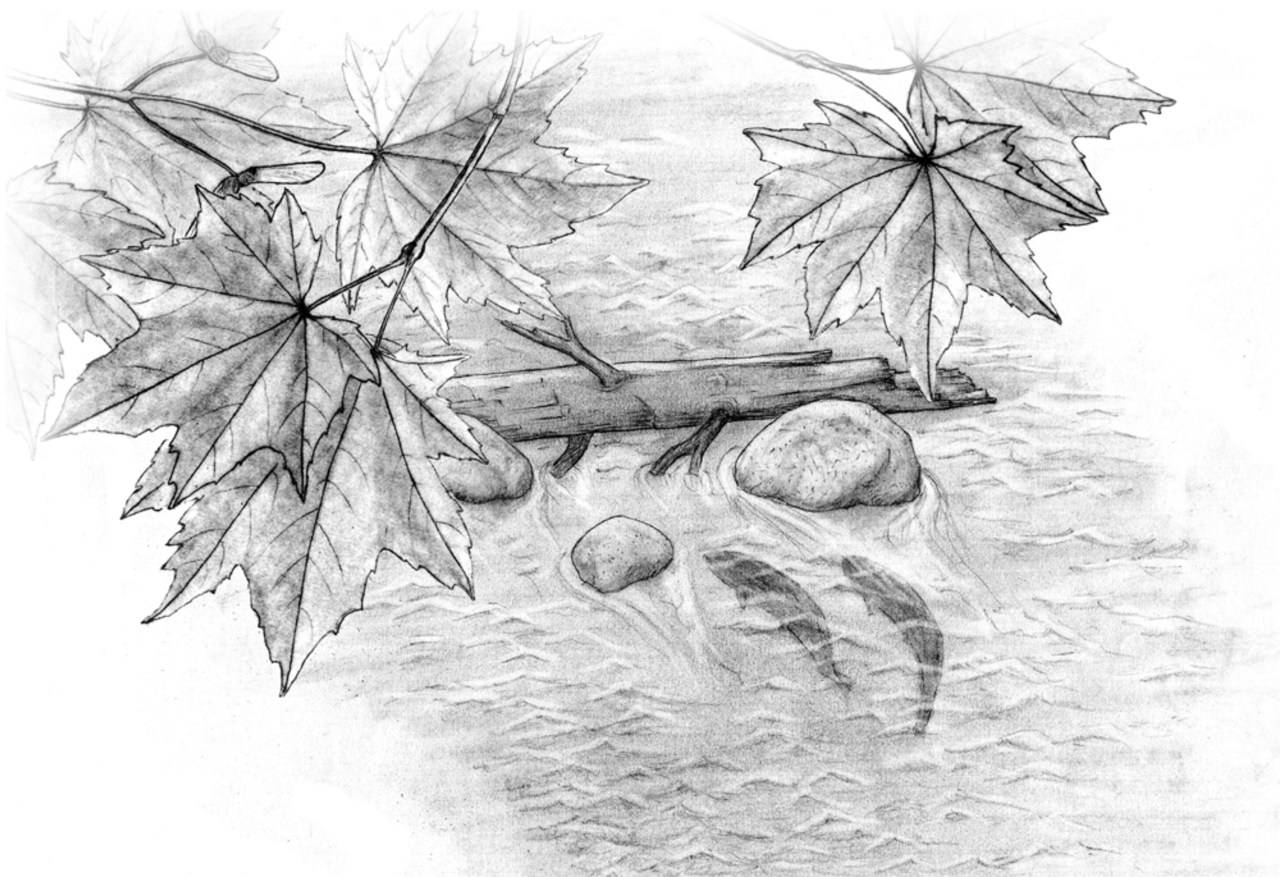
SALMONIDS IN THE CLASSROOM

INTERMEDIATE



Fisheries and Oceans Canada Pêches et Océans Canada

Canada

Salmonids in the Classroom: Intermediate

A Teachers' Resource
for Studying the Biology, Habitat and Stewardship of Pacific Salmon

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SALMONIDS IN THE CLASSROOM

Intermediate

DEDICATION

This package is dedicated to all of the teachers and students who have studied salmon over the years and especially to those classes who have gone on to turn study into action, aiding in the conservation of Pacific Salmon.

ORIGINAL VERSION

This publication takes inspiration from the original 1984 version and subsequent 1988 revised *Salmonids in the Classroom* package. Linda Bermbach, then Chief Curriculum Writer for Fisheries and Oceans Canada, coordinated the production of these first packages.

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Many thanks to Fisheries and Oceans Canada's Education Coordinators and the 116 teachers who participated in an extensive field test review of *Salmonids in the Classroom* over the 2000-2001 school year.

Foreword

Why Salmon?

"Long before the environmental stress on a river becomes obvious to most of us, it shows up in the fish. They are canaries in a mine – but canaries that cannot sing. We must pay attention to what the fish are telling us, and to the whispering voices of our rivers, for they are speaking about our future."[1]

"Because so many human activities have harmed Pacific salmon, a serious effort to save them will affect almost everyone in the Northwest"[2] Education is key to this effort.

This learning resource, which focusses on salmon, biology, and stewardship, encourages an ecological approach, integrating science with social studies. Knowledge of salmon biology and habitat are viewed as building blocks toward a stewardship ethic. Stewardship means "making informed decisions and taking appropriate actions to protect and conserve all plants and animals who share our planet."[3] And stewardship is one of the building blocks of a sustainable community where the economy, the environment and society are all taken into consideration when decisions are made. In short, this resource is about teaching kids how to "take care in our own lives so that salmon thrive!"

Whether small or large, class projects based on salmon have the potential to engage students in stewardship and sustainability. Studying a local creek, raising salmon in an incubator, or touring a watershed, are just a few of the projects that your class or school can undertake to make a difference for salmon and for us all!

Fisheries and Oceans Canada

Salmonids in the Classroom is funded by the Habitat and Enhancement Branch (HEB), Pacific Region, Fisheries and Oceans Canada (DFO). DFO's national vision is:

"Safe, healthy, productive waters and aquatic ecosystems, for the benefit of present and future generations, by maintaining the highest possible standards of: service to Canadians; marine safety and environmental protection; scientific excellence; and conservation and sustainable resource use."

HEB is responsible for the protection and restoration of fish habitat, salmonid enhancement programs, integrated resource management planning, community involvement programs and public education. HEB also operates a large number of facilities, such as fishways, hatcheries and spawning channels. HEB is headquartered in Vancouver, with area offices and staff throughout the Pacific Region, which includes B.C. and the Yukon.

[1]Mark Hume, *The Run of the River*
[2] Pacific Salmon Bring It All Back Home, *BioScience,* November, 1997, pp. 657-660
[3] *Water Stewardship: A Guide for Teachers, Students and Community Groups,* Ministry of Environment, Lands and Parks, 1995.

> “One of the most important vehicles we have for change on our planet is education. With the right teacher, learning about one’s natural environment while *experiencing* it can be a life-changing event that forever alters one’s perspective and understanding. I suppose I am living proof.”
>
> David Guggenheim,
> Vice President, The Ocean Conservancy

How to Use This Book

The foreword to this learning resource contains a table that lists seasonal activities for areas in B.C. and the Yukon. The foreword also contains tables of Integrated Resource Package (IRP) connections. The table of contents lists all of the units organized according to the salmon life cycle. Each unit has an introductory activity (use this for prior knowledge assessment) and at least one science-based activity. The wrap-up sections in each unit give teachers ideas for assessment, activities students can do at home and ways to tie the unit into salmon incubation if your class has an incubator.

Utilizing the seasonal activities and IRP tables, a teacher can plan a unit that makes sense for their timetable and that relates to the resources available in their area.

People and Connections That Can Help

Teachers are encouraged to contact a DFO office in their community and to talk to their area education coordinator or community advisor. These people will tell you about other fun DFO learning resources, classroom presentations or teacher workshops that may be available in your area. If you cannot find an office in your area, phone the Regional Office in Vancouver and ask for a community directory or visit the website http://www.pac.dfo-mpo.gc.ca.

Related Learning Resources

Fisheries and Oceans Canada has a number of other learning resources. Contact the B.C. Teachers Federation (1-800-663-9163) and ask for a catalogue or visit their web-site at http://www.bctf.bc.ca. For more depth on any education resources related to marine and aquatic environments, refer to the *Marine and Aquatic Educators Resource Guide*, produced by DFO and distributed by BCTF Lesson Aids.

Fisheries and Oceans Canada works cooperatively with other organizations involved in aquatic education, such as Wild B.C. Wild BC is a government-sponsored education program that produces a number of excellent resources on aquatic education. It is funded and administered by the Habitat Conservation Trust Fund. Call 1-800-387-9853 for more information on Wild B.C.

Bringing It All Together for Assessment

The following teaching strategies are suggested as a means of facilitating assessment.

Stewardship Activities and Field Study

"Creating Positive Human Impacts" in Unit 10 and the "Salmon Habitat Study Field Trip" in Unit 3 provide opportunities to introduce students to stewardship practices (taking care). Teachers are encouraged to implement these activities as a class project. For support, refer to "People and Connections That Can Help" on page vii of the foreword.

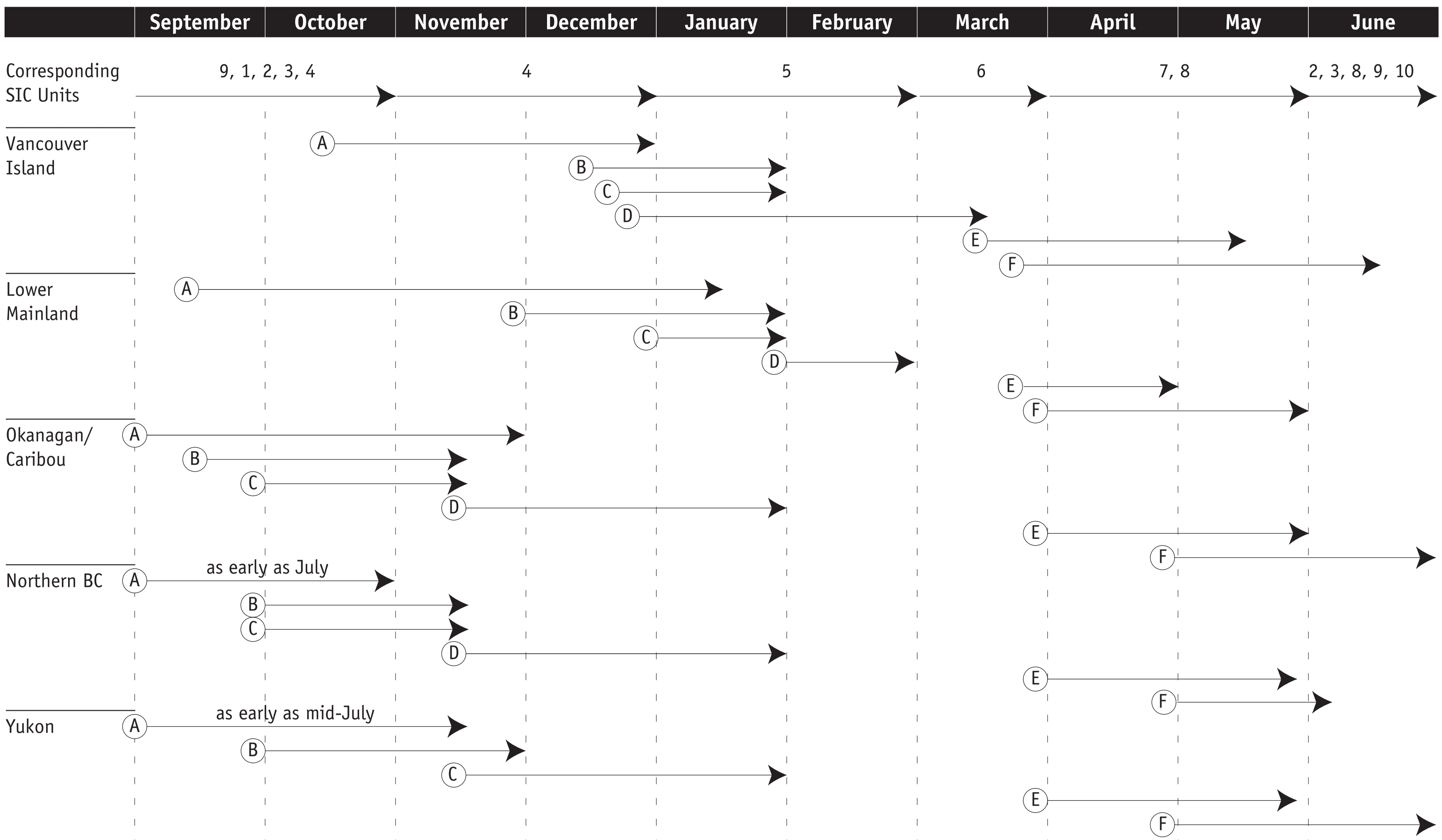
Ethical Discussions

Several of the activities in this manual involve growing plants or raising animals. Before beginning activities like this, set the ground rule for classroom conduct. *Introduce the basic rule that we must respect all living things.*

It is likely that questions about the difference between "wild", "native" and "cultured" will arise, but especially if your class wants to rear salmon or revegetate a streambank. If students want to raise salmon, talk to the area DFO education coordinator about where the eggs for your incubator will originate. DFO is trying to ensure that cultured juvenile salmon are returned to their home stream in most instances and children may not be able to release their salmon in the stream nearest to their school. If they want to revegetate a streambank talk to an area naturalist group first about what is native (i.e., grew and lived historically in the area) and either propagate native plant species or find a native plant nursery that sells native plants.

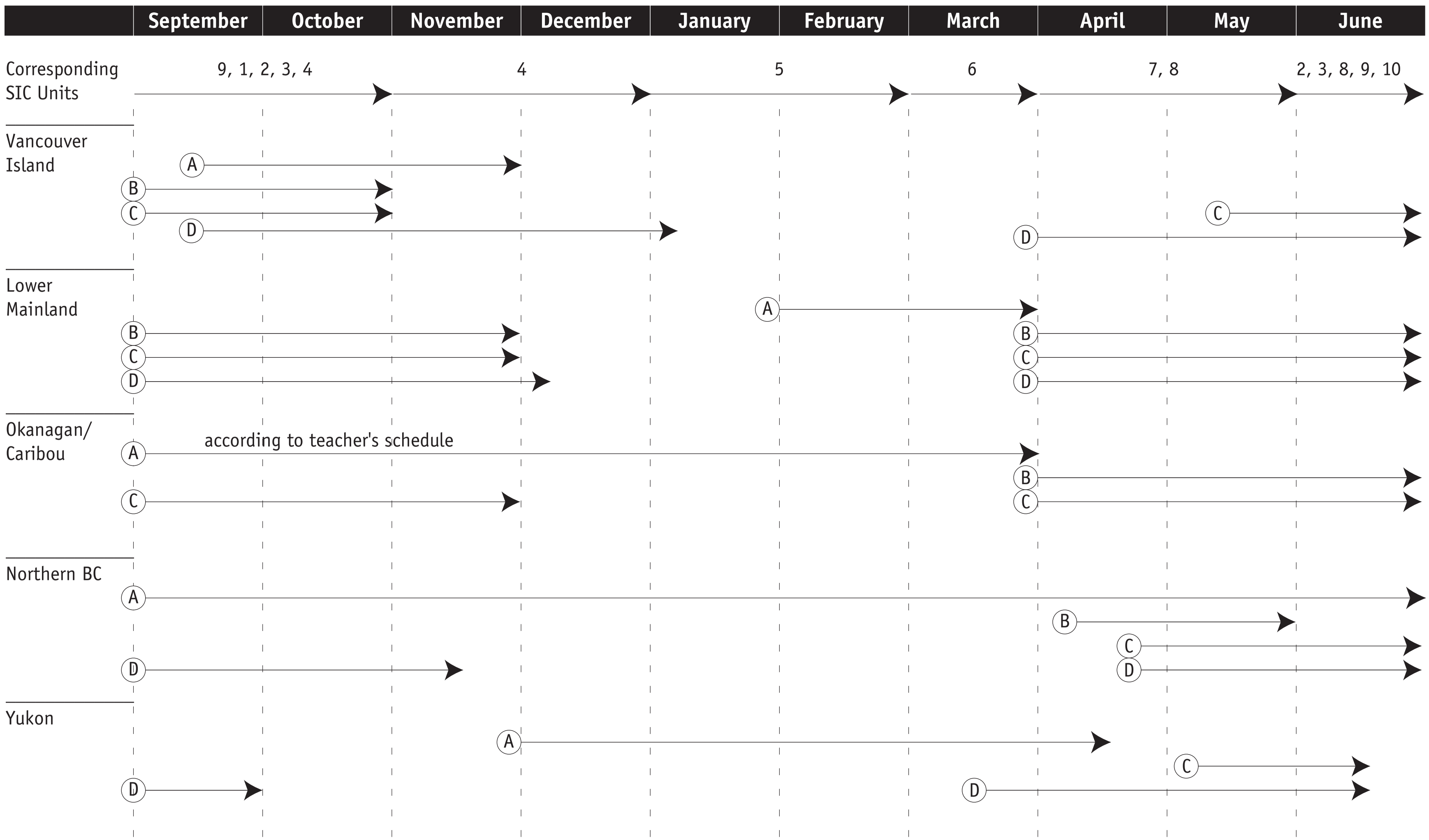
The genetic diversity activity in the Intermediate *Salmonids in the Classroom* resource facilitates discussions about "wild", "native" and "cultured". Maintaining genetic diversity (the native flora and fauna) is like maintaining a strong web. When we break the links (with non-native or cultured species), the web of life weakens. Alert the children to the fact that raising fish in the classroom is a positive achievement but that, alone, it will not solve the overall decline of salmon populations. Point out that their classroom incubator project will be most effective if it is just one tool in a whole array of community activities aimed at conserving native fish populations. Invite representatives of a local Streamkeepers group into your classroom and have them talk about the importance of habitat and stewardship.

Raising Salmon and Visiting Streams



Legend
(A) Spawning (includes all salmon species)
(B) Incubator set-up
(C) Egg delivery
(D) Eggs hatch
(E) Fry emerge
(F) Fry release

Stewardship Activities



Legend
- (A) Salmon dissections
- (B) Streamkeepers/stream clean-up
- (C) Storm drain marking
- (D) Gently down the stream/hatchery tours

Relevance to Curriculum

The following charts document the prescribed learning outcomes met by units in this resource.

