 1996. Acute Toxicity of Some Heavy Metals, Pesticides and Water Soluble Fractions of Diesel Oil to the Larvae of Some Brachyuran Crabs. J.Environ.Biol. 17(3):221-226.	18580	NoOrg	ECOTOX provides one 96-h LC50 of 99.40 µg/L for *Nanosesarma sp.* for this study. This SMAV is not sensitive relative to other species. Note, this test was not used in the 2001 cadmium WQC doc
Serra, R., E. Carpene, A.C. Marcantonio, and G. Isani. 1995. Cadmium Accumulation and Cd-Binding Proteins in the Bivalve Scapharca inaequivalvis. Comp.Biochem.Physiol.C 111(2):165-174.	16028	UEndp, UChron	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Shazili, N.A.M.. 1995. Effects of Salinity and Pre-exposure on Acute Cadmium Toxicity to Seabass, Lates calcarifer. Bull.Environ.Contam.Toxicol. 54(1):22-28.	14994	NonRes	
Shuster, C.N.Jr., and B.H. Pringle. 1969. Trace Metal Accumulation by the American Eastern Oyster, Crassostrea virginica. 1968 Proc.Natl.Shellfish Assoc. 59:91-103.	19929	UEndp, UChron	
Sick, L.V., and G.J. Baptist. 1979. Cadmium Incorporation by the Marine Copepod Pseudodiaptomus coronatus. Limnol.Oceanogr. 24(3):453-462.	15521	UEndp, Eff	
Sick, L.V., and H.L. Windom. 1975. Effects of Environmental Levels of Mercury and Cadmium on Rates of Metal Uptake and Growth Physiology of Selected Genera of Marine Phytoplankton. In: Mineral Cycling in Southeastern Ecosystems, National Technical Information Service, Springfield, VA :239-249.	59194	UEndp, Eff	
Sidoumou, Z., M. Gnassia-Barelli, and M. Romeo. 1997. Cadmium and Calcium Uptake in the Mollusc Donax rugosus and Effect of a Calcium Channel Blocker. Bull.Environ.Contam.Toxicol. 58(2):318-325.	17918	UEndp, Eff	
Simoes Goncalves, M.L.S., M.F.C. Vilhena, L.M.V. Machado, C.M.R. Pescada, and Moura De. 1989. Effect of Speciation on Uptake and Toxicity of Cadmium to Shrimp Crangon crangon (L.). Bull.Environ.Contam.Toxicol. 43(2):287-294.	2275	Con	
Skul'sky, I.A., I.V. Burovina, V.F. Vasilyeva, O.N. Lukyanova, V.A. Nikiforov, and I.G. Syasina. 1989. Uptake and Microlocalization of Cadmium in Marine Bivalve Mollusc Tissues. Comp.Biochem.Physiol.C 92(2):349-353.	898	UEndp, Eff	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Skwarzec, B., A. Kentzer-Baczewska, E. Styczynska-Jurewicz, and E. Neugebauer. 1984. Influence of Accumulation of Cadmium on the Content of Other Microelements of Two Species of Black Sea Decapods. Bull.Environ.Contam.Toxicol. 32(1):93-101.	10124	UEndp, Eff	
Smith, M.A.. 1983. The Effect of Heavy Metals on the Cytoplasmic Fine Structure of Skeletonema costatum (Bacillariophyta). Protoplasma 116(1):14-23.	11036	Con, UEndp, Eff	
Snell, T.W., and G. Persoone. 1989. Acute Toxicity Bioassays Using Rotifers. I. A Test for Brackish and Marine Environments with Brachionus plicatilis. Aquat.Toxicol. 14(1):65-80.	3827	Dur	24hr only
Snell, T.W., B.D. Moffat, C. Janssen, and G. Persoone. 1991. Acute Toxicity Tests Using Rotifers. III. Effects of Temperature, Strain, and Exposure Time on the Sensitivity of Brachionus plicatilis. Environ.Toxicol.Water Qual. 6:63-75.	16539	Dur	24hr only
Sorgeloos, P., C. Remiche-Van der Wielen, and G. Persoone. 1978. The Use of Artemia nauplii for Toxicity Tests - A Critical Analysis. Ecotoxicol.Environ.Saf. 2(3/4):249-255 (Author Communication Used).	5419	UEndp, Eff	
Soria-Dengg, S., and D. Ochavillo. 1990. Comparative Toxicities of Trace Metals on Embryos of the Giant Clam, Tridacna derasa. Asian Mar.Biol. 7:161-166.	20706	UEndp, Dur	
Stebbing, A.R.D.. 1976. The Effects of Low Metal Levels on a Clonal Hydroid. J.Mar.Biol.Assoc.U.K. 56(4):977-994.	15641	UEndp, Con	
Stroemgren, T.. 1980. The Effect of Lead, Cadmium, and Mercury on the Increase in Length of Five Intertidal Fucales. J.Exp.Mar.Biol.Ecol. 43(2):107-119.	9902	UEndp, Con	
Stromgren, T.. 1980. The Effect of Lead, Cadmium, and Mercury on the Increase in Length of Five Intertidal Fucales. J.Exp.Mar.Biol.Ecol. 43:107-119.	19931	UEndp, Dur, UChron	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Stromgren, T.. 1982. Effect of Heavy Metals (Zn, Hg, Cu, Cd, Pb, Ni) on the Length Growth of Mytilus edulis. Mar.Biol. 72(1):69-72.	10899	UEndp	
Sullivan, J.K.. 1977. Effects of Salinity and Temperature on the Acute Toxicity of Cadmium to the Estuarine Crab Paragrapsus gaimardii (Milne Edwards). Aust.J.Mar.Freshwater Res. 28(6):739-743.	8453	NonRes	
Sunda, W.G., D.W. Engel, and R.M. Thuotte. 1978. Effect of Chemical Speciation on Toxicity of Cadmium to Grass Shrimp, Palaemonetes pugio: Importance of Free Cadmium Ion. Environ.Sci.Technol. 12(4):409-413.	8454	UEndp	
Sunila, I., and R. Lindstrom. 1985. The Structure of the Interfilamentar Junction of the Mussel (Mytilus edulis L.) Gill and its Uncoupling by Copper and Cadmium Exposures. Comp.Biochem.Physiol.C 81(2):267-272.	11224	UEndp, Eff, Con	24hr only
Sunila, I. 1981. Toxicity of Copper and Cadmium to Mytilus edulis L. (Bivalvia) in Brackish Water. Ann.Zool.Fenn. 18:213-223.	15791	Dur, UEndp, Eff	ECOTOX provides one 96-h EC50 of 497.0 µg/L for this study. Combined with the other LC50s for *Mytilus edulis,* the SMAV would have been 827.0 µg/L. This SMAV is not sensitive relative to other species. Note, this test was not used in the 2001 cadmium WQC doc
Syasina, I.G., and O.N. Lukyanova. 1993. Ultrastructural and Biochemical Changes in Gonads of the Scallop Mizuhopecten yessoensis: Results of Cadmium Accumulation. Russ.J.Mar.Biol. 19(4):68-77.	16479	UEndp, Eff	
Tedengren, M., M. Arner, and N. Kautsky. 1988. Ecophysiology and Stress Response of Marine and Brackish Water Gammarus Species (Crustacea, Amphipoda) to Changes in Salinity and Exposure to Cadmium and. Mar.Ecol.Prog.Ser. 47(2):107-116.	13130	UEndp, Eff	
Temara, A., G. Ledent, M. Warnau, H. Paucot, M. Jangoux, and P. Dubois. 1996. Experimental Cadmium Contamination of Asterias rubens (Echinodermata). Mar.Ecol.Prog.Ser. 140(1-3):83-90.	20122	Field, Eff	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Temara, A., M. Warneau, P. Dubois, and W.J. Langston. 1997. Quantification of Metallothioneins in the Common Asteroid Asterias rubens (Echinodermata) Exposed Experimentally or Naturally to Cadmium. Aquat.Toxicol. 38:17-34.	18402	UEndp, Eff	
Thaker, A.A., and A.A. Haritos. 1989. Cadmium Bioaccumulation and Effects on Soluble Peptides, Proteins and Enzymes in the Hepatopancreas of the Shrimp Callianassa tyrrhena. Comp.Biochem.Physiol.C 94(1):63-70.	57	UEndp, Eff	
Thebault, M.T., A. Biegniewska, J.P. Raffin, and E.F. Skorkowski. 1996. Short Term Cadmium Intoxication of the Shrimp Palaemon serratus: Effect on Adenylate Metabolism. Comp.Biochem.Physiol.C 113(3):345-348.	16857	NonRes	
Theede, H., N. Scholz, and H. Fischer. 1979. Temperature and Salinity Effects on the Acute Toxicity of Cadmium to Laomedea loveni (Hydrozoa). Mar.Ecol.Prog.Ser. 1(1):13-19.	8457	Eff, Con	
Thomas, P., and H.W. Wofford. 1993. Effects of Cadmium and Aroclor 1254 on Lipid Peroxidation, Glutathione Peroxidase Activity, and Selected Antioxidants in Atlantic Croaker Tissues. Aquat.Toxicol. 27(1/2):159-178.	8235	UEndp, UChron	
Thomas, P., and J.M. Neff. 1985. Plasma Corticosteroid and Glucose Responses to Pollutants in Striped Mullet: Different Effects of Naphthalene, Benzo(a)pyrene and Cadmium Exposure. In: F.J.Vernberg, F.P.Thurberg, A.Calabrese, and W.Vernberg (Eds.), Marine Pollution and Physiology: Recent Advances :63-82.	4974	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Thompson, K.A., D.A. Brown, P.M. Chapman, and R.O. Brinkhurst. 1982. Histopathological Effects and Cadmium-Binding Protein Synthesis in the Marine Oligochaete Monopylephorus cuticulatus Following Cadmium Exposure. Trans.Am.Microsc.Soc. 101(1):10-26.	15442	UEndp, Eff, Con	
Thongra-ar, W., and O. Matsuda. 1995. Effects of Cadmium and Zinc on Growth of Thalassiosira weissflogii and Heterosigma akashiwo. In: A.Snidvongs, W.Utoomprukporn, and M.Hungspreugs (Eds.), Proceedings of the NRCT-JSPS Joint Seminar on Marine Science, Dec.2-3, 1993, Chulalongkorn University, Thailand, Bangkok :90-96.	18912	UEndp	
Thurberg, F.P., A. Calabrese, E. Gould, R.A. Greig, M.A. Dawson, and R.K. Tucker. 1977. Response of the Lobster, Homarus americanus, to Sublethal Levels of Cadmium and Mercury. Physiol.Responses Mar.Biota Pollut. 77:185-197.	8458	UEndp, Eff	
Thurberg, F.P., M.A. Dawson, and R.S. Collier. 1973. Effects of Copper and Cadmium on Osmoregulation and Oxygen Consumption in Two Species of Estuarine Crabs. Mar.Biol. 23(3):171-175.	8732	UEndp, Con	
Tort, L., and M. Rosell. 1989. Variations of Organ-Body Weight Allometric Relationship in the Dogfish After Chronic Subacute Cadmium Treatment. Comp.Physiol.Ecol. 14(2):49-56.	3370	UEndp, Dur, UChron	
Tort, L., P. Torres, and J. Hidalgo. 1984. Short-Term Cadmium Effects on Gill Tissue Metabolism. Mar.Pollut.Bull. 15(12):448-450.	10769	UEndp, Dur, UChron	
Triebskorn, R., H.R. Kohler, T. Zahn, G. Vogt, M. Ludwig, S. Rumpf, M. Kratzmann, G. Alberti, and V. Storch. 1991. Invertebrate Cells as Targets for Hazardous Substances. Z.Angew.Zool. 73(3):277-287.	16869	UEndp, Eff	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Udoidiong, O.M., and P.M. Akpan. 1991. Toxicity of Cadmium, Lead and Lindane to Egeria radiata Lamarck (Lamellibranchia, Donacidae). Rev.Hydrobiol.Trop. 24(2):111-117.	8515	AF, NonRes	
Varanasi, U., and D. Markey. 1978. Uptake and Release of Lead and Cadmium in Skin and Mucus of Coho Salmon (Oncorhynchus kisutch). Comp.Biochem.Physiol.60C:187-191 (1978) / Fed.Proc. 36(3):772 (ABS) (1977) (Author Communication Used).	15121	Eff, Con	
Varanasi, U.. 1978. Biological Fate of Metals in Fish. In: D.A.Wolfe (Ed.), Marine Biological Effects of OCS Petroleum Development, NOAA ERL, Boulder, CO :41-53.	5209	Eff, Con, UChron	
Vashchenko, M.A., V.B. Durkina, and S.M. Gnezdilova. 1988. The Influence of the Diesel Fuel Hydrocarbons and Cadmium on the Development of Sea Urchin Progeny. Ontogensis /Ontogenez 19(1):82-88 (RUS) (ENG ABS).	298	UEndp, UChron	
Vega, M.M., J.A. Marigomez, and E. Angulo. 1989. Quantitative Alterations in the Structure of the Digestive Cell of Littorina littorea on Exposure to Cadmium. Mar.Biol. 103(4):547-553.	712	UEndp, Eff	
Veldhuizen-Tsoerkan, M.B., C.A. Van der Mast, and D.A. Holwerda. 1992. Cadmium-Induced Changes in Macromolecular Synthesis at Transcriptional and Translational Level in Gill Tissue of Sea Mussels, Mytilus edulis L. Comp.Biochem.Physiol.C 103(2):411-417.	6735	UEndp, Eff	
Vernberg, W.B., P.J. De Coursey, and J. O'Hara. 1974. Multiple Environmental Factor Effects on Physiology and Behavior of the Fiddler Crab, Uca pugilator. In: F.J.Vernberg and W.B.Vernberg (Eds.), Pollution and Physiology of Marine Organisms, Academic Press, New York :381-425.	20409	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Vernberg, W.B., P.J. Decoursey, M. Kelly, and D.M. Johns. 1977. Effects of Sublethal Concentrations of Cadmium on Adult Palaemonetes pugio Under Static and Flow-Through Conditions. Bull.Environ.Contam.Toxicol. 17(1):16-24.	8466	UEndp, Eff	
Verriopoulos, G., and M. Moraitou-Apostolopoulou. 1981. Effects of Some Environmental Factors on the Toxicity of Cadmium to the Copepod Tisbe holothuriae. Arch.Hydrobiol. 91(3):287-293.	15444	UEndp, Con	
Verriopoulos, G., and M. Moraitou-Apostolopoulou. 1982. Differentiation of the Sensitivity to Copper and Cadmium in Different Life Stages of a Copepod. Mar.Pollut.Bull. 13(4):123-125.	11097	Con, Dur	
Viarengo, A., L. Canesi, M. Pertica, G. Poli, M.N. Moore, and M. Orunesu. 1990. Heavy Metal Effects on Lipid Peroxidation in the Tissues of Mytilus galloprovincialis Lam. Comp.Biochem.Physiol.C 97(1):37-42.	78	UEndp, Eff	
Visviki, I., and J.W. Rachlin. 1991. The Toxic Action and Interactions of Copper and Cadmium to the Marine Alga Dunaliella minuta, in Both Acute and Chronic Exposure. Arch.Environ.Contam.Toxicol. 20(2):271-275.	6	AF	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Vitale, A.M., J.M. Monserrat, P. Castilho, and E.M. Rodriguez. 1999. Inhibitory Effects of Cadmium on Carbonic Anhydrase Activity and Ionic Regulation of the Estuarine Crab Chasmagnathus granulata (Decapoda, Grapsidae). Comp.Biochem.Physiol.C 122(1):121-129.	19662	NonRes	96hr LC50 Crab
Von Westernhagen, H., and V. Dethlefsen. 1975. Combined Effects of Cadmium and Salinity on Development and Survival of Flounder Eggs. J.Mar.Biol.Assoc.U.K. 55(4):945-957.	15698	UEndp, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Von Westernhagen, H., and V. Dethlefsen. 1982. Effect of the Surfactant Corexit 7664 on Uptake of Cadmium by Organisms and Biological Matter in a Closed Circulated Brackish-Water System. Helgol.Meeresunters. 35(1):1-12.	11054	UEndp, Eff, Con	
Von Westernhagen, H., V. Dethlefsen, and H. Rosenthal. 1975. Combined Effects of Cadmium and Salinity on Development and Survival of Garpike Eggs. Helgol.Wiss.Meeresunters. 27(3):268-282.	15699	Eff, UChron	
Von Westernhagen, H., V. Dethlefsen, and H. Rosenthal. 1980. Correlation Between Cadmium Concentration in the Water and Tissue Residue Levels in Dab, Limanda limanda L., and Plaice, Pleuronectes platessa L. J.Mar.Biol.Assoc.U.K. 60(1):45-58.	9923	UEndp	
Voogt, P.A., P.J. Den Besten, G.C.M. Kusters, and M.W.J. Messing. 1987. Effects of Cadmium and Zinc on Steroid Metabolism and Steroid Level in the Sea Star Asterias rubens L. Comp.Biochem.Physiol.C 86(1):83-89.	12392	UEndp, Eff	
Voyer, R.A., and D.G. McGovern. 1991. Influence of Constant and Fluctuating Salinity on Responses of Mysidopsis bahia Exposed to Cadmium in a Life-Cycle Test. Aquat.Toxicol. 19(3):215-230.	3612	UEndp	ECOTOX provides three 28-d CVs of 4.445 µg/L for this study. Combined with the other CVs for *Americamysis bahia,* the SMCV would have been 5.661 µg/L. This SMAV is sensitive relative to other species and the criteria, however *Americamysis bahia* was already listed as sensitive. Note, this test was not used in the 2001 cadmium WQC doc
Voyer, R.A., and G. Modica. 1990. Influence of Salinity and Temperature on Acute Toxicity of Cadmium to Mysidopsis bahia Molenock. Arch.Environ.Contam.Toxicol. 19(1):124-131.	3008	Nom	ECOTOX provides twelve F,U and S,M 96-h LC50s ranging from 11.03 µg/L to 84.49 µg/L for this study. However, F,M tests exist for *Americamysis bahia,* so these values would not have been used. Note, this test was not used in the 2001 cadmium WQC doc
Voyer, R.A., C.E. Wentworth Jr., E.P. Barry, and R.J. Hennekey. 1977. Viability of Embryos of the Winter Flounder Pseudopleuronectes americanus Exposed to Combinations of Cadmium and Salinity at Selected Temperatures. Mar.Biol. 44(2):117-124.	8468	LT	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Voyer, R.A., J.A. Cardin, J.F. Heltshe, and G.L. Hoffman. 1982. Viability of Embryos of the Winter Flounder Pseudopleuronectes americanus Exposed to Mixtures of Cadmium and Silver in Combination with Selected Fixe. Aquat.Toxicol. 2(4):223-233.	10500	UEndp, Dur	
Voyer, R.A., J.F. Heltsche, and R.A. Kraus. 1979. Hatching Success and Larval Mortality in an Estuarine Teleost, Menidia menidia (Linnaeus), Exposed to Cadmium in Constant and Fluctuating Salinity Re. Bull.Environ.Contam.Toxicol. 23(4-5):475-481.	8467	Dur	
Voyer, R.A.. 1975. Effect of Dissolved Oxygen Concentration on the Acute Toxicity of Cadmium to the Mummichog, Fundulus heteroclitus (L.), at Various Salinities. Trans.Am.Fish.Soc. 104(1):129-134.	6172	Nom	ECOTOX provides fourteen S,U 96-h LC50s ranging from 28826 µg/L to 113316 µg/L for this study. However, F,M tests exist for *Fundulus heteroclitus,* so these values would not have been used. Note, this test was not used in the 2001 cadmium WQC doc
Vranken, G., R. Vandergaeghen, and C. Heip. 1991. Effects of Pollutants on Life-History Parameters of the Marine Nematode Monhystera disjuncta. ICES J Mar Sci 48:325-334.	7215	Con	
Wang, J., M. Zhang, J. Xu, and Y. Wang. 1995. Reciprocal Effect of Cu, Cd, Zn on a Kind of Marine Alga. Water Res. 29(1):209-214.	13720	UEndp	
Ward, S.H. 1989. The Requirements for a Balanced Medium in Toxicological Experiments Using Mysidopsis bahia with Special Reference to Calcium Carbonate. In: U.M.Cowgill and L.R.Williams (Eds.), Aquatic Toxicology and Hazard Assessment, ASTM STP 1027, Philadelphia, PA 12:402-412.	13866		ECOTOX provides twelve R,U 96-h LC50s ranging from 17.82 µg/L to 33.60 µg/L for this study. However, F,M tests exist for *Americamysis bahia,* so these values would not have been used. Note, this test was not used in the 2001 cadmium WQC doc
Warnau, M., J.L. Teyssie, and S.W. Fowler. 1995. Effect of Feeding on Cadmium Bioaccumulation in the Echinoid Paracentrotus lividus (Echinodermata). Mar.Ecol.Prog.Ser. 126(1-3):305-309.	18918	Eff	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Warnau, M., M. Iaccarino, A. De Biase, A. Temara, M. Jangoux, P. Dubois, and G. Pagano. 1996. Spermiotoxicity and Embryotoxicity of Heavy Metals in the Echinoid Paracentrotus lividus. Environ.Toxicol.Chem. 15(11):1931-1936.	17368	Dur	
Waterman, A.J.. 1937. Effect of Salts of Heavy Metals on Development of the Sea Urchin, Arbacia punctulata. Biol.Bull. 73(3):401-420.	17763	UEndp,Dur	
Watling, H.R., and R.J. Watling. 1983. Sandy Beach Molluscs As Possible Bioindicators of Metal Pollution 2. Laboratory Studies. Bull.Environ.Contam.Toxicol. 31(3):339-343.	10862	UEndp, Eff	
Watling, H.R.. 1978. Effect of Cadmium on Larvae and Spat of the Oyster Crassostrea gigas (Thunberg). Trans.R.Soc.S.Afr. 43(2):125-134.	10081	UEndp	
Watling, H.R.. 1983. Accumulation of Seven Metals by Crassostrea gigas, Crassostrea margaritacea, Perna perna, and Choromytilus meridionalis. Bull.Environ.Contam.Toxicol. 30(3):317-322.	7374	UEndp, Eff	
Watling, H.R.. 1983. Comparative Study of the Effects of Metals on the Settlement of Crassostrea gigas. Bull.Environ.Contam.Toxicol. 31(3):344-351.	11098	UEndp, Con	
Weis, J.S., P. Weis, and J.L. Ricci. 1981. Effects of Cadmium, Zinc, Salinity, and Temperature on the Teratogenicity of Methylmercury to the Killifish (Fundulus heteroclitus). Rapp.P.V.Reun.Comm.Int.Explor.Sci.Mer Mediterr. 178:64-70.	11419	UEndp	
Weis, J.S.. 1976. Effects of Mercury, Cadmium, and Lead Salts on Regeneration and Ecdysis in the Fiddler Crab, Uca pugilator. Fish.Bull. 74(2):464-467.	8044	UEndp, UChron	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Weis, J.S.. 1980. Effect of Zinc on Regeneration in the Fiddler Crab Uca pugilator and its Interactions with Methyl-Mercury and Cadmium. Mar.Environ.Res. 3(4):249-255.	9921	UEndp, Con	
Weis, J.S.. 1985. Cadmium Acclimation and Limb Regeneration in the Fiddler Crab, Uca pugilator: Sex Differences. Mar.Environ.Res. 16:199-214.	11417	UEndp	
Weis, P., and J.S. Weis. 1978. Methylmercury Inhibition of Fin Regeneration in Fishes and its Interaction with Salinity and Cadmium. Estuar.Coast.Mar.Sci. 6(3):327-334.	7211	UEndp, Con	
Weis, P., and J.S. Weis. 1986. Cadmium Acclimation and Hormesis in Fundulus heteroclitus During Fin Regeneration. Environ.Res. 39:356-363.	11420	UEndp, UChron	
Westernhagen, H.V., V. Dethlefsen, H. Rosenthal, G. Furstenberg, and J. Klinckmann. 1978. Fate and Effects of Cadmium in an Experimental Marine Ecosystem. Helgol.Wiss.Meeresunters. 31:471-484.	17305	UEndp, Eff	
White, S.L., and P.S. Rainbow. 1982. Regulation and Accumulation of Copper, Zinc and Cadmium by the Shrimp Palaemon elegans. Mar.Ecol.Prog.Ser. 8(1):95-101.	9120	UEndp, UChron	
White, S.L., and P.S. Rainbow. 1986. Accumulation of Cadmium by Palaemon elegans (Crustacea: Decapoda). Mar.Ecol.Prog.Ser. 32(1):17-25.	12244	UEndp, UChron	
Wikfors, G.H., and R. Ukeles. 1982. Growth and Adaptation Estuarine Unicellular Algae in Media with Excess Copper, Cadmium or Zinc, and Effects of Metal-Contaminated Algal Food on. Mar.Ecol.Prog.Ser. 7:191-206.	15508	UEndp, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Wilkowska, I., J. Kozuch, and J. Pempkowiak. 1994. The Influence of Selected Abiotic Factors (Salinity, Temperature) on the Accumulation of Cadmium from Sea Water by Blue Mussel Mytilus edulis. Bull.Sea Fish.Inst.Gdynia (Biul.Morsk.Inst.Ryback Gdynia) 131:61-65.	17103	UEndp, Eff	
Wo, K.T., P.K.S. Lam, and R.S.S. Wu. 1999. A Comparison of Growth Biomarkers for Assessing Sublethal Effects of Cadmium on a Marine Gastropod, Nassarius festivus. Mar.Pollut.Bull. 39(1-12):165-173.	20624	NonRes	
Wood, A.M.. 1983. Available Copper Ligands and the Apparent Bioavailability of Copper to Natural Phytoplankton Assemblages. Sci.Total Environ. 28:51-64.	11038	Eff, Dur	
Wright, D.A.. 1977. The Effect of Salinity on Cadmium Uptake by the Tissues of the Shore Crab Carcinus maenas. J.Exp.Biol. 67:137-146.	4146	Eff, UChron	
Yang, M.S., and J.A.J. Thompson. 1996. Binding of Endogenous Copper and Zinc to Cadmium-Induced Metal-Binding Proteins in Various Tissues of Perna viridis. Arch.Environ.Contam.Toxicol. 30(2):267-273.	16427	UEndp, Eff	
Yih, W., J.S. Yang, S.G. Jo, and E.Y. Chung. 1994. Effects of Suspended Solid and Cadmium on the Shallow-Sea Foodweb Ecosystem. 1. Reduction of Growth Rate and Biomass Yield of Coastal Diatom Clones. Bull.Korean Fish.Soc.(Han'Guk Susan Halchoiji) 27(4):373-379.	19358	Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Zanders, I.P., and W.E. Rojas. 1992. Cadmium Accumulation, LC50 and Oxygen Consumption in the Tropical Marine Amphipod Elasmopus rapax. Mar.Biol. 113(3):409-413.	6416	Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Zanders, I.P. and W.E. Rojas. 1996. Salinity Effects on Cadmium Accumulation in Various Tissues of the Tropical Fiddler Crab Uca rapax. Environ.Pollut. 94(3):293-299.	18382	UEndp, Eff	ECOTOX provides one 96-h EC50 of 377.7 µg/L for this study. This SMAV is not sensitive relative to other species. Note, this test was not used in the 2001 cadmium WQC doc
Zaroogian, G.E., and S. Cheer. 1976. Accumulation of Cadmium by the American Oyster, Crassostrea virginica. Nature 261(5559):408-410.	15703	UEndp, Eff	
Zaroogian, G.E.. 1979. Studies on the Depuration of Cadmium and Copper by the American Oyster Crassostrea virginica. Bull.Environ.Contam.Toxicol. 23(1/2):117-122.	15552	UEndp, Eff	
Zaroogian, G.E.. 1980. Crassostrea virginica as an Indicator of Cadmium Pollution. Mar.Biol. 58(4):275-284.	9926	UEndp, Eff	
Zauke, G.P., R. Von Lemm, H.G. Meurs, and W. Butte. 1995. Validation of Estuarine Gammarid Collectives (Amphipoda: Crustacea) as Biomonitors for Cadmium in Semi-Controlled Toxicokinetic Flow-Through Experiments. Environ.Pollut. 90(2):209-219.	16960	Eff, Dur	
	7425		24hr only; No information about the paper, just the reference number

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[92], EPA is providing a transparent rationale as to why they were not utilized (see below).

[92] U.S. EPA. 2001. 2001 Update of Ambient Water Quality Criteria for Cadmium. EPA-822-R-01-001.

For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable.

<u>General QA/QC failure because non-resident species in Oregon</u>

Tests with the following species were used in the EPA BE of OR WQS for cadmium in saltwater, but were not considered in the CWA review and approval/disapproval action of the standards because these species do not have a breeding wild population in Oregon's waters:

Nassarius	*festivus*	Snail	Wo et al. 1999
Nucella	*lapillus*	Dog whelk, Atlantic dogwinkle	Leung and Furness 1999
Americamysis	*bahia*	Opossum shrimp	Nimmo et al. 1977; Gentile et al. 1982; Lussier et al. 1985; Voyer and Modica 1990; De Lisle and Roberts 1998
Americamysis	*bigelowi*	Shrimp	Gentile et al. 1982

