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Issue Paper

Water Quality Standards Aquatic Life Toxics Criteria Update 2024: Issue Paper

DEQ

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Executive Summary

The Oregon Department of Environmental Quality (DEQ) is initiating a rulemaking to update Oregon's aquatic life criteria for toxic pollutants, as prioritized during the 2021 water quality standards Triennial Review. The updates will further protect aquatic life and help ensure Oregon's water quality standards are based on the latest science. EPA's nationally recommended criteria protect aquatic life from toxic effects and provide guidance to States and Tribes. Once EPA has released criteria recommendations for a given chemical, states must either adopt sufficiently protective criteria for that chemical into their standards or provide a reason for not doing so during their triennial review process. DEQ's last comprehensive update of aquatic life criteria happened in 2004, and EPA has issued new or revised criteria recommendations for several chemicals since that time.

State of Oregon
Department of Environmental Quality

To determine the extent of the proposed update to Oregon water quality standards, DEQ compared Oregon's aquatic life criteria with the latest EPA recommendations. DEQ found that Oregon has no aquatic life criteria for five chemicals (acrolein, aluminum, carbaryl, diazinon, nonylphenol) and criteria that are different than EPA recommendations for seven additional chemicals (endosulfan, cadmium, lindane, mercury, selenium, silver and tributyltin). After a review of each chemical, DEQ is proposing to update Oregon's aquatic life criteria to match EPA recommendations for aluminum, acrolein, cadmium, carbaryl, diazinon, and tributyltin.

DEQ is not proposing to update mercury or nonylphenol criteria at this time because the most recent EPA recommendations may not protect threatened and endangered salmonids, and mercury criteria are actively being litigated in the Pacific Northwest. DEQ is also not proposing to update selenium criteria at this time because successful application of the most recent selenium aquatic life criterion recommendation will require detailed development of implementation procedures that are beyond the scope and timeline of the present rulemaking. Further, Oregon already has aquatic life criteria for selenium, and Oregon waters do not typically contain high levels of selenium. Finally, DEQ is not proposing to update Oregon's lindane, endosulfan, and silver aquatic life criteria because they are more stringent than EPA recommendations, are based on sound scientific information and provide necessary protection to aquatic life. Further, EPA has not released new criteria recommendations for these chemicals since DEQ last reviewed them in 2004.

In addition to updating aquatic life criteria in rule, DEQ is proposing to remove the non-regulatory aquatic life water quality guidance values for toxic pollutants from Oregon rule for clarity. These values are not water quality criteria and are outdated.

The purpose of this issue paper is to provide background and technical information about the chemicals and aquatic life criteria that were considered in this review, as well as to document the policy implications and the public process during the rulemaking.

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Chapter 1: Standards review and status of aquatic life criteria for toxic pollutants

1.1 Reviewing and revising water quality criteria

1.1.1 Introduction

1.1.1.1 Why is an update needed?

The Clean Water Act gives the federal Environmental Protection Agency (EPA) authority to regulate the discharge of pollutants to surface waters. Under this authority, EPA is charged with recommending water quality criteria that protect beneficial uses of waterways. States are then responsible for adopting water quality standards, which include the beneficial uses of the state's waters and the criteria necessary to protect those uses. EPA periodically issues new or revised criteria recommendations for chemicals once sufficient data or new scientific evidence becomes available. Under section 303 of the Clean Water Act, States are expected to review their water quality standards every three years to incorporate new scientific information. Once new or revised criteria recommendations have been issued by EPA, the states are responsible for adopting criteria into state water quality standards or providing EPA with a reason for not doing so.

EPA has issued new or revised aquatic life criteria recommendations for several toxic chemicals since Oregon's last comprehensive update of aquatic life criteria for toxic chemicals in 2004 (ODEQ, 2004) . Therefore, the Oregon's existing aquatic life criteria for several chemicals are not based on EPA's latest recommendations, which incorporate new scientific information, and need to be updated.

1.1.1.2 Purpose of this issue paper

This issue paper provides the technical background and policy basis for Oregon's proposed aquatic life toxics criteria updates. This issue paper also documents the public process during the rulemaking.

1.1.2 Process for updating aquatic life criteria

1.1.2.1 Overview of major federal and state actions for adopting criteria

For a state to adopt water quality standards that are effective for Clean Water Act purposes, both state and federal action is required (Figure 1). Under Section 304(a)(1) of the Clean Water Act, the EPA is required to publish recommendations for water quality criteria that will protect against the known adverse effects of pollutants in water bodies. While EPA is required to publish recommendations for water quality criteria, it is up to the States and Tribes to adopt water quality criteria into their water quality standards to protect the designated uses of water bodies. Once EPA releases criteria for a given chemical, states must either adopt the criteria (or a scientifically defensible alternative) or provide a reason why they will not adopt criteria for that chemical.

The Clean Water Act requires states to review their water quality standards once every three years to ensure that their standards are based on the best available science. This process is called the Triennial Review. After possible criteria updates are identified, states identify the priority water quality standard projects to work on over the next three years, including rulemaking processes to adopt revised criteria if needed. Water quality standards adopted by a state become effective for Clean Water Act purposes only after they are approved by the EPA. During the approval process, the EPA is required to consult with the National Marine Fisheries Service and U.S. Fish and Wildlife Service (generally referred to as "the Services") under the Endangered Species Act. The Services independently analyze data to produce a biological opinion(s) that determines whether the revised criteria would adversely affect or jeopardize threatened and endangered species. If no jeopardy is determined, then EPA may approve the criteria and they become effective. If the proposed criteria are expected to cause jeopardy to endangered species, the federal agency identifies reasonable and prudent alternatives to address the jeopardy concerns. If reasonable and prudent alternatives cannot be identified or if the criteria prevent the reasonable and prudent alternatives from being achieved, EPA may disapprove the criteria, and they would not become effective for Clean Water Act purposes.

If EPA disapproves the adopted state criteria and the state does not move to revise the criteria, then it is EPA's duty to promulgate (that is, to put law into effect by proclamation) federal criteria to be effective in the state for Clean Water Act purposes until the state adopts (and EPA approves) alternate criteria, or until EPA withdraws the criteria.

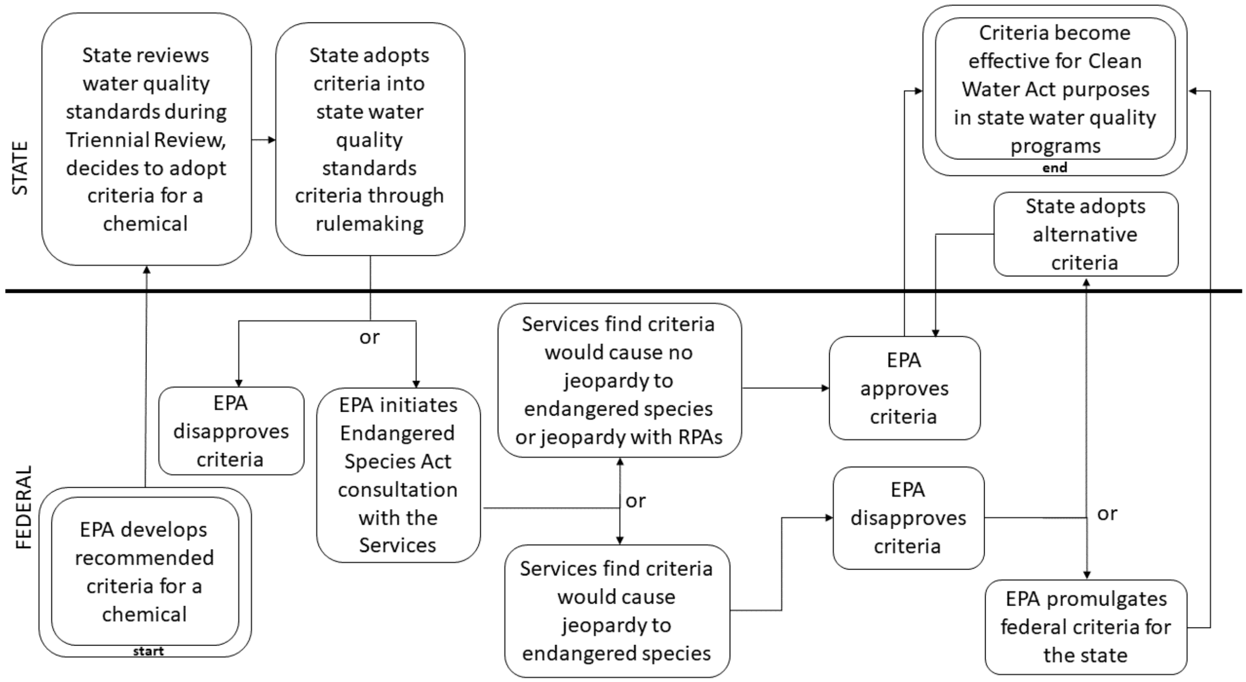

Figure 1. Major federal and state actions required for new or revised criteria to become applicable for Clean Water Act purposes in the state. "RPA" is "Reasonable and Prudent Alternative".

1.1.2.2 Oregon's state rulemaking process to update criteria

During the 2021 Triennial Review, Oregon identified several new or revised EPA aquatic life criteria recommendations that have not yet been incorporated into Oregon's water quality standards. To keep Oregon's rule up-to-date with EPA's recommendations, DEQ decided to initiate a rulemaking process to review and adopt some or all of the new or revised criteria into Oregon rule.

During this process, DEQ obtained technical and policy information on the proposed criteria changes. As part of the public process, Oregon DEQ convened a rulemaking advisory committee composed of multiple stakeholders to review the proposed changes. DEQ will also hold a public hearing and accept and respond to public comment. Once all internal, advisory committee, and public comment is considered, DEQ will make a recommendation regarding criteria adoption to the Environmental Quality Commission while also conveying the input received from the rulemaking advisory committee. In Oregon, the Environmental Quality Commission decides whether to adopt the criteria into state rule.

Once the Environmental Quality Commission adopts criteria into state rule, the criteria rulemaking package must be submitted to EPA for approval before the criteria become applicable for Clean Water Act purposes.

1.1.2.2.1 Rulemaking advisory committee

DEQ convened a rulemaking advisory committee to provide input on the fiscal and economic impacts of the proposed rule amendments, including whether small businesses would be adversely affected by the proposed rule. The committee consisted of representatives from state and federal agencies, local governments, recreational and sport fishing groups, business and industry, environmental organizations, and tribal interests. More information may be found on the committee's web page: Aquatic Life Toxics Criteria 2024 Rulemaking.

Aquatic Life Toxics Criteria Rulemaking Advisory Committee	
Name	**Representing**
Emily Bowes	Rogue Riverkeeper
Michael Campbell	Stoel Rives LLP
Catherine Corbett	Lower Columbia Estuary Partnership
Mike Eliason	Oregon Forest & Industries Council (OFIC)
Raj Kapur Alternate: Julia Crown	Oregon Association of Clean Water Agencies (OR-ACWA)
Hannah LaGassey Alternate: Marnie Keller	Cow Creek Band of the Umpqua Tribe of Indians
Sharla Moffett	Oregon Business & Industry
Lauren Poor	Oregon Farm Bureau
Glen Spain	Pacific Coast Federation of Fishermen's Associations (PCFFA)
Becky Anthony	Oregon Department of Fish and Wildlife
Jeremy Buck	U.S. Fish and Wildlife Service
Cory Engel	Oregon Department of Transportation
Michelle Maier	U.S. Environmental Protection Agency
Rebecca McCoun	Oregon Department of Forestry
Kathryn Rifenburg Alternate: Gilbert Uribe	Oregon Department of Agriculture
Greg Sieglitz	NOAA – National Marine Fisheries Service

DEQ held two rulemaking advisory committee meetings to discuss the proposed rule changes and receive input on the fiscal and economic impact of the proposed rules. Committee members focused on the effect of the environmental protection added by the proposed rules as well as the impacts of the proposed rules to regulated parties and agencies and that implement them. The committee was invited to provide verbal feedback on the first draft Fiscal and Economic Impact Statement at the second meeting on November 13, 2023 and submit any follow-up written comment on the first draft by November 17, 2023 and on the second draft by December 31, 2023.

During the two meetings, DEQ provided information on:

- Scope of the proposed rulemaking, purpose of the project
- Role of the rulemaking advisory committee
- Background on water quality standards and aquatic life toxics criteria in Oregon
- Background on non-regulatory aquatic life water quality guidance values for toxic pollutants
- Scientific and policy basis for the proposed rule amendments (including draft issue paper and draft fact sheet)
- Analysis of the fiscal and economic impact of the proposed rule amendments
- Draft proposed rule language
- The rulemaking process and anticipated timeline

During the first meeting on September 12, 2023, the committee discussed the scope of the rulemaking and expressed an interest in providing feedback on chemicals or chemical characteristics not presently included in the proposed rulemaking. The committee also discussed the technical and policy basis for the proposed criteria recommendations with special focus on utilizing the ‘bioavailable’ fraction of aluminum to apply the proposed criteria. Several committee members wanted to make sure that DEQ was aware of various data sources for the analyses in the draft issue paper.

At the second meeting on November 13, 2023, the committee continued to discuss the data used in the analyses in DEQ’s draft issue paper, noting select areas where data were sparse including stormwater discharge data. The committee discussed the practical impacts of the draft rule language, especially the fiscal and economic impacts of implementing the criteria. The committee also discussed DEQ’s proposal to remove Table 31 guidance values from rule and agreed that the removal of those values from rule was appropriate. Some committee members proposed that DEQ emphasize the environmental and economic benefit of adopting the proposed criteria in the fiscal and economic impact statement.

1.1.2.3 Scope and depth of current aquatic life criteria review

During Oregon's most recent 2021 Triennial Review process, DEQ committed to update aquatic life criteria for toxic pollutants during the 2021-2024 period. To do that, DEQ reviewed and evaluated any criteria for which Oregon's rule was different than the latest EPA criteria recommendations. This included aquatic life criteria in Oregon rule that were more stringent (lower), less stringent (higher), and non-existent compared to current EPA recommendations. The Clean Water Act requires that Oregon's water quality criteria be scientifically defensible, which typically means they must be at least as protective of fish and aquatic life as EPA recommended criteria.

Since Oregon's last comprehensive update of aquatic life criteria in 2004, EPA has issued new or revised aquatic life criteria recommendations for ten chemicals, two of which Oregon has since adopted into state water quality standards (copper and ammonia). DEQ reviewed and evaluated EPA's aquatic life criteria recommendations for the remaining eight chemicals (acrolein, aluminum, cadmium, carbaryl, diazinon, nonylphenol, selenium, and tributyltin). For several chemicals (mercury, endosulfan, lindane, and silver) EPA has not released updated criteria recommendations since Oregon's last comprehensive update of aquatic life toxics criteria in 2004, but Oregon's criteria differ from EPA's current recommendations. DEQ also reviewed and evaluated those criteria.

During the review of Oregon's aquatic life criteria, DEQ also reviewed the aquatic life water quality guidance values for toxic pollutants that can be found in Oregon water quality standards. Given that these values are not water quality criteria, DEQ questioned the appropriateness of retaining these values in Oregon rule.

As part of the review of aquatic life criteria, DEQ evaluated whether data from threatened and endangered Oregon species (or close surrogates) were included in EPA's recommended criteria calculations. DEQ did not seek further independent technical review to evaluate the EPA recommended criteria because the goal of this rulemaking was to bring Oregon's water quality standards up-to-date with current EPA recommendations in compliance with the Clean Water Act.

1.1.3 Existing rule

1.1.3.1 Oregon Administrative Rule under review (OAR 340-041-0033 and OAR 340-041-8033)

The objective of this rulemaking is to update Oregon's water quality standards for toxic substances in Oregon Administrative Rule (OAR) 340-041-8033 (Table 30 Aquatic Life Water Quality Criteria for Toxic Pollutants, Table 31 Aquatic Life Water Quality Guidance Values for

Toxic Pollutants, and corresponding reference text) and corresponding reference text in OAR 340-041-0033.

1.2 Protecting water quality and status of aquatic life criteria in Oregon

1.2.1 Background

1.2.1.1 Components of water quality standards

State water quality standards exist to protect and maintain water quality. They have three primary components:

1. Designated beneficial use: the goal for a waterbody, such as fish and aquatic life use.
2. Criteria: limits of a particular chemical or condition in a waterbody, designed to protect a designated use.
3. Antidegradation policy: state framework to maintain existing water quality.

These three components are applied together to protect and preserve water quality in Oregon and all of the uses that state waterbodies provide. Once states establish goals for waterbodies by designating the beneficial uses to be protected, corresponding criteria are established to ensure the uses are protected, i.e. to ensure the use goals are reached.

The designated beneficial uses of Oregon waters include:

- Fish and aquatic life
- Water contact recreation
- Fishing
- Domestic water supply
- Industrial water supply
- Boating
- Irrigation
- Livestock watering
- Aesthetic quality
- Wildlife and hunting
- Hydropower
- Commercial navigation and transportation

In Oregon, two types of numeric criteria currently exist for toxic pollutants. They are aquatic life criteria and human health criteria, and they are applied to waterbodies with select designated uses. Aquatic life criteria, for example, are designed to protect native aquatic life, such as fish, shellfish, and wildlife. In Oregon, aquatic life criteria apply to waters of the state that have been designated for fish and aquatic life uses. Human health criteria often have numeric values to address water consumption and fish and shellfish consumption, and they are designed to protect human health through the beneficial uses of domestic water supply and fishing.

1.2.1.2 How are aquatic life criteria utilized?

Aquatic life criteria are the basis for different water quality programs. Criteria are used to assess waters of the state and determine which need pollution control measures (i.e. Total Maximum Daily Load (TMDL)). Acute and chronic criteria may also be applied in other water quality programs, such as National Pollutant Discharge Elimination System (NPDES) permitting or 401 certification.

1.2.2 Aquatic life criteria and guidance values

1.2.2.1 How are aquatic life criteria structured?

Aquatic life criteria are designed to protect fish, shellfish, and other aquatic life. Recommendations differ for freshwater and saltwater habitats because the conditions and ecosystems are different. When sufficient data are available, aquatic life criteria are structured to protect against short-term (acute) and long-term (chronic) toxicity, including long-term effects like bioaccumulation. Criteria are typically structured to include a numeric value, frequency, and duration. For example, most of Oregon's aquatic life criteria recommendations are structured as follows:

"[Freshwater or saltwater] aquatic organisms and their uses a should not be affected unacceptably if the four-day average concentration of [Chemical X] does not exceed [Y] µg/L more than once every three years on the average and if the one-hour average concentration does not exceed [Z] µg/L more than once every three years on the average." In this example X is a chemical, Y is the chronic numeric value, and Z is the acute numeric value.

While the example above is the most traditional and common format that aquatic life criteria take, some EPA recommended criteria are more complex. Instead of a singular numeric water column value, some criteria are equations. These equations use water quality variables (such as hardness, pH, and/or dissolved organic carbon) to calculate criteria values. Further, some criteria are expressed as tissue concentration values rather than water column concentrations for chemicals that bioaccumulate. Frequencies and durations also might vary to more appropriately reflect the scientific context of the numeric value. For example, the latest chronic selenium criterion recommendation is a fish tissue value that is not to be exceeded.

1.2.2.2 How are aquatic life criteria determined?

EPA has established guidelines that clearly outline acceptable data sources and methods for systematic criterion development in *Guidelines for Deriving Numerical National Water Quality*

Criteria for the Protection of Aquatic Organisms and Their Uses (generally referred to as "the Guidelines") (Stephen et al., 1985). These criteria are designed to be protective of 95% of the aquatic community. Although aquatic life criteria are recommended based on data from the aquatic community, they may be lowered to accommodate sensitive economically or ecologically important species, or threatened or endangered species.

EPA produces recommendations for numeric aquatic life criteria by reviewing information on toxic chemical effects in aquatic organisms, including acute (short-term) and chronic (long-term) toxicity in plants and animals that may include the effects of bioaccumulation (Stephen et al., 1985). Toxicity data must be available from a variety of different families to estimate a chemical level that protects most of the aquatic community.

Generally, the methodology for determining freshwater acute criteria require toxicity test data from at least eight different animal families including vertebrates (such as fish, amphibians), invertebrates (such as insects, mollusks, or crustaceans), and specifically a fish in the family Salmonidae (salmonids). Saltwater acute criteria also require data from at least eight different families including a variety of vertebrates and invertebrates. Once all of the toxicity studies measuring short-term toxic effects (such as mortality) are assembled, toxic effect data are reported at the genus level, and data are then ordered by sensitivity using a species sensitivity distribution approach. Data from the most sensitive genera and safety factors are used to model an acute concentration that is protective of 95% of aquatic organisms for a given exposure period (Stephen et al., 1985). These protective values become the numeric values of the acute criteria. When a species sensitivity distribution approach is used, the four most sensitive genera are typically used in the calculation process, giving them the most weight in determining numeric the criteria values.

Chronic criteria (freshwater or saltwater) can be calculated directly if long-term toxic effect (growth, reproduction) studies are available for eight families, in the same manner as that used to establish acute criteria. Alternatively, if sufficient chronic toxicity data are not available from the appropriate number and diversity of taxonomic groups, the chronic criterion can be established using an acute-to-chronic ratio, which is calculated from paired acute and chronic toxic effect data conducted on the same species from the same laboratory. To use an acute-to-chronic ratio approach, toxicity data must be available from three families including a fish, an invertebrate, and an acutely sensitive species. Once those minimum data requirements are met, the acute toxicity value is divided by the acute-to-chronic ratio to establish the chronic numeric criterion value.

In some cases, EPA uses other data based on sensitive endpoints (behavioral, biochemical, physiological, microcosm, and field studies) to determine the appropriate criterion instead of typical acute or chronic direct toxicity test data. If bioaccumulation is a concern, as it was with selenium, then data demonstrating the adverse effects of bioaccumulated selenium may be used to establish a criterion. If other water quality variables (such pH, dissolved organic carbon, and/or hardness) affect toxicity and can be modeled, EPA may recommend numeric equations instead of singular numeric values, as is the case with aluminum, cadmium, and others. Regardless of the method for numeric criterion development, more weight is placed on data from sensitive species and genera to ensure that most of the aquatic community is protected by the resulting criteria.

During criteria recommendation development, EPA goes through its own process of external science peer-review, and later public comment before finalizing criteria recommendations.

1.2.2.3 What are aquatic life water quality guidance values for toxic pollutants?

In 1986, EPA produced a list of aquatic life water quality guidance values for toxic pollutants that could be used as benchmarks to protect aquatic life. EPA did not publish aquatic life criteria recommendations for these chemicals because there was not sufficient data to develop criteria using EPA's aquatic life criteria methodology described in Section 1.2.2.2 (EPA, 1986). Some of these chemicals are not identified as priority pollutants. EPA has subsequently developed criteria recommendations for some of the chemicals based on additional data. EPA has not recommended using these guidance values as benchmarks since their aquatic life criteria updates in 1992. (EPA, 1992).

1.2.2.3 EPA aquatic life criteria recommendation revisions and DEQ action

Federal recommendations for ambient water quality criteria date back to 1968 (Federal Water Pollution Control Administration, 1968). Since then, EPA has periodically revised national criteria recommendations for multiple chemicals at a time (the Blue Book (EPA, 1972) , the Red Book (EPA, 1976), the Gold Book (EPA, 1986), the Great Lakes Initiative (EPA, 1996), an update in 1999 (EPA, 1999)). With the National Toxics Rule (EPA, 1992) and California Toxics Rule (EPA, 2001b), EPA promulgated multiple criteria for select states with under protective criteria. EPA also releases criteria recommendations for individual chemicals. Once EPA recommends criteria, those recommendations remain in effect until the criteria are superseded by revised criteria recommendations or until EPA formally withdraws the criteria recommendations. A table of EPA's current nationally recommended aquatic life criteria for toxic chemicals is maintained on the EPA website (https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table) for quick reference.

DEQ's last comprehensive update of aquatic life toxics criteria occurred in 2004. Once Oregon adopted those toxics criteria, EPA initiated Endangered Species Act consultation with the Services. In 2013, after consultation was complete, EPA approved many of the criteria that Oregon adopted in 2004. However, EPA disapproved several of Oregon's freshwater criteria including those for aluminum, ammonia, cadmium, and copper. In the case of ammonia and copper, EPA issued revised criteria recommendations in the period between Oregon's submission in 2004 and EPA's action in 2013, rendering Oregon's adopted criteria for these chemicals at least in part under protective. For aluminum and cadmium, the Services found jeopardy for threatened and endangered species, leading to an EPA disapproval action for those criteria. Since 2013, Oregon DEQ has adopted new aquatic life criteria with EPA approval for ammonia and copper, and EPA has promulgated federal freshwater criteria for aluminum (effective April 19, 2021) and acute cadmium for Oregon (effective March 6, 2017).

1.2.2.4 Aquatic life criteria under review

Since DEQ's last update of aquatic life criteria, EPA has issued new criteria recommendations for acrolein, carbaryl, diazinon, and nonylphenol and revised recommendations for aluminum, cadmium, selenium, and tributyltin. For aluminum and acute cadmium specifically, EPA promulgated criteria for Oregon, although those criteria are not reflected within state standards. During the present review, DEQ identified 21 aquatic life criteria across nine chemicals for which Oregon's criteria are less stringent or non-existent compared to EPA recommended criteria (Table 1).