Intermediate IRP Prescribed Learning Outcomes Major Headings

Grade 4

Unit #	1	2	3	4	5	6	7	8	9	10
English Language Arts										
comprehend and respond (strategies & skills)	•	•	•	•	•	•	•	•	•	•
comprehend and respond (comprehension)	•	•	•	•	•	•	•	•	•	•
communicate ideas and information (composing & creating)	•		•	•	•	•	•	•	•	•
communicate ideas and information (presenting and valuing)		•	•	•	•	•	•	•	•	•
self and society (working together)	•	•	•	•	•	•	•	•	•	•
self and society (building community)	•	•	•	•	•	•	•	•	•	•
Social Studies										
environment		•	•	•	•	•	•	•	•	•
Math										
patterns and relationships (patterns)					•			•		•
shape and space (measurement)			•							
statistics and probability (data analysis)			•					•	•	•

Grade 5

Unit #	1	2	3	4	5	6	7	8	9	10
English Language Arts										
comprehend and respond (strategies & skills)	•	•	•	•	•	•	•	•	•	•
comprehend and respond (comprehension)	•	•	•	•	•	•	•	•	•	•
communicate ideas and information (knowledge of language)	•	•	•	•	•	•	•	•	•	•
communicate ideas and Information (composing & creating)	•		•	•	•	•	•	•	•	•
communicate ideas and Information (presenting and valuing)		•	•	•	•	•	•	•	•	•
self and society (working together)	•	•	•	•	•	•	•	•	•	•
self and society (building community)	•	•	•	•	•	•	•	•	•	•
Social Studies										
environment		•	•		•	•	•	•	•	•
Math										
patterns and relationships (patterns)								•	•	•
statistics and probability (data analysis)			•						•	•

Grade 6

	Unit #									
	1	2	3	4	5	6	7	8	9	10
English Language Arts										
comprehend and respond (strategies & skills)	•	•	•	•	•	•	•	•	•	•
comprehend and respond (comprehension)	•	•	•	•	•	•	•	•	•	•
communicate ideas and information (knowledge of language)	•	•	•	•	•	•	•	•	•	•
communicate ideas and information (composing & creating)	•		•	•	•	•	•	•	•	•
communicate ideas and information (presenting and valuing)		•	•	•	•	•	•	•	•	•
self and society (working together)	•	•	•	•	•	•	•	•	•	•
self and society (building community)	•	•	•	•	•	•	•	•	•	•
Social Studies										
environment								•		
Math										
patterns and relationships (patterns)									•	•
statistics and probability (data analysis)									•	•

Grade 7

	Unit #									
	1	2	3	4	5	6	7	8	9	10
English Language Arts										
comprehend and respond (strategies & skills)	•	•	•	•	•	•	•	•	•	•
comprehend and respond (comprehension)	•	•	•	•	•	•	•	•	•	•
communicate ideas and information (knowledge of language)	•	•	•	•	•	•	•	•	•	•
communicate ideas and information (composing & creating)	•		•	•	•	•	•	•	•	•
communicate ideas and information (presenting and valuing)		•	•	•	•	•	•	•	•	•
self and society (working together)	•	•	•	•	•	•	•	•	•	•
self and society (building community)	•	•	•	•	•	•	•	•	•	•
Math										
statistics and probability (data analysis)					•				•	•

Science IRP Prescribed Learning Outcomes
Grade 4

	Unit # 1	2	3	4	5	6	7	8	9	10
Applications of Science										
• predict the results of an experiment				•	•	•	•	•	•	
• use appropriate tools to assist in observation		•	•	•	•	•	•	•	•	•
• suggest possible interpretations for a set of observations		•	•	•	•	•	•	•	•	•
• demonstrate an ability to recognize a valid interpretation of their results	•	•	•	•	•	•	•	•	•	
• present their interpretation of the results from an experiment	•		•	•	•	•	•	•	•	
• demonstrate responsible action when using the scientific information and skills they have developed									•	•
• perform an experiment by following a procedure		•		•	•	•	•	•	•	•
• use a variety of media to present information		•	•	•	•	•	•	•	•	•
Earth and Space Science										
• outline the importance of water for life		•	•				•			
• use the physical properties of water to describe or illustrate the water cycle		•								
• compare and contrast fresh water and salt water								•		
• describe human impacts on the Earth's water system		•	•	•		•	•	•		•
Life Science										
• relate the structure and behaviour of local organisms to their survival in local environments	•			•	•	•	•	•	•	•
• discuss how changes in an organism's habitat can affect the survival of individual organisms and entire species	•	•	•	•	•	•	•	•	•	•
• give examples of how the differences in individuals of the same species may give an advantage in surviving and reproducing				•					•	
• relate the growth and survival of organisms to a variety of conditions	•		•	•	•	•	•	•	•	•
• describe the basic structure and function of the organs involved in digestion				•						
• compare and contrast the digestive systems of humans and various animals				•						
• describe the basic structure and function of the skeletal and muscular systems				•						
• compare and contrast the skeletal and muscular systems of humans and various animals				•						
• relate the life processes of an organism to its use of nutrients, water, and oxygen	•			•	•	•	•	•	•	
• describe the changing requirements of organisms as they grow	•				•	•	•	•	•	•
• relate dietary habits and behaviour to an organism's health	•					•				•

Science IRP Prescribed Learning Outcomes

Grade 5

Unit #

Applications of Science	1	2	3	4	5	6	7	8	9	10
• identify relevant variables in an experiment		•		•	•	•	•	•	•	•
• identify and test a prediction		•			•	•	•	•	•	•
• classify and order based on a set of keys and criteria				•			•		•	
• correctly state a hypothesis		•			•	•		•	•	
• differentiate between relevant and irrelevant information			•	•	•	•	•	•	•	•
• use appropriate technologies to record, measure, save, and retrieve data		•	•	•	•	•	•	•	•	•
• describe technologies that allow humans to extend their natural abilities	•									
• identify ways science is used responsibly in their communities								•	•	•

Life Science	1	2	3	4	5	6	7	8	9	10
• identify living resources in the local environment		•	•	•						•
• describe how humans use B.C.'s living resources								•	•	•
• describe the known and potential environmental impacts of using B.C.'s living resources	•		•				•	•	•	
• devise a strategy for sustaining a living resource				•					•	•
• compare and contrast the respiratory and circulatory systems of humans with those of other animals				•		•				
• describe the relationship between the respiratory and circulatory systems				•						
• describe the basic structure and function of the organs in the sensory system				•						
• compare and contrast the sensory systems of humans with those of animals				•						

Science IRP Prescribed Learning Outcomes
Grade 6

Unit #

Outcome	1	2	3	4	5	6	7	8	9	10
Applications of Science										
• design a scientific test and evaluate its fairness			•	•					•	
• use instruments to make a variety of direct measurements	•		•	•			•			
• draw reasonable conclusions from experiments		•	•	•	•	•	•	•	•	•
• organize and interpret information in simple tables and graphs	•			•	•	•		•	•	•
• write clear, step-by-step instructions for conducting investigations, operating something, or following a procedure									•	•
• compare ways of solving problems and finding explanations	•		•	•	•					
• demonstrate an appreciation of the importance of keeping honest and unbiased scientific records	•	•	•	•	•	•	•	•		
Life Science										
• classify plants and animals according to their internal and external features				•			•		•	
• develop common classification systems for organisms							•		•	

Science IRP Prescribed Learning Outcomes
Grade 7

	Unit # 1	2	3	4	5	6	7	8	9	10
Applications of Science										
• select an appropriate procedure for an investigation				•	•					•
• select appropriate equipment and techniques to collect useful quantitative and qualitative information				•	•					
• investigate how models may be used to think about processes that cannot be observed directly		•		•	•	•	•	•		•
• evaluate conclusions in relation to other evidence and sources		•	•	•	•	•	•	•	•	•
• use graphs to summarize experimental data								•		•
• propose and compare options when making decisions or taking action			•				•			•
• analyze costs and benefits of alternative scientific choices related to a community problem									•	•
• take responsibility for the safe and accurate use of equipment and procedures		•	•	•	•	•	•	•	•	•
• design an experiment involving two or more variables				•						
Life Science										
• describe all organisms in terms of their roles as part of interconnected food webs	•						•	•	•	
• describe ways in which species interact with each other	•	•		•			•	•	•	
• compare and contrast the major BC biogeoclimatic zones										
• determine the limiting factors for local ecosystems	•	•		•	•			•		•
• outline the stages of recovery of a damaged local ecosystem	•					•				
• compare and contrast asexual and sexual reproduction in both plants and animals						•				
• describe the growth and changes in the development of an organism	•	•		•	•	•		•	•	•
• outline factors that influence the length and quality of life	•		•	•	•	•	•	•	•	•
Physical Science										
• use the pH scale to classify a variety of substances			•		•	•				•
• identify chemical reactions that are important in the environment				•	•	•				•
• assess the impact of chemical pollution on a local environment			•			•	•			•
• collect, analyse, and interpret data on environmental quality			•		•	•	•		•	•

Table of Contents

UNIT 1

BUILDING KNOWLEDGE: The Salmon Life Cycle

Building Knowledge: The Salmon Life Cycle

Overview

This unit gives students an opportunity to:

- examine and discuss their pre-existing ideas about salmon;
- discuss what a life cycle is;
- review the stages of a salmon's life cycle.

Key Concept

The stages in a salmon's life form a cycle, but each stage has specific needs and is vulnerable to disruption and mortality.

Vocabulary

Salmon, life cycle, habitat, waste

Background Information

In addition to the information in "Handout 10.1: Salmon Survival” the following information may be useful:

Salmon life cycle needs and threats

Life cycle stage	Needs		Threats	
	Habitat	**Food**	**Predators**	**Other**
Egg • Head and body formation begins • Organ formation begins • Eyes become visible	• Oxygenated water • Temperature from 5° to 9°C • Silt-free gravel bed • Steady water flow • Stream cover	• Yolk of egg	• Trout • Sucker • Squawfish • Whitefish • Kingfisher • Gull • Merganser • Mink • Otter	• Gravel movement • Drastic change in water temperature • Drastic change in water level • Siltation • Fine sediment • Disease • Pollution
Alevin • Embryo breaks through egg membrane • Oxygen absorbed through gills • Lives in gravel spaces	• Oxygenated water • Temperature from 5° to 14°C • Silt-free gravel bed • Steady water flow • Stream cover	• Yolk sac	• Trout • Sucker • Squawfish • Whitefish • Kingfisher • Gull • Merganser • Mink • Otter	• Gravel movement • Drastic change in water temperature • Drastic change in water level • Siltation • Fine sediment • Disease • Pollution
Fry • Inflates swim bladder • Catches food • Exhibits darting reflex • Avoids light • Guards territory • Imprints home scent	• Stream cover • Oxygenated water • Temperature from 5 to 14°C • Even water level and flow	• Larval and adult terrestrial and aquatic insects, (e.g. mayfly, caddisfly, true flies) • Rotting fish carcasses • Fish eggs	• Trout • Sucker • Squawfish • Whitefish • Kingfisher • Gull • Merganser • Mink • Otter	• Gravel movement • Drastic change in water temperature • Drastic change in water level • Siltation • Fine sediment • Disease • Pollution • Blockage of migration route

Life cycle stage	Needs		Threats	
	Habitat	**Food**	**Predators**	**Other**
Smolt • Migrates to estuary • Adapts to salt water • Developes scales and silver colour develop • Increases size	• Unpolluted water in river and estuary • Estuary vegetation for shelter	• Zooplankton (copepods amphipods, euphausids) • Insects, (e.g. beetles, ants, grasshoppers, caterpillars) • Worms • Sandfleas • Shrimp	• Mackerel • Grayling • Trout • Char • Loon • Heron • Tern • Kingfisher • Hake • Pollack • Dogfish • Older salmon	• Filling or dredging of estuary • Pollution of estuary • Diversion of river water
Ocean Phase Salmon • Migrates into ocean • Increases size • Stocks intermingle, then return to home river	• Ocean water	• Zooplankton, (e.g. amphipods, copepods, euphausids) • Larval crustaceans, (e.g. crab shrimp) • Small fish, (e.g. herring, squid, mackerel)	• Tuna • Cod • Pollock • Hake • Lamprey • Gull • Heron • Cormorant • Seals • Whales • People	• "Lost" nets • Ocean pollution • Ocean temperature change • Fishing
Spawner • Eggs, milt develop • Secondary sexual characteristics develop (colour, shape, teeth) • Scales absorbed • Eating stops • Organs degenerate	• Migration route free from obstructions • Oxygenated water • Cool clean water • Silt-free gravel	• None	• Eagles • Bears • Otters • Minks • People	• Very high or low water levels • Warm river temperatures • Obstructions (dams, slides, log jams, etc.) • Diseases • Pollution

Looking Ahead at Salmon Studies

[discussion]

Adapted from Faye Brownlie and Susan Close, Beyond Chalk and Talk*, "Anticipation Guide", pages 54 - 67*

Materials:

- One copy of "Handout 1.1: Looking Ahead at Salmon Studies" for each student
- Writing supplies

Time required:
Approximately 30 minutes

Level of conceptual difficulty:
Simple

Suggestions for assessment:
Monitor the class discussion to assess the students' level of understanding of the language and concepts used in salmon studies.

Suggested Activities

Choose activities from these suggestions that are appropriate for your class.

Discussion

- Have students form pairs and explain that this activity will focus on their knowledge about salmon.
- Have students review the first statement on "Handout 1.1: Looking Ahead at Salmon Studies" and ask questions if they are unsure of the statement's meaning. When students understand the statement, give them two minutes to write whether they agree or disagree with the statement and to state their reason(s).
- Give students two minutes to discuss their answers and reasons with their partner and to confirm or change their answers.
- Repeat the process with the remaining statements.
- Ask the class to report the number of students who agree or disagree with each statement, and record the numbers on a chart. Ask some students to give reasons for agreeing or disagreeing with each statement.

Summation

Explain that the statements reflect some of the key ideas students will investigate in the salmon studies which follow. As they do the salmon studies activities, ask them to look for information that will help confirm or change what they wrote on the handout.

Introduction to Life Cycles

Materials:
None

Time required:
10 minutes

Discussion

- Ask students to explain what a life cycle is and to give some examples.
  A life cycle is the series of stages an organism goes through from birth to death, including the reproduction of a new generation.
- Have the class state the stages in the life cycle of a salmon.
  Egg, alevin, fry, smolt, adult, spawner.
- Explain that this unit gives students a chance to review the stages and conclude their salmon studies.

Salmon Life Cycle Chart

[Building-on-what-you-know]

Materials:
One copy of “Handout 1.2: Salmon Life Cycle Needs and Threats” for each student

Time required:
Approximately one period

Level of conceptual difficulty:
Moderate

Suggestions for assessment:
Review the lists the groups create and monitor the class discussion to ensure that the students can identify key factors affecting a salmon’s life during the egg stage.

Introduction

- Read the background information in each unit to familiarize yourself with the life cycle of the Pacific salmon. This should prepare you to answer any questions your students may have as they are introduced to the salmon’s life cycle.
- Use one of the references listed in the Marine and Aquatic Educators Resource Guide to show students a film of the salmon’s life cycle, or read them a book that briefly summarizes the stages in the life cycle of a salmon.
- Give each student a copy of “Handout 1.2: Salmon Life Cycle Needs and Threats”. Have the students fill in information based on what they have heard or already know about salmon needs and habitat. Tell students that they will add details to the chart and refer back to it as they study other stages in the salmon’s life cycle.

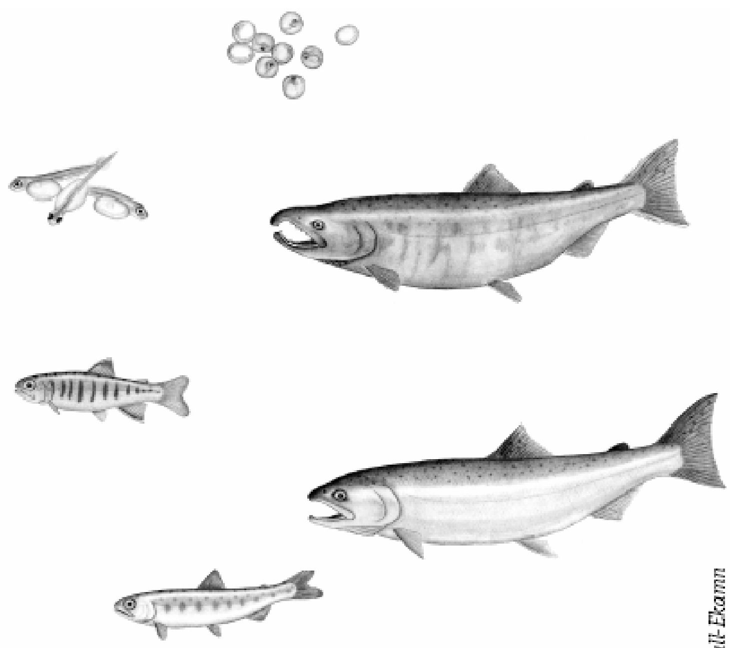


Illustration: Karen Uldall-Ekamn

BUILDING KNOWLEDGE: THE SALMON LIFE CYCLE

Wrap-up

Suggestions for Assessment

- Have students place “Handout 1.1: Looking Ahead at Salmon Studies” in a salmon studies notebook or portfolio where they can collect other materials from their salmon studies and review the contents later to see if their ideas have changed. Use the student notes or portfolio in a conference to assess student attitudes and affective changes during this unit.
- Repeat the activity after students complete their salmon studies and have them compare their answers. Have them write a reflective journal entry in which they examine how and why their opinions changed.

HANDOUT 1.1

Looking Ahead at Salmon Studies

Name ____

	What do you know about…	What Would You Like To Know About …
The salmon life cycle?		
Salmon needs and threats?		
Healthy salmon habitat		
Salmon anatomy?		
Incubation?		
Water Quality?		
Responsible Fishing?		
Stewardship?		

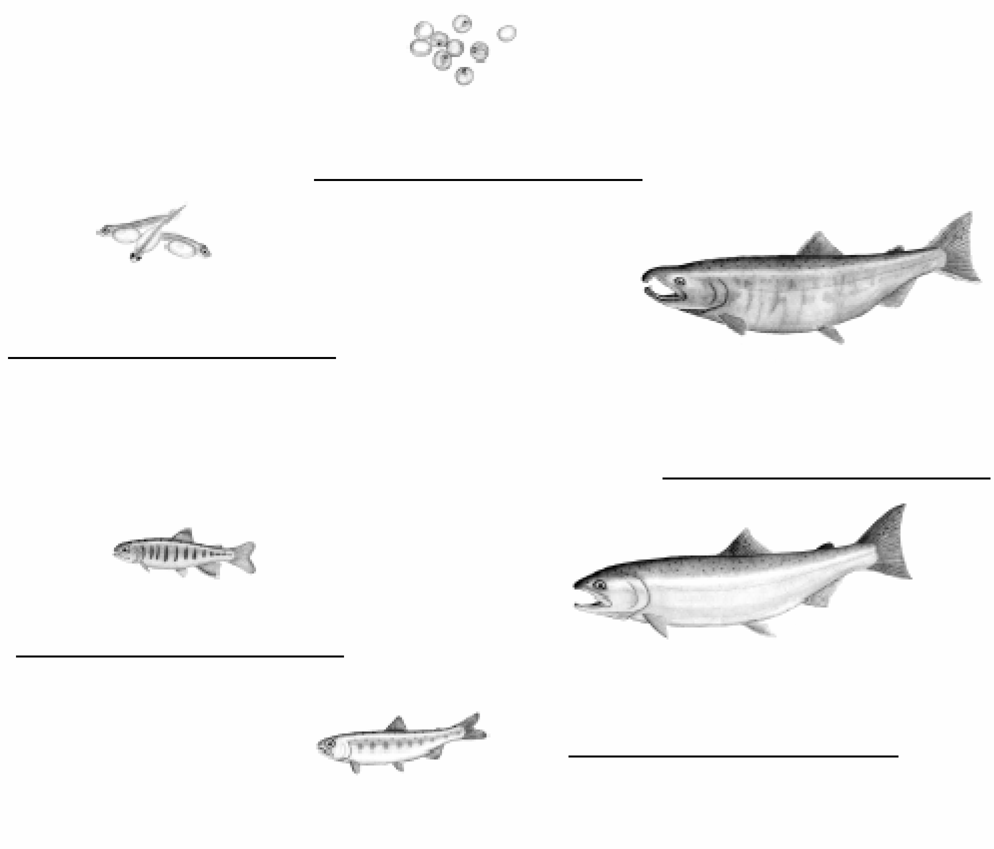
HANDOUT 1.2

Salmon Like Cycle Needs and Threats

Life cycle stage	Needs		Threats	
	Habitat	Food	Predators	Others
Egg				
Alevin				
Fry				
Smolt				
Adult salmon				
Spawner				

HANDOUT 1.2

Salmon Like Cycle
Needs and Threats



UNIT 2

WATER CYCLE, WATERSHED & THE SALMON

Water Cycle, Watershed and the Salmon

Overview

This unit gives students an opportunity to:

- discuss what the water cycle is;
- observe water cycling in a glass container;
- construct and discuss a model of a watershed;
- begin to construct a watershed wall mural or display linked to the stages of the salmon's life cycle;
- review the concepts they learned in the unit.

Note that some activities begun here will continue throughout the life cycle units.

Key Concept

The water cycle, the watershed and ocean conditions form the broad context in which salmon ecology and human ecology take place. Each stage in the salmon's life cycle relies on parts of the aquatic ecosystem in which they live.