Appendix P Copper (Saltwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Aagaard, A., and M.H. Depledge. 1993. Inter-Individual Variability in the Responses of Carcinus maenas to Copper Exposure. In: J.C.Aldrich (Ed.), Proc.27th Eur.Ma.Biol.Symp., Quantified Phenotypic Responses in Morphology and Physiology, Sept.7-11, 1992, Dublin, Ireland :275-280.	17945	UEndp	
Abalde, J., A. Cid, S. Reiriz, E. Torres, and C. Herrero. 1995. Response of the Marine Microalga Dunaliella tertiolecta (Chlorophyceae) to Copper Toxicity in Short Time Experiments. Bull.Environ.Contam.Toxicol. 54(2):317-324.	45175	UEndp	
Abbasi, A.R., and S.E. Shackley. 1995. The Effect of Copper on Developing Eggs of Herring, Clupea harengus L. Sindh Univ.Res.J.Sci. 27(1):35-44.	18239	Dur, UChron	
Abbasi, A.R., S.E. Shackley, and P.E. King. 1995. Effects of Copper on the Ultrastructure of Muscle Cells of Herring, Clupea harengus L. Pak.J.Zool. 27(1):83-87.	17605	UEndp	
Abel, P.D.. 1976. Effects of Some Pollutants on the Filtration Rate of Mytilus. Mar.Pollut.Bull. 7:228-231.	415	Con	
Absil, M.C.P., J.J. Kroon, and H.T. Wolterbeek. 1994. Availability of Copper from Phytoplankton and Water for the Bivalve Macoma balthica. I. Separation of Uptake Pathways Using the Radiotracer 64Cu. Mar.Biol. 118(1):123-127.	16336	UEndp	
Absil, M.C.P., L.J.A. Gerringa, and B.T. Wolterbeek. 1993. The Relation Between Salinity and Copper Complexing Capacity of Natural Estuarine Waters and the Uptake of Dissolved 64Cu by Macoma balthica. Chem.Spec.Bioavail. 5(4):119-128.	20704	UEndp	
Absil, M.C.P., M. Berntssen, and L.J.A. Gerringa. 1996. The Influence of Sediment, Food and Organic Ligands on the Uptake of Copper by Sediment-Dwelling Bivalves. Aquat.Toxicol. 34(1):13-29.	16133	Field, UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Adema, D.M.M., S.I. Deswaaf-Mooy, and P. Bais. 1972. Laboratoriumonderzoek Over De Invloed Van Koper Op Mosselen (Mytilus edilus). (Laboratory Investigations Concerning the Influence of Copper on. Tno Nieuws 27(9):482-487.	8213	UEndp	
Ahsanullah, M., and A.R. Williams. 1991. Sublethal Effects and Bioaccumulation of Cadmium, Chromium, Copper, and Zinc in the Marine Amphipod Allorchestes compressa. Mar.Biol. 108:59-65.	331	Eff	
Ahsanullah, M., and G.H. Arnott. 1978. Acute Toxicity of Copper, Cadmium, and Zinc to Larvae of the Crab Paragrapsus quadridentatus (H. Milne Edwards), and Implications for Water. Aust.J.Mar.Freshwater Res. 29(1):1-8.	8296	NonRes	
Ahsanullah, M., and T.M. Florence. 1984. Toxicity of Copper to the Marine Amphipod Allorchestes compressa in the Presence of Water-and Lipid-Soluble Ligands. Mar.Biol. 84(1):41-45.	10736	Con	
Ahsanullah, M., and W. Ying. 1995. Toxic Effects of Dissolved Copper on Penaeus merguiensis and Penaeus monodon. Bull.Environ.Contam.Toxicol. 55(1):81-88.	14951	NonRes	
Ahsanullah, M., D.S. Negilski, and M.C. Mobley. 1981. Toxicity of Zinc, Cadmium and Copper to the Shrimp Callianassa australiensis. I. Effects of Individual Metals. Mar.Biol. 64(3):299-304(Author Communication Used).	15338	NonRes	
Ahsanullah, M., D.S. Negilski, and M.C. Mobley. 1981. Toxicity of Zinc, Cadmium and Copper to the Shrimp Callianassa australiensis. III. Accumulation of Metals. Mar.Biol.64(3):311-316 (Used Ref 15338) (Author Communication Used).	15339	Eff, Dur	
Ahsanullah, M., M.C. Mobley, and P. Rankin. 1988. Individual and Combined Effects of Zinc, Cadmium and Copper on the Marine Amphipod Allorchestes compressa. Aust.J.Mar.Freshwater Res. 39(1):33-37.	13187	NonRes	
Akberali, H.B., and J.E. Black. 1980. Behavioural Responses of the Bivalve Scrobicularia plana (Dacosta) Subjected to Short-Term Copper (Cu II) Concentrations. Mar.Environ.Res. 4(2):97-107.	6095	NonRes	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Amiard-Triquet, C., J.C. Amiard, R. Ferrand, A.C. Andersen, and M.P. Dubois. 1986. Disturbance of a Met-Enkephalin-Like Hormone in the Hepatopancreas of Crabs Contaminated by Metals. Ecotoxicol.Environ.Saf. 11(2):198-209.	12111	UEndp	
Anderson, B.S., J.W. Hunt, H.R. McNulty, S.L. Turpen, and M. Martin. 1994. Off-Season Spawning and Factors Influencing Toxicity Test Development with Topsmelt Atherinops affinis. Environ.Toxicol.Chem. 13(3):479-485.	4223	Con	
Anderson, B.S., J.W. Hunt, W.J. Piekarski, B.M. Phillips, M.A. Englund, R.S. Tjeerdema, and J.D. Goetzl. 1995. Influence of Salinity on Copper and Azide Toxicity to Larval Topsmelt Atherinops affinis (Ayres). Arch.Environ.Contam.Toxicol. 29(3):366-372.	16025	UEndp, Uchron, Dur	4 Lines of data have LC50's (mort), 7 day DUR
Anderson, D.M., and F.M.M. Morel. 1978. Copper Sensitivity of Gonyaulax tamarensis. Limnol.Oceanogr. 23(2):283-295.	2848	UEndp, Eff, Con	
Andersson, S., and L. Kautsky. 1996. Copper Effects On Reproductive Stages Of Baltic Sea Fucus vesiculosus. Mar.Biol. 125(1):171-176.	19684	UEndp	
Arasu, S.M., and P.S. Reddy. 1994. Alterations in Oxidative Metabolism in the Gill and Muscle of Marine Bivalve Perna viridis During Cadmium and Copper Exposure. Fresenius Environ.Bull. 3(12):721-727.	16831	Dur	
Arnott, G.H., and M. Ahsanullah. 1979. Acute Toxicity of Copper, Cadmium and Zinc to Three Species of Marine Copepod. Aust.J.Mar.Freshwater Res. 30(1):63-71.	5563	Dur	
Arumugam, M., and M.H. Ravindranath. 1987. Copper Toxicity in the Crab, Scylla serrata, Copper Levels in Tissues and Regulation After Exposure to a Copper-Rich Medium. Bull.Environ.Contam.Toxicol. 39:708-715.	727	UEndp, Con	
Bailey, H.C., J.L. Miller, M.J. Miller, and B.S. Dhaliwal. 1995. Application of Toxicity Identification Procedures to the Echinoderm Fertilization Assay to Identify Toxicity in a Municipal Effluent. Environ.Toxicol.Chem. 14(12):2181-2186.	16375	Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Baker, J.T.P.. 1969. Histological and Electron Microscopical Observations on Copper Poisoning in the Winter Flounder (Pseudopleuronectes americanus). J.Fish.Res.Board Can. 26(11):2785-2793.	15553	UEndp	
Ballan-Dufrancais, C., C. Marcaillou, and C. Amiard-Triquet. 1991. Response of the Phytoplanktonic Alga Tetraselmis suecica to Copper and Silver Exposure: Vesicular Metal Bioaccumulation and Lack of Starch Bodies. Biol.Cell 72(1/2):103-112.	7698	UEndp, Eff	
Bambang, Y., P. Thuet, M. Charmantier-Daures, J.P. Trilles, and G. Charmantier. 1995. Effect of Copper on Survival and Osmoregulation of Various Developmental Stages of the Shrimp Penaeus japonicus Bate (Crustacea, Decapoda). Aquat.Toxicol. 33(2):125-139.	16111	NonRes	
Bat, L.. 1997. Studies on the Uptake of Copper, Zinc and Cadmium by the Amphipod Corophium volutator (Pallas) in the Laboratory. Turk.J.Mar.Sci. 3(2):93-109.	19858	UEndp	
Bay, S.M., P.S. Oshida, and K.D. Jenkins. 1983. A Simple New Bioassay Based on Echinochrome Synthesis by Larval Sea Urchins. Mar.Environ.Res. 8(1):29-39.	7919	UEndp	
Beaumont, A.R., and J.E. Toro. 1996. Allozyme Genetics of Mytilus edulis Subjected to Copper and Nutritive Stress. J.Mar.Biol.Assoc.U.K. 76:1061-1071.	18712	UEndp	
Beaumont, A.R., G. Tserpes, and M.D. Budd. 1987. Some Effects of Copper on the Veliger Larvae of the Mussel Mytilus edulis and the Scallop Pecten maximus (Mollusca, Bivalvia). Mar.Environ.Res. 21(4):299-309.	7975	Dur, Con	
Bechmann . 1994. . .		NonRes	
Bennett, R.O., and J.K. Dooley. 1982. Copper Uptake by Two Sympatric Species of Killifish Fundulus heteroclitus (L.)and F. majalis (Walbaum). J.Fish Biol. 21(4):381-398.	10491	UEndp, Eff	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Berail, G., P. Prudent, C. Massiani, and M. Pellegrini. 1992. Isolation of Heavy Metal-Binding Proteins from a Brown Seaweed Cystoseira barbata f. repens Cultivated in Copper or Cadmium Enriched Seawater. In: E.Merian and W.Haerdi (Eds.), Metal Compounds in Environment and Life, 4.Interrelation Between Chemistry and Biology, Science and Technology Letters, Northwood, Middlesex, UK :55-62.	2351	UEndp, Eff	
Betzer, S.B., and M.E.Q. Pilson. 1975. Copper Uptake and Excretion by Busycon canaliculatum L. Biol.Bull. 148(1):1-15.	722	Con, Eff	
Betzer, S.B., and P.P. Yevich. 1975. Copper Toxicity in Busycon canaliculatum L. Biol.Bull. 148:16-25.	721	Con, UEndp, Eff	
Bisbal, G.. 1987. Does Copper Affect the Mating Behavior of Gammarus annulatus Smith, 1873 (Amphipoda: Gammaridae)?. Biol.Bull. 173(2):429 (ABS).	2417	UEndp, Con	
Bjerregaard, P., and T. Vislie. 1986. Effect of Copper on Ion-and Osmoregulation in the Shore Crab Carcinus maenas. Mar.Biol. 91(1):69-76.	11800	LT, Eff	
Blasco, J., and J. Puppo. 1999. Effect of Heavy Metals (Cu, Cd and Pb) on Aspartate and Alanine Aminotransferase in Ruditapes phillippinarum (Mollusca: Bivalvia). Comp.Biochem.Physiol.C 122(2):253-263.	20072	UEndp	
Blust, R., L. Van Ginneken, and W. Decleir. 1994. Effect of Temperature on the Uptake of Copper by the Brine Shrimp, Artemia fraciscana. Aquat.Toxicol. 30(4):343-356.	17602	UEndp	Brine Shrimp
Bodammer, J.E.. 1985. Corneal Damage in Larvae of Striped Bass Morone saxatilis Exposed to Copper. Trans.Am.Fish.Soc. 114(4):577-583.	2479	UEndp, Con	
Bodammer, J.E.. 1987. A Preliminary Study on the Corneas of American San d Lance Larvae Exposed to Copper. In: W.A.Vernberg, A.Calabrese, F.P.Thurberg, and F.J.Vernberg (Eds.), Pollution of Estuarine Organisms, Univ.of SC Press, Columbia, SC :439-448.	4906	UEndp	
Boitel, F., and J.P. Truchot. 1989. Effects of Sublethal and Lethal Copper Levels on Hemolymph Acid-Base Balance and Ion Concentrations in the Shore Crab Carcinus maenas Kept in. Mar.Biol. 103(4):495-501.	715	UEndp, Eff	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Botton, M.L., K. Johnson, and L. Helleby. 1998. Effects of Copper and Zinc on Embryos and Larvae of the Horseshoe Crab, Limulus polyphemus. Arch.Environ.Contam.Toxicol. 35(1):25-32.	19307	Dur	ECOTOX provides six 96-h LC50s of 1660 - 709650 µg/L for this study. These values could have been considered for EPA's evaluation of saltwater cadmium, but the species is relatively insensitive to copper compared to others.
Bougis, P., M.C. Corre, and M. Etienne. 1979. Sea-Urchin Larvae As a Tool for Assessment of the Quality of Sea Water. Ann.Inst.Oceanogr. 55(1):21-25.	5564	Con, NonRes	
Brand, L.E., W.G. Sunda, and R.R.L. Guillard. 1986. Reduction of Marine Phytoplankton Reproduction Rates by Copper and Cadmium. J.Exp.Mar.Biol.Ecol. 96(3):225-250.	12014	UEndp	
Bresler, V., and V. Yanko. 1995. Acute Toxicity of Heavy Metals for Benthic Epiphytic Foraminifera Pararotalia spinigera (Le Calvez) and Influence of Seaweed-Derived DOC. Environ.Toxicol.Chem. 14(10):1687-1695.	15933	Dur	only 24 hrs
Brown, B., and M. Ahsanullah. 1971. Effect of Heavy Metals on Mortality and Growth. Mar.Pollut.Bull. 2:182-187.	2467	LT, Con	
Brown, C.L., and S.N. Luoma. 1995. Use of the Euryhaline Bivalve Potamocorbula amurensis as a Biosentinel Species to Assess Trace Metal Contamination in San Francisco Bay. Mar.Ecol.Prog.Ser. 124(1-3):129-142.	18036	Eff	
Browne, R.A.. 1980. Acute Response Versus Reproductive Performance in Five Strains of Brine Shrimp Exposed to Copper Sulphate. Mar.Environ.Res. 3(3):185-193.	5304	Con, LT	Brine Shrimp
Burdin, K.S., and K.T. Bird. 1994. Heavy Metal Accumulation by Carrageenan and Agar Producing Algae. Bot.Mar. 37:467-470.	45156	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Burgess, R.M., B.A. Rogers, S.A. Rego, J.M. Corbin, and G.E. Morrison. 1994. Sand Spiked with Copper as a Reference Toxicant Material for Sediment Toxicity Testing: A Preliminary Evaluation. Arch.Environ.Contam.Toxicol. 26(2):163-168.	13674	UEndp	
Burton, D.T., and D.J. Fisher. 1990. Acute Toxicity of Cadmium, Copper, Zinc, Ammonia, 3,3'-Dichlorobenzidine, 2,6-Dichloro-4-nitroaniline, Methylene Chloride, and 2,4,6-Trichlorophenol. Bull.Environ.Contam.Toxicol. 44(5):776-783.	3163	Con, Dur	
Calabrese et al. 1984.		UEndp	Bioaccumulation
Calabrese, A., J.R. MacInnes, D.A. Nelson, and J.E. Miller. 1977. Survival and Growth of Bivalve Larvae Under Heavy-Metal Stress. Mar.Biol. 41:179-184.	9064	Con	
Calabrese, A., J.R. MacInnes, D.A. Nelson, R.A. Greig, and P.P. Yevich. 1984. Effects of Long-Term Exposure to Silver or Copper on Growth, Bioaccumulation and Histopathology in the Blue Mussel Mytilus edulis. Mar.Environ.Res. 11(4):253-274.	10774	UEndp	
Calabrese, A., R.S. Collier, D.A. Nelson, and J.R. Mac Innes. 1973. The Toxicity of Heavy Metals to Embryos of the American Oyster Crassostrea virginica. Mar.Biol. 18(3):162-166.	2165	Con, Dur	
Canesi, L., A. Viarengo, C. Leonzio, M. Filippelli, and G. Gallo. 1999. Heavy Metals and Glutathione Metabolism in Mussel Tissues. Aquat.Toxicol. 46(1):67-76.	20096	UEndp	
Canli, M., and R.W. Furness. 1993. Toxicity of Heavy Metals Dissolved in Sea Water and Influences of Sex and Size on Metal Accumulation and Tissue Distribution in the Norway Lobster. Mar.Environ.Res. 36(4):217-236.	4563	UEndp, Eff	
Canterford, G.S., A.S. Buchanan, and S.C. Ducker. 1978. Accumulation of Heavy Metals by the Marine Diatom Ditylum brightwellii (West) Grunow. Aust.J.Mar.Freshwater Res. 29(5):613-622.	15455	UEndp	
Carmel, C.L.M., P.N.K. Nambisan, and R. Damodaran. 1983. Effect of Copper on Juvenile Penaeus indicus H. Milne Edwards. Indian J.Mar.Sci. 12(2):128-130.	13964	NonRes	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Carter, R.J., and R.S. Eriksen. 1992. Investigation into the Use of Zostera muelleri (Irmisch ex Aschers) as a Sentinel Accumulator for Copper. Sci.Total Environ. 125:185-192.	7597	UEndp, Eff	
Chan, H.M.. 1988. Accumulation and Tolerance to Cadmium, Copper, Lead and Zinc by the Green Mussel Perna viridis. Mar.Ecol.Prog.Ser. 48(3):295-303.	2970	NonRes	
Chapman, H.F., J.M. Hughes, and R.L. Kitching. 1985. Burying Response of an Intertidal Gastropod to Freshwater and Copper Contamination. Mar.Pollut.Bull. 16(11):442-445.	11461	NonRes	
Chelomin, V.P., and N.N. Belcheva. 1992. The Effect of Heavy Metals on Processes of Lipid Peroxidation in Microsomal Membranes from the Hepatopancreas of the Bivalve Mollusc Mizuhopecten. Comp.Biochem.Physiol.C 103(2):419-422.	6730	UEndp, Eff	
Chen, C., L. Zhang, and Y. Wu. 1988. The Complexing Capacity of Natural Organic Matters for Copper in Estuarine Water and Its Effect on Growth of Diatom in Xiamen Estuarine Harbor. China Environ.Sci.(Zhongguo Huanjing Kexue) 8(1):29-35 (CHI) (ENG ABS).	3841	Dur, Con	
Chen, I.M.. 1994. The Effects of Copper on the Respiration of Oyster Crassotrea gigas (Thunberg). Fish.Sci. 60(6):683-686.	16242	UEndp	
Chen, J.C., and P.C. Liu. 1987. Accumulation of Heavy Metals in the Nauplii of Artemia salina. J.World Aquacult.Soc. 18(2):84-93.	2749	UEndp, Eff	Brine Shrimp
Cheung, S.G., and L.S. Wong. 1999. Effect of Copper on Activity and Feeding in the Subtidal Prosobranch Babylonia lutosa (Lamarck) (Gastropoda: Buccinidae). Mar.Pollut.Bull. 39(1-12):106-111.	20620	UEndp	
Cid, A., C. Herrero, and J. Abalde. 1996. Functional Analysis of Phytoplankton by Flow Cytometry: A Study of the Effect of Copper on a Marine Diatom. Sci.Mar.60(Suppl. 1):303-308.	3097	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Coglianese, M.P., and M. Martin. 1981. Individual and Interactive Effects of Environmental Stress on the Embryonic Development of the Pacific Oyster, Crassostrea gigas. I. The Toxicity of. Mar.Environ.Res. 5(1):13-27.	15740	UEndp	
Coglianese, M.P.. 1982. The Effects of Salinity on Copper and Silver Toxicity to Embryos of the Pacific Oyster. Arch.Environ.Contam.Toxicol. 11(3):297-303.	15377	UEndp	
Correia, A.D., and M.H. Costa. 2000. Effects of Sediment Geochemical Properties on the Toxicity of Copper-Spiked Sediments to the Marine Amphipod Gammarus locusta. Sci.Total Environ. 247:99-106.	48393	UEndp	
Courtois, L.A.. 1974. Physiological Responses of Striped Bass, Roccus saxatilis (Walbaum), to Changes in Diet, Salinity, Temperature, and Acute Copper Exposure. Ph.D.Thesis, University of California, Davis, CA:118 p.; Diss.Abstr.Int.B Sci.Eng.35(6):2976.	8522	UEndp, Eff	
Cui, K., Y. Liu, and L. Hou. 1987. Effects of Six Heavy Metals on Hatching Eggs and Survival of Larval of Marine Fish. Oceanol.Limnol.Sin./Haiyang Yu Huzhao 18(2):138-144 (CHI) (ENG ABS).	3222	NonRes	
D'Agostino, A., and C. Finney. 1974. The Effect of Copper and Cadmium on the Development of Tigriopus japonicus. In: F.J.Vernberg and W.B.Vernberg (Eds.), Pollution and Physiology of Mar.Organisms, Academic Press, NY :445-463.	15558	UEndp	
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Hughes, J.M., H.F. Chapman, and R.L. Kitching. 1987. Effects of Sublethal Concentrations of Copper and Freshwater on Behaviour in an Estuarine Gastropod Polinices sordidus. Mar.Pollut.Bull. 18(3):127-131.	8335	NonRes	2 lines of data with 96hr LC50 info
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Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
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Itow, T., T. Igarashi, M.L. Botton, and R.E. Loveland. 1998. Heavy Metals Inhibit Limb Regeneration in Horseshoe Crab Larvae. Arch.Environ.Contam.Toxicol. 35(3):457-463.	20180	UEndp	
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Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
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Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
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Larrain, A., A. Riveros, J. Silva, and E. Bay-Schmith. 1999. Toxicity of Metals and Pesticides Using the Sperm Cell Bioassay with the Sea Urchin Arbacia spatuligera. Bull.Environ.Contam.Toxicol. 62(6):749-757.	20469	Dur	
Lawrence, A.J., and C. Poulter. 1998. Development of a Sub-lethal Pollution Bioassay Using the Estuarine Amphipod Gammarus duebeni. Water Res. 32(3):569-578.	18971	UEndp	
Lee, H.H., and C.H. Xu. 1984. Effects of Metals on Sea Urchin Development: A Rapid Bioassay. Mar.Pollut.Bull. 15(1):18-21.	10086	UEndp, Dur	
Liao, I.C., and C.S. Hsieh. 1990. Toxicity of Three Heavy Metals to Macrobrachium rosenbergii. In: R.Hirano and I.Hanyu (Eds.), Proc.of the 2nd Asian Fisheries Forum, April 17-22, 1989, Tokyo, Japan, Asian Fisheries Society, Manila, Philippines :923-926.	16218	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Lin, W., M.A. Rice, and P.K. Chien. 1992. The Effects of Copper, Cadmium and Zinc on Particle Filtration and Uptake of Glycine in the Pacific Oyster Crassostrea gigas. Comp.Biochem.Physiol.C 103(1):181-187.	6506	UEndp, Dur	
Liu, P.C., and J.C. Chen. 1987. Effects of Heavy Metals on the Hatching Rates of Brine Shrimp Artemia salina Cysts. J.World Aquacult.Soc. 18(2):78-83.	4256	UEndp	Brine Shrimp
Lorenzon, S., M. Francese, and E.A. Ferrero. 2000. Heavy Metal Toxicity and Differential Effects on the Hyperglycemic Stress Response in the Shrimp Palaemon elegans. Arch.Environ.Contam.Toxicol. 39(2):167-176.	51641	NonRes	
Lovegrove, T.. 1979. Anti-Fouling Paint in Farm Ponds. Fish Farming Int. 6(2):13-15,39.	7563	UEndp	
Lumsden, B.R., and T.M. Florence. 1983. A New Algal Assay Procedure for the Determination of the Toxicity of Copper Species in Seawater. Environ.Technol.Lett. 4:271-276.	10266	UEndp, Con	
Luoma, S.N., D.J. Cain, K. Ho, and A. Hutchinson. 1983. Variable Tolerance to Copper in Two Species From San Francisco Bay. Mar.Environ.Res. 10(4):209-222.	11399	Dur, UChron	
Lustigman, B., J.M. McCormick, G. Dale, and J.J.A. McLaughlin. 1987. Effect of Increasing Copper and Salinity on Glycerol Production by Dunaliella salina. Bull.Environ.Contam.Toxicol. 38(2):359-362.	6017	UEndp	
MacDonald, J.M., J.D. Shields, and R.K. Zimmer-Faust. 1988. Acute Toxicities of Eleven Metals to Early Life-History Stages of the Yellow Crab Cancer anthonyi. Mar.Biol. 98(2):201-207.	12861	UEndp	
MacInnes, J.R., and A. Calabrese. 1979. Combined Effects of Salinity, Temperature, and Copper on Embryos and Early Larvae of the American Oyster, Crassostrea virginica. Arch.Environ.Contam.Toxicol. 8(5):553-562.	15627	UEndp	
MacInnes, J.R., and F.P. Thurberg. 1973. Effects of Metals on the Behavior and Oxygen Consumption of the Mud Snail. Mar.Pollut.Bull. 4(12):185-186.	8902	UEndp, Eff	
MacRae, T.H., and A.S. Pandey. 1991. Effects of Metals on Early Life Stages of the Brine Shrimp, Artemia: A Developmental Toxicity Assay. Arch.Environ.Contam.Toxicol. 20(2):247-252.	4	Dur, UEndp	Brine Shrimp

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
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Magni, P.. 1993. Effect of Oxygen Concentration on the Bioavailability of Copper for the Bivalve 'Macoma balthica'. Stage Report June 1992-Feb.1993, Inst.voor Oecologisch Onderzoek, Heteren, Netherland s:27.	17396	UEndp	
Malea, P., S. Haritonidis, and T. Kevrekidis. 1995. The Short-Term Uptake of Copper by the Two Parts of the Seagrass Halophila stipulacea (Forsk.) Aschers. and Leaf-Cells Viability. Fresenius Environ.Bull. 4(2):117-122.	15111	UEndp	
Manley, A.R.. 1983. The Effects of Copper on the Behaviour, Respiration, Filtration and Ventilation Activity of Mytilus edulis. J.Mar.Biol.Assoc.U.K. 63:205-222.	10752	UEndp, Eff	
Marcano, L., O. Nusetti, J. Rodriguez-Grau, and J. Vilas. 1996. Uptake and Depuration of Copper and Zinc in Relation to Metal-Binding Protein in the Polychaete Eurythoe camplanata. Comp.Biochem.Physiol.C 114(3):179-184.	18575	NonRes	
Martin, J.L.M.. 1979. Schema of Lethal Action of Copper on Mussels. Bull.Environ.Contam.Toxicol. 21(6):808-814.	8393	UEndp	
Martincic et al. 1992.		Field, UEndp	Bioaccum
Mathew, R., and N.R. Menon. 1983. Effects of Heavy Metals on Byssogenesis in Perna viridis (Linn.). Indian J.Mar.Sci. 12(2):125-127.	11120	NonRes	
Mathew, R., and N.R. Menon. 1983. Oxygen Consumption in Tropical Bivalves Perna viridis (Linn.) and Meretrix casta (Chem.) Exposed to Heavy Metals. Indian J.Mar.Sci. 12(1):57-59.	11085	UEndp	
McLeese, D.W.. 1975. Chemosensory Response of American Lobsters (Homarus americanus) in the Presence of Copper and Phosphamidon. J.Fish.Res.Board Can. 32(11):2055-2060.	8143	UEndp, Eff	
McLusky and Phillips. 1975.		UEndp, Det	Bioaccum

