Science Unit: *The Journey of the Pacific Salmon*

Lesson 9: *Smolting*

School Year:	2010/2011
Developed for:	Thunderbird Elementary School, Vancouver School District
Developed by:	Linda Hanson (scientist); Kelly Tait and Shantelle Dixon (teachers)
Grade level:	Presented to grade 5/6; appropriate for grades 3 – 7 with age appropriate modifications
Duration of lesson:	2 hours
Notes:	The lesson length can be adjusted by decreasing the introduction or the students can start the experiment, do other work and finish the experiment later on. The experiment can run for longer than 30 minutes but should not run for less than 30 minutes as this will not be sufficient for a noticeable change in weight.

Objectives

1. Learn about salmon smolts and smoltification.
2. Learn about the process of osmosis.
3. Explore the process and consequences of osmosis by doing an experiment to observe osmosis in action. Students will relate this to what happens to salmon in freshwater, saltwater and brackish water.

Background Information

To prepare for life in the ocean juvenile salmon must undergo a variety of physical and physiological changes; this process is known as smoltification. Depending on the species of salmon, juveniles (i.e. smolts) can spend anywhere from days to years in the estuary preparing for life in the ocean. One of the biggest changes in moving from a freshwater to a saltwater environment is the change in the environment's salinity. Osmosis is a process by which water moves across a membrane (such as an organism's skin) from an area of high concentration to one of lower concentration. As a result of osmosis fish in freshwater tend to gain water. This is problematic as all living organisms must maintain a particular salt and water balance (or osmolarity) within their cells to in order to survive. To maintain their osmolarity fish in freshwater produce large amounts of dilute urine to rid themselves of excess water. Their gills also contain special cells to take up salts from the surrounding water, as some salts will unavoidably be excreted in the urine. On the other hand, fish in seawater tend to lose water to the environment and must compensate by drinking large amounts of seawater. To rid their bodies of the excess salt they ingest they have special salt secreting cells on their gills. This lesson helps students understand the concept of osmosis and the challenges it creates for outmigrating smolts.

Vocabulary

Alevin:	The first stage of a juvenile salmon's lifecycle after hatching. Alevin still have an attached yolk sac.
Fry:	The second stage of the juvenile salmon's lifecycle after it has absorbed its yolk sac.
Smolt:	A juvenile salmon undergoing changes to prepare it to live in the ocean.
Smoltification:	The changes in appearance, behavior and body processes that occur in salmon in preparation for life in the ocean.
Salinity:	A measure of the amount of salt in water.

Estuary:	An area where a river or stream empties into the ocean and freshwater from the stream/river mixes with the seawater to create an area of brackish water.
Brackish water:	A mixture of seawater and freshwater. It has a salinity somewhere between seawater and freshwater.
Osmolarity:	A measure of the salt and water balance within a fluid.

Materials

- Potatoes (russets work well)
- plastic cups
- worksheets and pencils
- 2 L freshwater (tap water is fine)
- 2 L brackish water – add 15g salt per liter of water (30g per 2 liters)
- 2 L "seawater" – add 37g salt per liter of water (74g per 2 liters)
- scale(s) capable of recording to at least 1 decimal place
- knife and cutting board to prepare potatoes

In the Classroom

Introductory Discussion

1. Today we are going to continue learning about coho salmon.
    - Last week we learned about salmon eggs and redds and we got to see some salmon eggs hatch.
    - What are salmon called after they hatch? (Alevin). This is the life stage of your salmon.
    - Where do Alevin live in the wild? (in the gravel in the stream).
    - What life stage do Alevin turn into? (fry)
    - Where do fry live? (in the stream)
    - What life stage comes after fry? (smolts) What about after smolts? (adults)
    - Where do adult salmon live? (ocean)
    - If fry live in the stream and adults live in the ocean where do smolts live? (estuary; may say stream)
    - What is an estuary? (where stream water and ocean water mix)
    - What is a smolt? (salmon preparing to move from freshwater to saltwater) This process is also known as smoltification.
    - Why do you think salmon need to prepare to change habitats from the stream to the ocean? What differences exist between the two habitats?
        - Salinity
        - Temperature
        - Type of predators
        - Size
        - Different food sources

- Which change do you think is the hardest for the salmon to cope with? (students will have a variety of answers; record them on the blackboard and discuss them briefly)
- Today we are going to talk about one of the biggest changes, salinity. We are going to do an experiment to demonstrate how changes in salinity can affect a salmon.
- Let's talk about why salinity might be a problem for fish.
- Who has ever felt really thirsty after running around in gym class on a hot day? Why? (need to replace water you sweat out). Who has ever felt really thirsty after eating a lot of salty snack food like chips or pretzels? Why do you think you felt thirsty, you weren't losing any water? (had too much salt) Why is too much salt a problem? Your body functions best when your water and salt levels are in balance. If this balance gets disrupted (by too much sweating or by eating too much salt) your brain sends a signal for you to fix it (by drinking). A word scientists use to describe the salt and water balance in your body is osmolarity.
- A salmon is the same as a human. It needs to keep its osmolarity at just the right level. (For salmon this is equivalent to a 7% salt solution.)
- So what does this have to do with salmon moving from the stream to the ocean?
- Well what happens to your fingers when you stay in the bath too long? (they get wrinkly) Why? (it is likely one student will know the answer but if not ask leading questions to have them suggest that water movement is to blame)
- I'll give you a hint. First, is our skin wrinkly because it is shrinking or because it is swelling? Think about how it might swell? To make it swell up something must be getting into your skin. We know that our skin, like a fish's skin and scales is a barrier that helps protect us, but can our skin stop everything or can some things move through it? Can air? Can water?
- Right, water is passing through the outer layers of our skin and into our cells and causing the cells to swell up.
- The same thing happens to a fish in freshwater, water moves through the skin and into the fish. To keep its osmolarity balanced it needs to excrete the extra water as urine. Fish in freshwater absorb so much water through their skin that they don't need to drink.
- We are going to do an experiment to see this in action, but we are going to use potatoes instead of fish.