Vocabulary

Water cycle, hydrologic cycle, life cycle, habitat, watershed, transpiration, evaporation, ecology, atmosphere, lake, pond, stream, creek, river, deforestation, runoff, solar energy

In science, the term "watershed" refers to the division between two drainage basins; however, the term is often used to include the division and the drainage basin, as well as the plants and animals living within it. The latter definition is used in this unit.

Background Information

The information below supplements the information in "Handout 2.2: The Water Cycle and the Watershed" and "Handout 2.5: An Overview of the Salmon Life Cycle".

Water stewardship

All living things need water. People need about 80 litres a day for domestic, agricultural and industrial uses (although North Americans use an average of 500 litres a day).

British Columbia and the Yukon contain some of the world's richest aquatic systems, with thousands of kilometres of coastline and some of the biggest rivers and watersheds in the world. Many areas on the Pacific coast receive over 1,000 millimetres of precipitation every year. The interior regions receive enough rainfall for extensive forests and grasslands to thrive, and most of the southern drylands can be irrigated by large lake and river systems.

These waterways are habitats for a great diversity of plants and animals, including Pacific salmon which migrate, sometimes thousands of kilometers, from small, clear lakes and streams to the ocean and then back again. To understand the life of the Pacific salmon, students need to start with the salmon's aquatic habitat.

Understanding water systems involves several key concepts (Adapted from McLaren et al., *Water Stewardship*, pages 19 to 21):

- Water is essential for life and all living thing depend on water.
- All water is part of the hydrologic or water cycle.
- Streams, lakes, rivers and other water bodies are part of larger systems known as watersheds.
- Watersheds are dynamic; they change over time as a result of geological and biological processes, as well as human activities.
- Humans are major users of water.
- Although part of an ongoing cycle, water is finite, and clean water is very limited.
- Aquatic habitats are essential elements of the biosphere.
- Contaminants and toxins can move within water and can have harmful effects on life.
- Different human cultures have different values about water and different patterns of use.
- Human activities that are harmful to water supplies and aquatic environments can be reduced. People can practise water stewardship to protect water resources for the future.

When students learn how their own activities, and the activities of their communities, affect the aquatic habitat of salmon and other species, they can begin to practise water stewardship in their own lives.

Introduction

Materials:
None

Time required:
10 minutes

Suggested Activities

Choose activities from these suggestions that are appropriate for your class.

- Ask students to describe how much rain falls every year, where it comes from, and if it will ever run out.
- Ask students to explain why rain will never completely stop falling, and why the ocean will never be empty (at least not for many millions of years).
    - *Falling rain runs down and refills the oceans.*
    - *The oceans return moisture to the atmosphere through evaporation in an ongoing cycle.*
- Ask students to explain what a cycle is.
  A circle or a period of time in which events recur.
- Explain that this unit will look at the water cycle and how it forms part of human and fish ecology.

Illustration: Karen Uldall-Ekman

The Water Cycle

[experiment]

Depending on the abilities of your class, you may prefer to do this activity as a demonstration or have students do the experiment themselves.

Materials:

- One heat-proof glass container containing approximately one litre of water (The container should have a small opening, but should not close completely.)
- One heat source for a demonstration or for each student
- One copy of “Handout 2.1: Water Cycle Procedure” for each student
- One copy of “Handout 2.2: The Water Cycle and Watersheds” for each student
- Writing supplies

Time required:
Approximately 60 minutes in two periods

Level of conceptual difficulty:
Moderate

Suggestions for assessment:
Review the students’ written observations and conclusions to ensure that the students can trace the cycling of water in the container. Monitor their discussion and atmospheric diagrams to ensure that they can trace the cycling of water in the environment and identify potential human impacts.

Experiment

Give students a copy of “Handout 2.1: Water Cycle Procedure” and have them carry out the steps listed. Alternatively, lead the class in a demonstration of the experiment.

Discussion

- Use the chalkboard to diagram the experiment observations in the form of a cycle. Have students identify what drives and what limits the cycling.
  The energy from the heat source drives the cycle. The container walls and the cool outside air limit it by condensing the vapour and returning the water.
- Have students use their own knowledge or “Handout 2.2: The Water Cycle and Watersheds” to compare the water cycle in the experiment with the atmospheric water cycle. If necessary, prompt them with questions, such as:
  - Where do we see water that is part of the atmospheric water cycle?
    In the form of rain, snow, lakes, ponds, streams, oceans, etc.
  - What is the energy source that drives the atmospheric water cycle?
    Solar energy.
  - What causes water vapour to condense and fall back to earth?
    Cool upper elevation atmosphere.
  - How does condensed water return to the oceans?
    Through precipitation falling on the ocean, or falling on land and flowing through streams and rivers or underground to the sea.
  - How long will the water continue to cycle through the oceans and the sky?
    Forever, or at least as long as the water and the sun exist.
- Have students describe what would happen to the water cycle in the container if the cycle were disrupted. If necessary, prompt them with questions, such as:
  - What would happen if the heat source were hotter?
    The water would boil and it might destroy the container.
  - What would happen if the heat source were removed?
    The water would not form vapour and the cycle would end.

- What would happen if the container were open? *The vapour would escape, the water would dry up and the cycle would end.*
- How are interruptions to the water cycle in the container similar to or different from interruptions to the water cycle on earth?
  The water and energy on earth are not likely to end, but small changes could still have major effects.

■ Have students describe what might happen if the water cycle on earth were disrupted. If necessary, prompt them with questions, such as:

- If atmospheric change were to increase the solar energy that drives the water cycle, what might happen?
  The atmosphere might get warmer and more humid, possibly causing storms and changing climate and weather patterns. This is similar to global warming, in which the sun's energy builds up in the earth's atmosphere and the climate becomes warmer.
- If atmospheric change were to decrease the solar energy that drives the water cycle, what might happen?
  The atmosphere and ocean might get cooler, possibly changing the climate and weather patterns responsible for plant and animal growth.
- If atmospheric pollution were to contaminate moisture in the air, what might happen?
  Pollution might reduce the solar energy that drives the water cycle and change climate patterns, or it might dissolve in the water that falls as precipitation and pollute land and water.

Summation

■ Have students create parallel diagrams, comparing the cycling of water in the container with the cycling of water in the environment. Have them describe the cycle in a paragraph.

Option: Have students use maps of the local area (lakes, stream, mountains, etc.) to diagram local aspects of the water cycle, including sources of atmospheric moisture, locations where it falls to earth, and ways in which it returns to the sea.

A Watershed Model

[simulation]

Adapted from Water Stewardship, *pages 70–71*

Materials:

- Copies of "Handout 2.2: The Water Cycle and the Watershed"
- Copies of "Handout 2.3: Building a Watershed Model"
- Copies of "Handout 2.4: Watershed Model Experiment Procedure"
- A water table with a waterproof liner
- Sand, stones and other materials for model landforms
- Sod, carpet or other materials to simulate vegetation
- Hand gardening tools
- A watering can with a fine sprinkler

Preparation:
Build the box for the water table, as illustrated in "Handout 2.3: Building a Watershed Model", unless you intend to have students build one. Or use a simpler alternative, such as a water table or sand box from a primary grade classroom.

Time required:
Several hours to gather and prepare materials.
One 40-minute period for construction, one 40-minute period for in-class tests

Introduction

- Have students refer to "Handout 2.2: The Water Cycle and the Watershed" and have them explain what a watershed is. *An area that drains into one river or stream, usually separated by a ridge or mountain range, and the plants and animals that live in the area.*

- Have students use the diagram in "Handout 2.3: Building a Watershed Model" to create a model of a watershed, including mountains, streams, rivers and a lake or ocean.

  Options:

  A. You may want to make the model in advance and use it as an activity station for a small group study.

  B. For a simpler procedure, have students create a small-scale landscape in a basin using modelling clay, or by wrapping paper hills with layers of plastic. Many primary classes have plastic water tables you could borrow.

  C. Or, if you have access to a natural area, find a spot with open, sloping ground, uncovered by grass or other vegetation. A loose sand or gravel bank is ideal. Use a garden hose or buckets of water to create a landscape, letting water flow downsteam across the bank. Be careful to keep the waterflow quite low and gentle – you are modelling a river on a small scale.

- Have students discuss how well the model reflects actual conditions in a natural watershed. If necessary, prompt them with questions, such as:

  - How is the model similar to or different from a natural watershed?
    The model is similar in shape, but the scale of one material to another is different, they may be more or less porous, have little vegetation, different slope, etc. It does not include the living organisms that are also part of the watershed.

  - What difference would real vegetation make?
    It would likely absorb more water.

  - Will the model give a reasonable imitation of what happens in a real watershed?
    It can indicate how the landforms affect the direction of flow and how the rate of flow differs on a variety of surfaces.

Level of conceptual difficulty:
Moderate

Suggestions for assessment:
Review students' written observations and conclusions and monitor class discussions to ensure that the students can describe environmental and human factors that influence the watershed.

Experiment

- Give students a copy of "Handout 2.4: Watershed Model Experiment Procedure" and have them carry out the steps listed or lead the class in a demonstration of the experiment.

  Option: Have students use the model to test the effects of other factors that might disrupt the water cycle on a local or global basis (e.g., deforestation, dams, road construction).

Discussion

- Have students report their observations and conclusions to the class. Discuss how well the model reflects actual conditions in a natural watershed. If necessary, prompt them with questions, such as:
  - Where did the water flow in the model?
    Through low areas to the "lake".
  - What evidence did you see that the water changes the landscape?
    Depending on the materials used, there may be erosion, flooding, channel formation, etc.
  - What was the effect of increasing the water flow?
    Increased erosion, flooding.
  - Were the effects the same in all parts of the model?
    Different slopes and materials change the effect of the water.

Summation

- If feasible, have students use the watershed model to test what happens when the water cycle is interrupted by natural or human activity (e.g., have students add a dam to a watercourse, remove vegetation, add roads, ditches or paved areas).
- Have students in small groups hypothesize ways in which disruptions to the water cycle on a local or global basis could affect the life cycle of the salmon. Have them record their hypotheses and look for evidence to support or disprove them in the units that follow.

  Option: Have students make posters, pamphlets and/or displays identifying actions that students can take to protect natural water resources.

A Watershed Mural or Display

Materials:
- Copies of "Handout 2.5: An Overview of the Salmon Life Cycle" for each student
- art supplies

Time required:
Two 40-minute lessons, plus ongoing time in future lessons

Level of conceptual difficulty:
Simple

Suggestions for assessment:
Review the students' displays and monitor class discussions to ensure that the students can describe environmental and human factors that influence the watershed.

Introduction

Point out that cycles are one of the important themes in science, and ask students to identify a number of cycles they have studied *(e.g., the water cycle, the nitrogen cycle, the carbon cycle, plant and animal life cycles, waste recycling)*.

Discussion

- Have students identify activities in their own or their family's lives that illustrate one phase of a cycle.
- Point out that all living things go though a cycle of growing up, growing old, having offspring and dying, and the life cycle of the salmon will be one illustration of that cycle.

Summation

- Have students review the life cycle of a salmon from previous knowledge or from "Handout 2.5: An Overview of the Salmon Life Cycle" and predict where salmon live in the watershed at each stage of the salmon's life cycle.
- Have the class create a large poster or bulletin board display to which they can refer and add in the following units. Have them show small streams draining into larger ones, then into a river, an estuary and the ocean, leaving enough space at each area to show life cycle stages of a salmon.
- In future lessons, have the class look for information they can add to the display to make a mural showing the complete life cycle of the salmon and the habitat at each stage.

Review

- Give students five minutes to review their notes and to list at least six important ideas or facts about salmon and the water cycle.
- Give students five minutes to share their lists in groups of four and to write on chart paper the four most important ideas agreed on by the group.
- Have the groups post their charts on the classroom wall, then lead a class discussion on the common ideas and differences noted on the charts.
- Have students add their lists and any additional comments to a salmon science notebook or portfolio.

Materials:
None

Time required:
20 minutes

Wrap-up

Extension Activities

- Have students view a video on a watershed and discuss how it relates to the life cycle stages of a salmon. Refer to the list of videos in the support materials section.
- In the schoolyard or on a nearby property, create a "natural" watershed that is exposed to the weather. For details, see Fisheries and Oceans Canada's *The Watershed Works,* pages 30–31.
- Have students create a public announcement using posters, video, hypertext or other media to inform others of the importance of protecting watersheds.
- Have students take a field trip to a local stream and identify physical and biological factors in the local environment that form part of a watershed. Have them use the on-site studies guide in Unit Three: Salmon Habitat – On-Site Studies to examine and record features of the watershed that relate to the water cycle and the salmon life cycle.
- During the activities, have students gather information about ways in which different users use a watershed, e.g., fish, animals, a forest company, a utility company, a farmer, First Nations, recreationists. Have students prepare for a city council meeting in which the different users debate, from their perspectives, for balanced use of the watershed. (See support materials for resources that offer detailed role-play scenarios.)
- Contact your local water supplier (usually a municipal or regional government) and invite a representative to talk to your class about the water supply in your community.
- To demonstrate the slow and not so noticeable processes of evaporation, condensation, precipitation and climate change, have your students build a biosphere model. A lesson plan is available at www.geoec.org/lessons/biosphere-bottle.pdf. (PDF requires Acrobat Reader.)

Suggestions for Assessment

- Have students place pictures of the salmon life cycle stages in the correct order and position on a watershed diagram, then write an explanation of how each stage relates to the water cycle in a watershed.
- Monitor student discussions of the life cycle handout and mural to ensure that the students can identify the stages of the salmon's life cycle.
- Monitor the discussion as students make and present their lists in the review activity to ensure that they can use factual information from the activities to support an opinion about salmon and the water cycle.
- Have students write quiz questions about salmon and the water cycle on one side of an index card and answers on the other. Have them quiz each other by asking the questions or using a *Jeopardy*-style format by giving the answers and asking for a question.
- Have students add their notes, experiment observations and other materials to a salmon science notebook or portfolio.
- Have students use "Appendix 2: Student Assessment Sheet" to review their group work and their own learning.

W A T E R   C Y C L E ,   W A T E R S H E D
A N D   T H E   S A L M O N

Wrap-up

Home and Community Connections

- Have students ask an adult to help them identify the source of the water they use in their home, the means by which it arrives at their home and the destination of waste water and storm water runoff.
- Suggest that the class begin a project to identify and protect any streams, drainage ditches or storm drains that carry rainwater from built-up areas in the community to waterways inhabited by fish and other aquatic life. (For directions, refer to Unit Ten: Review: The Salmon Life Cycle, Activity 5, “Creating Positive Human Impacts”.)

Salmon Incubator

If you have a classroom salmon egg incubator, have students learn the names of its components, examine how it works and set it up for receiving salmon eggs. For assistance, refer to "People and Connections That Can Help" on page vii of the Foreword.

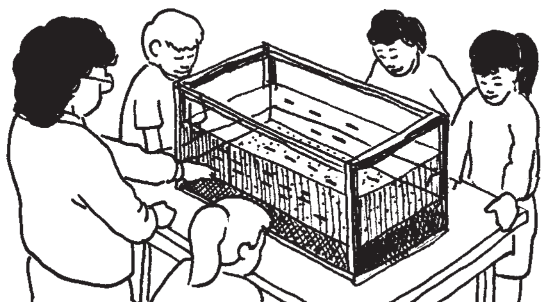


Illustration: Donald Gunn

- Have students create a chart (such as the one below) comparing the parts of the incubator and the functions they fill with the way the functions are filled in nature.

In the tank	In nature
• Water supply provides fresh water • Pump/hose keeps water circulating • Riser tubes oxygenate and circulate water • Foam cover provides darkness, and keeps water cool • Dechlorinator removes chlorine • Gravel filter changes ammonia to nitrates • Gravel cleaner removes food and waste	• Water sources (lakes, streams, rain, etc.) • Water moved downstream by gravity • Riffles oxygenate moving water • Darkness comes from gravel cover • Water does not contain chlorine • Micro-organisms in water convert ammonia • Water organisms eat and convert wastes • Water is chilled by cold atmosphere

Handout 2.1

Water Cycle Procedure

Name ____

Hypothesis

When water is heated in a closed container, it forms vapour, then condenses and returns to its original state.

Procedure and Observations

1. Place approximately one litre of water in a large heat-proof glass container. Place a top on the container loosely enough to allow any steam that forms to escape.

2. Place the container over a heat source. USE CAUTION AROUND HEAT SOURCES.

3. Describe any changes that you see in the glass container:

   ____

   ____

   ____

   ____

4. When vapour begins to form, reduce the heat to maintain the water at approximately the same temperature.

5. Describe what happens to the vapour inside the container.
   (Where does it come from? Where does it go?)

   ____

   ____

   ____

   ____

Conclusion

6. What do your observations tell you about the hypothesis?

   ____

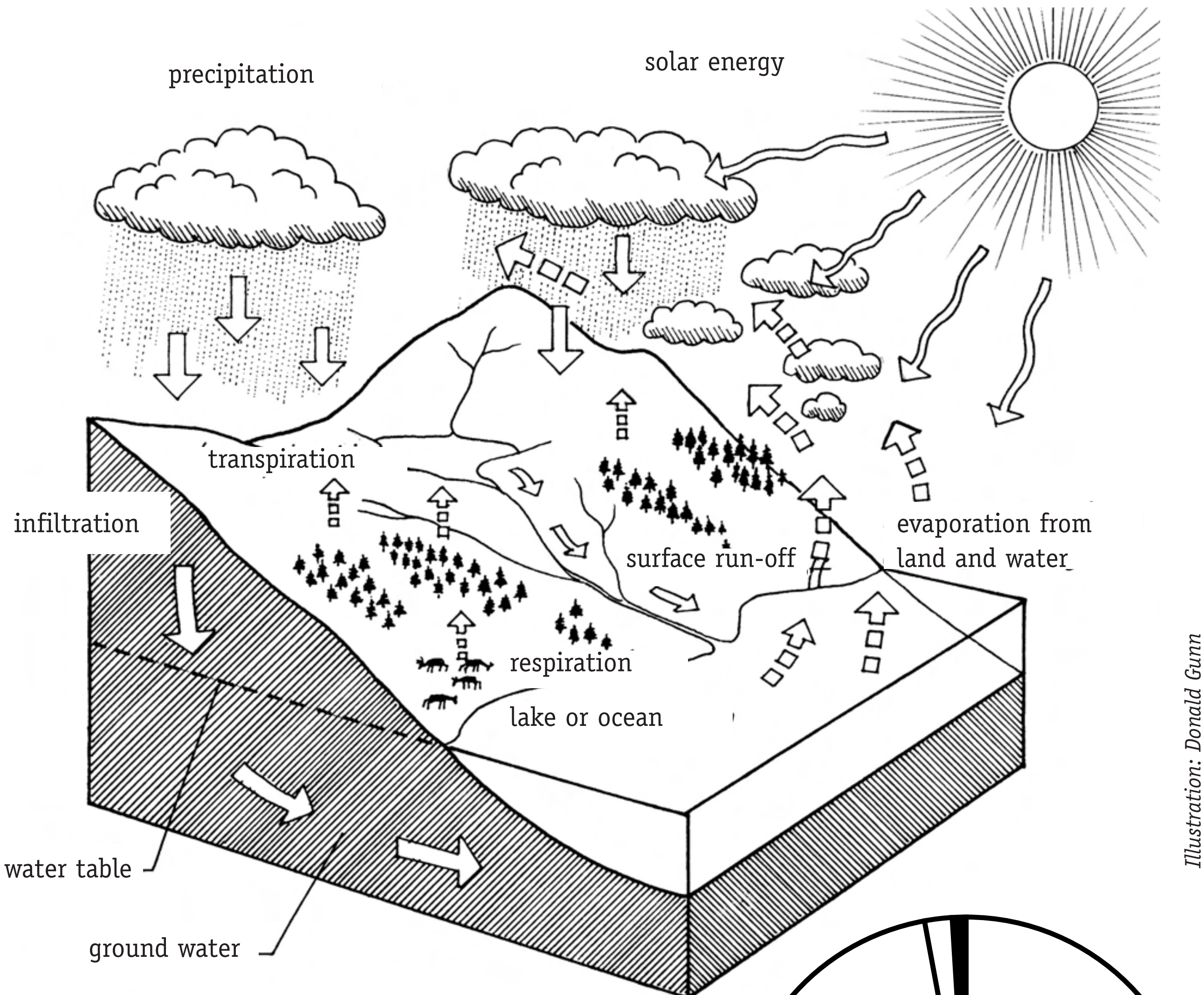
   ____

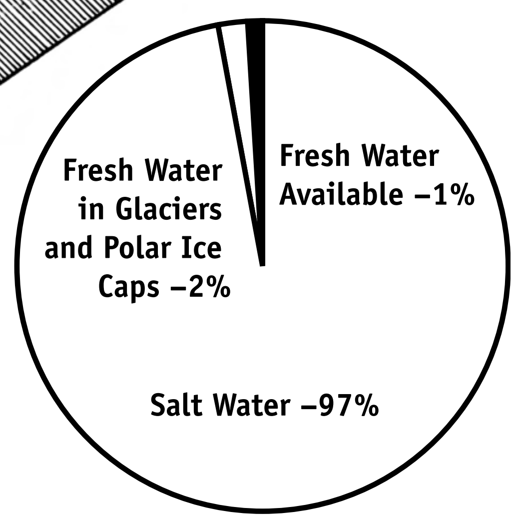
   ____

   ____

Handout 2.2

The Water Cycle and the Watershed





Earth's Water supply

Water covers 72 per cent of the earth's surface. Only three per cent of this is fresh water; the rest is salt water. Two-thirds of the fresh water is frozen in glaciers and the polar ice caps.