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Menasria, R., and J.F. Pavillon. 1994. Toxic Effects of Two Trace Metals, Copper and Silver, on a Crustacean Harpacticoid Copepod Tigriopus brevicornis (Muller). Lethal and Sublethal. J.Rech.Oceanogr.19(3/4):157-165 (Fre) (Eng Abs).	18833	NonRes	
Millward, R.N., and A. Grant. 1995. Assessing the Impact of Copper on Nematode Communities from a Chronically Metal-Enriched Estuary Using Pollution-Induced Community Tolerance. Mar.Pollut.Bull. 30(11):701-706.	18052	LT	
Minniti, F.. 1987. Effects of Copper Pollution on the Hepatopancreas of Cyclope neritea L. (Mollusca: Gastropoda). Zool.Anz. 219(3-4):141-146.	574	UEndp, Eff, Con	
Moore, M.N., J. Widdows, J.J. Cleary, R.K. Pipe, P.N. Salkeld, P. Donkin, S.V. Farrar, and S.V.Evans . ... 1984. Responses of the Mussel Mytilus edulis to Copper and Phenanthrene: Interactive Effects. Mar.Environ.Res. 14(1-4):167-183.	11537	UEndp	
Moraitou-Apostolopoulou, M., and G. Verriopoulos. 1982. Individual and Combined Toxicity of Three Heavy Metals, Cu, Cd, and Cr, for the Marine Copepod Tisbe holothuriae. Hydrobiologia 87(1):83-87.	15726	NonRes	
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Moreno Garrido, I., L.M. Lubian, and A.M.V.M. Soares. 1999. Oxygen Production Rate as a Test for Determining Toxicity of Copper to Rhodomonas salina Hill and Wehterbee (Cryptophyceae). Bull.Environ.Contam.Toxicol. 62(6):776-782.	20472	Eff	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Mortimer, M.R., and G.J. Miller. 1994. Susceptibility of Larval and Juvenile Instars of the Sand Crab, Portunus pelagicus (L.), to Sea Water Contaminated by Chromium, Nickel or Copper. Aust.J.Mar.Freshwater Res. 45(7):1107-1121.	16331	UEndp, Dur	ECOTOX provides a 96-h LC50 of 41.50 µg/L for this study. When combined with other LC50s for *Portunus pelagicus*, the SMAV would have been 891.4 µg/L. This value could have been considered for EPA's evaluation of saltwater copper, but the species is relatively insensitive to copper compared to others. Note, this test was not used in the 1995 GLI for copper.
Murugadas, T.L., S.M. Phang, and S.L. Tong. 1995. Heavy Metal Accumulation Patterns in Selected Seaweed Species of Malaysia. Asia Pacific J.Mol.Biol.Biotechnol. 3(4):290-310.	19239	UEndp	
Myint, U.M., and P.A. Tyler. 1982. Effects of Temperature, Nutritive and Metal Stressors on the Reproductive Biology of Mytilus edulis. Mar.Biol. 67(2):209-223.	12950	UEndp	
Nacci, D., E. Jackim, and R. Walsh. 1986. Comparative Evaluation of Three Rapid Marine Toxicity Tests: Sea Urchin Early Embryo Growth Test, Sea Urchin Sperm Cell Toxicity Test and Microtox. Environ.Toxicol.Chem. 5:521-525.	17742	Dur	
Nacci, D., P. Comeleo, E. Petrocelli, A. Kuhn-Hines, G. Modica, and G. Morrison. 1991. Performance Evaluation of Sperm Cell Toxicity Test Using the Sea Urchin, Arbacia punctulata. In: M.A.Mayes and M.G.Barron (Eds.), Aquatic Toxicology and Risk Assessment, 14th Volume, ASTM STP 1124, Philadelphia, PA :324-336.	16722	Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Nacci, D.E., and E. Jackim. 1985. Rapid Aquatic Toxicity Assay Using Incorporation of Tritiated-Thymidine Into Sea Urchin, Arbacia punctulata, Embryo: Evaluation of Toxicant. In: R.C.Bahner and D.J.Hansen (Eds.), Aquatic Toxicology and Hazard Assessment, 8th Symposium, ASTM STP 891, Philadelphia, PA :382-394.	9394	Con, Dur	
Nagabhushanam, R., K.S. Rao, and R. Sarojini. 1986. Acute Toxicity of Three Heavy Metals to Marine Edible Crab, Scylla serrata. J.Adv.Zool. 7(2):97-99.	12895	NonRes	
Narayanan, K.R., S. Ajmalkhan, and S. Pechimuthu. 1994. Histopathological Changes Due to Effects of Sublethal Concentrations of Copper Sulphate on the Hepatopancreas of Edible Crab, Scylla serrata (Forskal). J.Environ.Biol. 15(4):289-293.	13516	UEndp	
Nassiri, Y., T. Ginsburger-Vogel, J.L. Mansot, and J. Wery. 1996. Effects of Heavy Metals on Tetraselmis suecica: Ultrastructural and Energy-Dispersive X-Ray Spectroscopic Studies. Biol.Cell 86(2/3):151-160.	19512	NonRes	
Nasu, Y., and M. Kugimoto. 1981. Lemna (Duckweed) As an Indicator of Water Pollution I. The Sensitivity of Lemna paucicostata to Heavy Metals. Arch.Environ.Contam.Toxicol. 10(2):159-169.	9489	UEndp, Con	
Neiheisel, T.W., and M.E. Young. 1992. Use of Three Artificial Sea Salts to Maintain Fertile Sea Urchins (Arbacia punctulata) and to Conduct Fertilization Tests with Copper and Sodium. Environ.Toxicol.Chem. 11(8):1179-1185.	3959	Dur	
Nell, J.A., and R. Chvojka. 1992. The Effect of bis-Tributyltin Oxide (TBTO) and Copper on the Growth of Juvenile Sydney Rock Oysters Saccostrea commercialis (Iredale and Roughley) and. Sci.Total Environ. 125:193-201.	4136	UEndp	
Nelson, D.A., J.E. Miller, and A. Calabrese. 1988. Effect of Heavy Metals on Bay Scallops, Surf Clams, and Blue Mussels in Acute and Long-Term Exposures. Arch.Environ.Contam.Toxicol. 17(5):595-600.	15056	NonRes	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Nelson, W.G.. 1990. Use of the Blue Mussel, Mytilus edulis, in Water Quality Toxicity Testing and In Situ Marine Biological Monitoring. In: W.G.Landis and W.H.Van der Schalie (Eds.), Aquatic Toxicology and Risk Assessment, 13th Volume, ASTM STP 1096, Philadelphia, PA :167-175.	18927	UEndp, Eff	
Neuhoff, H.G.. 1983. Synergistic Physiological Effects of Low Copper and Various Oxygen Concentrations on Macoma balthica. Mar.Biol. 77:39-48.	14336	Eff, UEndp	
Nias, D.J., S.C. McKullup, and K.S. Edyvane. 1993. Imposex in Lepsiella vinosa from Southern Australia. Mar.Pollut.Bull. 26(7):380-384.	9714	UEndp,	
Nicola Giudici, M., and S.M. Guarino. 1989. Effects of Chronic Exposure to Cadmium or Copper on Idothea baltica (Crustacea, Isopoda). Mar.Pollut.Bull. 20(2):69-73.	9979	UEndp	
Niemi, A.. 1972. Effects of Toxicants on Brackish-Water Phytoplankton Assimilation. Commentat.Biol.Soc.Sci.Fenn. 55:22.	9155	UEndp	
Nonnotte, L., F. Boitel, and J.P. Truchot. 1993. Waterborne Copper Causes Gill Damage and Hemolymph Hypoxia in the Shore Crab Carcinus maenas. Can.J.Zool. 71(8):1569-1576.	9229	UEndp	
Nusetti, O., R. Salazar-Lugo, J. Rodriguez-Grau, and J. Vilas. 1998. Immune and Biochemical Responses of the Polychaete Eurythoe complanata Exposed to Sublethal Concentration of Copper. Comp.Biochem.Physiol.C 119(2):177-183.	19139	NonRes	
Okamoto, O.K., L. Shao, J.W. Hastings, and P. Colepicolo. 1999. Acute and Chronic Effects of Toxic Metals on Viability, Encystment and Bioluminescence in the Dinoflagellate Gonyaulax polyedra. Comp.Biochem.Physiol.C 123(1):75-83.	20347	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Okazaki, R.K. 1976. Copper Toxicity in the Pacific Oyster Crassostrea gigas. Bull.Environ.Contam.Toxicol. 16(6):658-664.	8413	UEndp, See note	ECOTOX provides a F,M 96-h LC50 of 464.8 µg/L for this study. Had this value been use, the other values, all from S,U or S,M tests, would have been rejected. This value is less sensitive to copper than the original SMAV, both of which are above the criteria. Note, this test was not used in the 1995 GLI for copper.
Overnell, J.. 1976. Inhibition of Marine Algal Photosynthesis by Heavy Metals. Mar.Biol.(Berl.) 38(4):335-342.	15868	Eff	
Ozoh, P.T.E., and N.V. Jones. 1990. Capacity Adaptation of Hediste (Nereis) diversicolor Embryogenesis to Salinity, Temperature and Copper. Mar.Environ.Res. 29(3):227-243.	5658	UEndp	
Ozoh, P.T.E., and N.V. Jones. 1990. The Effects of Salinity and Temperature on the Toxicity of Copper to 1-Day and 7-Day-Old Larvae of Hediste (Nereis) diversicolor (O.F.Muller). Ecotoxicol.Environ.Saf. 19(1):24-32.	3197	UEndp, Con	
Pablo, F., R.T. Buckney, and R.P. Lim. 1997. Toxicity of Cyanide, Iron-Cyanide Complexes, and a Blast Furnace Effluent to Larvae of the Doughboy Scallop, Chlamys asperrimus. Bull.Environ.Contam.Toxicol. 58:93-100.	17482	NonRes	
Pace, F., R. Ferrara, and G. Del Carratore. 1977. Effects of Sub-Lethal Doses of Copper Sulphate and Lead Nitrate on Growth and Pigment Composition of Dunaliella salina Teod. Bull.Environ.Contam.Toxicol. 17(6):679-685.	7612	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Pagano, G., M. Cipollaro, G. Corsale, A. Esposito, E. Ragucci, G.G. Giordano, and N.M. Trieff. 1986. The Sea Urchin: Bioassay for the Assessment of Damage from Environmental Contaminants. In: J.Cairns,Jr.(Ed.), Community Toxicity Testing, ASTM STP 920, Philadelphia, PA :66-92.	18937	UEndp	
Park, J.S., and H.G. Kim. 1978. Bioassays on Marine Organisms: Acute Toxicity Test of Mercury, Cadmium and Copper to Arkshell, Anadara broughtonii, From Jin-Dong Bay, and to Oyster,. J.Oceanol.Soc.Korea 13(1):35-43.	8418	Con, Eff, NonRes	ECOTOX provides a 96-h LC50 of 2108 µg/L for this study. When combined with other LC50s for *Crassostrea gigas*, the SMAV is 20.69. This value could have been considered for EPA's evaluation of saltwater copper, but the species is relatively insensitive to copper compared to others. Furthermore, this LC50 is over 10x the original SMAV and can probably be considered an outlier. Note, this test was not used in the 1995 GLI for copper.
Park, J.S., and H.G. Kim. 1979. Bioassays on Marine Organisms. II. Acute Toxicity Test of Mercury, Copper and Cadmium to Clam, Meretrix lusoria. Bull.Korean Fish.Soc.(Han'Guk Susan Halchoiji) 12(2):113-117.	8419	NonRes	
Park, J.S., and H.G. Kim. 1979. Bioassays on Marine Organisms. III. Acute Toxicity Test of Mercury, Copper and Cadmium to Yellowtail, Seriola quinqueradiata and Rock Bream,. Bull.Korean Fish.Soc.(Han'Guk Susan Halchoiji) 12(2):119-123 (Used 8419 for Ref).	8420	NonRes	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Parker, J.G.. 1984. The Effects of Selected Chemicals and Water Quality on the Marine Polychaete Ophryotrocha diadema. Water Res. 18(7):865-868.	10890	Con	
Patel, B., and K. Anthony. 1991. Uptake of Cadmium in Tropical Marine Lamellibranchs, and Effects on Physiological Behaviour. Mar.Biol. 108:457-470.	340	UEndp, Eff, Con	
Patin, S.A., and V.N. Tkachenko. 1974. Effect of Metals on Photosynthesis of Marine Phytoplankton. Biol.Nauki (Mosc.) 17(5):67-69 (RUS).	8669	UEndp, Eff	
Patterson, J., and T.V. Fernandez. 1995. Influence of Salinity on the Total Body Burden of Fish Etroplus maculatus Exposed to Ni, Cu and Their Mixture. Indian J.Mar.Sci. 24(4):211-214.	5344	UEndp	
Paulij, W.P., W. Zurburg, J.M. Denuce, and E.J. Van Hannen. 1990. The Effect of Copper on the Embryonic Development and Hatching of Sepia officinalis L.. Arch.Environ.Contam.Toxicol. 19(5):797-801.	20564	UEndp	
Persoone, G., and G. Uyttersprot. 1975. The Influence of Inorganic and Organic Pollutants on the Rate of Reproduction of a Marine Hypotrichous Ciliate: Euplotes vannus Muller. Rev.Int.Oceanogr.Med. 37-38:125-151.	5922	UEndp	
Pesch and Morgan. 1978.		UEndp, Det	Bioaccum
Pesch, G., N. Stewart, and C. Pesch. 1979. Copper Toxicity to the Bay Scallop (Argopecten irradians). Bull.Environ.Contam.Toxicol. 23(6):759-765.	5287	Eff, Con	1 line of data with a 42d EC50
Peterson, S.M., and J.L. Stauber. 1996. New Algal Enzyme Bioassay for the Rapid Assessment of Aquatic Toxicity. Bull.Environ.Toxicol.Chem. 56(5):750-757.	19926	Dur	1 line of data with a 72hr EC50
Phillips, D.J.H.. 1976. The Common Mussel Mytilus edulis As an Indicator of Pollution by Zinc, Cadmium, Lead and Copper. I. Effects of Environmental Variables on Uptake of. Mar.Biol. 38(1):59-69.	15633	UEndp, Eff	
Phinney, J.T., and K.W. .Bruland. 1994. Uptake of Lipophilic Organic Cu, Cd, and Pb Complexes in the Coastal Diatom Thalassiosira weissflogii. Environ.Sci.Technol. 28(11):1781-1790.	45097	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Phinney, J.T., and K.W. Bruland. 1997. Effects of Dithiocarbamate and 8-Hydroxyquinoline Additions on Algal Uptake of Ambient Copper and Nickel in South San Francisco Bay Water. Estuaries 20(1):66-76.	20300	UEndp	
Pipe, R.K., J.A. Coles, F.M.M. Carissan, and K. Ramanathan. 1999. Copper Induced Immunomodulation in the Marine Mussel, Mytilus edulis. Aquat.Toxicol. 46(1):43-54.	20089	UEndp	
Powell, M.I., and K.N. White. 1989. Influence of the Heavy Metals Copper and Cadmium on the Behaviour of Semibalanus balanoides and Balanus crenatus. Mar.Behav.Physiol. 14(2):115-127.	5438	Dur, Con	
Prabhudeva, K.N., and N.R. Menon. 1990. Metal Interaction During Accumulation in Perna indica. I. Effects of Silver on Copper Accumulation. In: R.Hirano and I.Hanyu (Eds.), Proc.of the 2nd Asian Fisheries Forum, April 17-22, 1989, Tokyo, Japan, Asian Society, Manila, Philippines :951-954 (ABS).	14759	UEndp	
Price, R.K.J., and R.F. Uglow. 1979. Some Effects of Certain Metals on Development and Mortality Within the Moult Cycle of Crangon crangon (L.). Mar.Environ.Res. 2(4):287-299.	8423	Con, LT	
Price, R.K.J., and R.F. Uglow. 1980. Cardiac and Ventilatory Responses of Crangon crangon to Cadmium, Copper and Zinc. Helgol.Wiss.Meeresunters. 33(1/4):59-67.	9879	UEndp, Con	
Pyefinch, K.A., and J.C. Mott. 1948. The Sensitivity of Barnacles and Their Larvae to Copper and Mercury. J.Exp.Biol. 25(3):276-298.	10199	Con, Dur	
Rainbow, P.S., A.G. Scott, E.A. Wiggins, and R.W. Jackson. 1980. Effect of Chelating Agents on the Accumulation of Cadmium by the Barnacle Semibalanus balanoides, and Complexation of Soluble Cd, Zn and Cu. Mar.Ecol.Prog.Ser. 2(2):143-152.	6714	UEndp, Eff	
Rainbow, P.S., and S.L. White. 1989. Comparative Strategies of Heavy Metal Accumulation by Crustaceans: Zinc, Copper and Cadmium in a Decapod, an Amphipod and a Barnacle. Hydrobiologia 174(3):245-262.	18778	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Rainbow, P.S.. 1985. Accumulation of Zn, Cu and Cd by Crabs and Barnacles. Estuar.Coast.Shelf Sci. 21(5):669-686.	9713	UEndp, Eff	
Ralph, P.J., and M.D. Burchett. 1998. Photosynthetic Response of Halophila ovalis to Heavy Metal Stress. Environ.Pollut. 103(1):91-101.	19866	UEndp	
Rao, K.S., and M. Balaji. 1994. Toxicity of Copper to Mytilopsis sallei (Recluz) and Some Aspects of Its Control in Indian Waters. In: M.F.Thompson, R.Nagabhushanam, R.Sarojini, and M.Fingerman (Eds.), Recent Developments in Biofouling Control, Oxford & IBH Publ.Co., New Delhi, India :409-415.	17117	NonRes	
Rao, V.N.R., and G.M. Latheef. 1989. Effect of Copper on Artemia salina Linn. and of Skeletonema costatum (Grev.) Cleve as Feed. Comp.Physiol.Ecol. 14(2):41-48.	9558	UChron, Dur	Brine Shrimp
Rao, Y.P., V.U. Devi, and D.G.V. Rao. 1986. Copper Toxicity in Tropical Barnacles, Balanus amphitrite amphitrite and Balanus tintinnabulum tintinnabulum. Water Air Soil Pollut. 27(1-2):109-115.	11765	UEndp	
Raymont, J., E.G., and J. Shields. 1963. Toxicity of Copper and Chromium in the Marine Environment. Int.J.Air Water Pollut. 7:435-443.	20209	UEndp	
Redpath, K.J.. 1985. Growth Inhibition and Recovery in Mussels (Mytilus edulis) Exposed to Low Copper Concentrations. J.Mar.Biol.Assoc.U.K. 65(2):421-431.	10973	Con	
Reed, R.H., and L. Moffat. 1983. Copper Toxicity and Copper Tolerance in Enteromorpha compressa (L.) Grev. J.Exp.Mar.Biol.Ecol. 69(1):85-103.	11161	UEndp	
Reeve, M.R., G.D. Grice, V.R. Gibson, M.A. Walter, K. Darcy, and T. Ikeda. 1976. A Controlled Environmental Pollution Experiment (CEPEX) and its Usefulness in the Study of Larger Marine Zooplankton Under Toxic Stress. In: Effects of Pollutants on Aquatic Organisms 2:145-162 (U.S.NTIS PB-259395/2ST).	6045	Dur	
Reeve, M.R., M.A. Walter, K. Darcy, and T. Ikeda. 1977. Evaluation of Potential Indicators of Sub-Lethal Toxic Stress on Marine Zooplankton (Feeding, Fecundity, Respiration, and Excretion): Controlled Eco. Bull.Mar.Sci. 27(1):105-113.	6079	Con, UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Regoli, F., E. Orlando, M. Mauri, M. Nigro, and G.A. Cognetti. 1991. Heavy Metal Accumulation and Calcium Content in the Bivalve Donacilla cornea. Mar.Ecol.Prog.Ser. 74(2/3):219-224.	8705	UEndp, Eff	
Reiriz, S., A. Cid, E. Torres, J. Abalde, and C. Herrero. 1994. Different Reponses of the Marine Diatom Phaeodactylum tricornutum to Copper Toxicity. Microbiologia 10(3):263-272.	16173	UEndp	
Reish, D.J., and R.S. Carr. 1978. The Effect of Heavy Metals on the Survival, Reproduction, Development and Life Cycles for Two Species of Polychaetous Annelids. Mar.Pollut.Bull. 9(1):24-27.	8428	UEndp	
Reish, D.J., F. Piltz, J.M. Martin, and J.Q. Word. 1974. Induction of Abnormal Polychaete Larvae by Heavy Metals. Mar.Pollut.Bull. 5(8):125-126.	8635	UEndp, Con	
Rihjstenbil, J.W., F. Dehairs, R. Ehrlich, and J.A. Wijnholds. 1998. Effect of the Nitrogen Status on Copper Accumulation and Pools of Metal-Binding Peptides in the Planktonic Diatom Thalassiosira pseudonana. Aquat.Toxicol. 42(3):187-209.	19145	UEndp	
Rijstenbil, J.W., A. Sandee, J. Van Drie, and J.A. Wijnholds. 1994. Interaction of Toxic Trace Metals and Mechanisms of Detoxification in the Planktonic Diatoms Ditylum brightwellii and Thalassiosira pseudonana. FEMS (Fed.Eur.Microbiol.Soc.) Microbiol.Rev. 14:387-396.	14606	UEndp	
Roesijadi, G.. 1980. Influence of Copper on the Clam Protothaca staminea: Effects on Gills and Occurrence of Copper-Binding Proteins. Biol.Bull. 158(2):233-247.	9888	LT	
Rtal, A., and J.P. Truchot. 1996. Haemolymph Transport and Tissue Accumulation of Exogenous Copper in the Shore Crab, Carcinus maenas. Mar.Pollut.Bull. 32(11):802-811.	19841	UEndp	
Ruiz, J.M., G.W. Bryan, and P.E. Gibbs. 1994. Chronic Toxicity of Water Tributyltin (TBT) and Copper to Spat of the Bivalve Scrobicularia plana: Ecological Implications. Mar.Ecol.Prog.Ser. 113:105-117.	14453	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Ruiz, J.M., G.W. Bryan, G.D. Wigham, and P.E. Gibbs. 1996. Effects of Copper on the 48-H Embryonic Development of the Bivalve Scrobicularia plana. J.Mar.Biol.Assoc.U.K. 76(3):829-832.	9910	UEndp	
Rumbold, D.G., and S.C. Snedaker. 1997. Evaluation of Bioassays to Monitor Surface Microlayer Toxicity in Tropical Marine Waters. Arch.Environ.Contam.Toxicol. 32(2):135-140.	17830	Dur	
Saifullah, S.M.. 1978. Inhibitory Effects of Copper on Marine Dinoflagellates. Mar.Biol. 44(4):299-308.	2260	NonRes	
Saliba, L.J., and M. Ahsanullah. 1973. Acclimation and Tolerance of Artemia salina and Ophryotrocha labronica to Copper Sulphate. Mar.Biol. 23(4):297-302.	5168	UEndp, LT, Dur	
Sanders, B.M., L.S. Martin, S.R. Howe, W.G. Nelson, E.S. Hegre, and D.K. Phelps. 1994. Tissue-Specific Differences in Accumulation of Stress Proteins in Mytilus edulis Exposed to a Range of Copper Concentrations. Toxicol.Appl.Pharmacol. 125(2):206-213.	4978	UEndp, Eff	
Sanders, I.M.. 1984. Sublethal Effects of Copper on Juveniles of the Queen Conch Strombus gigas Linne. J.Shellfish Res. 4(1):31-35.	4249	UEndp	
Sanders, J.G., and G.F. Riedel. 1993. Trace Element Transformation During the Development of an Estuarine Algal Bloom. Estuaries 16(3A):521-532.	13354	Field, UEndp	
Sarasquete, M.C., M.L. Gonzales de Canales, and S. Gimeno. 1992. Comparative Histopathological Alterations in the Diestive Gland of Marine Bivalves Exposed to Cu and Cd. Eur.J.Histochem. 36(2):223-232.	9518	UEndp	
Sasikumar, N., A.S. Clare, D.J. Gerhart, D. Stover, and D. Rittschof. 1995. Comparative Toxicities of Selected Compounds to Nauplii of Balanus amphitrite amphitrite Darwin and Artemia sp.. Bull.Environ.Contam.Toxicol. 54:289-296.	53890	Dur	Brine Shrimp
Sathyanathan, B.. 1996. Kinetics and Mechanism of Tolerance Induction on Acclimation of Villorita cyprinoides (Hanley) to Copper and Zinc. J.Biosci. 21(6):809-818.	20158	Eff, UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Savant, K.B., and G.K. Amte. 1992. Respiratory Response of Estuarine Crab Ilyoplax gangetica Exposed to Three Metallic Chemicals. J.Ecotoxicol.Environ.Monit. 2(4):259-262.	17564	UEndp	
Scott, D.M., and C.W. Major. 1972. The Effect of Copper (II) on Survival, Respiration, and Heart Rate in the Common Blue Mussel, Mytilus edulis. Biol.Bull. 143:679-688.	15476	UEndp	
Seeliger, U., and C. Cordazzo. 1982. Field and Experimental Evaluation of Enteromorpha sp. as a Quali-Quantitative Monitoring Organism for Copper and Mercury in Estuaries. Environ.Pollut.Ser.A Ecol.Biol. 29(3):197-206.	11220	UEndp, Con	
Segner, H., and T. Braunbeck. 1990. Qualitative and Quantitative Assessment of the Response of Milkfish, Chanos chanos, Fry to Low-Level Copper Exposure. In: F.O.Perkins and T.C.Cheng (Eds.), Pathology in Marine Science, Proc.of the 3rd Int.Colloquium on Pathology in Mar.Aquaculture, Oct.2-6, 1988, Gloucester Pt., VA, Academic Press, San Diego, CA :347-368.	4125	UEndp, Eff	
Selvakumar, S., and T.M. Haridasan. 2000. Toxic Effects of Heavy Metals Copper, Zinc, Cadmium and Mercury on the Zoeal Development of Sesarminid Crab Nanosesarma (Beanium) batavicum. J.Environ.Biol. 21(2):101-104.	54052	UEndp	
Selvakumar, S., S.A. Khan, and A.K. Kumaraguru. 1996. Acute Toxicity of Some Heavy Metals, Pesticides and Water Soluble Fractions of Diesel Oil to the Larvae of Some Brachyuran Crabs. J.Environ.Biol. 17(3):221-226.	18580	NonRes	
Shuster, C.N.Jr., and B.H. Pringle. 1969. Trace Metal Accumulation by the American Eastern Oyster, Crassostrea virginica. 1968 Proc.Natl.Shellfish Assoc. 59:91-103.	19929	UEndp, Field	Bioaccum
Snell, T.W., and G. Persoone. 1989. Acute Toxicity Bioassays Using Rotifers. I. A Test for Brackish and Marine Environments with Brachionus plicatilis. Aquat.Toxicol. 14(1):65-80.	3827	Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Sobral, P., L. Castro, H. Costa, and I. Peres. 1995. The Influence of Diet on the Accumulation of Copper and Zinc in the Clam Ruditapes decussatus. Physiological Assessment. In: D.Bellan, G.Bonin, and C.Emig (Eds.), Functioning and Dynamics of Natural and Perturbed Ecosystems, Lavoisier Intercept Ltd., Paris, France :583-591.	19364	Eff, UEndp	
Soria-Dengg, S., and D. Ochavillo. 1990. Comparative Toxicities of Trace Metals on Embryos of the Giant Clam, Tridacna derasa. Asian Mar.Biol. 7:161-166.	20706	UEndp	
Soto, M., and I. Marigomez. 1997. BSD Extent, an Index for Metal Pollution Screening Based on the Metal Content Within Digestive Cell Lysosomes of Mussels as Determined by. Ecotoxicol.Environ.Saf. 37:141-151.	18327	UEndp	
Soto, M., I. Quincoces, X. Lekube, and I. Marigomez. 1998. Autometh allographed Metal Content in Digestive Cells of Winkles: A Cost-Effecive Screening Tool for Monitoring Cu and Zn Pollution. Aquat.Toxicol. 40(2/3):123-140.	18951	UEndp	
Spicer, J.I.. 1995. Effect of Water-Borne Copper on Respiratory and Cardiac Function During the Early Ontogeny of the Brine Shrimp, Artemia franciscana Kellogg 1908. J.Comp.Physiol.B Biochem.Syst.Environ.Physiol. 165(6):490-495.	19536	UEndp	
Staples, L.S., P.F. Shacklock, and J.S. Craigie. 1995. Rapid Growth of Clones of the Red Alga Chondrus crispus: Applications in Assays of Toxic Substances and in Physiological Studies. Mar.Biol. 122(3):471-477.	19429	UEndp	
Stauber, J.L., and T.M. Florence. 1987. Mechanism of Toxicity of Ionic Copper and Copper Complexes to Algae. Mar.Biol. 94(4):511-519.	12971	UEndp	
Stauber, J.L.. 1995. Toxicity Testing Using Marine and Freshwater Unicellular Algae. Aust.J.Ecotoxicol. 1(1):15-24.	19056	Dur	3 lines of data with 72hr EC50 on green algae and diatoms
Stebbing, A.R.D., and V.J.R. Santiago-Fandino. 1983. The Combined and Separate Effects of Copper and Cadmium on the Growth of Campanularia flexuosa (Hydrozoa) Colonies. Aquat.Toxicol. 3(3):183-193.	11562	UEndp	
Stebbing, A.R.D.. 1976. The Effects of Low Metal Levels on a Clonal Hydroid. J.Mar.Biol.Assoc.U.K. 56(4):977-994.	15641	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Stephenson, R.R., and D. Taylor. 1975. The Influence of EDTA on the Mortality and Burrowing Activity of the Clam (Venerupis decussata) Exposed to Sub-Lethal Concentrations of Copper. Bull.Environ.Contam.Toxicol. 14(3):304-308.	8223	UEndp	
Stroemgren, T.. 1980. The Effect of Dissolved Copper on the Increase in Length of Four Species of Intertidal Fucoid Algae. Mar.Environ.Res. 3(1):5-13.	9901	UEndp, Con	
Stromgren, T., and M.V. Nielsen. 1991. Spawning Frequency, Growth and Mortality of Mytilus edulis Larvae, Exposed to Copper and Diesel Oil. Aquat.Toxicol. 21:171-180.	3857	UChron	1 line of data with a 30d EC50
Stromgren, T.. 1982. Effect of Heavy Metals (Zn, Hg, Cu, Cd, Pb, Ni) on the Length Growth of Mytilus edulis. Mar.Biol. 72(1):69-72.	10899	UEndp	
Stromgren, T.. 1986. The Combined Effect of Copper and Hydrocarbons on the Length Growth of Mytilus edulis. Mar.Environ.Res. 19:251-258.	45177	UEndp	
Subramanian, A., B.R. Subramanian, and V.K. Venugopalan. 1980. Toxicity of Copper and Zinc on Cultures of Skeletonema costatum (Grev.) Cleve and Nitzschia longissima. Curr.Sci. 49(7):266-268.	9903	UEndp	
Sullivan, B.K., and P.J. Ritacco. 1988. Effects of Nutrients and Copper on Copepod Population Dynamics: A Mesocosm Study. Adv.Environ.Sci.Technol. 21:335-357.	13124	Field, UEndp	
Sunila, I., and R. Lindstrom. 1985. The Structure of the Interfilamentar Junction of the Mussel (Mytilus edulis L.) Gill and its Uncoupling by Copper and Cadmium Exposures. Comp.Biochem.Physiol.C 81(2):267-272.	11224	UEndp, Con	
Sunila, I.. 1981. Toxicity of Copper and Cadmium to Mytilus edulis L. (Bivalvia) in Brackish Water. Ann.Zool.Fenn. 18:213-223.	15791	Dur	
Syasina, I.G., M.A. Vaschenko, and V.B. Durkina. 1992. Histopathological Changes in the Gonads of Sea Urchins Exposed to Heavy Metals. Russ.J.Mar.Biol.(Eng Transl) of Biol.Morya (4):79-89 (Vladivostok) 17:244-251.	19065	UEndp	
Tadros, M.G., P. Mbuthia, and W. Smith. 1990. Differential Response of Marine Diatoms to Trace Metals. Bull.Environ.Contam.Toxicol. 44(6):826-831.	18878	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Targett, N.M., and W.R. Stochaj. 1994. Natural Antifoulants and Their Analogs: Applying Nature's Defense Strategies to Problems of Biofouling Control. In: M.F.Thompson, R.Nagabhushanam, R.Sarojini, and M.Fingerman (Eds.), Recent Developments in Biofouling Control, Oxford & IBH Publ.Co., New Delhi, India :221-228.	16469	UEndp	
Thomas, A.. 1915. Effects of Certain Metallic Salts upon Fishes. Trans.Am.Fish.Soc. 44:120-124.	2865	UEndp, Dur	
Thomsen, J.P.. 1980. A Study on the Possible Association of Copper Pollution with Vibriosis in Eel. Nord.Vet.Med. 30:90-95.	10209	UEndp, Con	
Thurberg, F.P., M.A. Dawson, and R.S. Collier. 1973. Effects of Copper and Cadmium on Osmoregulation and Oxygen Consumption in Two Species of Estuarine Crabs. Mar.Biol. 23(3):171-175.	8732	UEndp,Con	
Torres, P., L. Tort, and R. Flos. 1987. Acute Toxicity of Copper to Mediterranean Dogfish. Comp.Biochem.Physiol.C 86(1):169-171.	12386	Dur	1 line with 48hr LC50 data
Valente, R.M., E.M. Cosper, and C.F. Wurster. 1987. Interactive Effects of Copper and Silicic Acid on Resting Spore Formation and Viability in a Marine Diatom. J.Phycol. 23(1):156-163.	4380	UEndp	
Vedel, G.R., and M.H. Depledge. 1995. Stress-70 Levels in the Gills of Carcinus maenas Exposed to Copper. Mar.Pollut.Bull. 31(1-3):84-86.	18722	UEndp	
Verma, S.R., S.K. Bansal, and R.C. Dalela. 1978. Toxicity of Selected Organic Pesticides to a Fresh Water Teleost Fish, Saccrobranchus fossilis and its Application in Controlling Water Pollution. Arch.Environ.Contam.Toxicol. 7(3):317-323.	661	UEndp	
Verriopoulos, G., and M. Moraitou-Apostolopoulou. 1982. Differentiation of the Sensitivity to Copper and Cadmium in Different Life Stages of a Copepod. Mar.Pollut.Bull. 13(4):123-125.	11097	NonRes	
Verriopoulos, G., M. Moraitou-Apostolopoulou, and E. Milliou. 1987. Combined Toxicity of Four Toxicants (Cu, Cr, Oil, Oil Dispersant) to Artemia salina. Bull.Environ.Contam.Toxicol. 38(3):483-490.	9336	Con	Brine Shrimp

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Verriopoulos, G.. 1992. Effects of Sublethal Concentrations of Zinc, Chromium and Copper on the Marine Copepods Tisbe holothuriae and Acartia clausi. In: G.P.Gabrielides (Ed.), Proc.of the FAO/UNEP/IOC Workshop on the Biological Effects of Pollutants on Marine Organisms, Malta, 10-14 Sept., 1991, UNEP, Athens, Greece, MAP Tech.Rep.Ser.No.69 :265-275.	4091	UEndp	
Viarengo, A., G. Zanicchi, M.N. Moore, and M. Orunesu. 1981. Accumulation and Detoxication of Copper by the Mussel Mytilus galloprovinicialis Lam.: A Study of the Subcellular Distribution in the Digestive. Aquat.Toxicol. 1(3/4):147-157.	15415	UEndp	
Viarengo, A., L. Canesi, M. Pertica, G. Poli, M.N. Moore, and M. Orunesu. 1990. Heavy Metal Effects on Lipid Peroxidation in the Tissues of Mytilus galloprovincialis Lam. Comp.Biochem.Physiol.C 97(1):37-42.	78	UEndp, Eff	
Viarengo, A., M. Pertica, G. Mancinelli, B. Burlando, L. Canesi, and M. Orunesu. 1996. In Vivo Effects of Copper on the Calcium Homeostasis Mechanisms of Mussel Gill Cell Plasma Membranes. Comp.Biochem.Physiol.C 113(3):421-425.	16858	UEndp	
Vogt, G., and E.T. Quinitio. 1994. Accumulation and Excretion of Metal Granules in the Prawn, Penaeus monodon, Exposed to Water-Borne Copper, Lead, Iron and Calcium. Aquat.Toxicol. 28(3/4):223-241.	16561	UEndp	
Vranken, G., C. Tire, and C. Heip. 1988. The Toxicity of Paired Metal Mixtures to the Nematode Monhystera disjuncta (Bastian, 1865). Mar.Environ.Res. 26(3):161-179.	2801	Eff	
Wang, J., M. Zhang, J. Xu, and Y. Wang. 1995. Reciprocal Effect of Cu, Cd, Zn on a Kind of Marine Alga. Water Res. 29(1):209-214.	13720	UEndp	
Warnau, M., M. Iaccarino, A. De Biase, A. Temara, M. Jangoux, P. Dubois, and G. Pagano. 1996. Spermiotoxicity and Embryotoxicity of Heavy Metals in the Echinoid Paracentrotus lividus. Environ.Toxicol.Chem. 15(11):1931-1936.	17368	Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Waterman, A.J.. 1937. Effect of Salts of Heavy Metals on Development of the Sea Urchin, Arbacia punctulata. Biol.Bull. 73(3):401-420.	17763	UEndp	
Watling, H.R., and R.J. Watling. 1983. Sandy Beach Molluscs As Possible Bioindicators of Metal Pollution 2. Laboratory Studies. Bull.Environ.Contam.Toxicol. 31(3):339-343.	10862	UEndp	
Watling, H.R.. 1983. Accumulation of Seven Metals by Crassostrea gigas, Crassostrea margaritacea, Perna perna, and Choromytilus meridionalis. Bull.Environ.Contam.Toxicol. 30(3):317-322.	7374	UEndp, Eff	
Watling, H.R.. 1983. Comparative Study of the Effects of Metals on the Settlement of Crassostrea gigas. Bull.Environ.Contam.Toxicol. 31(3):344-351.	11098	UEndp, Con	
Weber, R.E., A. De Zwaan, and A. Bang. 1992. Interactive Effects of Ambient Copper and Anoxic, Temperature and Salinity Stress on Survival and Hemolymph and Muscle Tissue Osmotic Effectors in. J.Exp.Mar.Biol.Ecol. 159(2):135-156.	7501	UChron, Dur	
Weeks, J.M., and P.S. Rainbow. 1991. The Uptake and Accumulation of Zinc and Copper from Solution by Two Species of Talitrid Amphipods (Crustacea). J.Mar.Biol.Assoc.U.K. 71(4):811-826.	3628	UEndp, Eff	
Weis, P.. 1984. Metallothionein and Mercury Tolerance in the Killifish, Fundulus heteroclitus. Mar.Environ.Res. 14(1-4):153-166.	11357	UEndp	
White, S.L., and P.S. Rainbow. 1982. Regulation and Accumulation of Copper, Zinc and Cadmium by the Shrimp Palaemon elegans. Mar.Ecol.Prog.Ser. 8(1):95-101.	9120	UEndp	
Wikfors, G.H., and R. Ukeles. 1982. Growth and Adaptation Estuarine Unicellular Algae in Media with Excess Copper, Cadmium or Zinc, and Effects of Metal-Contaminated Algal Food on. Mar.Ecol.Prog.Ser. 7:191-206.	15508	UEndp, Con	
Wilson, R.W., and E.W. Taylor. 1993. Differential Responses to Copper in Rainbow Trout (Oncorhynchus mykiss) Acclimated to Sea Water and Brackish Water. J.Comp.Physiol.B Biochem.Syst.Environ.Physiol. 163(3):239-246.	4741	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Wilson, W.B., and L.R. Freeburg. 1980. Toxicity of Metals to Marine Phytoplankton Cultures. EPA-600/3-80-025, U.S.EPA, Narragansett, RI :110 p.(U.S.NTIS PB80-182843).	5557		Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Wong, C.K., J.K.Y. Cheung, and K.H. Chu. 1995. Effects of Copper on Survival, Development and Growth of Metapenaeus ensis Larvae and Postlarvae (Decapoda: Penaeidae). Mar.Pollut.Bull. 31(4-12):416-419.	18436	UEndp	
Wong, C.K., K.H. Chu, K.W. Tang, T.W. Tam, and L.J. Wong. 1993. Effects of Chromium, Copper and Nickel on Survival and Feeding Behaviour of Metapenaeus ensis Larvae and Postlarvae (Decapoda: Penaeidae). Mar.Environ.Res. 36(2):63-78.	4127	NonRes	
Wong, P.P.K., L.M. Chu, and C.K. Wong. 1999. Study of Toxicity and Bioaccumulation of Copper in the Silver Sea Bream Sparus sarba. Environ.Int. 25(4):417-422.	20630	NonRes	
Wright, D.A., and C.D. Zamuda. 1987. Copper Accumulation by Two Bivalve Molluscs: Salinity Effect is Independent of Cupric Ion Activity. Mar.Environ.Res. 23(1):1-14.	9147	UEndp	
Wright, D.A., and C.D. Zamuda. 1991. Use of Oysters as Indicators of Copper Contamination in the Patuxent River, Maryland. Hydrobiologia 222:39-48.	5233	UEndp	
Wright, D.A.. 1986. Trace Metal Uptake and Sodium Regulation in Gammarus marinus From Metal Polluted Estuaries in England. J.Mar.Biol.Assoc.U.K. 66(1):83-92.	5405	UEndp, Eff, Con	
Wu, Z., and G. Chen. 1988. Studies of Acute Intoxication by Some Harmful Substances on Penaeus orientalis K. Mar.Sci./Haiyang Kexue (4):36-40 (CHI) (ENG ABS).	3232	NonRes	
Young, J.S., R.L. Buschbom, J.M. Gurtisen, and S.P. Joyce. 1979. Effects of Copper on the Sabellid Polychaete, Eudistylia vancouveri: I. Concentration Limits for Copper Accumulation. Arch.Environ.Contam.Toxicol. 8(1):97-106.	15581	UEndp	Bioaccum

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment(s)
Young, J.S., R.R. Adee, I. Piscopo, and R.L. Buschbom. 1981. Effects of Copper on the Sabellid Polychaete, Eduistylia vancouveri. II. Copper Accumulation and Tissue Injury in the Brachil Crown. Arch.Environ.Contam.Toxicol. 10(1):87-104.	9510	UEndp	
Yuan, Y.X., C.N. Gao, and D.X. Zhang. 1992. Egg Hatching and Metamorphosis to Protozoea of Penaeus chinensis (Osbeck) by Removal of Heavy Metals from Rearing Systems with Polymeric Absorbent. Aquaculture 107:303-311.	7425	UEndp, Dur	
Zaroogian, G.E., and M. Johnson. 1983. Copper Accumulation in the Bay Scallop, Argopecten irradians. Arch.Environ.Contam.Toxicol. 12(2):127-133.	12988	UEndp	Bioaccum
Zolotukhina, E.Y., E.E. Gavrilenko, and K.S. Burdin. 1987. Effect of Zinc and Copper Ions on Photosynthesis and Respiration of Marine Macroalgae. Soviet Plant Physiol.(Eng.Trans.Fiziol.Rast.) 34(2):212-220.	6673	UEndp, Eff	

C. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[93], EPA is providing a transparent rationale as to why they were not utilized (see below).

For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable.

<u>General QA/QC failure because non-resident species in Oregon</u>

[93] U.S. EPA. 1995. Ambient Water Quality Criteria – Saltwater Copper Addendum. U.S. EPA, Narragansett, RI.

Tests with the following species were used in the EPA BE of OR WQS for copper in saltwater, but were not considered in the CWA review and approval/disapproval action of the standards because these species do not have a breeding wild population in Oregon's waters:

Isognomon	*californicum*	Purse oysters	Ringwood 1992
Crassostrea	*virginica*	Eastern oyster	MacInnes and Calabrese 1978; Calabarese et al. 1973
Crassostrea	*rhizophorae*	Mangrove oyster	Chung 1980
Crassostrea	*madrasensis*	Oyster	Kumaraguru and Ramamoorthi 1978
Crassostrea	*cucullata*	Oyster	Watling 1982
Mytilus	*galloprovincialis*	Mediterranean mussel	Taneeva 1973

<u>Other Acute tests failing QA/QC by species</u>

Mytilus spp. – Mussel

City of San Jose. 1998. Toxicities of ten metals to *Crassostrea gigas* and *Mytilus edulis* embryos and *Cancer magister* larvae. Mar. Pollut. Bull. 12(9): 305-308 (Author Communication Used).
These values were determined to be for *Mytilus edulis* and used for that species.

