August Mean Dissolved Oxygen and Salish Sucker

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Species Information

Common Name: Salish Sucker
Genus: Catostomus sp.

Stressor Details

Stressor Name: August Mean Dissolved Oxygen
Units: mg/L (= ppm)
Metric: Average Disolved Oxygen for the month of August (ideally integrated using continous data, or the most representative data available).
Scale: linear
Function Type: continuous
Vital Rate/Process: Growth

Life Stage & Context

Life Stages: Adults, Juvenile
Geography: Lower Fraser Valley (British Columbia), Washington State (US)
Activity: All activities
Season: All seasons

Descriptions

Overview

The general effects of DO on system capacity were inferred based on a meta-analysis examining the effect of Dissolved Oxygen (DO) concentration on specific growth rate of fish, which evaluated data from 38 studies on 30 freshwater and marine species (Rosenfeld and Lee 2022). The shape of the curve and threshold value (5.0 mg/L) is based on segmented regression of specific growth rate as a function of dissolved oxygen averaged across 30 species. The inference implicit in using growth as the response variable is that threshold effects of low DO on individual growth will be similar to population-level effects. Although the average segmented regression across all species is highly significant and the threshold of 5.0 mg/L is consistent with previous analyses and regulatory guidelines for water quality, it should be noted that there remains great inter-specific variation around the mean response. Some species are relatively insensitive to hypoxia, particularly warmwater species, and others (particularly coolwater species and salmonids) showing higher sensitivity (see Fig. 1 below from Rosenfeld and Lee 2022).

However, in terms of general application, the stressor-response function from Rosenfeld and Lee (2022) is based on lab growth assays where DO levels were fixed at constant values that did not vary over time. While this is a necessary feature of controlled lab experiments, the assumption of homogenous DO concentrations does not translate well to actual DO stressor metrics collected from natural streams, which vary with time, typically on a daily time scale with diurnal cycles in photosynthesis and respiration. In order to integrate the effects of time-varying DO over the summer growing season from May-August, we applied the "primary" DO stressor-response function from Rosenfeld and Lee 2022 (described elsewhere in this SR Library documentation as "Dissolved Oxygen and Salish Sucker") to hourly DO measurements over May-August to derive a secondary SR function where the stressor (X-axis) is mean Aug. dissolved oxygen, which is a much more easily obtained metric (in principle) than a continuous trace of DO over the summer growing season.

To achieve this, system capacity was estimated based on the modelled reduction in specific growth rate integrated over a continuous DO trace (see attached supplementary Excel file) at 33 sites measured for 3-5 days each month and inferred to be representative of the May-Aug. growing season, using data from lower Fraser Valley streams from the M.Sc. thesis of Samantha Ramirez (2024). Continuous monthly traces (hourly time series) of DO were used to integrate growth reduction over time using the primary growth reduction SR function based on homogenous DO from laboratory experiments from

Rosenfeld and Lee (2022). Modelled integrated growth reduction across the 4 months (May-Aug.) for all 33 sites was then regressed against mean August DO data from all sites to generate the secondary growth reduction SR function featured here, with average Aug. DO as the stressor metric. The secondary derived SR function is very similar to the primary DO SR function, but it has a notably higher intercept because the DO in early summer (e.g., May or June) may be high enough to support growth even when the DO in August is 0 mg/l.

NOTE: The primary DO SR function from Rosenfeld and Lee (2022), representing the average response of 30 species, was modified somewhat to account for the ecology and potential/inferred hypoxia tolerance of Salish sucker. Unlike Nooksack dace, which are a riffle-specialist species, and therefor presumably somewhat adapted to well-oxygenated riffle habitat (based on this assumption we applied the average species tolerance to Nooksack dace), Salish sucker are a benthic species that preferentially occupy deep, slow mainstem pool habitat or deeper off-channel habitat, including ponds, marshes, and wetlands. These habitat are the most likely to go hypoxic, so we consequently assumed that Salish sucker were somewhat more tolerant of hypoxia; we therefore adjusted the species-average threshold for growth reduction down from 5 mg/l to 4 mg/l for the Salish sucker SR function, and similarly deceased the threshold for zero down growth from the average of 1 mg/l to 0.5 mg/l.