Table 1. Status of Oregon's aquatic life criteria relative to EPA recommendations for select chemicals under review

Chemical	Aquatic Life Criteria			
	Freshwater (µg/L)		Saltwater (µg/L)	
	Acute Criterion (CMC)	Chronic Criterion (CCC)	Acute Criterion (CMC)	Chronic Criterion (CCC)
Acrolein	none	None	-	-
Aluminum	none [a]	none [a]	-	-
Cadmium	less stringent [b]	equal [c]	less stringent	less stringent
Carbaryl	none	None	none	-
Diazinon	none	None	none	none
Endosulfan	more stringent	more stringent	more stringent	more stringent
Lindane	equal	more stringent	equal	-
Mercury	less stringent	more stringent	equal	more stringent
Nonylphenol	none	none	none	none
Selenium	more stringent	less stringent	equal	equal
Silver	equal	more stringent	equal	-
Tributyltin	equal	more stringent	more stringent	less stringent

'none' indicates a criterion for which EPA has made a recommendation but Oregon has no criterion in State standards.
'-' indicates there is no recommended EPA criterion.
[a] EPA has promulgated federal freshwater criteria that are effective for Clean Water Act purposes in Oregon, but they have not been adopted into Oregon's standards rules. These federally promulgated criteria (see 40 CFR 131.47) are based on EPA's latest recommended criteria for aluminum (EPA, 2018).
[b] EPA has promulgated a federal freshwater acute criterion that is effective for Clean Water Act purposes in Oregon, but it has not been adopted into Oregon's standards rules. This federally promulgated criterion (see 40 CFR 131.46) is based on EPA's latest recommended criterion for cadmium (EPA, 2016).
[c] This assessment of Oregon's freshwater cadmium criterion is based on a recent court case in Arizona that vacated EPA's 2016 freshwater chronic cadmium criterion recommendation (*Center for Biological Diversity v. United States Environmental Protection Administration et al*, 2023), and not the 2016 recommended criterion (EPA, 2016).

DEQ is proposing to adopt EPA's new or revised recommended criteria for six of the nine chemicals for which at least one of Oregon's aquatic life criteria is less stringent or non-existent compared to current EPA recommendations. This would include adopting all of the most recently recommended criteria for a given chemical, even if that means lowering one criterion (i.e. saltwater chronic) but increasing another (i.e. freshwater acute). The following chemicals are proposed for criteria adoption or revision:

1. Acrolein
2. Aluminum
3. Cadmium
4. Carbaryl
5. Diazinon
6. Tributyltin

For mercury, nonylphenol, and selenium, DEQ is not proposing to adopt new values into state standards at this time. Mercury criteria are actively being litigated in the Pacific Northwest, and concerns have been raised that EPA's most recently recommended mercury aquatic life criteria may not protect salmonids, which comprise several threatened and endangered species in Oregon. DEQ is proposing to wait until EPA and the federal fisheries agencies have agreed upon protective criteria for listed species before updating Oregon's aquatic life criteria for mercury. In the meantime, the EPA's most protective chronic criteria recommendations for mercury have been adopted by Oregon and will remain in effect.

Nonylphenol criteria are currently under ESA consultation, and concerns have been raised about whether they fully protect threatened and endangered species in the Pacific Northwest.

Therefore, DEQ will wait until the ESA review and corresponding biological opinion are completed and addressed by EPA before adopting nonylphenol criteria into state standards.

For selenium, EPA's recommended chronic criterion will require complex and detailed implementation to be successfully applied in water quality programs (permitting, assessment, TMDL, etc.). Given that Oregon already has criteria for selenium and Oregon waters do not have high levels of selenium, DEQ is proposing not to adopt the new selenium criterion recommended by EPA at this time. DEQ may adopt the EPA recommended selenium criteria at a later date after developing and evaluating implementation options.

For endosulfan, lindane, and silver, Oregon's criteria are more stringent than current EPA recommendations because EPA withdrew those criteria recommendations. In 2004, DEQ elected to maintain those withdrawn criteria in Oregon's water quality standards because they were based on sound scientific information and were necessary to protect aquatic life uses. Given that EPA has not issued any criteria recommendation updates since these chemicals were reviewed in 2004, DEQ is proposing to continue to retain the current aquatic life toxics criteria.

More information regarding each chemical considered during the present update can be found in Chapter 2 and the Appendix. Chapter 3 contains a summary of all the numeric aquatic life criteria changes that DEQ is proposing at this time.

1.2.2.5 Aquatic life water quality guidance values for toxic pollutants under review

During the last comprehensive update of aquatic life criteria in 2004, DEQ elected to retain the non-regulatory water quality guidance values for toxic pollutants (Table 31, OAR 340-041-8033) in Oregon rule. Originally, these values were included in the Gold Book by EPA in 1986 (EPA, 1986) for chemicals when there were not sufficient data to generate water quality criteria using using EPA's aquatic life criteria methodology (EPA, 1986). Beginning in 1992, however, EPA no longer maintained this list of guidance values with the release of the National Toxics Rule (EPA, 1992). During DEQ's last review of water quality criteria in 2004, technical advisory committee members found that there was technical value to keeping the guidance values in rule. However, during the present review, DEQ found that these values were non-regulatory, outdated, and seldomly used by water quality programs. For clarity and consistency, DEQ is proposing to remove these non-regulatory values from Oregon's water quality standards, in favor of developing clear procedures for addressing pollutants without national recommended water quality criteria.

Chapter 2: Chemical-specific summary information

2.1 Introduction

For each chemical considered during DEQ's aquatic life toxics criteria update, this chapter provides information about Oregon's current criteria and the proposed criteria. This section also includes a summary of information and considerations that DEQ used to decide whether to update aquatic life criteria for a chemical at this time. For most chemicals under consideration, DEQ performed an analysis to compare chemical concentrations in Oregon ambient waters and discharges to the recommended criteria concentrations to roughly quantify the relative impact of adopting EPA's criteria recommendations. Details of those analyses can be found in Appendix A.2. A summary of EPA's technical basis for the numeric criteria value recommendations may be found in Appendix A.1.

2.2 Chemicals proposed for criteria adoption

2.2.1 Acrolein

2.2.1.1 Acrolein criteria

2.2.1.1.1 Effective acrolein criteria in Oregon

Oregon currently has no aquatic life criteria for acrolein. However, Oregon does have human health criteria for acrolein (Water + Organism = 0.88 µg/L, Organism only 0.93 µg/L; OAR 340-041-8033 Table 40) that are lower than the latest EPA recommended acrolein criteria (EPA, 2009).

2.2.1.1.2 Latest EPA nationally recommended acrolein aquatic life criteria

EPA finalized the aquatic life criteria recommendation for acrolein in 2009 (EPA, 2009). The recommendation is based on a literature search through June 2009 and only includes acute and chronic criteria for freshwater given that saltwater toxicity data were insufficient to produce a recommendation (Table 2). Acrolein criteria are intended to be applied and implemented as the "total" sample fraction.

Table 2. Current acrolein aquatic life criteria in Oregon and the latest EPA recommendations

Acrolein Criteria (CAS 107028)	Aquatic Life Criteria			
	Freshwater (µg/L)		Saltwater (µg/L)	
	Acute Criterion (CMC)	Chronic Criterion (CCC)	Acute Criterion (CMC)	Chronic Criterion (CCC)
Oregon Water Quality Standards	-	-	-	-
EPA Recommendation (2009)	3.0 [a]	3.0 [b]	-	-

"-" indicates no criterion.

[a] The one-hour average concentration is not to exceed the CMC more than once every three years on average.

[b] The four-day average concentration is not to exceed the CCC more than once every three years on average.

2.2.1.2 Summary for acrolein and decision to adopt acrolein criteria

Acrolein is primarily used as a restricted use pesticide, although it may also be produced naturally. Oregon standards do not contain aquatic life criteria for acrolein, although they do contain acrolein human health criteria at levels below proposed aquatic life criteria. The 2009 EPA recommended aquatic life criteria for acrolein include freshwater acute and chronic values. Data for threatened and endangered salmonids were considered in the development of the acute criterion, indicating that the criterion is likely to protect these species. Acrolein criteria are intended to be applied as the "total" sample fraction. In Oregon surface waters, acrolein is typically measured at levels below the proposed acute and chronic aquatic life criteria (See Appendix A.2.1). DEQ cannot determine whether acrolein concentrations in Oregon discharges are higher or lower than the criteria because the laboratory reporting (quantification) limit for wastewater is typically higher than the proposed criteria. However, most of the available discharge measurements of acrolein are below 5.0 µg/L.

DEQ is proposing to adopt acrolein criteria at this time to add protection for fish and aquatic life in Oregon waters and to be up-to-date with EPA recommendations.

2.2.2 Aluminum

2.2.2.1 Aluminum criteria

2.2.2.1.1 Effective aluminum criteria in Oregon

Oregon's water quality standards do not contain aquatic life or human health criteria for aluminum. However, in 2021, EPA promulgated aluminum freshwater aquatic life criteria for

Oregon (EPA, 2021b) (Table 3, Table 4). Oregon adopted EPA's 1988 recommended aluminum aquatic life criteria (EPA, 1988) in 2004, and EPA subsequently disapproved those criteria in 2013 following ESA consultation. EPA was then required by law to provide new criteria for Oregon by the end of 2020. On April 19, 2021, EPA's promulgated aluminum aquatic life criteria became effective in Oregon for Clean Water Act purposes. These freshwater criteria are based on EPA's 2018 nationally recommended aluminum aquatic life criteria (EPA, 2018). The freshwater acute and chronic criteria magnitude values vary based on other water quality parameters including pH, dissolved organic carbon (DOC), and total hardness. Criteria values are calculated by inputting these variables into the Aluminum Criteria Calculator.

Table 3. Federally promulgated aluminum criteria language effective for Clean Water Act purposes in Oregon. See 40 CFR 131.47 for additional language and details.

Metal	CAS No.	Criterion maximum concentration (CMC)[3] (µg/L)	Criterion continuous concentration (CMC)[4] (µg/L)
Aluminum [1 2]	7429905	Acute (CMC) and chronic (CCC) freshwater aluminum criteria values for a site shall be calculated using the 2018 Aluminum Criteria Calculator (Aluminum Criteria Calculator V.2.0.xlsx), or a calculator in R or other software package using the same 1985 Guidelines calculation approach and underlying model equations as in the Aluminum Criteria Calculator V.2.0.xlsx, as defined in EPA's Final Aquatic Life Ambient Water Quality Criteria for Aluminum.[5]	

[1] To apply the aluminum criteria for Clean Water Act purposes, criteria values based on ambient water chemistry conditions must protect the water body over the full range of water chemistry conditions, including during conditions when aluminum is most toxic.

[2] These criteria are based on aluminum toxicity studies where aluminum was analyzed using total recoverable analytical methods. Oregon may utilize total recoverable analytical methods to implement the criteria. For characterizing ambient waters, Oregon may also utilize, as scientifically appropriate and as allowable by State and Federal regulations, analytical methods that measure the bioavailable fraction of aluminum (e.g., utilizing a less aggressive initial acid digestion, such as to a pH of approximately 4 or lower, that includes the measurement of amorphous aluminum hydroxide yet minimizes the measurement of mineralized forms of aluminum such as aluminum silicates associated with suspended sediment particles or clays). Oregon shall use measurements of total recoverable aluminum where required by Federal regulations.

[3] The CMC is the highest allowable one-hour average ambient concentration of aluminum. The CMC is not to be exceeded more than once every three years. The CMC is rounded to two significant figures.

[4] The CCC is the highest allowable four-day average ambient concentration of aluminum. The CCC is not to be exceeded more than once every three years. The CCC is rounded to two significant figures.

[5] EPA–822–R–18–001, Final Aquatic Life Ambient Water Quality Criteria for Aluminum—2018, December 2018, is incorporated by reference into this section with the approval of the Director of the Federal Register under 5 U.S.C. 552(a) and 1 CFR part 51. All approved material is available from U.S. Environmental Protection Agency, Office of Water, Health and Ecological Criteria Division (4304T), 1200 Pennsylvania Avenue, NW, Washington, DC 20460; telephone number: (202) 566–1143, www.epa.gov/wqc/aquatic-life-criteria-aluminum. It is also available for inspection at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, email fedreg.legal@nara.gov or go to www.archives.gov/federal-register/cfr/ibr-locations.html.

Table 4. Example aluminum aquatic life criteria values in Oregon based on the federally promulgated Aluminum Criteria Calculator (v. 2.0) outputs

Aluminum Criteria (CAS 7429905)	Example Aquatic Life Criteria based on select Aluminum Criteria Calculator (v 2.0) input values [a]			
	Freshwater (µg/L)		Saltwater (µg/L)	
	Acute Criterion (CMC)	Chronic Criterion (CCC)	Acute Criterion (CMC)	Chronic Criterion (CCC)
Oregon Water Quality Standards	-	-	-	-
Effective in Oregon	980 [a,b,d]	380 [a,c,d]	-	-
EPA Recommendation (2018)	980 [a,b]	380 [a,c]	-	-

"-" indicates no criterion.

[a] Criteria values provided are based on a pH of 7, a dissolved organic carbon (DOC) concentration of 1 mg/L, and a total hardness concentration of 100 mg/L as $CaCO_3$ and apply to those conditions only. Criteria magnitude values vary and may be calculated based on pH, DOC, and total hardness at a site using the Aluminum Criteria Calculator v.2.0.

[b] The one-hour average concentration is not to exceed the CMC more than once every three years on average.

[c] The four-day average concentration is not to exceed the CCC more than once every three years on average.

[d] These criteria are not included in Oregon's water quality standards rules, but have been promulgated by EPA. See Table 3 (also 40 CFR 131.47) for promulgated aluminum criteria language.

2.2.2.1.2 Latest EPA nationally recommended aluminum aquatic life criteria

The most recent EPA recommended aluminum freshwater aquatic life criteria were released in 2018 (EPA, 2018). Criteria magnitude values vary with pH, DOC, and total hardness, and example criteria values are provided in Table 4. To obtain aluminum criteria magnitude values for a given sample, pH, DOC, and total hardness are entered into the Aluminum Criteria Calculator v. 2.0. It is important to recognize that the 2018 recommended criteria are expressed as "total recoverable", largely because laboratory waters used to determine toxicity were devoid of colloidal, particulate, and clay-bound aluminum. However, EPA has acknowledged that in natural waters, total recoverable aluminum measurements may overestimate toxicity because they include non-bioavailable forms (and therefore non-toxic forms) of aluminum. Therefore, while the federally promulgated aluminum aquatic life criteria in Oregon are expressed as "total recoverable" aluminum, the rule allows DEQ to apply the criteria as "bioavailable" aluminum in ambient waters (which relies on a different analytical method) where appropriate (Table 3, footnote 2). Total recoverable aluminum measurements are required for wastewater until wastewater methods for bioavailable aluminum are approved. However, for assessments of aluminum in natural waters, bioavailable aluminum is the more appropriate sample fraction to apply the proposed criteria considering because it may more accurately reflect aluminum's toxicity in natural waters.

2.2.2.2 Summary for aluminum and decision to adopt aluminum criteria

Aluminum is the most abundant metal in the Earth's crust and can enter the aquatic environment through natural processes and human activities. In the aquatic environment, a significant fraction of the aluminum is typically not bioavailable or toxic to aquatic life because much of it is bound in clays and sediments or complexed with other ions. Aluminum's toxicity varies with pH, DOC, and total hardness. Therefore, the freshwater acute and chronic criteria magnitudes must be calculated using the Aluminum Criteria Calculator, which calculates criteria values dependent on the water chemistry. EPA's 2021 promulgation of the freshwater aluminum criteria in Oregon means that these criteria recommendations have successfully passed through Endangered Species Act consultation with the Services and have recently been deemed protective of threatened and endangered species in Oregon. An analysis of total recoverable aluminum in surface waters and discharges in Oregon suggests that waters of the State have the potential to exceed the aluminum criteria if total recoverable aluminum is used to assess surface waters (See Appendix A.2.2). Further, some dischargers may find it difficult to meet permit limits derived from aluminum criteria expressed as total recoverable. Limited data from bioavailable aluminum measurements instead suggest that surface waters are not likely to exceed the aluminum criteria when considering only the toxic (i.e. bioavailable) portion of aluminum in the water. An effort to increase bioavailable aluminum measurements in ambient surface waters over the next two years is underway at DEQ.

DEQ is proposing to adopt EPA's 2018 freshwater aluminum criteria recommendation into state water quality standards so it is clear to the public that they are effective and being implemented by Oregon's water quality programs. Since the federal promulgation of the aluminum standard in 2021, Oregon has been applying and implementing EPA's aluminum criteria recommendation. The state does not intend to change the way the standard is applied and implemented but will include additional language in the proposed rule that clarifies DEQ's application procedures. For Oregon's proposed aluminum rule language, please see Chapter 3 in this document or the *Notice of Proposed Rulemaking* that may be found on the Aquatic Life Toxics Criteria 2024 Rulemaking web page. Further, Oregon intends to preferentially use bioavailable aluminum where federal regulations allow when applying the criteria, which will have positive impacts for the state's water quality programs while protecting fish and aquatic life.

2.2.3 Cadmium

2.2.3.1 Cadmium criteria

2.2.3.1.1 Effective cadmium criteria in Oregon

In 2004, Oregon revised the state's aquatic life criteria for cadmium based on EPA's 2001 recommendations (EPA, 2001a). In 2013, EPA approved Oregon's freshwater chronic cadmium criterion, but disapproved the acute criterion, citing the National Marine Fisheries Service Biological Opinion that the acute criterion would jeopardize endangered species in Oregon (NOAA, 2012).

EPA released updated national cadmium criteria recommendations in 2016, using additional toxicity data for endangered species to address the concerns of the National Marine Fisheries Service. Because EPA disapproved the freshwater acute criterion based on EPA's 2001 recommendation in Oregon, EPA was required to promulgate the revised acute cadmium criterion for Oregon. The federally promulgated freshwater acute cadmium criterion based on the 2016 cadmium criteria recommendations became effective for Clean Water Act purposes in Oregon on March 16, 2017 (EPA, 2017) (Table 5). However, because Oregon has not yet adopted the revised criterion, it is not reflected in Oregon's water quality standards and needs to be updated in Oregon rule. Currently, the freshwater acute cadmium criterion reflected in Oregon rule is based on EPA's 1985 recommendation, which remained in state standards after the 2001 recommendation was disapproved by EPA (Table 6).

Oregon's saltwater acute and chronic cadmium aquatic life criteria are now outdated because EPA updated their criteria recommendations for all the cadmium criteria in 2016 (EPA, 2016). The 1985, 2001, and 2016 freshwater criteria recommendations are equation-based criteria that vary with total hardness (Table 5), while the saltwater criteria recommendations are discrete values that do not vary with other water quality parameters. The freshwater and saltwater cadmium aquatic life criteria (2001 and 2016 recommendations only) are expressed as the dissolved sample fraction, given that the dissolved portion is responsible for toxicity to aquatic life. Oregon does not have human health criteria for cadmium.

Table 5. Full hardness-based equation EPA recommendations for freshwater aquatic life criteria magnitudes

EPA Cadmium Criteria Recommendations by Year	Freshwater Aquatic Life Criteria (µg/L) [a]	
	Acute Criterion Magnitudes (CMC)	Chronic Criterion Magnitudes (CCC)
1985	$e^{(1.128[\ln(hardness)]-3.828)}$ [b]	$e^{(0.7852[\ln(hardness)]-3.490)}$ [b]
2001	$e^{(1.0166 \times \ln(hardness) - 3.924)} \times CF$ [c, d]	$e^{(0.7409[\ln(hardness)]-4.719)} \times CF$ [c, e]
2016	$e^{(0.9789 \times \ln(hardness) - 3.866)} \times CF$ [c, d]	$e^{(0.7977 \times \ln(hardness) - 3.909)} \times CF$ [c, e, f]

[a] The exponential constant is a mathematical constant and is denoted by the symbol 'e'. It is approximately equal to 2.718.
[b] Criterion expressed in terms of "total" concentrations in the water column.
[c] Criterion expressed in terms of "dissolved" concentrations in the water column.
[d] CMC CF (conversion factor from total to dissolved) = 1.136672 – [(ln hardness) x (0.041838)].
[e] CCC CF (conversion factor from total to dissolved) = 1.101672 – [(ln hardness) x (0.041838)].
[f] This criterion was vacated by a recent court decision, making it no longer the most recent EPA recommended freshwater chronic criterion for cadmium (*Center for Biological Diversity v. United States Environmental Protection Administration et al*, 2023).

Table 6. Current cadmium aquatic life criteria in Oregon and the latest EPA recommendations

Cadmium Criteria (CAS 7440439)	Aquatic Life Criteria			
	Example freshwater values based on default hardness [a] (µg/L)		Saltwater (µg/L)	
	Acute Criterion (CMC)	Chronic Criterion (CCC)	Acute Criterion (CMC)	Chronic Criterion (CCC)
Oregon Water Quality Standards	3.9 [a, b, f]	0.25 [a, c, e]	40 [e]	8.8 [e]
Effective in Oregon	1.8 [a, b, d, e]	0.25 [a, c, e]	40 [e]	8.8 [e]
EPA Recommendation [g]	1.8 [a, b, e]	0.25 [a, c, e]	33 [e]	7.9 [e]

[a] Criteria values are based a total hardness concentration of 100 mg/L as $CaCO_3$ and apply to those conditions only. Criteria magnitude values vary may be calculated on using hardness-based equations found in Table 5.
[b] The one-hour average concentration is not to exceed the CMC more than once every three years on average.
[c] The four-day average concentration is not to exceed the CCC more than once every three years on average.

[d] The effective freshwater acute criterion is not included in state water quality standards, but has been promulgated by EPA. See 40 CFR 131.46.
[e] Criterion expressed in terms of "dissolved" concentrations in the water column.
[f] Criterion expressed in terms of "total" concentrations in the water column.
[g] EPA's current criteria recommendations for cadmium are comprised of the 2016 freshwater acute and saltwater acute and chronic criteria recommendations (EPA, 2016) combined with EPA's 2001 freshwater chronic criterion recommendation (EPA, 2001a) after a recent court case vacated EPA's 2016 freshwater chronic criterion recommendation (*Center for Biological Diversity v. United States Environmental Protection Administration et al*, 2023).

2.2.3.1.2 Latest EPA nationally recommended cadmium aquatic life criteria

EPA last updated aquatic life criteria recommendations for cadmium in 2016 (EPA, 2016). These updates include both fresh and saltwater acute and chronic criteria recommendations and incorporate toxicity data through late 2015. Freshwater acute and chronic criteria magnitudes are expressed as hardness-based equations (Table 5), given that toxicity to cadmium is reduced by increasing hardness. Saltwater acute and chronic magnitudes are not equation-based. Both fresh and saltwater criteria are expressed in terms of dissolved concentrations in the water column, after EPA determined that the dissolved sample fractions more closely approximate the toxic portion of cadmium in the aquatic environment (EPA, 1995).

Note: In 2023, a U.S. district court decision vacated EPA's 2016 freshwater chronic cadmium criterion recommendation (*Center for Biological Diversity v. United States Environmental Protection Administration et al*, 2023), making EPA's 2001 recommendation the most up to date aquatic life criterion for freshwater chronic cadmium.

2.2.3.2 Summary for cadmium and decision to update cadmium criteria

Cadmium is a metal that can enter the aquatic environment through a variety of human activities. The most recent cadmium criteria recommendations are intended to be applied as dissolved cadmium, and the freshwater acute and chronic recommendations are expressed as equations that vary with hardness. EPA's recent (2017) promulgation of the freshwater acute cadmium criterion in Oregon completed Endangered Species Act consultation in Oregon. Cadmium concentrations in Oregon surface waters are generally lower than the conservative 10^{th} percentile acute and chronic criteria based on Oregon water quality (See Appendix A.2.3). In discharges, most measurements were below the 10^{th} percentile chronic criterion. Given the range of laboratory reporting limits for discharges it may be challenging to determine whether discharge measurements are below the proposed freshwater criteria. Although measurements were limited, cadmium in saltwater was always below the proposed criteria (See Appendix A.2.3).

Oregon is proposing to adopt EPA's 2016 cadmium aquatic life criteria recommendations for freshwater acute and saltwater acute and chronic criteria into state water quality standards for clarity, accuracy, and consistency for use by Oregon's water quality programs and the public. Given that EPA's 2016 freshwater chronic criterion recommendation has been vacated by a recent court case (*Center for Biological Diversity v. United States Environmental Protection Administration et al*, 2023), Oregon's freshwater chronic criterion is the same as the most recent federal recommendation (EPA, 2001a). This action would bring no functional change to the federally promulgated freshwater acute criterion already applied in Oregon. It would also not change Oregon's current freshwater chronic criterion but it would make the saltwater acute and chronic criteria slightly more stringent.

2.2.4 Carbaryl

2.2.4.1 Carbaryl criteria

2.2.4.1.1 Effective carbaryl criteria in Oregon

Oregon currently has no aquatic life or human health criteria for carbaryl.

2.2.4.1.2 Latest EPA nationally recommended carbaryl aquatic life criteria

EPA finalized the aquatic life criteria recommendation for carbaryl in 2012 (EPA, 2012). The recommendation was developed based on scientific literature published through May 2009. The nationally recommended criteria includes freshwater acute and chronic criteria as well as a saltwater acute criterion. EPA did not have sufficient data to recommend a saltwater chronic criterion (Table 7). The criteria are expressed as the total carbaryl sample fraction in the water column.

Table 7. Current carbaryl aquatic life criteria in Oregon and the latest EPA recommendations

Carbaryl Criteria (CAS 63252)	Aquatic Life Criteria			
	Freshwater (µg/L)		Saltwater (µg/L)	
	Acute Criterion (CMC)	Chronic Criterion (CCC)	Acute Criterion (CMC)	Chronic Criterion (CCC)
Oregon Water Quality Standards	-	-	-	-
EPA Recommendation (2012)	2.1 [a]	2.1 [b]	1.6 [a]	-

"-" indicates no criterion.
[a] The one-hour average concentration is not to exceed the CMC more than once every three years on average.
[b] The four-day average concentration is not to exceed the CCC more than once every three years on average.