Handout 2.2

The water is constantly in motion. The **water cycle**, or **hydrologic cycle**, transports water from water bodies into the atmosphere and back again.

Energy from the sun, or **solar energy**, powers the cycle. It:

- evaporates water from the seas, from fresh water lakes, rivers and streams, and from the surface of the soil
- gives plants energy to take up moisture and give off **water vapour** from their leaves in a process called **transpiration**
- creates wind, which blows vapour through the atmosphere until cool air causes the vapour to **condense**

Water in the atmosphere falls to the ground as rain or snow. The moisture in the atmosphere falls to earth every 9 to 12 days, and it is replaced just as quickly.

When rain falls on land, it flows through streams and rivers until it rejoins the sea. Some water trickles into the soil, forming part of an underground, or **groundwater**, water system.

An area that drains into one river or stream is known as a **watershed**. The land, plants and animals form part of the watershed. The watershed is where plants and animals live. Animals, like salmon, rely on a watershed to meet their needs. Animals also affect how water moves back into the atmosphere and to the sea. Plant roots can draw water out of the soil, creating pockets where water gathers temporarily. The roots can slow or stop erosion by slowing water as it moves in the soil. Beavers build dams that divert the water, and micro-organisms can slowly break down rocks in the water.

The water cycle renews and cleans the water flowing in watersheds. Humans rely on water from local watersheds for drinking water, for cleaning, for recreation and for industry. But our actions can divert, dry up or even poison local watersheds. When we cover even part of a watershed with concrete or asphalt, it can change the water flow, sometimes even causing floods.

Handout 2.3

Building a Watershed Model

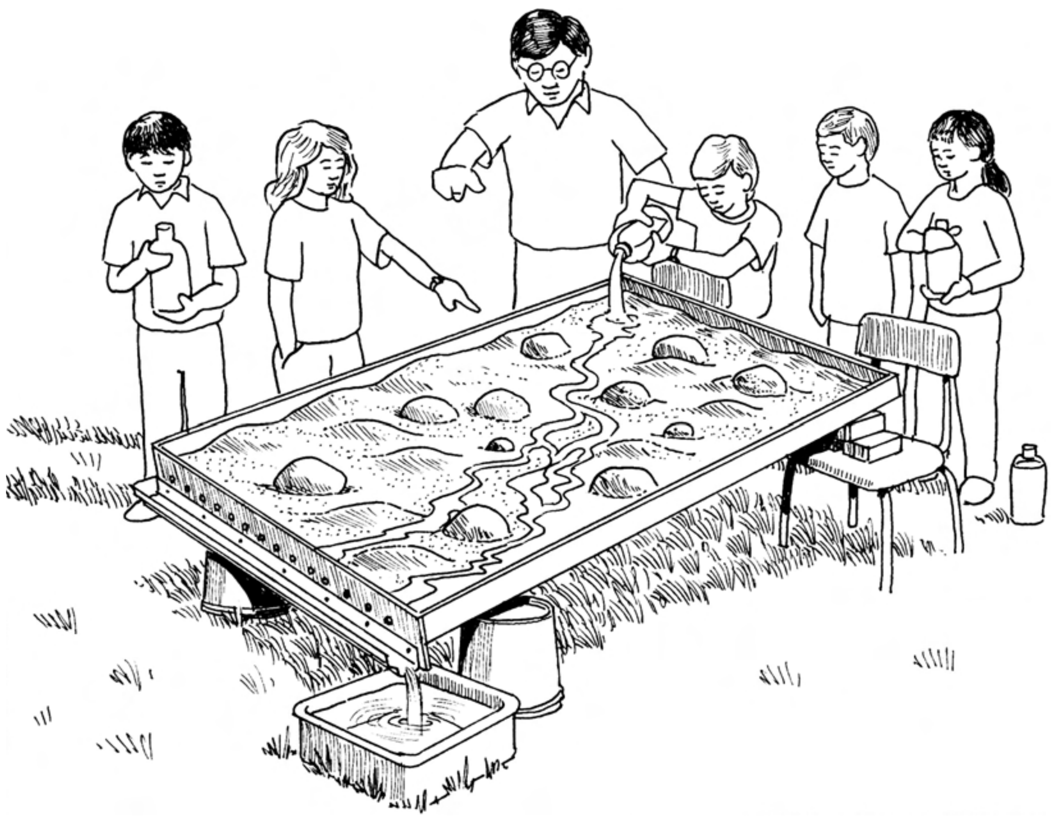


Illustration: Donald Gunn

Handout 2.3

Building the Box

Materials

- One sheet of plywood, approximately 4' x 6' or 4' x 8' feet
- 1" by 4" inch boards the same length as the plywood edges
- Gutter material the length of the short edge
- Screws or nails
- Plastic sheeting or silicone caulking
- Bricks or other materials to prop up the box

1. Screw or nail the boards to the edges of the plywood to make a box.
2. Drill holes in one of the short boards so that water will run out of the box.
3. Attach the gutter to the short board so that it will catch water from the holes. On one side, attach it at an angle to run the water into a basin.
4. Use the bricks to prop up and support the end of the box opposite the holes.
5. Line the box with plastic sheeting or seal the edges with silicone caulking.

Creating the Environment

Materials and equipment

- Sand, stones and other materials for model landforms (available from building and gardening stores)
- Sod, carpet or other materials to simulate vegetation
- Gardening tools
- A watering can with a fine sprinkler or small tubing

1. Use the sand and stones to build an environment in the box. Create hills at the end opposite the holes. (You might want to use foam under the hills to reduce the weight.)
2. Shape the sand into several valleys, with tributaries and rivers flowing down to a lake.
3. Line some valleys and the edge of the lake with sod (or use carpet to simulate vegetation).
4. Gently sprinkle water on the hills and trace its path toward the lake. Use a very gentle flow of water. Too much water will wash out the landscape.
5. Try a variety of landscapes with different slopes, angles, materials, etc.

HANDOUT 2.4

Watershed Model Experiment Procedure

Name ____

Draw the landscape created in your model watershed.

Hypothesis Water sprinkled gently on a model of a watershed will: ______________________

____

____

____

____

Handout 2.4

Procedure

1. Gently sprinkle a small amount of water over the mountain section of the model.

2. Describe where the water flows and what happens to it. ______

3. Describe the effect of the water on the model. ______

4. Repeat Step 1, but sprinkle a larger amount of water on the model.

5. Describe the effect of increasing the water flow on the model. ______

6. Compare the effects after Step 1 with the effects after Step 4.

Conclusion

7. What do your observations tell you about your hypothesis? ______

Handout 2.5

An Overview of the Salmon Life Cycle

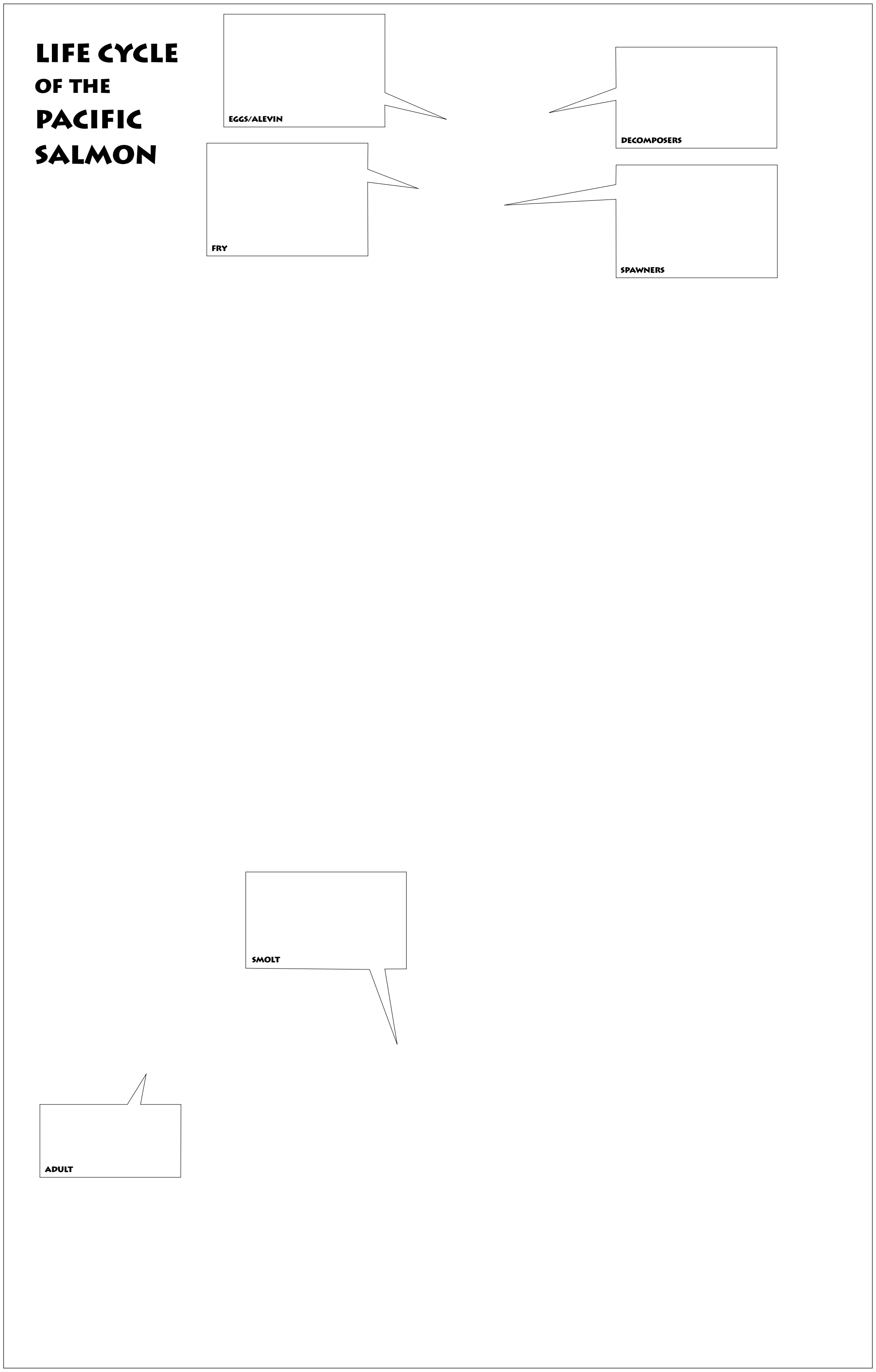


Illustration: Robert Browne

Handout 2.5

Salmon begin their life in freshwater streams, rivers and lakes. Their life begins in the gravel of stream or lakebeds. Mature females dig a nest, called a **redd**, in the gravel. Here they lay as many as 6,000 eggs (chinook may lay up to 17,000 eggs). The average is between 2,500 and 3,000. The male salmon fertilizes the eggs, and the female covers them with gravel for protection.

The eggs slowly develop under the gravel over the winter months. When the eggs hatch they are called **alevins**. Alevins continue to live in the gravel and take nourishment from a **yolk sac** attached to the underside of their bodies. By the spring, they finish the yolk sac, and miniature salmon called **fry** come out from the gravel.

Coho, chinook and sockeye salmon and steelhead trout remain in fresh water for a time. Chum and pink salmon travel downstream to the sea soon after they come out from the gravel.

Salmon fry eat constantly and grow quickly. When they reach what is called the **smolt** stage, they move downstream to the **estuary**, where the river meets the sea. They stay in the estuary for a time while their bodies adapt to being in salt water. Once the smolts can survive easily in salt water, they travel into the ocean.

Some types of salmon wander as far as 3,200 kilometres from their home stream. Others stay closer to home. As they grow to adulthood, the salmon eat small fish and tiny animals that live in the sea.

When they are ready to **spawn**, or lay their eggs, the salmon return to the stream or lake where they hatched. During the difficult journey to the spawning grounds, their bodies change colour and shape. Once they lay and fertilize their eggs, their life cycle is complete and the salmon die.

U N I T 3

SALMON HABITAT On-site Studies

Salmon Habitat On-Site Studies

Overview

This unit gives students an opportunity to:

- select a site for on-site stream studies;
- review rules for on-site stream studies;
- research items that make a good salmon habitat;
- conduct on-site stream studies;
- review and discuss their on-site observations.

Key Concept

A stream or lake may be a salmon's home. Streams and lakes have features that make them more or less attractive to salmon.

Vocabulary

Dissolved oxygen, pH, back-eddy, riffle, velocity, turbidity, bedrock, boulder, cobble, gravel

Suggested Approach

From the suggested activities, choose those that are appropriate for your class.

Advance Preparation

Materials:
None

Time required:

10 minutes

Suggested Activities

Choose activities from these suggestions that are appropriate for your class.

Fisheries and Oceans Canada has published a series of stream survey field guides entitled *Gently Down the Stream* for approximately 20 different West Coast rivers or streams. These guides provide detailed information and student worksheets for streams in each region of British Columbia and the Yukon. Contact the community advisor for your region for copies of the local guide and for information about field trip locations and leaders who might be available for your class. (If there is no guide for your area, you can use an existing guide as a model to create one, with help from a community advisor, stewardship coordinator or educational coordinator for your region.)

- Review any rules your school has regarding student safety around water and ensure that adequate precautions are in place. Some streams and lakes may be a hazard for young students, particularly if they have strong currents, slippery rocks or unstable banks.
- If possible, tell the class that you have selected a variety of sites for a salmon habitat study and ask them to choose the site they would prefer to visit.
- Select an appropriate location and confirm transportation and any bookings necessary for visiting the site. If possible, choose a site within walking distance from your school so that students can relate the field trip to their own life experience and will be able to visit the site with their family outside of class hours.
- Arrange adequate supervision from parent helpers or other volunteers. Most sites cannot provide supervision, although those with school programs can provide information and activities when informed in advance. If there is an on-site program, check what it offers and how to prepare the class.
- Walk the site before the class visit to check for appropriateness, safety and educational opportunities.
- Prepare the handouts and other materials the students will need. Arrange permissions, as required by your school. Advise students to bring warm clothing, waterproof boots, a snack and a backpack.
- If necessary, have students conduct “Activity 5.4: Parts per Million” to gain an understanding of the ppm units used in the handouts and discussion.

Rules for Salmon Habitat Study

[research/discussion]

Materials:

- Copies of “Handout 3.1: Rules for Salmon Habitat Study” for each student

Time required:
Approximately 20 minutes

Level of conceptual difficulty:
Simple

Suggestions for assessment:
Monitor the group and class discussions to ensure that the students can explain and agree with all the rules.

DISCUSSION

- Shortly before the visit, give students a copy of “Handout 3.1: Rules for Salmon Habitat Study”. Have students, in groups, read the handout and discuss the reasons for each rule.
- Have groups report to the class the reasons for each rule. Discuss with the students whether they agree or disagree.
- Ask the class if there are any rules they want to add or remove from the list and have them write out any changes.

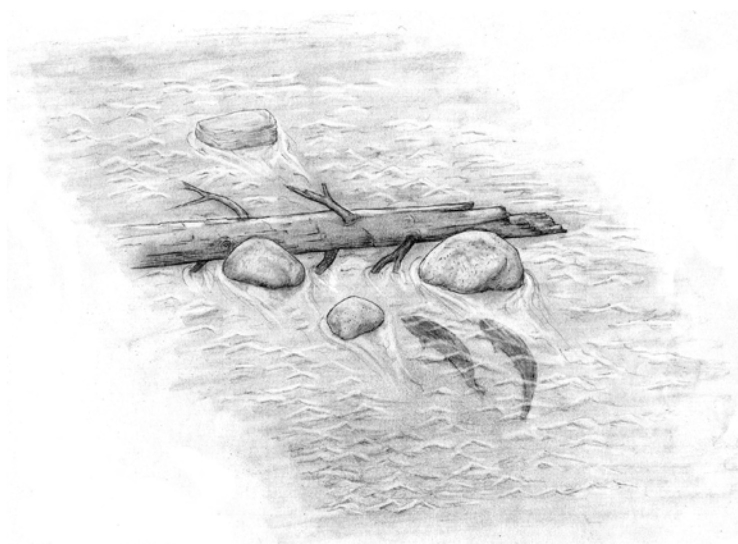


Illustration: Karen Uldall-Ekman

Nature Journalling

Materials:
- 8” X 11” plain white copy paper
- Pencils/ball point/felt tipped pens
- Hard surface, e.g., cardboard/ textbook/clipboard
- Magnifying glasses
- Field guides

Optional:
- Coloured pencils
- Watercolours
- D-net/plankton net
- Small buckets and/or ice-cube trays

Introduction

"The nature journal is not a new phenomenon in the history of scientific study, or, for that matter, in the history of liberal arts education. It springs from an ancient tradition of record keeping: tribe, village, or parish records; farming ledgers; native people’s accounts of the seasons and hunts; records of scientific expeditions; travel journals; accounts of investigations by self-taught naturalists; units of study in rural schools."

-Clare Walker Leslie,
Into the Field:
A Guide to Locally Focused Teaching

To soothe the voice that says, “But I can’t draw (or perhaps write)!” take ease in knowing that nature journalling is less about accurately portraying detail and more about developing observation skills. Nature journal drawings are meant to provide visual evidence of what a student has seen and learned. Keep in mind that co-teaching with an art teacher may be an option. It is important, however, that you draw and write alongside students so that you can see (and experience for yourself) the challenges and joys of nature journaling.

Note: You may wish to implement this activity in conjunction with the “Salmon Habitat Study Field Trip” on page 42 of this Unit.

Discussion

- Decide where you are going to go. Though most elements that make up a healthy salmon habitat can be found in your schoolyard, it is recommended that you visit a nearby stream, wetland, estuary or ocean to provide an authentic experience relevant to your salmon study.
- Ask students what they think a naturalist and/or a scientist is and why they keep journals. A naturalist is someone who studies nature through observation. A scientist is someone who tries to determine how things work. Each of them ask questions, learn with their senses, notice details and record their observations in journals.

"....[Nature journalling] involves the illustrator directly in what he observes. The illustrator recreates what he sees and does not merely record. He expresses what seems important, hence worthy to stress and convey in a single compelling image. He can strengthen his impression with written description and commentary. This creative process is at the heart of natural history observation, and it helps to make the best of experiences also the most lasting in memory for anyone wishing to enjoy it."

