

# 2022 Aquatic Life Use Updates: Dissolved Oxygen Use Subcategories

## Rulemaking Advisory Committee Discussion Draft

### Rulemaking Program

700 NE Multnomah  
Portland, OR 97232  
Phone: 503-229-5696  
800-452-4011  
Fax: 503-229-6124

[www.oregon.gov/DEQ](http://www.oregon.gov/DEQ)

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State of Oregon  
Department of  
Environmental  
Quality

This report prepared by:

Oregon Department of Environmental Quality  
700 NE Multnomah Street, Suite 600  
Portland, OR 97232  
1-800-452-4011  
[www.oregon.gov/deq](http://www.oregon.gov/deq)

Contact:  
James McConaghie  
503-229-5619

Debra Sturdevant  
503-229-6691

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DRAFT

# 1 Methodology for designating aquatic life use subcategories – Dissolved Oxygen

## 1.1 Introduction

The objective of the water quality standard for dissolved oxygen is to protect aquatic life from anthropogenic disruption of dissolved oxygen levels. There are various cold-water, cool-water and warm-water aquatic life communities in Oregon that each have different general dissolved oxygen requirements. Since fish and aquatic life is a beneficial use that is designated for essentially every waterbody in Oregon, each water body will be assigned one of these year-round aquatic life use subcategories for dissolved oxygen.

DEQ adopted the existing dissolved oxygen standards in 1996. The use subcategories for dissolved oxygen have not been designated in rule. However, Oregon has applied the standards consistently for many years as described in memos to EPA in 1998 and 2004. These memos identify where and when the various dissolved oxygen criteria are applied to protect aquatic life and have been DEQ's standard practice since 1998. DEQ is proposing to adopt use subcategory designations in rule consistent with these existing procedures where appropriate. The new use designations shall be amendments to the basin-specific beneficial use rules in OAR-340-041-101 to OAR-340-041-340.

Unlike the beneficial use subcategories for temperature criteria, which are based on identifying the most sensitive individual species, the use subcategories for dissolved oxygen are based on protecting aquatic communities (Table 1). The dissolved oxygen criteria were designed to protect community assemblages in estuarine, marine, and freshwater systems dominated by warm, cool, and cold-water species with similar dissolved oxygen requirements. Therefore, use subcategories are not identical between the temperature and dissolved oxygen standards. Since salmonids are among the most sensitive species in terms of dissolved oxygen requirements, the use subcategories for dissolved oxygen overlap with some of the aquatic life use subcategories for temperature.

Because dissolved oxygen concentration varies through time in the natural environment, the water quality standard includes 7-day and 30-day mean criteria in addition to an instantaneous minimum of dissolved oxygen concentration. It also recognizes that dissolved oxygen concentration may not be optimal at all times or in all places for every individual organism. The water quality standards for dissolved oxygen were developed based on requirements of the most sensitive aquatic species in each community, but allow for an acceptable level of risk to occur for individual organisms as long as the community is protected (DEQ 1995a). Given these circumstances, the policy objective for the dissolved oxygen standard was to minimize risk to aquatic ecosystems from anthropogenic impacts.

**Table 1. Dissolved oxygen use categories and criteria metrics. Multiple metrics apply, including a 30-day mean of daily mean concentration (30-D) a 7-day mean of daily mean (7-D), a 7-day mean of the daily minimum (7-Mi) concentration, and absolute minimum (Min) metrics. The 7-day and 30-day metrics are calculated from continuously monitored data sets. Concentrations shown in grey shaded boxes are used as a minimum allowed concentration when evaluating grab or instantaneous samples. All criteria apply to the water column except for the inter-gravel dissolved oxygen limit (IGDO) for salmonid spawning.**

Use Subcategory	Metrics and Concentration (mg/L)			
	30-D	7- D	7- Mi	Min
Salmonid Spawning		11.0		9.0
				8.0 (IGDO)
Cold Water Aquatic Life	8.0		6.5	6.0
Cool Water Aquatic Life	6.5		5.0	4.0
Warm Water Aquatic Life	5.5			4.0
Estuarine Waters				6.5
Marine	Narrative - No change from background			

## 1.2 Beneficial Use Designations for Dissolved Oxygen– Year-Round Uses

The following decision rules are proposed to identify the aquatic life use subcategories for dissolved oxygen that occur year-round, including throughout the summer.