2.2.4.2 Summary for carbaryl and decision to adopt carbaryl criteria

Carbaryl is an insecticide used in urban and agricultural settings. Oregon currently does not have water quality criteria for carbaryl. The 2012 EPA recommended criteria include freshwater acute and chronic criteria, as well as a saltwater acute criterion. Carbaryl criteria recommendations are expressed as the total sample fraction and are expected to be protective of Oregon's threatened and endangered salmonids. Laboratory reporting limits for carbaryl fall below the recommended criteria. Measurements of carbaryl in surface waters indicate that the vast majority of ambient concentrations in Oregon are below the recommended freshwater criteria (See Appendix A.2.4). While saltwater and discharge data were more limited that surface water data, these measurements also fell below the recommended criteria (See Appendix A.2.4).

DEQ is proposing to adopt EPA's 2012 recommended aquatic life criteria for carbaryl to add protection for fish and aquatic life in Oregon waters and to be up-to-date with the national recommendations.

2.2.5 Diazinon

2.2.5.1 Diazinon criteria

2.2.5.1.1 Effective diazinon criteria in Oregon

Oregon currently has no aquatic life or human health criteria for diazinon.

2.2.5.1.2 Latest EPA nationally recommended diazinon aquatic life criteria

The EPA finalized latest aquatic life criteria recommendations for diazinon in 2005 (EPA, 2005a). The last comprehensive literature search for data to inform the 2005 recommendation was performed in 1999, with limited additional data regarding effects on olfaction added in 2004. The recommendation includes both freshwater and saltwater acute and chronic criteria (Table 8). Diazinon is intended to be expressed as the total sample fraction.

Table 8. Current diazinon aquatic life criteria in Oregon and the latest EPA recommendations

Diazinon Criteria (CAS 333415)	Aquatic Life Criteria			
	Freshwater (µg/L)		Saltwater (µg/L)	
	Acute Criterion (CMC)	Chronic Criterion (CCC)	Acute Criterion (CMC)	Chronic Criterion (CCC)
Oregon Water Quality Standards	-	-	-	-
EPA Recommendation (2005)	0.17 [a]	0.17 [b]	0.82 [a]	0.82 [b]

"-" indicates no criterion.

[a] The one-hour average concentration is not to exceed the CMC more than once every three years on average.

[b] The four-day average concentration is not to exceed the CCC more than once every three years on average.

2.2.5.2 Summary for diazinon and decision to adopt diazinon criteria

Diazinon is a restricted use pesticide that is currently used in Oregon. Oregon does not currently have water quality criteria for this insecticide. The EPA's 2005 aquatic life criteria recommendations for diazinon include fresh and saltwater acute and chronic criteria. Diazinon criteria recommendations are expressed as the total sample fraction, and available data suggest they will protect Oregon's freshwater threatened and endangered salmonids. Laboratory reporting limits for diazinon fall below the recommended criteria for ambient waters. Measurements of diazinon in surface waters indicate that the vast majority of ambient concentrations in Oregon are below the recommended freshwater criteria (See Appendix A.2.5). While saltwater and discharge data were more limited than surface water data, these measurements in Oregon saltwater fell below the recommended criteria (See Appendix A.2.5). For discharges, laboratory reporting limits were often higher than the criteria, leaving it unclear whether discharges typically fall above or below the criteria (See Appendix A.2.5), although diazinon is not expected to be present in discharges at high levels.

DEQ is proposing to adopt EPA's 2005 recommended aquatic life criteria for diazinon to add protection for fish and aquatic life in Oregon waters and to be up-to-date with EPA recommendations.

2.2.6 Tributyltin

2.2.6.1 Tributyltin criteria

2.2.6.1.1 Effective tributyltin criteria in Oregon

Oregon's current aquatic life criteria for tributyltin (Table 9) are based on the draft recommendations that EPA compiled in 1997 (EPA, 1997). EPA recommended those criteria to states and tribes in 1999, acknowledging that these criteria recommendations were released before EPA considered public comment on the draft recommendations (EPA, 1999). Oregon adopted the draft 1999 aquatic life criteria recommendations in 2004 during the last comprehensive update of aquatic life toxics criteria in Oregon.

Oregon does not have human health criteria for tributyltin.

2.2.6.1.2 Latest EPA nationally recommended tributyltin aquatic life criteria

The 2003 recommended aquatic life criteria for tributyltin include data from a comprehensive literature search through 1997, with some additional data added after that as a response to public comment (EPA, 2003). Tributyltin is intended to be applied as the "total" sample fraction in the water column.

Table 9. Current water quality criteria in Oregon and the latest EPA recommendations for tributyltin

Tributyltin Criteria	Aquatic Life Criteria			
	Freshwater (µg/L)		Saltwater (µg/L)	
	Acute Criterion (CMC)	Chronic Criterion (CCC)	Acute Criterion (CMC)	Chronic Criterion (CCC)
Oregon Water Quality Standards	0.46 [a]	0.063 [b]	0.37 [a]	0.01 [b]
EPA Recommendation (2003)	0.46 [a]	0.072 [b]	0.42 [a]	0.0074 [b]

[a] The one-hour average concentration is not to exceed the CMC more than once every three years on average.
[b] The four-day average concentration is not to exceed the CCC more than once every three years on average.

2.2.6.2 Summary for tributyltin and decision to update tributyltin criteria

Tributyltin is a biocide that has historically been used in antifouling paints on hulls of ships. Severe toxic effects in aquatic life, which included endocrine disruption leading to reproductive effects, created international concern and eventually led tributyltin use restrictions by state and federal governments. Oregon's current aquatic life criteria for tributyltin are based on EPA's 1999 recommendations and vary only slightly from the 2003 finalized EPA recommendations. Tributyltin criteria are intended to be implemented as the total amount of tributyltin in the water column. Surface water data for tributyltin were not available in Oregon's water quality database. A limited number of discharge data had reporting limits above the proposed freshwater criteria, making it unclear whether those measurements were above or below the criteria. A limited number of historical tributyltin measurements have been reported in Coos Bay below the recommended saltwater acute criterion and roughly equal-to-double the recommended saltwater criterion. It is not clear how those historical measurements compare to values in Oregon marinas and estuaries today, after legislation significantly limited tributyltin use in the aquatic environment (See Appendix A.2.6). Given that the current tributyltin aquatic life criteria in Oregon are so similar to the proposed criteria, adopting these criteria may not be likely to have a large impact on dischargers or other water quality programs.

DEQ is proposing to adopt EPA's 2003 recommended aquatic life criteria for tributyltin to be up-to-date with EPA recommendations. Adopting these criteria will result in small changes to Oregon's criteria as shown in Table 9.

2.3 Chemicals that will not be updated at this time

2.3.1 Mercury

2.3.1.1 Background for mercury criteria

During the comprehensive update of aquatic life toxics criteria in 2004, DEQ elected not to update the state's mercury criteria based on the EPA's 1995 recommendations (ODEQ, 2004). DEQ's decision was based on the Services' Biological Opinion of EPA's California Toxics Rule that cited concerns over the 1995 mercury criteria recommendations for threatened and endangered west coast salmonids (USFWS & NMFS, 2000). When EPA promulgated the California Toxics Rule in 2000, EPA elected to 'reserve' mercury criteria at that time, effectively withdrawing the criteria until concerns could be resolved (EPA, 2001b). Given that Oregon has threatened and endangered salmonids, DEQ elected to wait until concerns over the 1995 mercury criteria recommendations were resolved before revising Oregon's mercury criteria.

2.3.1.2 Effective and recommended mercury aquatic life criteria

The 1995 nationally recommended aquatic life criteria remain EPA's latest update for mercury criteria (EPA, 1996). The values for the 1995 fresh and saltwater chronic criteria are less stringent than Oregon's current criteria, which are based on the EPA's 1984 recommendations (Table 10).

Table 10. Current mercury aquatic life criteria in Oregon and the latest EPA recommendations

Mercury Criteria (CAS)	Aquatic Life Criteria			
	Freshwater (µg/L)		Saltwater (µg/L)	
	Acute Criterion (CMC)	Chronic Criterion (CCC)	Acute Criterion (CMC)	Chronic Criterion (CCC)
Oregon Water Quality Standards (CAS 7439976)	2.4 [a, c]	0.012 [b,c]	2.1 [a, c]	0.025 [b, c]

EPA Recommendation (1995, CAS No. 7439976, 22967926)	1.4 [a, d]	0.77 [b, d]	1.8 [a, d]	0.94 [b, d]

[a] The one-hour average concentration is not to exceed the CMC more than once every three years on average.
[b] The four-day average concentration is not to exceed the CCC more than once every three years on average.
[c] Criterion expressed in terms of "total" concentrations in the water column.
[d] Criterion expressed in terms of "dissolved" concentrations in the water column.

2.3.1.3 Decision not to update mercury aquatic life criteria at this time

Mercury aquatic life criteria are currently being litigated in the Pacific Northwest (See Appendix A.2.7 for more detail). Therefore, DEQ is proposing not to update mercury aquatic life criteria at this time and wait until ESA concerns have been resolved. EPA is expected to update the criteria within the next two years, although subsequent ESA consultation may take additional time. Once the Services and EPA agree on protective aquatic life criteria for mercury, DEQ will consider updating Oregon's criteria.

2.3.2 Nonylphenol

2.3.2.1 Nonylphenol criteria

2.3.2.1.1 Effective nonylphenol criteria in Oregon

Oregon currently has no aquatic life or human health criteria for nonylphenol.

2.3.2.1.2 Latest EPA nationally recommended nonylphenol aquatic life criteria

EPA finalized the aquatic life criteria recommendations for nonylphenol in 2005 (EPA, 2005b). The last comprehensive literature search for scientific data occurred in 1999, with a limited number of additional studies added after that time. The recommendation includes both freshwater and saltwater criteria (Table 11) to be applied as the total sample fraction of nonylphenol in the water column. Nonylphenol is present in several different forms in the environment. However, the recommended aquatic life criteria specifically apply to nonylphenol with the Chemical Abstracts Service (CAS) numbers 84852-15-3 (branched 4-nonylphenol) and 25154-52-3 (nonylphenol).(EPA, 2005b).

Table 11. Current nonylphenol aquatic life criteria in Oregon and the latest EPA recommendations

Nonylphenol Criteria (CAS 84852153, 25154523)	Aquatic Life Criteria			
	Freshwater (µg/L)		Saltwater (µg/L)	
	Acute Criterion (CMC)	Chronic Criterion (CCC)	Acute Criterion (CMC)	Chronic Criterion (CCC)

Oregon Water Quality Standards	-	-	-	-
EPA Recommendation (2005)	28 [a]	6.6 [b]	7.0 [a]	1.7 [b]

"-" indicates no criterion.
[a] The one-hour average concentration is not to exceed the CMC more than once every three years on average.
[b] The four-day average concentration is not to exceed the CCC more than once every three years on average.

2.3.2.2 Summary for nonylphenol and decision not to adopt nonylphenol criteria at this time

Nonylphenol is a man-made industrial chemical that is used for a variety of purposes. Oregon currently has no water quality criteria for nonylphenol. The 2005 EPA recommended aquatic life criteria for nonylphenol include fresh and saltwater acute and chronic criteria. These criteria recommendations apply to only two of the many nonylphenol isomers in industrial use. The nonylphenol criteria are intended to be applied as the total sample fraction. Nonylphenol data are not available for Oregon ambient waters or discharges, presenting a large data gap in assessing how environmental levels of this contaminant compare against the proposed aquatic life criteria. However, supplemental data from other states indicate that the majority of nonylphenol measurements in surface waters fell below the recommended acute and chronic criteria for nonylphenol (See Appendix A.2.8).

DEQ is not proposing to adopt the 2005 nonylphenol criteria at this time because EPA has expressed concern about whether they are sufficiently protective of threatened and endangered species in their recent analysis of water quality standards for the Swinomish Tribe in Washington (See Appendix A.2.8) DEQ therefore proposes to wait until ESA concerns have been resolved before adopting aquatic life criteria for nonylphenol into state standards.

2.3.3 Selenium

2.3.3.1 Selenium criteria

2.3.3.1.1 Effective selenium criteria in Oregon

Oregon's current aquatic life criteria for selenium are based on EPA's 1999 selenium update (EPA, 1999). The acute freshwater criteria are expressed as the dissolved sample fraction, are formula-based, and incorporate two different forms of selenium: selenite and selenate. The saltwater acute and chronic selenium criteria are discrete values, which are expressed as the dissolved sample fraction, regardless of the selenium form (Table 12). Oregon also has human health criteria for selenium for water + organism (120 µg/L) and organism only (420 µg/L), applied as total recoverable selenium.

2.3.3.1.2 Latest EPA nationally recommended selenium aquatic life criteria

EPA most recently updated the aquatic life criteria recommendations for freshwater selenium in 2016, with non-substantial revisions to the criteria in 2021 (EPA, 2021a). The freshwater chronic criterion recommendation incorporates new understanding of the reproductive effects of bioaccumulative selenium on aquatic vertebrates. Given that long term reproductive toxicity was the most sensitive measure of selenium effects in the environment, the 2016 EPA freshwater recommendations do not include an acute criterion.

EPA's freshwater chronic criterion recommendation for selenium is composed of four elements, to be used together as a single criterion. If all four parts are applied together, they are designed to protect fish, amphibians, and invertebrates from the chronic effects of selenium. The first element provides a limit of 15.1 mg/kg dry weight (dw) in fish egg/ovary not to be exceeded as the preferred criterion element from which all subsequent elements of the criterion at least partially derive. If no fish egg/ovary data are available, then the criterion can be expressed in terms of fish muscle (11.3 mg/kg dw skinless, boneless filet not to be exceeded) or body tissue (8.5 mg/kg dw whole body tissue, not to be exceeded). The third and fourth elements of the chronic criterion are water column values, to be utilized in the absence of fish tissue data, or for instances of 1) fishless waters, or 2) new selenium discharges for which selenium has not yet reached steady state in the ecosystem. Steady state may take from months to years depending on physical conditions. The chronic water column criterion can be expressed as a water column value (1.5 µg/L in lentic (standing) aquatic systems or 3.1 µg/L in lotic (flowing) aquatic systems) not to be exceeded more than once in a 30-day period in three years on average. Finally, the freshwater chronic criterion contains a provision for intermittent exposure based on a 30-day water (lentic or lotic) criterion expressed as an equation (Table 12). Footnote *e* in Table 12 includes additional provisions specific to the four-part criterion that further describe the nuances of when to use each element. Unlike previous versions of the freshwater selenium criteria, the 2016 recommendation no longer distinguishes among selenium oxidation states. Further, the recommended chronic criterion is also protective of potential acute selenium effects, thus removing the need for an acute selenium criterion. The fish tissue portion of the recommended chronic criterion is applied as "total" selenium, while the water column values are applied at "dissolved" selenium in the water column.

Table 12. Current selenium aquatic life criteria in Oregon and the latest EPA recommendations

Selenium Criteria (CAS 7782492)	Aquatic Life Criteria			
	Freshwater (µg/L)		Saltwater (µg/L)	
	Acute Criterion	Chronic Criterion	Acute Criterion	Chronic Criterion

	(CMC)	(CCC)	(CMC)	(CCC)
Oregon Water Quality Standards	see *a, b, c*	4.6 [b,d]	290 [b,c]	71 [b,d]
EPA Recommendations (2016)	-	*e*	290 [b,c]	71 [b,d]

"-" indicates no criterion.

[a] The CMC=(1/[(f1/CMC1)+(f2/CMC2)]µg/L) * CF where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC1 and CMC2 are 185.9 µg/L and 12.82 µg/L, respectively. See expanded endnote F for the Conversion Factor (CF) for selenium. [Note: According to endnote F of Table 30, Oregon Administrative Rules 340, Division 41 (ODEQ n.d.), the conversion factors (CFs) for selenium are as follows:

Conversion Factors for Selenium			
Freshwater		Saltwater	
Acute	Chronic	Acute	Chronic
0.996	0.922	0.998	0.998

[b] Criterion expressed in terms of "dissolved" concentrations in the water column.

[c] The one-hour average concentration is not to exceed the CMC more than once every three years on average.

[d] The four-day average concentration is not to exceed the CCC more than once every three years on average.

[e] The recommended chronic criterion is as follows:

Media Type	Fish Tissue[1]		Water Column [4]	
Criterion Element	Egg/Ovary [2]	Fish Whole Body or Muscle [3]	Monthly Average Exposure	Intermittent Exposure
Magnitude	15.1 mg/kg dw	8.5 mg/kg dw whole body <u>or</u> 11.3 mg/kg dw muscle (skinless, boneless filet)	1.5 µg/L in lentic aquatic systems 3.1 µg/L in lotic aquatic systems	$WQC_{int} = \frac{WQC_{30\text{-}day} - C_{bkgrnd}(1-f_{int})}{f_{int}}$
Duration	Instantaneous measurement [6]	Instantaneous measurement [6]	30 days	Number of days/months with an elevated concentration
Frequency	Not to be exceeded	Not to be exceeded	Not more than once in three years on average	Not more than once in three years on average

1. Fish tissue elements are expressed as steady-state.
2. Egg/Ovary supersedes any whole-body, muscle, or water column element when fish egg/ovary concentrations are measured, except as noted in footnote 4 below.
3. Fish whole-body or muscle tissue supersedes water column element when both fish tissue and water concentrations are measured, except as noted in footnote 4 below.
4. Water column values are based on dissolved total selenium in water and are derived from fish tissue values via bioaccumulation modeling. When selenium inputs are increasing, water column values are the applicable criterion element in the absence of steady-state condition fish tissue data.

5. Where WQC30-day is the water column monthly element, for either a lentic or lotic waters; C_{bkgrnd} is the average background selenium concentration, and f_{int} is the fraction of any 30-day period during which elevated selenium concentrations occur, with f_{int} assigned a value ≥0.033 (corresponding to 1 day).
6. Fish tissue data provide instantaneous point measurements that reflect integrative accumulation of selenium over time and space in fish population(s) at a given site.

2.3.3.2 Summary for selenium and decision not to update selenium criteria at this time

Selenium is naturally occurring but may move into the aquatic environment through natural and human-driven processes. Oregon's current aquatic life criteria for selenium are based on EPA's 1999 recommendation (EPA, 1999). EPA's 2016 recommended aquatic life chronic criterion for selenium (EPA, 2021a) is based on bioaccumulative reproductive toxicity in fish and is expected to protect Oregon's threatened and endangered salmonids. It is intended to be applied in four-parts, including tissue values (egg/ovary or whole body/muscle) and water column values (lentic/lotic). Tissue concentrations are applied as total selenium, while water column values are applied as dissolved selenium. Tissue criterion values take primacy over water column values in steady-state conditions, and all available tissue data in Oregon, including data from more susceptible lentic environments, fall below the tissue whole body or muscle tissue criterion values (See Appendix A.2.9). However, surface water measurements may present a challenge given that laboratory reporting limits for water measurements are often higher than the lentic water column value. Available data indicate that in the absence of fish tissue data, water column measurements in lentic environments may be higher than the criterion. In contrast, lotic environments in Oregon appear to be more thoroughly sampled with few values higher than the water column value. Oregon discharges were rarely higher than the lotic water column criterion value, which is the more appropriate comparison given that discharges are not typically permitted into lentic areas.

DEQ is not proposing to adopt EPA's 2016 selenium criterion at this time because of the crucial need for implementation guidance to make it feasible for Oregon to apply the complex four-part criterion effectively and efficiently in state water quality programs. Further, Oregon does not have high concentrations of selenium in state waters compared with other regions of the U.S, and Oregon currently has water-column criteria for selenium to protect fish and aquatic life that is only slightly higher (5.0 µg/L) compared with the 2016 recommendation (3.1 µg/L or 1.5 µg/L). DEQ may propose to adopt the 2016 selenium criterion in the future if DEQ can work with EPA to develop selenium criterion implementation guidance before adopting the criteria.

2.3.4 Endosulfan, Lindane, and Silver

2.3.4.1 Effective and recommended endosulfan, lindane, and silver aquatic life criteria

Oregon state standards include fresh and saltwater acute and chronic criteria for endosulfan, freshwater chronic criteria for lindane, and freshwater chronic criteria for silver despite EPA withdrawals of those values. All of Oregon's remaining criteria for lindane and silver are up to date with the most recent EPA recommendations (freshwater acute lindane (EPA, 1996), saltwater acute lindane (EPA, 1980a), and fresh and saltwater acute silver (EPA, 1980b)) (Table 13).

Table 13. Current water quality criteria in Oregon and the latest EPA recommendations for endosulfan, lindane, and silver

Criteria (CAS Number)	Aquatic Life Criteria			
	Freshwater (µg/L)		Saltwater (µg/L)	
	Acute Criterion (CMC)	Chronic Criterion (CCC)	Acute Criterion (CMC)	Chronic Criterion (CCC)
Oregon Water Quality Standards – Endosulfan (CAS 115297)	0.22 [a, b ,e]	0.056 [a, b ,e]	0.034 [a, b ,e]	0.0087 [a, b ,e]
EPA Recommended – Endosulfan (CAS 115297)	-	-	-	-
Oregon Water Quality Standards - BHC Gamma (Lindane) (CAS 58899)	0.95 [c, e]	0.08 [a ,e]	0.16 [a ,e]	-
EPA Recommended - BHC Gamma (Lindane) (CAS 58899)	0.95 [c, e]	-	0.16 [a ,e]	-
Oregon Water Quality standards - Silver	3.2 [c, f , g]	0.10 [d, f]	1.9 [c, f]	-
EPA Recommended - Silver	3.2 [f, g h]	-	1.9 [f, h]	-

"-" indicates no criterion.

[a] Alternate Frequency and Duration for Certain Pesticides: This criterion is based on EPA recommendations issued in 1980 that were derived using guidelines that differed from EPA's 1985 Guidelines which update minimum data requirements and derivation procedures. The CMC may not be exceeded at any time and the CCC may not be exceeded based on a 24-hour average. The CMC may be applied using a one hour averaging period not to be exceeded more than once every three years, if the CMC values given are divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.

[b] This value is based on the criterion published in Ambient Water Quality Criteria for Endosulfan (EPA 440/5-80-046) and should be applied as the sum of alpha- and beta-endosulfan.
[c] The one-hour average concentration is not to exceed the CMC more than once every three years on average.
[d] The four-day average concentration is not to exceed the CCC more than once every three years on average.
[e] Criterion expressed in terms of "total" concentrations in the water column.
[f] Criterion expressed in terms of "dissolved" concentrations in the water column.
[g] The freshwater acute silver criterion is hardness-dependent and the numeric value listed is calculated for a total hardness of 100 mg/L. The freshwater acute criterion is expressed as an equation where CMC = $e^{(1.72 \times \ln(\text{hardness}) - 6.59)}$ x CF, and CF = 0.85.
[h] Alternate Frequency and Duration: This criterion is based on EPA recommendations issued in 1980 that were derived using guidelines that differed from EPA's 1985 Guidelines which update minimum data requirements and derivation procedures. The CMC may not be exceeded at any time and the CCC may not be exceeded based on a 24-hour average. The CMC may be applied using a one hour averaging period not to be exceeded more than once every three years, if the CMC values given are divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.

2.3.4.2 Decision not to update endosulfan, lindane, and silver criteria at this time

EPA has not made any new recommendations for the pesticides endosulfan or lindane or silver (a metal) aquatic life criteria since the DEQ last considered the criteria for these chemicals (See Appendix A.2.10 for more detail). At this time, DEQ is proposing to maintain the criteria for these chemicals in Oregon rule, in keeping with the recommendation made by technical and policy advisory committees in 2004. In 2004, DEQ concluded that these criteria were based on sound science and that maintaining Oregon's criteria for these chemicals was the best way to protect beneficial uses.

Chapter 3: Summary of proposed changes to Oregon's aquatic life criteria

This chapter contains a summary of the proposed changes to Oregon's aquatic life criteria for reference. To review the full draft rule language associated with this rulemaking, refer to the *Notice of Proposed Rulemaking*, which may be found on the Aquatic Life Toxics Criteria 2024 Rulemaking web page.

Table 14. Summary of proposed changes to aquatic life criteria in Oregon water quality standards compared to current criteria.

Chemical (CAS Number)	Aquatic Life Criteria							
	Freshwater (µg/L)				Saltwater (µg/L)			
	Current Acute Criterion (CMC)	Proposed Acute Criterion (CMC)	Current Chronic Criterion (CCC)	Proposed Chronic Criterion (CCC)	Current Acute Criterion (CMC)	Proposed Acute Criterion (CMC)	Current Chronic Criterion (CCC)	Proposed Chronic Criterion (CCC)
Acrolein (CAS 107028)	-	3.0 [a, b]	-	3.0 [b, c]	-	-	-	-
Aluminum (CAS 7429905)	- [d]	See Table B	- [d]	See Table B	-	-	-	-
Cadmium (CAS 7440439)	See Table C [d]	See Table D	See Table C	See Table D	40 [a, e]	33 [a, e,]	8.8 [c, e]	7.9 [c, e,]
Carbaryl (CAS 63252)	-	2.1 [a, b]	-	2.1 [b, c]	-	1.6 [a, b]	-	-
Diazinon (CAS 333415)	-	0.17 [a, b]	-	0.17 [b, c]	-	0.82 [a, b]	-	0.82 [b, c]
Tributyltin	0.46 [a, b]	0.46 [a, b]	0.063 [b, c]	0.072 [b, c]	0.37 [a, b]	0.42 [a, b]	0.01 [b, c]	0.0074 [b, c]

"-" indicates no criterion.
[a] The one-hour average concentration is not to exceed the CMC more than once every three years on average.
[b] Criterion expressed in terms of "total" concentrations in the water column.
[c] The four-day average concentration is not to exceed the CCC more than once every three years on average.
[d] Note that there is a federally promulgated criterion that is effective for Clean Water Act purposes but not reflected in OR standards. See Table A for aluminum and Table C for cadmium.
[e] Criterion expressed in terms of "dissolved" concentrations in the water column.