Harrison, F.L. 1985. Effect of physicochemical form on copper availability to aquatic organisms. In: R.D. Cardwell, R. Purdy, and R.C. Bahner (Eds.), Aquatic Toxicology and Hazard Assessment, 7th Symposium, ASTM STP 854, Philadelphia, PA: 469-484.
This test was not used for determining the most representative SMAV in this CWA review and approval/disapproval action of these standards because a more sensitive lifestage was available.

Mytilus edulis – Common bay mussel, blue mussel

Nelson, D.A., J.E. Miller and A. Calabrese. 1988. Effect of heavy metals on bay scallops, surf clams, and blue mussels in acute and long-term exposures. Arch. Environ. Contam. Toxicol. 17(5): 595-600.
This test was not used for determining the most representative SMAV in this CWA review and approval/disapproval action of these standards because a more sensitive lifestage was available.

ToxScan. 1991a. Toxicities of ten metals to *Crassostrea gigas* and *Mytilus edulis* embryos and *Cancer magister* larvae. Mar. Pollut. Bull. 12(9): 305-308 (Author Communication Used).
Listed as *Mytilus edulis* in the 1995 Saltwater Addendum and used to calculate ALC SMAV in the 1995 Saltwater Copper Addendum; not used for WA 3-18 because this value was re-calculated as an IC50 using measured concentrations for low, med and high concentrations, and interpolated concentrations in between. Some data from this study was used.

***Paralichthys dentatus* – Summer flounder**

Cardin, J.A. 1985. Results of Acute Toxicity Tests Conducted with Copper at ERL, Narragansett. U.S. EPA, Narragansett, RI: 10 p.
This test was not used for determining the most representative SMAV in this CWA review and approval/disapproval action of these standards because a more sensitive lifestage was available.

CH2M Hill 1999. Bioassay Report Acute Toxicity of Copper to Summer Flounder (*Paralichthys dentatus*). Prepared for U.S. Navy, Norfolk, VA.
This test was not used for determining the most representative SMAV in this CWA review and approval/disapproval action of these standards because a more sensitive lifestage was available.

***Mulinia lateralis* – Clam**

Ho, M.S. and P.L. Zubkoff. 1982. The effects of mercury, copper, and zinc on calcium uptake by larvae of the clam, *Mulinia lateralis*. Water Air Soil Pollut. 17(4): 409-414.
This test was not used for determining the most representative SMAV in this CWA review and approval/disapproval action of these standards because of excessive control mortality.

<u>Other Chronic tests failing QA/QC by species</u>

***Mytilus trossulus* – Pacific mussel**

Karaseva, E.M. and L.A. Medvedeva. 1993. Morphological and functional changes in the offspring of *Mytilus trossulus* and *Mizuhopecten yessoensis* after parental exposure to copper and zinc. Russ. J. Mar. Biol. 19(4): 276-280; Biol. Morya (Vladivost) (4): 83-89 (RUS).

This test was not used in this CWA review and approval/disapproval action of these standards because it was not a life-cycle test.

Appendix Q Lead (Saltwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comments
Alcutt, F., and J.T. Pinto. 1994. Glutathione Concentrations in the Hard Clam, Mercenaria mercenaria, Following Laboratory Exposure to Lead (a Potential Model System for Evaluating. Comp.Biochem.Physiol.C 107(3):347-352.	14073	UEndp	
Almeida, M.J., G. Moura, T. Pinheiro, J. Machado, and J. Coimbra. 1998. Modifications in Crassostrea gigas Shell Composition Exposed to High Concentrations of Lead. Aquat.Toxicol. 40(4):323-334.	17349	UEndp	
Benijts-Claus, C., and F. Benijts. 1975. The Effect of Low Lead and Zinc Concentrations on the Larval Development of the Mud-Crab Rhithropanopeus harrisii Gould. In: J.H.Koeman and J.J.T.W.A.Strik (Eds.), Sublethal Effects of Toxic Chemicals on Aquat.Animals, Elsevier Sci.Publ., Amsterdam, NY :43-52.	15451	UEndp	
Blasco, J., and J. Puppo. 1999. Effect of Heavy Metals (Cu, Cd and Pb) on Aspartate and Alanine Aminotransferase in Ruditapes phillippinarum (Mollusca: Bivalvia). Comp.Biochem.Physiol.C 122(2):253-263.	20072	Eff	
Brown, B., and M. Ahsanullah. 1971. Effect of Heavy Metals on Mortality and Growth. Mar.Pollut.Bull. 2:182-187.	2467	LT	
Burdin, K.S., and K.T. Bird. 1994. Heavy Metal Accumulation by Carrageenan and Agar Producing Algae. Bot.Mar. 37:467-470.	45156	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comments
Canli, M., and R.W. Furness. 1993. Toxicity of Heavy Metals Dissolved in Sea Water and Influences of Sex and Size on Metal Accumulation and Tissue Distribution in the Norway Lobster. Mar.Environ.Res. 36(4):217-236.	4563	UEndp	
Canterford, G.S., A.S. Buchanan, and S.C. Ducker. 1978. Accumulation of Heavy Metals by the Marine Diatom Ditylum brightwellii (West) Grunow. Aust.J.Mar.Freshwater Res. 29(5):613-622.	15455	UEndp	
Chinni, S., R.N. Khan, and P.R. Yallapragada. 2000. Oxygen Consumption, Ammonia-N Excretion, and Metal Accumulation in Penaeus indicus Postlarvae Exposed to Lead. Bull.Environ.Contam.Toxicol. 64(1):144-151.	48202	UEndp	
Congiu, A.M., E. Calendi, and G. Ugazio. 1984. Effects of Metal Ions and CCl4 on Sea Urchin Embryo (Paracentrotus lividus). Res.Commun.Chem.Pathol.Pharmacol. 43(2):317-323.	625	UEndp	
Cui, K., Y. Liu, and L. Hou. 1987. . .	3222	NonRes	
Denton, G.R.W., and C. Burdon-Jones. 1981. Influence of Temperature and Salinity on the Uptake, Distribution and Depuration of Mercury, Cadmium and Lead by the Black-Lip Oyster Saccostrea echinata. Mar.Biol. 64:317-326.	14335	UEndp	
Denton, G.R.W., and C. Burdon-Jones. 1986. . .	4327	NonRes	
Domouhtsidou, G.P., and V.K. Dimitriadis. 2000. Ultrastructural Localization of Heavy Metals (Hg,Ag,Pb, and Cu) in Gills and Digestive Gland of Mussels, Mytilus galloprovincialis (L.). Arch.Environ.Contam.Toxicol. 38(4):472-478.	48771	UEndp	
Eldon, J., M. Pekkarinen, and R. Kristoffersson. 1980. Effects of Low Concentrations of Heavy Metals on the Bivalve Macoma balthica. Ann.Zool.Fenn. 17:233-242.	17309	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comments
Elliott, N.G., R. Swain, and D.A. Ritz. 1985. The Influence of Cyclic Exposure on the Accumulation of Heavy Metals by Mytilus edulis planulatus (Lamarck). Mar.Environ.Res. 15(1):17-30.	11669	UEndp	
Fernandez Leborans, G., Y.O. Herrero, and A. Novillo. 1998. Toxicity and Bioaccumulation of Lead in Marine Protozoa Communities. Ecotoxicol.Environ.Saf. 39(3):172-178.	19269	UEndp	
Fernandez-Leborans, G., and A. Novillo. 1992. Hazard Evaluation of Lead Effects Using Marine Protozoan Communities. Aquat.Sci. 54(2):128-140.	6208	UEndp	
Fernandez-Leborans, G., and A. Novillo. 1994. Effects of Periodic Addition of Lead on a Marine Protistan Community. Aquat.Sci. 56(3):191-205.	14135	UEndp	
Fisher, N.S., V.T. Breslin, and M. Levandowsky. 1995. Accumulation of Silver and Lead in Estuarine Microzooplankton. Mar.Ecol.Prog.Ser. 116(1-3):207-215.	17381	Eff	
Gould, E., and R.A. Greig. 1983. Short-Term Low-Salinity Response in Lead-Exposed Lobsters, Homarus americanus (Milne Edwards). J.Exp.Mar.Biol.Ecol. 69:283-295.	14609	UEndp	
Gray, J.S., and R.J. Ventilla. 1973. Growth Rates of Sediment-Living Marine Protozoan as a Toxicity Indicator for Heavy Metals. Ambio 2(4):118-121.	6355	UEndp	
Gray, J.S.. 1974. Synergistic Effects of Three Heavy Metals on Growth Rates of a Marine Ciliate Protozoan. In: F.J.Vernberg and W.B.Vernberg (Eds.), Pollution and Physiology of Marine Organisms, Academic Press, NY :465-485.	8558	UEndp	
Haglund, K., M. Bjorklund, S. Gunnare, A. Sandberg, U. Olander, and M. Pedersen. 1996. . .	18453	NonRes	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comments
Haritonidis, S.. 1985. Uptake of Cd, Zn, Cu and Pb by Marine Macrophyceae Under Culture Conditions. Mar.Environ.Res. 17(2-4):198-199.	6414	UEndp	
Hessler, A.. 1975. The Effects of Lead on Algae. II. Mutagenesis Experiments on Platymonas sabcordiformis (Chlorophyta: Volvocales). Mutat.Res. 31(1):43-47.	15840	UEndp	
Hollibaugh, J.T., D.L.R. Seibert, and W.H. Thomas. 1980. A Comparison of the Acute Toxicities of Ten Heavy Metals to Phytoplankton From Saanich Inlet, B.C., Canada. Estuar.Coast.Mar.Sci. 10(1):93-105.	5282	UEndp	
Ikuta, K.. 1987. Localization of Heavy Metals in the Viscera and the Muscular Tissues of Haliotis discus Exposed to Selected Metal Concentration Gradients. Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 53(12):2269-2274.	3215	UEndp	
Ithack, E., and C.P. Gopinathan. 1995. The Effect of Heavy Metals on the Physiological Changes of Microalgae. Cmfri Spec.Publ. 61:45-52.	19399	UEndp	
Itow, T., R.E. Loveland, and M.L. Botton. 1998. Developmental Abnormalities in Horseshoe Crab Embryos Caused by Exposure to Heavy Metals. Arch.Environ.Contam.Toxicol. 35(1):33-40.	19470	UEndp	
Itow, T., T. Igarashi, M.L. Botton, and R.E. Loveland. 1998. Heavy Metals Inhibit Limb Regeneration in Horseshoe Crab Larvae. Arch.Environ.Contam.Toxicol. 35(3):457-463.	20180	UEndp	
Karbe, L.. 1972. Marine Hydroids as Test Organisms for Assessing the Toxicity of Water Pollutants. The Effect of Heavy Metals on Colonies of Eirene viridula. Mar.Biol. 12(4):316-328 (GER) (ENG ABS).	15654	UEndp	
Khan, I.A., and P. Thomas. 2000. Lead and Aroclor 1254 Disrupt Reproductive Neuroendocrine Function in Atlantic Croaker. Mar.Environ.Res. 50:119-123.	56608	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comments
Lakshmanan, P.T., and P.N.K. Nambisan. 1989. Bioaccumulation and Depuration of Some Trace Metals in the Mussel, Perna viridis (Linnaeus). Bull.Environ.Contam.Toxicol. 43(1):131-138.	3240	Eff	
Lorenzon, S., M. Francese, and E.A. Ferrero. 2000. . .	51641	NonRes	
Lussier, S.M., W.S. Boothman, S. Poucher, D. Champlin, and A. Helmstetten. 1999. Comparison of Dissolved and Total Metals Concentrations from Acute Tests with Saltwater Organisms. Environ.Toxicol.Chem. 18(5):889-898.	51695	UEndp	
Mathew, R., and N.R. Menon. 1983. Oxygen Consumption in Tropical Bivalves Perna viridis (Linn.) and Meretrix casta (Chem.) Exposed to Heavy Metals. Indian J.Mar.Sci. 12(1):57-59.	11085	UEndp	
Odzak, N., and T. Zvonaric. 1995. Cadmium and Lead Uptake from Food by the Fish Dicentrarchus labrax. Water Sci.Technol. 32(9/10):49-55.	18263	UEndp	
Odzak, N., D. Martincic, T. Zvonaric, and M. Branica. 1994. Bioaccumulation Rate of Cd and Pb in Mytilus galloprovincialis Foot and Gills. Mar.Chem. 46(1/2):119-131.	16644	UEndp	
Okamoto, O.K., L. Shao, J.W. Hastings, and P. Colepicolo. 1999. Acute and Chronic Effects of Toxic Metals on Viability, Encystment and Bioluminescence in the Dinoflagellate Gonyaulax polyedra. Comp.Biochem.Physiol.C 123(1):75-83.	20347	UEndp	
Parker, J.G.. 1984. The Effects of Selected Chemicals and Water Quality on the Marine Polychaete Ophryotrocha diadema. Water Res. 18(7):865-868.	10890	Dur	A 48hr LC50 for a Polychaete
Persoone, G., and G. Uyttersprot. 1975. The Influence of Inorganic and Organic Pollutants on the Rate of Reproduction of a Marine Hypotrichous Ciliate: Euplotes vannus Muller. Rev.Int.Oceanogr.Med. 37-38:125-151.	5922	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comments
Phillips, D.J.H.. 1976. The Common Mussel Mytilus edulis As an Indicator of Pollution by Zinc, Cadmium, Lead and Copper. I. Effects of Environmental Variables on Uptake of. Mar.Biol. 38(1):59-69.	15633	UEndp	
Phinney, J.T., and K.W. .Bruland. 1994. Uptake of Lipophilic Organic Cu, Cd, and Pb Complexes in the Coastal Diatom Thalassiosira weissflogii. Environ.Sci.Technol. 28(11):1781-1790.	45097	UEndp	
Prakash, N.T., and K.S.J. Rao. 1995. Modulations in Antioxidant Enzymes in Different Tissues of Marine Bivalve Perna viridis During Heavy Metal Exposure. Mol.Cell.Biochem. 146(2):107-113.	17902	UEndp	
Pringle, B.H., D.E. Hissong, E.L. Katz, and S.T. Mulawka. 1968. Trace Metal Accumulation by Estuarine Mollusks. J.Sanit.Eng.Div.Proc.Am.Soc.Civ.Eng. 94:455-475.	58894	UEndp	
Ralph, P.J., and M.D. Burchett. 1998. Photosynthetic Response of Halophila ovalis to Heavy Metal Stress. Environ.Pollut. 103(1):91-101.	19866	UEndp	
Reish, D.J., and R.S. Carr. 1978. The Effect of Heavy Metals on the Survival, Reproduction, Development and Life Cycles for Two Species of Polychaetous Annelids. Mar.Pollut.Bull. 9(1):24-27.	8428	UEndp	
Rivkin, R.B.. 1979. Effects of Lead on Growth of the Marine Diatom Skeletonema costatum. Mar.Biol. 50:239-247.	58891	Dur, UChron	
Schulz-Baldes, M., and R.A. Lewin. 1976. Lead Uptake in Two Marine Phytoplankton Organisms. Biol.Bull. 150(1):118-127.	2244	UEndp	
Schulz-Baldes, M.. 1974. Lead Uptake From Sea Water and Food, and Lead Loss in the Common Mussel Mytilus edulis. Mar.Biol. 25(3):177-193.	8707	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comments
Soria-Dengg, S., and D. Ochavillo. 1990. Comparative Toxicities of Trace Metals on Embryos of the Giant Clam, Tridacna derasa. Asian Mar.Biol. 7:161-166.	20706	UEndp	
Stroemgren, T.. 1980. The Effect of Lead, Cadmium, and Mercury on the Increase in Length of Five Intertidal Fucales. J.Exp.Mar.Biol.Ecol. 43(2):107-119.	9902	UEndp	
Stromgren, T.. 1980. The Effect of Lead, Cadmium, and Mercury on the Increase in Length of Five Intertidal Fucales. J.Exp.Mar.Biol.Ecol. 43:107-119.	19931	UEndp	
Stromgren, T.. 1982. Effect of Heavy Metals (Zn, Hg, Cu, Cd, Pb, Ni) on the Length Growth of Mytilus edulis. Mar.Biol. 72(1):69-72.	10899	UEndp	
Sun, Y., and C. Chen. 1988. Effects of Hg, Zn, Pb on Embryonic Development of Black Progy, Sparus macrocephalus Basilewsky. Mar.Sci./Haiyang Kexue (3):54-57 (CHI) (ENG ABS).	3371	UEndp	
Tan, W.H., and L.H. Lim. 1984. The Tolerance to and Uptake of Lead in the Green Mussel, Perna viridis (L.). Aquaculture 42(3-4):317-332.	10857	Eff, Dur	Has two 7d LC50's for green mussels
Thomas, P.. 1988. Reproductive Endocrine Function in Female Atlantic Croaker Exposed to Pollutants. Mar.Environ.Res. 24(1-4):179-183.	13127	UEndp	
Thomas, P.. 1990. Teleost Model for Studying the Effects of Chemicals on Female Reproductive Endocrine Function. J.Exp.Zool.(Suppl. 4):126-128.	8682	UEndp	
Tolba, M.R., A.E. Hagras, and A. Hilmy. 1995. Effect of Some Heavy Metals on the Growth of Sphaeroma serratum (Crustacea: Isopoda). J.Environ.Sci. 10(1):219-231.	45118	UEndp	
Udoidiong, O.M., and P.M. Akpan. 1991. . .	8515	NonRes	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comments
Varanasi, U., and D. Markey. 1978. Uptake and Release of Lead and Cadmium in Skin and Mucus of Coho Salmon (Oncorhynchus kisutch). Comp.Biochem.Physiol.60C:187-191 (1978) / Fed.Proc. 36(3):772 (ABS) (1977) (Author Communication Used).	15121	Eff	
Varanasi, U.. 1978. Biological Fate of Metals in Fish. In: D.A.Wolfe (Ed.), Marine Biological Effects of OCS Petroleum Development, NOAA ERL, Boulder, CO :41-53.	5209	Eff, UEndp	
Vogt, G., and E.T. Quinitio. 1994. Accumulation and Excretion of Metal Granules in the Prawn, Penaeus monodon, Exposed to Water-Borne Copper, Lead, Iron and Calcium. Aquat.Toxicol. 28(3/4):223-241.	16561	UEndp	
Watling, H.R., and R.J. Watling. 1983. Sandy Beach Molluscs As Possible Bioindicators of Metal Pollution 2. Laboratory Studies. Bull.Environ.Contam.Toxicol. 31(3):339-343.	10862	UEndp	
Watling, H.R.. 1983. Accumulation of Seven Metals by Crassostrea gigas, Crassostrea margaritacea, Perna perna, and Choromytilus meridionalis. Bull.Environ.Contam.Toxicol. 30(3):317-322.	7374	UEndp	
Watling, H.R.. 1983. Comparative Study of the Effects of Metals on the Settlement of Crassostrea gigas. Bull.Environ.Contam.Toxicol. 31(3):344-351.	11098	UEndp	
Weis, J.S.. 1976. Effects of Mercury, Cadmium, and Lead Salts on Regeneration and Ecdysis in the Fiddler Crab, Uca pugilator. Fish.Bull. 74(2):464-467.	8044	UEndp	
Weis, P., and J.S. Weis. 1982. Toxicity of Methylmercury, Mercuric Chloride, and Lead in Killifish (Fundulus heteroclitus) From Southampton, New York. Environ.Res. 28(2):364-374.	15614	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comments
Woolery, M.L., and R.A. Lewin. 1976. The Effects of Lead on Algae IV . Effects of Pb on Respiration and Photosynthesis of Phaeodactylum tricornutum (Bacillariophyceae). Water Air Soil Pollut. 6(1):25-31.	15972	UEndp	
Wu, Z., and G. Chen. 1988. . .	3232	NonRes	
Yan, T., L.H. Teo, and Y.M. Sin. 1997. Effects of Mercury and Lead on Tissue Glutathione of the Green Mussel, Perna viridis L. Bull.Environ.Contam.Toxicol. 58:845-850.	17980	UEndp	
Yuan, Y.X., C.N. Gao, and D.X. Zhang. 1992. Egg Hatching and Metamorphosis to Protozoea of Penaeus chinensis (Osbeck) by Removal of Heavy Metals from Rearing Systems with Polymeric Absorbent. Aquaculture 107:303-311.	7425	UEndp	24hr only
Zaroogian, G.E., G. Morrison, and J.F. Heltshe. 1979. Crassostrea virginica as an Indicator of Lead Pollution. Mar.Biol. 52(2):189-196.	15704	UEndp	
Zimmermann, S., B. Sures, and H. Taraschewski. 1999. Experimental Studies on Lead Accumulation in the Eel-Specific Endoparasites Anguillicola crassus (Nematoda) and Paratenuisentis ambiguus (Acanthocephala) as Compared with Their Host, Anguilla anguilla. Arch.Environ.Contam.Toxicol. 37(2):190-195.	20449	UEndp	

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[94], EPA is providing a transparent rationale as to why they were not utilized (see below).

For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable.

General QA/QC failure because non-resident species in Oregon

Tests with the following species were used in the EPA BE of OR WQS for lead in saltwater, but were not considered in the CWA review and approval/disapproval action of the standards because these species do not have a breeding wild population in Oregon's waters:

Fundulus	*heteroclitus*	Mummichog	Dorfman 1977; Jackim et al. 1970
Cancer	*anthonyi*	Yellow rock crab	MacDonald et al. 1988
Mytilus	*galloprovincialis*	Mediterranean mussel	Taneeva 1973
Ampelisca	*abdita*	Amphipod	Scott et al. 1982

[94] U.S. EPA. 1984. Ambient Water Quality Criteria Documents for Lead. EPA-440/5-84-027.

Appendix R Nickel (Saltwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Ahsanullah, M.. 1982. Acute Toxicity of Chromium, Mercury, Molybdenum and Nickel to the Amphipod Allorchestes compressa. Aust.J.Mar.Freshwater Res. 33(3):465-474.	10628	NonRes	
Calabrese, A., J.R. MacInnes, D.A. Nelson, and J.E. Miller. 1977. Survival and Growth of Bivalve Larvae Under Heavy-Metal Stress. Mar.Biol. 41:179-184.	9064	Con, UChron	
Cardin, J.A.. 1985. Results of Acute Toxicity Tests Conducted with Nickel at ERL, Narragansett. U.S.EPA, Narragansett, RI :1.	3755	See Note	Duplicate data to Gentile and Cardin 1982
Darmono, G.R.W.D., and R.S.F. Campbell. 1990. The Pathology of Cadmium and Nickel Toxicity in the Banana Shrimp (Penaeus merguiensis de Man). Asian Fish.Sci. 3(3):287-297.	9711	UEndp	
Denton, G.R.W., and C. Burdon-Jones. 1986. Environmental Effects on Toxicity of Heavy Metals to Two Species of Tropical Marine Fish from Northern Australia. Chem.Ecol. 2(3):233-249.	4327	NonRes	
Eisler, R.. 1977. Acute Toxicities of Selected Heavy Metals to the Softshell Clam, Mya arenaria. Bull.Environ.Contam.Toxicol. 17(2):137-145.	2166	Con, UChron	
Eldon, J., M. Pekkarinen, and R. Kristoffersson. 1980. Effects of Low Concentrations of Heavy Metals on the Bivalve Macoma balthica. Ann.Zool.Fenn. 17:233-242.	17309	Con	
Haglund, K., M. Bjorklund, S. Gunnare, A. Sandberg, U. Olander, and M. Pedersen. 1996. New Method for Toxicity Assessment in Marine and Brackish Environments Using the Macroalga Gracilaria tenuistipitata (Gracilariales, Rhodophyta). Hydrobiologia 326/327:317-325.	18453	NonRes	
Haley, M.V., and C.W. Kurnas. 1993. Aquatic Toxicity and Fate of Nickel Coated Graphite Fibers, with Comparisons to Iron and Aluminum Coated Glass Fibers. Rep.No.ERDEC-TR-090, Edgewood Res.Dev.Eng.Center, Aberdeen Proving Ground, MD:19 p.(U.S.NTIS AD-A270/411/2).	4939	See Note	ECOTOX provides one 96-h LC50 of 5346 µg/L for this study. These values could have been considered for EPA's evaluation of saltwater nickel, but the species is relatively insensitive to nickel compared to others.

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Krishnakumari, L.P.K.V., S.N. Gajbhiye, K. Govindan, and V.R. Nair. 1983. Toxicity of Some Metals on the Fish Therapon jarbua (Forsskal, 1775). Indian J.Mar.Sci. 12(1):64-66.	11014	NonRes	
Lee, H.H., and C.H. Xu. 1984. Effects of Metals on Sea Urchin Development: A Rapid Bioassay. Mar.Pollut.Bull. 15(1):18-21.	10086	Dur, UEndp	
Lussier, S.M., and J. Walker. 1985. Results of Acute Toxicity Tests Conducted with Nickel at ERL, Narragansett. U.S.EPA, Narragansett, RI :2.	3828	UEndp	Duplicate data to Gentile and Cardin 1982
Mortimer, M.R., and G.J. Miller. 1994. Susceptibility of Larval and Juvenile Instars of the Sand Crab, Portunus pelagicus (L.), to Sea Water Contaminated by Chromium, Nickel or Copper. Aust.J.Mar.Freshwater Res. 45(7):1107-1121.	16331	NonRes	
Pesch, C.E., D.J. Hansen, W.S. Boothman, W.J. Berry, and J.D. Mahony. 1995. The Role of Acid-Volatile Sulfide and Interstitial Water Metal Concentrations in Determining Bioavailability of Cadmium and Nickel from Contaminated. Environ.Toxicol.Chem. 14(1):129-141.	18028	Dur	
Stromgren, T.. 1982. Effect of Heavy Metals (Zn, Hg, Cu, Cd, Pb, Ni) on the Length Growth of Mytilus edulis. Mar.Biol. 72(1):69-72.	10899	UEndp	
Taylor, D., B.G. Maddock, and G. Mance. 1985. The Acute Toxicity of Nine "Grey List" Metals (Arsenic, Boron, Chromium, Copper, Lead, Nickel, Tin, Vanadium and Zinc) to Two Marine Fish Species:. Aquat.Toxicol. 7(3):135-144.	11451	NonRes	
Verriopoulos, G., and S. Dimas. 1988. Combined Toxicity of Copper, Cadmium, Zinc, Lead, Nickel, and Chrome to the Copepod Tisbe holothuriae. Bull.Environ.Contam.Toxicol. 41(3):378-384.	13179	NonRes	
Wilson, W.B., and L.R. Freeburg. 1980. Toxicity of Metals to Marine Phytoplankton Cultures. EPA-600/3-80-025, U.S.EPA, Narragansett, RI :110 p.(U.S.NTIS PB80-182843).	5557	NonRes	
Wong, C.K., K.H. Chu, K.W. Tang, T.W. Tam, and L.J. Wong. 1993. Effects of Chromium, Copper and Nickel on Survival and Feeding Behaviour of Metapenaeus ensis Larvae and Postlarvae (Decapoda: Penaeidae). Mar.Environ.Res. 36(2):63-78.	4127	NonRes	

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

3) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[95], EPA is providing a transparent rationale as to why they were not utilized (see below).
4) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix R).

General QA/QC failure because non-resident species in Oregon

Tests with the following species were used in the EPA BE of OR WQS for nickel in saltwater, but were not considered in the CWA review and approval/disapproval action of the standards because these species do not have a breeding wild population in Oregon's waters:

Mysidopsis	*intii*	Shrimp	Hunt et al. 2002
Heteromysis	*formosa*	Opossom shrimp	Gentile and Cardin 1982
Mercenaria	*mercenaria*	Northern quahog or hard clam	Calabrese and Nelson 1974
Americamysis	*bahia*	Opossom shrimp	Gentile and Cardin 1982; Ho et al. 1999
Americamysis	*bigelowi*	Shrimp	Gentile and Cardin 1982
Crassostrea	*virginica*	Eastern oyster	Calabrese et al. 1973

[95] U.S. EPA. 1986. Ambient Water Quality Criteria for Nickel – 1986. EPA 440-5-86-004.

Appendix S Pentachlorophenol (Saltwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
"Anderson, B.S., and J.W. Hunt". 1988. "Bioassay Methods for Evaluating the Toxicity of Heavy Metals, Biocides and Sewage Effluent Using Microscopic Stages of Giant Kelp Macrocystis pyrifera". Mar.Environ.Res. 26(2):113-134.	2349	UEndp	Has a 48hr NOEC for Giant Kelp
"Anderson, R.S., C.S. Giam, and L.E. Ray". 1984. Effects of Hexachlorobenzene and Pentachlorophenol on Cellular and Humoral Immune Parameters in Glycera dibranchiata. Mar.Environ.Res. 14(1-4):317-326.	11040	UEndp, Eff	
"Anderson, R.S., C.S. Giam, L.E. Ray, and M.R. Tripp". 1981. Effects of Environmental Pollutants on Immunological Competency of the Clam Mercenaria mercenaria: Impaired Bacterial Clearance. Aquat.Toxicol. 1:187-195.	15061	UEndp, Eff	
"Benner, D.B., and R.S. Tjeerdema". 1993. Toxicokinetics and Biotransformation of Pentachlorophenol in the Topsmelt (Atherinops affinis). J.Biochem.Toxicol. 8(3):111-117.	4100	Eff, Dur	24hr only
"Brannon, A.C., and P.J. Conklin". 1978. "Effect of Sodium Pentachlorophenate on Exoskeletal Calcium in the Grass Shrimp, Palaemonetes pugio". "In: K.R.Rao (Ed.), Pentachlorophenol: Chemistry, Pharmacology and Environmental Toxicology, Plenum Press, NY :205-211".	45291	UEndp, Eff, Dur	
"Cantelmo, A.C., P.J. Conklin, F.R. Fox, and K.R. Rao". 1978. "Effects of Sodium Pentachlorophenate and 2,4-Dinitrophenol on Respiration in Crustaceans". "In: K.R.Rao (Ed.), Pentachlorophenol: Chemistry, Pharmacology and Environmental Toxicology, Plenum Press, New York, NY :251-263".	7018	UEndp, Eff, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
"Cantelmo, F.R., and K.R. Rao". 1978. Effect of Pentachlorophenol (PCP) on Meiobenthic Communities Established in an Experimental System. Mar.Biol. 46(1):17-22.	7020	UEndp	
"Cantelmo, F.R., and K.R. Rao". 1978. Effects of Pentachlorophenol on the Meiobenthic Nematodes in an Experimental System. "In: K.R.Rao (Ed.), Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology, Plenum Press, New York, NY :165-174".	7021	UEndp	
"Carr, R.S., and J.M. Neff". 1981. Biochemical Indices of Stress in the Sandworm Neanthes virens (Sars). I. Responses to Pentachlorophenol. Aquat.Toxicol. 1:313-327.	13867	UEndp, Eff, Dur	
"Carr, R.S., M.D. Curran, and M. Mazurkiewicz". 1986. Evaluation of the Archiannelid Dinophilus gyrociliatus for Use in Short-Term Life-Cycle Toxicity Tests. Environ.Toxicol.Chem. 5(7):703-712.	11940	NonRes, UEndp, Dur	
"Conklin, P.J., and K.R. Rao". 1977. "Toxicity of Sodium Pentachlorophenate to the Grass Shrimp, Palaemonetes pugio, in Relation to the Molt Cycle". "In: K.R.Rao (Ed.), Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology, Plenum Press, New York, NY :181-192".	6674	UEndp	
"Cook, W.L., D. Fielder, and A.W. Bourquin". 1980. "Succession of Microfungi in Estuarine Microcosms Perturbed by Carbaryl, Methyl Parathion and Pentachlorophenol". Bot.Mar. 23:129-131.	15421	UEndp	
"Crawford, R.B., and A.M. Guarino". 1976. Sand Dollar Embryos as Monitors of Environmental Pollutants. Bull.Mt.Desert Isl.Biol.Lab. 16:17.	13938	UEndp, Dur	
"Crawford, R.B., and A.M. Guarino". 1985. Effects of Environmental Toxicants on Development of a Teleost Embryo. J.Environ.Pathol.Toxicol. 6:185-194.	14348	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
"Dimick, R.E., and W.P. Breese". 1965. Bay Mussel Embryo Bioassay. "Proc.12th Pacific Northwest Ind.Waste Conf., University of Washington, Seattle, W A:165-175".	3758	UEndp, Dur	
"Doughtie, D.G., and K.R. Rao". 1978. "Ultrastructural Changes Induced by Sodium Pentachlorophenate in the Grass Shrimp, Palaemonetes pugio, in Relation to the Molt Cycle". "In: K.R.Rao (Ed.), Pentachlorophenol: Chemistry, Pharmacology and Environmental Toxicology, Plenum Press, NY :213-250".	45293	UEndp, Eff, Dur	
"Erickson, S.J.". 1980. Unpublished Laboratory Data. "U.S.EPA, Gulf Breeze, FL :8".	3652	UEndp, Eff, Dur	
"Erickson, S.J.". 1981. Inhibition of Photosynthesis in Estuarine Phytoplankton by Mixtures of Copper and Pentachlorophenol. "Unpublished Manuscript, U.S.EPA, Gulf Breeze, F L:11".	4802	UEndp, Eff, Dur	
"Erickson, S.J., and A.E. Freeman". 1978. Toxicity Screening of Fifteen Chlorinated and Brominated Compounds Using Four Species of Marine Phytoplankton. "In: R.L.Jolley, H.Gorchev, and D.H.Hamilton (Eds.), Water Chlorination: Environmental Impact and Health Effects, Ann Arbor Sci.Publ., Ann Arbor, MI 2:307-310".	13851	UEndp, Eff, Dur	
"Ernst, W.". 1979. Factors Affecting the Evaluation of Chemicals in Laboratory Experiments Using Marine Organisms. Ecotoxicol.Environ.Saf. 3:90-93.	3709	Eff	
"Faas, L.F., and J.C. Moore". 1979. Determination of Pentachlorophenol in Marine Biota and Sea Water by Gas-Liquid Chromatography and High-Pressure Liquid Chromatography. J.Agric.Food Chem. 27(3):554-557.	13807	UEndp, Eff	
"Folke, J., J. Birklund, A.K. Sorensen, and U. Lund". 1983. The Impact on the Ecology of Polychlorinated Phenols and Other Organics Dumped at the Bank of a Small Marine Inlet. Chemosphere 12(9/10):1169-1181.	14232	Field, UEndp, Eff	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
"Gates, V.L., and R.S. Tjeerdema". 1993. Disposition and Biotransformation of Pentachlorophenol in the Striped Bass (Morone saxatilis). Pestic.Biochem.Physiol. 46(2):161-170.	9658	Eff, Dur	
"Goerke, H.". 1984. Testing the Fate of Xenobiotics in Nereis diversicolor and Nereis virens (Polychaeta). "In: Persoone,G., E.Jaspers, and C.Claus (Eds.), Ecotoxicol.Testing for the Mar.Environ., State Univ.Ghent and Inst.Mar.Sci.Res., Bredene, Belgium 2:53-66".	4027	UEndp,Eff	
"Hansen, D.J., and M.E. Tagatz". 1980. A Laboratory Test for Assessing Impacts of Substances on Developing Communities of Benthic Estuarine Organisms. "In: J.G.Eaton, P.R.Parrish, and A.C.Hendricks (Eds.), Aquatic Toxicology, ASTM STP 707, Philadelphia, PA :40-57".	14007	UEndp	
"Helmstetter, M.F., and Iii". 1995. Passive Trans-Chorionic Transport of Toxicants in Topically Treated Japanese Medaka (Oryzias latipes) Eggs. Aquat.Toxicol. 32(1):1-13.	14875	UEndp, Eff, Dur	
"Helmstetter, M.F., and Iii". 1995. Toxic Responses of Japanese Medaka (Oryzias latipes) Eggs Following Topical and Immersion Exposures to Pentachlorophenol. Aquat.Toxicol. 32(1):15-29.	14876	RouExp, Dur	One or two values look okay
"Hiatt, R.W., J.J. Naughton, and D.C. Matthews". 1953. "Effects of Chemicals on a Schooling Fish, Kuhlia sandvicensis". Biol.Bull. 104:28-44.	10010	UEndp, Eff, Dur	
"Hori, H., M. Tateishi, K. Takayanagi, and H. Yamada". 1996. Applicability of Artificial Seawater as a Rearing Seawater for Toxicity Tests of Hazardous Chemicals by Marine Fish Species. Nippon Suisan Gakkaishi /Bull.Jpn.Soc.Sci.Fish.(4):614-622 (JPN) (ENG ABS).	16999	NonRes, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
"Kaitala, S., and V.N. Maximov". 1986. The Desirability Function in Evaluation of the Response of Phytoplankton Communities to Toxicants. Toxic.Assess. 1(1):85-101.	11846	Field, UEndp	
"Kobayashi, K., H. Akitake, and T. Tomiyama". 1969. "Studies on the Metabolism of Pentachlorophenate, a Herbicide in Aquatic Organisms I. Turnover of Absorbed PCP in Tapes philippinarum". Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 35(12):1179-1183 (JPN) (ENG ABS).	3667	UEndp, Eff, Dur	
"Kobayashi, K., Y. Oshima, S. Hamada, and C. Taguchi". 1987. Induction of Phenol-Sulfate Conjugating Activity by Exposure to Phenols and Duration of Its Induced Activity in Short-Necked Clam. Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 53(11):2073-2076.	3216	UEndp, Eff, Dur	
"Krajnovic-Ozretic, M., and B. Ozretic". 1987. Specific Alteration of Transaminases in Marine Organisms Under Pollution Impact. "In: W.B.Vernberg, A.Calabrese, F.P.Thurberg, and F.J.Vernberg (Eds.), Pollution Physiology of Estuarine Organisms :207-230".	13582	UEndp, Eff, Dur	
"Kusk, K.O., and N. Nyholm". 1991. Evaluation of a Phytoplankton Toxicity Test for Water Pollution Assessment and Control. Arch.Environ.Contam.Toxicol. 20(3):375-379.	163	Eff, Dur	
"Linden, E., B.E. Bengtsson, O. Svanberg, and G. Sundstrom". 1979. "The Acute Toxicity of 78 Chemicals and Pesticide Formulations Against Two Brackish Water Organisms, the Bleak (Alburnus alburnus) and the Harpacticoid". Chemosphere 8(11/12):843-851 (Author Communication Used) (OECDG Data File).	5185	NonRes	Has a 96hr LC50 for Harpacticoid copepod