### 1. Cold Water Aquatic Life

The most sensitive fish and aquatic life use subcategory for dissolved oxygen is for protection of Oregon’s native cold-water communities as described in **OAR-340-041-016 Table 21**. These communities are identified as waters dominated by populations of cold- water fish that may include native salmon, steelhead, mountain whitefish, char including bull trout, and native

resident trout. The criteria for this use subcategory present no measurable risk to cold-water native fish and invertebrates species.

**Decision Rules**

DEQ designates the **Cold Water Aquatic Life** use for waters:

1. With a designated use subcategory for temperature of “Core Cold Water Habitat”
2. With a designated use subcategory for temperature of “Bull Trout Spawning and Juvenile Rearing”
3. When the beneficial use subcategory for temperature is:
  - a. Redband or Lahontan Cutthroat Trout or
  - a. Salmon and Trout Rearing and Migration, the dissolved oxygen subcategory is either cool or cold, depending on the ecoregion the waterbody is located in.

DEQ designates waters NOT otherwise designated for the "Cool Water Aquatic Life" use within NHD-PLUS catchments intersecting the following EPA Level III and Level IV Ecoregions designated as “Cold water aquatic life”:

Level III Ecoregion:	Level IV Ecoregions:
Coast Range	All
Cascades	All
Klamath Mountains	All
Willamette Valley	Willamette Valley Foothills
Eastern Cascades Slope and Foothills	Ponderosa Pine/Bitterbrush Woodland
	Pumice Plateau Basins
	Fremont Pine/Fir Forest
	Southern Cascade Slope
	Grand Fir Mixed Forest
	Pumice Plateau
Blue Mountains	John Day/Clarno Highlands
	Maritime-Influenced Zone
	Melange
	Wallowas/Seven Devil’s Mountains
	Canyons and Dissected Highlands
	Continental Zone Highlands
	Mesic Forest Zone
Subalpine-Alpine Zone	
	Cold Basins

DEQ is updating habitat distribution data for the 'Core Cold Water' and "Bull Trout Spawning & Juvenile Rearing" use subcategories for temperature based on the most recent data in ODFW's FHD for salmon, steelhead, and Bull Trout and additional Bull Trout habitat distribution from the USFWS Final Critical Habitat Rule (75 FR 63898, October 18, 2010). And the most recent life stage activity timing information provided by ODFW.

In addition, habitat distribution data for potential Bull Trout spawning and juvenile rearing habitat that is necessary for long-term health and viability of Bull Trout populations consistent with recovery plans and restoration goals for the "Bull Trout Spawning & Juvenile Rearing" use subcategory identified through consultation with ODFW and the USFWS.

Revisions to methods for identifying waters for the "Cold Water Aquatic Life" designation through revised Ecoregion-based boundaries and habitat distribution of species indicating mixed cool/cold and cool-water communities follows the revisions for "Cool Water Aquatic Life" described in the following section.

## 2. Cool Water Aquatic Life

The cool water aquatic life use subcategory recognizes that there are waters in Oregon dominated by cool water communities in the summer months that are also used by some cold-water species at least part of the year as described in **OAR-340-041-016 Table 21**. The cool-water aquatic life community is identified as those waters supporting mixed populations of native cool-water species, such as sculpin, sucker, smelt, chub, and minnows (cyprinids). Salmon, trout, and other cold-water biota may be present during part or all of the year but do not form a dominant component of the community structure. The criteria that protect this use present no measurable risk to cool-water native fish and invertebrate species and minimal risk to cold-water species, which may be present for limited times during the year.

### Decision Rules

DEQ designates **Cool Water Aquatic Life Use** for waters where any of the following conditions are met:

1. the designated use subcategory for temperature is "Cool Water Species" and the waters are **NOT** specifically identified as "Warm Water Aquatic Life" (see Warm Water Aquatic Life below).
2. the designated use subcategory for temperature is "Salmon and Steelhead Migration Corridors"
3. Waterbodies that contain cool water species according to ODFW's fish habitat distribution database (FHD) (see **Table 2** in Appendix A, below).
4. In waters where the designated use subcategory for temperature is:
  - a. 'Redband or Lahontan Cutthroat Trout' or
  - b. 'Salmon and Trout Rearing and Migration'

the dissolved oxygen subcategory is either cool or cold, depending on the ecoregion where the waterbody is located.