Table A. Federally promulgated aluminum criteria language effective for Clean Water Act purposes in Oregon See 40 CFR 131.47 for additional language and details.

Metal	CAS No.	Criterion maximum concentration (CMC)[3] (µg/L)	Criterion continuous concentration (CCC)[4] (µg/L)
Aluminum [1 2]	7429905	Acute (CMC) and chronic (CCC) freshwater aluminum criteria values for a site shall be calculated using the 2018 Aluminum Criteria Calculator (Aluminum Criteria Calculator V.2.0.xlsx), or a calculator in R or other software package using the same 1985 Guidelines calculation approach and underlying model equations as in the Aluminum Criteria Calculator V.2.0.xlsx, as defined in EPA's Final Aquatic Life Ambient Water Quality Criteria for Aluminum.[5]	
[1] To apply the aluminum criteria for Clean Water Act purposes, criteria values based on ambient water chemistry conditions must protect the water body over the full range of water chemistry conditions, including during conditions when aluminum is most toxic.			

[2] These criteria are based on aluminum toxicity studies where aluminum was analyzed using total recoverable analytical methods. Oregon may utilize total recoverable analytical methods to implement the criteria. For characterizing ambient waters, Oregon may also utilize, as scientifically appropriate and as allowable by State and Federal regulations, analytical methods that measure the bioavailable fraction of aluminum (e.g., utilizing a less aggressive initial acid digestion, such as to a pH of approximately 4 or lower, that includes the measurement of amorphous aluminum hydroxide yet minimizes the measurement of mineralized forms of aluminum such as aluminum silicates associated with suspended sediment particles or clays). Oregon shall use measurements of total recoverable aluminum where required by Federal regulations.
[3] The CMC is the highest allowable one-hour average ambient concentration of aluminum. The CMC is not to be exceeded more than once every three years. The CMC is rounded to two significant figures.
[4] The CCC is the highest allowable four-day average ambient concentration of aluminum. The CCC is not to be exceeded more than once every three years. The CCC is rounded to two significant figures.
[5] EPA–822–R–18–001, Final Aquatic Life Ambient Water Quality Criteria for Aluminum—2018, December 2018, is incorporated by reference into this section with the approval of the Director of the Federal Register under 5 U.S.C. 552(a) and 1 CFR part 51. All approved material is available from U.S. Environmental Protection Agency, Office of Water, Health and Ecological Criteria Division (4304T), 1200 Pennsylvania Avenue, NW, Washington, DC 20460; telephone number: (202) 566–1143, www.epa.gov/wqc/aquatic-life-criteria-aluminum. It is also available for inspection at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, email fedreg.legal@nara.gov or go to www.archives.gov/federal-register/cfr/ibr-locations.html.

Table B. Proposed aluminum aquatic life criteria language for Oregon.

Pollutant	CAS No.	Criterion maximum concentration (CMC) (µg/L)	Criterion continuous concentration (CCC) (µg/L)
Aluminum	7429905	See O, P	See O, P

[O] The freshwater criterion for aluminum is a function of the pH, dissolved organic carbon, and total hardness in the water column. Acute (CMC) and chronic (CCC) freshwater aluminum criteria values for a site shall be calculated using the 2018 Aluminum Criteria Calculator (Aluminum Criteria Calculator V.2.0.xlsx), or a calculator in R or other software package using the same 1985 Guidelines calculation approach and underlying model equations as in the Aluminum Criteria Calculator V.2.0.xlsx, as defined in EPA's Final Aquatic Life Ambient Water Quality Criteria for Aluminum (EPA 822-R-18-001) and referenced at the bottom of Table 30. See also endnote O for procedures and information.

[P] Oregon will use analytical methods that measure the bioavailable fraction of aluminum unless total recoverable aluminum measurements are required by Federal regulations.

Endnote O: Deriving freshwater aluminum criteria

The freshwater aluminum criteria are derived using the Aluminum Criteria Calculator (v 2.0, EPA 2018; EPA 822-R-18-001) based on a concurrently measured set of calculator input parameter values. The Aluminum Criteria Calculator (ACC) uses dissolved organic carbon (DOC), pH, and total hardness to derive 1-hour acute exposure (CMC) and 96-hour chronic exposure (CCC) criteria values for aluminum based on the site and time specific water chemistry that determines the toxicity of aluminum to aquatic life. If measured data for one or more of the ACC input parameters is not available, the procedures in section (1), (2), or (3) of this endnote will be used as specified to substitute an estimated or a default value for the missing input parameter or to apply default criteria derived using ecoregional data.

ACC outputs based on sufficient concurrent measured input parameter data are more accurate, preferred, and supersede results based on estimates or default values or applied default ecoregional criteria values. The acceptable ACC software is version 2.0, referenced in "Final Aquatic Life Ambient Water Quality Criteria for Aluminum": EPA 822-R-18-001, December 2018. The criteria are expressed as total recoverable in micrograms per liter (to two significant figures). However, the criteria may also be applied using the bioavailable fraction of aluminum if federal regulations allow.

(1) Input Parameter Estimation Procedures to Derive ACC Outputs

If the measured value for the input parameters needed to derive an ACC output are not available, DEQ will substitute a calculated or estimated input value according to the procedures described in this section [Endnote O (1)].

(a) DOC
DEQ will use total organic carbon (TOC) measurements to estimate DOC measurements that are not available. Total organic carbon (TOC) measurements will be multiplied by 0.83 to convert the TOC value to an equivalent dissolved organic carbon (DOC) value; except where sufficient TOC and DOC data are available for a site, DEQ will calculate and apply a site-specific translator in place of 0.83 to convert TOC values to DOC for use in the Aluminum Criteria Calculator. If neither DOC nor TOC measurements are available, substitute a default DOC value as described in Endnote O (2).

(b) Total Hardness
If total hardness is not available, DEQ will estimate total hardness by substituting dissolved hardness as an input parameter for the Aluminum Criteria Calculator. If neither total nor dissolved hardness data are available, DEQ will use the equation in Table O-1 to estimate total hardness using specific conductance. Specific conductance measurements must be concurrent with the other input parameters for the Aluminum Criteria Calculator. If total hardness cannot be estimated from concurrent data, DEQ will apply the applicable ecoregional default aluminum criterion described in Endnote O (3).

Table O-1 Equation to estimate total hardness from specific conductance	
Parameter	**Regression Equation**

Total Hardness	Total Hardness = $\exp^{(1.050 \cdot [\ln(SpC)] - 1.211)}$

Where, "SpC" is a measurement of specific conductance in µmhos/cm, "ln" is the natural logarithm, and "exp" is a mathematical constant that is the base of the natural logarithm.

(2) Applying a Default Value for DOC to Derive ACC Outputs

If concurrently measured DOC is not available to derive an ACC output and DOC cannot be estimated as specified in Endnote O (1)(a) above, DEQ will use a conservative default DOC input value as described in this section [Endnote O (2)] to derive an ACC output. The default DOC input value will be used for Clean Water Act purposes until measured or estimated DOC input data are available to derive aluminum criteria based on site-specific water chemistry.

(a) The default input parameter values for DOC will be the percentile value from the distribution of the high-quality data available for surface waters in the region as shown in Table O-2.

Table O-2
Percentile of data distribution to be used as default value by region

Region	DOC percentile
Willamette	15th
Coastal	30th
Cascades	20th
Eastern	15th
Columbia River	10th

b) The regional default DOC values will be updated periodically as additional high-quality data become available and are added to DEQ's database.
(c) The resulting regional default input values for DOC are shown on DEQ's website.
(d) The regions listed in Table O-2 are the same as those listed in Endnote N(2)(d).

(3) Applying Aluminum Default Ecoregional Criteria

If data for pH is missing or hardness is missing and cannot be estimated as described in Endnote O (1)(b), DEQ will apply an ecoregional default aluminum criteria value.

(a) The default ecoregional acute (CMC) and chronic (CCC) criteria values will be the 10th percentile value from the distribution of all ACC outputs calculated from concurrently measured high quality input data available for Oregon surface waters by EPA Level III ecoregion with the Columbia River mainstem treated separately.
(b) The ecoregional default aluminum criteria values will be updated periodically as additional high quality data become available and are added to DEQ's database.
(c) The resulting ecoregional default aluminum criteria values are shown on DEQ's website.

(4) General Policies

(a) The ACC produces outputs that vary at a site over time reflecting the effect of local water chemistry on aluminum toxicity to aquatic organisms. To apply the aluminum criteria for Clean Water Act purposes, criteria values based on ambient water chemistry conditions must protect the water body over the full range of water chemistry conditions, including during conditions when aluminum is most toxic.
(b) When applying the aluminum criteria, DEQ will use approaches that give preference to the use of ACC outputs based on concurrently measured or estimated (as described in Endnote O(1)) input parameter data (in the order listed) and concurrently measured aluminum data.

Table C. Aquatic life criterion for cadmium in Oregon. See 40 CFR 131.46 for additional language and details.

Metal	CAS No.	Criterion maximum concentration (CMC)[3]
Cadmium [1 2]	7440439	$[e^{(0.9789 \times \ln(\text{hardness}) - 3.866)}] \times CF$ Where $CF = 1.136672 - [(\ln \text{hardness}) \times (0.041838)]$.

[1] The criterion for cadmium is expressed as the dissolved metal concentration.
[2] CF is the conversion factor used to convert between the total recoverable and dissolved forms of cadmium. The term (ln hardness) in the CMC and the CF equation is the natural logarithm of the ambient hardness in mg/L (CaCO3). The default hardness concentrations from the applicable ecoregion in Table 2 of paragraph (c) of this section shall be used to calculate cadmium criteria in the absence of sufficiently representative ambient hardness data.
[3] The CMC is the highest allowable one-hour average instream concentration of cadmium. The CMC is not to be exceeded more than once every three years. The CMC is rounded to two significant figures.

Table D. Cadmium aquatic life criteria, Oregon's current and proposed, which are hardness-based equations.

Cadmium Criteria	Freshwater Aquatic Life Criteria (µg/L)	
	Acute Criterion Magnitudes (CMC)	Chronic Criterion Magnitudes (CCC)

Oregon Rule	$e^{(1.128[\ln(\text{hardness})]-3.828)}$ [a]	$e^{(0.7409[\ln(\text{hardness})]-4.719)}$ x CF [b, c]
Proposed	$e^{(0.9789 \times \ln(\text{hardness}) - 3.866)}$ x CF [b, d, e]	$e^{(0.7409[\ln(\text{hardness})]-4.719)}$ x CF [b, c]

"e" is the exponential constant is a mathematical constant and is approximately equal to 2.718.

[a] Criterion expressed in terms of "total" concentrations in the water column.

[b] Criterion expressed in terms of "dissolved" concentrations in the water column.

[c] CCC CF (conversion factor from total to dissolved) = 1.101672-[(ln hardness) x (0.041838)].

[d] CMC CF (conversion factor from total to dissolved) = 1.136672 – [(ln hardness) x (0.041838)].

[e] The proposed freshwater acute criterion is already the applicable criterion in OR because EPA promulgated that criterion (See 40 CFR 131.46). However, this criterion is not currently in Oregon's standards rule.

Chapter 4: References

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Appendix: Chemical-specific analyses and information

A.1 Introduction

A.1.1 Scope of background and technical information review

In the following sections, each chemical reviewed for new or revised aquatic life criteria adoption is considered in depth. For each chemical, provided information generally includes chemical sources and uses, mode of toxic action, environmental fate, Oregon's current criteria, a summary of the scientific basis for the proposed EPA recommended criteria, and chemical measurement data in Oregon ambient waters and/or discharges. A summary of this information for each chemical may be found in Chapter 2. For chemicals that have different aquatic life criteria in Oregon compared to current EPA recommended criteria but are not under consideration for an update at this time, less detailed information is presented.

A.1.2 Details of chemical measurement data in Oregon waters and data assumptions

Data are presented to show the distribution of chemical measurements in Oregon waters and in wastewater effluent. DEQ preferentially used Oregon's Ambient Water Quality Monitoring System (AWQMS) database to obtain chemical measurement data in Oregon. This system includes access to DEQ and partner data for rivers and streams, lakes, estuaries, beaches and groundwater resources throughout Oregon. In addition, AWQMS provides a direct exchange to the Water Quality Exchange network which will integrate DEQ water quality data with other publicly available data sources, including USEPA and USGS. If data for a specific chemical were not available in AWQMS, an alternative data source (published literature, EPA database, etc.) was used and noted in-text.

In some cases, the amount of a chemical measured was so low that it could not be reliably reported. These measurements are generally referred to as 'censored data'. In this issue paper, censored data are split into two categories: 1) "not detected" and 2) "detected, not quantified". In samples where a given chemical was "not detected", the chemical was either not present in the sample or it was present at a level below the ability of the laboratory to detect it. In samples where a given chemical was "detected, not quantified," the chemical was detected, but at a level that was lower than the ability of the laboratory to accurately report how much of it was in the sample. Because of the increased uncertainty associated with censored data, those data were reported but not numerically included in an analysis of the distributions of measured (quantified) data in Oregon waters.

In cases where it was appropriate, the recommended criteria were overlayed onto the distribution of measured data to allow for a general comparison of concentrations in Oregon waters, discharges, or fish tissue concentrations and the proposed criteria. For this general comparison, DEQ compared saltwater criteria to chemical concentrations in estuaries and the ocean. DEQ compared freshwater criteria to all other ambient surface waters, fish tissue, and discharges. Although discharges are present in saltwater, they are more commonly found in freshwater. However, it is important to note that water quality programs have specific methods for determining whether a water body is impaired or whether a permit limit is needed. Thus, these comparisons with criteria are presented for general information only.

A.1.2.1 Data quality

Chemical data for Oregon waters were carefully screened before inclusion in analyses. Data was pulled from Oregon's Ambient Water Quality Monitoring System (AWQMS), which is maintained by DEQ. In general, methods for determining if data were of sufficient quality for inclusion were based on similar same criteria used for inclusion in assessment used in the Integrated Report.

Table A.1 Data Quality Requirements for Inclusion

AWQMS Parameter Name	Included Values
Result_status	"Accepted", "Final", "Validated"
DQL	"A", "B", NA
QualifierAbbr	"J", "A", "B", "OTHER", "FQC", NA
Statistical_Base	NA
SampleMedia	"Water", "Tissue"

A.1.2.2 Ambient water and discharge classifications

In order to compare relevant chemical data to the appropriate criteria, data were grouped according to monitoring location type. Surface waters were generally presumed to be freshwater unless they were explicitly a type that is associated with saltwater (ocean, estuary). Surface waters were also further classified as lentic (standing) or lotic (flowing) for the selenium analyses only, given that the proposed chronic criterion is different based on the those differences.

Table A.2 Classification of Water by Monitoring Location Type

AWQMS Monitoring Location Type	Selenium Classification	Overall Classification
Stream/River	Lotic	Surface Water
BEACH Program Site – River/Stream		
River/Stream Perennial		
CERCLA Superfund Site[1]		
Canal Irrigation		
Canal Transport		
Canal Drainage		
Facility Public Water Supply (PWS)[2]		
Reservoir	Lentic	
Wetland Undifferentiated		
Lake		
Facility Public Water Supply (PWS)[2]		
Storm Sewer	NA	Discharge
Facility Industrial		
Facility Other		
Facility Municipal Sewage (POTW)		
Pipe, Unspecified Source		
Estuary	NA	Saltwater
Ocean		
BEACH Program Site – Ocean		
Pond-Anchialine		

[1] This dataset only contained Portland Harbor Superfund sites, which are located on the Willamette River.

[2] These sites are all surface water intakes. Most represent flowing waters including rivers and creeks (inclusion in "Lotic" selenium classification), although one of these sites was a lake (inclusion in "Lentic" selenium classification)

A.1.2.3 Sample fraction designation

It is important to use the correct sample fraction while comparing chemical measurements to criteria values. For example, organic contaminants are typically applied as the "total" sample fraction. Criteria for many metals are often applied as "dissolved" sample fraction, because "dissolved" sample fractions which have been filtered, much more closely approximate the amount of metal that is biologically available to cause toxicity. For aluminum specifically, it is the "bioavailable" sample fraction that causes toxicity in ambient waters. Because AWQMS contains data from a variety of sources, there are many different sample fraction designations that needed to be translated into a single form that could be compared to criteria (total, dissolved, or bioavailable). DEQ translated these different designations based on the method used in the Water Quality Assessment Program to process data for the Integrated Report.

Table A.3 Classification of condensed sample fraction for analysis based on Sample Fraction terms in AWQMS

AWQMS Sample_Fraction	Condensed Sample Fraction for Analysis
Total	Total
Extractable	
Recoverable	
Total Recoverable	
Total Residual	
None	
Volatile	
Semivolatile	
NA	
Dissolved	Dissolved
Filtered, field	
Filtered, lab	
Diss	
Bioavailable	Bioavailable

A.1.2.4 Conversion of selenium from wet weight to dry weight basis in historical tissue data

AWQMS selenium fish tissue data are currently reported on a wet weight basis. However, the recommended selenium chronic criterion for fish tissue is expressed on a dry weight basis (EPA, 2021a). The EPA has drafted a technical support document for the selenium criterion that details methods for converting historical wet weight data to dry weight, so that selenium concentrations can be appropriately compared to the recommended criterion (EPA, 2021c). The equation for wet weight (WW) to dry weight (DW) conversion is:

$$DW = WW / [1 - (\text{percent moisture}/100)]$$ (EPA, 2011)

The EPA recommends using percent moisture data for a given species and tissue type to make the conversion to dry weight. When data for a species is unavailable, percent data for a similar species (i.e., same genus or same family) can be used. Although the draft technical support document provides percent moisture values from fish tissues in a variety of species, the available fish tissue data for Oregon included some species not reviewed in the technical support document or closely related to those that were included. As a way to estimate percent moisture for Oregon’s historical fish tissue data, DEQ used the maximum values for percent moisture in whole body tissue and muscle tissue listed in the 2021 draft selenium technical support document (EPA, 2021c) to create a dry weight fish tissue estimates. Using maximum percent moisture values produced dry weight selenium tissue measurements that were biased high (i.e. worst-case scenario) and could then be compared against the recommended criterion.

Table A.4 Percent moisture used to convert historical wet weight tissue measurements to dry weight measurements

Tissue	Percent Moisture (%)	Source fish measurement
Whole Body	74.8 [1]	*Lepomis macrochirus*, Bluegill
Muscle	81.22 [2]	*Ictalurus punctatus*, Channel Catfish

[1] Fish whole-body moisture value sourced from (EPA, 2014) referenced in the October 2021 Draft Technical Support Document (EPA, 2021c).

[2] Maximum fish muscle moisture value originally sourced from (Pinkney, 2003) referenced in the October 2021 Draft Technical Support Document (EPA, 2021c).

A.2 Chemical-specific information and analyses

A.2.1 Acrolein

A.2.1.1 Acrolein sources and uses

Acrolein has both artificial and natural sources. When produced industrially, acrolein is primarily used as a pesticide in irrigation canals to control the growth of aquatic weeds. It is a restricted use pesticide, which means that it is not available to the general public, and it can only be used by a professional applicator. It is also used to control algae, weeds, mollusks, and slime in closed industrial water systems. To be effective as a pesticide, acrolein must be added to waters at levels (e.g. 15 mg/L) that are high enough to kill fish, insects, crayfish, and amphibians. In Oregon, acrolein has been approved for uses in places like irrigation canals or impoundments (Washington State Pest Management Resource Service, 2020) in cases where the loss of aquatic life is considered acceptable. Aside from its use as a pesticide, acrolein is an intermediate product in the manufacture of acrylic acid, as well as a tool to fight microorganisms in fuel production (ASTDR, 2007; EPA, 2009).

Acrolein can also be released into the environment through natural and chemical processes. For example, acrolein is present as a by-product of the incomplete combustion of organic matter (e.g. fossil fuel combustion, burning wood, cooking, cigarette smoke) or chlorination and is also produced from the volatilization of oak tree essential oils (EPA, 2009).

A.2.1.2 Acrolein mode of action and environmental fate

Acrolein is highly reactive, binding to and destroying cellular components. In general, the most damage occurs in the organ system that is exposed first (WHO, 2002).

Acrolein can enter the aquatic environment by direct pesticide application, industrial discharge, or from water treatment processes that produce acrolein as a by-product of chlorination (EPA, 2009). Acrolein released as a combustion by-product typically results in air pollution. Acrolein has a strong affinity for water, meaning that it does not bind to or stay in the sediment in aquatic environments. It degrades by volatilization, microbial degradation, or absorption to plants. In freshwater, acrolein has a half-life (the time it takes for half of the quantity present in the environment to degrade) of roughly seven hours (Nordone et al., 1998), although environmental factors (temperature, presence and composition of a microbial community, the amount of acrolein present) can have an impact on acrolein degradation (EPA, 2009). Given its high reactivity and short half-life, acrolein is not bioaccumulative nor persistent.

A.2.1.3 Basis for the latest recommended acrolein criteria

The freshwater acute criterion for acrolein of 3.0 µg/L measured as a one-hour average, which is not to be exceeded more than once every three years on average, was determined based on data from 14 different genera. Invertebrates tended to be the least sensitive to acrolein. The four most sensitive species tested were vertebrates. The acute criterion was calculated based on toxicity data from the following species, from most to least sensitive:

1. African clawed frog (tadpole: *Xenopus laevis*)
2. White sucker (*Catostomus commersoni*)
3. Bluegill (*Lepomis macrochirus*)
4. Fathead minnow (*Pimephales promelas*)

Acute data for Coho salmon (*Oncorhynchus kisutch*) and rainbow trout (*O. mykiss*) were included in the analysis, and *Oncorhynchus* was the fifth most acutely sensitive genus. While these data were not directly used to calculate the acute criterion, the acute criterion is protective of coho salmon and rainbow trout because they are less sensitive.

The freshwater chronic criterion for acrolein of 3.0 µg/L measured as a four-day average, which is not to be exceeded more than once every three years on average, was determined using acute freshwater data in conjunction with acute-to-chronic ratios for the following species, from most to least sensitive:

1. Fathead minnow (*Pimphales promelas*)
2. Cladoceran (*Daphnia magna*)
3. Flagfish (*Jordanella floridae*)

Direct chronic data for salmonids or other threatened and endangered species were not available. However, the acute data used during the acute-to-chronic ratio calculation to determine the chronic criteria did consider data from the genus *Oncorhynchus*, which was not among the four most sensitive genera (see above).

A.2.1.4 Acrolein measurements in Oregon waters

A.2.1.4.1 Acrolein in Oregon surface waters

A total of 91 surface water measurements were obtained from AWQMS. For 89 of those measurements, acrolein was either not detected, or detected but not quantified. The most common quantifiable reporting limit for acrolein was 1.5 µg/L, indicating that measurements that were not quantified were likely below the recommended acrolein freshwater acute and chronic criteria (3.0 µg/L). Of the two acrolein measurements that were quantified, both were below the recommended freshwater acute and chronic criteria (Figure A.1).

A.2.1.4.2 Acrolein in Oregon discharges

In all 476 samples of Oregon discharges, acrolein was either not detected or detected but not quantified. The most common reporting limit listed for acrolein in wastewater was 5.0 µg/L, indicating that it is unclear whether the concentrations of acrolein reported in discharges are likely to be above or below recommended freshwater acute and chronic criteria (3.0 µg/L).

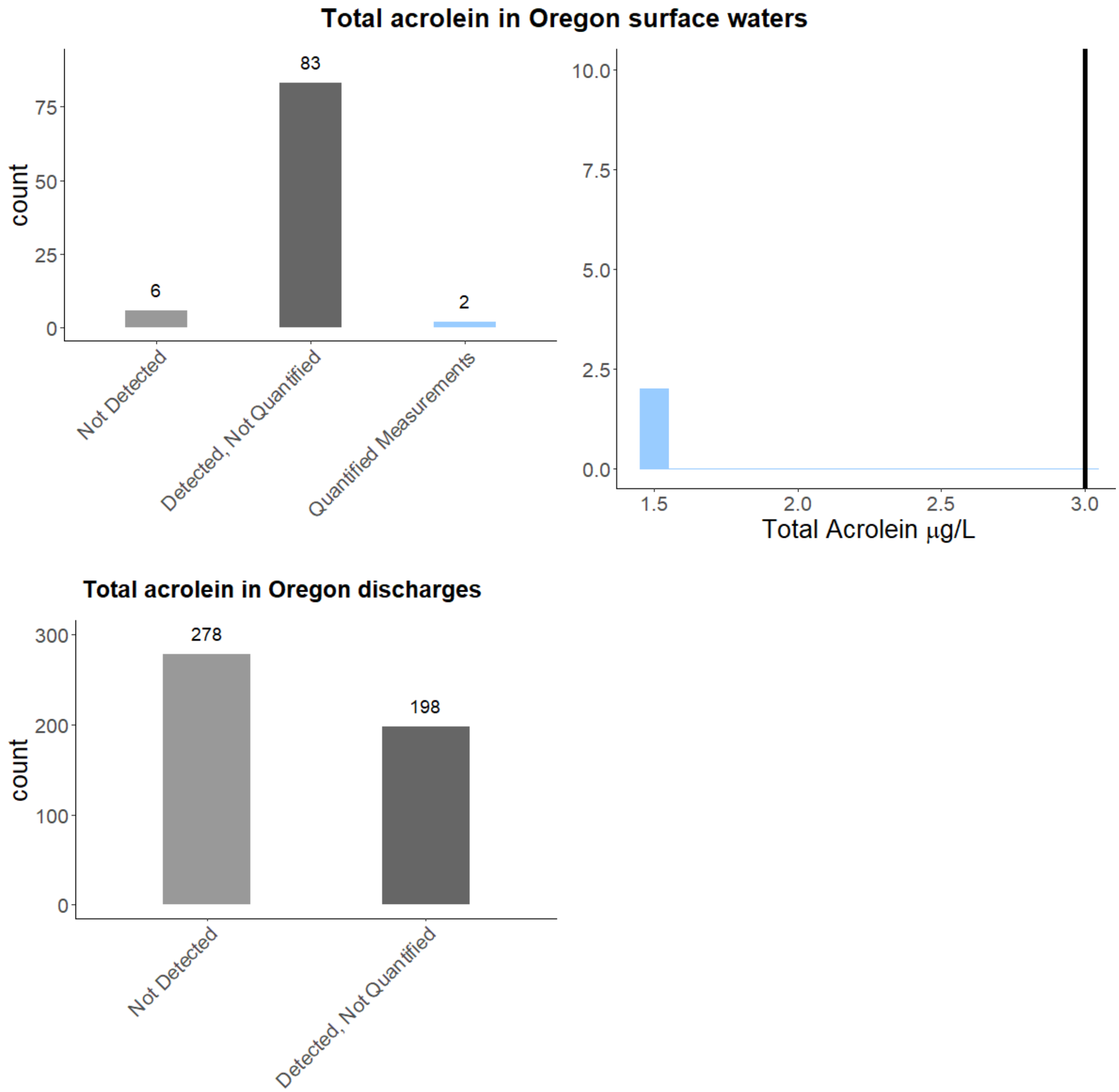


Figure A.1. Acrolein measured in Oregon surface waters and discharges. Bar graphs show the proportion of measurements that were not detected, detected but not quantified, and quantified. Histograms display the distribution of quantified measurements relative to the proposed criteria. The solid black vertical line corresponds to the proposed freshwater acute and chronic criteria for acrolein (3.0 µg/L). All quantified measurements to the left of that line are also below the proposed criteria.