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
"Martello, L.B., R.S. Tjeerdema, W.S. Smith, R.J. Kauten, and D.G. Crosby". 1998. Influence of Salinity on the Actions of Pentachlorophenol in Haliotis as Measured by In Vivo 31P NMR Spectroscopy. Aquat.Toxicol. 41(3):229-250.	9361	UEndp, Eff, Dur	
"McCulloch, W.L., and W.J. Rue". 1989. Evaluation of Seven-Day Chronic Toxicity Estimation Test Using Cyprinodon variegatus. "In: U.M.Cowgill and L.R.Williams (Eds.), Aquatic Toxicology and Hazard Assessment, ASTM STP 1027, Philadelphia, PA 12:355-364".	13864	UEndp, Det	Has six 7d NOEC's
"Missimer, C.L., D.P. Lemarie, and W.L. Rue". 1989. Evaluation of a Chronic Estimation Toxicity Test Using Skeletonema costatum. "In: U.M.Cowgill and L.R.Williams (Eds.), Aquatic Toxicology and Hazard Assessment, 12th Volume, ASTM STP 1027, Philadelphia, PA :345-354".	2057	Eff	
"North, W.J., and M.B. Schaefer". 1964. An Investigation of the Effects of Discharged Wastes on Kelp. "Calif.State Water Control Board, Publ No.26 :124 p.".	58038	UEndp, Eff	
"Ozretic, B., and M. Krajnovic-Ozretic". 1985. Morphological and Biochemical Evidence of the Toxic Effect of Pentachlorophenol on the Developing Embryos of the Sea Urchin. Aquat.Toxicol. 7(4):255-263.	12957	Eff, Dur	
"Ozretic, B., and M. Krajnovic-Ozretic". 1986. Sea Urchin Gametes and Their Developing Embryos in Marine Toxicology Studies. "In: Papers Presented at the FAO/UNEP Meeting on the Toxicity and Bioaccumulation of Selected Substances in Marine Organisms, Rovinj, Yugoslavia, 5-9 Nov., 1984, FAO Fish.Rep.No.334(Suppl.) :111-121".	4047	UEndp, Eff, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
"Rao, K.R., P.J. Conklin, and A.C. Brannon". 1978. "Inhibition of Limb Regeneration in the Grass Shrimp, Palaemonetes pugio, by Sodium Pentachlorophenate". "In: K.R.Rao (Ed.), Pentachlorophenol: Chemistry, Pharmacology and Environmental Toxicology, Plenum Press, New York, NY :193-203".	6904	UEndp	Has two 22d EC50's and two 66d EC50's
"Roszell, L.E., and R.S. Anderson". 1996. Effect of Chronic In Vivo Exposure to Pentachlorophenol on Non-Specific Immune Functions in Fundulus heteroclitus. Mar.Environ.Res. 42(1-4):191-194.	19446	UEndp, Eff	
"Roszell, L.E., and R.S. Anderson". 1996. Effect of In Vivo Pentachlorophenol Exposure on Fundulus heteroclitus Phagocytes: Modulation of Bactericidal Activity. Dis.Aquat.Org. 26(3):205-211.	19517	UEndp, Eff	
"Schimmel, S.C., and R.L. Garnas". 1985. Interlaboratory Comparison of the ASTM Bioconcentration Test Method Using the Eastern Oyster. "In: R.C.Bahner and D.J.Hansen (Eds.), Aquatic Toxicology and Hazard Assessment, 8th Symposium, ASTM STP 891, Philadelphia, PA :227-287".	5310	Eff, Dur	
"Shofer, S.L., and R.S. Tjeerdema". 1993. Comparative Disposition and Biotransformation of Pentachlorophenol in the Oyster (Crassostrea gigas) and Abalone (Haliotis fulgens). Pestic.Biochem.Physiol. 46(2):85-95.	16471	Eff, Dur	5h only
"Shofer, S.L., and R.S. Tjeerdema". 1998. Effects of Hypoxia and Toxicant Exposure on Adenylate Energy Charge and Cytosolic ADP Concentrations in Abalone. Comp.Biochem.Physiol.C 119(1):51-57.	18958	UEndp, Eff, Dur	2h only
"Shofer, S.L., J.A. Willis, and R.S. Tjeerdema". 1996. Sublethal Effects of Pentachlorophenol and Hypoxia on Rates of Arginine Kinase Flux in Red Abalone (Haliotis rufescens) as Measured by 31P. Mar.Environ.Res. 42(1-4):363-367.	15533	UEndp, Eff, Dur	2h only

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
"Soto, E., A. Larrain, and E. Bay-Schmith". 2000. Sensitivity of Ampelisca araucana Juveniles (Crustacea: Amphipoda) to Organic and Inorganic Toxicants in Tests of Acute Toxicity. Bull.Environ.Contam.Toxicol. 64(4):574-578.	54390	NonRes, Dur	
"Tachikawa, M., A. Hasegawa, R. Sawamura, A. Takeda, S. Okada, and M. Nara". 1987. Difference between Fresh- and Seawater Fishes in the Accumulation and Effect of Environmental Chemical Pollutants. I. Intakes of Chlordane. J.Hyg.Chem./Eisei Kagaku 33(2):98-105 (JPN) (ENG ABS).	12737	UEndp, Dur	24hr only
"Tachikawa, M., and R. Sawamura". 1994. The Effects of Salinity on Pentachlorophenol Accumulation and Elimination by Killifish (Oryzias latipes). Arch.Environ.Contam.Toxicol. 26(3):304-308.	13665	UEndp, Eff, Dur	
"Tagatz, M.E., C.H. Deans, G.R. Plaia, and J.D. Pool". 1983. Impact on and Recovery of Experimental Macrobenthic Communities Exposed to Pentachlorophenol. Northeast Gulf Sci. 6(2):131-136.	4808	UEndp	
"Tagatz, M.E., J.M. Ivey, and M. Tobia". 1978. Effects of Dowicide (Trade Name) G-ST on Development of Experimental Estuarine Macrobenthic Communities. "In: K.R.Rao (Ed.), Pentachlorophenol, Plenum Publ.Corp., New York, NY, EPA-600/J-78-077, Environ.Res.Lab., U.S.EPA :9 p.(U.S.NTIS PB-290037)".	7189	UEndp	
"Tagatz, M.E., J.M. Ivey, J.C. Moore, and M. Tobia". 1977. Effects of Pentachlorophenol on the Development of Estuarine Communities. J.Toxicol.Environ.Health 3(3):501-506.	7497	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
"Tagatz, M.E., J.M. Ivey, N.R. Gregory, and J.L. Oglesby". 1981. Effects of Pentachlorophenol on Field- and Laboratory-Developed Estuarine Benthic Communities. Bull.Environ.Contam.Toxicol. 26(1):137-143.	6384	UEndp	
"Thomas, P., and H.W. Wofford". 1984. "Effects of Metals and Organic Compounds on Hepatic Glutathione, Cysteine, and Acid-Soluble Thiol Levels in Mullet (Mugil cephalus L.)". Toxicol.Appl.Pharmacol. 76:172-182.	13632	UEndp, Eff	
"Thomas, P., R.S. Carr, and J.M. Neff". 1981. Biochemical Stress Responses of Mullet Mugil cephalus and Polychaete Worms Neanthes virens to Pentachlorophenol. "In: F.J.Vernberg, A.Calabrese, F.P.Thurberg, and W.B.Vernberg (Eds.), Biological Monitoring of Marine Pollutants, Academic Press, New York :73-103".	4835	UEndp, Eff, Dur	
"Tjeerdema, R.S., and D.G. Crosby". 1992. Disposition and Biotransformation of Pentachlorophenol in the Red Abalone (Haliotis rufescens). Xenobiotica 22(6):681-690.	7440	Eff, Dur	
"Tjeerdema, R.S., K.L. Lukrich, and E.M. Stevens". 1994. Toxicokinetics and Biotransformation of Pentachlorophenol in the Sea Urchin (Strongylocentrotus purpuratus). Xenobiotica 24(8):749-757.	10618	Eff, Dur	24hr only. Has a 24hr NOEC for the purple sea urchin
"Tjeerdema, R.S., R.J. Kauten, and D.G. Crosby". 1991. Interactive Effects of Pentachlorophenol and Hypoxia in the Abalone (Haliotis rufescens) as Measured by In Vivo 31P NMR Spectroscopy. Aquat.Toxicol. 21:279-294.	3861	UEndp, Eff, Dur	6hr only

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
"Tjeerdema, R.S., R.J. Kauten, and D.G. Crosby". 1993. Interactive Effects of Pentachlorophenol and Temperature in the Abalone (Haliotis rufescens) as Measured by In Vivo 31P-NMR Spectroscopy. Aquat.Toxicol. 26(1/2):117-132.	8264	UEndp, Eff, Dur	
"Tjeerdema, R.S., T.W.M. Fan, R.M. Higashi, and D.G. Crosby". 1991. Sublethal Effects of Pentachlorophenol in the Abalone (Haliotis rufescens) as Measured by In Vivo 31P NMR Spectroscopy. J.Biochem.Toxicol. 6(1):45-56.	3798	UEndp, Eff, Dur	6hr and 5hr durations
"Tjeerdema, R.S., W.S. Smith, L.B. Martello, R.J. Kauten, and D.G. Crosby". 1996. Interactions of Chemical and Natural Stresses in the Abalone (Haliotis rufescens) as Measured by Surface-Probe Localized 31P NMR. Mar.Environ.Res. 42(1-4):369-374.	14745	UEndp, Eff, Dur	
"Tomiyama, T., and K. Kawabe". 1962. "The Toxic Effect of Pentachlorophenate, a Herbicide, on Fishery Organisms in Coastal Waters-I. The Effect on Certain Fishes and a Shrimp". Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 28(3):379-382 (JPN) (ENG ABS).	5832	NonRes, UEndp, Eff, Dur	
"Tomiyama, T., K. Kobayashi, and K. Kawabe". 1962. "The Toxic Effect of Pentachlorophenate, a Herbicide, on Fishery Organisms in Coastal Waters-III. The Effect on Venerupis philippinarum". Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 28(4):417-421 (JPN) (ENG ABS).	13528	UEndp, Eff, Dur	
"Trujillo, D.A., L.E. Ray, H.E. Murray, and C.S. Giam". 1982. Bioaccumulation of Pentachlorophenol by Killifish (Fundulus similus). Chemosphere 11(1):25-31.	10451	Eff, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
"Walsh, G.E.". 1981. Effects of Pesticides and Industrial Wastes on Unicellular Algae and Seagrass. "In: Research and Development: Experimental Environments Branch, Progress Report for Fiscal Year 1981, Unpublished Laboratory Data, U.S.EPA, ERL-Gulf Breeze, FL :3-26".	4803	Eff, Dur	
"Walsh, G.E., D.L. Hansen, and D.A. Lawrence". 1982. A Flow-Through System for Exposure of Seagrass to Pollutants. Mar.Environ.Res. 7(1):1-12.	11630	Eff, Dur	
"Wang, W.X., and J. Widdows". 1993. "Interactive Effects of Pentachlorophenol (PCP) and Hypoxia on the Energy Metabolism of the Mussel, Mytilus edulis". Mar.Environ.Res. 35:109-113.	14206	UEndp, Eff, Dur	
"Woelke, C.E.". 1965. Development of a Bioassay Method Using the Marine Algae - Monochrysis lutheri. "Progress Report - Shellfish Research, Washington Dep.of Fisheries and Shellfish, Seattle, W A:9".	3757	UEndp, Eff, UChron	
"Yoshida, T., T. Maruyama, H.I. Kojima, I. Allahpichay, and S. Mori". 1986. "Evaluation of the Effect of Chemicals on Aquatic Ecosystem by Observing the Photosynthetic Activity of a Macrophyte, Porphyra yezoensis". Aquat.Toxicol. 9(4-5):207-214.	12512	Eff, Dur	

C. Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

1) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[96], EPA is providing a transparent rationale as to why they were not utilized (see below).

[96] U.S. EPA. 1986. Ambient Water Quality Criteria for Pentachlorophenol - 1986. EPA-440-5-86-009.

2) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix S).

General QA/QC failure because non-resident species in Oregon

The test with the following species was used in the EPA BE of OR WQS for pentachlorophenol in saltwater, but was not considered in the CWA review and approval/disapproval action of the standards because this species does not have a breeding wild population in Oregon's waters:

Lagodon	*rhomboides*	Pinfish	Schimmel et al. 1978; Borthwick and Schimmel 1978
Pseudodiaptomus	*coronatus*	Calanoid copepod	Hauch et al. 1980
Crassostrea	*virginica*	Eastern oyster	Borthwick and Schimmel 1978; Office of Pesticide Programs 2000; Zaroogian 1981; Davis and Hidu 1969

Other Acute tests failing QA/QC by species

Clupea pallasii – Pacific herring

Vigers, G.A., J.B. Marliave, R.G. Janssen and P. Borgmann. 1978. Use of larval herring in bioassays. In: J.C. Davis, G.L. Greer and I.K. Birtwell (Eds.), Proc. 4th Annual Aquatic Toxicol. Workshop, Nov. 8-10, 1977, Vancouver, B.C., Can. Fish. Mar. Serv. Tech. Rep. No. 818: 31-52.
Two values from this study were rejected for use in calculating the SMAV in the 1986 ALC document because data for a more sensitive lifestage was available. Other data from this study was used to calculate the SMAV for this species.

Appendix T Silver (Saltwater)

Studies Not Pertinent to this Determination

(Note: Codes Described in Attachment 3 of Appendix B)

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Abbe, G.R., and J.G. Sanders. 1990. Pathways of Silver Uptake and Accumulation by the American Oyster (Crassostrea virginica) in Chesapeake Bay. Estuar.Coast.Shelf Sci. 31:113-123.	20201	UEndp	
Abbe, G.R., J.G. Sanders, and J.M. Bianchi. 1988. Pathways of Silver Accumulation by the American Oyster (Crassostrea virginica Gmelin) in Chesapeake Bay. J.Shellfish Res.7(1):107 (ABS).	3126	UEndp, Con	
Amiard, J.C.. 1976. Phototactic Variations in Crustacean Larvae Due to Diverse Metallic Pollutants Demonstrated by a Sublethal Toxicity Test. Mar.Biol.34(3):239-245 (Fre) (Eng Abs).	5628	Con	
Bailey, H.C., J.L. Miller, M.J. Miller, and B.S. Dhaliwal. 1995. Application of Toxicity Identification Procedures to the Echinoderm Fertilization Assay to Identify Toxicity in a Municipal Effluent. Environ.Toxicol.Chem. 14(12):2181-2186.	16375	Dur	
Ballan-Dufrancais, C., C. Marcaillou, and C. Amiard-Triquet. 1991. Response of the Phytoplanktonic Alga Tetraselmis suecica to Copper and Silver Exposure: Vesicular Metal Bioaccumulation and Lack of Starch Bodies. Biol.Cell 72(1/2):103-112.	7698	UEndp	
Berry, W.J., M.G. Cantwell, P.A. Edwards, J.R. Serbst, and D.J. Hansen. 1999. Predicting Toxicity of Sediments Spiked with Silver. Environ.Toxicol.Chem. 18(1):40-48.	19382	Dur, UChron	
Berthet, B.. 1990. Effect of the Contamination Vector on the Physico-Chemical Forms of Silver in Crassostrea gigas Thunberg. Oceanis 16(5):349-357 (FRE) (ENG ABS).	20592	UEndp, Eff	
Berthet, B., J.C. Amiard, C. Amiard-Triquet, M. Martoja, and A.Y. Jeantet. 1992. Bioaccumulation, Toxicity and Physico-Chemical Speciation of Silver in Bivalve Molluscs: Ecotoxicological and Health Consequences. Sci.Total Environ. 125:97-122.	6930	UEndp	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Brown, C.L., and S.N. Luoma. 1995. Use of the Euryhaline Bivalve Potamocorbula amurensis as a Biosentinel Species to Assess Trace Metal Contamination in San Francisco Bay. Mar.Ecol.Prog.Ser. 124(1-3):129-142.	18036	Eff	
Calabrese, A., F.P. Thurberg, and E. Gould. 1977. Effects of Cadmium, Mercury and Silver on Marine Animals. MFR Paper 1244, Mar Fish Rev 39:5-11.	12206	Eff, Dur	
Calabrese, A., J.R. MacInnes, D.A. Nelson, and J.E. Miller. 1977. Survival and Growth of Bivalve Larvae Under Heavy-Metal Stress. Mar.Biol. 41:179-184.	9064	Con, Dur	
Calabrese, A., J.R. MacInnes, D.A. Nelson, R.A. Greig, and P.P. Yevich. 1984. Effects of Long-Term Exposure to Silver or Copper on Growth, Bioaccumulation and Histopathology in the Blue Mussel Mytilus edulis. Mar.Environ.Res. 11(4):253-274.	10774	Eff, UEndp	
Canterford, G.S., A.S. Buchanan, and S.C. Ducker. 1978. Accumulation of Heavy Metals by the Marine Diatom Ditylum brightwellii (West) Grunow. Aust.J.Mar.Freshwater Res. 29(5):613-622.	15455	UEndp, Eff	
Carvalho, R.A., M.C. Benfield, and P.H. Santschi. 1999. Comparative Bioaccumulation Studies of Colloidally Complexed and Free-Ionic Heavy Metals in Juvenile Brown Shrimp Penaeus aztecus (Crustacea: Decapoda: Penaeidae). Limnol.Oceanogr. 44(2):403-414.	48059	Eff, UEndp	
Clarke, G.L.. 1947. Poisoning and Recovery in Barnacles and Mussels. Biol.Bull. 92:73-91.	14811	UEndp	
Connell, D.B., J.G. Sanders, G.F. Riedel, and G.R. Abbe. 1991. Pathways of Silver Uptake and Trophic Transfer in Estuarine Organisms. Environ.Sci.Technol. 25(5):921-924.	11561	UEndp	
Dinnel, P.A., J.M. Link, and Q.J. Stober. 1987. Improved Methodology for a Sea Urchin Sperm Cell Bioassay for Marine Waters. Arch.Environ.Contam.Toxicol. 16:23-32.	2610	Con, Dur	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Domouhtsidou, G.P., and V.K. Dimitriadis. 2000. Ultrastructural Localization of Heavy Metals (Hg,Ag,Pb, and Cu) in Gills and Digestive Gland of Mussels, Mytilus galloprovincialis (L.). Arch.Environ.Contam.Toxicol. 38(4):472-478.	48771	UEndp	
Fisher, N.S., M. Bohe, and J.L. Teyssie. 1984. Accumulation and Toxicity of Cd, Zn, Ag, and Hg in Four Marine Phytoplankters. Mar.Ecol.Prog.Ser. 18(3):201-213.	11805	UEndp, Eff	
Fisher, N.S., V.T. Breslin, and M. Levandowsky. 1995. Accumulation of Silver and Lead in Estuarine Microzooplankton. Mar.Ecol.Prog.Ser. 116(1-3):207-215.	17381	Eff, Ace	
Gould, E., and J.R. MacInnes. 1977. Short-Term Effects of Two Silver Salts on Tissue Respiration and Enzyme Activity in the Cunner (Tautogolabrus adspersus). Bull.Environ.Contam.Toxicol. 18(4):401-408.	6125	UEndp	
Grosell, M., G. DeBoeck, O. Johannsson, and C.M. Wood. 1999. The Effects of Silver on Intestinal Ion and Acid-Base Regulation in the Marine Teleost Fish, Parophrys vetulus. Comp.Biochem.Physiol. 124c(3):259-270.	49761	UEndp, Dur	
Hannan, P.J., and C. Patouillet. 1972. Effects of Pollutants on Growth of Algae. Rep.NRL (Nav.Res.Lab.) Prog.:1-8 (Author Communication Used).	9095	UEndp, Dur	
Heitmuller, P.T., T.A. Hollister, and P.R. Parrish. 1981. Acute Toxicity of 54 Industrial Chemicals to Sheepshead Minnows (Cyprinodon variegatus). Bull.Environ.Contam.Toxicol. 27(5):596-604 (OECDG Data File).	10366	Dur, UChron	
Hogstrand, C., and C.M. Wood. 1996. The Toxicity of Silver to Marine Fish. In: 4th Int.Conf.Proc.: Transport, Fate and Effects of Silver in the Environment, Aug.25-28, 1996, Madison, WI :109-112.	20143	UEndp	
MacInnes, J.R., and F.P. Thurberg. 1973. Effects of Metals on the Behavior and Oxygen Consumption of the Mud Snail. Mar.Pollut.Bull. 4(12):185-186.	8902	UEndp, Eff	
Mathew, R., and N.R. Menon. 1983. Oxygen Consumption in Tropical Bivalves Perna viridis (Linn.) and Meretrix casta (Chem.) Exposed to Heavy Metals. Indian J.Mar.Sci. 12(1):57-59.	11085	UEndp, Eff, Con	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Metayer, C., C. Amiard-Triquet, and J.P. Baud. 1990. Species-Related Variations of Silver Bioaccumulation and Toxicity to Three Marine Bivalves. Water Res. 24(8):995-1001 (FRE) (ENG ABS).	10496	UEndp, Eff, Con	
Nacci, D., E. Jackim, and R. Walsh. 1986. Comparative Evaluation of Three Rapid Marine Toxicity Tests: Sea Urchin Early Embryo Growth Test, Sea Urchin Sperm Cell Toxicity Test and Microtox. Environ.Toxicol.Chem. 5:521-525.	17742	Dur	
Nolan, C., and H. Dahlgaard. 1991. Accumulation of Metal Radiotracers by Mytilus edulis. Mar.Ecol.Prog.Ser. 70(2):165-174.	20303	Eff	
Office of Pesticide Programs. 2000. Pesticide Ecotoxicity Database (Formerly: Environmental Effects Database (EEDB)). Environmental Fate and Effects Division, U.S.EPA, Washington, D.C..	344		ECOTOX provides one 96-h LC50 of 93.50 µg/L for this study. This is similar to the data used in the analysis. These values could have been considered for EPA's evaluation of saltwater silver, but the species is relatively insensitive to silver compared to others.
Pentreath, R.J.. 1977. The Accumulation of 110m Ag by the Plaice, Pleuronectes platessa L. and the Thornback Ray, Raja clavata L. J.Exp.Mar.Biol.Ecol. 29(3):315-325.	7141	Con, Eff	
Pereira, J.J., and K. Kanungo. 1981. Effects of Silver on Respiration and on Ion and Water Balance in Neanthes virens. In: F.J.Vernberg, A.Calabrese, F.P.Thurberg, and W.B.Vernberg (Eds.), Biological Monitoring of Marine Pollutants, Academic Press, Inc., NY :107-125.	13465	UEndp, Eff	
Shaw, J.R., W.J. Birge, and C. Hostrand. 1996. Parameters that Influence Silver Toxicity: Ammonia and Salinity. In: 4th Int.Conf.Proc.: Transport, Fate and Effects of Silver in the Environment, Aug.25-28, 1996, Madison, WI :155-159.	20142	Eff	ECOTOX provides one 96-h LC50 of 564.4 µg/L for this study. This is similar to the data used in the analysis. These values could have been considered for EPA's evaluation of saltwater silver, but the species is relatively insensitive to silver compared to others.
Thurberg, F.P., A. Calabrese, and M.A. Dawson. 1974. Effects of Silver on Oxygen Consumption of Bivalves at Various Salinities. In: F.J.Vernberg and W.B.Vernberg (Eds.), Pollution and Physiology of Mar.Organisms, Academic Press, NY :67-78.	8733	UEndp, Eff, Con	
Thursby, G.B., and R.L. Steele. 1986. Comparison of Short-and Long-Term Sexual Reproduction Tests with the Marine Red Alga Champia parvula. Environ.Toxicol.Chem. 5(11):1013-1018.	12976	UEndp, Con	

Article Number and Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Voyer, R.A., J.A. Cardin, J.F. Heltshe, and G.L. Hoffman. 1982. Viability of Embryos of the Winter Flounder Pseudopleuronectes americanus Exposed to Mixtures of Cadmium and Silver in Combination with Selected Fixe. Aquat.Toxicol. 2(4):223-233.	10500	UEndp, Dur	
Warnau, M., M. Iaccarino, A. De Biase, A. Temara, M. Jangoux, P. Dubois, and G. Pagano. 1996. Spermiotoxicity and Embryotoxicity of Heavy Metals in the Echinoid Paracentrotus lividus. Environ.Toxicol.Chem. 15(11):1931-1936.	17368	Dur	
Wilson, W.B., and L.R. Freeburg. 1980. Toxicity of Metals to Marine Phytoplankton Cultures. EPA-600/3-80-025, U.S.EPA, Narragansett, RI :110 p.(U.S.NTIS PB80-182843).	5557	Dur	

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[97], EPA is providing a transparent rationale as to why they were not utilized (see below).

For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable.

<u>General QA/QC failure because non-resident species in Oregon</u>

Tests with the following several species were used in the EPA BE of OR WQS for silver in saltwater, but were not considered in the CWA review and approval/disapproval action of the standards because these species do not have a breeding wild population in Oregon's waters:

[97] U.S. EPA. 1980. Ambient Water Quality Criteria Document for Silver. EPA-440/5-80-071.

Paralichthys	*dentatus*	Opossum shrimp	Cardin 1980; Shaw et al. 1997
Crassostrea	*virginica*	Eastern oyster	Calabrese et al. 1973; MacInnes and Calabrese 1978; Zaroogian Manuscript
Mercenaria	*mercenaria*	Northern quahog or hard clam	Calabrese and Nelson 1974
Argopecten	*Irradians*	Bay scallop	Nelson et al. 1976

<u>Other Acute tests failing QA/QC by species</u>

Crassostrea gigas – Pacific oyster

The following test was included in EPA's BE of the OR WQS for silver in saltwater, but was not used in this CWA review and approval/disapproval action of these standards because it was a greater than value and more definitive data was available for this species.

Coglianese, M.P. 1982. The effects of salinity on copper and silver toxicity to embryos of the Pacific oyster. Arch. Environ. Contam. Toxicol. 11:297-303.