Edward O. Wilson
Research Professor, Harvard University
Honorary Curator in Entomology,
Museum of Comparative Zoology

Preparation

- Provide students with art and/or writing supplies.
- On a blank piece of paper, have students write the following information and ask students why they think the information is important.
  - The date (important to recall time of year, seasonal changes, etc.)
  - Their name (identifies their work)
  - Where they are (defines habitat and elements within habitat)
  - The time of day (affects light and animal activity)
  - The present weather (affects light, plant and animal activity)
  - Optional: temperature/barometric pressure
  - Optional: length of day and night according to an almanac or daily newspaper, and the phase of the moon (In addition to connecting us with the sun and the moon, this recording helps give us a sense of the ancient exploration of time),

Investigation

- Go outdoors to form a circle. Do this in silence. Ask students questions, such as:
  - What's going on outside?
  - What season is it?
  - What's happening to the trees outside?
  - What animals do you know live nearby?
  - How would you describe your landscape?
- Have students face outward from the circle and take 10 steps forward. After another few moments of silence, ask students to write down three things they hear.
- Give students 2-3 minutes to complete their descriptions and/or drawings for each of the following exercises. Keep this fun and task-oriented until you and your students are in the rhythm of drawing from your own discoveries.

The creative process is at the heart of natural history observation. It involves the illustrator directly in what he [she] observes.

Edward O. Wilson
Research Professor, Harvard University
Honorary Curator in Entomology,
Museum of Comparative Zoology

- Guide students to a source of water. Ask students to describe and/or draw what they see, making note of water depth, colour, velocity (how fast the water is flowing), natural and man-made elements, rocks, logs, other debris, and other elements of interest.
- Guide students to a stream bank, beach or lakeshore. Ask students to describe and/or draw any vegetation, signs of animal activity, and other elements of interest.

  Option: Insert a D-net into the stream (or plankton net if you are near the ocean) with the water flowing through the opening. Lift up various rocks that are in the stream, allowing any insects to float into the net. Place any insects so obtained into buckets or ice-cube trays filled with water for student observations. Upon completion, be sure to return all insects to the location from which they came.
- Ask students to search for and draw and/or describe any insects they find.
- Ask students to search for and draw and/or describe any signs of human activity.
- Ask students to draw and/or describe any other observations of interest. Encourage them to think about the associations between living and nonliving things.

Summation

Option: Have students reference field guides or other materials to complete their illustrations.

- Have students, in small groups, share the observations they recorded while in the field. Have them list how each of their items may or may not be elements of a healthy salmon habitat and explain why.
- As a class, list all of the things that the students determined would make a healthy salmon habitat. Have students verify their list with “Handout 3.2: A Healthy Salmon Habitat.”

Salmon Habitat Study Field Trip

[research/discussion]

Materials:

- Copies of "Handout 3.3: Habitat Survey and Data Sheet" for each student
- Copies of "Handout 3.4: Advanced Habitat Survey and Data Sheet" for each student
- HACH field testing kits to measure dissolved oxygen
- pH testing kit
- Thermometers for measuring air and water temperature
- Metre sticks or other measuring tools
- Stopwatch or other watch with a second hand
- Writing and drawing supplies

Time required:
Several hours for field trip

Level of conceptual difficulty:
Simple to moderate

Suggestions for assessment:
Monitor student discussions and review their written observations to ensure that the students can describe the site and identify features that make the habitat suitable for salmon.

Advance Preparation

Fisheries and Oceans Canada's Community Advisors (CA's) may be able to help you with the following activity. For more than 18 years, CA's have been responsible for delivering a variety of programs for Fisheries and Oceans Canada in the Pacific Region. They know about Fisheries and Oceans' operations and about salmon biology, including all aspects of fish culture, habitat requirements, migration patterns, and more. They will also be aware of contacts in your community who support the important work that you are about to undertake. To find a CA in your area, visit http://www-heb.pac.dfo-mpo.gc.ca/community/contacts/ca_e.htm or call 604-666-6614.

Since its inception in 1995, the *Pacific Streamkeepers Federation* (PSkF) has also helped British Columbians become involved in the protection and restoration of their local streams and watersheds. As a part of the Streamkeepers Program, several equipment kits have been assembled and are available at various locations in the province. These kits contain invertebrate samplers, water quality test kits and surveying supplies. Contact your local community advisor to find out if an equipment kit is available in your area. For information about local Streamkeeper groups with which you could become involved, visit their website (www.pskf.ca), contact your local community advisor or call 1-800-723-7753; in the Vancouver area, call 604-986-5059.

Field Research

- Assemble the class into five groups, with an adult supervisor for each group. (Adult supervisors can also rotate between groups if fewer than five are available). Remind the class of the class rules for habitat study.

  Option: Have the class walk the banks of the stream or lake, either together or in their groups. Every two to three minutes stop and have students describe the general sights, sounds, smells and other characteristics of the site. Have students write or draw their observations in a notebook. Have students sketch a map of the site.

- Have students, in their groups, use "Handout 3.3: Habitat Survey and Data Sheet" and/or "Handout 3.4: Advanced Habitat Survey and Data Sheet" to record information about the stream.

Note: you may wish to laminate the handout sheets for future reuse, in which case overhead pens may be required for recording information.

- Have the class look for evidence of people near the stream or lake.
  Signs, construction, trails, pipes, waste, etc.
  Have the students record their observations.
- Have the class look for things they could do to make the site better for salmon and other animals.
  Remove waste, restore minor damage, replant shoreline vegetation, etc.

Illustration: Donald Gunn

Debrief in Class

[research/discussion]

Materials:
- Student observations from field trip
- Writing supplies

Time required:
Two to three lessons

Level of conceptual difficulty:
Moderate to advanced

Suggestions for assessment:
Review student descriptions or drawings to ensure that the students can identify features from the field trip that make the habitat suitable or unsuitable for salmon.

Discussion

- Have students, in pairs, read or describe their observations to a partner.
- With the class, discuss whether or not the stream or lake is a healthy salmon habitat. If necessary, prompt them with questions, such as:
  - Did the stream or lake have water that is healthy for salmon?
    Cool, clear, running with riffles and still pools.
  - Did the stream or lake have a bed that is healthy for salmon?
    Clean rocks and gravel.
  - Did the stream or lake have shade and protection for salmon?
    Overhung with vegetation.
  - Did the stream or lake have food for salmon?
    Insects, small fish.

Summation

- Have students prepare an illustrated report describing the site and identifying features of the stream or lake that make it healthy or unhealthy for salmon.

  Option: Have students write a thank-you letter to adult volunteers or site managers identifying at least one thing they enjoyed or learned on the field trip.

Illustration: Karen Uldall-Ekman

Wrap-Up

Extension and Integration

- Invite a local naturalist or other resource person to the class to prepare students or to lead the visit.
- Arrange a visit to another type of salmon resource, such as a local hatchery or salmon enhancement project, a local spawning stream or lake, an estuary, a traditional Aboriginal fishery or cultural centre, a salmon-processing facility or a commercial fishing boat. Discuss the kinds of jobs people have working with salmon.
- Have students imagine the site from a bird's-eye view. Have them identify the main visible features, such as the road, parking lot, stream, clearings, trees, buildings. Have students draw the site as they would see it if they were a bird flying overhead. Obtain an aerial photograph of the site from the local planning office and have them compare their views with the photograph.
- Arrange for the class, or for a group of students, to view the site at different seasons and to compare their observations using notes, illustrations, photos or other media.
- Have students discuss links between their observations in the field and activities such as "Activity 6.5: A Model Landfill" and "Activity 7.5: Aquatic Life". Have students carry out a habitat stewardship activity, such as marking storm drains. (Contact your local community advisor for information and resources on how students can take part in marking storm drains.)
- Have students make a map of a local stream or lake, showing its main features and ways of protecting them from damage. Alternatively, have students add the features they observed to a topographical map of the site.
- Have the class paint a mural showing the site and labelling features that salmon would like.

Evidence for Unit Assessment

- Have students make notes listing at least six important ideas or facts about the stream they studied.
- Have students share their lists in pairs and negotiate an agreement on the four most important ideas about the stream they studied.
- Have the pairs share their ideas with the class and discuss any differences between the lists the different pairs negotiated.
- Have students use "Appendix 2: Student Assessment Sheet" to review their group's work and their own learning.

Home and Community Connections

- Have students guide an adult around a stream or lake, identifying features about the stream or lake that make it a healthy salmon habitat.
- Suggest that the class begin a project to create an inventory of waterways near the school and the plants and animals that form the aquatic and shoreline ecosystems. (For directions, refer to Unit Ten: Review: The Salmon Life Cycle, "Activity 10.5: Creating Positive Human Impacts".)

Handout 3.1

Rules For Salmon Habitat Studies

1. Follow directions.
2. Stay in your groups.
3. Walk only. Do not run.
4. Play only where allowed.
5. Stay on the paths. Do not go into the water.
6. Do not pick plants.
7. Do not disturb fish or other animals.
8. Take your belongings with you when you leave.

Illustration: Donald Gunn

Handout 3.2

A Healthy Salmon Habitat

Small streams and lakes produce most of the West Coast's fish. They spawn in shallow water, and many species spend a year or more in the stream or lake after they hatch. Salmon habitat is easily damaged, but human activities are changing to protect streams and revitalize waterways that have been damaged in the past.

Water. Salmon prefer cool, clean water (between 5ºC and 9ºC is best). A healthy salmon stream runs over a gravel bottom containing a mix of rock sizes. Water flowing over riffles picks up oxygen and washes away silt. Salmon need at least seven parts per million (7 ppm) of oxygen in the water.

Young salmon also need still pools that form at the edge of a stream and behind rocks, logs or other debris. The still water allows the salmon to rest and to hide from predators. Eggs need 2 - 30 centimetres of water; fry need 10 - 40 centimetres.

Young salmon are very sensitive to pollutants. Household chemicals, such as bleach, oil or paint, can be fatal. Unless diverted, runoff from roads can carry hazardous pollutants into a stream. Ideally, the water in a salmon stream should be clear, with a pH between 6.5 and 8.

Stream banks and lakeshores. The banks of a stream soak up water during heavy rain, then release it slowly into the stream. This prevents flooding and reduces the chance of streams and lakes drying up in hot weather. Thick vegetation along the banks of a stream shades the water, keeping it cool and allowing salmon to hide in the shadows. Insects that fall from overhanging bushes and trees provide food for the salmon. To protect the stream banks, laws prohibit construction or logging within 50 or 100 metres of streams.

Food. Salmon fry catch tiny insects that float past them. As they grow, the fry can also catch larger insects and caterpillars that fall into the stream or lake, as well as mayflies and stoneflies that land on the water to lay their eggs. When they are large enough, the fry can also eat smaller fish in the stream or lake.

People. People disturb streams and lakeshores when they remove the vegetation, divert the waterflow, pollute the water or build docks. People sometimes erode the banks by playing or driving along the edges of a stream or lake. This can crush salmon eggs in the gravel. People and pets sometimes harass spawning salmon in shallow streams, and people sometimes leave garbage along the banks and in the water.

Handout 3.3

Habitat Survey and Data Sheet

Name ____

Name of stream or lake ____

Habitat checklist

Check the box if you see any evidence that the stream or lake meets these conditions.

- ❏ 1. The stream or lake bed has clean gravel.
- ❏ 2. The stream or lake has clean flowing water.
- ❏ 3. The stream or lake does not dry up.
- ❏ 4. The stream or lake floods easily.
- ❏ 5. The stream or lake is not blocked by waterfalls.
- ❏ 6. The stream or lake has vegetation on its banks.
- ❏ 7. There are signs of animals near the stream or lake.
- ❏ 8. The stream or lake is not damaged by people.
- ❏ 9. The stream or lake is cared for by people.

Does the stream or lake appear to be a good salmon habitat? What makes it look like a good or poor habitat? ____

____

____

____

What could be done to make the stream or lake a better habitat for salmon? ____________________

____

____

____

Who could do something to make the stream or lake a better habitat for salmon? ________________

____

____

____

Other evidence you observe ____

____

____

____

Handout 3.3

Habitat Survey and Data Sheet

Physical characteristics of the stream or lake banks and bottom					
1. Stream or lake bank Estimate the portion of the bank that is made up of:	N/A	25%	50%	75%	All
Bedrock (solid rock):					
Boulders (rock pieces 30 cm across or larger)					
Cobble (rock pieces 10 to 30 cm across)					
Gravel (rock pieces 1 to 10 cm across)					
2. Stream or lake bottom Estimate how much of the bottom is made up of:	N/A	25%	50%	75%	All
Bedrock (solid rock):					
Boulders (rock pieces 30 cm across or larger)					
Cobble (rock pieces 10 to 30 cm across)					
Gravel (rock pieces 1 to 10 cm across)					
Sand					
Mud					
3. Plant life along the stream or lake banks Estimate the portion of the bank with the following types of vegetation:	N/A	25%	50%	75%	All
Tall trees					
Low bushes					
Overhanging bushes					
Ferns					
Grass					

Handout 3.4

Advanced Habitat Survey and Data Sheet

Group One

Chemical characteristics of the water

1. Dissolved oxygen

   Follow the directions on the HACH field testing kit. If you can, take a water sample and record the results for the areas noted below. Take care not to splash water or get air bubbles in the sample. Bubbles will add oxygen to the sample and make the dissolved oxygen level appear higher than it really is.

   Test results in a pool or back-eddy:

   _______ Mg/L (or parts per million)

   Test results at the bottom end of a riffle:

   _______ Mg/L (or parts per million)

   Test results from a swampy or dead water area:

   _______ Mg/L (or parts per million)

2. pH

   Follow the directions on the pH testing kit. If possible, take a water sample and record the results for the areas noted below.

   Test results in a pool or back-eddy:

   _______ pH

   Test results at the bottom end of a riffle:

   _______ pH

   Test results from a swampy or dead water area:

   _______ pH

HANDOUT 3.4

Advanced Habitat Survey and Data Sheet

Group Two

Physical characteristics of the water

1. Air temperature
   Air temperature away from the water:

   _______ °C

2. Water temperature
   Water temperature in the main current:

   _______ °C

   Water temperature in a pool:

   _______°C

   Water temperature in a shallow back-eddy:

   _______ °C

   Water temperature in the study area:

   _______ °C

   Water temperature at the bottom of the study area:

   _______ °C

3. Turbidity (clarity) of water
   Mark the box that best describes the water.

   ❑ Clear

   ❑ Slightly silty

   ❑ Muddy

   ❑ Brown

4. Stream or lake level
   Mark the box that is your best guess about the stream or lake level, based on your knowledge of the stream or lake and any evidence you see at the site.

   ❑ Normal

   ❑ Slightly higher than normal

   ❑ Much higher than normal

   ❑ Slightly lower than normal

   ❑ Much lower than normal

5. Stream or lake flow
   Mark the box that is the best description of the water.

   ❑ Mainly flat and still

   ❑ Mainly moving quickly

   ❑ Mainly flowing in waves or whitewater

   ❑ Flowing quickly around the edges or centre only

   ❑ Evenly mixed between still and moving water

Handout 3.4

Advanced Habitat Survey and Data Sheet

Group Three

Physical characteristics of the water - continued

1. Stream width (measure or estimate visually)

   Width at the widest part of the stream:

   _______ metres

   Width at the narrowest part of the stream:

   _______ metres

   Width at an average part of the stream:

   _______ metres

2. Stream depth (measure or estimate visually)

   Depth at the shallowest part of the stream:

   _______ cm

   Depth at the deepest part of the stream:

   _______ cm

   Depth at an average part of the stream:

   _______ cm

3. Stream velocity (speed of water movement)

   a. Measure a five or ten-metre distance along the bank of the stream from a rock or tree. (Try to avoid areas with still pools.)

      Distance: ____________ metres

   b. Use a watch with a second hand to count the time it takes for a piece of wood to float from the upstream end of the measured area to the downstream end. Record the time. Repeat the test two more times.

      Time 1: ______________ seconds

      Time 2: ______________ seconds

      Time 3: ______________ seconds

   c. To find the average water speed, add the total number of seconds, then divide by 3.

      Total Time: ________ seconds divided by 3

      Equals: __________ seconds

      5 or 10 metres divided by ___________ seconds = __________ m/sec

HANDOUT 3.4

Advanced Habitat Survey and Data Sheet

Group Four

Physical characteristics of the stream or lake banks and bottom					
1. Stream or lake bank Estimate the portion of the bank that is made up of:	N/A	25%	50%	75%	All
Bedrock (solid rock):					
Boulders (rock pieces 30 cm across or larger)					
Cobble (rock pieces 10 to 30 cm across)					
Gravel (rock pieces 1 to 10 cm across)					
2. Stream or lake bottom Estimate how much of the bottom is made up of:	N/A	25%	50%	75%	All
Bedrock (solid rock):					
Boulders (rock pieces 30 cm across or larger)					
Cobble (rock pieces 10 to 30 cm across)					
Gravel (rock pieces 1 to 10 cm across)					
Sand					
Mud					
3. Plant life along the stream or lake banks Estimate the portion of the bank with the following types of vegetation:	N/A	25%	50%	75%	All
Tall trees					
Low bushes					
Overhanging bushes					
Ferns					
Grass					

Handout 3.4

Advanced Habitat Survey and Data Sheet

1. Sand: ___________ per cent

   Mud: ____________ per cent

2. Stability of banks
   Mark the box that best describes the banks.

   ❏ Eroding quickly

   ❏ Eroding slowly

   ❏ Not changing

3. Steepness of banks
   Mark the box that best describes the banks.

   ❏ Very steep

   ❏ Moderately steep

   ❏ Gently rising

   ❏ Very flat

Plant life in the stream or lake

Indicate which types of plant life you see in the stream or lake.

❏ Grass ❏ Leaves ❏ Twigs

❏ Logs ❏ Algae

❏ Other: ________________________________

Handout 3.4

Advanced Habitat Survey and Data Sheet

Group Five

Evidence of aquatic life

Use "Handout 7.4: Aquatic Life Guide" to identify the number and types of aquatic insects you can see in or on the surface of the water.

Describe (and identify if possible) any evidence of:

Fish: ____________________

Birds: ____________________

Mammals: ____________________

Evidence of harmful human activity

Describe (and identify if possible) any evidence of:

Drains entering the water ____________________

Mud or silt washing into the water ____________________

Debris or garbage in the water or gravel ____________________

Oil or other liquids in the water ____________________

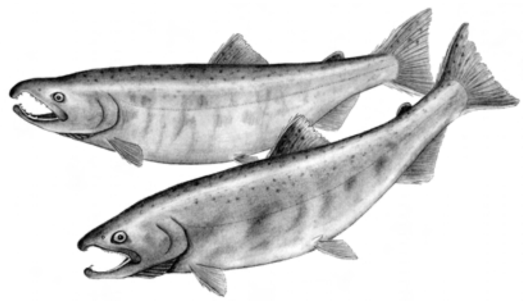
Damage to the streambed or stream bank ____________________

Vegetation removed along the stream bank ____________________

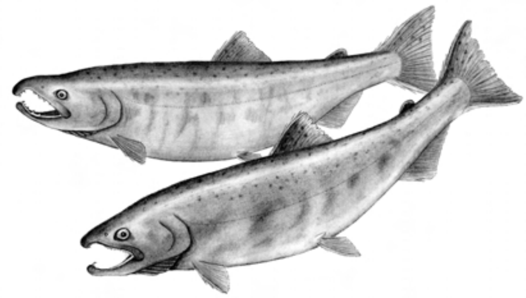
Other evidence you observe ____________________

U N I T 4

THE SALMON SPAWNER



The Salmon Spawner



Overview

This unit gives students an opportunity to:

- discuss why salmon swim upstream in the fall;
- simulate and discuss the importance of salmon returning upstream;
- test the significance of fish carcasses to plant growth;
- observe genetic diversity in the class and discuss its importance;
- test the effect of pollution on the scent of water samples;
- review the concepts the students learned in the unit.

Key Concept

Spawners travel upriver to their home stream or lakeshore, where they lay eggs and fertilize them to continue the life cycle. Salmon die after spawning but their bodies support the growth of the next generation.

Vocabulary

Genetic variation, genetic diversity, spawn, spawning ground, pollutant, redd, fertilize, carcass

Background Information

The information which follows can be used to supplement "Handout 4.1: The Salmon Spawner".