A.2.2 Aluminum

A.2.2.1 Aluminum sources and uses

Aluminum occurs naturally and is the most abundant metal in the Earth's crust. It is found in most rocks, and in clays, soils, and sediments, often complexed with oxygen or silica. Because it is naturally so abundant on Earth's crust, aluminum enters waterways through natural weathering processes. Human activities that move aluminum into surface waters include aluminum mining and smelting, fertilizer application and use, fossil fuel combustion, and the use of alum (potassium aluminum sulfate) as a coagulant to clarify drinking and wastewater and sometimes lakes. In particular, alum is used to remove phosphorus during wastewater treatment. Bauxite (aluminum ore) mines can also be a significant source of aluminum in the environment. In Oregon, the majority of bauxite mine records (14) occur in Columbia County, with an additional record in Marion County and another in Josephine County (McClaughry et al., 2022). Several smelting and aluminum processing facilities have existed in Oregon, and one of these smelting facilities is now a Superfund program site in the Dalles, OR. Along with heavy precipitation and snow melt, acid rain can mobilize aluminum in aquatic environments (EPA, 2018).

A.2.2.2 Aluminum mode of action and environmental fate

Despite being so prevalent in the environment, aluminum has no known biological function, and is therefore considered a non-essential metal. Aluminum causes toxicity to aquatic animals by affecting ion regulation and respiratory processes. In fish, specifically, aluminum accumulates at the gill causing damage to the cells there and resulting disfunction related to ion balance (EPA, 2018).

Aluminum can be found in many different forms depending on environmental conditions, and certain forms are more toxic to aquatic life than others. These environmental conditions affect the bioavailability of aluminum, or the aluminum that is able to have a biological effect. Aluminum toxicity in the aquatic environment varies depending on other water quality parameters in natural waters, especially pH, DOC, and total hardness (EPA, 2018). A large proportion of aluminum remains bound to clays and sediments, or complexed with other ions, and therefore is not available to cause harm to aquatic organisms. However, at high and low pH, aluminum solubility in water increases, making it more toxic at extreme pH's than in neutral waters. In the presence of dissolved organic carbon (DOC), aluminum may form organic aluminum complexes, becoming less bioavailable to aquatic organisms. Because aluminum is affected by other ions in the water, as total hardness (a measure of calcium and magnesium ions in the water) increases, aluminum becomes less bioavailable because aluminum ions must now compete with other ions being taken up by organisms. However, pH also affects the extent to which total hardness reduces bioavailability.

A.2.2.3 Basis for the latest recommended aluminum criteria

The 2018 nationally recommended criteria used an approach that normalized aluminum toxicity in invertebrates and vertebrate fish using models to account for the combined effects of pH, DOC, and total hardness on aluminum toxicity. This approach is in line with the methods outlined in EPA's 1985 Guidelines because there was sufficient evidence to demonstrate that those water quality parameters affected aluminum toxicity.

The magnitude of the freshwater acute criterion for aluminum, measured as a one-hour average, which is not to be exceeded more than once every three years on average, is dependent on pH, DOC, and total hardness and can be calculated using the Aluminum Criteria Calculator v. 2.0. Acute toxicity data from 20 different genera normalized to models accounting for pH, DOC, and total hardness were used to establish criteria values. While the ranked order of the genera that are most sensitive to aluminum change with water chemistry, the following were the four most sensitive genera at a pH of 7, total hardness of 100 mg/L, and DOC of 1.0 mg/L:

1. Cladocerans (*Daphnia magna and D. pulex*)
2. Smallmouth bass (*Micopterus dolomieu*)
3. Rainbow trout (*Oncorhynchus mykiss*)
4. Cladocerans (*Ceriodaphnia dubia* and *C. reticulata*)

Acute data for rainbow trout (*O. mykiss*) and brook trout (*Salvelinus fontinalis*) were included in the analysis at the described conditions. *Oncorhynchus* was the third most acutely sensitive genus, and the recommended criteria magnitudes are protective of salmonids in the genera *Oncorhynchus* and *Salvelinus*, which include threatened and endangered species in Oregon.

The magnitude of the freshwater chronic criterion for aluminum measured as a four-day average, which is not to be exceeded more than once every three years on average, is dependent on pH, DOC, and total hardness and can be calculated using the Aluminum Criteria Calculator v. 2.0. Chronic toxicity data from 13 different genera normalized to models accounting for pH, DOC, and total hardness were used to establish criteria values. While the ranked order of the genera that are most sensitive to aluminum change with water quality, the following were the four most sensitive genera at a pH of 7, total hardness of 100 mg/L, and DOC of 1.0 mg/L:

1. Atlantic salmon (*Salmo salar*)
2. Brook trout (*Salvelinus fontinalis*)
3. Cladocerans (*Daphnia magna*)
4. Fatmucket (*Lampsilis siliquoidea*)

Salmonids (Atlantic salmon (*Salmo salar*) and brook trout (*Salvelinus fontinalis*)) comprised the two most sensitive genera assessed for chronic aluminum toxicity. The chronic criterion recommendations are expected to be protective of these sensitive fish as well as threatened and endangered species that share the same genus in Oregon.

Although EPA reviewed saltwater aluminum toxicity data, they were insufficient to determine saltwater criteria recommendations.

A.2.2.4 Aluminum measurements in Oregon waters

2.2.2.4.1 Aluminum in Oregon surface waters

Because the freshwater aluminum criteria magnitudes must be calculated using concurrent water quality parameters, there are no singular acute or chronic criteria values that can be visually compared to the distribution of aluminum measurements in surface waters to get a sense of whether the proposed criteria tended to fall above or below ambient measurements. DEQ elected to instead display the 10^{th} and 50^{th} percentiles of acute and chronic criteria magnitudes calculated from waters in the state of Oregon (Figure A.2). The 10^{th} percentile comparison represents a conservative approach (as a sort of 'worst case scenario') in comparing Oregon water aluminum concentrations with proposed aluminum criteria. By definition, 90% of criteria magnitudes from Oregon waters will be higher than those displayed. The 50^{th} percentile analysis compares concentrations to the median acute and chronic aluminum criteria values based on data from Oregon waters.

Both total recoverable and bioavailable sample fraction data are presented for aluminum (Figure A.2, Table A.5). A total of 4,381 total recoverable aluminum measurements and 111 bioavailable aluminum measurements were available in AWQMS. For both total recoverable and bioavailable aluminum, measurements below detection most frequently had detection limits on the order of 10 µg/L, while samples in which aluminum was detected but not quantified typically had reporting limits on the order of 20 µg/L. In all cases where aluminum measurements (total recoverable or bioavailable) were below the quantification limit, they were also below the 10^{th} percentile of recommended acute and chronic criteria values in Oregon.

Of the 4,234 quantified total recoverable aluminum measurements (Table A.2), 975 were greater than the 10^{th} percentile recommended acute criterion, while 1,737 were greater than the 10^{th} percentile recommended chronic criterion. Four-hundred and nineteen were greater than the 50^{th} percentile recommended acute criterion, while 948 were greater than the 50^{th} percentile recommended chronic criterion. The total recoverable aluminum measurements with the highest concentrations tended to come from areas of canal transport. Several extremely high total recoverable aluminum measurements (> 1,000,000 µg/L) came from historical data or other less well-characterized surface water data. However, those data met data quality criteria, so they were included in the analysis. Still, it is important to note that total recoverable measurements that were more specifically described in AWQMS did sometimes exceed 10,000 µg/L in some rivers and streams. Whether surface water total recoverable measurements actually exceed aluminum criteria must be determined by using pH, DOC, and total hardness data for each sample.

Of the 16 quantified bioavailable aluminum measurements, none were greater than either the 10th or 50th percentile chronic or acute recommended criteria. Although bioavailable measurements were limited, DEQ intends to increase bioavailable sampling in ambient waters over the next two years.

Table A.5. Statistical summary for quantified aluminum concentrations in Oregon waters

Measurement Type	n	Aluminum (µg/L)								
		minimum	Percentile							maximum
			5th	10th	25th	50th	75th	90th	95th	
Surface Waters – bioavailable sample fraction	16	22.2	22.65	23	23.35	25.6	30.175	43.55	46.875	48.3
Surface Waters – total recoverable sample fraction	4,234	0.3	47	73	150	313	674	1,470	2,543	8,000,000
Discharges – total recoverable sample fraction	725	4.1	14.04	20	46	126	400	1,636	3,686	11,000,000

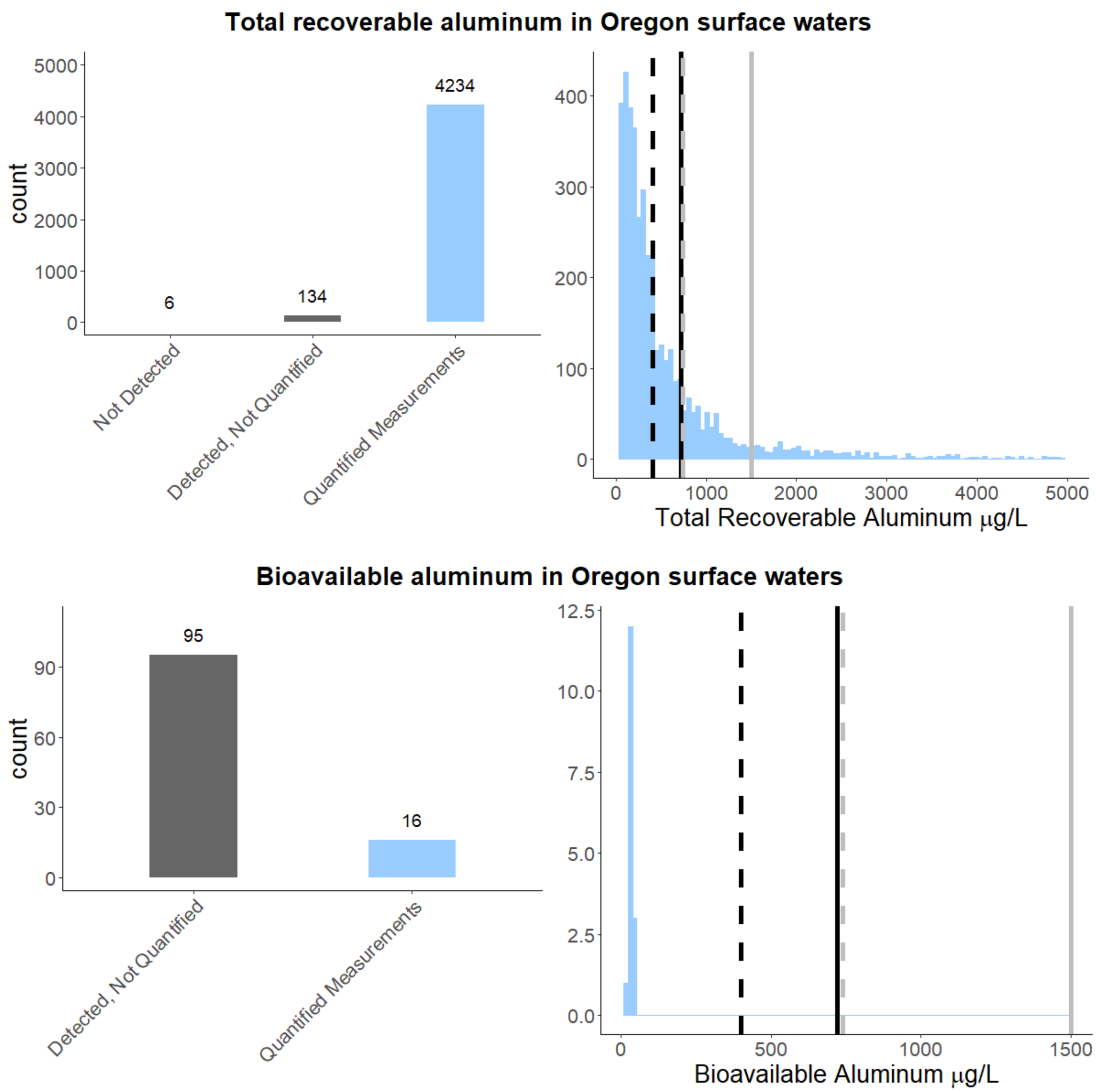


Figure A.2. Aluminum measured in Oregon surface waters and discharges. Bar graphs show the proportion of measurements that were not detected, detected but not quantified, and quantified. Histograms display the distribution of quantified measurements relative to the proposed criteria. Both total recoverable and bioavailable aluminum measurements are displayed separately for comparison. The x-axes are truncated to better visualize data. The solid black vertical line corresponds to the proposed freshwater acute 10th percentile aluminum criterion (720 µg/L), while the dashed black vertical line corresponds to the proposed freshwater chronic 10th percentile aluminum criterion (400 µg/L). The solid gray vertical line corresponds to the proposed freshwater acute 50th percentile aluminum criterion (1,500 µg/L), while the dashed gray vertical line corresponds to the proposed freshwater chronic 50th percentile aluminum criterion (740 µg/L). All quantified measurements to the left of those lines are below the proposed 10th and 50th percentile criteria.

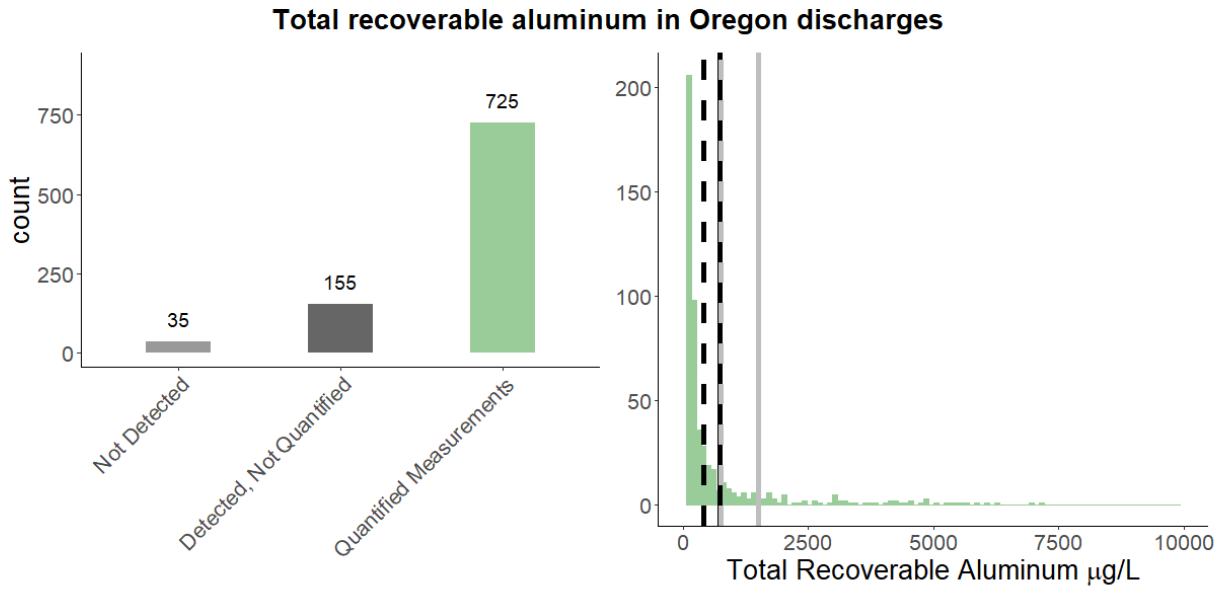


Figure A.2 (continued).

A.2.2.4.2 Aluminum in Oregon discharges

As with aluminum surface water measurements, discharge measurements were compared to a conservative 10th percentile and a median 50th percentile of recommended acute and chronic criteria values based on surface water data.

For discharges, only total recoverable aluminum data are displayed because bioavailable aluminum measurements are not approved for wastewater. For discharge measurements below quantification, detection limits were often 10 µg/L, while reporting limits were most often 50 µg/L. For the 190 measurements at or below quantification (Figure A.2), all of those measurements were also below the 10th percentile recommended acute and chronic criteria.

Of the 725 total recoverable aluminum measurements that were quantified (Table A.5), 124 were above the 10th percentile recommended acute criterion, and 182 were above the 10th percentile recommended chronic criterion. Seventy-eight were above the 50th percentile recommended aluminum acute criterion, and 124 were above the 50th percentile chronic criterion. The highest total recoverable aluminum concentrations (above the 95th percentile) came from wastewater treatment plant effluents. The range of total recoverable aluminum concentrations in Oregon discharges suggests that some dischargers may be challenged by trying to meet permit limits determined by the total recoverable aluminum criteria.

A.2.3 Cadmium

A.2.3.1 Cadmium sources and uses

Cadmium is a naturally occurring metal associated with mineral deposits. In the absence of human activities, it is typically found at low concentrations in the environment. Industrially, cadmium is used in batteries, pigments, plastic stabilizers, and electronics. Nickel-cadmium batteries account for most of current cadmium consumption. Cadmium is also sometimes used during the manufacture of nanoparticles for photovoltaic devices. To a lesser extent, cadmium can be present in mine wastes, fossil fuels, iron and steel, cement, and fertilizers (EPA, 2016). Cadmium is no longer actively mined in the U.S., and there is no record of cadmium mining in Oregon (McClaughry et al., 2022).

Most cadmium in the aquatic environment is the result of anthropogenic inputs, although natural processes such as weathering and erosion of rock and soils is also a source. Atmospheric deposition from fossil fuel combustion or agricultural applications of phosphate fertilizers are both significant sources of cadmium in surface waters (EPA, 2016).

A.2.3.2 Cadmium mode of action and environmental fate

Cadmium is a non-essential element, meaning it has no known biological function in aquatic animals. In the short term, it causes toxicity primarily by affecting ion balance and causing oxidative damage. Cadmium is also responsible for a variety of long-term effects including developmental defects, endocrine disruption, reduction in growth and reproduction, and immune system disfunction. Cadmium is bioaccumulative and is also capable of causing cancer (EPA, 2016).

In the aquatic environment, most cadmium is not biologically available to cause toxicity in aquatic organisms because it readily adsorbs to clays and organic materials and is precipitated out into sediments. Cadmium toxicity is affected by a variety of environmental parameters including pH, hardness, alkalinity and organic matter. For example, as total hardness increases, cadmium toxicity decreases (EPA, 2016).

A.2.3.3 Basis for the latest recommended cadmium criteria

The 2016 nationally recommended freshwater criteria for cadmium account for changes in toxicity as a result of changes in hardness for a variety of species, as they were in previous recommendations (EPA, 1985, 2001a). This approach is in line with the methods outlined in the Guidelines because there was sufficient evidence and data demonstrating that hardness affected freshwater cadmium toxicity. For the saltwater criteria, the magnitudes do not vary with hardness or any other water quality parameter.

The magnitude of the freshwater acute criterion for cadmium of 1.8 μg/L measured as a one-hour average, which is not to be exceeded more than once every three years on average, applies only when total hardness is 100 mg/L. It was derived based on data from 75 different genera. The most sensitive genus toxicity value came from *Salvelinus* (bull trout), although those data were not directly used in calculating the criteria. Instead, data from the second through the fifth most sensitive genera were used to determine the acute criterion, in accordance with procedures listed in the Guidelines when over 59 taxa have acute toxicity information available. Data from the following genera (most sensitive to least sensitive) were used to calculate the acute criterion magnitude given a total hardness of 100 mg/L:

2. Sculpins (*Cottus bairdii and C. confuses*)
3. Brown trout (*Salmo trutta*)
4. Striped bass (*Morone saxatilis*)
5. Pacific salmon and Pacific trout (*Oncorhynchus mykiss, O. clarkia, O. kisutch, O. tshawytscha*)

Although fish in the genus *Oncorhynchus* collectively comprised the fifth most sensitive genus, rainbow trout (*O. mykiss*) as a species was the most sensitive species, even compared to bull trout (*Salvelinus*). Thus, as recommended by the Guidelines, EPA lowered the overall acute criterion recommendation to protect the commercially and recreationally important rainbow trout. Lowering the criterion magnitude to protect rainbow trout ensures that other threatened and endangered salmonids (genus *Oncorhynchus, Salmo, Salvelinus*) are also protected by the freshwater acute criterion.

Note that 2016 the freshwater chronic criterion for cadmium has recently been vacated by a U.S. district court decision. The basis for that vacated criterion is not discussed here.

The saltwater acute criterion for cadmium of 33 μg/L measured as a one-hour average, which is not to be exceeded more than once every three years on average, was derived based on data from 79 different genera. The most sensitive genus was a mysid (*Neomysis america*), although those data were not directly used in calculating the criteria. Instead, data from the second through fifth most sensitive genera were used to determine the acute criterion, in accordance with procedures listed in the Guidelines when over 59 taxa have acute toxicity information available. Data from the following genera (from most to least sensitive), were used to calculate the saltwater acute criterion magnitude:

2. Copepod (*Tigriopus brevicornis*)
3. Moon jellyfish (*Aurelia aurita*)
4. Mysid (*Americamysis bahia* and *A. bigelowi*)
5. Striped bass (*Morone saxatilis*)

Data for Oregon's threatened and endangered species were not available for inclusion in determining the saltwater acute criterion.

The saltwater chronic criterion for cadmium of 7.9 µg/L measured as a four-day average, which is not to be exceeded more than once every three years on average, was determined using acute saltwater data in conjunction with acute-to-chronic ratios from the following genera, from most to least sensitive:

1. Brown trout (freshwater: *Salmo trutta*)
2. Rainbow trout and Chinook salmon (freshwater: *Oncorhynchus mykiss* and *O. tshawytscha*)
3. Mysids (saltwater: *Americamysis bahia* and *A. bigelow*)
4. Mottled sculpin (freshwater: *Cottus bairdii*)
5. Fathead minnow (freshwater: *Pimephales promelas*)
6. Cladoceran (freshwater: *Ceriodaphnia dubia*)
7. Cladoceran (freshwater: *Daphnia magna* and *D. pulex*)

Although mysids were the only saltwater genus for which acute-to-chronic ratio were available, EPA relied on acute-to-chronic ratio data from six other freshwater genera to establish the chronic saltwater criterion for cadmium in accordance with methods outlined in the Guidelines. This approach captured toxic effects in a diversity of aquatic life. It also included a genus (*Oncorhynchus*) which also includes some of Oregon's threatened and endangered species.

A.2.3.4 Cadmium measurements in Oregon waters

A.2.3.4.1 Cadmium in Oregon surface waters

Because the freshwater cadmium criteria magnitudes must be calculated using concurrent total hardness data, there is no singular acute or chronic criterion value that can be visually compared to the distribution of cadmium measurements in surface waters to get a sense of whether the proposed criteria tend to fall above or below ambient measurements. DEQ elected to instead display the 10th and 50th percentile of acute and chronic criteria magnitudes calculated from waters in the state of Oregon. The 10th percentile represents a conservative approach (a sort of 'worst case scenario') in comparing Oregon water cadmium concentrations with proposed cadmium criteria. By definition, 90% of criteria magnitudes from Oregon waters will be higher than those displayed. The 50th percentile analysis compares concentrations to the median acute and chronic aluminum criteria values based on data from Oregon waters.

A total of 4,420 dissolved cadmium measurements were available in AWQMS (Figure A.3). A total of 1,352 samples were below detection and most frequently had detection limits on the order of 0.10 µg/L. In the 2,952 samples where cadmium was detected but not quantified, reporting limits were typically on the order of 0.06 to 0.10 µg/L. Given that the detection and reporting limits were so low, it is evident that the vast majority of measurements that could not be quantified came from the samples where dissolved cadmium was below the 10th percentile criteria.