DEQ designates waters within NHD-PLUS catchments wholly contained within the following EPA Level III and Level IV Ecoregions as “Cool water aquatic life”:

Level III Ecoregion:	Level IV Ecoregions:
Columbia Plateau	All
Snake River Plain	All
Northern Basin and Range	All
Willamette Valley	Willamette River and Tributaries
	Gallery Forest
	Prairie Terraces
Eastern Cascades Slope and Foothills	Portland/Vancouver Basin
	Oak/Conifer Foothills
	Klamath/Goose Lake Basins
Blue Mountains	Klamath Juniper Woodland
	John Day/Clarno Uplands
	Canyons and Dissected Uplands
	Continental Zone Foothills
	Blue Mountain Basins
	Deschutes River Valley

DEQ using the most recent updated habitat distribution date from 2021 ODFW-FHD to determine where the designated use subcategory for temperature is 'Cool Water Species'. This also shows the extent of known habitat for species of concern indicating cool water communities of aquatic life.

Since 2010, DEQ has differentiated waters in the cool- and cold-water aquatic life use subcategories for purposes of implementation through a list of EPA Level III and Level IV Ecoregions. Ecoregions are delineated based on multiple factors related to geology, landforms, soils, vegetation, climate, land use, wildlife, and hydrology. The ecoregion boundaries do not generally align well with NHD watershed and catchment boundaries. Because the ecoregion boundaries are not hydrologically based, their geometry creates undesirable edge effects when these divide streams oriented longitudinally to the ecoregion boundaries. Alignment with the boundaries of NHD-PLUS catchments within these Ecoregions addresses those edge effects.

DEQ also proposes to identify waters for the "Cool" community based on distribution of cool-water species habitat in the ODFW FHD. A list of species that indicate "Cool" communities is derived from the temperature and dissolved oxygen issue papers.

### 3. Warm Water Aquatic Life

The "Warm-Water Aquatic Life" use subcategory applies to aquatic communities that are adapted to warm-water conditions and do not contain either cold- or cool-water species as described in **OAR-340-041-016 Table 21**. The warm water community is identified as those

waters whose populations are characterized by native or introduced warm-water species. The criteria that protect this use are based on a level that presents no measurable risk to warm-water native fish and invertebrates species but may present a slight risk to cold and cool-water species that are present.

DEQ designates the **warm water aquatic life** use subcategory for waters:

1. With a designated use subcategory for temperature of “Borax Lake Chub”
2. The following waters:
  - a. Malheur River – Namorf Creek to Mouth
  - b. Willow Creek – Brogan Creek to Mouth
  - c. Bully Creek - Reservoir to Mouth
  - d. Owyhee River - River Mile 0 to 18
  - e. Malheur Lake Basin - Natural lakes; water associated with Borax Lake and Lower Borax Lake
  - f. Goose and Summer Lakes Basin - Highly alkaline and saline lakes

No revisions to the established implementation procedures currently used for identifying this subcategory dissolved oxygen are being considered at this time.

DEQ has more accurate waterbody delineation available in the from the NHD- High Resolution waterbody dataset. These boundaries can be used to better identify natural lakes in the Malheur Lake Basin and highly alkaline and saline lakes in the Goose and Summer Lakes Basin for designation of waters for "Warm Water Aquatic Life". Natural lakes will be identified as the NHD waterbodies coded with the feature type (FType) for lake/pond (390). Highly alkaline and saline lakes will be identified as the NHD waterbodies coded with the FType for lakes/ponds and described by the Oregon Lakes Atlas<sup>1</sup> as saline or highly alkaline, or identified as NHD waterbodies coded with the FType for playa (361).

#### **4. Estuarine Waters**

Estuarine waters have a separate dissolved oxygen criterion from freshwaters, as stated in **OAR-340-041-0016 (5)**. Estuarine waters are defined in **OAR-340-041-0002 (22)** as all mixed fresh and oceanic waters in estuaries or bays from the point of oceanic water intrusion inland to a line connecting the outermost points of the headlands or protective jetties.