Appendix U Tributyltin (Saltwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Anderson, R.S., E.M. Burreson, and M.A. Unger. 1995. The Effects of Environmental Contaminants on the Progression of Perkinsus marinus Infection in the Eastern Oyster [R/CBT-22]. In: E.J.Olmi III, B.Hens, P.Hill, and J.G.Sanders (Eds.), Chesapeake Bay Environmental Effects Studies, Toxics Research Program, 1994 Workshop Report, Solomons, MD :150-155.	19555	UEndp, Eff, Dur	
Axiak, V., M. Sammut, P. Chircop, A. Vella, and B. Mintoff. 1995. Laboratory and Field Investigations on the Effects of Organotin (Tributyltin) on the Oyster, Ostrea edulis. Sci.Total Environ. 171(1-3):117-120.	18725	UEndp	
Bauer, B., P. Fioroni, U. Schulte-Oehlmann, J. Oehlmann, and W. Kalbfus. 1997. The Use of Littorina littorea for Tributyltin (TBT) Effect Monitoring - Results from the German TBT Survey 1994/1995 and Laboratory Experiments. Environ.Pollut. 96(3):299-309.	18345	UEndp, Eff, UChron	
Beaumont, A.R., and M.D. Budd. 1984. High Mortality of the Larvae of the Common Mussel at Low Concentrations of Tributyltin. Mar.Pollut.Bull. 15(11):402-405.	10800	UEndp, Dur	
Beaumont, A.R., and P.B. Newman. 1986. Low Levels of Tributyl Tin Reduce Growth of Marine Micro-Algae. Mar.Pollut.Bull. 17(10):457-461.	12011	UEndp, Dur	
Bettin, C., J. Oehlmann, and E. Stroben. 1996. TBT-Induced Imposex in Marine Neogastropods is Mediated by an Increasing Androgen Level. Helgol.Meeresunters. 50:299-317.	17946	UEndp	
Blanck, H., and B. Dahl. 1996. Pollution-Induced Community Tolerance (PICT) in Marine Periphyton in a Gradient of Tri-n-butyltin (TBT) Contamination. Aquat.Toxicol. 35(1):59-77.	17783	UEndp, Det	
Bryan, G.W., D.A. Bright, L.G. Hummerstone, and G.R. Burt. 1993. Uptake, Tissue Distribution and Metabolism of 14C-Labelled Tributyltin (TBT) in the Dog-Whelk, Nucella lapillus. J.Mar.Biol.Assoc.U.K. 73(4):889-912.	4159	UEndp, Eff	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Bryan, G.W., P.E. Gibbs, G.R. Burt, and L.G. Hummerstone. 1987. The Effects of Tributyltin (TBT) Accumulation on Adult Dog-Whelks, Nucella lapillus: Long-Term Field and Laboratory Experiments. J.Mar.Biol.Assoc.U.K. 67(3):525-544.	9998	UENdp, Eff, Field	
Bryan, G.W., P.E. Gibbs, L.G. Hummerstone, and G.R. Burt. 1986. The Decline of the Gastropod Nucella lapillus Around South-West England: Evidence for the Effect of Tributyltin from Antifouling Paints. J.Mar.Biol.Assoc.U.K. 66:611-640.	4420	UEndp, Eff, UChron	
Bryan, G.W., P.E. Gibbs, L.G. Hummerstone, and G.R. Burt. 1989. Uptake and Transformation of 14C-Labelled Tributyltin Chloride by the Dog-Whelk, Nucella lapillus: Importance of Absorption from the Diet. Mar.Environ.Res. 28:241-245.	18308	UEndp, Eff, UChron	
Buccafusco, R.. 1976. Acute Toxicity of Tri-N-Butyltin oxide to Channel Catfish (Ictalurus punctatus), the Fresh Water Clam (Elliptio complanatus), the Common Mummichog. U.S.EPA-OPP Registration Standard.	12995	Dur, No Conc, AF	possile LC50 (18 ug/L) for mummichog but no salinity
Burridge, T.R., T. Lavery, and P.K.S. Lam. 1995. Acute Toxicity Tests Using Phyllospora comosa (Labillardiere) C. Agardh (Phaeophyta: Fucales) and Allorchestes compressa Dana (Crustacea: Amphipoda). Bull.Environ.Contam.Toxicol. 55(4):621-628.	14985	UEndp, Dur, NonRes	
Burridge, T.R., T. Lavery, and P.K.S. Lam. 1995. Effects of Tributyltin and Formaldehyde on the Germination and Growth of Phyllospora comosa (Labillardiere) C. Agardh (Phaeophyta: Fucales). Bull.Environ.Contam.Toxicol. 55(4):525-532.	14987	UEndp, Eff, Dur, NonRes	
Bushong, S.J., M.C. Ziegenfuss, M.A. Unger, and L.W. Hall Jr.. 1990. Chronic Tributyltin Toxicity Experiments With the Chesapeake Bay Copepod, Acartia tonsa. Environ.Toxicol.Chem. 9(3):359-366.	3199	Dur	
Chiles, T.C., P.D. Pendoley, and R.B. Laughlin Jr.. 1989. Mechanisms of Tri-N-Butyltin Bioaccumulation by Marine Phytoplankton. Can.J.Fish.Aquat.Sci. 46(5):859-862.	19095	UEndp, Eff, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Cima, F., L. Ballarin, G. Bressa, G. Martinucci, and P. Burighel. 1996. Toxicity of Organotin Compounds on Embryos of a Marine Invertebrate (Styela plicata; Tunicata). Ecotoxicol.Environ.Saf. 35(2):174-182.	18435	UEndp, Dur	
Cima, F., L. Ballarin, G. Bressa, G.B. Martinucci, and P. Burighel. 1996. Embryotoxic Effects of Organotin Compounds on Styela plicata (Tunicata; Ascidiacea). Fresenius Environ.Bull. 5(11/12):718-722.	20235	UEndp, Eff, Dur	
Cramm, G.. 1979. Acute and Chronic Toxicity of Tributyltin oxide (TBTO) to Sheepshead Minnows (Cyprinodon variegatus). U.S.EPA-OPP Registration Standard.	12998	UEndp, Dur	
Dahl, B., and H. Blanck. 1996. Pollution-Induced Community Tolerance (PICT) in Periphyton Communities Established Under Tri-n-butyltin (TBT) Stress in Marine Microcosms. Aquat.Toxicol. 34(4):305-325.	17785	UEndp, Eff, Dur, UChron, No Org	
Dahl, B., and H. Blanck. 1996. Use of Sand-Living Microalgal Communities (Epipsammon) in Ecotoxicological Testing. Mar.Ecol.Prog.Ser. 144(1-3):163-173.	19988	Eff, Dur, No Org	
Davies, I.M., and J.C. McKie. 1987. Accumulation of Total Tin and Tributyltin in Muscle Tissue of Farmed Atlantic Salmon. Mar.Pollut.Bull. 18(7):405-407.	2489	UEndp, Eff, Con, Dur	
Deutsch, U., and P. Fioroni. 1996. Effects of Tributyltin (TBT) and Testosterone on the Female Genital System in the Mesogastropod Littorina littorea (Prosobranchia). Helgol.Meeresunters. 50:105-115.	18847	UEndp, UChron	
Deutsch, U., J. Oehlmann, and E. Stroben. 1993. Morphological Effects of Tributyltin (TBT) In Vitro on the Genital System of the Mesogastropod Littorina littorea (L.) (Prosobranchia). In: J.C.Aldrich (Ed.), Proc.27th Eur.Mar.Biol.Symp., Quantified Phenotypic Responses in Morphology and Physiology, Sept.7-11, 1992, Dublin, Ireland :297-300.	17524	UEndp, UChron	
Dimitriou, P., J. Castritsi-Catharios, and H. Miliou. 2003. Acute Toxicity Effects of Tributyltin Chloride and Triphenyltin Chloride on Gilthead Seabream, Sparus aurata L., Embryos. Ecotoxicol.Environ.Saf. 54(1):30-35.	68277	UEndp, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Dixon, D.R., and H. Prosser. 1986. An Investigation of the Genotoxic Effects of an Organotin Antifouling Compound(Bis(Tributyltin) oxide) on the Chromosomes of the Edible Mussel,. Aquat.Toxicol. 8(3):185-195.	11949	UEndp	
Ebdon, L., K. Evans, and S. Hill. 1989. The Accumulation of Organotins in Adult and Seed Oysters from Selected Estuaries Prior to the Introduction of U.K. Regulations Governing the Use of. Sci.Total Environ. 83(1/2):63-84.	3345	UEndp, Eff, Field	
Fisher, W.S., L.M. Oliver, W.W. Walker, C.S. Manning, and T.F. Lytle. 1999. Decreased Resistance of Eastern Oysters (Crassostrea virginica) to a Protozoan Pathogen (Perkinsus marinus) After Sublethal Exposure to Tributyltin. Mar.Environ.Res. 47:185-201.	20625	UEndp, Eff	
Franchet, C., M. Goudeau, and H. Goudeau. 1999. Tributyltin Impedes Early Sperm-Egg Interactions at the Egg Coat Level in the Ascidian Phallusia mammillata but Does not Prevent Sperm-Egg Fusion in Naked Eggs. Aquat.Toxicol. 44(3):213-228.	20099	UEndp, Eff, Dur, Con	
Francois, R., F.T. Short, and J.H. Weber. 1989. Accumulation and Persistence of Tributyltin in Eelgrass (Zostera marina L.) Tissue. Environ.Sci.Technol. 23(2):191-196.	2580	UEndp, UChron, Con	
Gibbs, P.E., P.L. Pascoe, and G.R. Burt. 1988. Sex Change in the Female Dog-Whelk, Nucella lapillus, Induced by Tributyltin from Antifouling Paints. J.Mar.Biol.Assoc.U.K. 68(3):715-731.	9997	Field, UEndp, Eff,	
Girard, J.P., C. Ferrua, and D. Pesando. 1997. Effects of Tributyltin on Ca2+ Homeostasis and Mechanisms Controlling Cell Cycling in Sea Urchin Eggs. Aquat.Toxicol. 38:225-239.	18400	UEndp, Eff, Dur	
Gomez-Ariza, J.L., E. Morales, and I. Giraldez. 1999. Uptake and Elimination of Tributyltin in Clams, Venerupis decussata. Mar.Environ.Res. 47:399-413.	20627	Eff, UChron	
Gomez-Ariza, J.L., I. Giraldez, and E. Morales. 2000. Temporal Fluctuations of Tributyltin in the Bivalve Venerupis decussata at Five Stations in Southwest Spain. Environ.Pollut. 108(2):279-290.	49630	UEndp, Eff, Dur, UChron	
Guolan, H., and W. Yong. 1995. Effects of Tributyltin Chloride on Marine Bivalve Mussels. Water Res. 29(8):1877-1884.	15027	UEndp, Eff	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Hall, L.W.Jr., S.J. Bushong, M.C. Ziegenfuss, W.E. Johnson, R.L. Herman, and D.A. Wright. 1988. Chronic Toxicity of Tributyltin to Chesapeake Bay Biota. Water Air Soil Pollut. 39(3-4):365-376.	13209	UEndp	
Hattori, T., and Y. Shizuri. 1996. A Screening Method for Antifouling Substances Using Spores of the Fouling Macroalga Ulva conglobata Kjellman. Fish.Sci. 62(7):955-958.	10263	UEndp	
Heitmuller, T. 1977. Toxicity of Tri-N-Butyltin oxide (TBTO) to Pink Shrimp (Penaeus duorarum). U.S.EPA-OPP Registration Standard.	12991	Dur	ECOTOX provides one 96-h LC50 of 11.00 µg/L for this study. These values could have been considered for EPA's evaluation of saltwater TBT, but the species is relatively insensitive to TBT compared to others. Note, this test was not used in the 2003 TBT WQC doc.
Hollister, T.. 1977. Toxicity of Tri-N-Butyltin oxide (TBTO) to Embryos of Eastern Oysters (Crassostrea virginica). U.S.EPA-OPP Registration Standard.	12993	Dur	
Holm, G., L. Norrgren, and O. Linden. 1991. Reproductive and Histopathological Effects of Long-Term Experimental Exposure to bis(Tributyltin)oxide(TBTO) on the Three-Spined Stickleback. J.Fish Biol. 38(3):373-386.	3541	UEndp, Eff, Tox	
Itow, T., R.E. Loveland, and M.L. Botton. 1998. Developmental Abnormalities in Horseshoe Crab Embryos Caused by Exposure to Heavy Metals. Arch.Environ.Contam.Toxicol. 35(1):33-40.	19470	UEndp, Dur	
Itow, T., T. Igarashi, M.L. Botton, and R.E. Loveland. 1998. Heavy Metals Inhibit Limb Regeneration in Horseshoe Crab Larvae. Arch.Environ.Contam.Toxicol. 35(3):457-463.	20180	UEndp, UChron	
Jak, R.G., M. Ceulemans, M.C.T. Scholten, and N.M. Van Straalen. 1998. Effects of Tributyltin on a Coastal North Sea Plankton Community in Enclosures. Environ.Toxicol.Chem. 17(9):1840-1847.	19460	UEndp, Dur, Field	
Johansen, K., and F. Mohlenberg. 1987. Impairment of Egg Production in Acartia tonsa Exposed to Tributyltin Oxide. Ophelia 27(2):137-141.	4236	UEndp, Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Karande, A.A., and S.S. Ganti. 1994. Laboratory Assays of Tributyltin Toxicity to Some Common Marine Organisms. In: M.F.Thompson, R.Nagabhushanam, R.Sarojini, and M.Fingerman (Eds.), Recent Developments in Biofouling Control, Oxford and IBH, New Delhi, India :115-123 (Publ in Part As 13603).	17675	UEndp, UChron	
Karande, A.A., S.S. Ganti, and M. Udhayakumar. 1993. Toxicity of Tributyltin to Some Bivalve Species. Indian J.Mar.Sci. 22(2):153-154.	13603	UChron, Eff, NonRes	
Kawamata, M., K. Kon-Ya, and W. Miki. 1994. Trigonelline, an Antifouling Substance Isolated from an Octocoral Dendronephthya sp. Fish.Sci. 60(4):485-486.	16323	Dur	
Kelly, J.R., D.T. Rudnick, R.D. Morton, L.A. Buttel, and S.N. Levine. 1990. Tributyltin and Invertebrates of a Seagrass Ecosystem: Exposure and Response of Different Species. Mar.Environ.Res. 29(4):245-276.	8002	UEndp, Eff	
Kelly, J.R., S.N. Levine, L.A. Buttel, K.A. Carr, D.T. Rudnick, and R.D. Morton. 1990. The Effects of Tributyltin Within a Thalassia Seagrass Ecosystem. Estuaries 13(3):301-310.	7816	UEndp, Eff	
Kusk, K.O., and S. Petersen. 1997. Acute and Chronic Toxicity of Tributyltin and Linear Alkylbenzene Sulfonate to the Marine Copepod Acartia tonsa. Environ.Toxicol.Chem. 16(8):1629-1633.	18078	Dur	
Langston, W.J., and G.R. Burt. 1991. Bioavailability and Effects of Sediment-Bound TBT in Deposit-Feeding Clams, Scrobicularia plana. Mar.Environ.Res. 32(1-4):61-77.	3214	Eff	
Lapota, D., D.E. Rosenberger, and D. Duckworth. 1996. A Bioluminescent Dinoflagellate Assay for Detecting Toxicity in Coastal Waters. In: A.K.Campbell, L.J.Kricka, and P.E.Stanley (Eds.), Bioluminescence and Chemiluminescence, Fundamentals and Applied Aspects, John Wiley & Sons, NY :156-159.	19990	Eff, Dur	
Lapota, D., D.E. Rosenberger, M.F. Platter-Rieger, and P.F. Seligman. 1993. Growth and Survival of Mytilus edulis Larvae Exposed to Low Levels of Dibutyltin and Tributyltin. Mar.Biol. 115:413-419.	6982	UEndp, AF	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Laughlin, R.B.J., and W. French. 1988. Concentration Dependence of Bis(Tributyl)tin Oxide Accumulation in the Mussel, Mytilus edulis. Environ.Toxicol.Chem. 7(12):1021-1026.	8015	Eff, UChron, Con	
Laughlin, R.B.J., and W. French. 1989. Population-Related Toxicity Responses to Two Butyltin Compounds by Zoeae of the Mud Crab Rhithropanopeus harrisii. Mar.Biol. 102(3):397-401.	19081	UEndp, Dur, Con	
Laughlin, R.B.J., R. Gustafson, and P. Pendoley. 1988. Chronic Embryo-Larval Toxicity of Tributyltin (TBT) to the Hard Shell Clam Mercenaria mercenaria. Mar.Ecol.Prog.Ser. 48(1):29-36.	2971	UEndp, Dur	
Laughlin, R.B.J., R.G. Gustafson, and P. Pendoley. 1989. Acute Toxicity of Tributyltin (TBT) to Early Life History Stages of the Hard Shell Clam, Mercenaria mercenaria. Bull.Environ.Contam.Toxicol. 42(3):352-358.	2859	Con, UChron	
Laughlin, R.B.J., W. French, and H.E. Guard. 1986. Accumulation of Bis(Tributyltin) Oxide by the Marine Mussel Mytilus edulis. Environ.Sci.Technol. 20(9):884-890.	11905	Eff, Con	
Laughlin, R.B.J., W. French, R.B. Johannesen, H.E. Guard, and F.E. Brinckman. 1984. Predicting Toxicity Using Computed Molecular Topologies: The Example of Triorganotin Compounds. Chemosphere 13(4):575-584.	10187	Con, UChron, Dur	
Lawler, I.F., and J.C. Aldrich. 1987. Sublethal Effects of Bis(Tri-n-Butyltin)Oxide on Crassostrea gigas Spat. Mar.Pollut.Bull. 18(6):274-278.	29	UEndp, Eff, UChron	
Lee, R.F., A.O. Valkirs, and P.F. Seligman. 1989. Importance of Microalgae in the Biodegradation of Tributyltin in Estuarine Waters. Environ.Sci.Technol. 23:1515-1518.	18429	UEndp, Dur, No Org	
Li, Q., M. Osada, K. Takahashi, T. Matsutani, and K. Mori. 1997. Accumulation and Depuration of Tributyltin Oxide and Its Effect on the Fertilization and Embryonic Development in the Pacific Oyster, Crassostrea gigas. Bull.Environ.Contam.Toxicol. 58(3):489-496.	18005	Eff	
Liberatore, G.L., D.K. Christian, and J.M. Raines. 1977. Standard Bioassay Using the Barnacle Larva. David W.Taylor Naval Ship Res.Dev.Ctr., Annapolis, MD :12 p.(U.S.NTIS AD-A036562).	6019	Dur	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Lignot, J.H., F. Pannier, J.P. Trilles, and G. Charmantier. 1998. Effects of Tributyltin Oxide on Survival and Osmoregulation of the Shrimp Penaeus japonicus (Crustacea, Decapoda). Aquat.Toxicol. 41(4):277-299.	19156	NonRes, UEndp, Eff, Dur	
Manning, C.S., T.F. Lytle, W.W. Walker, and J.S. Lytle. 1999. Life-Cycle Toxicity of Bis(Tributyltin) Oxide to the Sheepshead Minnow (Cyprinodon variegatus). Arch.Environ.Contam.Toxicol. 37(2):258-266.	20452	UEndp	
Maruyama, T., D. Sun, S. Hashimoto, and A. Miura. 1991. Toxic Effects of Triorganotins on the Adhesion and Germination - Growth of Conchospores of Porphyra yezoensis, Red Arga. Mar.Pollut.Bull. 23:729-731.	7937	Con, Dur	
Matthiessen, P., R. Waldock, J.E. Thain, M.E. Waite, and S. Scrope-Howe. 1995. Changes in Periwinkle (Littorina littorea) Populations Following the Ban on TBT-Based Antifoulings on Small Boats in the United Kingdom. Ecotoxicol.Environ.Saf. 30(2):180-194.	15325	UEndp, Eff, Dur, Tox	
Meador, J.P.. 1993. The Effect of Laboratory Holding on the Toxicity Response of Marine Infaunal Amphipods to Cadmium and Tributyltin. J.Exp.Mar.Biol.Ecol. 174(2):227-242.	4114	Con	Same data reported in another study, used for SMAV calculation
Meador, J.P.. 1997. Differential Sensitivity of Marine Infaunal Amphipods to Tributyltin. Mar.Biol. 116(2):231-239.	8519	Dur	
Mercier, A., E. Pelletier, and J.F. Hamel. 1996. Toxicological Response of the Symbiotic Sea Anemone Aiptasia pallida to Butyltin Contamination. Mar.Ecol.Prog.Ser. 144(1-3):133-146.	6838	UEndp, Eff, Dur	
Mercier, A., E. Pelletier, and J.F. Hamel. 1998. Response of Temperate Sea Anemones to Butyltin Contamination. Can.J.Fish.Aquat.Sci. 55(1):239-245.	18651	UEndp, Eff, Dur	
Molander, S., B. Dahl, H. Blanck, J. Jonsson, and M. Sjostrom. 1992. Combined Effects of Tri-n-butyl Tin (TBT) and Diuron on Marine Periphyton Communities Detected as Pollution-Induced Community Tolerance. Arch.Environ.Contam.Toxicol. 22(4):419-427.	6117	Eff, Dur, Con, No Org	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Morcillo, Y., and C. Porte. 2000. Evidence of Endocrine Disruption in Clams - Ruditapes decussata - Transplanted to a Tributyltin-Polluted Environment. Environ.Pollut. 107(1):47-52.	52364	Field, Eff	
Morcillo, Y., M.J.J. Ronis, and C. Porte. 1998. Effects of Tributyltin on the Phase I Testosterone Metabolism and Steroid Titres of the Clam Ruditapes decussata. Aquat.Toxicol. 42(1):1-13.	19153	Eff	
Nell, J.A., and R. Chvojka. 1992. The Effect of bis-Tributyltin Oxide (TBTO) and Copper on the Growth of Juvenile Sydney Rock Oysters Saccostrea commercialis (Iredale and Roughley) and. Sci.Total Environ. 125:193-201.	4136	UEndp, UChron	
Nias, D.J., S.C. McKullup, and K.S. Edyvane. 1993. Imposex in Lepsiella vinosa from Southern Australia. Mar.Pollut.Bull. 26(7):380-384.	9714	UEndp, UChron, Pur	
Oehlmann, J., and C. Bettin. 1996. Tributyltin-Induced Imposex and the Role of Steroids in Marine Snails. Malacol.Rev.(Suppl. 6):157-161.	17953	UEndp, UChron	
Pickwell, G.V., and S.A. Steinert. 1988. Uptake and Accumulation of Organotin Compounds by Oyster and Mussel Hemocytes: Correlation with Serum Biochemical and Cytological Factors and. Aquat.Toxicol. 11(3/4):419-420 (ABS).	9646	UEndp, UChron, Con	
Pinkney, A.E.. 1989. Biochemical, Histological, and Physiological Effects of Tributyltin Compounds in Estuarine Fish. Diss.Abstr.Int.B Sci.Eng.49(8):3080 / Ph.D.Thesis, University of Maryland, College Park, MD :109 p..	3128	UEndp, Eff, UChron, Con	
Reader, S., and E. Pelletier. 1992. Biosorption and Degradation of Butyltin Compounds by the Marine Diatom Skeletonema costatum and the Associated Bacterial Community at Low Temperature. Bull.Environ.Contam.Toxicol. 48(4):599-607.	14967	UEndp, Eff	
Ringwood, A.H.. 1992. Comparative Sensitivity of Gametes and Early Developmental Stages of a Sea Urchin Species (Echinometra mathaei) and a Bivalve Species (Isognomon. Arch.Environ.Contam.Toxicol. 22:288-295.	3886	Dur, UChron	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Roman, G., A. Rudolph, J. Morillas, and R. Ahumada. 1992. Observations on Sublethal and Acute Toxicity on Choromytilus chorus (Molina, 1782), Produced by Tributyltin (TBT). Bol.Soc.Biol.Concepcion 63:175-184 (SPA) (ENG ABS).	16522	UEndp, Eff, NonRes	
Ruiz, J.M., G.W. Bryan, and P.E. Gibbs. 1994. Bioassaying the Toxicity of Tributyltin-(TBT)-Polluted Sediment to Spat of the Bivalve Scrobicularia plana. Mar.Ecol.Prog.Ser. 113:119-130.	14426	UEndp, UChron, NonRes	
Ruiz, J.M., G.W. Bryan, and P.E. Gibbs. 1994. Chronic Toxicity of Water Tributyltin (TBT) and Copper to Spat of the Bivalve Scrobicularia plana: Ecological Implications. Mar.Ecol.Prog.Ser. 113:105-117.	14453	UEndp, UChron, NonRes	
Ruiz, J.M., G.W. Bryan, and P.E. Gibbs. 1995. Effects of Tributyltin (TBT) Exposure on the Veliger Larvae Development of the Bivalve Scrobicularia plana (da Costa). J.Exp.Mar.Biol.Ecol. 186(1):53-63.	16564	UEndp, Dur, NonRes	
Ruiz, J.M., G.W. Bryan, and P.E. Gibbs. 1995. Acute and Chronic Toxicity of Tributyltin (TBT) to Pediveliger Larvae of the Bivalve Scrobicularia plana. Mar.Biol. 124(1):119-126.	19051	UEndp, Eff, UChron, NonRes	
Ruiz, J.M., G.W. Bryan, G.D. Wigham, and P.E. Gibbs. 1995. Effects of Tributyltin (TBT) Exposure on the Reproduction and Embryonic Development of the Bivalve Scrobicularia plana. Mar.Environ.Res. 40(4):363-379.	18221	UEndp, Dur, NonRes	
Salazar, M.H., and S. Salazar. 1993. Mussles as Bioindicators: Effects of TBT on Survival, Bioaccumulation and Growth Under Natural Conditions. In: M.A.Champ and P.F.Seligman (Eds.), Organotins: Environmental Fate and Effects, Elsevier, NY :43 p..	9682	Field, UEndp, Eff	
Salazar, M.H., and S.M. Salazar. 1987. Tributyltin Effects on Juvenile Mussel Growth. In: Proc.Oceans, 1987, Halifax, Nova Scotia, Canada, Sept.28-Oct.1, 1987, Organotin Symposium 4:1504-1510.	9685	Field, UEndp, Eff, Tox	
Salazar, M.H., and S.M. Salazar. 1988. Tributyltin and Mussel Growth in San Diego Bay. In: Proc.Oceans, 1988, Baltimore, MD, Oct.31-Nov.2, 1988, Organotin Symposium 4 :1188-1197.	9683	Field, UEndp, Eff	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Sasikumar, N., A.S. Clare, D.J. Gerhart, D. Stover, and D. Rittschof. 1995. Comparative Toxicities of Selected Compounds to Nauplii of Balanus amphitrite amphitrite Darwin and Artemia sp.. Bull.Environ.Contam.Toxicol. 54:289-296.	53890	Dur	
Scammell, M.S., G.E. Batley, and C.I. Brockbank. 1991. A Field Study of the Impact on Oysters of Tributyltin Introduction and Removal in a Pristine Lake. Arch.Environ.Contam.Toxicol. 20(2):276-281.	68549	Field, UEndp, Eff	
Smith, B.S.. 1981. Tributyltin Compounds Induce Male Characteristics on Female Mud Snails Nassarius obsoletus = Ilyanassa obsoleta. J.Appl.Toxicol. 1(3):141-144.	2503	UChron, Con	
Snell, T.W., B.D. Moffat, C. Janssen, and G. Persoone. 1991. Acute Toxicity Tests Using Rotifers. III. Effects of Temperature, Strain, and Exposure Time on the Sensitivity of Brachionus plicatilis. Environ.Toxicol.Water Qual. 6:63-75.	16539	Dur	
Spooner, N., P.E. Gibbs, G.W. Bryan, and L.J. Goad. 1991. The Effect of Tributyltin upon Steroid Titres in the Female Dogwhelk, Nuclella lapillus, and the Development of Imposex. Mar.Environ.Res. 32(1-4):37-49.	3655	UEndp, Tox	
Stenalt, E., B. Johansen, S.V. Lillienskjold, and B.W. Hansen. 1998. Mesocosm Study of Mytilus edulis Larvae and Postlarvae, Including the Settlement Phase, Exposed to a Gradient of Tributyltin. Ecotoxicol.Environ.Saf. 40(3):212-225.	19280	Field, UEndp, Eff, Dur	
Stephenson, M.. 1991. A Field Bioassay Approach to Determining Tributyltin Toxicity to Oysters in California. Mar.Environ.Res. 32(1-4):51-59.	5682	Field, UEndp, Eff	
Stroben, E., J. Oehlmann, and P. Fioroni. 1992. Hinia reticulata and Nucella lapillus. Comparison of Two Gastropod Tributyltin Bioindicators. Mar.Biol. 114(2):289-296.	18430	UEndp, Eff, UChron	
Stroemgren, T., and T. Bongard. 1987. The Effect of Tributyltin Oxide on Growth of Mytilus edulis. Mar.Pollut.Bull. 18(1):30-31.	8946	UEndp, Con	
Stromgren, T., and T. Bongard. 1987. The Effect of Tributyltin Oxide on Growth of Mytilus edulis. Mar.Pollut.Bull. 18(1):30-31.	3449	UEndp, Con	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Sujatha, C.H., S.M. Nair, and J. Chacko. 1996. Tributyltin Oxide Induced Physiological and Biochemical Changes in a Tropical Estuarine Clam. Bull.Environ.Contam.Toxicol. 56(2):303-310.	16439	UEndp, Eff	
Tsuda, T., S. Aoki, M. Kojima, and H. Harada. 1990. Differences Between Freshwater and Seawater-Acclimated Guppies in the Accumulation and Excretion of Tri-N-Butyltin Chloride and Triphenyltin Chloride. Water Res. 24(11):1373-1376.	3486	UEndp, Eff, Con	
Valkirs, A.O., B.M. Davidson, and P.F. Seligman. 1987. Sublethal Growth Effects and Mortality to Marine Bivalves From Long-Term Exposure to Tributyltin. Chemosphere 16(1):201-220.	12445	UEndp, Con, AF	
Van Slooten, K.B., and J. Tarradellas. 1994. Accumulation, Depuration and Growth Effects of Tributyltin in the Freshwater Bivalve Dreissena polymorpha Under Field Conditions. Environ.Toxicol.Chem. 13(5):755-762.	4194	Field, UEndp, Eff	
Walsh, G.E., L.L. McLaughlan, E.M. Lores, M.K. Louie, and C.H. Deans. 1985. Effects of Organotins on Growth and Survival of Two Marine Diatoms, Skeletonema costatum and Thalassiosira pseudonana. Chemosphere 14(3-4):383-392.	11353	Dur, Con	
Walsh, G.E., L.L. McLaughlin, M.K. Louie, C.H. Deans, and E.M. Lores. 1986. Inhibition of ARM Regeneration by Ophioderma brevispina (Echinodermata, Ophiuroidea) by Tributyltin oxide and Triphenyltin oxide. Ecotoxicol.Environ.Chem. 12(1):95-100.	12007	UEndp	
Weis, J.S., and K. Kim. 1988. Tributyltin is a Teratogen in Producing Deformities in Limbs of the Fiddler Crab, Uca pugilator. Arch.Environ.Contam.Toxicol. 17(5):583-587.	2352	UEndp	
Weis, J.S., J. Gottlieb, and J. Kwiatkowski. 1987. Tributyltin Retards Regeneration and Produces Deformities of Limbs in the Fiddler Crab, Uca pugilator. Arch.Environ.Contam.Toxicol. 16:321-326.	15091	UEndp	
Weis, J.S., P. Weis, and F. Wang. 1987. Developmental Effects of Tributyltin on the Fiddler Crab, Uca pugilator, and the Killifish, Fundulus heteroclitus. In: Proc.Oceans, 1987, Halifax, Nova Scotia, Canada, Sept.28-Oct.1, 1987, Organotin Symposium 4:1456-1460.	4851	UEndp	

Citation	ECOTOX EcoRef #	Rejection Code(s)	Comment
Widdows, J., and D.S. Page. 1993. Effects of Tributyltin and Dibutyltin on the Physiological Energetics of the Mussel, Mytilus edulis. Mar.Environ.Res. 35(3):233-249.	7000	UEndp, Eff	
Yamada, H., and K. Takayanagi. 1992. Bioconcentration and Elimination of Bis(Tributyltin)Oxide (TBTO) and Triphenyltin Chloride (TPTC) in Several Marine Fish Species. Water Res. 26(12):1589-1595.	6077	Eff, Dur	
Yamada, H., M. Tateishi, and K. Takayanagi. 1994. Bioaccumulation of Organotin Compounds in the Red Sea Bream (Pagrus major) by Two Uptake Pathways: Dietary Uptake and Direct Uptake from Water. Environ.Toxicol.Chem. 13(9):1415-1422.	13509	UEndp, Eff	
Yla-Mononen, L.. 1989. The Effects of Tri-n-Butyltin Chloride (TBTC) on the Early Life Stages of Perch (Perca fluviatilis L.) in Brackish Water. Aqua Fenn. 19(2):129-133.	87	UEndp	

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[98], EPA is providing a transparent rationale as to why they were not utilized (see below).

For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable.

General QA/QC failure because non-resident species in Oregon

[98] U.S. EPA. 2003. Ambient Water Quality Criteria for Tributyltin (TBT) - Final. EPA-882-R-03-031.

Tests with the following species were used in the EPA BE of OR WQS for tributyltin in saltwater, but were not considered in the CWA review and approval/disapproval action of the standards because these species do not have a breeding wild population in Oregon's waters:

Crassostrea	*virginica*	Eastern oyster	U.S. EPA 2000; Roberts 1987
Mercenaria	*mercenaria*	Hard clam	Roberts 1987
Nucella	*lapillus*	Atlantic dogwhinkle	Harding et al. 1996

<u>Other Acute tests failing QA/QC by species</u>

Holmesimysis sculpta – Mysid

Davidson, B.M., A.O. Valkirs and P.F. Seligman. 1986a. Acute and Chronic Effects of Tributyltin on the Mysid *Acanthomysis sculpta* (Crustacea, Mysidacea). NOSC-TR-1116 or AD-A175-294-8. National Technical Information Service, Springfield, VA.
One LC50 value from an R,M test of 0.42 µg/L. This test was not used for determining the most representative SMAV in this CWA review and approval/disapproval action of these standards because the test was not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for these species.

Davidson, B.M., A.O. Valkirs and P.F. Seligman. 1986b. Acute and chronic effects of tributyltin on the mysid *Acanthomysis sculpta* (Crustacea, Mysidacea). In: Oceans 86, Vol. 4. Proceeding International Organotin Symposium. Marine Technology Society, Washington, DC.: 1219-1225.
The LC50 value from an R,M test of 0.42 µg/L reported in this study is a repeat of the LC50 reported in Davidson et al. (1986a) above. This test was not used for determining the most representative SMAV in this CWA review and approval/disapproval action of these standards because the test was not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for these species.

Valkirs, A., B. Davidson and P. Seligman. 1985. Sublethal growth effects and mortality to marine bivalves and fish from long-term exposure to tributyltin. NOSC-TR-1042 or AD-A162-629-0. National Technical Information Service, Springfield, VA.
One test in this study was not used in this CWA review and approval/disapproval action of these standards because a more sensitive lifestage was available for this species from this study.

Acartia tonsa – Copepod

U'ren, S.C. 1983. Acute toxicity of bis(tributyltin) oxide to a marine copepod. Mar. Pollut. Bull. 14: 303-306.

One LC50 value from an R,U test of 0.6326 µg/L. This test was not used in this CWA review and approval/disapproval action of these standards because the test was not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for these species.

Kusk, K.O. and S. Petersen. 1997. Acute and chronic toxicity of tributyltin and linear alkylbenzene sulfonate to the marine copepod *Acartia tonsa*. Environ. Toxicol. Chem. 16: 1629-1633.
Two LC50 values from S,U tests ranging from 0.24 to 0.47 µg/L. These values were not used in this CWA review and approval/disapproval action of these standards because the test was not based on the preferred flow-through measured test conditions; however, other flow-through measured test concentrations were available for these species.

Crassostrea gigas* – *Pacific oyster

Thain, J.E. 1983. The acute toxicity of bis(tributyltin) oxide to the adults and larvae of some marine organisms. Int. Counc. Explor. Sea, Mariculture Committee E: 13. 5 pp.
One test in this study was not used in this CWA review and approval/disapproval action of these standards because a more sensitive lifestage was available for this species from this study.