Of the 116 quantified surface water cadmium measurements, 9 were above the 10th percentile recommended acute criterion, and 22 were above the 10th percentile recommended chronic criterion. Five were above the 50th percentile acute criterion, and 10 were above the 50th percentile chronic criterion. In fact, the 75th percentile of dissolved cadmium measurements in Oregon was still below the 10th percentile recommended freshwater chronic criterion, and the 90th percentile of dissolved cadmium measurements in Oregon was below the 10th percentile recommended acute criterion (Table A.6). The highest measurements of dissolved cadmium (≥ 1.0 µg/L) came from historical measurements from the Willamette, Coquille, Rogue, and Clackamas Rivers. However, it is important to note that the 10th and 50th percentile acute and chronic criteria values are presented here are for a general comparison purposes, and that hardness must be used to calculate the exact applicable criteria to determine whether a cadmium measurement exceeds the criteria.

A.2.3.4.2 Cadmium in Oregon saltwater

Unlike the freshwater cadmium criteria, the recommended saltwater criteria have discrete values that do not vary with water quality parameters. A total of 110 cadmium measurements in saltwater were available in AWQMS (Figure A.3). Measurements that were below detection (42) had a detection limit of 0.10 µg/L, while measurements that were below the reporting limit (67) most commonly had a reporting limit of 0.10 µg/L and always below 1.5 µg/L. This indicated that all measurements below the reporting limit were also lower than the recommended saltwater acute and chronic criteria. Only a single saltwater measurement was quantified with a value of 3.0 µg/L, indicating that it was also below the recommended saltwater acute and chronic criteria.

A.2.3.4.2 Cadmium in Oregon discharges

As with surface water measurements, cadmium discharge measurements were compared against the 10th and 50th percentile of freshwater recommended acute and chronic criteria based on surface water measurement data.

Of the 528 cadmium measurements from Oregon discharges in AWQMS, over half were either below detection (87) or below quantification (242) (Figure A.3). The most common detection limits reported were 0.10 and 0.25 µg/L, while the most common reporting limits were 0.05 and 0.25 µg/L. Given the range of detection and reporting limits, it was not clear how many of the measurements at or below the reporting limit were also lower than the 10th percentile recommended chronic criterion, but it was clear that the majority of these measurements were below the 10th percentile recommended acute criterion.

Of the 199 quantified cadmium measurements, 33 were above the 10th percentile acute criterion, while 72 were above the 10th percentile chronic criterion. Twenty-two were above the 50th percentile acute criterion, while 36 were above the 50th percentile chronic criterion. However it is important to note that data higher than the 10th or 50th percentile values may not necessarily indicate that the measurements were higher than actual calculated criteria for that measurement. Further, the methods for determining limits in permitting discharges are complex and consider other factors (such as the water quality of the waterbody receiving the discharge).

Table A.6. Statistical summary for quantified dissolved cadmium concentrations in Oregon waters

Measurement Type	n	Cadmium (µg/L)								
		minimum	Percentile							maximum
			5th	10th	25th	50th	75th	90th	95th	
Surface Water	116	0.005	0.008	0.012	0.020	0.060	0.16	0.32	0.48	4.0
Saltwater	1	3.0	-	-	-	-	-	-	-	3.0
Discharge	199	0.020	0.026	0.030	0.050	0.12	0.27	0.78	1.6	8.8

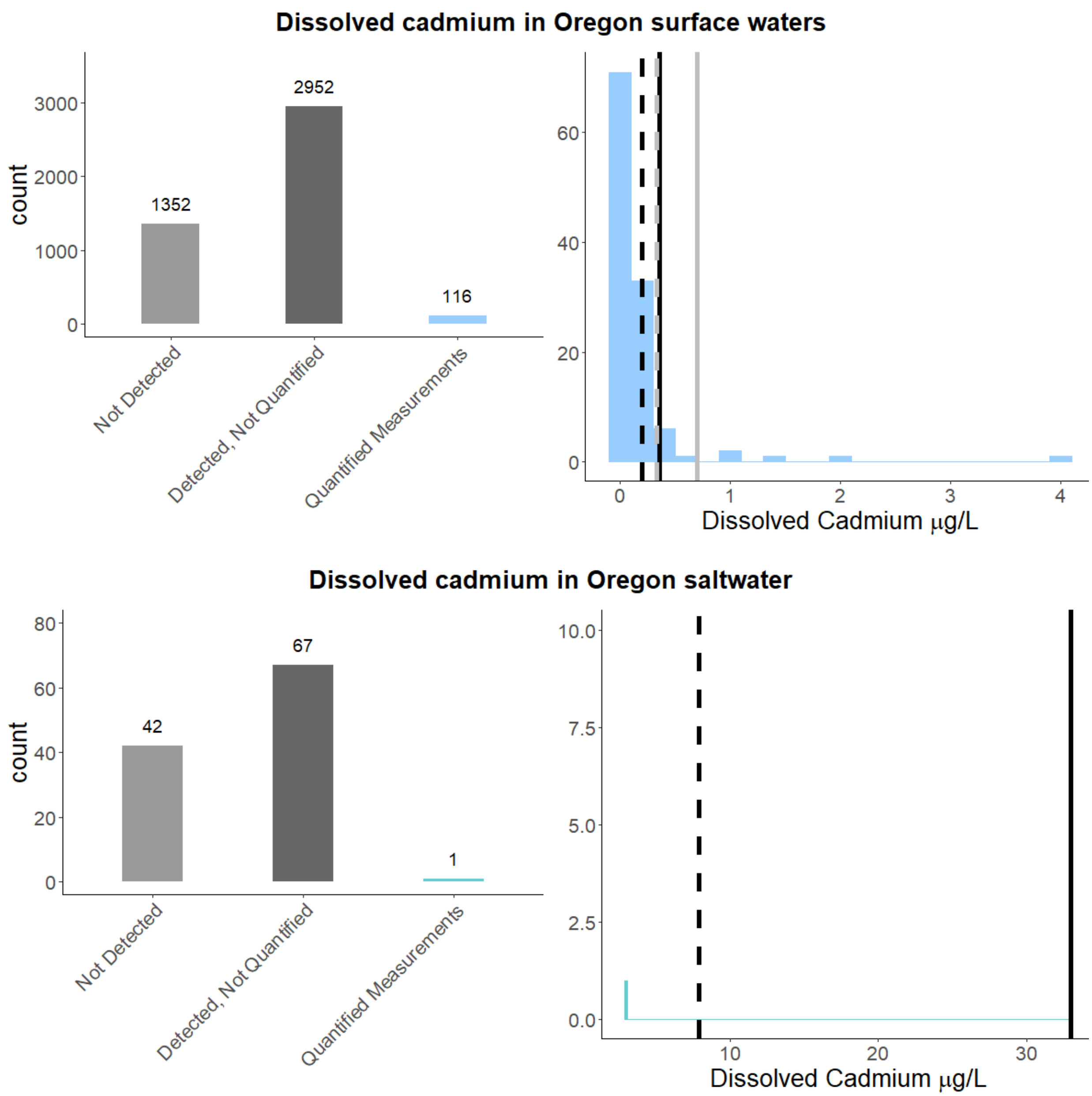


Figure A.3. Cadmium measured in Oregon surface waters, saltwater and discharges. Bar graphs show the proportion of measurements that were not detected, detected but not quantified, and quantified. Histograms display the distribution of quantified measurements relative to the proposed criteria. For surface waters and discharges, the solid black vertical line corresponds to the proposed freshwater acute 10th percentile cadmium criterion (0.36 µg/L), while the dashed black vertical line corresponds to the proposed freshwater 10th percentile cadmium criterion (0.20 µg/L). For surface waters and discharges, the solid gray vertical line corresponds to the proposed freshwater acute 50th percentile cadmium criterion (0.70 µg/L), while the dashed gray vertical line corresponds to the proposed freshwater 10th percentile cadmium criterion (0.34 µg/L). For saltwater, the solid black vertical line corresponds to the proposed saltwater acute cadmium criterion (33 µg/L)., while the dashed black vertical line corresponds to the proposed saltwater chronic criterion (7.9 µg/L). All quantified measurements to the left of those lines are below the proposed 10th or 50th percentile criteria (freshwater and discharges) or the proposed criteria (saltwater).

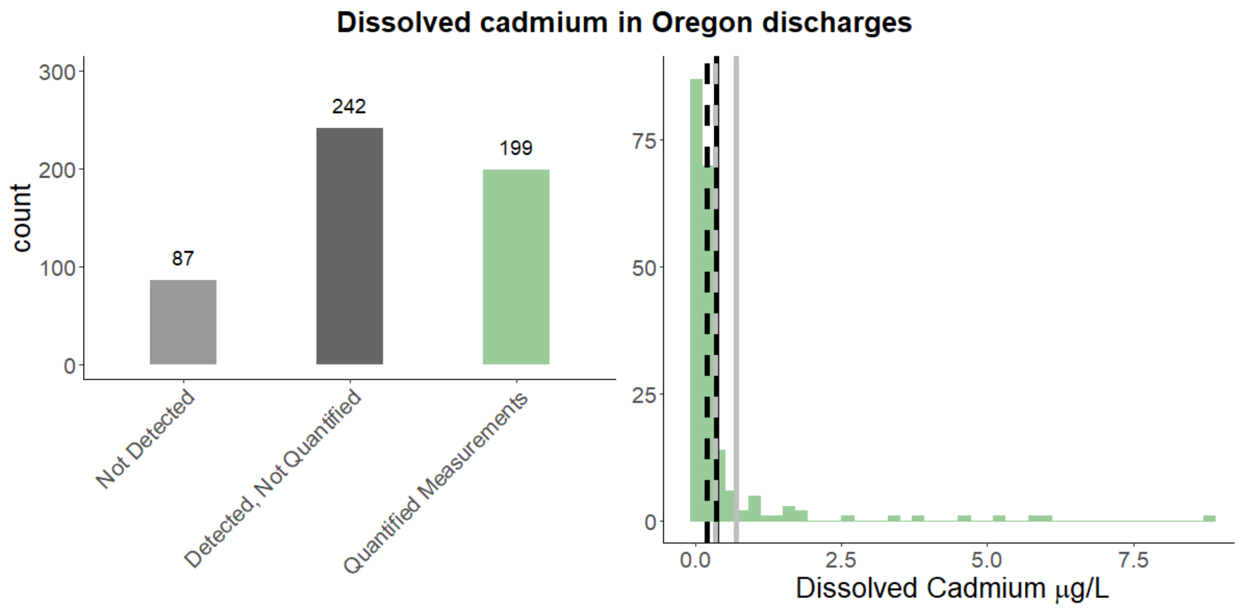


Figure A.3 (continued).

A.2.4 Carbaryl

A.2.4.1 Carbaryl sources and uses

Carbaryl is a man-made general use insecticide that was first used agriculturally in the late 1950s (NPIC, 2016). As of 2020, carbaryl was registered for over 120 agricultural, non-crop, and residential uses in Oregon (ODA, 2020). From 2000 to 2017, the USGS estimates that most agricultural carbaryl in Oregon was applied to orchards and grapes, followed by vegetables and fruits, with occasional applications on alfalfa, wheat, and other crops as well (USGS, 2020). Aside from its primary use as an insecticide, carbaryl is also used to thin fruit trees. Although residential use of carbaryl is not as easily quantified, it is sufficient to result in measurable carbaryl levels in urban waterways. In fact, one national USGS study of pesticides in urban rivers and streams showed that carbaryl exceeded aquatic life benchmarks in roughly 10% streams in the U.S. for the period 2002 to 2011 (Stone et al., 2014).

A.2.4.2 Carbaryl mode of action and environmental fate

Carbaryl is a carbamate insecticide. Insecticides in this class cause their toxicity by acting on the nervous system, eventually resulting in paralysis followed by death (EPA, 2012).

Carbaryl enters the aquatic environment through runoff after rain events as well as through spray drift, and to some extent, volatilization followed by deposition (EPA, 2012). Carbaryl is not expected to significantly bioaccumulate (EPA, 2010). Depending on environmental conditions, the half-life of carbaryl ranges from 0.13 to 12 days. The presence of microbes and alkaline conditions increase the rate of degradation (EPA, 2012).

A.2.4.3 Basis for the latest recommended carbaryl criteria

The freshwater acute criterion for carbaryl of 2.1 µg/L, measured as a one-hour average, which is not to be exceeded more than once every three years on average, was determined based on data from 47 different genera. Insects tended to be the most sensitive to carbaryl, which was expected because carbaryl is an insecticide. In fact, the 15 most sensitive genera for which toxicity information was available were insects and crustaceans. Fish tended to be far less acutely sensitive to carbaryl. Stoneflies were the most sensitive, and the freshwater acute criterion was calculated based on toxicity data from the following stonefly species, from most to least sensitive:

1. Stonefly (*Isogenus sp*.)
2. Stonefly (*Skwala sp*.)
3. Stonefly (*Pteronarcys californica*)
4. Stonefly (*Claassenia sabulosa*)

Acute data were available for a variety genera that also contain threatened and/or endangered species in Oregon, including *Salvelinus* (Brook trout (*S. fontinalis*) and Lake trout (*S. namaycush*)), *Acipenser* (Shortnosed sturgeon (*A. brevirostrum*)), and *Oncorhynchus* (Apache trout (*O. apache*), Coho salmon (*O. kisutch*), Chinook salmon (*O. tshawytscha*), Cutthroat trout (*O. clarkii*) and Rainbow trout (*O. mykiss*). The most sensitive of these genera was *Oncorhynchus*, which was over 500 times less sensitive than the most sensitive stonefly, indicating that the recommended acute freshwater criterion is protective of *Oncorhynchus* and other threatened and endangered species in Oregon.

The freshwater chronic criterion for carbaryl of 2.1 µg/L measured as a four-day average, which is not to be exceeded more than once every three years on average, was determined using acute freshwater data in conjunction with acute-to-chronic ratios from the following species, from most to least sensitive:

1. Cladoceran (*Ceriodaphnia dubia*)
2. Cladoceran (*Daphnia magna*)

Chronic freshwater toxicity data for animals sharing the same genus as Oregon's threatened and endangered species were not available. However, fish data (Fathead minnow, *Pimephales promelas* and Colorado pikeminnow, *Ptychochelius lucius*) tended to indicate that fish were less sensitive (over 60 times) than invertebrates.

The saltwater acute criterion for carbaryl of 1.6 µg/L measured as a one-hour average, which is not to be exceeded more than once every three years on average, was determined based on data from 11 different genera. The most sensitive groups were crustaceans, and the saltwater acute criterion was calculated based on data from the following genera, from most to lease sensitive:

1. Mysid (*Americamysis bahia*)
2. Dungeness crab (*Metacarcinus magister* formerly *Cancer magister*)
3. Ghost shrimp (*Callianassa californiensis*)
4. Mud shrimp (*Upogebia pugettensis*)

None of the saltwater acute data correspond to genera comprising Oregon's threatened or endangered species.

A.2.4.4 Carbaryl measurements in Oregon waters

A.2.4.4.1 Carbaryl in Oregon surface waters

For the vast majority of surface water samples (5,748 of 6,279), carbaryl was detected but at levels below quantification (Figure A.4). Carbaryl was not detected in 36 samples. In all cases where carbaryl concentrations were too low to be quantified or detected, the low laboratory reporting limits (most commonly 0.005 µg/L) indicated that these measurements were also below the recommended freshwater criteria. Of the 495 quantified measurements (Table A.7), only two were greater than the freshwater acute and chronic criteria (Figure A.4), with one measurement coming from the North Fork Deep Creek at Hwy 212, upstream of Boring and the other coming from Mill Creek at Wright Road in the Dalles.

A.2.4.4.2 Carbaryl in Oregon saltwater

In all saltwater measurements of carbaryl (56), carbaryl was detected but too low to be quantified. In these cases, the low laboratory reporting limits (most commonly 0.005 µg/L) indicated that the carbaryl measurements were also below the recommended saltwater acute criterion (Figure A.4).

A.2.4.4.3 Carbaryl in Oregon discharges

Carbaryl was measured in a total of 96 discharge samples. In the majority of those discharge samples (74), carbaryl was detected but not quantified (Figure A.4). In all cases where carbaryl concentrations were too low to be quantified, the low laboratory reporting limits (most commonly 0.05 µg/L) indicated that these measurements were also below the recommended freshwater criteria. Of the 19 quantified measurements of carbaryl in Oregon discharges, none of them were higher than the recommended freshwater criteria (Figure A.4, Table A.7).

Table A.7. Statistical summary for quantified carbaryl concentrations in Oregon waters

Measurement Type	n	Carbaryl (µg/L)								
		minimum	Percentile							maximum
			5th	10th	25th	50th	75th	90th	95th	
Surface Waters	495	0.003	0.0054	0.0060	0.0080	0.015	0.038	0.12	0.20	14
Discharges	19	0.048	0.048	0.049	0.049	0.051	0.073	0.19	0.24	0.66

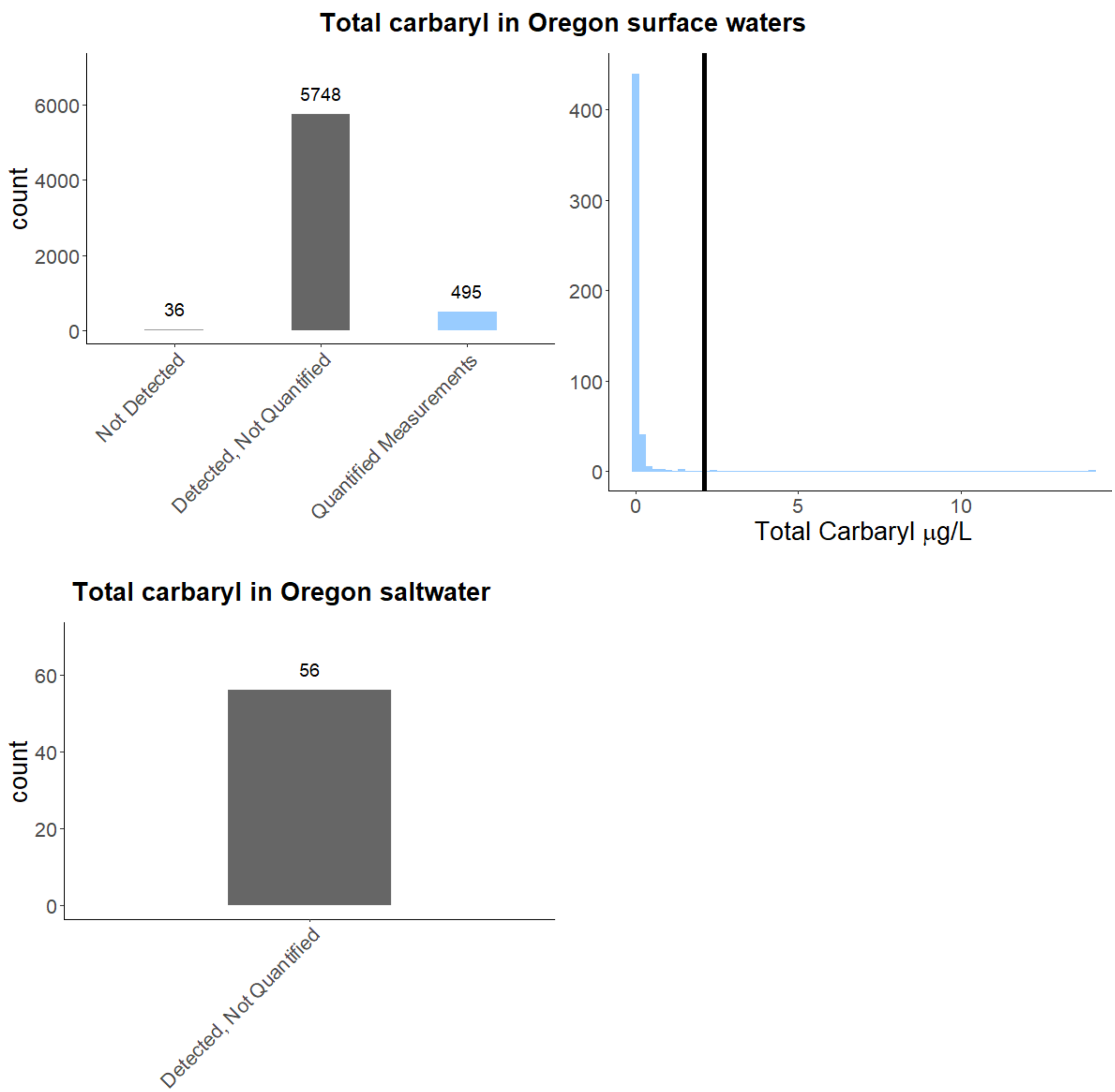


Figure A.4. Carbaryl measured in Oregon surface waters, saltwater and discharges. Bar graphs show the proportion of measurements that were not detected, detected but not quantified, and quantified. Histograms display the distribution of quantified measurements relative to the proposed criteria. The solid black vertical line corresponds to the proposed freshwater acute and chronic criteria (2.1 µg/L) for carbaryl. All quantified measurements to the left of that line are also below the proposed criteria.

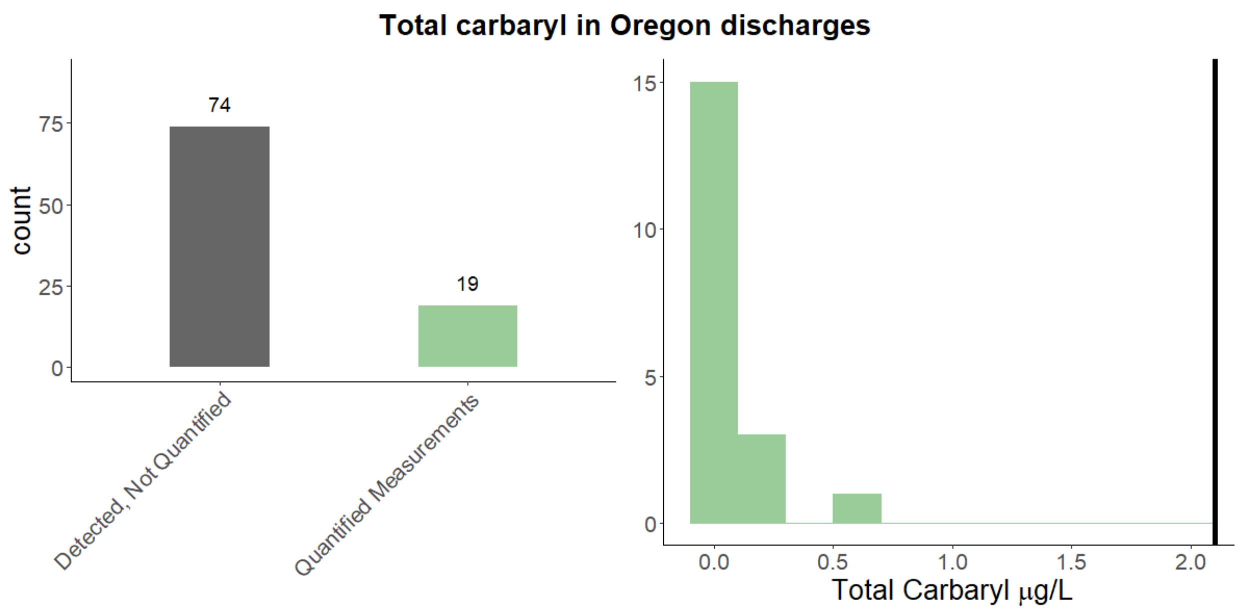


Figure A.4 (continued).

A.2.5 Diazinon

A.2.5.1 Diazinon sources and uses

Diazinon is a pesticide that was first used in the United States in 1956. It is currently a restricted use pesticide, registered for at least 55 agricultural and non-crop uses in Oregon (ODA, 2020). It was approved for residential and household use until 2004, when it was banned for those uses (NPIC, 2009). From 2000 to 2017, the USGS estimates that most agricultural diazinon use in Oregon has been applied to orchards and grapes, followed by vegetables and fruits, with occasional applications on corn and other crops as well (USGS, 2020). Diazinon use in urban settings has been limited by its classification as a restricted use pesticide in the early 2000s, and a national USGS study of pesticides in rivers and streams showed that the frequency of diazinon detections in urban streams decreased for the period 2002-2011, reflecting this change in policy (Stone et al., 2014).

A.2.5.2 Diazinon mode of action and environmental fate

Diazinon is an organophosphate insecticide. Pesticides in this class are neurotoxicants. Inhibition of a key enzyme in the nervous system leads to a repeated firing of nerve impulses, causing paralysis and eventually death (EPA, 2005a).

Diazinon enters the aquatic environment through runoff during rain events and spray drift (EPA, 2005a). It is not expected to pose a severe bioaccumulation risk in fish tissues. In water, diazinon breaks down through several processes. Diazinon is stable for up to 6 months at neutral pH, but breaks down most rapidly in acidic, followed by alkaline environments (EPA, 2005a).

A.2.5.3 Basis for the latest recommended diazinon criteria

The freshwater acute criterion for diazinon of 0.17 µg/L measured as a one-hour average, which is not to be exceeded more than once every three years on average, was determined based on data from 20 different genera. Insects tended to be the most sensitive to diazinon, which was expected because diazinon is an insecticide. In fact, the seven most sensitive genera were insects and crustaceans. Fish tended to be far less acutely sensitive to diazinon. The freshwater acute criterion was calculated based on toxicity data from the following species, from most to least sensitive:

1. Cladoceran (*Ceriodaphnia dubia*)
2. Cladoceran(*Daphnia*)
3. Cladoceran (*Simocephalus serrulatus*)
4. Amphipod (*Gammarus*)

Acute data were available for a variety of genera that also contain threatened and/or endangered species in Oregon, including *Salvelinus* (Brook trout (*S. fontinalis*) and Lake trout (*S. namaycush*)) and *Oncorhynchus* (Cutthroat trout (*O. clarkii*) and Rainbow trout (*O. mykiss*)). The most sensitive of these groups was *Salvelinus*, which was over 1,700 times less sensitive than the most sensitive cladoceran, indicating that the recommended acute freshwater criteria are protective of *Salvelinus* and other threatened and endangered species in Oregon.