DEQ uses the estuary classification used by the Oregon Department of Land Conservation and Development (DLCD) Oregon Coastal Management Program<sup>2</sup> to delineate estuarine waters<sup>3</sup>. **Estuarine waters** include waters within the Estuarine Coastal, Estuarine Open Water, and

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<sup>1</sup> <https://oregonlakesatlas.org/>

<sup>2</sup> Oregon Coastal Management Program <https://www.oregon.gov/LCD/OCMP/pages/index.aspx>

<sup>3</sup> DEQ 2017, Water Quality Program Memorandum: Methods for Delineating Estuarine Water Type for Mapping Beneficial Uses and Applying Criteria

Estuarine Open Water Subtidal classes of the Oregon Department of Land Conservation and Development's Oregon Estuary and Shorelands Habitat Atlas.<sup>4</sup> The estuary delineation from the DLCD classification for the purposes of applying Oregon's water quality standards is available in a web-based GIS tool<sup>5</sup>.

No revisions to the established implementation procedures currently used for dissolved oxygen are being considered at this time. Use of the CMECS boundaries to identify estuarine waters has been used in implementation of the dissolved oxygen standard since 2017.

## 5. Ocean Waters

The "Ocean Waters" or marine waters are defined in **OAR-340-041-002 (34)** as all oceanic, offshore waters outside of estuaries or bays and within the territorial limits (3 nautical miles) of the State of Oregon. Ocean waters are determined to begin immediately offshore of designated estuarine waters and open coastline.

DEQ designates the **ocean waters** aquatic life use subcategory for the waters that meet the definition of ocean/marine waters in OAR 340-041-0002(34).

No revisions to the established implementation procedures currently used for identifying this subcategory dissolved oxygen are being considered at this time.

## 1.3 Beneficial Use Designations for Dissolved Oxygen–Seasonal Uses

### 1. Salmonid Spawning locations

"Salmonid Spawning" is a seasonal use that applies to waters with native salmon, steelhead, resident trout and char spawning habitat. The spawning criteria apply for part of the year when spawning and incubation of embryos occurs, until emergence of the fry from the gravels. The criteria established to protect this use provide a level of low to no risk of impairment to spawning, egg development and incubation to emergence from the gravels for sensitive native fish species, other native fish, and invertebrates.

#### Salmon, steelhead, and char spawning locations

DEQ identifies salmonid spawning by anadromous salmon and steelhead populations and native char in waters where:

1. Salmon & Steelhead Spawning is designated following the procedures for designating use subcategories for temperature. These subcategories will be designated on the following sub-basin maps set out at OAR 340-041-0101 to 340-041-0340: Tables 101B, and 121B, and Figures 130B, 151B, 160B, 170B, 220B, 230B, 271B, 286B, 300B, 310B, 320B, and 340B.

<sup>4</sup> <https://www.coastalatlantlas.net/estuarymaps/>

<sup>5</sup> <https://hdcgex2.deq.state.or.us/HVR291/?viewer=wqsa>

2. Where 'Bull Trout Spawning and Juvenile Rearing' is designated following the procedures for designating use subcategories for temperature.

### **Resident Trout Spawning Locations**

The spawning criteria for dissolved oxygen also apply to “active spawning areas used by resident trout species.” Therefore, resident trout spawning is a seasonal use in waterbodies or reaches that are either known or presumed to support resident trout spawning.

DEQ proposes to designate active spawning areas used by resident trout species for waters:

1. Where the ODFW FHD indicates “Primarily spawning” for a resident trout species.

In addition, spawning criteria for dissolved oxygen shall be applied where spawning use by resident trout species is presumed to occur in waters where:

2. The ODFW FHD indicates "Resident- multiple use" or "Unknown" habitat use with the following exceptions:
  - a. Resident trout spawning is **NOT** presumed to occur in waters where any of the following conditions are met:
    - i. Where 'Cool Water Species' is the designated use subcategory for temperature.
    - ii. Within timing units where ODFW's timing tables specifically indicate spawning use by resident trout species does not occur.
    - iii. Within estuarine waters (CMECS)
    - iv. Within tidally influenced riverine waters (CMECS)
    - v. Where a site-specific determination of habitat indicates habitat characteristics do not support resident trout spawning (i.e. substrate, velocity, depth, channel size)<sup>6</sup>

DEQ is updating habitat distribution for ‘primarily spawning’ habitat indicated for salmonids, including steelhead, trout, and char from the ODFW fish habitat database compiled in 2003 to the 2021 ODFW-FHD. The 2021 FHD includes much expended information about the location of resident trout habitat.