Appendix V Zinc (Saltwater)
Studies Not Pertinent to this Determination
(Note: Codes Described in Attachment 3 of Appendix B)

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Abel, P.D.. 1976. Effects of Some Pollutants on the Filtration Rate of Mytilus. Mar.Pollut.Bull. 7:228-231.	415	Con	More sensitive endpoint exists
Ahsanullah, M., and A.R. Williams. 1991. Sublethal Effects and Bioaccumulation of Cadmium, Chromium, Copper, and Zinc in the Marine Amphipod Allorchestes compressa. Mar.Biol. 108:59-65.	331	Eff	
Ahsanullah, M., and G.H. Arnott. 1978. Acute Toxicity of Copper, Cadmium, and Zinc to Larvae of the Crab Paragrapsus quadridentatus (H. Milne Edwards), and Implications for Water. Aust.J.Mar.Freshwater Res. 29(1):1-8.	8296	Eff	
Ahsanullah, M., D.S. Negilski, and M.C. Mobley. 1981. Toxicity of Zinc, Cadmium and Copper to the Shrimp Callianassa australiensis. I. Effects of Individual Metals. Mar.Biol. 64(3):299-304(Author Communication Used).	15338	Eff	
Ahsanullah, M., D.S. Negilski, and M.C. Mobley. 1981. Toxicity of Zinc, Cadmium and Copper to the Shrimp Callianassa australiensis. III. Accumulation of Metals. Mar.Biol.64(3):311-316 (Used Ref 15338) (Author Communication Used).	15339	Eff	
Ahsanullah, M., M.C. Mobley, and P. Rankin. 1988. Individual and Combined Effects of Zinc, Cadmium and Copper on the Marine Amphipod Allorchestes compressa. Aust.J.Mar.Freshwater Res. 39(1):33-37.	13187	NonRes	
Ahsanullah, M.. 1976. Acute Toxicity of Cadmium and Zinc to Seven Invertebrate Species From Western Port, Victoria. Aust.J.Mar.Freshwater Res. 27(2):187-196.	2445	NonRes	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Ajmalkhan, S., K. Rajendran, and R. Natarajan. 1986. Effect of Zinc on Zoeal Development of the Estuarine Hermit Crab Clibanarius olivaceus (Henderson). Proc.Indian Acad.Sci.Anim.Sci. 95(5):515-524.	3985	UEndp	
Amado Filho, G.M., C.S. Karez, L.R. Andrade, Y. Yoneshigue-Valentin, and W.C. Pfeiffer. 1997. Effects on Growth and Accumulation of Zinc in Six Seaweed Species. Ecotoxicol.Environ.Saf. 37:223-228.	18321	UEndp	
Amado Filho, G.M., C.S. Karez, W.C. Pfeiffer, Y. Yoneshigue-Valentin, and M. Farina. 1996. Accumulation, Effects on Growth, and Localization of Zinc in Padina gymnospora (Dictyotales, Phaeophyceae). Hydrobiologia 326/327:451-456.	17512	UEndp, Eff	
Amiard, J.C., C. Amiard-Triquet, B. Berthet, and C. Metayer. 1987. Comparative Study of the Patterns of Bioaccumulation of Essential (Cu, Zn) and Non-Essential (Cd, Pb) Trace Metals in Various Estuarine and Coastal Organ. J.Exp.Mar.Biol.Ecol. 106(1):73-89.	7913	UEndp, Eff, Con	
Amiard-Triquet, C., J.C. Amiard, R. Ferrand, A.C. Andersen, and M.P. Dubois. 1986. Disturbance of a Met-Enkephalin-Like Hormone in the Hepatopancreas of Crabs Contaminated by Metals. Ecotoxicol.Environ.Saf. 11(2):198-209.	12111	UEndp, Eff	
Anderson, B.S., and J.W. Hunt. 1988. Bioassay Methods for Evaluating the Toxicity of Heavy Metals, Biocides and Sewage Effluent Using Microscopic Stages of Giant Kelp Macrocystis pyrifera. Mar.Environ.Res. 26(2):113-134.	2349	Dur	Six 48hr NOEC's
Andrade, L., S.M.F. Azevedo, and W.C. Pfeiffer. 1994. Effects of High Zinc Concentrations in Phytoplankton Species from Sepetiba Bay (Brazil). Arq.Biol.Tecnol. 37(3):655-666.	19200	UEndp	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Andryushchenko, V.V., and G.G. Polikarpov. 1974. An Experimental Study of Uptake of Zn65 and DDT by Ulva rigida From Seawater Polluted with Both Agents. Hydrobiol.J.10(4):41-46 / Gidrobiol Zh. 10(4):56-62 (RUS).	7588	Eff, Con	
Arnott, G.H., and M. Ahsanullah. 1979. Acute Toxicity of Copper, Cadmium and Zinc to Three Species of Marine Copepod. Aust.J.Mar.Freshwater Res. 30(1):63-71.	5563	Dur, Con	24hr only
Aunaas, T., S. Einarson, T.E. Southon, and K.E. Zachariassen. 1991. The Effects of Organic and Inorganic Pollutants on Intracellular Phosphate Compounds in Blue Mussels (Mytilus edulis). Comp.Biochem.Physiol.C 100(1/2):89-93.	3968	UEndp, Eff	
Baby, K.V., and N.R. Menon. 1986. Oxygen Uptake in the Brown Mussel, Perna indica (Kuriakose & Nair) Under Sublethal Stress of Hg, Cd & Zn. Indian J.Mar.Sci. 15(2):127-128.	12318	UEndp, AF, NonRes	
Bat, L.. 1997. Studies on the Uptake of Copper, Zinc and Cadmium by the Amphipod Corophium volutator (Pallas) in the Laboratory. Turk.J.Mar.Sci. 3(2):93-109.	19858	UEndp	
Benijts-Claus, C., and F. Benijts. 1975. The Effect of Low Lead and Zinc Concentrations on the Larval Development of the Mud-Crab Rhithropanopeus harrisii Gould. In: J.H.Koeman and J.J.T.W.A.Strik (Eds.), Sublethal Effects of Toxic Chemicals on Aquat.Animals, Elsevier Sci.Publ., Amsterdam, NY :43-52.	15451	UEndp	
Bervoets, L., R. Blust, and R. Verheyen. 1996. Uptake of Zinc by the Midge Larvae Chironomus riparius at Different Salinities: Role of Speciation, Acclimation, and Calcium. Environ.Toxicol.Chem. 15(8):1423-1428.	17236	UEndp	
Boikova, E.E.. 1978. Effect of Zinc Acetate on Paramecium putrinum. Protozoologiya 3:105-111 (RUS) (ENG ABS).	6998	UEndp, Dur, Con	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Bologa, A.S.. 1984. Uptake of 59Fe, 65Zn and 85Sr by Mytilus galloprovincialis and Mya arenaria from the Romanian Black Sea Shore. Cercet.Mar.(Rech.Mar.) 17:285-295.	4090	Eff, Con	
Botton, M.L., K. Johnson, and L. Helleby. 1998. Effects of Copper and Zinc on Embryos and Larvae of the Horseshoe Crab, Limulus polyphemus. Arch.Environ.Contam.Toxicol. 35(1):25-32.	19307	Dur	ECOTOX provides six 48- and 72-h LC50s of <94.6->946000 µg/L for this study. This value could have been considered for EPA's evaluation of saltwater zinc, but the species is relatively insensitive to zinc compared to others. Some LC50s for this species were entered into ECOTOX as approximate values or ranges.
Boyden, C.R., H. Watling, and I. Thornton. 1975. Effect of Zinc on the Settlement of the Oyster Crassostrea gigas. Mar.Biol. 31(3):227-234.	15885	UEndp	
Braek, G.S., D. Malnes, and A. Jensen. 1980. Heavy Metal Tolerance of Marine Phytoplankton. IV. Combined Effect of Zinc and Cadmium on Growth and Uptake in Some Marine Diatoms. J.Exp.Mar.Biol.Ecol. 42:39-54.	9761	UEndp, Con	
Brereton, A., H. Lord, I. Thornton, and J.S. Webb. 1973. Effect of Zinc on Growth and Development of Larvae of the Pacific Oyster Crassostrea gigas. Mar.Biol. 19(2):96-101.	8776	UEndp	
Brown, B., and M. Ahsanullah. 1971. Effect of Heavy Metals on Mortality and Growth. Mar.Pollut.Bull. 2:182-187.	2467	LT, Con	
Brown, C.L., and S.N. Luoma. 1995. Use of the Euryhaline Bivalve Potamocorbula amurensis as a Biosentinel Species to Assess Trace Metal Contamination in San Francisco Bay. Mar.Ecol.Prog.Ser. 124(1-3):129-142.	18036	UEndp, Eff	
Bryan, G.W.. 1969. The Absorption of Zinc and Other Metals by the Brown Seaweed Laminaria digitata. J.Mar.Biol.Assoc.U.K. 49(1):225-243.	2268	UEndp, Con	
Bryan, G.W.. 1969. The absorption of zinc and other metals by the brown seaweed, Laminaria digitata.. J. Mar. Biol. Assoc. U.K. 49: 225-243..		Eff	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Bryant, V., D.M. Newbery, D.S. McKlusky and R. Campbell. 1985. Effect of temperature and salinity on the toxicity of nickel and zinc to two estuarine invertebrates (Corophium volutator, Macoma balthica). Mar. Ecol. Prog. Ser. 24: 139-153..		NonRes	
Bryant, V., D.M. Newbery, D.S. McLusky, and R. Campbell. 1985. Effect of Temperature and Salinity on the Toxicity of Nickel and Zinc to Two Estuarine Invertebrates (Corophium volutator, Macoma balthica). Mar.Ecol.Prog.Ser. 24(1-2):139-153.	11875	NonRes	
Burbidge, F.J., D.J. Macey, J. Webb, and V. Talbot. 1994. A Comparison Between Particulate (Elemental) Zinc and Soluble Zinc (ZnCl2) Uptake and Effects in the Mussel, Mytilus edulis. Arch.Environ.Contam.Toxicol. 26(4):466-472.	13661	UEndp	
Burdin, K.S., and K.T. Bird. 1994. Heavy Metal Accumulation by Carrageenan and Agar Producing Algae. Bot.Mar. 37:467-470.	45156	UEndp, Eff	24hr only
Burton, D.T., and D.J. Fisher. 1990. Acute Toxicity of Cadmium, Copper, Zinc, Ammonia, 3,3'-Dichlorobenzidine, 2,6-Dichloro-4-nitroaniline, Methylene Chloride, and 2,4,6-Trichlorophenol. Bull.Environ.Contam.Toxicol. 44(5):776-783.	3163	Con, Dur	
Calabrese, A., J.R. MacInnes, D.A. Nelson, and J.E. Miller. 1977. Survival and Growth of Bivalve Larvae Under Heavy-Metal Stress. Mar.Biol. 41:179-184.	9064	Con, UEndp	
Calapaj, G.G.. 1974. Ricerche Di Laboratorio Sull'Inquinamento Chimico Dei Mitili Nota II: Cadmio, Zinco. (Chemical Pollution of Mytilus. II. Cadmium and Zinc). Ig.Mod. 67(2):136-145 (ITA) (ENG ABS).	8508	UEndp, Eff	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Canli, M., and R.W. Furness. 1993. Toxicity of Heavy Metals Dissolved in Sea Water and Influences of Sex and Size on Metal Accumulation and Tissue Distribution in the Norway Lobster. Mar.Environ.Res. 36(4):217-236.	4563	UEndp, Eff	
Canterford, G.S., A.S. Buchanan, and S.C. Ducker. 1978. Accumulation of Heavy Metals by the Marine Diatom Ditylum brightwellii (West) Grunow. Aust.J.Mar.Freshwater Res. 29(5):613-622.	15455	UEndp, Con	
Canterford, G.S., and D.R. Canterford. 1980. Toxicity of Heavy Metals to the Marine Diatom Ditylum brightwellii (West) Grunow: Correlation between Toxicity and Metal Speciation. J.Mar.Biol.Assoc.U.K. 60(1):227-242.	6405	UEndp	5d EC50 for a Diatom
Carvalho, R.A., M.C. Benfield, and P.H. Santschi. 1999. Comparative Bioaccumulation Studies of Colloidally Complexed and Free-Ionic Heavy Metals in Juvenile Brown Shrimp Penaeus aztecus (Crustacea: Decapoda: Penaeidae). Limnol.Oceanogr. 44(2):403-414.	48059	Eff	
Chan, H.M., and P.S. Rainbow. 1993. On the Excretion of Zinc by the Shore Crab Carcinus maenas (L.). Ophelia 38(1):31-45.	17027	UEndp, Eff	
Chan, H.M., and P.S. Rainbow. 1993. The Accumulation of Dissolved Zinc by the Shore Crab Carcinus maenas (L.). Ophelia 38(1):13-30.	17026	Eff	
Chan, H.M., P. Bjerregaard, P.S. Rainbow, and M.H. Depledge. 1992. Uptake of Zinc and Cadmium by Two Populations of Shore Crabs Carcinus maenas at Different Salinities. Mar.Ecol.Prog.Ser. 86(1):91-97.	7546	UEndp, Eff	
Chan, H.M. 1988. Accumulation and Tolerance to Cadmium, Copper, Lead and Zinc by the Green Mussel Perna viridis. Mar.Ecol.Prog.Ser. 48(3):295-303.	2970	UEndp, Eff	ECOTOX provides a 96-h LC50 of 5761 µg/L for this study. This value could have been considered for EPA's evaluation of saltwater zinc, but the species is relatively insensitive to zinc compared to others.

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Chapman, P.M., and C. McPherson. 1993. Comparative Zinc and Lead Toxicity Tests with Arctic Marine Invertebrates and Implications for Toxicant Discharges. Polar Rec.29(168):45-54; In: E.G.Baddaloo, S.Ramamoorthy and J.W.Moore (Eds.), Proc.19th Annual Aquatic Toxicity Workshop, Oct.4-7, 1992, Edmondton, Alberta, Can.Tech.Rep.Fish.Aquat.Sci.No.1942:7-22.	4092	UEndp, Dur	
Chen, J.C., and P.C. Liu. 1987. Accumulation of Heavy Metals in the Nauplii of Artemia salina. J.World Aquacult.Soc. 18(2):84-93.	2749	UEndp, Eff	
Chung, K.S.. 1980. Acute Toxicity of Selected Heavy Metals to Mangrove Oyster Crassostrea rhizophorae. Bull.Jpn.Soc.Sci.Fish.(Nippon Suisan Gakkaishi) 46(6):777-780.	5308	Con	
Clarke, G.L.. 1947. Poisoning and Recovery in Barnacles and Mussels. Biol.Bull. 92:73-91.	14811	UENdp	
Conroy, P.T., J.W. Hunt, and B.S. Anderson. 1996. Validation of a Short-Term Toxicity Test Endpoint by Comparison with Longer-Term Effects on Larval Red Abalone Haliotis rufescens. Environ.Toxicol.Chem. 15(7):1245-1250.	17224	Dur, UChron	
Cotter, A.J.R., D.J.H. Phillips, and M. Ahsanullah. 1982. The Significance of Temperature, Salinity and Zinc as Lethal Factors for the Mussel Mytilus edulis in a Polluted Estuary. Mar.Biol. 68(2):135-141.	15528	UEndp	
Crespo, S., and J. Balasch. 1980. Mortality, Accumulation, and Distribution of Zinc in the Gill System of the Dogfish Following Zinc Treatment. Bull.Environ.Contam.Toxicol. 24(6):940-944.	2844	Con, Dur	
Crespo, S., and R. Sala. 1986. Ultrastructural Alterations of the Dogfish (Scyliorhinus canicula) Gill Filament Related to Experimental Aquatic Zinc Pollution. Dis.Aquat.Org. 1(2):99-104.	12525	UEndp, Eff	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Crespo, S., E. Soriano, C. Sampera, and J. Balasch. 1981. Zinc and Copper Distribution in Excretory Organs of the Dogfish Scyliorhinus canicula and Chloride Cell Response Following Treatment with Zinc Sulphate. Mar.Biol. 65(2):117-123.	15350	UEndp, Con	
Cui, K., Y. Liu, and L. Hou. 1987. Effects of Six Heavy Metals on Hatching Eggs and Survival of Larval of Marine Fish. Oceanol.Limnol.Sin./Haiyang Yu Huzhao 18(2):138-144 (CHI) (ENG ABS).	3222	Con	
Davies, N.A., and K. Simkiss. 1996. The Uptake of Zinc from Artificial Sediments by Mytilus edulis. J.Mar.Biol.Assoc.U.K. 76:1073-1079.	18668	UEndp, Eff	
Davies, N.A., M.G. Taylor, and K. Simkiss. 1997. The Influence of Particle Surface Characteristics on Pollutant Metal Uptake by Cells. Environ.Pollut. 96(2):179-184.	18661	UEndp, Eff	
Denton, G.R.W., and C. Burdon-Jones. 1986. Environmental Effects on Toxicity of Heavy Metals to Two Species of Tropical Marine Fish from Northern Australia. Chem.Ecol. 2(3):233-249.	4327	See note	ECOTOX provides two 96-h LC50s of 17501 µg/L and 11825 µg/L for this study. These values could have been considered for EPA's evaluation of saltwater zinc, but the species is relatively insensitive to zinc compared to others.
Deutch, B., B. Borg, L. Kloster, H. Meyer, and M.M. Moller. 1980. The Accumulation of 65Zn by Various Marine Organisms. Ophelia (Suppl 1):235-240.	9785	Eff	
Devi, V.U., and Y.P. Rao. 1989. Heavy Metal Toxicity to Fiddler Crabs, Uca annulipes Latreille and Uca triangularis (Milne Edwards): Respiration on Exposure to Copper, Mercury,. Bull.Environ.Contam.Toxicol. 43(1):165-172.	2150	UEndp, Eff	
Devi, V.U., and Y.P. Rao. 1989. Zinc Accumulation in Fiddler Crabs Uca annulipes Latreille and Uca triangularis (Milne Edwards). Ecotoxicol.Environ.Saf. 18(2):129-140.	2385	UEndp, Eff, Con	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Devi, V.U.. 1987. Heavy Metal Toxicity to Fiddler Crabs, Uca annulipes latreille and Uca triangularis (Milne Edwards): Tolerance to Copper, Mercury, Cadmium. Bull.Environ.Contam.Toxicol. 39:1020-1027.	2602	NonRes	
Devineau, J., and C.A. Triquet. 1985. Patterns of Bioaccumulation of an Essential Trace Element (Zinc) and a Pollutant Metal (Cadmium) in Larvae of the Prawn Palaemon serratus. Mar.Biol. 86(2):139-143.	10835	UEndp	
Drifmeyer, J.E.. 1980. Uptake of 65Zn by Eelgrass, Zostera marina, L. Sci.Total Environ. 16(3):263-265.	9789	UEndp, Eff, Con	
Durkina, V.B.. 1994. Development of Offspring of the Sea Urchin Strongylocentrotus intermedius Exposed to Copper and Zinc. Russ.J.Mar.Biol. 20(4):232-235.	17580	UEndp	
Earnshaw, M.J., S. Wilson, H.B. Akberali, R.D. Butler, and K.R.M. Marriott. 1986. The Action of Heavy Metals on the Gametes of the Marine Mussel, Mytilus edulis(L.)-III. The Effect of Applied Copper and Zinc on Sperm Motility in. Mar.Environ.Res. 20(4):261-278.	12324	UEndp	
Eisler, R., and G.R. Gardner. 1973. Acute Toxicology to an Estuarine Teleost of Mixtures of Cadmium, Copper and Zinc Salts. J.Fish Biol. 5(2):131-142.	8342	UEndp, Eff	
Eldon, J., M. Pekkarinen, and R. Kristoffersson. 1980. Effects of Low Concentrations of Heavy Metals on the Bivalve Macoma balthica. Ann.Zool.Fenn. 17:233-242.	17309	UEndp, Eff	
Elliott, N.G., R. Swain, and D.A. Ritz. 1985. The Influence of Cyclic Exposure on the Accumulation of Heavy Metals by Mytilus edulis planulatus (Lamarck). Mar.Environ.Res. 15(1):17-30.	11669	UEndp, Eff, Con	
Elliott, N.G., R. Swain, and D.A. Ritz. 1986. Metal Interaction During Accumulation by the Mussel Mytilus edulis planulatus. Mar.Biol. 93(3):395-399.	12054	UEndp, Eff	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Fernandez, T.V., and N.V. Jones. 1990. Studies on the Toxicity of Zinc and Copper Applied Singly and Jointly to Nereis diversicolor at Different Salinities and Temperatures. Trop.Ecol. 31(1):47-55.	7744	Con, UEndp, LT	
Fisher, N.S., and D. Frood. 1980. Heavy Metals and Marine Diatoms: Influence of Dissolved Organic Compounds on Toxicity and Selection for Metal Tolerance Among Four Species. Mar.Biol. 59(2):85-93.	6470	UEndp	
Fisher, N.S., and G.J. Jones. 1981. Heavy Metals and Marine Phytoplankton: Correlation of Toxicity and Sulfhydryl-Binding. J.Phycol. 17(1):108-111.	14681	Dur	Has 24-72hr EC50 for a diatom
Fisher, N.S., M. Bohe, and J.L. Teyssie. 1984. Accumulation and Toxicity of Cd, Zn, Ag, and Hg in Four Marine Phytoplankters. Mar.Ecol.Prog.Ser. 18(3):201-213.	11805	UEndp, Eff	
Foster, P.. 1976. Concentrations and concentration factors of heavy metals in brown algae. Environ. Pollut. 10: 45-53.		Eff, Det	
Fowler, S.W., and L.F. Small. 1970. Distribution of Ingested Zinc-65 in the Tissues of Some Marine Crustaceans. J.Fish.Res.Board Can. 27(6):1051-1058.	9563	UEndp, Eff, Con	
Gajbhiye, S.N., and R. Hirota. 1990. Toxicity of Heavy Metals to Brine Shrimp Artemia. J.Indian Fish.Assoc. 20:43-50.	17792	UEndp	Brine Shrimp
Garnham, G.W., G.A. Codd, and G.M. Gadd. 1992. Kinetics of Uptake and Intracellular Location of Cobalt, Manganese and Zinc in the Estuarine Green Alga Chlorella salina. Appl.Microbiol.Biotechnol. 37(2):270-276.	6220	UEndp, Eff	
Gnassia-Barelli, M., and M. Romeo. 1987. Uptake of Zinc by Cultured Phytoplankters Hymenomonas elongata. Dis.Aquat.Org. 3(1):45-49.	4242	UEndp, Eff	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Goh, B.P.L., and L.M. Chou. 1997. Effects of the Heavy Metals Copper and Zinc on Zooxanthellae Cells in Culture. Environ.Monit.Assess. 44:11-19.	45184	UEndp	
Gray, J.S., and R.J. Ventilla. 1973. Growth Rates of Sediment-Living Marine Protozoan as a Toxicity Indicator for Heavy Metals. Ambio 2(4):118-121.	6355	UEndp	
Gray, J.S.. 1974. Synergistic Effects of Three Heavy Metals on Growth Rates of a Marine Ciliate Protozoan. In: F.J.Vernberg and W.B.Vernberg (Eds.), Pollution and Physiology of Marine Organisms, Academic Press, NY :465-485.	8558	UEndp	
Greenwood, J.G., and D.R. Fielder. 1983. Acute Toxicity of Zinc and Cadmium to Zoeae of Three Species of Portunid Crabs (Crustacea: Brachyura). Comp.Biochem.Physiol.C 75(1):141-144.	10063	Dur, NonRes	
Hansen, I.V., J.M. Weeks, and M.H. Depledge. 1995. Accumulation of Copper, Zinc, Cadmium and Chromium by the Marine Sponge Halichondria panicea Pallas and the Implications for Biomonitoring. Mar.Pollut.Bull. 31(1-3):133-138.	18038	UEndp, Eff	
Haritonidis, S., H.J. Jager, and H.O. Schwantes. 1983. Accumulation of Cadmium, Zinc, Copper and Lead by Marine Macrophyceae Under Culture Conditions. Angew.Bot. 57(5/6):311-330.	11369	UEndp, Eff	
Haritonidis, S.. 1985. Uptake of Cd, Zn, Cu and Pb by Marine Macrophyceae Under Culture Conditions. Mar.Environ.Res. 17(2-4):198-199.	6414	UEndp, Eff, Con	
Harland, A.D., G.W. Bryan, and B.E. Brown. 1990. Zinc and Cadmium Absorption in the Symbiotic Anemone Anemonia viridis and the Non-Symbiotic Anemone Actinia equina. J.Mar.Biol.Assoc.U.K. 70(4):789-802.	7819	UEndp, Eff	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Harmon, V.L., and C.J. Langdon. 1996. A 7-D Toxicity Test for Marine Pollutants Using the Pacific Mysid Mysidopsis intii. 2. Protocol Evaluation. Environ.Toxicol.Chem. 15(10):1824-1830.	17251	UChron?	Has Seven values made up of 7d LC50's and 7d NOEC's for Opossum shrimp and mysids
Haya, K., B.A. Waiwood, and D.W. Johnston. 1983. Adenylate Energy Charge and ATPase Activity of Lobster (Homarus americanus) During Sublethal Exposure to Zinc. Aquat.Toxicol./ Can.Tech.Rep.Fish.Aquat.Sci.No.1151.(1987) p.87-188 (ABS) 3(2):115-126.	5632	UEndp, Eff	
Herbert, D.W.M., and A.C. Wakeford. 1964. The Susceptibility of Salmonid Fish to Poisons Under Estuarine Conditions - I. Zinc Sulphate. Int.J.Air Water Pollut. 8(3/4):251-256.	14398	Dur	has two 48hr LC50's for rainbow trout
Heyward, A.J.. 1988. Inhibitory Effects of Copper and Zinc Sulphates on Fertilization in Corals. In: Proc.6th Int.Coral Reef.Symp., Aug.8-12, 1988, Australia 2:299-303.	4735	UEndp	
Hietanen, B., I. Sunila, and R. Kristoffersson. 1988. Toxic Effects of Zinc on the Common Mussel Mytilus edulis L. (Bivalvia) in Brackish Water. I. Physiological and Histopathological Studies. Ann.Zool.Fenn. 25(4):341-347.	2361	Dur, UEndp	24hr only
Hietanen, B., I. Sunila, and R. Kristoffersson. 1988. Toxic Effects of Zinc on the Common Mussel Mytilus edulis L. (Bivalvia) in Brackish Water. II. Accumulation Studies. Ann.Zool.Fenn. 25(4):349-352.	3685	UEndp, Eff	
Hilmy, A.M., N.F. Abdel-Hamid, and K.S. Ghazaly. 1985. Toxic Effects of Both Zinc and Copper on Size and Sex of Portunus pelagicus (L) (Crustacea: Decapoda). Bull.Inst.Oceanogr.Fish.(Cairo) 11:207-215.	17415	NonRes	Has four 96hr LC50's for crab

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Ho, M.S., and P.L. Zubkoff. 1982. The Effects of Mercury, Copper, and Zinc on Calcium Uptake by Larvae of the Clam, Mulinia lateralis. Water Air Soil Pollut. 17(4):409-414.	15513	UEndp, Eff	
Hollibaugh, J.T., D.L.R. Seibert, and W.H. Thomas. 1980. A Comparison of the Acute Toxicities of Ten Heavy Metals to Phytoplankton From Saanich Inlet, B.C., Canada. Estuar.Coast.Mar.Sci. 10(1):93-105.	5282	UEndp, Con	
Hopkins, R., and J.M. Kain. 1971. The Effect of Marine Pollutants on Laminarea hyperboria. Mar.Pollut.Bull. 2(5):75-77.	9356	UEndp, Con	
Howell, R.. 1983. Heavy Metals in Marine Nematodes: Uptake, Tissue Distribution and Loss of Copper and Zinc. Mar.Pollut.Bull. 14(7):263-268.	11121	UEndp, Eff, Con	
Hunt, J.W., B.S. Anderson, S.L. Turpen, A.R. Coulon, M. Martin, F.H. Palmer, and J.J. Janik. 1989. Marine Bioassay Project. 4th Report. Experimental Evaluation of Effluent Toxicity Testing Protocols with Giant Kelp, Mysids, Red Abalone. No.89-5WQ, State Water Resources Control Board, State of California, Sacramento, CA :144.	19130	Dur	
Ismail, P.. 1988. Influence of Salinity on the Toxicity of Zinc and Copper to Guppy. Malays.Appl.Biol. 17(1):31-38.	2882	Con	
Ithack, E., and C.P. Gopinathan. 1995. The Effect of Heavy Metals on the Physiological Changes of Microalgae. Cmfri Spec.Publ. 61:45-52.	19399	UEndp	
Itow, T., R.E. Loveland, and M.L. Botton. 1998. Developmental Abnormalities in Horseshoe Crab Embryos Caused by Exposure to Heavy Metals. Arch.Environ.Contam.Toxicol. 35(1):33-40.	19470	UEndp	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Itow, T., T. Igarashi, M.L. Botton, and R.E. Loveland. 1998. Heavy Metals Inhibit Limb Regeneration in Horseshoe Crab Larvae. Arch.Environ.Contam.Toxicol. 35(3):457-463.	20180	UEndp	
Jayaseeli, A.C., and J. Azariah. 1993. Accumulation and Distribution of Zinc in Green Mussel Perna viridis (Linnaeus). Pollut.Res. 12(3):127-133.	14820	Eff, Dur	Appears to be one or two values for perna viridis
Jensen, A., B. Rystad, and S. Melsom. 1974. Heavy Metal Tolerance of Marine Phytoplankton. I. The Tolerance of Three Algal Species to Zinc in Coastal Sea Water. J.Exp.Mar.Biol.Ecol. 15(2):145-157.	2269	UEndp, Eff	
Johnson, I.T., and M.B. Jones. 1990. Effects of Zinc on Osmoregulation of Gammarus duebeni (Crustacea: Amphipoda) from the Estuary and the Sewage Treatment Works at Looe, Cornwall. Ophelia 31(3):187-196.	18866	UEndp	
Kaitala.S.. 1988. Multiple Toxicity and Accumulation of Heavy Metals in Two Bivalve Mollusc Species. Water Sci.Technol. 20(6/7):23-32.	905	UEndp, Eff	
Kaland, T., T. Andersen, and K. Hylland. 1993. Accumulation and Subcellular Distribution of Metals in the Marine Gastropod Nassarius reticulatus L. In: R.Dallinger and P.S.Rainbow (Eds.), Ecotoxicology of Metals in Invertebrates, Lewis Publ. :37-53.	13829	UEndp, Eff	
Karaseva, E.M., and L.A. Medvedeva. 1993. Morphological and Functional Changes in the Offspring of Mytilus trossulus and Mizuhopecten yessoensis After Parental Exposure to Copper and Zinc. Russ.J.Mar.Biol.19(4):276-280; Biol.Morya (Vladivost) (4):83-89 (RUS).	17028	UEndp	
Karaseva, E.M.. 1993. Accumulation of Heavy Metals in Gonads and Somatic Organs of Bivalve Molluscs. Biol.Morya (Vladivost.) 2:66-76 (ENG TRANSL, RUS Paper Attached).	4644	UEndp, Eff	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Karbe, L.. 1972. Marine Hydroids as Test Organisms for Assessing the Toxicity of Water Pollutants. The Effect of Heavy Metals on Colonies of Eirene viridula. Mar.Biol. 12(4):316-328 (GER) (ENG ABS).	15654	UEndp, Con	
Karez, C.S., G.M. Amado, R.P. Luoro, and M. Farina. 1996. Accumulation of Zinc by the Brown Alga Padina gymnospora. Bull.Inst.Oceanogr.Monaco 14(4):233-238.	20401	UEndp	
Karez, C.S., M. Romeo, and M. Gnassia-Barelli. 1988. Uptake of Zn and Cd by Coastal Phytoplankton Species in Culture. In: U.Seeliger, L.D.De Lacerda, and S.R.Patchineelam (Eds.) Metals in Coastal Environments of Latin America, Springer-Verlag New York, Inc., Secaucus, NJ :130-139.	13214	UEndp	
Kobayashi, N., T.K. Naidenko, and M.A. Vashchenko. 1994. Standardization of a Bioassay Using Sea-Urchin Embryos. Russ.J.Mar.Biol. 20(6):351-357.	16686	UEndp	
Kobayashi, N.. 1971. Fertilized Sea Urchin Eggs As an Indicatory Material for Marine Pollution Bioassay, Preliminary Experiments. Mar.Biol.Lab 18(6):379-406.	2963	UEndp	
Kobayashi, N.. 1990. Marine Pollution Bioassay by Sea Urchin Eggs, an Attempt to Enhance Sensitivity. Publ.Seto Mar.Biol.Lab. 34(4-6):225-237.	9717	UEndp, Dur	
Krishnakumari, L.P.K.V., S.N. Gajbhiye, K. Govindan, and V.R. Nair. 1983. Toxicity of Some Metals on the Fish Therapon jarbua (Forsskal, 1775). Indian J.Mar.Sci. 12(1):64-66.	11014	Con	
Kumar, K.P., and V.U. Devi. 1995. Effect of Heavy Metals on Toxicity and Oxygen Consumption of Intertidal Gastrodpods nerita albicilla and Nerita chamaeleon. J.Ecotoxicol.Environ.Monit. 5(1):1-5.	18886	NonRes	
Lakshmanan, P.T., and P.N.K. Nambisan. 1989. Bioaccumulation and Depuration of Some Trace Metals in the Mussel, Perna viridis (Linnaeus). Bull.Environ.Contam.Toxicol. 43(1):131-138.	3240	Eff	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Lapota, D., D.E. Rosenberger, and D. Duckworth. 1996. A Bioluminescent Dinoflagellate Assay for Detecting Toxicity in Coastal Waters. In: A.K.Campbell, L.J.Kricka, and P.E.Stanley (Eds.), Bioluminescence and Chemiluminescence, Fundamentals and Applied Aspects, John Wiley & Sons, NY :156-159.	19990	Eff	
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Lee, H.H., and C.H. Xu. 1984. Effects of Metals on Sea Urchin Development: A Rapid Bioassay. Mar.Pollut.Bull. 15(1):18-21.	10086	UEndp, Dur	
Lemus, M., J. Chopite, and B. Gamboa. 1989. Effect of Salinity in the Zinc Bioaccumulation and in Na Super(+), K Super(+), and Ca Super(++) Concentrations in Tissues of Orthopristis ruber. Bol.Inst.Esp.Oceanogr. 28(1/2):159-164 (SPA) (ENG ABS).	17342	UEndp, Eff	
Liao, I.C., and C.S. Hsieh. 1990. Toxicity of Three Heavy Metals to Macrobrachium rosenbergii. In: R.Hirano and I.Hanyu (Eds.), Proc.of the 2nd Asian Fisheries Forum, April 17-22, 1989, Tokyo, Japan, Asian Fisheries Society, Manila, Philippines :923-926.	16218	UEndp	
Lin, S.J., and Y.Y. Tin. 1993. The Toxicity of Heavy Metals to Juvenile Penaeus penicillatus in Each Stage. J.Taiwan Fish.Res.1(2):55-65 (Chi) (Eng Abs).	14402	Dur	Has five 24hr LC50's, five 48hr LC50's, five 72hr LC50's