The freshwater chronic criterion for diazinon of 0.17 µg/L measured as a four-day average, which is not to be exceeded more than once every three years on average, was determined using acute freshwater data in conjunction with acute-to-chronic ratios from the following species, from most to least sensitive:

1. Cladoceran (*Ceriodaphnia dubia*)
2. Mysid (*Americamysis bahia*)

It is important to note that although mysids are saltwater species, the Guidelines allow for the use of saltwater species data to inform freshwater criteria development, particularly in cases where the range of freshwater acute-to-chronic ratios was very large, as it was with diazinon. None of the chronic freshwater data correspond to genera comprising Oregon's threatened or endangered species, but the acute data used in the acute-to-chronic ratio approach do include salmonid data (see above).

The saltwater acute criterion for diazinon of 0.82 µg/L measured as a one-hour average, which is not to be exceeded more than once every three years on average, was determined based on data from 9 different genera. The most sensitive groups were crustaceans, and the saltwater acute criterion was calculated based on data from the following genera, from most to lease sensitive:

1. Copepod (*Acartia tonsa*)
2. Grass shrimp (*Palaemonetes pugio*)
3. Mysid (*Americamysis bahia*)
4. Amphipod, (*Ampelisca abdita*)

None of the acute saltwater data correspond to genera comprising Oregon's threatened or endangered species.

The saltwater chronic criterion for diazinon of 0.82 µg/L measured as a four-day average, which is not to be exceeded more than once every three years on average, was determined using acute saltwater data in conjunction with acute-to-chronic ratios from the following species, from most to least sensitive:

1. Cladoceran (*Ceriodaphnia dubia*)
2. Mysid (*Americamysis bahia*)

It is important to note that although cladocerans are freshwater species, the Guidelines allow for the use of freshwater species data to inform saltwater criteria development when no other saltwater acute-to-chronic data were available. None of the chronic saltwater data correspond to genera comprising Oregon's threatened or endangered species.

A.2.5.4 Diazinon measurements in Oregon waters

A.2.5.4.1 Diazinon in Oregon surface waters

For the vast majority of samples (8,101 of 8,282), diazinon was detected but at levels below quantification (Figure A.5). Diazinon was not detected in 40 samples. In most cases where diazinon concentrations were too low to be quantified or detected, the low laboratory reporting limits (most commonly 0.025 µg/L) indicated that the measurements were also below the recommended freshwater criteria. Thirty of the 141 quantified measurements were greater than the recommended freshwater acute and chronic criteria (Figure A.5), with those measurements coming from rivers and streams across the state. The 75th percentile of Oregon surface water measurements are below the recommended freshwater criteria (Table A.8).

A.2.5.4.2 Diazinon in Oregon saltwater

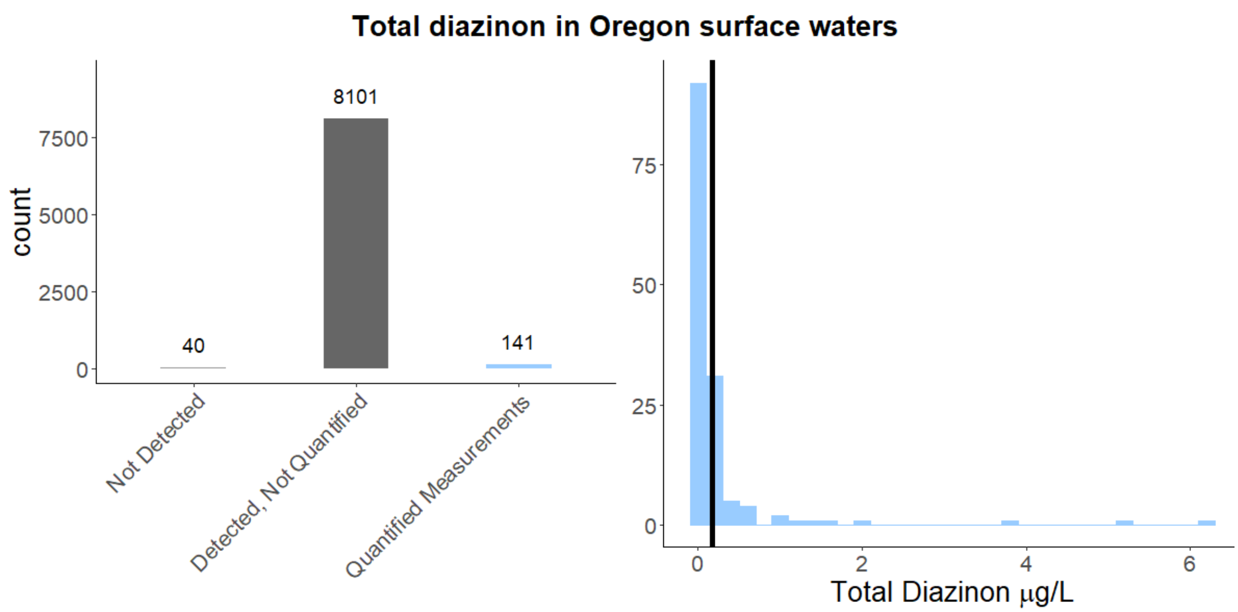
In all saltwater samples (56) where diazinon was measured, diazinon was detected but not quantified (Figure A.5). In all cases where diazinon concentrations were too low to be quantified, the low laboratory reporting limits (most commonly 0.022 µg/L) indicated that the measurements were also below the recommended saltwater criterion.

A.2.5.4.3 Diazinon in Oregon discharges

In the majority of discharge samples (109 of 121) where diazinon was measured, diazinon was detected but not quantified (Figure A.5). In 12 samples, diazinon was not detected. However, the most common laboratory reporting limit for discharge samples was roughly 0.40 µg/L, which is above the freshwater acute and chronic criteria for diazinon, so it remains unclear whether these discharge detections were higher or lower than the recommended criteria.

Table A.8. Statistical summary for quantified diazinon concentrations in Oregon waters

Measurement Type	n	Diazinon (µg/L)								
		minimum	Percentile							maximum
			5th	10th	25th	50th	75th	90th	95th	
Surface Waters	141	0.012	0.016	0.023	0.035	0.065	0.15	0.44	1.1	6.2



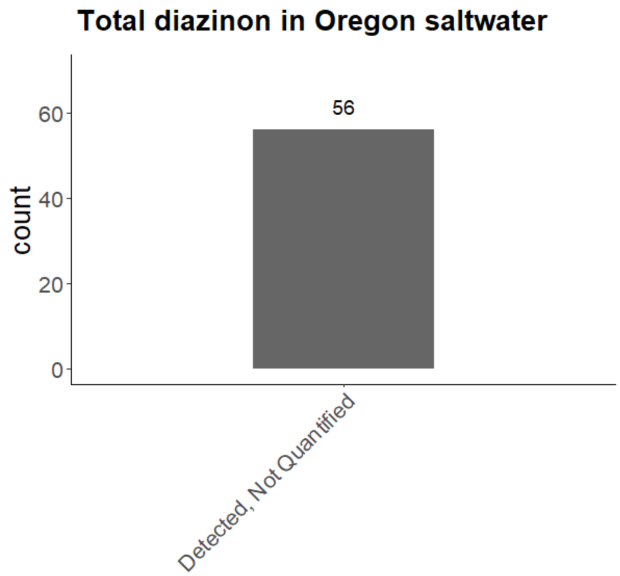


Figure A.5. Diazinon measured in Oregon surface waters, saltwater and discharges. Bar graphs show the proportion of measurements that were not detected, detected but not quantified, and quantified. Histograms display the distribution of quantified measurements relative to the proposed criteria. The solid black vertical line corresponds to the proposed freshwater acute and chronic criteria (0.17 µg/L) for diazinon. All quantified measurements to the left of that line are below the proposed criteria.

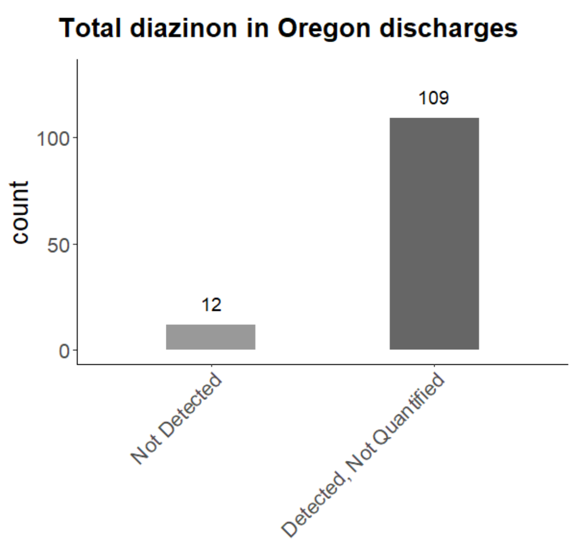


Figure A.5 (continued)

A.2.6 Tributyltin

A.2.6.1 Tributyltin sources and uses

Tributyltin is a man-made compound that is used as a biocide in paints for the bottoms of ship hulls. It is incorporated in paints that prevent the attachment of fouling communities (i.e. barnacles, algae, and other marine organisms). Tributyltin has also been used industrially as a stabilizer for plastics. However, the primary source of tributyltin in the aquatic environment comes from its use in antifouling paints, either through direct leaching of tributyltin into the water, or through chipping during in preparation for periodic hull repainting.

In the 1980s, the effects of tributyltin on the Pacific oyster (*Crassostrea gigas*) and dogwhelks (*Nucella lapillus*) in marinas and estuaries caused international concern. As a result, federal and state legislation significantly restricted the use of tributyltin in antifouling paints. In the state of Oregon specifically, tributyltin antifouling paint is restricted to use on vessels with hull lengths over 25 meters. Further, when tributyltin containing paint may be used, the paint must be low-leaching (ORS 634.500-634.520). These provisions were designed to specifically reduce tributyltin in marinas and estuaries, where the greatest environmental impacts have been noted.

A.2.6.2 Tributyltin mode of action and environmental fate

Short-term tributyltin exposure causes toxicity to aquatic life by disrupting ion transfer across cell membranes. However, tributyltin is also a potent endocrine disruptor in gastropods. Tributyltin causes a condition in dogwhelks called "imposex" or the imposition of male sex organs onto female genitalia, by increasing the hormone testosterone. In the Pacific oyster, tributyltin causes severe shell malformations and increased larval mortality.

Once in the aquatic environment, tributyltin adsorbs to sediments and suspended solids. In the water column, tributyltin more readily degrades into di- and mono-butyltin. Tributyltin is bioaccumulative and degrades slowly once partitioned into the sediment.

A.2.6.3 Basis for the latest recommended tributyltin criteria

The freshwater acute criterion for tributyltin of 0.46 µg/L measured as a one-hour average, which is not to be exceeded more than once every three years on average, was determined based on data from 12 different genera. The freshwater acute criterion was calculated based on toxicity data from the following species, from most to least sensitive:

1. Hydra (*Hydra littoralis* and *H. oligactis*)
2. Hydra (*Chlorohydra viridissmia*)
3. Fathead minnow (*Pimephales promelas*)
4. Amphipod (*Gammarus pseudolimnaeus*)

Acute data were available for lake trout (genus *Salvelinus*) and rainbow trout (genus *Oncorhynchus*), genera that also contain threatened or endangered salmonid species in Oregon. The most sensitive of these groups was *Oncorhynchus*, which was over three times less sensitive than the most sensitive hydra. Therefore the freshwater acute criterion for tributyltin is expected to protect salmonids in the state.

The freshwater chronic criterion for tributyltin of 0.072 µg/L measured as a four-day average, which is not to be exceeded more than once every three years on average, was determined using acute freshwater data in conjunction with acute-to-chronic ratios from the following freshwater and saltwater species, from most to least sensitive:

1. Copepod (*Eurytemora affinis*: saltwater)
2. Fathead minnow (*Pimephales promelas*: freshwater)
3. Cladoceran (*Daphnia magna*: freshwater)

It is important to note that although the copepod is saltwater species, the Guidelines allow for the use of saltwater species data to inform freshwater criteria development. None of the chronic freshwater data correspond to genera comprising Oregon's threatened or endangered species, although the acute criterion (derived from data in the same genus as some threatened and endangered species in Oregon) was used in the chronic criterion development.

The saltwater acute criterion for tributyltin of 0.42 µg/L measured as a one-hour average, which is not to be exceeded more than once every three years on average, was determined based on data from 30 different genera. The saltwater acute criterion was calculated based on data from the following genera, from most to lease sensitive:

1. Mysid (*Acanthomysis sculpta*)
2. Copepod (*Acartia tonsa*)
3. Chinook salmon (*Oncorhynchus tshawytscha*)
4. Hard clam (*Mercenaria mercenaria*)

Data for Chinook salmon (*Oncorhynchus tshawytscha*), a threatened species in Oregon, were used to calculate saltwater acute criteria. Further, an economically important species in Oregon, the Pacific oyster (*Crassostrea gigas*), was in the 10^{th} most sensitive genus for which saltwater toxicity data were available, so it was not directly used to calculate the acute saltwater criteria, but both Chinook salmon (and other threatened and endangered salmonids) and the Pacific oyster are expected to be protected by the acute saltwater criterion.

The saltwater chronic criterion for tributyltin of 0.0074 µg/L measured as a four-day average, which is not to be exceeded more than once every three years on average, was determined based on alternative data that demonstrate tributyltin is a potent endocrine disruptor. After review of all saltwater acute data and an acute-to-chronic ratio analysis, EPA determined that the chronic criteria generated from traditional chronic toxicity assays were not sufficient to protect saltwater aquatic life from other effects including imposex abnormalities and immune system suppression. Instead, EPA based the saltwater chronic criterion for tributyltin on a long-term study that demonstrated significant reproductive effects in the ecologically important dogwhelk (*Nucella lapillus*) above 0.0074 µg/L. The Guidelines allow for the use of alternative scientific information in setting protective criteria.

A.2.6.4 Tributyltin in Oregon waters

A.2.6.4.1 Tributyltin in Oregon surface waters

No tributyltin surface water data were available in AWQMS.

A.2.6.4.2 Tributyltin in Oregon saltwater

No tributyltin saltwater data were available in AWQMS. Some limited work by DEQ and others detected tributyltin in five of seven samples taken from the Coos Bay estuary in 1986 and 1987. The concentrations ranged from 0.007 to 0.014 µg/L (Wolniakowski et al., 1987). These values are well below the recommended acute saltwater criterion, and roughly equal-to-double the recommended chronic saltwater criterion.

A.2.6.4.3 Tributyltin in Oregon discharges

Tributyltin was detected but not quantified in all discharge data measurements (92) available in AWQMS (Figure A.6). For all measurements, the laboratory reporting limit for discharge samples was 2 µg/L, which is above the proposed freshwater acute and chronic criteria for tributyltin, so it remains unclear whether these discharge detections were higher or lower than the recommended criteria.

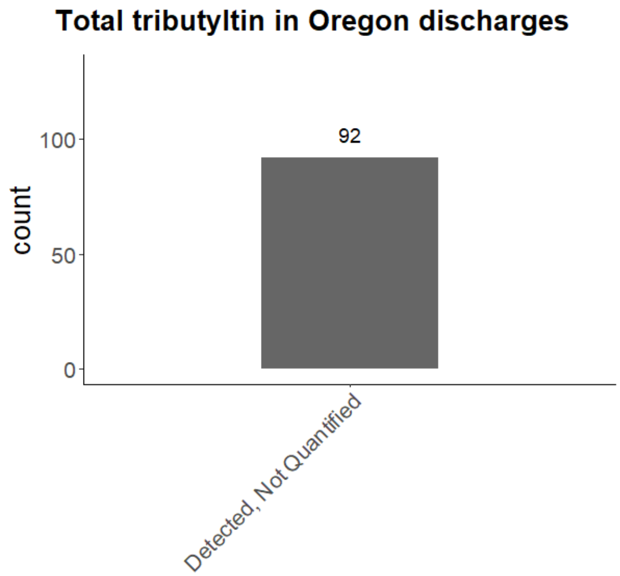


Figure A.6 Tributyltin measured in Oregon discharges. All discharge measurements were detected but not quantified.

A.2.7 Mercury

A.2.7.1 Recent actions related to mercury aquatic life criteria in the Pacific Northwest

Idaho removed the 1995 numeric mercury aquatic life criteria from state water quality standards in 2006, in favor of using the state's narrative toxics criterion in combination with the fish tissue based human health mercury criterion instead. Idaho made this change because the state concluded that available science no longer supported the 1995 mercury criteria recommendations and using the more stringent human health fish tissue criteria value would be more protective of aquatic life. In 2008, EPA subsequently disapproved Idaho's use of the mercury human health criteria values in conjunction with the narrative toxics criterion, leaving the 1984 mercury criteria recommendations in effect in Idaho for Clean Water Act purposes (EPA, 2008). During subsequent consultation by the Services, the 1984 freshwater chronic criteria value of 0.012 µg/L was not considered stringent enough to protect threatened and endangered species, and the Services directed EPA to promulgate a more appropriate, new freshwater chronic criterion in Idaho by May 7, 2021 (USFWS, 2015). To date, new mercury criteria have not been established or promulgated.

As part of a pending 2022 settlement agreement that resulted from subsequent litigation against the Services and EPA regarding mercury aquatic life criteria in Idaho, EPA has proposed to release new mercury aquatic life criteria for Idaho and initiate any needed ESA consultation with the Services within a term of 27 months (EPA, 2022b). The National Recommended Water Quality Criteria – Aquatic Life Criteria Table that is maintained on EPA's website (https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table) still displays the 1995 mercury recommendations, but features a footnote that reads:

> "*It is important to note that the mercury aquatic life criterion includes a caution that it might not be adequately protective of such important fishes as the rainbow trout, coho salmon and bluegill. The criterion was derived from data for inorganic mercury (II), but is applied to total mercury and may be under-protective if a substantial portion of the mercury in the water column is methylmercury. Also, even though inorganic mercury is converted to methylmercury and methylmercury bioaccumulates to a great extent, this criterion does not account for uptake via the food chain because sufficient data were not available when the criterion was derived. In light of these issues, EPA is working on an update to the mercury criterion*." (Accessed 10/27/2022)

A.2.8 Nonylphenol

A.2.8.1 Nonylphenol sources and uses

Nonylphenol is man-made and occurs as a mixture of isomers. The three most industrially abundant isomers are branched 4-nonylphenol (Chemical Abstract Service (CAS) No. 84852-15-3), 4-nonylphenol (CAS No. 104-40-5), and nonylphenol, (CAS No. 25154-52-3) (EPA, 2005b). The majority of industrial nonylphenol is used as an intermediate to produce other chemicals, including nonylphenol ethoxylates (NPEs), which are nonionic surfactants used in industrial processes and many consumer products including plastics, pesticides, and detergents. To a lesser extent, nonylphenol is also used in copper extraction and to color fuel oil (EPA, 2005b). Nonylphenol is produced and ubiquitously used in the United States (EPA, 2005b). In 2014, the EPA proposed a significant new use rule that will require companies to report use and manufacture for 15 different nonylphenol and NPE chemicals (Certain Nonylphenols and Nonylphenol Ethoxylates; Significant New Use Rule, 2014).

A.2.8.2 Nonylphenol mode of action and environmental fate

Nonylphenol has a non-specific mode of action that often results in a reversible cellular narcosis, or a disruption in cellular activity caused by organic chemicals. Exposure to nonylphenol has also been linked to endocrine disruption because of its estrogenicity, which is associated with reproductive effects in organisms (Environment Canada, 2002).

Nonylphenol moves into the aquatic environment through wastewater and surface runoff. Once NPEs are in the environment, they eventually degrade into nonylphenol (Mao et al., 2012). Nonylphenol is lipophilic and is generally found at greater concentrations in the sediment than in surface water (Mao et al., 2012). Nonylphenol is moderately bioaccumulative in animals.

However, laboratory and field studies do not support the level of bioaccumulation expected, demonstrating that organisms are able to metabolize nonylphenol to some degree. Once in the environment, biodegradation occurs when nonylphenol is exposed to microorganisms (EPA, 2005b).

A.2.8.3 Basis for the latest recommended nonylphenol criteria

The freshwater acute criterion for nonylphenol of 28 µg/L measured as a one-hour average, which is not to be exceeded more than once every three years on average, was determined based on data from 15 different genera. The freshwater acute criterion was calculated based on toxicity data from the following invertebrate and vertebrate species, from most to least sensitive:

1. Amphipod (*Hyalella azteca*)
2. Boreal toad (*Bufo boreas*)
3. Fathead minnow (*Pimephales promelas*)
4. Claoderan (*Daphnia magna*)

Acute data were available for the genus *Oncorhynchus* that includes threatened and endangered species in Oregon. Data were available for greenback cutthroat trout (*O. clarki stomais*), Lahontan cutthroat trout (*O. clarki henshawi*), Apache trout (*O. apache*), and rainbow trout (*O. mykiss*). Overall, *Oncorhynchus* was the eighth most sensitive genus and while *Oncorhynchus* data were not explicitly used to derive the acute criterion, the recommended acute criterion is protective of these salmonids.

The freshwater chronic criterion for nonylphenol of 6.6 µg/L measured as a four-day average, which is not to be exceeded more than once every three years on average, was determined using acute freshwater data in conjunction with the acute-to-chronic ratio from the following species:

1. Mysid (*Americamysis bahia*)

It is important to note that although mysids are saltwater species, EPA mysid data were used in lieu of other freshwater data in accordance with methods outlined in the Guidelines. Chronic freshwater data were available for a limited number of species, including rainbow trout (*O. mykiss*). The freshwater recommended chronic criterion value was lower than the chronic toxic effect value for *O. mykiss*, indicating that the recommended criteria would be protective of salmonids in the genus *Oncorhynchus,* which also contains other Oregon threatened and endangered species.

The saltwater acute criterion for nonylphenol of 7.0 µg/L measured as a one-hour average, which is not to be exceeded more than once every three years on average, was determined based on data from 11 different genera. The saltwater acute criterion was calculated based on data from the following genera, from most to lease sensitive:

1. Winter flounder (*Pleuonectes americanus*)
2. Coot clam (*Mulinia lateralis*)
3. Mysid (*Americamysis bahia*)
4. Grass shrimp (*Palaemonetes vulgaris*)

None of the acute saltwater data correspond to genera containing Oregon's threatened or endangered species.

The saltwater chronic criterion for nonylphenol of 1.7 µg/L measured as a four-day average, which is not to be exceeded more than once every three years on average, was determined using acute saltwater data in conjunction with acute-to-chronic ratios from the following species:

1. Mysid (*Americamysis bahia*)

None of the chronic saltwater data correspond to genera comprising Oregon's threatened or endangered species.

A.2.8.4 Nonylphenol in Oregon waters

No nonylphenol data from Oregon waters were available in AWQMS for comparison with the recommended EPA criteria. However, the EPA's Water Quality Exchange contained nonylphenol surface water data from several other states (Wisconsin, Utah, New Mexico, Colorado, Arkansas, Indiana, California, and Washington) (National Water Quality Monitoring Council, 2020). Of these 198 nonylphenol measurements, 133 of them were below the laboratory detection or reporting limit. Most commonly, the quantification limit was roughly 0.050 µg/L, indicating that most (>85%) censored nonylphenol measurements were also below the chronic nonylphenol criterion of 6.6 µg/L. The remainder of the measurements had quantification limits higher than the criteria which made it impossible to determine whether nonylphenol concentrations were above or below acute and chronic criteria.

Of the 65 quantifiable nonylphenol surface water measurements in other states, the 75th percentile of nonylphenol was still below the chronic criterion (Table A.9). High measurements of nonylphenol (20+ µg/L) were all collected from channelized streams in Washington state.

Table A.9. Statistical summary for quantified nonylphenol concentrations in surface waters from other states

	n	Nonylphenol (µg/L)

Measurement Type		minimum	Percentile							maximum
			5th	10th	25th	50th	75th	90th	95th	
Surface Water (Other States)	65	0.098	0.56	0.62	0.80	1.42	3.60	15.49	30	80

A.2.8.1 Recent findings related to nonylphenol aquatic life criteria

In June 2022, the EPA published the biological evaluation assessing the impacts of the Water Quality Standards adopted by Swinomish Tribe in the Pacific Northwest on threatened and endangered species (EPA, 2022a). That analysis indicated that EPA's 2005 recommended nonylphenol criteria would be likely to directly adversely affect Chinook Salmon, Steelhead, Bull Trout, Chum Salmon and likely to indirectly affect the prey species of Chinook Salmon, Steelhead, Bull Trout, and the Marbled Murrelet. All of the named species are also threatened or endangered species in Oregon. Based on this finding, it seems unlikely that the 2005 recommended nonylphenol aquatic life criteria will successfully pass through ESA consultation and be approved by EPA.

A.2.9 Selenium

A.2.9.1 Selenium sources and uses

Selenium is a naturally occurring element that is essential in small quantities but toxic at concentrations that are not much higher. It is a common component of sedimentary rocks, with shales tending to have the highest concentrations. Natural weathering can enrich selenium concentrations in surface waters. Certain anthropogenic activities can also lead to selenium enrichment. The mining of metals and minerals, the refinement and use of fossil fuels, and irrigation of selenium-rich soils or use of selenium-rich groundwater are the most common anthropogenic activities that move selenium into the aquatic environment (EPA, 2021a; Seiler, 1995)

Mining can bring selenium-rich minerals to the surface, which can lead to natural weathering. Selenium pollution can be common in areas of heavy phosphate mining including Idaho, Montana, Wyoming, and Utah, as well as areas of heavy coal mining including West Virginia, Kentucky, Virginia, and Tennessee. Selenium is also often released during the mining and refinement of sulfide deposits of iron, uranium, copper, lead, mercury, silver, and zinc (EPA, 2021a). The Oregon Department of Geology and Mineral Industries (DOGAMI) provides data regarding mineral and mine locations in Oregon. Of 21,101 records of mineral deposits and past or present mines in Oregon, 164 list coal and only two list phosphorus as a commodity. Other minerals that are commonly associated with selenium (see above) are listed as commodities for a total of 3,672 records (Niewendorp & Geitgey, 2020).