NOTE 2: See the attached Excel file "Data_SS_ meanDO_SysCapacity_2026.xlsx" for additional detailed data, notes, and figures.

NOTE 3: Also note that the original segmented regression analysis in Rosenfeld and Lee (2022) was re-analyzed as a random effects segmented regression rather than treating study-species combinations as fixed effects. The final regression was very similar to that presented in Rosenfeld and Lee (2022), but is the one used here to generate the generic species-average regression, which was then modified for Salish sucker as described above.

Function Derivation

Based on data from other species; Empirical data (experimental manipulation); Published

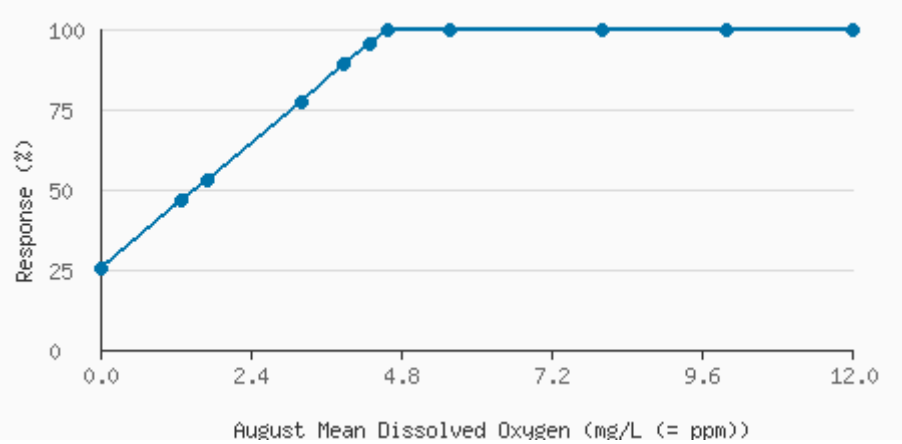
Transferability of Function

As local adaptations are likely minimal among different Salish Sucker populations, we would not expect much variation in true tolerance among populations. This function should therefore be broadly applicable to all populations of the species, with the caveat that it is based on generic data from other species.

Source of Stressor Data

DO data is available for several reaches in Bertrand, Pepin, Fishtrap Creeks, and the Salmon River, collected as part of reconnaissance surveys to assess fish distribution, monitoring associated with habitat restoration, and mark–recapture population assessments that took place between 2003 and 2018. A predictive model to estimate DO as a function of temperature, flow, and associated covariates will need to be generated to create the dissolved oxygen stressor dataset, in particular mean August dissolved oxygen. This STRESSOR ESTIMATION FUNCTION has been generated using data from Ramirez et al. (2024, M.Sc. thesis UBC), and is available in this SR Function Library by searching for "August Mean Dissolved Oxygen Stressor Estimation Function".

Stressor Response Data



Aug Mean DO (mg/L)	Mean System Capacity (%)	SD	low.limit	up.limit
0.00	25.09	4.42	0	100
1.30	46.35	3.15	0	100
1.70	52.89	3.09	0	100
3.20	77.41	4.34	0	100
3.90	88.86	5.38	0	100
4.30	95.40	6.03	0	100
4.60	100.00	2.49	0	100
5.60	100.00	2.49	0	100
8.00	100.00	2.20	0	100
10.00	100.00	2.20	0	100
12.00	100.00	2.20	0	100
12.00	100.00	2.20	0	100

Citations

Rosenfeld, J.S., and Lee, R. 2022. Thresholds for Reduction in Fish Growth and Consumption Due to Hypoxia: Implications for Water Quality Guidelines to Protect Aquatic Life. Environmental Management https://doi.org/10.1007/s00267-022-01678-9

Usoof, A.M. and Rosenfeld, J.S. 2024. Relationship between system capacity and Dissolved Oxygen concentration for Salish Sucker.

Ramirez, Samantha. 2024. MODELLING THE IMPACT OF HUMAN DEVELOPMENT AND WATER QUALITY ON HYPOXIA. UBC Masters thesis, UBC Institute for the Oceans and Fisheries.