DEQ is also updating life stage activity timing information for reaches where “adult spawning” and “egg development through fry emergence” life-stage activities from ODFW’s life stage activity timing tables originally compiled in 2003 to the recently updated 2021 version.

The data on distribution on resident trout habitat in ODFW's FHD is much more comprehensive that was available previously. ODFW estimates it has identified as much as 95% of the

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<sup>6</sup> ODFW Letter to DEQ of April 10, 2006. <https://www.oregon.gov/deq/FilterDocs/ResidentTroutLetter.pdf>  
ODFW Letter to DEQ of July 2014. <https://www.oregon.gov/deq/FilterDocs/2014TroutSpawn.pdf>  
ODFW Letter to DEQ of August 14, 2014 <https://www.oregon.gov/deq/FilterDocs/2014UrbanStreamTrout.pdf>  
Clarification of Resident Rainbow Trout and Coastal Cutthroat Spawning Use in the Coquille, Nov. 13, 2020  
<https://www.oregon.gov/deq/wq/Documents/ir1820coqTroutSpawnResub.pdf>

distribution of resident trout species within Oregon in the current database. In some areas ODFW has also specifically identified where 'Primarily Spawning' habitat occurs. However, most of the habitat is identified for "Resident- Multiple Uses" where multiple life stage activities, such as spawning, rearing, and foraging, can be co-supported but ODFW has not determined the specific uses that occur at the reach level.

Without specific information about which habitat is suitable for spawning where resident trout species are 'Resident', DEQ shall presume spawning use in these waters unless there is additional information that the specific habitat and life history use by resident trout species in a waterbody excludes suitability for spawning and application of the spawning criteria under the dissolved oxygen standard.

DEQ has identified some factors which can be identified with readily available data sets that indicate resident trout spawning is not a use that could be supported in waterbodies with specific characteristics. DEQ will also work with ODFW to identify a site-specific evaluation method that can be used to determine whether a specific waterbody where resident trout species are 'resident' can or cannot support spawning as one of the multiple uses. These will be detailed in the TSD.

## 2. Salmonid spawning dates

The dates when "Salmon & Steelhead Spawning" spawning are designated, or as revised in this rule, for the temperature use subcategory also apply for the dissolved oxygen spawning criteria to protect spawning and egg incubation for anadromous salmon and steelhead. Both the temperature and dissolved oxygen criteria for spawning are derived from studies of requirements for salmonid life stages of egg incubation from adult spawning to hatch.

DEQ proposes to use the following procedures to designate when the resident trout spawning use occurs. DEQ will use data from ODFW's life stage timing tables, which include more specific data on spawn timing for resident trout species than was previously available.

### Start Dates for Resident Trout Spawning Designation

DEQ proposes to designate resident trout spawning use **starting** on the following dates:

1. On the initial data of peak use according to ODFW's timing tables, but no later than **January 1**.

### End Dates for Resident Trout Spawning Designation

DEQ proposes to apply spawning through emergence use **ending** on the following dates,:

2. On **May 15** in waters designated for resident trout spawning.
3. On **June 15** in waters where the designated use subcategory for temperature is "Core Cold-water habitat".