The return of salmon to their home streams and lakes is an essential part of the West Coast ecosystem. Not all salmon have to migrate to the sea – some landlocked populations grow and produce offspring without journeying to the ocean. Those that do migrate to the sea must return so as to find an environment that is suitable for their offspring to mature. Salmon eggs and fry cannot survive in the salty water and unprotected conditions of the sea.

The salmons' return also allows them to nurture their offspring and to provide sustenance for other species, even after their death, by fertilizing the forest environment with their remains. West Coast watersheds, including lakes, streams and stream banks, are often low in nutrients essential for plant growth, especially nitrogen. Recent studies have shown that nutrients from the sea make an important contribution to plants and animals along salmon spawning streams. Spawners bring these nutrients from the sea and leave them in their carcasses when they die.

Some animals take up marine nutrients by eating the salmon carcasses. A single dead spawner can feed thousands of insect larvae, which in their turn form the food source for fry that will spend the winter in lakes and rivers. Algae, fungi and bacteria, which live in the water, also take up marine nutrients before dying and providing food for small invertebrates which are then eaten by salmon fry. Forest lakes and streams provide little nutrition compared with the richness of the estuary and ocean, and many species might not survive without the nutrients released by decaying spawners. After the spawners return to their spawning grounds, the increased nutrients in the water can allow fry to double their rate of growth.

When salmon cannot return to their home lakes and rivers because of overfishing or blockages en route, or when their carcasses are removed, the lack of nutrients can mean that fewer survive in the next generation. The result can be a long-term decline in the number of survivors, and a threat to already weak runs of salmon.

Salmon carcasses may also form part of the forest ecosystem. Birds, bears and smaller mammals drag some carcasses ashore, carrying marine nutrients through the forest adjacent to lakes and streams, and depositing the nutrients in their feces. The remains of the salmon fertilize the forest soil in regions where heavy rainfalls quickly leach out nutrients that are essential for strong tree growth.

The salmons' return also ensures continuing genetic diversity. When a population is lost, the genetic diversity contained in that population is also lost. Biologist Paul Erlich suggests that diversity is like a strong web that supports life when the links of the web remain strong and unbroken. When the links break, the web weakens.

Introduction

Materials:
None

Time required:
10 minutes

Suggested Activities

Choose activities from these suggestions that are appropriate for your class.

- Have the students describe what they have heard or read recently about salmon in local streams and lakes. (If you do this activity in the fall, some students will likely have heard of salmon returning to spawn. If not, introduce the subject by pointing out that, throughout the West Coast and the Fraser River watershed, millions of salmon swim from the ocean and up the rivers to the small streams and lakes where they were hatched.)
- Ask students why salmon swim from the ocean to small lakes and streams.
  They swim upstream to lay their eggs in the cold fresh water that their eggs, alevins and fry need to survive.
- Explain that this unit will be about the salmon's journey upstream to spawn and how that contributes to the environment.

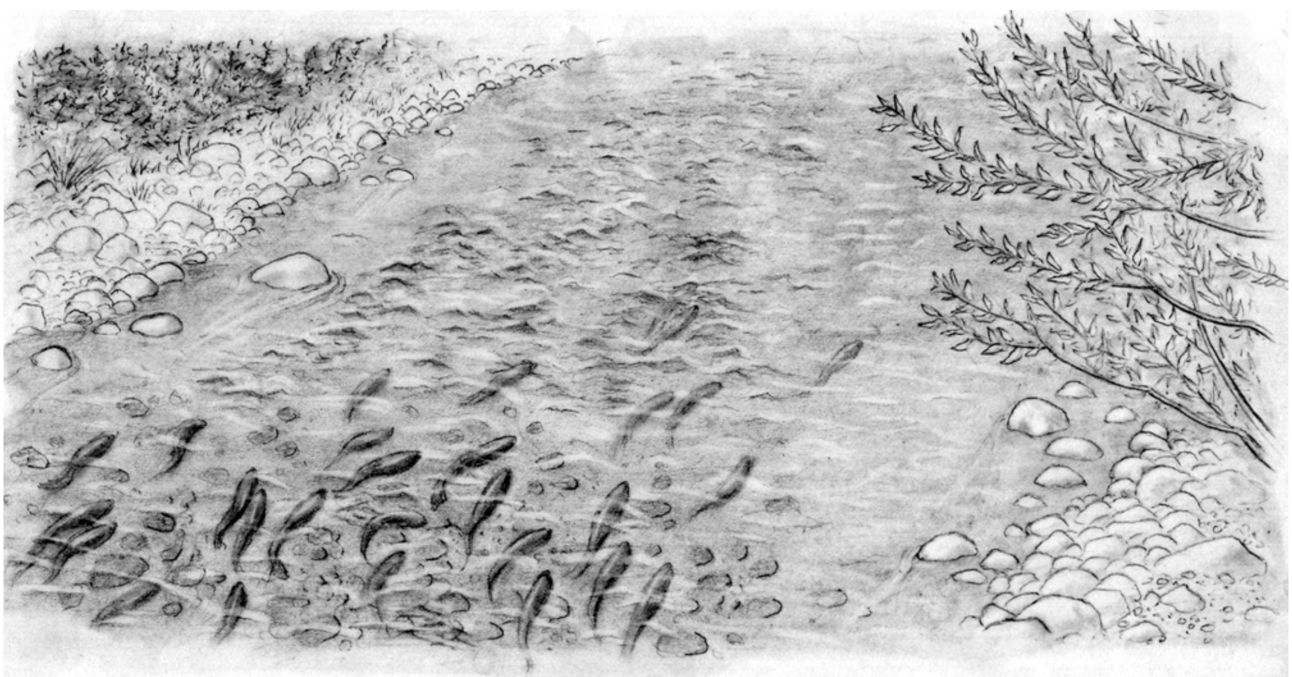


Illustration: Karen Uldall-Ekman

The Salmon Spawner

[simulation]

Adapted from Wildlife Trees in British Columbia, *"Activity 12: Waterlogged".*

Materials:

- Two 25-metre lengths of rope
- Four pylons or cones
- Four to six floor mats, tied into rolls
- One copy of "Handout 4.1: The Salmon Spawner" for each student
- Writing supplies or art supplies

Time required:
Approximately 30 minutes in the gym and 30 minutes in class

Level of conceptual difficulty:
Simple

Suggestions for assessment:
Monitor the class discussions and review the students' lists, written descriptions and drawings to ensure that the students can identify the difficulties a salmon faces on its trip upstream.

Preparation

- In a gym or open area, place two ropes on the floor, parallel to each other and about four metres apart. Mark the ends of each rope with pylons or cones. Explain that the ropes represent the banks of a straight-sided stream.
- Have the students find a place in the gym where they can sit without being close enough to touch anyone else. Ask them to find a comfortable position and close their eyes as you read "Handout 4.1: The Salmon Spawner" to them. This should help them to relax and focus on the instructions, while minimizing any potential "rough play".

Simulation

- Have about six students move slowly between the ropes, as if they were spawners swimming upstream. Have another six students link arms and move rapidly (but carefully) side-by-side between the ropes in the opposite direction to the spawners. Explain that they represent a wave of water moving downstream. Have the rest of the class observe how the rapidly moving water pushes the spawners along.
- Lay some rolled-up mats across the ropes so they are partly in and partly out of the "stream". Explain that the mats represent logs, boulders and other obstructions in the stream. Have another group of spawners move upstream, while another wave moves downstream. Have the class observe how spawners can hide behind the logs to rest and to avoid the wave.
- Explain that gravel can accumulate in slow-moving waters and change the shape of the stream bank. Move the ropes so that they curve around the logs and obstructions. Have another group of spawners move upstream, while another wave moves downstream. Have the rest of the class observe how the wave becomes slower as it move around the curves, and how it can move the stream bank, itself.

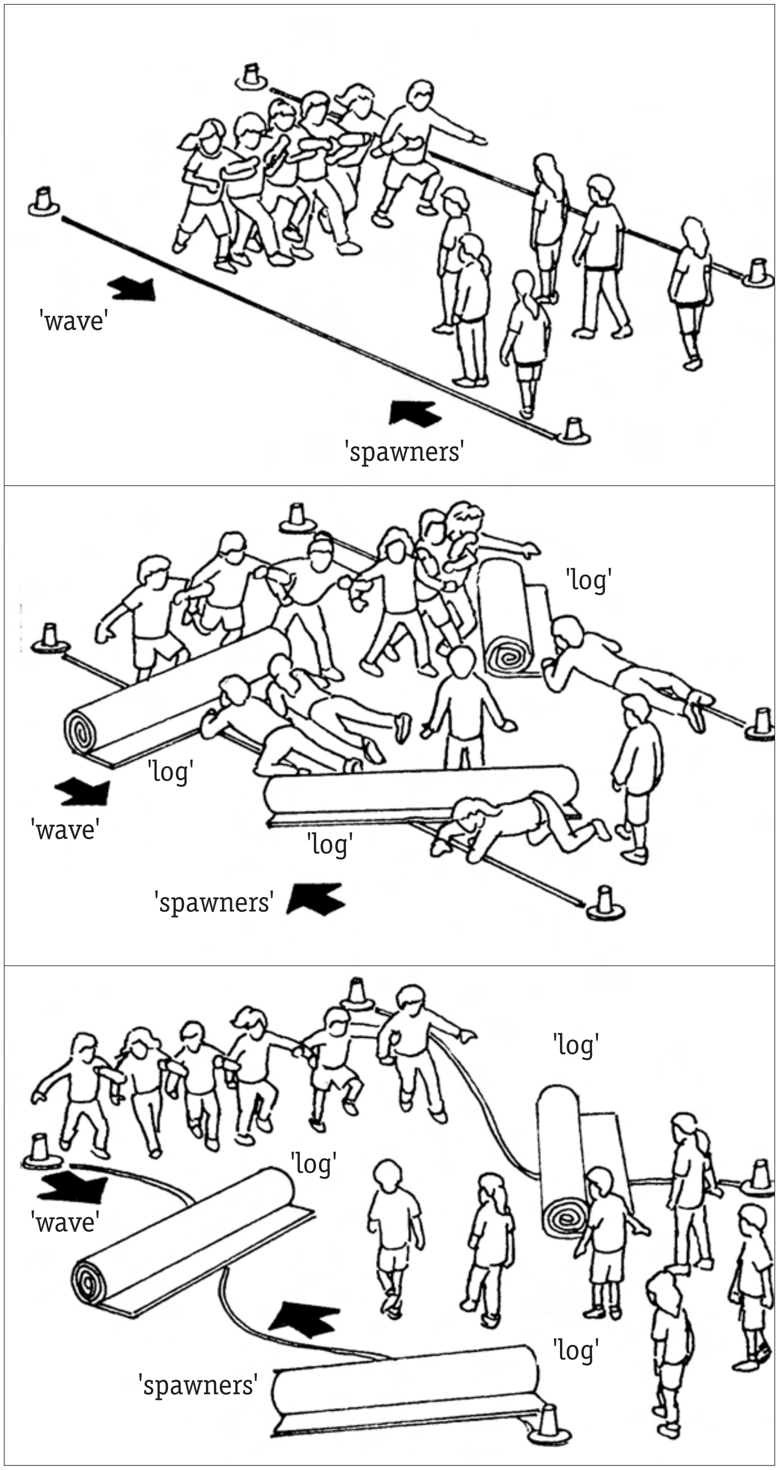


Illustration: Donald Gunn

Discussion

- Have students describe the difficulties in working along the stream under the different conditions. If necessary, prompt them with questions, such as:
  - In which stream did spawners have the most trouble? In which was it easiest to make it to the end?
  - What made one part harder than another?
  - In what ways is the stream similar to the streams a salmon must travel on its trip upstream? How is it different?
    A salmon also has to jump and slide past a variety of obstacles. It may be easier for a salmon to swim through a wave of water, but its trip is much longer, and the salmon has no hands or feet to help it.
  - What kinds of obstacles does a salmon have to pass on its migration upstream?
    Rapids and waterfalls, logs, dams, dried out sections of streams, fishing nets, polluted water, predators, etc.
  - What natural features help a salmon in its migration upstream?
    Salmon can find pools behind rocks and logs to rest, and slower water along the edges of a river. Also, their skin becomes very tough, they can jump very high, and use their strong muscles to push their way along.

Summation

- Have students, in groups, review "Handout 4.1: The Salmon Spawner" and list at least five changes that salmon face in the last stage of their life. Have students, as individuals, draw or describe in writing the changes that help a salmon complete its journey upriver.

Fish Fertilizer

[experiment]

Depending on your students, you may prefer to do this experiment as a class or in small groups.

Materials:

- One copy of "Handout 4.1: The Salmon Spawner" for each student
- Commercial fish fertilizer
- Fast-growing seeds, such as alfalfa or radish
- Potting soil and containers
- Water
- One copy of "Appendix 1: Science Experiment Sheet" for each student (optional)
- Writing supplies

Time required:
60 to 90 minutes in two periods, plus time for observations over two weeks or more

Level of conceptual difficulty:
Simple

Suggestions for assessment:
Monitor the class discussion and review the students' written observations and conclusions to ensure that they describe the effect of fish fertilizer in the experiment and in nature.

Introduction

- Refer to the end of "Handout 4.1: The Salmon Spawners" and ask students what happens to the bodies of salmon spawners after they die.
  They are eaten by birds, bears and other wildlife or their bodies decompose, fertilizing the spawning lakes and rivers. Plants and micro-organisms grow in the rich and productive environment, providing a habitat and food source for salmon fry when they are growing.

- Ask the class to act as scientists who want to test how the bodies of dead salmon affect plants growing in the environment. Have them form a hypothesis and develop a procedure, similar to the one below, which they can use to test their hypothesis.

Experiment

- Have students plant fast-growing seeds (e.g., alfalfa or radish) approximately one inch deep in soil, in two identical pots. Have them label one pot, "Control", and the other, "Fish Fertilizer", before placing the pots in a warm, bright location in the class. Make sure the seeds receive about one inch of water per week and a little more when they are first developing. Don't overwater, though – too much water causes more damage than too little.

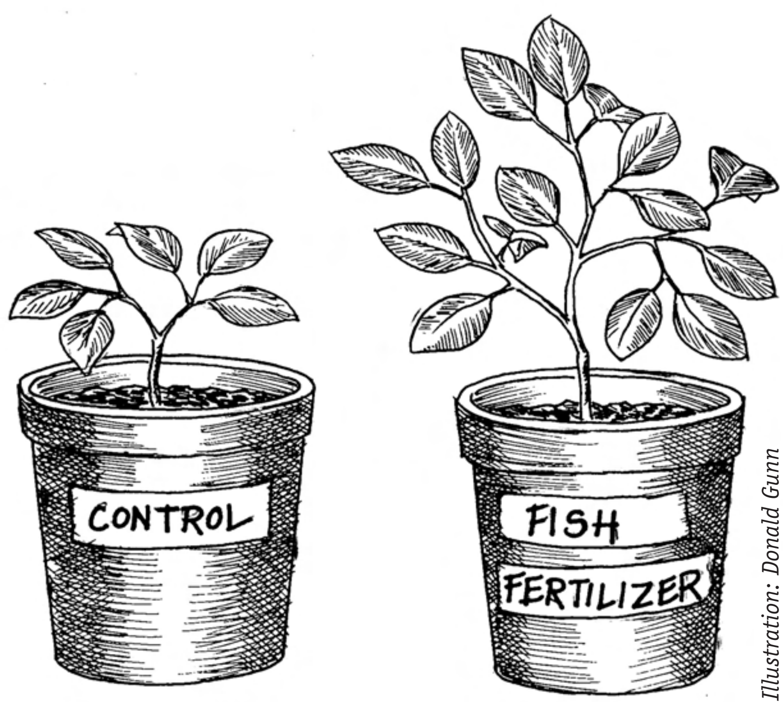


Illustration: Donald Gunn

Explanation

- Ask students to describe their experiences at home using fertilizer to encourage the growth of plants and gardens. Explain that fish fertilizer is made from fish scraps from processing plants. The scraps are composted in a way that resembles what happens to fish bodies when they decompose in nature. Have students water the pot labelled "Control" with water and the pot labelled "Fish Fertilizer" with a solution of commercial fish fertilizer. Read the instructions on the fish fertilizer label to determine when and how much to fertilize young plants (often fertilizing occurs when plants have developed their second set of leaves). Have students observe and record the growth of the plants over one to two weeks.

  Note: Although some fish fertilizer products claim to have low or no odour, we encourage you not to use these so the students will experience a rich opportunity that enhances their direct experience with nature.

Summation

- Have students use the data from their experiments to form a conclusion about their hypothesis. Have them create a written description of the experiment in their notebooks, or use the blank form in "Appendix 1: Science Experiment Sheet".

- Discuss what the results show about the significance of salmon bodies in the environment. If necessary, prompt the students with questions, such as:

  - How did the growth of the plants with the fertilizer compare with the growth of the other plants?
    The plants with the fertilizer should be bigger.

  - What could explain the results?
    Nutrients, especially nitrogen, in the fertilizer gave the plants food to grow bigger.

  - How is the experiment similar to what happens in nature? How is it different?
    In both cases, the fish remains provide nutrients for plant growth. However, in nature, salmon bodies decay slowly and release their nutrients over a longer period of time. Unless the salmon bodies are carried onto the land by animals, they fertilize aquatic plants and micro-organisms.

- With the class, discuss how the bodies of dead salmon contribute to the forest and stream environment. Have students describe in writing what would happen if there were no salmon bodies in a lake or stream.
  The aquatic growth would be reduced, and salmon fry and other animals would not find as much to eat. The forest might lose ocean nutrients that are not otherwise available.

Pacific Salmon Bring It All Back Home

Like other species of Pacific salmon, coho hatch out of eggs laid in streambed gravel; migrate out to sea, where they spend most of their adult life; and return to natal streams to spawn and die. "Salmon are the only animals that return nutrients to the land from the sea," says Jeff Cederholm, a salmon biologist for the Washington Department of Natural Resources.

"The healthiest salmon streams," he points out, "are loaded with salmon carcasses." Cederholm and his coworkers observed a surprising array of species feasting on dead coho, including otters, black bears, raccoons, and skunks. These larger animals often pulled carcasses onto streambanks, where leftovers were scavenged by wrens, shrews, mice, and other small creatures. Coho spawn in the fall, and their carcasses remain through the winter, the hungriest time of year for wildlife in the Pacific Northwest forests. Perhaps most, if not all, woodland animals rely on salmon to help sustain them until spring. Even white-tailed deer sometimes feed on salmon carcasses.

BioScience, Vol.47 No. 10, 1997

Salmon Feed Forests; Forests Shelter Salmon

"Salmon benefit from the plants that line the banks of their spawning grounds. These trees and bushes, known as riparian vegetation for their proximity to rivers' natural banks, provide many of the conditions that salmon need for successful spawning.

The riparian plants provide shade, which helps to regulate the temperature of the spawning grounds. Trees and large bushes provide snags and other debris that create sheltered areas along the river in which young salmon can find refuge. Their roots also keep river sediments in place, reducing erosion."

Cat Lazaroff, *Environment News Service*,
September 2001

Genetic Diversity
[investigation]

Materials:
- One copy of "Handout 4.2: Genetic Diversity" for each student
- Writing supplies

Time required:
Approximately 60 minutes

Level of conceptual difficulty:
Moderate to advanced

Suggestions for assessment:
Monitor the class discussion and review students' sentences on specific genetic variations to ensure that the students can identify how genetic variation contributes to species survival.

Introduction

- Give students a copy of "Handout 4.2: Genetic Diversity" and explain that they will use it when analysing the genetic diversity of the class.

Investigation

- Have students start from the centre of the wheel and work their way to the outside, colouring the segment of the circle that applies to them.
  For example, on the innermost circle, have them colour the male or female side, then the eye colour segment of the male or female half that applies to them, etc. Note that "widow's peak" is the tendency of the hairline to come to a V in the centre of the forehead; "tongue curl" is the ability to curl the tongue to form a tube shape.
- Have students read out the number they arrived at in the outermost circle, then see if anyone shares a number with other students. If no one shares a number, the class has high genetic diversity. The more people who share numbers, the less the genetic diversity. (Most students, other than members of a family, will likely have a unique number.) Have students compare their circles with others and note where they differ.

