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Predictions for Salmonid Egg Development

Teleost eggs are strongly influenced by temperature during embryonic development. The number of accumulated temperature units (ATUs or °C-days) to a specific developmental stage is often considered to be a constant for a species:

$$\text{ATU} = \text{Temperature} \times \text{Days} = \text{constant}$$

This model is reasonably accurate at temperatures above 5°C but increasingly overestimates incubation times at lower temperatures. Better models have been used

by many researchers to predict many development stages. A recent book chapter by Billard & Jensen (1996) contains a series of predictions for Pacific salmon and steelhead trout and for other salmonid species.

Two tables from this work are presented here as quick estimates of development rates to hatching, as well as to yolk plug closure and eyed stages for species of *Oncorhynchus* (Pacific salmon and steelhead trout).

Table 1. Predicted embryonic development times for five species of Pacific salmon and steelhead trout, using the models listed in Table 3 from Billard and Jensen (1996).

Species	Temperature °C	Yolk plug closure		Eyed stage		50% hatch	
		Days	ATUs (°C-days)	Days	ATUs (°C-days)	Days	ATUs (°C-days)
Chinook (<i>O. tshawytscha</i>)	5	26.7	133.5	51.5	257.5	102.4	511.8
	7.5	17.9	134.5	34.2	256.6	70.3	527.5
	10	13.4	133.5	24.9	249.2	52.6	526.4
	12.5	10.6	132.1	19.2	240.5	42.1	525.7
Chum (<i>O. keta</i>)	5	31.9	159.6	50.1	250.3	99.6	498.2
	7.5	19.3	145.1	32.4	243.3	72.3	542.3
	10	13.3	133.0	22.9	229.0	54.4	544.5
	12.5	9.9	123.2	17.1	214.1	42.7	533.2
Coho (<i>O. kisutch</i>)	5	22.8	114.1	46.1	230.6	93.6	467.8
	7.5	16.3	122.1	31.5	236.6	63.1	473.6
	10	12.0	119.7	22.8	227.8	45.9	459.5
	12.5	9.0	112.9	17.1	214.4	35.6	444.8
Pink (<i>O. gorbuscha</i>)	5	36.7	183.4	51.4	257.2	109.0	545.0
	7.5	22.2	166.2	32.3	242.5	80.9	606.4
	10	15.1	151.5	23.1	231.4	63.0	629.6
	12.5	11.2	139.4	17.8	222.7	54.0	674.9
Sockeye (<i>O. nerka</i>)	5	27.3	136.4	48.2	240.9	122.8	613.8
	7.5	18.3	137.0	34.3	257.2	90.5	679.0
	10	12.6	126.0	25.0	249.6	69.3	693.2
	12.5	8.9	111.4	18.5	231.7	55.4	692.5
Steelhead (<i>O. mykiss</i>)	5	17.6	88.0	34.3	171.4	70.7	353.4
	7.5	11.7	87.5	23.9	179.5	47.2	354.0
	10	8.5	84.6	17.1	171.0	32.9	328.6
	12.5	6.5	81.1	12.5	155.9	24.8	309.8

Table 2. Predicted embryonic development times (in days and ATUs) to hatch for various salmonid species based on models listed in Table 5 in Billard and Jensen (1996)(i.e., time to hatch was determined by taking the average of as many as 3 modelled predictions for temperatures ranging from 5 to 12.5°C).

Species	Temperature °C	Time to 50% Hatch	
		Days	ATUs (°C-days)
Arctic char (<i>Salvelinus alpinus</i>)	5	89.6	447.8
	7.5	56.8	425.7
	10	37.8	377.6
	12.5	26.1	326.5
Atlantic salmon (<i>Salmo salar</i>)	5	98.3	491.3
	7.5	66.8	501.2
	10	47.7	477.2
	12.5	35.4	442.5
Brook trout (<i>Salvelinus fontinalis</i>)	5	91.7	458.5
	7.5	64.2	481.8
	10	46.5	464.7
	12.5	34.5	430.8
Brown trout (<i>Salmo trutta</i>)	5	90.4	452.0
	7.5	57.9	434.0
	10	38.3	383.0
	12.5	26.0	325.5
Danube salmon (<i>Hucho hucho</i>)	5	60.7	303.3
	7.5	34.6	259.5
	10	24.0	240.3
	12.5	18.2	227.4
Rainbow trout (<i>Oncorhynchus mykiss</i>)	5	87.2	436.0
	7.5	56.2	421.8
	10	38.7	386.6
	12.5	27.9	348.4

Acknowledgement

The 2 tables above are reprinted from *Principles Of Salmonid Culture*, edited by W. Pennell and B.A. Barton, 1996, 1040 pp, with kind permission from Elsevier Science - NL, Sara Burgerhartstraat 25, 1055 KV Amsterdam, The Netherlands.

References

Billard, R., and Jensen, J.O.T. 1996. Gamete removal, fertilization and incubation. Pages 291-363 In: W. Pennell and B.A.Barton, Editors. *Developments in Aquaculture and Fisheries Science V. 29: Principles of Salmonid Culture*. Elsevier, Amsterdam.

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