Coal fired power plants can contribute to selenium pollution through coal combustion, but also through the deposition of fly ash in waste ponds that are enriched for selenium and can leach into surrounding waterways (Gillespie & Baumann, 1986). Portland General Electric own Oregon's only remaining coal-fired power plant near Boardman, OR, which closed in 2020 (PGE, personal communication, January 14, 2010).

Compared with other regions of the United States, Oregon has a lower concentration of selenium in surficial soils than many regions. Mean county values in the U.S. range from 0.01 to 5.32 parts-per-million selenium (USGS, 2017). Oregon soils with the highest concentration of selenium can be found along the coast, in the Portland metro area, as well as in eastern Oregon. Irrigation with selenium-rich groundwater can also cause selenium loading in surface waters (Seiler, 1995).

A.2.9.2 Selenium mode of action and environmental fate

Although acutely toxic at high concentrations, the worst effects of selenium in the aquatic environment occur through chronic exposures, when selenium bioaccumulates in animal tissue. Selenium causes severe toxicity in egg-laying vertebrates. In most cases, acutely toxic levels of selenium are much higher than observed environmental levels. It is clear that the worst effects of selenium are dictated primarily by the uptake of selenium into primary producer, and selenium bioaccumulation as a result of dietary uptake rather than direct uptake via the water column (Chapman et al., 2010). Chronic selenium toxicity is therefore a greater concern than acute toxicity, and occurs when selenium is transferred to eggs, causing reproductive toxicity in egg-laying vertebrates.

Selenium enters the aquatic environment through runoff from irrigation of selenium-rich soils or with selenium-rich groundwater, natural weathering of selenium rich sedimentary rocks, mining runoff, coal fired power plant fly ash discharge, and runoff or deposition from the refinement and use of fossil fuels (EPA, 2021a). In the aquatic environment, selenium can exist as inorganic selenium, although it is the organic form of selenium (organoselenium) in plants and microbes which is then transferred up through the food web and becomes a toxic threat to animals in higher trophic levels. In surface waters, the primary dissolved species of selenium are inorganic selenate and selenite, followed by organic selenides in fine particulate matter. There is very little conversion between the forms in surface waters, and the form is dictated by the selenium source. Selenate predominates in waters contaminated by agricultural irrigation drainage, treated oil refinery effluent, mountaintop coal mining, and copper mine discharge, while selenite comes from oil refinery effluent, fly ash disposal effluent, and phosphate mining overburden leachate. Organoselenium may come from treated agricultural drainage in ponds (EPA, 2021a). The largest step in selenium bioaccumulation comes when dissolved selenate, selenite, and organic selenides are incorporated into the tissues of algae and other microorganisms where the selenium is then transformed into organoselenium. Bioaccumulation factors at this stage can range from several hundred to tens of thousands.

A.2.9.3 Basis for the latest recommended selenium criteria

Low concentrations of selenium in the aquatic environment can cause significant reproductive toxicity in fish and other vertebrates through bioaccumulation through dietary uptake. The most sensitive biological effects (larval deformities and mortality from selenium bioaccumulation in adult fish) cannot be observed in typical acute and chronic measures of toxic effect. Thus, the EPA's 2016 recommended freshwater selenium chronic criterion was derived from studies that demonstrate quantitative chronic effects of long-term exposure to selenium. Although the minimum data requirements of eight taxonomic groups recommended by the Guidelines were not met, the EPA concluded that the missing data came from groups that were less sensitive than fish (insects, crustaceans) and a genus-level sensitivity distribution approach was used to derive the chronic criterion for selenium (EPA, 2021a).

The primary element of the selenium chronic criterion of 15.1 mg/kg dry-weight selenium in egg/ovary tissue not to be exceeded, was determined based on data from eight different genera. These data included reproductive studies measuring effects in offspring in cases where selenium in the mothers was transferred via the eggs. All of the data on reproductive effects came from fish species, because they were the most sensitive to the effects of selenium. Data from the following species were used to establish the primary egg/ovary element of the recommended selenium criterion.

1. White sturgeon (*Acipenser transmontanus*)
2. Bluegill sunfish (*Lepomis macrochirus*)
3. Brown trout (*Salmo trutta*)
4. Rainbow and cutthroat trout (*Oncorhynchus*)

Egg/ovary data for the most sensitive genera included threatened and/or endangered species in Oregon. White sturgeon (*A. transmontanus*), Cutthroat trout (*O. clarkii*) and rainbow trout (*O. mykiss*) were among the most sensitive genera tested, and Dolly Varden (*Salvelinus malma*) was the 8th most sensitive species, indicating that the recommended egg/ovary criterion element is designed to be protective of these sensitive groups.

The secondary element of the selenium chronic criterion of 8.5 mg/kg dw whole body or 11.3 mg/kg dw muscle (skinless, boneless filet) not to be exceeded, was determined based on data from 15 different genera used to translate the reproductive study values to whole body or muscle tissue values. Data from the following genera were used to establish whole body and muscle criterion elements, in order of most to least sensitive (by tissue type listed).

1. *Acipenser* (whole body and muscle)
2. *Lepomis* (whole body), *Oncorhynchus* (muscle)
3. *Oncorhynchus* (whole body), *Lepomis* (muscle)
4. *Salmo* (whole body and muscle)

As with the egg/ovary element, these data included genera from threatened and endangered species in Oregon (*Acipenser, Oncorhynchus*).

The water column criterion was determined by using a mechanistic model of bioaccumulation to translate egg-ovary concentrations into water column values. One value was determined for lentic (standing) systems (1.5 µg/L) and one for lotic (flowing) systems (3.1 µg/L) to reflect the different dynamics due to physical conditions. These values are expressed 30-day averages not to be exceeded more than once in three years on average. The 30-day average period is specified to account for the long term, bioaccumulative nature of selenium. The final element of the chronic criterion is an intermittent exposure water criterion intended to limit cumulative exposure to selenium and was produced as a reorganization of the 30-day average element. The equation for the intermittent element can be found in footnote *e* Table 15.

Because both the secondary fish tissue element of the selenium chronic criterion and the subsequent water column values were translated or modeled using the same genera that determined the primary criterion element, these elements are expected be protective of the same genera containing threatened and endangered species as the primary element.

A.2.9.4 Selenium in Oregon tissue and water

A.2.9.4.1 Selenium in Oregon fish tissue

Although no egg/ovary fish tissue data were available from Oregon waters to compare with the primary egg/ovary chronic selenium criterion value, both whole body and muscle fish tissue data were available to compare against the secondary whole body and muscle tissue criterion values. All the available whole body and muscle tissue values in AWQMS were reported as wet weight samples, while the selenium criterion is expressed as dry weight. To estimate dry weight measurements from the wet weights in AWQMS, DEQ followed the procedure provided in EPA's draft selenium guidance (See Appendix A.1.2.4).

Selenium was detected but not quantified in six whole body fish tissue samples and in 92 muscle tissue samples. For both sample sets, the laboratory reporting limits for selenium in tissue (1 mg/kg or below), were well below the values for whole body or muscle tissue recommended criteria, indicating that samples where selenium was detected but not quantified were also below the recommended tissue criterion values. In addition, all the quantified whole body (44) and muscle tissue samples (21) were below the recommended criteria as well (Table A.10, Figure A.7). The most frequently sampled fish were rainbow trout (*Oncorhynchus mykiss*), smallmouth bass, (*Micropterus dolomieu*), largemouth bass (*M. salmoides*), and white sturgeon (*Acipenser transmontanus).* The four highest selenium tissue concentrations (>10 mg/kg dw but below the applicable criterion of 11.3 mg/kg dw) came from largemouth bass muscle tissue in Hagg lake, a lentic environment. Lentic environments are generally considered higher risk for selenium bioaccumulation.

Given that all fish tissue measurements that could not be quantified were below the criteria as well as all of the quantified measurements, it is useful to note that over half of the muscle tissue measurements (74 of 113) came from lentic environments, along with eight of the 50 whole body measurements. While more fish tissue data especially from lentic environments may be needed to understand the potential of Oregon fish to exceed the recommended tissue criterion, preliminary tissue concentration data indicate no measurements higher than the recommended whole body and muscle tissue criteria.

Table A.10. Statistical summary for quantified selenium concentrations in Oregon fish tissue

Measurement Type	n	Selenium (mg/kg dry weight)								
		minimum	Percentile							maximum
			5th	10th	25th	50th	75th	90th	95th	
Whole Body	44	0.29	0.53	0.79	1.2	1.2	4.0	5.2	5.5	5.7
Muscle	21	2.2	2.2	2.4	3.3	4.3	9.6	10.1	10.1	11.2

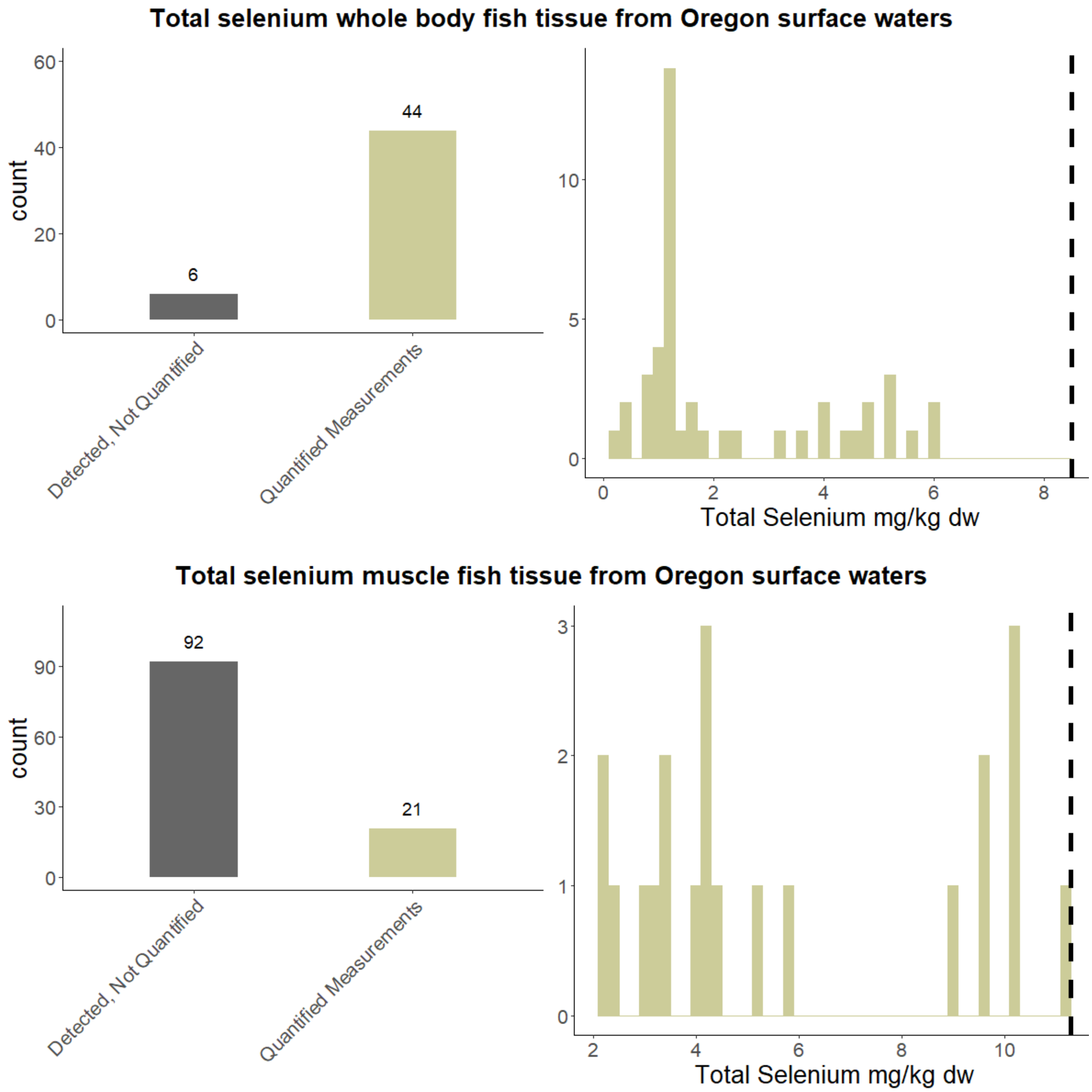


Figure A.7. Selenium measured in whole body and muscle fish tissue from Oregon surface waters. Bar graphs show the proportion of measurements that were not detected, detected but not quantified, and quantified. Histograms display the distribution of quantified measurements relative to the proposed criteria. The dashed black vertical lines correspond to the proposed freshwater chronic criterion tissue values (8.5 µg/L for whole body, 11.3 µg/L for muscle tissue) for selenium. All quantified measurements to the left of that line are also below the proposed criterion.

A.2.9.4.2 Selenium in Oregon surface waters

A total of 4,440 dissolved selenium measurements in lotic waters were available in AWQMS (Figure A.8). Of the 3,889 measurements that could not be quantified in lotic waters, the most common detection and reporting limits were on the order of 0.5 to 2.0 µg/L indicating that for the vast majority of cases, selenium concentrations were below the lotic criterion of 3.1 µg/L. Of the 551 measured selenium water samples from lotic environments, only 15 were higher than the recommended criterion. The maximum measured concentration was 4.9 µg/L in rivers and streams (Table A.11).

In contrast, dissolved selenium data from lentic systems was only available for 62 samples in AWQMS (Figure A.8), and most of those (57) were unable to be quantified. Given that the most common reporting limit was 2.0 µg/L, which was above the lentic criterion of 1.5 µg/L, it is not possible to know whether those 57 sample measurements are higher or lower than the criterion. All five of the quantified lentic water measurements were higher than the lentic criterion, even though the maximum measurement was only 3.8 µg/L. All quantified lentic measurements came from Cooper Creek Reservoir, Crane Prairie Reservoir, Bully Creek Reservoir, and Howard Prairie Lake. The lack of quantifiable data in lentic areas combined with all quantified measurements being higher than the recommended criterion suggests that lakes and reservoirs in Oregon may be at risk for exceeding the recommended water column criterion.

A.2.9.4.3 Selenium in Oregon discharges

A total of 410 dissolved selenium measurements in discharges were available in AWQMS (Figure A.8). For the vast majority of discharge samples where selenium was not detected or quantified, laboratory reporting limits (most commonly 1.0 to 2.0 µg/L) were also below the lotic criterion value (3.1 µg/L). Discharges are typically not permitted in lakes so the lotic criterion is a more appropriate comparison for discharges.

Of the 140 quantified selenium discharge samples, only eight were higher than the recommended lotic recommended criterion (Table A.11, Figure A.8). The maximum concentration of selenium in discharge of 30 µg/L was measured in a storm sewer in Portland, although most other samples that were above the lotic criterion were on the order of 10 µg/L or below.

Table A.11. Statistical summary for quantified selenium concentrations in Oregon waters

Measurement Type	n	Selenium (µg/L)								
		minimum	Percentile							maximum
			5th	10th	25th	50th	75th	90th	95th	

Surface Water - Lotic	551	0.011	0.027	0.037	0.060	0.12	0.26	0.58	0.85	4.9
Surface Water - Lentic	5	2.0	2.1	2.2	2.4	2.6	3.2	3.6	3.7	3.8
Discharge	140	0.068	0.12	0.14	0.22	0.37	1.2	2.4	4.0	30

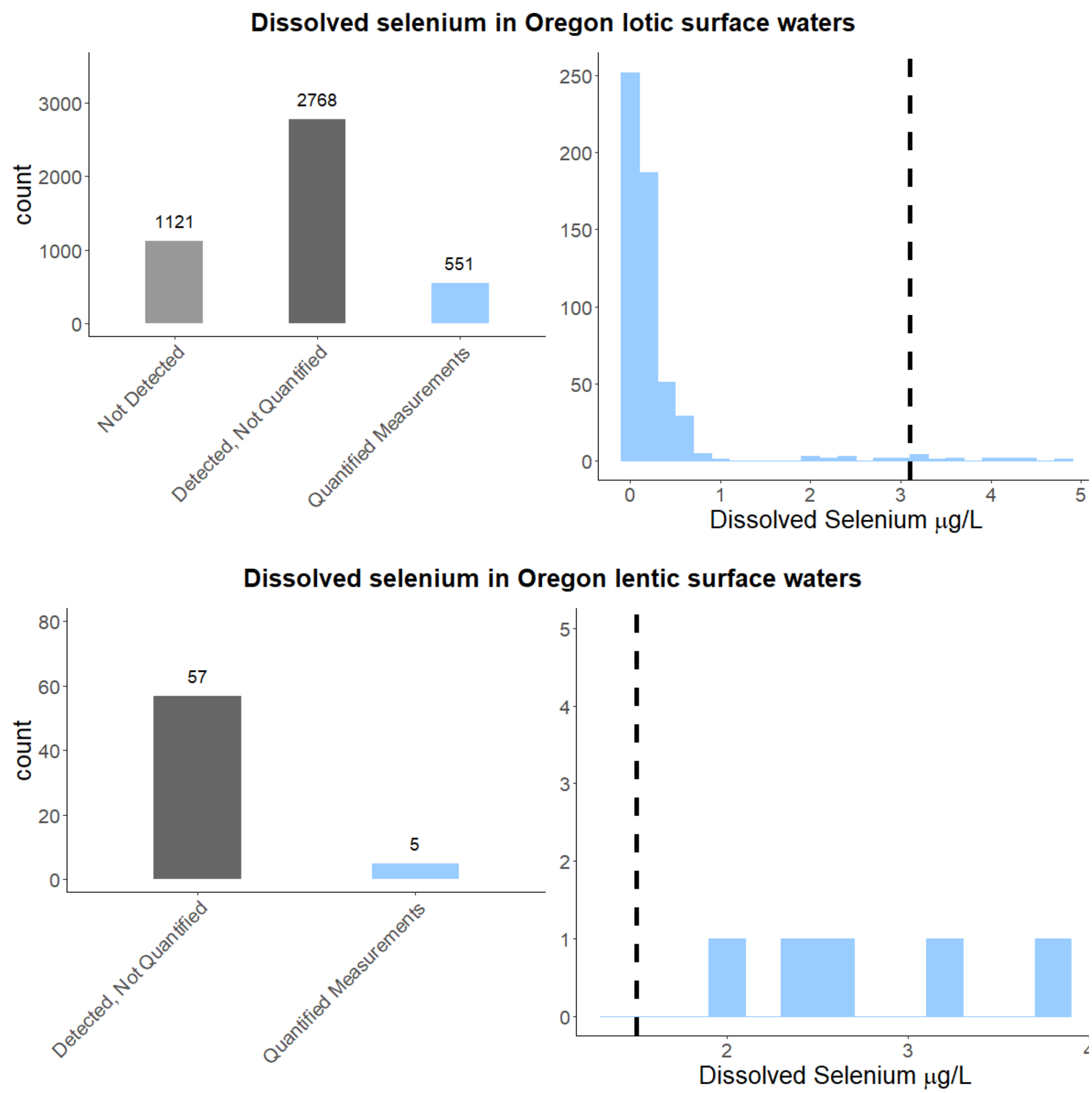


Figure A.8. Selenium measured in Oregon surface waters discharges. Bar graphs show the proportion of measurements that were not detected, detected but not quantified, and quantified. Histograms display the distribution of quantified measurements relative to the proposed criteria. The dashed black vertical lines correspond to the proposed freshwater chronic criterion values (3.1 µg/L for lotic, 1.5 µg/L for lentic) for selenium. For discharges, only the lotic criterion is displayed because discharges are typically not permitted into lentic environments. All quantified measurements to the left of that line are also below the proposed criteria.

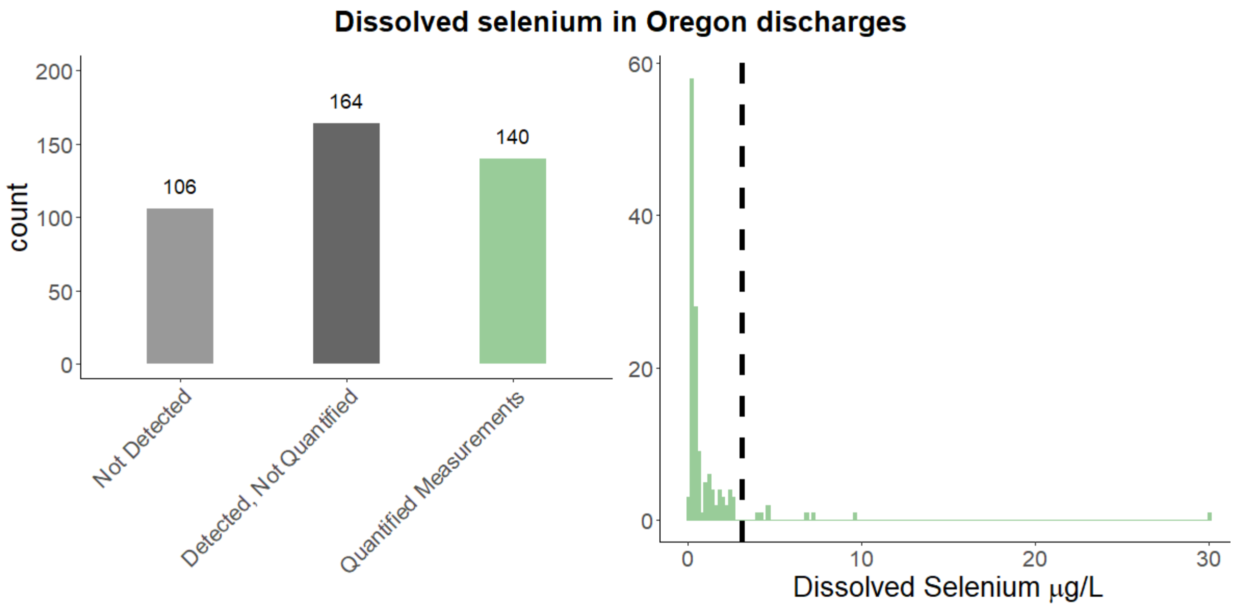


Figure A.8 (continued).

A.2.9.5 A note about implementing the 2016 recommended selenium aquatic life criteria

EPA's 2016 recommended chronic criterion is a complex four-part chronic criterion comprised of fish tissue and water column values. To successfully apply this criterion in water quality programs, Oregon would need to develop detailed implementation guidance. The criterion's specification of "steady-state" indicates that site-specific data will need to be acquired before determining which portion of the criterion to apply. If DEQ elects to adopt the criterion without developing detailed implementation guidelines, it could potentially place a large burden on Oregon's water quality programs. In the case of selenium, DEQ is mindful of the balance between the resource needs for criterion implementation and the added protection that adopting the 2016 recommended chronic criterion would provide. A preliminary discussion between DEQ and EPA in June 2023 reinforced the value that Oregon perceives in working closely with EPA to develop the complex implementation procedures for the selenium criterion before DEQ proposes to adopt the criterion.

A.2.10. Endosulfan, Lindane, and Silver

A.2.10.1 Background for endosulfan, lindane, and silver criteria

During DEQ's last comprehensive update of aquatic life toxics criteria in 2004, DEQ considered whether it should keep or remove several aquatic life criteria for which EPA had withdrawn recommendations. The 1999 EPA aquatic life criteria recommendations on which the 2004 Oregon update was based did not contain criteria for endosulfan (freshwater acute, freshwater chronic, marine acute, marine chronic), lindane (freshwater chronic), or silver (freshwater chronic), indicating that these criteria recommendations had been withdrawn (EPA, 1999). DEQ sought input from a technical advisory committee and a policy advisory committee about whether to keep or remove the existing criteria from Oregon rule (ODEQ, 2004).

EPA withdrew total endosulfan criteria but replaced them with alpha-endosulfan and beta-endosulfan criteria that had the same values as the total endosulfan criteria. In the 1999 EPA aquatic life criteria recommendation update, however, EPA included a footnote that these new criteria would be "most appropriately applied to the sum of alpha-endosulfan and beta-endosulfan" (EPA, 1999). In 2004, DEQ's technical advisory committee was concerned that this footnote would be missed given the removal of total endosulfan from the criteria recommendations, potentially resulting in an exceedance of Oregon's total endosulfan criteria while complying individually with the alpha- and beta-endosulfan criteria. Therefore, DEQ elected to keep the total endosulfan criteria because it captured the intent of EPA (ODEQ, 2004).

EPA withdrew its recommended freshwater chronic criterion for lindane in 1995 because the removal of data for fathead minnow had caused the collective toxicity data to fall below the eight minimum family data requirements for calculation of the criterion. The 2004 DEQ technical advisory committee advised DEQ to keep the freshwater chronic criterion because lindane was still used in Oregon at that time and because the committee thought the data were scientifically sound (ODEQ, 2004).

Oregon adopted the now-withdrawn freshwater chronic value for silver after it was issued in the 1986 EPA Gold Book (EPA, 1986). Subsequent publications of EPA criteria do not contain the freshwater chronic silver criterion recommendations. However, DEQ's 2004 technical advisory committee found that the data used in the chronic criterion development were credible and that the calculation of that criterion was consistent with EPA methods. Therefore, DEQ retained the freshwater chronic criterion at that time (ODEQ, 2004).