  Option: Have students use an electronic spreadsheet program to record classroom variations at each level of the circle and graph the results. Have them calculate the probabilities that students will share characteristics at each stage.

Discussion

- Point out that, with only seven variables, chances are only one in 128 that any individual will match all the characteristics on the circle. Humans and other animals have many millions of variables in their genetic make-up, so everyone on earth is unique (except identical twins).
- Have the class suggest ways in which genetic diversity helps a species survive. If necessary, prompt them with questions, such as:
  - How might it help if some people could see in the dark better than others?
    They could hunt better at night.

- How might it help if some people could run faster than others?
  They could avoid dangerous predators.

- How might it help if some people could think more creatively than others?
  They could invent new tools.

- If everyone had exactly the same abilities and a more powerful predator came along, what danger would the community face?
  The predator might be able to destroy the whole community.

- If everyone had very different abilities and a more powerful predator came along, what advantage would the community have?
  Some members of the community might escape to create a new community.

Summation

■ Have students discuss how specific variations suggested in the handout would affect the ability of salmon to survive as a species.

For example:

- The ability to survive warmer temperatures could help if vegetation removal contributed to an increase in stream temperature.

- The ability to jump high out of the water could help when there are obstructions in a river.

- The ability to lay more than one batch of eggs could help if one batch was destroyed, and could also increase species diversity, particularly if a second male fertilized the eggs.

- Smaller size might help if it allowed more salmon to slip through fishing nets.

Dissecting a Salmon

[demonstration]

Adapted from procedures described by Chris Zimich, Helping Teacher, School District #36, Surrey, and Bev O'Connor, School District #39, Vancouver.

Materials:
For each group conducting a dissection:
- A whole salmon (may require time to thaw)
- A sharp, thin kitchen knife
- A spoon
- A plastic drinking straw
- Paper plates
- A magnifying lens
- Toothpicks or bamboo skewers (optional)
- Newspapers
- Paper towels
- Thin latex or plastic gloves
- A bucket of water with disinfectant for cleaning
- Heavy plastic garbage bags for waste
- One copy of "Handout 4.3: Dissecting a Salmon" for each student
- One copy of "Handout 4.4: Salmon External Anatomy" for each student
- One copy of "Handout 4.5: Salmon Internal Anatomy" for each student
- Writing supplies

Time required:
Approximately 60 minutes in two periods

Preparation

Option: Some independent education suppliers, education supply stores and science education catalogues carry cloth fish, 3-D models and posters that could help you to introduce this dissection activity to your students. You may also want to photocopy "Handout 4.4: Salmon External Anatomy" and "Handout 4.5: Salmon Internal Anatomy" onto an overhead transparency for reference.

- Depending on your students and the availability of salmon for dissection, you may prefer to do this activity as a demonstration or as a hands-on activity with pairs or groups of students dissecting a salmon as you model the procedure. If you do it as a hands-on activity, have pairs or groups of students take turns carrying out the steps as you model them. Have the non-participating students write notes describing the procedure and their observations on the handout. If you do the activity as a demonstration, have students pass the dissected parts and the magnifying lens around the observation table.
- Obtain a whole salmon for each group of students, plus one for modelling correct dissection. Spawning pinks, sockeye or coho are usually the best size and can be obtained from hatcheries. However, silver adults taken from streams also work well if you prefer to do the dissection in Unit Nine: Adult Salmon. You will need to obtain the fish from a fish hatchery or fish farm, as most commercially caught whole salmon are gutted at sea. Contact the community advisor for your area for assistance and discuss whether the salmon carcasses should be returned or disposed of in some other way.
- Advise students in advance to wear clothes that can get messy.

Introduction

- Have a discussion with students about showing respect for all species. This should serve as a guiding principle for the students' behaviour during the following activity. You may wish to refer to "Ethical Discussions" on page viii of the foreword for inspiring quotes specific to salmon.
- Provide each student with a copy of "Handout 4.4: Salmon External Anatomy" and "Handout 4.5: Salmon Internal Anatomy". Sketch an outline of a human on the chalkboard. Refer to the salmon handouts, as needed,

Level of conceptual difficulty:
Simple

Suggestions for assessment:
Monitor the students' responses during the dissection and review their dissection observations and comparisons to ensure that the students can identify and describe the parts of a fish, their functions and their relationships to human physiology.

to explain the dissection. Refer to the human sketch to compare human physiology with fish physiology. (If convenient, you may prefer to make overhead transparencies from the illustrations.)

- Warn students to use care when using the knife, as it is very sharp. If the students are not doing the dissection, have them use toothpicks or bamboo skewers as probes when you ask them to feel the samples.
- Advise students that, if they feel uncomfortable during the dissection, they can look away or move their chair farther back.
- Have students in pairs or individually use "Handout 4.3: Dissecting a Salmon" to follow the dissection and record their information.

Demonstration

- Have students observe the salmon as you dissect it and compare the salmon's anatomy with the anatomy of other animals or other organisms they know. Prompt them with questions, such as:

Slime layer and scales

- What is the first thing you notice when you hold a fish?
  The fish is slippery. Many fish, including salmon, have a layer of slime covering their body. The slime layer helps the fish to:
  - *slip away from predators, such as bears;*
  - *slip over rocks to avoid injuries;*
  - *slide easily through water when swimming;*
  - *avoid fungi, parasites, disease and pollutants that might be in the water. (It's a sort of living plastic bag in which the salmon lives.)*
- What covers the fish's body under the slime layer?
  Most fish, including salmon, have a layer of scales covering their skin.
  Scales are small, hard plates like fingernails that cover a fish's whole body.
  The scales overlap to form a flexible armour plating that protects fish from predators and bruising.
  Salmon don't grow their scales until the fry stage or

later. They start to reabsorb their scales when they become spawners. (Scales aren't usually completely reabsorbed at the time of death.)
The way the scales are arranged in rows or patterns is different for each species of fish. You can tell one species from another by the size of the scales and the way they are arranged.
Fish have the same number of scales all their lives. As the fish grows, the scales grow. They form lines, like the rings in a tree. Biologists can tell the age of a fish and how many years it spent in freshwater or saltwater from the lines on its scales.
If a fish loses a scale, it can grow another to replace it. New scales have a clear centre, because they do not have the growth lines.

- Remove a scale and have students examine it later under a hand lens or microscope.

Fish shape and features

- What shape is a fish? What shape is a salmon? Why are fish shaped this way?
  Fish come in many shapes, although torpedo shape is the most common. Salmon are torpedo shaped. However, some fish, like flounder and halibut, are flat. Some are almost string-like and a few are round, like a balloon.
  The streamlined shape of a fish lets it move easily through water. Water has much more resistance to movement than air does, so it takes much more energy to move through water. A streamlined shape saves energy.
- What are the main parts of a salmon that you can see?
  On the head, you can see the mouth, eyes, nostrils and gills.
  On the body, you can see the fins and tail, the vent and the lateral line.

Fins and tail

- How many fins can you see? How are they arranged?
  Salmon have eight fins, including the tail.
  Some fins are arranged in pairs, one on each side of the salmon's body.
  The pectoral fins are in the front, below the shoulder.
  The pelvic, or ventral, fins are on the belly, farther back from the head.

The others, known as median fins, are arranged in a line on the salmon's belly and back.
The dorsal fin is in the centre of the back.
The anal fin is in the centre of the belly, just in front of the tail.
The adipose fin is on the back, in front of the tail. (The adipose fin is sometimes clipped off in hatchery fish to help identify the fish when they return or are caught.)
The tail is a special fin at the back of the body, called the caudal fin. It includes the end of the backbone.

- What do the fins do?
  The fins each have a different function.
  The caudal fin, or tail, is the largest and most powerful. It pushes from side to side and moves the fish forward in a wavy path.
  The dorsal fin acts like a keel on a ship. It keeps the fish upright and it also controls the direction in which the fish moves.
  The anal fin also helps keep the fish stable and upright.
  The pectoral and pelvic fins are used for steering and for balance. They can also move the fish up and down in the water.
  The adipose fin has no known function. It does not seem to harm salmon if it is cut off from nursery fish.

  Note that a fish uses its whole body to move through water, but the fins give it much more control. Even without fins, however, a fish would be able to swim, but it would not be able to right itself easily.

■ Hold the salmon by the tail, with the belly facing away from you. Without cutting deeply into the belly, cut open the salmon from the vent to the pelvic fins. Cut through the pelvic fins and remove them.

- What do the fins (except the adipose fin) have in common?
  The fins are made up of a fan of bone-like spines with a thin skin stretched between them.
  The fins are embedded in the salmon's muscle, not linked to other bones, as limbs are in people. This gives them a great deal of flexibility and manoeuvrability.

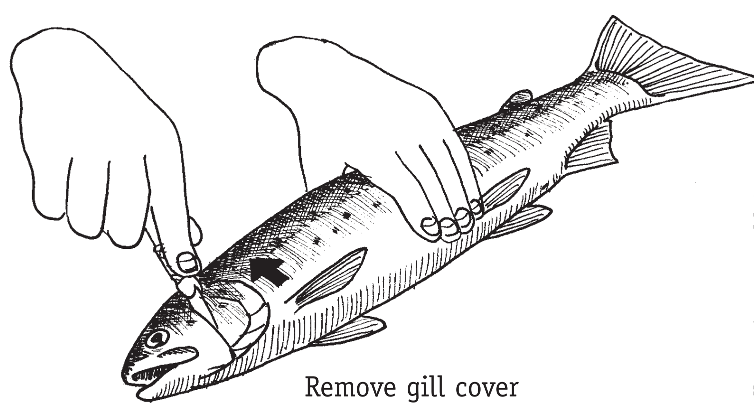
■ Place the pelvic fins on a paper plate and have students examine them.

Gills and gill rakers

- How do fish breathe? Can someone demonstrate the motions for the class?
  Fish gulp water through their mouth, then close their mouth and throat.
  They force the water out through an opening in the back of the their throat. Gills line the opening.
  Gills are very thin membranes (two cells wide) that line the gill passage. Oxygen dissolved in the water diffuses through the membrane into the fish's blood. (This is similar to the way oxygen in the air diffuses through the membranes in an animal's lungs.)
  Carbon dioxide in the fish's blood diffuses out through the gills.
  Salmon also secrete excess salt through their gills when they are in salt water.
  Gills are much more efficient at extracting oxygen than lungs are. They can extract oxygen if there are as few as five molecules of dissolved oxygen for every million parts of water. Animals with lungs are used to one part oxygen to five parts of air (200,000 parts per million).

- What protects the outside of the gills?
  The operculum, or gill cover, is a hard outer lining like a flexible plate that the fish opens and closes to let water through.

■ Remove both sets of gill covers. Cut through the bone from the apex near the throat, then pare away upward toward the spine on both sides. Cut only as far as necessary. Once the gills are freed, pull them out with the fingers. Place them on a paper plate and have students examine them with a magnifying lens.



Remove gill cover

Illustration: Donald Gunn

- What colour are the gills? Why? What do they look like?
  The gills are red because they are filled with blood. They look like fine, branched structures, like a Christmas tree. The branching structure gives the greatest possible surface area to absorb oxygen from the water.

■ Cut the gill rakers from the opening of the throat. Place them on a paper plate and have students examine them.

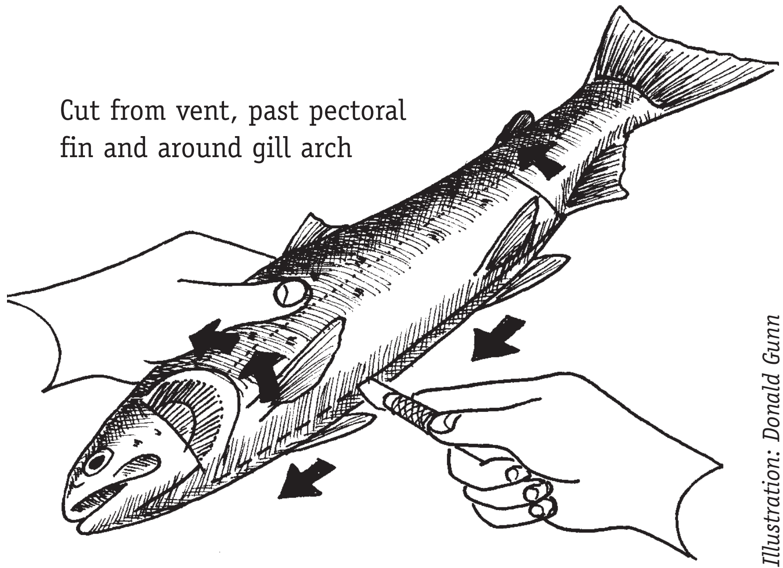


Illustration: Donald Gunn

- Why does a fish need spines lining the gill opening on the inside of the throat?
  The spines prevent food from entering the gill passages and guide it into the throat.

Eggs or milt

- What hypothesis would you make about whether the fish is male or female?
  If the fish is female, much of the body cavity will be filled with eggs.
  If it is ready to spawn, the eggs will be loose. More likely, they will be enclosed within a membrane.
  If the fish is male, you will see a white bladder of milt.

■ Gently pull the egg or milt sack away from the body and detach it. Place it on a paper plate, cut it open and have students examine it.

- Why does one salmon have so many eggs?
  A female coho salmon has about 2,500 eggs, while other salmon species have from 2,000 to 5,000.
  In coho, only about 15 per cent survive to hatch and

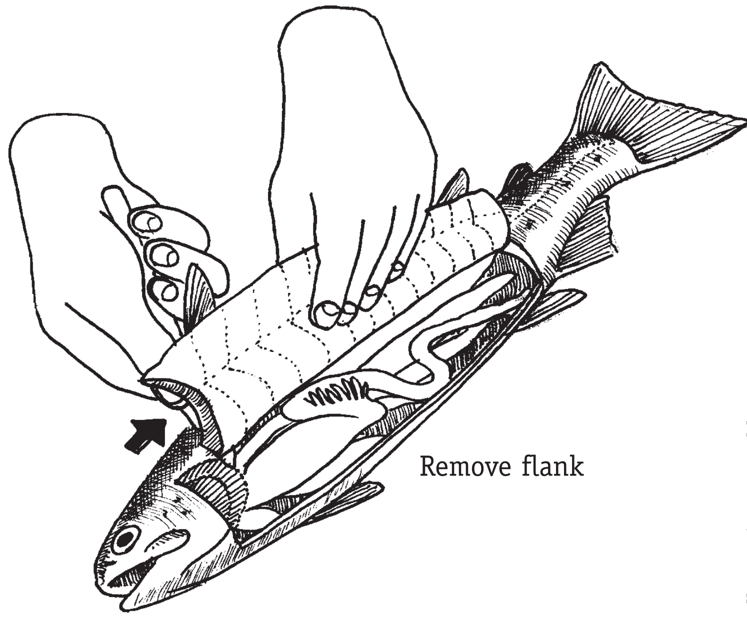


Illustration: Donald Gunn

only about 30 survive the first year. About four will grow to become adults, and only two will live long enough to spawn. So each female produces enough eggs to replace only one pair of fish.

The liver

- What is the largest organ in the fish's body (and in a person's body, too)?
  The liver is the largest organ.
  It is dark red and firm in texture.
  The liver cleans the blood, and manufactures and secretes nutrients into the blood. The liver is essential for maintaining the proper level of blood chemicals and sugars.
  The gall bladder is attached to the liver. It contains green bile, which is used in the digestion process.

- Gently pull the liver away from the body and detach it. Place it on a paper plate, cut it open and have students examine it.

The heart

- Where would you look for the heart?
- Why is the heart located so close to the throat?
  It is very close to the gills, where the blood gets refreshed, just as the heart is close to the lungs in humans.

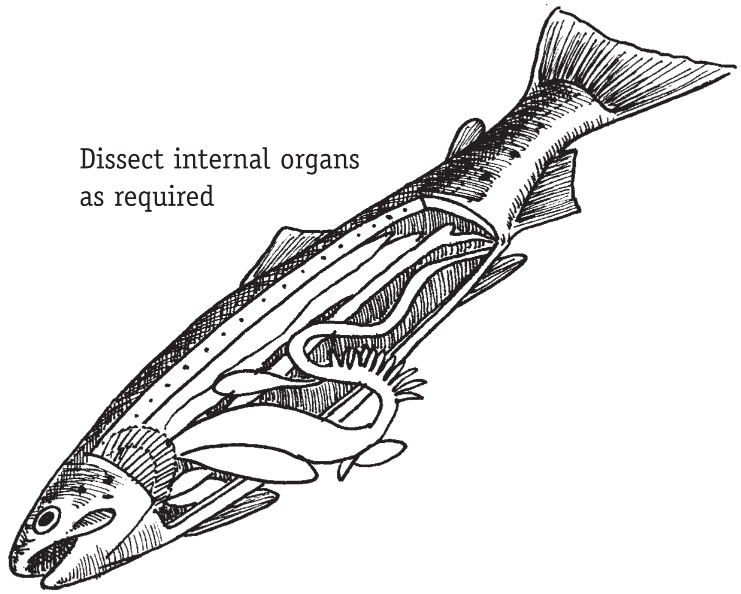


Illustration: Donald Gunn

- Carefully cut the skin from the belly to the throat. Locate the heart in the cavity in the throat area near the gills. Pull the heart out. Place it on a paper plate, cut it open and have students examine it.

  - What does the heart feel like? Why?
    The heart feels tough but flexible. It is a strong muscle, but it has two hollow chambers that pump blood around the fish.

The digestive system

- How would you find the digestive system?
  The digestive system consists of several pieces, attached to the mouth at one end and the vent, or anus, at the other end.

- Gently push the straw through the mouth of the salmon, down the throat and into the digestive system.

- Detach the system at the throat and vent. Place it on a paper plate and have students examine it.
  The first part of the system, the stomach, extrudes digestive juices that break down food and absorb nutrients into the blood. It is similar to the small intestine in people.
  A red spleen is attached to the digestive system. It acts as a storehouse of blood for emergencies and it recycles worn-out red blood cells.
  Food absorption occurs mainly in the intestine, the tube-like section at the end of the system.
  The digestive system of a fish is much shorter and simpler than the digestive system of mammals. Because fish are

cold-blooded, they do not use as much energy as a warm-blooded animal of the same size. They do not need to extract as much energy from their food when they digest it, so they can expel it more quickly.

The swim bladder

- Most fish swallow air into their swim bladder to counteract the weight of their bodies. Where would you look for the swim bladder?
  The swim bladder is attached to the throat, along the top of the abdominal cavity.

- Gently detach the swim bladder, without tearing it, by stripping it out with your fingers. Cut open one end and insert the straw. Have a student gently inflate the bladder by blowing through the straw, then twist the end and float it in the bucket of water. Place the bladder on a paper plate and have students examine it.
  Salmon can adjust the air in their swim bladder so they can hover comfortably at different levels in the water without sinking or rising.
  Because the swim bladder is located just below the centre of the fish, it keeps the fish slightly off-balance. This is why fish float upside down when they die.

The kidney

- The kidney cleans the blood and produces red blood cells. It is also critical in the salmon's smolting process (going from fresh to salt water) in a process called osmoregulation. What colour should the kidney be?
  The kidney looks like a dark red line along the backbone.

- Slice through the membrane holding the kidney in place and use the spoon carefully to lift it off. Place it on a paper plate and have students examine it.
  The front part of the salmon's kidney replaces red blood cells and the back part filters waste products out of the blood.

The ribs and backbone

- What are the bones that surround the abdominal cavity?
  The ribs are lightweight, curved bones that give the fish its shape, just as ribs create the barrel-like shape of a human torso. The ribs serve to protect that salmon's internal organs.

- Slice through the membrane on either side of a rib and pull it up toward the backbone. Pull to disconnect it, place it on a paper plate and have students examine it.
  - Fish share a very important characteristic with mammals: their flexible backbone. What does the backbone look like?
    The backbone is made up of a series of interlocked disks. They can move from side to side, but fish can only bend up and down a small amount.
    The backbone protects the spinal cord that runs through the body to the brain and gives structure to the fish's body.
- Cut off the tail, and expose a segment of backbone. Place the tail on a paper plate.

