Jager 2011: Chinook Salmon Eggs and Temperature

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Species Information

Common Name: Chinook Salmon
Genus: Oncorhynchus tshawytscha

Stressor Details

Stressor Name: Temperature
Units: °C
Metric: Incubation Temperature
Scale: linear
Function Type: continuous
Vital Rate/Process: Survival

Life Stage & Context

Life Stages: Egg
Geography: Laboratory Experiment
Activity: Incubation
Season: Winter/Spring

Descriptions

Overview

> Directly quoted from Bratovich et al 2020:
>
> "Jager (2011) reviewed and compiled mortality and exposure duration data from constanttemperature laboratory studies for Chinook salmon eggs (fertilization to hatching) and alevins(hatching to emergence). For each study, Jager (2011) standardized the survival data by dividingby the maximum survival over all temperature treatments for each study. If the study did not reportthe duration of the two lifestages, a temperature relationship was fitted to the lifestage to estimateduration.
>
> Studies incorporated for the fertilized egg relationship included Murray and McPhail (1988),Combs and Burrows (1957), Garling and Masterson (1985), Beacham and Murray (1989), Jensenand Groot (1991), and Heming (1982). Due to lack of duration data, exposure durations wereestimated for fertilized eggs for the Combs and Burrows (1957) data. Studies used in the alevinrelationship included Murray and McPhail (1988), Garling and Masterson (1985), Beacham andMurray (1989), and Jensen and Groot (1991). Due to a reported lack of lifestage duration data,durations were estimated for alevins for the Garling and Masterson (1985) and Jensen and Groot(1991) data. For studies where replicate treatments were conducted, survival rates from thereplicates were averaged (using a weighted average based on starting number of eggs or alevin)together for each water temperature treatment.
>
> Based on these data, Jager (2011) developed a model relating daily survival of Chinook salmonfertilized eggs and alevins to water temperature using a double Weibull model (Figure 6). Theright-hand side of the function for eggs (i.e., at 0% daily survival) is driven by two data pointsfrom Jensen and Groot (1991). These two data points were excluded from the Water Forumfertilized egg function development (this TM) because mortality reached 100% prior to 50% hatch,and duration to mortality was not reported. In addition, although mortality reached 100% prior to50% hatch, it is unlikely that the daily survival rate was actually 0%, particularly for the 64.4°Ftreatment. Although the equation to calculate daily survival based on cumulative survival andduration will result in a 0% daily survival rate, results from other laboratory studies (Seymour1956 and USFWS 1999) that exposed fertilized eggs to water temperatures of 64-64.6°F indicate that daily mortality rates ranged from 2.8% to 15%. In addition, short-term thermal exposure (“heat shock”) experiments found that mortality rates of Chinook salmon cleavage egg and embryo lifestages exposed to 22°C (71.6°F) for 8 hours were 10% and

3%, respectively (Neitzel and Becker 1985).

Similar to the fertilized egg function, the right-hand side of the pre-emergent fry (“alevin”)function is driven by only one data point, also from Jensen and Groot (1991), for the 61.5°Ftreatment. This data point also was excluded from the Water Forum alevin function (this TM) dueto concern over the inconsistency in the duration from 50% hatch to emergence for this temperaturetreatment relative to other treatments. Although Jager (2011) calculated the exposure durationbased on water temperature, it is unlikely that, despite the cumulative survival of 0%, that the dailysurvival rate was 0% (i.e., all alevins perished in one day) at 61.5°F, in consideration of the otherwater temperature studies. For example, daily alevin mortality rates of Sacramento River fall-runand winter-run Chinook salmon associated with exposure to 62°F across 8 replicates ranged from2.4% to 20.6% (USFWS 1999).."

Function Derivation

Manual

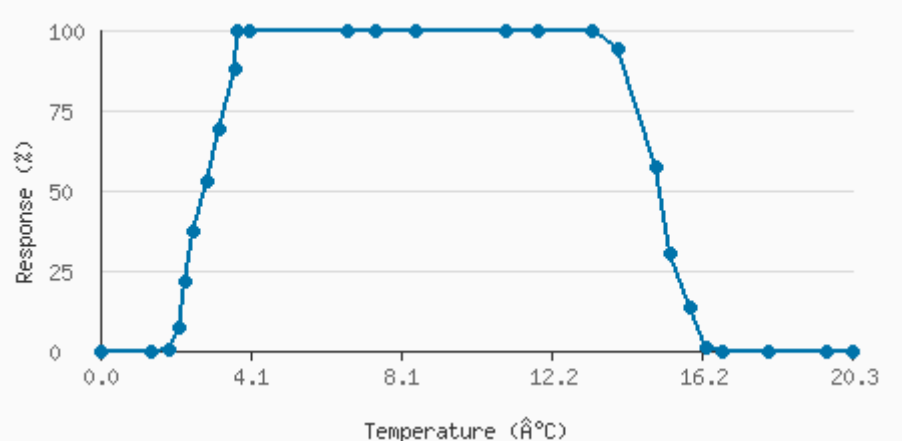
Transferability of Function

Very limited. Especially on the cold (right-hand side).

Source of Stressor Data

Lab studies

Stressor Response Data



Stressor (X)	Mean System Capacity (%)	SD	low.limit	up.limit
0	0	0	0	100
1.37	0	0	0	100
1.86	0.55	0	0	100
2.16	6.99	0	0	100
2.3	21.34	0	0	100
2.5	37.18	0	0	100
2.89	53.03	0	0	100
3.23	69.36	0	0	100
3.67	87.68	0	0	100
3.72	100	0	0	100
4.02	100	0	0	100

6.66	100	0	0	100
7.45	100	0	0	100
8.53	100	0	0	100
10.93	100	0	0	100
11.81	100	0	0	100
13.28	100	0	0	100
13.96	94.11	0	0	100
15.04	57.48	0	0	100
15.39	30.25	0	0	100
15.92	13.42	0	0	100
16.37	1.05	0	0	100
16.81	0	0	0	100
18.03	0	0	0	100
19.6	0	0	0	100
20.29	0	0	0	100

Citations

Bratovich, P., M. Neal, A. Ransom, P. Bedore, and M. Bryan. 2020. Chinook Salmon Early Lifestage Survival & Folsom Dam Power Bypass Considerations. Prepared for the Sacramento Water Forum. September 2020.

Jager, H. I. 2011. Quantifying Temperature Effects on Fall Chinook Salmon. ORNL/TM2011/456.

References

Bratovich et al 2020 - https://waterforum.org/wp-content/uploads/2020/09/Water-Forum-Water-Temp-Embryo-Survival-TM-9-23-20.pdf