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
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Liu, P.C., and J.C. Chen. 1987. Effects of Heavy Metals on the Hatching Rates of Brine Shrimp Artemia salina Cysts. J.World Aquacult.Soc. 18(2):78-83.	4256	UEndp	Brine Shrimp
Lobel, P.B.. 1987. Short-Term and Long-Term Uptake of Zinc by the Mussel, Mytilus edulis: a Study in Individual Variability. Arch.Environ.Contam.Toxicol. 16(6):723-732.	5974	UEndp, Eff, Con	
Lorenzon, S., M. Francese, and E.A. Ferrero. 2000. Heavy Metal Toxicity and Differential Effects on the Hyperglycemic Stress Response in the Shrimp Palaemon elegans. Arch.Environ.Contam.Toxicol. 39(2):167-176.	51641	NonRes	
Lussier, S.M., W.S. Boothman, S. Poucher, D. Champlin, and A. Helmstetten. 1999. Comparison of Dissolved and Total Metals Concentrations from Acute Tests with Saltwater Organisms. Environ.Toxicol.Chem. 18(5):889-898.	51695	UEndp	
Lussier, S.M., W.S. Boothman, S. Poucher, D. Champlin, and A. Helmstetten. 1999. Comparison of Dissolved and Total Metals Concentrations from Acute Tests with Saltwater Organisms. Environ.Toxicol.Chem. 18(5):889-898.	51695	UEndp	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
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MacInnes, J.R., and F.P. Thurberg. 1973. Effects of Metals on the Behavior and Oxygen Consumption of the Mud Snail. Mar.Pollut.Bull. 4(12):185-186.	8902	UEndp< Eff	
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Madhupratap, M., C.T. Achuthankutty, and S.R.S. Nair. 1981. Toxicity of Some Heavy Metals to Copepods Acartia spinicauda and Tortanus forcipatus. Indian J.Mar.Sci. 10:382-383.	15722	Dur, Eff	
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Marcano, L., O. Nusetti, J. Rodriguez-Grau, and J. Vilas. 1996. Uptake and Depuration of Copper and Zinc in Relation to Metal-Binding Protein in the Polychaete Eurythoe camplanata. Comp.Biochem.Physiol.C 114(3):179-184.	18575	NonRes	
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Mathew, R., and N.R. Menon. 1983. Effects of Heavy Metals on Byssogenesis in Perna viridis (Linn.). Indian J.Mar.Sci. 12(2):125-127.	11120	Con	
McKenney, C.L.J., and J.M. Neff. 1979. Individual Effects and Interactions of Salinity, Temperature, and Zinc on Larval Development of the Grass Shrimp Palaemonetes pugio. I. Survival and. Mar.Biol.(Berl.) 52(2):177-188.	15812	UEndp	
McKenney, C.L.Jr., and J.M. Neff. 1981. The Ontogeny of Resistance Adaptation and Metabolic Compensation to Salinity and Temperature by the Caridean Shrimp, Palaemonetes pugio, and Modification by Sublethal Zinc Exposure. In: F.J.Vernberg, A.Calabrese, F.P.Thurberg, and W.B.Vernberg (Eds.), Biological Monitoring of Marine Pollutants, Academic Press, New York :205-240.	4838	UEndp	
Milner, N.J.. 1982. The Accumulation of Zinc by O-Group Plaice, Pleuronectes platessa (L.), From High Concentrations in Sea Water and Food. J.Fish Biol. 21(3):325-336.	10970	UEndp, Con	
Mizrahi, L., and Y. Achituv. 1994. Effects of Cd, Hg and Zn on the Metabolism of the Gastropod Nassarius gibbolosa. In: Final Reports on Research Projects Dealing with Toxicity of Pollutants on Marine Organisms, UNEP, Athens, Greece, MAP Tech.Rep.Ser.No.79 :79-89.	17414	UEndp, Eff	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
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Mo, C., and B. Neilson. 1993. Weight and Salinity Effects on Zinc Uptake and Accumulation for the American Oyster (Crassostrea virginica Gmelin). Environ.Pollut. 82(3):191-196.	13353	UEndp, Eff, Con	
Morris, A.W. and A.J. Bale. 1975. The accumulation of cadmium, copper, manganese and zinc by Fucus vesiculosus in the Bristol Channel. . Estuarine Coastal Mar. Sci. 3: 153-163..		Eff	
Munda, I.M., and M. Veber. 1996. Simultaneous Effects Of Trace Metals And Excess Nutrients On The Adriatic Seaweed Fucus virsoides (Don.). Bot.Mar. 39(4):297-309.	19671	UEndp	
Murugadas, T.L., S.M. Phang, and S.L. Tong. 1995. Heavy Metal Accumulation Patterns in Selected Seaweed Species of Malaysia. Asia Pacific J.Mol.Biol.Biotechnol. 3(4):290-310.	19239	UEndp, Eff	24hr only
Myint, U.M., and P.A. Tyler. 1982. Effects of Temperature, Nutritive and Metal Stressors on the Reproductive Biology of Mytilus edulis. Mar.Biol. 67(2):209-223.	12950	UEndp, Con	
Nacci, D., E. Jackim, and R. Walsh. 1986. Comparative Evaluation of Three Rapid Marine Toxicity Tests: Sea Urchin Early Embryo Growth Test, Sea Urchin Sperm Cell Toxicity Test and Microtox. Environ.Toxicol.Chem. 5:521-525.	17742	Dur	
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Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
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Nipper, M.G., C. Badaro-Pedroso, V.F. Jose, and S.L.R. Melo. 1993. Toxicity Testing with Coastal Species of Southeastern Brazil. Mysids and Copepods. Bull.Environ.Contam.Toxicol. 51:99-106.	6825	NonRes	
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Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
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Nugegoda, D., and P.S. Rainbow. 1989. Salinity, Osmolality, and Zinc Uptake in Palaemon elegans (Crustacea: Decapoda). Mar.Ecol.Prog.Ser. 55:149-157.	18839	UEndp	
Nugegoda, D., and P.S. Rainbow. 1989. Zinc Uptake Rate and Regulation Breakdown in the Decapod Crustacean Palaemon elegans Rathke. Ophelia 30(3):199-212.	18900	UEndp	
Nugegoda, D., and P.S. Rainbow. 1995. The Uptake and Dissolved Zinc and Cadmium by the Decapod Crustacean Palaemon elegans. Mar.Pollut.Bull. 31(4-12):460-463.	17692	UEndp, Eff	
Overnell, J.. 1976. Inhibition of Marine Algal Photosynthesis by Heavy Metals. Mar.Biol.(Berl.) 38(4):335-342.	15868	UEndp, Eff	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
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Pagliarani, A., V. Ventrella, F. Trombetti, M. Pirini, G. Trigari, and A.R. Borgatti. 1996. Mussel Microsomal Na+ -Mg2+ -ATPase Sensitivity to Waterborne Mercury, Zinc and Ammonia. Comp.Biochem.Physiol.C 113(2):185-191.	16850	UEndp, Eff	
Parker, J.G.. 1984. The Effects of Selected Chemicals and Water Quality on the Marine Polychaete Ophryotrocha diadema. Water Res. 18(7):865-868.	10890	Con, Dur	
Patel, B., and K. Anthony. 1991. Uptake of Cadmium in Tropical Marine Lamellibranchs, and Effects on Physiological Behaviour. Mar.Biol. 108:457-470.	340	UEndp, Eff, Con	
Pavicic, J., M. Skreblin, I. Kregar, M. Tusek-Znidaric, and P. Stegnar. 1994. Embryo-Larval Tolerance of Mytilus galloprovincialis, Exposed to the Elevated Sea Water Metal Concentrations-I. Toxic Effects of Cd, Zn and Hg in. Comp.Biochem.Physiol.C 107(2):249-257.	4073	Dur, Con, UEndp	
Pentreath, R.J.. 1973. The Accumulation and Retention of 65Zn and 54Mn by the Plaice, Pleuronectes platessa L. J.Exp.Mar.Biol.Ecol. 12(1):1-18.	2175	Eff, Con	
Pentreath, R.J.. 1973. The Accumulation From Sea Water of 65Zn, 54Mn, 58Co and 59Fe by the Thornback Ray, Raja clavata L. J.Exp.Mar.Biol.Ecol. 12(3):327-334.	2133	Eff, Con	
Pentreath, R.J.. 1973. The Accumulation From Water of 65Zn, 54Mn, 58Co, and 59Fe by the Mussel, Mytilus edulis. J.Mar.Biol.Assoc.U.K. 53:127-143.	2176	Eff, Con	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Persoone, G., and G. Uyttersprot. 1975. The Influence of Inorganic and Organic Pollutants on the Rate of Reproduction of a Marine Hypotrichous Ciliate: Euplotes vannus Muller. Rev.Int.Oceanogr.Med. 37-38:125-151.	5922	UEndp	
Peterson, S.M., and J.L. Stauber. 1996. New Algal Enzyme Bioassay for the Rapid Assessment of Aquatic Toxicity. Bull.Environ.Toxicol.Chem. 56(5):750-757.	19926	Dur	72hr EC50 for Green algae
Phillips, D.J.H.. 1976. The Common Mussel Mytilus edulis As an Indicator of Pollution by Zinc, Cadmium, Lead and Copper. I. Effects of Environmental Variables on Uptake of. Mar.Biol. 38(1):59-69.	15633	UEndp, Eff	
Portmann, J.E.. 1972. Results of Acute Toxicity Tests with Marine Organisms, Using a Standard Method. In: M.Ruivo (Ed.), Marine Pollution and Sea Life, FAO, Rome, Italy; Fishing News (Books) Ltd., London, England :212-217 (Author Communication Used).	9258	Con, Dur	
Price, R.K.J., and R.F. Uglow. 1979. Some Effects of Certain Metals on Development and Mortality Within the Moult Cycle of Crangon crangon (L.). Mar.Environ.Res. 2(4):287-299.	8423	Con, UEndp, LT	
Price, R.K.J., and R.F. Uglow. 1980. Cardiac and Ventilatory Responses of Crangon crangon to Cadmium, Copper and Zinc. Helgol.Wiss.Meeresunters. 33(1/4):59-67.	9879	UEndp, Eff	
Pringle, B.H., D.E. Hessong, E.L. Katz and S.T. Mulawka. 1968. Trace Metal Accumulation by estuarine mollusks. Am. Soc. Civ. Eng., J. Sanit. Eng. Div. 94: 455-475..		Eff	
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Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
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Rainbow, P.S., and S.L. White. 1989. Comparative Strategies of Heavy Metal Accumulation by Crustaceans: Zinc, Copper and Cadmium in a Decapod, an Amphipod and a Barnacle. Hydrobiologia 174(3):245-262.	18778	UEndp	
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Rainbow, P.S.. 1985. Accumulation of Zn, Cu and Cd by Crabs and Barnacles. Estuar.Coast.Shelf Sci. 21(5):669-686.	9713	UEndp	
Ralph, P.J., and M.D. Burchett. 1998. Photosynthetic Response of Halophila ovalis to Heavy Metal Stress. Environ.Pollut. 103(1):91-101.	19866	UEndp, Eff	
Ray, S., D.W. McLeese, B.A. Waiwood and D. Pezzack. 1980. The disposition of cadmium and zinc in Pandalus montagui.. Arch. Environ. Contam. Toxicol. 9: 675-681..		Eff	
Reish, D.J., and R.S. Carr. 1978. The Effect of Heavy Metals on the Survival, Reproduction, Development and Life Cycles for Two Species of Polychaetous Annelids. Mar.Pollut.Bull. 9(1):24-27.	8428	UEndp	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
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Sauer, G.R., and N. Watabe. 1984. Zinc Uptake and its Effect on Calcification in the Scales of the Mummichog, Fundulus heteroclitus. Aquat.Toxicol. 5(1):51-66.	10110	UEndp, Eff	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Sauer, G.R., and N. Watabe. 1989. Temporal and Metal-Specific Patterns in the Accumulation of Heavy Metals by the Scales of Fundulus heteroclitus. Aquat.Toxicol. 14(3):233-248.	3501	UEndp, Eff	
Sauer, G.R., and N. Watabe. 1989. Ultrastructural and Histochemical Aspects of Zinc Accumulation by Fish Scales. Tissue & Cell 21(6):935-943.	137	UEndp, Eff	
Sauer, G.R.. 1987. The Effect of Cadmium and Zinc on Calcium Uptake and Scale Regeneration in Fundulus heteroclitus. In: W.A.Vernberg, A.Calabrese, F.P.Thurberg, and F.J.Vernberg (Eds.), Pollution of Estuarine Organisms, Univ.of SC Press, Columbia, SC :373-399.	4904	UEndp	
Savant, K.B., and G.K. Amte. 1992. Respiratory Response of Estuarine Crab Ilyoplax gangetica Exposed to Three Metallic Chemicals. J.Ecotoxicol.Environ.Monit. 2(4):259-262.	17564	UEndp, Eff	
Scharek, R., M.A. Van Leeuwe, and H.J.W. De Baar. 1997. Responses of Southern Ocean Phytoplankton to the Addition of Trace Metals. Deep-Sea Res. 44(1/2):209-227.	19972	UEndp, Eff	
Selvakumar, S., and T.M. Haridasan. 2000. Toxic Effects of Heavy Metals Copper, Zinc, Cadmium and Mercury on the Zoeal Development of Sesarminid Crab Nanosesarma (Beanium) batavicum. J.Environ.Biol. 21(2):101-104.	54052	UEndp	
Selvakumar, S., S.A. Khan, and A.K. Kumaraguru. 1996. Acute Toxicity of Some Heavy Metals, Pesticides and Water Soluble Fractions of Diesel Oil to the Larvae of Some Brachyuran Crabs. J.Environ.Biol. 17(3):221-226.	18580	NonRes	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
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Shuster, C.N.Jr., and B.H. Pringle. 1969. Trace Metal Accumulation by the American Eastern Oyster, Crassostrea virginica. 1968 Proc.Natl.Shellfish Assoc. 59:91-103.		Eff	
Sivadasan, C.R., P.N.K. Nambisan, and R. Damodaran. 1986. Toxicity of Mercury, Copper and Zinc to the Prawn Metapenaeus dobsoni (Mier). Curr.Sci. 55(7):337-340.	11853	Con	
Smith, M.A.. 1983. The Effect of Heavy Metals on the Cytoplasmic Fine Structure of Skeletonema costatum (Bacillariophyta). Protoplasma 116(1):14-23.	11036	Con, Eff, UEndp	
Sobral, P., L. Castro, H. Costa, and I. Peres. 1995. The Influence of Diet on the Accumulation of Copper and Zinc in the Clam Ruditapes decussatus. Physiological Assessment. In: D.Bellan, G.Bonin, and C.Emig (Eds.), Functioning and Dynamics of Natural and Perturbed Ecosystems, Lavoisier Intercept Ltd., Paris, France :583-591.	19364	UEndp, Eff	
Somasundaram, B., P.E. King, and S.E. Shackley. 1984. Some Morphological Effects of Zinc upon the Yolk-Sac Larvae of Clupea harengus L. J.Fish Biol. 25(3):333-343.	11169	UEndp	
Somasundaram, B., P.E. King, and S.E. Shackley. 1984. The Effect of Zinc on the Ultrastructure of the Trunk Muscle of the Larva of Clupea harengus L. Comp.Biochem.Physiol.C 79(2):311-315.	11222	UEndp	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Soto, M., I. Quincoces, X. Lekube, and I. Marigomez. 1998. Autometallographed Metal Content in Digestive Cells of Winkles: A Cost-Effecive Screening Tool for Monitoring Cu and Zn Pollution. Aquat.Toxicol. 40(2/3):123-140.	18951	UEndp, Eff	
Stauber, J.L., and T.M. Florence. 1990. Mechanism of Toxicity of Zinc to the Marine Diatom Nitzschia closterium. Mar.Biol. 105(3):519-524.	3256	UEndp	Has an IC50 for a diatom
Stromgren, T.. 1982. Effect of Heavy Metals (Zn, Hg, Cu, Cd, Pb, Ni) on the Length Growth of Mytilus edulis. Mar.Biol. 72(1):69-72.	10899	UEndp	
Subramanian, A., B.R. Subramanian, and V.K. Venugopalan. 1980. Toxicity of Copper and Zinc on Cultures of Skeletonema costatum (Grev.) Cleve and Nitzschia longissima. Curr.Sci. 49(7):266-268.	9903	UEndp	
Sun, Y., and C. Chen. 1988. Effects of Hg, Zn, Pb on Embryonic Development of Black Progy, Sparus macrocephalus Basilewsky. Mar.Sci./Haiyang Kexue (3):54-57 (CHI) (ENG ABS).	3371	UEndp	
Swedmark, M., and A. Granmo. 1981. Effects of Mixtures of Heavy Metals and a Surfactant on the Development of Cod (Gadus morhua L.). Rapp.P.-V.Reun.Cons.Int.Explor.Mer. 178:95-103.	195	UEndp	
Syasina, I.G., M.A. Vaschenko, and V.B. Durkina. 1992. Histopathological Changes in the Gonads of Sea Urchins Exposed to Heavy Metals. Russ.J.Mar.Biol.(Eng Transl) of Biol.Morya (4):79-89 (Vladivostok) 17:244-251.	19065	UEndp, Eff	
Tadros, M.G., P. Mbuthia, and W. Smith. 1990. Differential Response of Marine Diatoms to Trace Metals. Bull.Environ.Contam.Toxicol. 44(6):826-831.	18878	UEndp	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Taneeva, A.I.. 1973. Toxicity of Some Heavy Metals for Hydrobionts. In: V.N.Greze (Ed.), Proc.Mater.Vses.Simp.Izuch.Chern.Sredizemnogo Morei, Ispol'Z Okhr.Ikh.Resur.Kiev, USSR Ser.4 :114-117 (RUS).	9001	Con, Dur	
Taylor, D., B.G. Maddock, and G. Mance. 1985. The Acute Toxicity of Nine "Grey List" Metals (Arsenic, Boron, Chromium, Copper, Lead, Nickel, Tin, Vanadium and Zinc) to Two Marine Fish Species:. Aquat.Toxicol. 7(3):135-144.	11451	Con	
Thongra-ar, W., and O. Matsuda. 1995. Effects of Cadmium and Zinc on Growth of Thalassiosira weissflogii and Heterosigma akashiwo. In: A.Snidvongs, W.Utoomprukporn, and M.Hungspreugs (Eds.), Proceedings of the NRCT-JSPS Joint Seminar on Marine Science, Dec.2-3, 1993, Chulalongkorn University, Thailand, Bangkok :90-96.	18912	UEndp	
Thorpe, G.J.. 1988. A Toxicological Assessment of Cadmium Toxicity to the Larvae of Two Estuarine Crustaceans, Rhithropanopeus harrisii and Palaemonetes pugio. Ph.D.Thesis, Duke University, Durham, NC:120 p.; Diss.Abstr.Int.B Sci.Eng.50(6):2306 (1989).	3035	UEndp, Eff	
Tolba, M.R., A.E. Hagras, and A. Hilmy. 1995. Effect of Some Heavy Metals on the Growth of Sphaeroma serratum (Crustacea: Isopoda). J.Environ.Sci. 10(1):219-231.	45118	UEndp	
Tort, L., R. Flos, and J. Balasch. 1984. Dogfish Liver and Kidney Tissue Respiration After Zinc Treatment. Comp.Biochem.Physiol.C 77(2):381-384.	10979	Con, UEndp, Eff	
Tort, L., S. Crespo, and J. Balasch. 1982. Oxygen Consumption of the Dogfish Gill Tissue Following Zinc Treatment. Comp.Biochem.Physiol.C 72(1):145-148.	15580	Con, UEndp, Eff	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Tsukidate, J.. 1974. Tracer Experiments on the Effect of Micronutrients on the Growth of Porphyra Plants-II Manganese-54 and Zinc-65 Assimilation in Relation to. Bull.Nansei.Reg.Fish.Res.Lab. (7):9-18.	8741	UEndp, Eff	
Verriopoulos, G., and D. Hardouvelis. 1988. Effects of Sublethal Concentration of Zinc on Survival and Fertility in Four Successive Generations of Tisbe. Mar.Pollut.Bull. 19(4):162-166.	7569	UEndp	
Verriopoulos, G., and M. Moraitou-Apostolopoulou. 1989. Toxicity of Zinc to the Marine Copepod Tisbe holothuriae; the Importance of the Food Factor. Arch.Hydrobiol. 114(3):457-463.	2084	Dur	Has five 48hr LC50 for Harpacticoid
Verriopoulos, G.. 1992. Effects of Sublethal Concentrations of Zinc, Chromium and Copper on the Marine Copepods Tisbe holothuriae and Acartia clausi. In: G.P.Gabrielides (Ed.), Proc.of the FAO/UNEP/IOC Workshop on the Biological Effects of Pollutants on Marine Organisms, Malta, 10-14 Sept., 1991, UNEP, Athens, Greece, MAP Tech.Rep.Ser.No.69 :265-275.	4091	UEndp	
Viarengo, A., L. Canesi, M. Pertica, G. Poli, M.N. Moore, and M. Orunesu. 1990. Heavy Metal Effects on Lipid Peroxidation in the Tissues of Mytilus galloprovincialis Lam. Comp.Biochem.Physiol.C 97(1):37-42.	78	UEndp, Eff	
Viswanathan, S., and M.K. Manisseri. 1995. Histopathological Studies on Zinc Toxicity in Penaeus indicus H. Milne Edwards. Cmfri Spec.Publ. 61:25-29.	19405	NonRes, UEndp	
Voogt, P.A., P.J. Den Besten, G.C.M. Kusters, and M.W.J. Messing. 1987. Effects of Cadmium and Zinc on Steroid Metabolism and Steroid Level in the Sea Star Asterias rubens L. Comp.Biochem.Physiol.C 86(1):83-89.	12392	UEndp, Eff	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Vranken, G., C. Tire, and C. Heip. 1988. The Toxicity of Paired Metal Mixtures to the Nematode Monhystera disjuncta (Bastian, 1865). Mar.Environ.Res. 26(3):161-179.	2801	Eff	
Vranken, G., R. Vandergaeghen, and C. Heip. 1991. Effects of Pollutants on Life-History Parameters of the Marine Nematode Monhystera disjuncta. ICES J Mar Sci 48:325-334.	7215	Con	
Wang, J., M. Zhang, J. Xu, and Y. Wang. 1995. Reciprocal Effect of Cu, Cd, Zn on a Kind of Marine Alga. Water Res. 29(1):209-214.	13720	UEndp	
Waterman, A.J.. 1937. Effect of Salts of Heavy Metals on Development of the Sea Urchin, Arbacia punctulata. Biol.Bull. 73(3):401-420.	17763	UEndp	
Watling, H.R., and R.J. Watling. 1983. Sandy Beach Molluscs As Possible Bioindicators of Metal Pollution 2. Laboratory Studies. Bull.Environ.Contam.Toxicol. 31(3):339-343.	10862	UEndp, Eff	
Watling, H.R.. 1983. Accumulation of Seven Metals by Crassostrea gigas, Crassostrea margaritacea, Perna perna, and Choromytilus meridionalis. Bull.Environ.Contam.Toxicol. 30(3):317-322.	7374	UEndp, Eff	
Watling, H.R.. 1983. Comparative Study of the Effects of Metals on the Settlement of Crassostrea gigas. Bull.Environ.Contam.Toxicol. 31(3):344-351.	11098	UEndp	
Weeks, J.M., and P.S. Rainbow. 1991. The Uptake and Accumulation of Zinc and Copper from Solution by Two Species of Talitrid Amphipods (Crustacea). J.Mar.Biol.Assoc.U.K. 71(4):811-826.	3628	UEndp, Eff	
Weeks, J.M., and P.S. Rainbow. 1993. The Relative Importance of Food and Seawater as Sources of Copper and Zinc to Talitrid Amphipods (Crustacea; Amphipoda; Talitridae). J.Appl.Ecol. 30(4):722-735.	13607	UEndp, Eff	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Weis, J.S., P. Weis, and J.L. Ricci. 1981. Effects of Cadmium, Zinc, Salinity, and Temperature on the Teratogenicity of Methylmercury to the Killifish (Fundulus heteroclitus). Rapp.P.V.Reun.Comm.Int.Explor.Sci.Mer Mediterr. 178:64-70.	11419	UEndp	
Weis, J.S.. 1980. Effect of Zinc on Regeneration in the Fiddler Crab Uca pugilator and its Interactions with Methyl-Mercury and Cadmium. Mar.Environ.Res. 3(4):249-255.	9921	UEndp, Con	
Weis, P., and J.S. Weis. 1980. Effect of Zinc on Fin Regeneration in the Mummichog Fundulus heteroclitus, and its Interaction with Methylmercury. Fish.Bull. 78(1):163-166.	9922	UEndp, Con	
White, K.N., and G. Walker. 1981. Uptake, Accumulation, and Excretion of Zinc by the Barnacle, Balanus balanoides (L.). J.Exp.Mar.Biol.Ecol. 51(2-3):285-298.	9506	UEndp, Eff	
White, S.L., and P.S. Rainbow. 1982. Regulation and Accumulation of Copper, Zinc and Cadmium by the Shrimp Palaemon elegans. Mar.Ecol.Prog.Ser. 8(1):95-101.	9120	UEndp	
Wikfors, G.H., and R. Ukeles. 1982. Growth and Adaptation Estuarine Unicellular Algae in Media with Excess Copper, Cadmium or Zinc, and Effects of Metal-Contaminated Algal Food on. Mar.Ecol.Prog.Ser. 7:191-206.	15508	UEndp, Con	
Willis, J.N., and W.G. Sunda. 1984. Relative Contributions of Food and Water in the Accumulation of Zinc by Two Species of Marine Fish. Mar.Biol. 80(3):273-279.	10673	UEndp, Eff, Con	

Citation	ECOTOX EcoRef 3	Rejection Code(s)	Comment
Wilson, W.B., and L.R. Freeburg. 1980. Toxicity of Metals to Marine Phytoplankton Cultures. EPA-600/3-80-025, U.S.EPA, Narragansett, RI :110 p.(U.S.NTIS PB80-182843).	5557	Dur	Plants do not drive criteria, and therefore, are not included in CWA review and approval of OR WQS
Wright, D.A.. 1986. Trace Metal Uptake and Sodium Regulation in Gammarus marinus From Metal Polluted Estuaries in England. J.Mar.Biol.Assoc.U.K. 66(1):83-92.	5405	UEdp, Eff, Con	
Wu, Z., and G. Chen. 1988. Studies of Acute Intoxication by Some Harmful Substances on Penaeus orientalis K. Mar.Sci./Haiyang Kexue (4):36-40 (CHI) (ENG ABS).	3232	Con	
Young, M.L.. 1975. The Transfer of Zn65 and Fe59 Along a Fucus serratus (L.)-Littorina obtusata (L.) Food Chain. J.Mar.Biol.Assoc.U.K. 55(3):583-610.	2272	Eff	
Young, M.L.. 1977. The Roles of Food and Direct Uptake From Water in the Accumulation of Zinc and Iron in the Tissues of the Dogwhelk, Nucella lapillus (L.). J.Exp.Mar.Biol.Ecol. 30:315-325.	2731	Eff, Con	
Yuan, Y.X., C.N. Gao, and D.X. Zhang. 1992. Egg Hatching and Metamorphosis to Protozoea of Penaeus chinensis (Osbeck) by Removal of Heavy Metals from Rearing Systems with Polymeric Absorbent. Aquaculture 107:303-311.	7425	UEndp, Dur	
Zolotukhina, E.Y., E.E. Gavrilenko, and K.S. Burdin. 1987. Effect of Zinc and Copper Ions on Photosynthesis and Respiration of Marine Macroalgae. Soviet Plant Physiol.(Eng.Trans.Fiziol.Rast.) 34(2):212-220.	6673	UEndp, Eff	

Studies That EPA Considered But Did Not Utilize In This Determination

EPA evaluated these studies and determined that the results were not reliable for use in this determination, either because they were not pertinent to this determination or they failed the QA/QC procedures listed in Appendix A.

3) For the studies that were not utilized, but the most representative SMAV/2 or most representative SMCV fell below the criterion, or, if the studies were for a species associated with one of the four most sensitive genera used to calculate the FAV in the most recent national ambient water quality criteria dataset used to derive the CMC[99], EPA is providing a transparent rationale as to why they were not utilized (see below).
4) For the studies that were not utilized because they were not found to be pertinent to this determination (including failing the QA/QC procedures listed in Appendix A) upon initial review of the download from ECOTOX, EPA is providing the code that identifies why EPA determined that the results of the study were not reliable (see Appendix V).

<u>General QA/QC failure because non-resident species in Oregon</u>

Tests with the following species were used in the EPA BE of OR WQS for zinc in saltwater, but were not considered in the CWA review and approval/disapproval action of the standards because these species do not have a breeding wild population in Oregon's waters:

Nanosesarma	*sp.*	Crab	Selvakumar et al. 1996
Mercenaria	*mercenaria*	Northern quahog or hard clam	Calabrese and Nelson 1974
Crassostrea	*virginica*	Eastern oyster	MacInnes and Calabrese 1978; Calabrese et al. 1973

<u>Other Acute tests failing QA/QC by species</u>

Crassostrea cucullata - Oyster

The following test was included in EPA's BE of the OR WQS for zinc in saltwater, but was not used in this CWA review and approval/disapproval action of these standards because it is not a North American resident.

Watling, H.R. 1982. Comparative study of the effects of zinc, cadmium, and copper on the larval growth of three oyster species. Bull. Environ. Contam. Toxicol. 28: 195-201.

[99] U.S. EPA. 1987. Ambient Water Criteria for Zinc - 1987. EPA-440-5-87-003.

Crassostrea rhizophorae – Mangrove oyster

The following test was included in EPA's BE of the OR WQS for zinc in saltwater, but was not used in this CWA review and approval/disapproval action of these standards because it is not a North American resident.

Chung, K.S. 1980. Acute toxicity of selected heavy metals to mangrove oyster *Crassostrea rhizophorae*. Bull. Jpn. Soc. Sci. Fish. (Nippon Suisan Gakkaishi) 46(6): 777-780.

Crassostrea gigas – Pacific oyster

The following test was included in EPA's BE of the OR WQS for zinc in saltwater, but was not used in this CWA review and approval/disapproval action of these standards because the values were greater than values and were based on mortality, rather than shell development and mortality which is a preferred endpoint.

Watling, H.R. 1982. Comparative study of the effects of zinc, cadmium, and copper on the larval growth of three oyster species. Bull. Environ. Contam. Toxicol. 28: 195-201.

Acanthomysis costata - Mysid

Hunt, J.W., B.S. Anderson, S.L. Turpen, A.R. Coulon, M. Martin, F.H. Palmer and J.J. Janik. 1989. Marine Bioassay Project. 4th Report. Experimental Evaluation of Effluent Toxicity Testing Protocols with Giant Kelp, Mysids, Red Abalone. No. 89-5WQ, State Water Resources Control Board, State of California, Sacramento, CA: 144.
This was a less than value. Other data from this study was used.

The following test was included in EPA's BE of the OR WQS for zinc in saltwater, but was not used in this CWA review and approval/disapproval action of these standards because a more sensitive lifestage was available.

Martin, M., J.W. Hunt, B.S. Anderson and S.L. Turpen. 1989. Experimental evaluation of the mysid *Holmesimysis costata* as a test organism for effluent toxicity testing. Environ. Toxicol. Chem. 8(11): 1003-1012.
This was a greater than value. Other data from this study was used.

Other Chronic tests failing QA/QC by species

Haliotis rufescens* - *Red abalone

The following tests were included in EPA's BE of the OR WQS for zinc in saltwater, but were not used in this CWA review and approval/disapproval action of these standards because of duration.

Hunt, J.W. and B.S. Anderson. 1989. Sublethal effects of zinc and municipal effluents on larvae of the red abalone *Haliotis rufescens*. Mar. Biol. 101(4): 545-552.
9-day chronic test.

Anderson, B.S., J.W. Hunt, M. Martin, S.L. Turpen and F.H. Palmer. 1988. Marine Bioassay Project. 3rd Report. Protocol Development: Reference Toxicant and Initial Complex Effluent Testing. No. 88-7WQ, State Water Resources Control Board, State of California, Sacramento, CA: 154.
9-day chronic test.

Conroy, P.T., J.W. Hunt and B.S. Anderson. 1996. Validation of a short-term toxicity test endpoint by comparison with longer-term effects on larval red abalone *Haliotis rufescens*. Environ. Toxicol. Chem. 15(7): 1245-1250.
10-day chronic test. The concentrations were also unmeasured for this test.