## Spawning Dates for “Bull trout spawning and juvenile rearing” Use Designations

In waters where the designated use subcategory for temperature is 'Bull Trout Spawning & Juvenile Rearing' on the following specific dates in the administrative basins indicated below<sup>7</sup>:

- a. **August 15 - May 15** - Deschutes, Hood, Powder
- b. **August 15 - May 30** - Klamath, Willamette, Malheur River
- c. **August 15 - March 31** - Grande Ronde- Wenaha sub-basin
- d. **August 15 - May 31** - Grande Ronde - Imnaha sub-basin
- e. **September 15 - April 30** - John Day, Umatilla, Walla Walla
- f. **September 15 - April 15** - Grande Ronde – Upper Grande Ronde sub-basin
- g. **September 15 - May 15** - Grande Ronde – Wallowa sub-basin

DEQ is also updating life stage activity timing information for reaches where “adult spawning” and “egg development through fry emergence” life-stage activities to the recently updated 2021 version of ODFW’s life stage activity timing tables. The tables contain much expanded information about timing for resident trout species than was available in 2003.

Since 2004, DEQ has used January 1 as the assumed start date for spawning of resident trout species. Like steelhead these are spring spawning species, it also assumed that waterbodies which support resident trout spawning would be able to attain the dissolved oxygen criterion by this date under natural conditions.

Analysis of new updated data for resident trout species in ODFW's timing tables shows resident trout populations initiate spawning between Nov. 1 and March 15. January 1 is the most common start date for resident trout spawning in populations across the state. Only 22 populations of resident trout identified by timing unit statewide (1.5%) start spawning before January 1. Therefore, DEQ proposed to start application of the spawning criteria by the start of peak spawning for these particularly early populations and continue to apply the current implementation procedure of January 1 for the rest. This is only slightly different from the current implementation procedures for applying dissolved oxygen spawning.

No revisions to the established implementation procedures currently used for identifying resident trout spawning end dates are being considered at this time. The method for applying spawning criteria is the same as for the 'Salmon & Steelhead Spawning' use subcategory for temperature. End dates for resident trout species are the same that apply to steelhead, which are also spring spawners and a subspecies of *Oncorhynchus mykiss* along with Rainbow and Redband trout.

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<sup>7</sup> DEQ Letter to EPA Region 10 of February 4, 2004. <https://www.oregon.gov/deg/FilterDocs/standardsclar.pdf>

## Appendix A: List of data sources

Originator	Data Set	Type	Source
OR Dept. of Fish and Wildlife	Fish Habitat Distribution Database	Organismal surveys, habitat surveys, professional opinion	<a href="https://nrimp.dfw.state.or.us/DataClearinghouse/default.aspx?p=202&amp;XMLname=1167.xml">https://nrimp.dfw.state.or.us/DataClearinghouse/default.aspx?p=202&amp;XMLname=1167.xml</a>
OR Dept. of Fish and Wildlife	Timing / In Water Work Unit Database	Locations of life stage timing	<a href="https://nrimp.dfw.state.or.us/nrimp/default.aspx?pn=timinggisdata">https://nrimp.dfw.state.or.us/nrimp/default.aspx?pn=timinggisdata</a>
OR Dept. of Fish and Wildlife	Life stage Activity Timing Tables	Observed timing of life stage presence and habitat use	<a href="https://nrimp.dfw.state.or.us/nrimp/default.aspx?pn=timingtables">https://nrimp.dfw.state.or.us/nrimp/default.aspx?pn=timingtables</a>
U.S. Fish and Wildlife Service	Bull Trout Critical Habitat Designation	Habitat surveys	<a href="https://www.fws.gov/pacific/bulltrout/finalcrithab/BT_FCH_GIS_2010.zip">https://www.fws.gov/pacific/bulltrout/finalcrithab/BT_FCH_GIS_2010.zip</a>
U.S. Forest Service	NorWeST Observed Temperature Data	Observed water temperatures	<a href="https://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST/StreamTemperatureDataSummaries.shtml">https://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST/StreamTemperatureDataSummaries.shtml</a>
U.S. Geological Survey	Occurrence locations and trait data for freshwater fishes, amphibians, and reptiles native to the state of Oregon	Observed species occurrence	<a href="https://www.sciencebase.gov/catalog/item/5bbd20f2e4b0fc368eae96a">https://www.sciencebase.gov/catalog/item/5bbd20f2e4b0fc368eae96a</a>
U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center	Foothill yellow-legged frog ( <i>Rana boylei</i> ) surveys in Oregon 2019	Observed species occurrence and eDNA	<a href="https://www.sciencebase.gov/catalog/item/5db72623e4b0b0c58b5a48ad">https://www.sciencebase.gov/catalog/item/5db72623e4b0b0c58b5a48ad</a>
Oregon DEQ Ambient Water Quality Monitoring System (AWQMS) Database	Continuous Temperature Data compiled for the Integrated Reports	Observed water temperatures	<a href="https://www.oregon.gov/deq/wq/pages/wqdata.aspx">https://www.oregon.gov/deq/wq/pages/wqdata.aspx</a>

Table 2 Species list of non-salmonid cool water community indicator species<sup>8</sup> in the FHD.