2. Short description of other items to discuss or review.
    - Remind students to clean up any spilled water to prevent slips and falls.
3. Briefly describe science experiment/activity.
    - Students will work in groups of three. Students will use chunks of potato to simulate fish. Each group will have one "fish" in freshwater, one in brackish water and one in seawater.
    - Students will weigh their potato/fish prior to starting the experiment, place it in their assigned water type, leave it for 30 minutes and then reweigh the potato to determine the change in mass. Students will also make observations on any changes in appearance or physical characteristics.
4. For this experiment students will be making predictions, recording observations and results and developing conclusions based on their results.
5. Briefly describe safety guidelines.
    - The potato will be cut into chunks by the teacher or scientist.

- Do not eat the potato or drink the saltwater.

Science Experiment

Experiment Title: Osmolarity: Why do salmon drink seawater?

Purpose of Experiment: To understand the process of osmosis and how it differentially affects salmon living in freshwater and saltwater.

Experimental Treatments: The variable being tested is salinity. The levels of salinity are freshwater (0%), brackish water (15%) and seawater (37%).

Prediction or Hypothesis: Students will record their predictions on their worksheets prior to starting each stage of the experiment.
Methods and Instructions:
Set-up prior to experiment: Potatoes should be cut into small chunks 50+ grams in size prior to starting the experiment but not prior to the lesson (as the ends of the potato will dry out preventing water transfer and influencing the results).
Brief description of how students will work in groups or pairs: Students will work in groups of three so that each group has one piece of potato in each of the three salinity levels.

1. Give each student a cup and have them label the cup with their name and assigned salinity (one student per group for each salinity)
2. Have students line up at the scale (2 groups at a time) with their worksheets and help them weigh their potato chunks. Have them immediately record the weight to one decimal place. Ensure you tare the scale between each reading. If there are more scales available older students can work in groups and weigh the potato chunks on their own.
3. While students are waiting to weigh their potatoes have the students make a prediction. If water moves into our skin in freshwater what will happen to your potato in freshwater? Will this make it heavier or lighter? (record predictions on worksheet)
4. What do you think will happen to the potato in seawater? Brackish water?
5. Have student record their predictions and place the potato in their labeled cup. Leave the potatoes for ~30 minutes. During this time students can fill out their worksheets and if time permits do an additional activity – e.g. the extension activity alevins and fry from Lesson 3.
6. After 30 minutes. Have the students remove their potatoes from the various solutions, gently blot them dry and re-weigh them. They should record the weight and any additional observations on their worksheets.

Closure Discussion

1. What happened to the potato in freshwater? (got heavier, very firm) Why? (gained water)
2. What happened to the potato in seawater? (got lighter, edges feel mushy) Why? (lost water)
3. What happened to the potato in brackish water? (got heavier, but not as heavy as the one in freshwater) - the results will depend on the salinity of the brackish water used for the experiment.
4. So if salmon in freshwater gain water through their skin, why don't they get bloated? How do they get rid of the extra water? (excrete larger volumes of dilute urine)
5. Do salmon in seawater gain or lose water? (lose).
6. How do they replace the lost water? (hint, what do you do when you are thirsty? Or look at your worksheet) (they drink seawater)

7. Can people drink nothing but seawater? (no)
8. Why not? (too much salt upsets the salt balance in your body)
9. How do you think salmon deal with the increase in salt (i.e. increased osmolarity) in their bodies? (excrete excess salt through the gills)
10. Would they need to excrete excess salt in freshwater? (no)
11. So then what is one of the things salmon smolts need to do to prepare for life in the ocean? (get their salt excretion cells ready)
12. Depending on the species salmon fry can spend anywhere from days to years growing in the estuary preparing for the next phase of their life-cycle, moving into the ocean. What are some other preparations salmon need to make for life in the ocean? (Brainstorm on board)
13. Can lead the discussion by revisiting the differences between the two habitats recorded earlier: salt versus freshwater, different predators, size, different food sources, temperature etc.
14. How else are smolts different than ocean living fish? Appearance - discuss parr marks: camouflage: dappled effect due to streamside vegetation, shadows from ripples and rock etc. In ocean camouflage is to not be seen by predators above (dark) and below (white)

Name:_____

Date:_____

LESSON 9: Osmolarity: Why do salmon drink seawater?

Materials and Methods

List the materials used for this experiment:

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_____

Draw a picture of your group's experiment and describe the experimental design

_____

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Predictions

Predict what will happen to each of the potatoes after 30 minutes in the water.

1. The potato in freshwater

_____

2. The potato in brackish water

_____

3. The potato in seawater

_____

Name:_____

Date:_____

Observations

Water Type	Potato weight at start	Potato weight after 30 min	Change in weight	Does the potato weigh more or less that at the start of the experiment?
Fresh (stream)				
Brackish (estuary)				
Seawater (ocean)				

Conclusions

Describe the changes you observed after the potato spent 30 minutes in freshwater. Why you think they occurred?

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_____

Describe the changes you observed after the potato spent 30 minutes in seawater. Why you think they occurred?

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_____

Based on your observations above why do you think salmon living in the ocean drink seawater?

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_____

Name:_____

Date:_____

How would drinking seawater change a salmon's osmolarlity? What would happen to the salt levels in its body?

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Why are salmon able to drink seawater when people cannot?

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How do salmon smolts prepare for life in the ocean?

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