

PREDICT THE HATCH

Salmon eggs develop at a rate that is partially determined by water temperature. Even cold water contributes thermal energy that is measured in Thermal Units (TUs). When a salmon egg has accumulated enough TUs, it hatches. Very cold water will result in slower egg development and a later hatch date. Warmer water will result in quicker egg development and an earlier hatch date. The optimal temperature for developing salmon eggs is 40-55 degrees F, with 48 degrees as a desirable goal. Eggs will survive temperatures close to freezing but develop very slowly. If the water is too warm, the eggs die.

Accumulated Thermal Units (ATUs) provide us with a way of using math to predict salmon hatch date and when they will be free-swimming as fry.

Here is a chart with some examples of ATUs for various salmon species (Note - we only raise chum and coho salmon for Salmon in the Schools):

Accumulated Temperature Units (ATUs) in Fahrenheit Required to Reach Developmental Stages in Salmonids		
SPECIES	HATCH	FRY
Chinook	920-980 (avg. 950)	1500-1800 (avg. 1650)
Chum	870-1000 (avg. 935)	1520-1900 (avg. 1710)
Coho	820-900 (avg. 860)	1360-1520 (avg. 1440)
Pink	1000-1200 (avg. 1100)	1600-1900 (avg. 1750)
Sockeye	1120-1280 (avg. 1200)	1720-2000 (avg. 1860)

This is how ATU prediction of salmon egg hatch date works:

1. ATU is the addition of each day's temperature increment over freezing to the previous sum. In degrees Fahrenheit, 32 is freezing. If your chiller is set to 48 degrees Fahrenheit, each day your eggs will accumulate 16 ATUs because $48-32=16$. Similarly, if your chiller is set to 50 degrees Fahrenheit, each day your eggs will accumulate 18 ATUs because $50-32=18$.
2. Your hatchery will provide the date the salmon were spawned and the temperature the eggs have been kept at. Looking at calendar, have the kids count out how many days have elapsed since egg fertilization (spawn date) and eyed-egg delivery to your school.
 - a. Example:
 - i. The eggs were spawned on November 20, 2021.
 - ii. Eyed eggs were delivered to your school on January 3, 2022.
 - iii. The eggs were kept at an average of 48 degrees Fahrenheit every day.
 - iv. Looking at the calendar, 44 days have elapsed between spawning and egg delivery (not counting the day of delivery).
 - v. We use our formula of average daily temperature – freezing temperature to calculate $48-32=16$
 - vi. We multiply days by ATUs, so $44 \text{ days} \times 16 \text{ ATUs} = 704$. This means our eggs have already accumulated 704 thermal units.
3. Using the table above, we know that Chum salmon need an average of 935 ATUs to hatch and 1710 ATUs to start swimming freely as fry. To calculate hatch date, we need to subtract the ATUs the fish have already

accumulated in the hatchery from the total ATUs required to hatch and become fry. Then we need to divide this number of ATUs by the average temperature of the classroom aquarium.

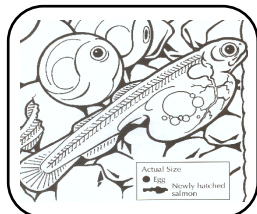
a. Example:

- i. Chum need 935 ATUs to hatch. Our eggs have already accumulated 704 ATUs.
 1. To calculate remaining ATUs needed, we find that $935 - 704 = 231$
 - ii. Next, we need to divide our remaining ATUs to hatch by the average tank temperature (in this case, 16 ATUs per day since our tank chiller is set at 48 degrees Fahrenheit)
 1. We calculate $231 / 16 = 14$ days
 - iii. Now we know that our eggs should hatch approximately 14 days.
 - iv. Have your students look at a calendar to count out how many days from now that is. In this example, it would be a predicted hatch date of January 16, 2022.
4. Do the same calculations to predict days until the eggs are fry as you did for hatch.
 5. Use the following worksheets to predict hatch date and fry stage with your students.