Family	Common Name	Genus	Species
Acipenseridae	Green sturgeon	<i>Acipenser</i>	<i>medirostris</i>
Acipenseridae	White sturgeon	<i>Acipenser</i>	<i>transmontanus</i>
Centrarchidae	Smallmouth bass	<i>Micropterus</i>	<i>dolomieu</i>
Clupeidae	American shad	<i>Alosa</i>	<i>Sapidissima</i> spp. <i>Clupeidae</i>
Cottidae	Columbia mottled sculpin	<i>Cottus</i>	<i>hubbsi</i>
Cottidae	Klamath Lake sculpin	<i>Cottus</i>	<i>princeps</i>
Cottidae	Klamath marbled sculpin	<i>Cottus</i>	<i>klamathensis</i>
Cottidae	Malheur mottled sculpin	<i>Cottus</i>	<i>bendirei</i>
Cottidae	Margined sculpin	<i>Cottus</i>	<i>marginatus</i>
Cottidae	Mottled sculpin	<i>Cottus</i>	<i>bairdii</i>
Cottidae	Paiute sculpin	<i>Cottus</i>	<i>beldingii</i>
Cottidae	Pit sculpin	<i>Cottus</i>	<i>pitensis</i>
Cottidae	Prickly sculpin	<i>Cottus</i>	<i>asper</i>
Cottidae	Reticulate sculpin	<i>Cottus</i>	<i>perplexus</i>
Cottidae	Slender sculpin	<i>Cottus</i>	<i>tenuis</i>
Cottidae	Torrent sculpin	<i>Cottus</i>	<i>rhotheus</i>
Cyprinidae	Tui chub	<i>Siphateles</i>	<i>bicolor</i>
Catostomidae	Goose Lake sucker	<i>Catostomus</i>	<i>Occidentalis</i> spp. <i>lacusanserinus</i>
Catostomidae	Klamath largescale sucker	<i>Catostomus</i>	<i>snyderi</i>
Catostomidae	Klamath smallscale sucker	<i>Catostomus</i>	<i>rimiculus</i>
Catostomidae	Largescale sucker	<i>Catostomus</i>	<i>macrocheilus</i>
Catostomidae	Lost River sucker	<i>Deltistes</i>	<i>luxatus</i>
Catostomidae	Modoc sucker	<i>Catostomus</i>	<i>microps</i>
Catostomidae	Mountain sucker	<i>Catostomus</i>	<i>platyrhynchus</i>
Catostomidae	Shortnose sucker	<i>Chasmistes</i>	<i>brevirostris</i>
Catostomidae	Tahoe sucker	<i>Catostomus</i>	<i>tahoensis</i>
Catostomidae	Warner sucker	<i>Catostomus</i>	<i>warnerensis</i>
Osmeridae	Eulachon	<i>Thaleichthys</i>	<i>pacificus</i>
Percopsidae	Sand roller	<i>Percopsis</i>	<i>transmontana</i>
Pogonichthyinae	Speckled Dace	<i>Rhinichthys</i>	<i>osculus</i>
Pogonichthyinae	Longnose Dace	<i>Rhinichthys</i>	<i>cataractae</i>
Pogonichthyinae	Leopard Dace	<i>Rhinichthys</i>	<i>falcatus</i>
Pogonichthyinae	Klamath Speckled Dace	<i>Rhinichthys</i>	<i>osculus</i> spp. <i>klamathensis</i>
Pogonichthyinae	Umpqua Dace	<i>Rhinichthys</i>	<i>evermanni</i>

<sup>8</sup> See DEQ issue papers for temperature (DEQ 1995b) and dissolved oxygen (DEQ 1995a)

# Literature cited

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