Introducing the worksheets to students:

1. Begin the worksheet by asking students what factors might influence when the eggs will hatch. They will probably think of temperature. Students may be aware that birds sit on their eggs to make them hatch. Body heat is a form of energy and energy is needed for growth. Discuss how fish also get energy from their immediate surroundings - the water. Challenge students to think of how they could predict when their fish eggs will hatch.
2. Students will probably offer comments like "When they get warm enough (get enough heat) they will hatch". Discuss the temperature of your aquarium. You have probably been monitoring this daily during the week prior to getting the eggs. How could water temperature affect egg hatching?
3. Explain to students that salmon eggs need energy—heat or thermal energy—to develop and hatch. The more heat they get, the faster they develop. This heat is measured in Thermal Units or TUs. Show students the Thermal Unit Chart and distribute the When Will the Eggs Hatch and the When Will the Salmon Become Fry worksheets. Work as a class or in small groups to determine what information is needed to predict exactly when hatching will occur.
4. Students should write down the information and the steps they will take to get their predictions. Help them do this by writing all the relevant information for the whole class to see - the date fish were spawned, the average water temperature at the hatchery, the average water temperature in your aquarium and the number of TU's required for hatching.
5. Ensure you have collected all the data needed for your calculations.
6. Complete the worksheets or have students devise their own way of presenting the information.
7. Each day record the water temperature. If it changes at all during the day, take two readings and find the average temperature. Use the weekly tank care sheet to record the number of TU's that accumulate each week.
8. After hatching, compare predictions to what actually happened. If the fish did not hatch on the predicted day, discuss what factors might have been involved— temperature variations throughout the day, using average temperature, miscalculations, etc.

Name: _____



WHEN WILL THE EGGS HATCH?

Chum Salmon eggs need between 870 and 1000 Accumulated Thermal Units (ATUs) to hatch. The average ATUs to hatch is 935. A Thermal Unit is the average temperature in degrees Fahrenheit minus 32 degrees (freezing).

1 Date the eggs were spawned: _____ Number of days at the hatchery: _____
Date the eggs were delivered: _____ hatchery: _____

To find the amount of TUs the eggs received while at the hatchery:

Temperature at the hatchery: _____

— 32 deg. F

Equals: _____

Multiplied by the days at the hatchery: x _____

Equals the amount of TUs the eggs have accumulated by arrival: _____

2

To find the amount of TUs left until hatching:

	Lower	Upper	Average
Thermal Units needed to hatch:	<u>870</u>	<u>1000</u>	<u>935</u>
Minus the amount of TUs the eggs had accumulated by arrival:	— _____	— _____	— _____
Equals Thermal Units left until hatching:	_____	_____	_____

3

To find the amount of TUs the eggs will receive each day:

Average temperature in the aquarium: _____

— 32 deg. F

Equals the amount of TUs the eggs receive each day: _____

4

To estimate hatch time:

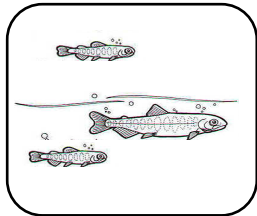
	Lower	Upper	Average
Thermal Units (TUs) left until hatching:	_____	_____	_____
Divided by the TUs the eggs receive each day:	÷ _____	÷ _____	÷ _____
Equals # of days left until the eggs hatch:	_____	_____	_____

5

Use a calendar to count the # of days for lower, upper, & average hatch dates.

6 I predict the eggs will hatch between _____ and _____.
The average date the eggs may hatch is _____.

Name: _____



WHEN WILL THE SALMON BECOME FRY?

Chum Salmon eggs need between 1520 and 1900 Accumulated Thermal Units (ATUs) to start swimming freely as fry. The average ATUs to hatch is 1710. A Thermal Unit is the average temperature in degrees Fahrenheit minus 32 degrees (freezing).

1

Date the eggs were spawned: _____ Number of days at the hatchery: _____
Date the eggs were delivered: _____ hatchery: _____

To find the amount of TUs the eggs received while at the hatchery:

Temperature at the hatchery: _____

— 32 deg. F

Equals: _____

Multiplied by the days at the hatchery: x _____

Equals the amount of TUs the eggs have accumulated by arrival: _____

2

To find the amount of TUs left until fry stage:

	Lower	Upper	Average
Thermal Units needed to become fry:	<u>1520</u>	<u>1900</u>	<u>1710</u>
Minus the amount of TUs the eggs had accumulated by arrival:	— _____	— _____	— _____
Equals Thermal Units left until fry stage:	_____	_____	_____

3

To find the amount of TUs the eggs will receive each day:

Average temperature in the aquarium: _____

— 32 deg. F

Equals the amount of TUs the eggs receive each day: _____

4

To estimate when the salmon become fry:

	Lower	Upper	Average
Thermal Units (TUs) left until fry stage:	_____	_____	_____
Divided by the TUs the eggs receive each day: ÷	_____ ÷	_____ ÷	_____ ÷
Equals # of days left until salmon are fry:	_____	_____	_____

5

Use a calendar to count the # of days for lower, upper, & average fry dates.

6

I predict the salmon will become fry between _____ and _____.

The average date the salmon may become fry is _____.