Lateral line

- Have students examine the cross-section of the body and note the indentation where the lateral line runs along the fish.
  - What is the lateral line for?
    The lateral line is a specialized organ which all fish have, and which functions like an ear. It detects vibrations and pressure waves in the water, just as an ear does in air.
    The lateral line is a series of liquid-filled canals below the skin along the side of the fish.
    It combines aspects of an organ of touch, an organ of hearing and an organ of seeing.
    Fish use the lateral line mainly to tell distance and water flow, and to detect disturbances in the water.
    Some fish can use the lateral line to find their way when it is too dark or muddy to see, feel movement around them and detect changes in the water.

  Option: If the fish is edible, filet the fish by slicing the flesh away from the ribs and backbone, first on one side, then on the other, exposing the ribs and backbone. Refrigerate the filets.

The head

- Reach under the gill with a finger and push up to loosen the muscles around the eye. Then cut the muscles attaching the eye to the eye socket and pull it out. Place the eye on a paper plate and have students examine it.

- How are fish eyes similar to and different from people's eyes?
  Salmon have two eyes but, unlike people,salmon do not have binocular vision, which would give them depth perception. However, the salmon can swivel each eye independently forward and backward, to cover a much wider field of vision than people have.
  Fish have very sharp vision under water. Some can see five metres or more.
  Fish have no eyelids. Their eyes are continuously washed in water.

- How do salmon smell?
  Fish have nostrils above their mouth, but no noses. The nostrils are a small indentation that is not connected to the mouth cavity.
  Their scent organs detect chemicals in the water in very tiny concentrations. They use this information to detect harmful pollution and avoid potential threats, if possible. They also use smells to recognize their way home.

- Can salmon hear?
  Fish have an inner ear, but no outer ear. Sound waves travel through the water and through their body to the inner ear.
  Fish may also detect sound waves through their lateral line.
  The hearing range in fish is probably not as wide as in humans. However, fish probably use hearing to detect predators and other threats.

- How do salmon taste?
  Salmon have taste buds inside their mouth, like people do. They probably taste salt, sweet, bitter and acid, but their sense of taste has not been studied in detail.

The brain

■ Split the head open by placing the fish on its back, pressing the knife vertically into the backbone at the base of the head, and levering forward into the mouth. The brain will be visible in the split.

- What organ do salmon use to process all the information their senses gather and to respond to stimuli in their environment?
  Like all chordates, salmon have a brain at the end of their spinal cord where the nervous system transmits

the information they receive about their environment. Salmon brains have three pea-shaped sections. The forebrain controls the salmon's sense of smell. The midbrain controls vision, learning and responses to stimuli. The hindbrain coordinates movement, muscles and balance

Clean-up and conclusion

- If students are conducting a dissection, have them gather all scraps, rubber gloves, newspaper, paper towels, paper plates, etc. in the garbage bags (unless you have made provisions for returning or disposing of the waste).
- Have students use buckets of clean water with disinfectant and paper towels to thoroughly clean the knife, tables, chairs, sink, etc.
- Have students draw a stick figure on a sheet of paper, with a large thought bubble on one side and a speech balloon on the other. Have them write in the thought bubble words that describe how they felt during the dissection. Have them write in the speech balloon words that describe what a scientist would conclude following the dissection.
- Invite students to share their thought bubbles and speech balloons with the class and discuss their reactions. If necessary, prompt them with questions, such as:
    - What would make people feel uncomfortable during a dissection?
      Cutting open a body, unusual sights and smells, etc.
    - How do scientists react if they feel uncomfortable?
      They talk about their concerns, discuss why they feel uncomfortable, and why they want to continue or stop the investigation.
    - What would a scientist conclude from the observations?
      Salmon have many complex biological systems in order to live. Some have similarities to humans and other animals. Some are unique to fish.
- Have students refer to their notes and information sheets and compare the structural and internal anatomy of a fish with that of a human, including the muscular, skeletal, respiratory, digestive and reproductive systems.

Review and Build on What You Know

Materials:
None

Time required:
20 minutes

Review

- Give students five minutes to review their notes and list at least six important ideas or facts about the life of salmon spawners.
- Give students five minutes to share their lists, in groups of four, and write on chart paper the four most important ideas agreed on by the group.
- Have the groups post their charts on the classroom wall, then lead a class discussion on the common ideas and differences recorded on the charts.

Summation

- Have students add their lists and any additional comments to a salmon science notebook or portfolio.
- Have students add information about salmon spawners to their salmon life cycle chart. (See Unit One: Building Knowledge: The Salmon Life Cycle.)
- Have students add information about salmon spawners to their salmon habitat mural.

Wrap-Up

Extension Activities

- Have students look for newspaper and magazine articles or videotape television news programs discussing the return of salmon to local waterways, then report their findings to the class.
- Have students take a field trip to a stream or fish ladder through which spawning salmon pass, or to a local fish hatchery. Have them use "Handout 3.3: Basic Salmon Habitat Survey and Data Sheet" and/or "Handout 3.4: Advanced Habitat Survey and Data Sheet" to examine and record features of a stream or lake that relate to the spawning stage of a salmon's life cycle.
- Have students research the effect on salmon spawners of hydroelectric development or other blockages on rivers and streams. Have them research any species of landlocked salmon found in their areas.
- Have students write a letter to the editor presenting evidence to support an argument for or against a development that would affect a hypothetical salmon stream.

Suggestions for Assessment

- Have students identify environmental changes caused by humans that help salmon spawn (e.g., culverts, fish ladders, spawning beds) and those that interfere with salmon (e.g., dams, fisheries, siltation). Have students present arguments, orally or in writing, for or against the expanded use of each.
- Monitor the discussion as students make and present their lists in the review activity to ensure that the students can use factual information from the activities to support opinions about the life of salmon spawners.
- Monitor student discussions of the class' habitat mural and life cycle chart to ensure that the students can identify the needs of salmon spawners, as well as their habitat and threats to it.
- Have students write quiz questions about salmon spawners on one side of an index card and answers on the other. Have them quiz each other by asking the questions or using a *Jeopardy*-style format by giving the answers and asking for a question.
- Have students add their notes, experiment observations and other materials to a salmon science notebook or portfolio.
- Have students use "Appendix 2: Student Assessment Sheet" to review their group work and their own learning.

Home and Community Connections

- Have students ask an adult to take them to visit a local salmon spawning area, where they describe to an adult what is happening.
- Suggest that the class begin a project to identify and protect any waterways in the community used by spawning salmon or to restore damaged spawning habitat. (For directions, refer to Unit Ten: Review: The Salmon Life Cycle, "Activity 5: Creating Positive Human Impacts".)

Handout 4.1

The Salmon Spawner

In the final stage of their life cycle, salmon re-enter their home river and swim back to the stream or lakeshore from which they emerged as fry. Some travel many hundreds or even thousands of kilometres, swimming from 30 to 50 km a day against the current. They follow the scent of the water to their home stream. Fishers and predators such as bears, otters, racoons and eagles catch many salmon on their trip upstream.

When they enter fresh water, salmon usually stop eating and live only on stored body fat. To save energy, they lose the slimy coating that helps protect them, their skin becomes thick and leathery, and they start to absorb their scales. Some internal organs may fail on the journey.

The salmon's appearance changes dramatically, with males and females developing distinct differences. They lose their silvery colour and take on deep red, green, purple, brown and grey colours. Their teeth become long, and they develop a hooked jaw, which is particularly pronounced in males. Their body shape can change, with some species developing a distinct hump on their back. Eggs develop in the ovaries of females, while males develop sperm.

When she reaches her home stream or lake, the female uses her fins and tail to find a spot with the right gravel size and water conditions. With her tail, she rearranges the stones in the gravel bed to form a redd, the nest-like depression in the stream- or lakebed where she will lay her eggs.

The female deposits her eggs in the redd, then the male deposits his sperm to fertilize them. Some species deposit up to 6,000 eggs, but the average is about 2,500. The female covers the eggs with gravel to protect them, often moving on to build a second or third redd which may be fertilized by other males.

Both males and females die within a few days of spawning. (Steelhead and cutthroat may survive to spawn more than once, although once is most common. If they survive, they go back out to sea as kelts, spawned-out salmon, then return to the spawning area in another year or two. Altogether, they may spawn three or four times.) The salmons' bodies decompose, releasing valuable nutrients, including minerals from the sea. The nutrients from the salmon carcasses form a rich food source for other wildlife, as well as fertilizing the stream and lake along the shore. When salmon carcasses are carried onto the riverbank, they also fertilize the forest and bushes. The ocean compounds in the salmons' bodies can be very scarce in the upstream environment. If few adult salmon return to spawn, the lack of nutrients can make the forest and the water a poor environment, with few nutrients for growing salmon fry and other species.

Handout 4.2

Genetic Diversity

Find your own number on the genetics wheel. Colour the side of the centre circle that represents your sex. On the next circle, colour the segment that represents your eye colour. Continue until you reach the outside circle.

This wheel represents only seven possible differences, but it produces 128 possible results. Humans, and many other species, have millions of possible differences. The number of possible results is uncountable. No one on earth is genetically the same as anyone else – except identical twins.

Species that have many differences among their members can adapt to many different conditions. Genes for muscular bodies, for example, allow people to survive when they have to work hard to raise food. Genes for quick thinking allow people to survive when they must respond quickly to dangers in the environment.

Genetic variations are important in other species, too. Among salmon, some may be better able to survive if the water becomes warmer or becomes polluted. If herring become scarce in the ocean, some salmon may be able to catch other species. If all the salmon were identical, a change in the environment could be devastating to them as a species.

Write a sentence describing how each of these variations might help salmon survive.

The ability to survive warmer temperatures. ____

____

____

The ability to jump high out of the water.____

____

____

The ability to lay more than one batch of eggs. ____

____

____

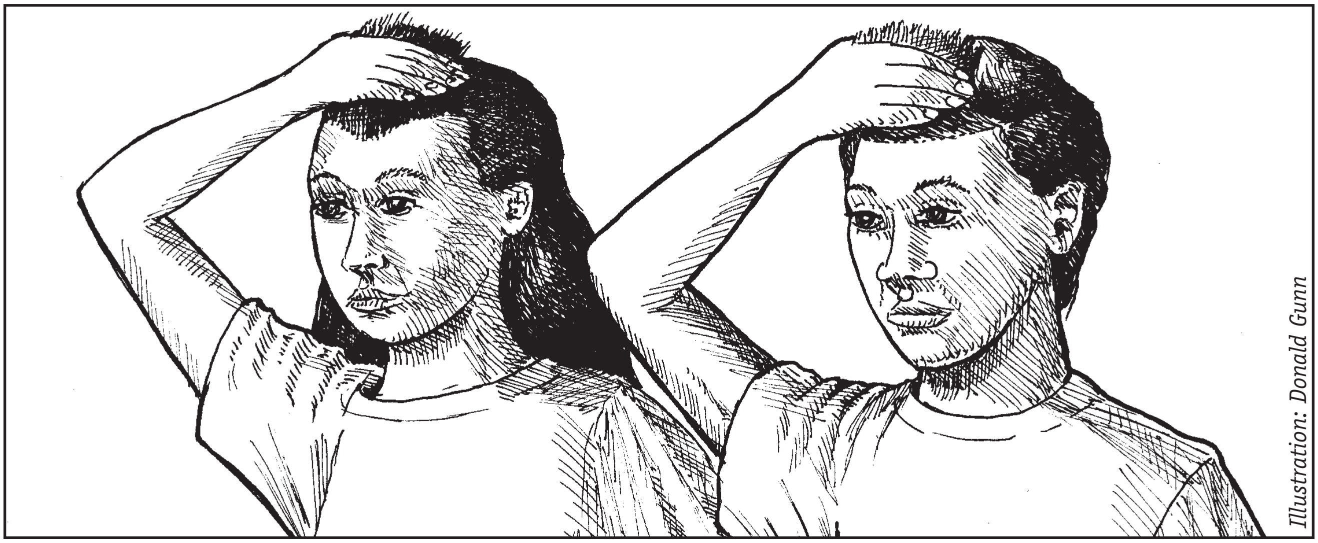
The ability to grow larger or smaller than other salmon. ______________________________

____

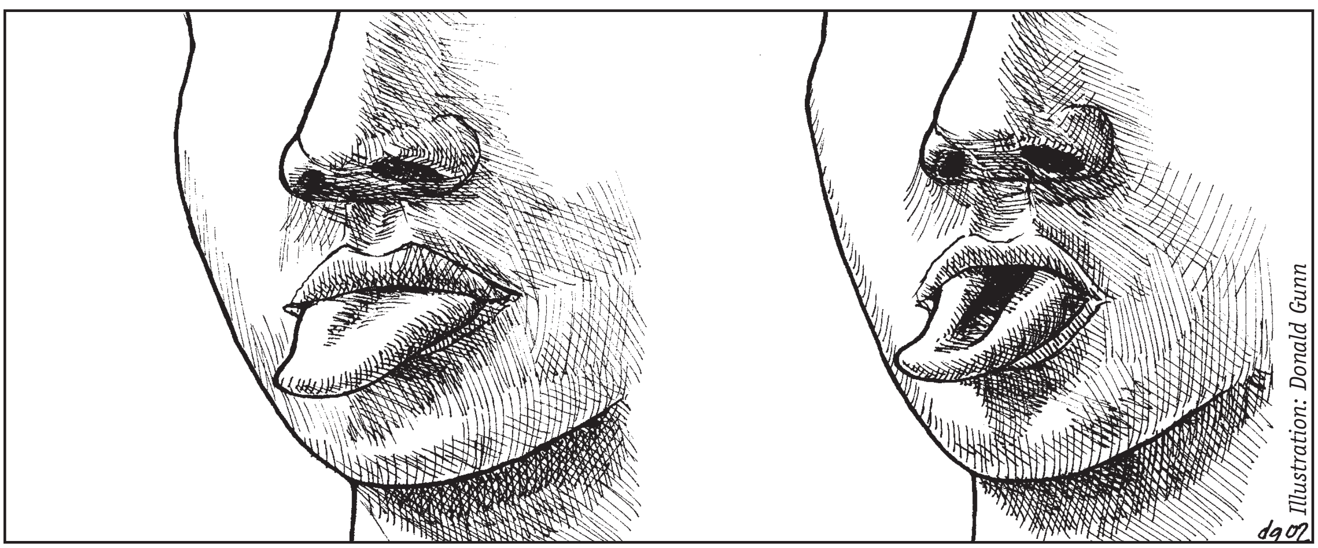
____

Handout 4.2
Genetic Diversity

Widow's Peak



Tongue Roll



Handout 4.2

Genetic Diversity

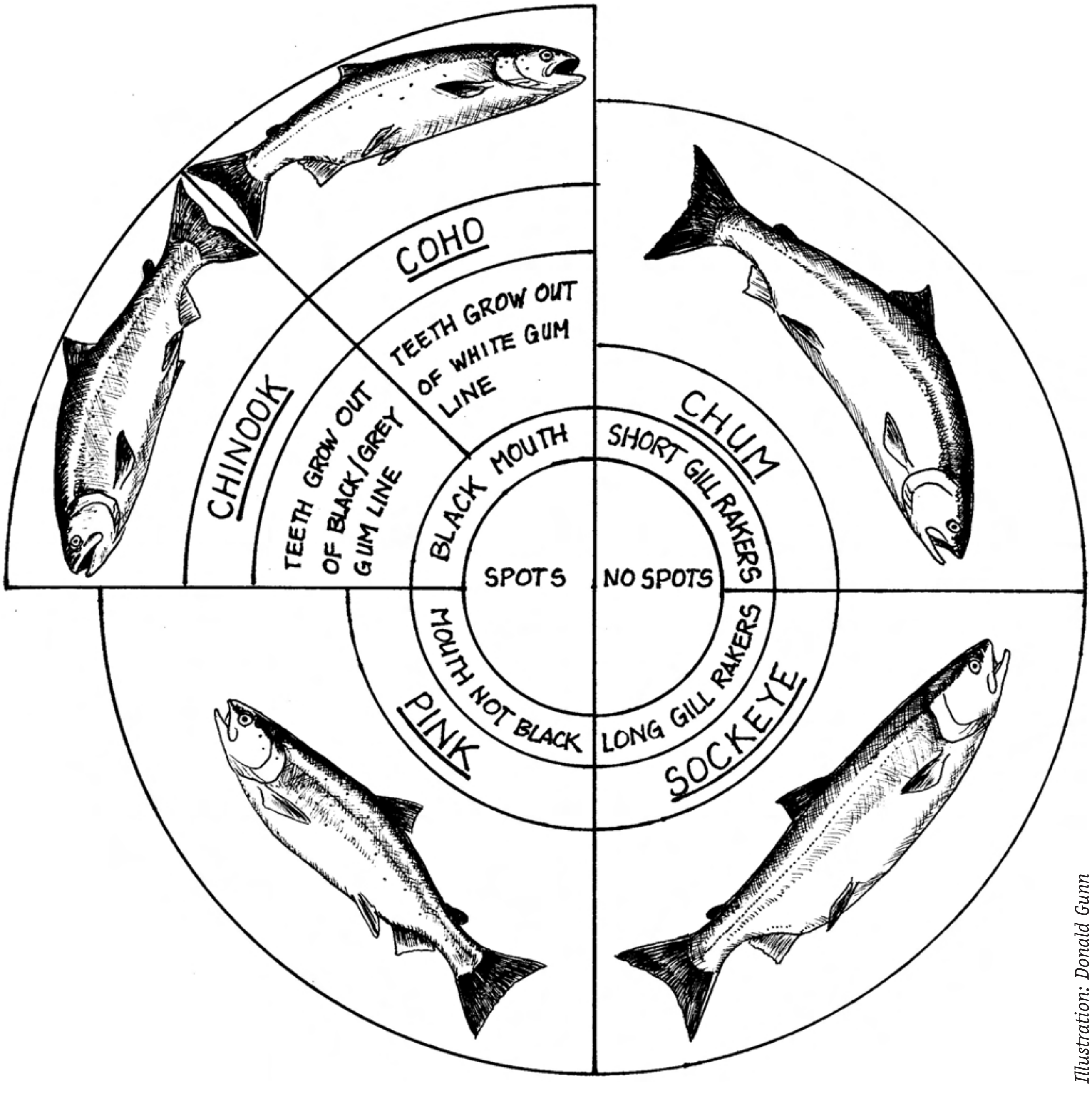


Illustration: Donald Gunn

Handout 4.3

Dissecting a Salmon

Name ____

Slime layer and scales

The slime layer helps salmon to: ____________________________________

____

____

____

Draw a salmon scale, showing its growth lines.

Fish shape and features

Draw the main external features you can see on a salmon.

HANDOUT 4.3

Dissecting a Salmon

Fins and tail

On your diagram, label four median fins and two sets of paired fins you see on a salmon.

Draw one of the salmon's bony fins, showing its parts.

Gills and gill rakers

Write three or more observations about the gills and gill rakers. ______________________________

____

____

____

Eggs or milt

State whether your fish is male or female and explain how you know. _________________________

____

____

____

Describe the egg or milt sack from the dissection (e.g., its shape, texture, any features, number of eggs)

____

____

____

Handout 4.3

Dissecting a Salmon

The liver

Describe the colour and texture of the liver, then describe the appearance of the inside. ____________

____

____

____

The heart

Describe where the heart is located and explain why it is located there.__________________________

____

____

____

____

The digestive system

Draw and label the main parts of the digestive system.

The swim bladder

What happens when a swim bladder is inflated with air? ___________________________________

____

____

____

____

Handout 4.3

Dissecting a Salmon

The kidney

Describe the salmon kidney. ____

____

____

____

The ribs and backbone

Sketch the skeleton of a salmon, showing the ribs and backbone.

Lateral line

Draw a cross-section of the salmon, near the tail.

HANDOUT 4.3

Dissecting a Salmon

The head

What sense organs are located in the head of a salmon? ____

____

____

____

The brain

Draw the location of the brain on your sketch of the salmon's skeleton.

Handout 4.4

Salmon External Anatomy

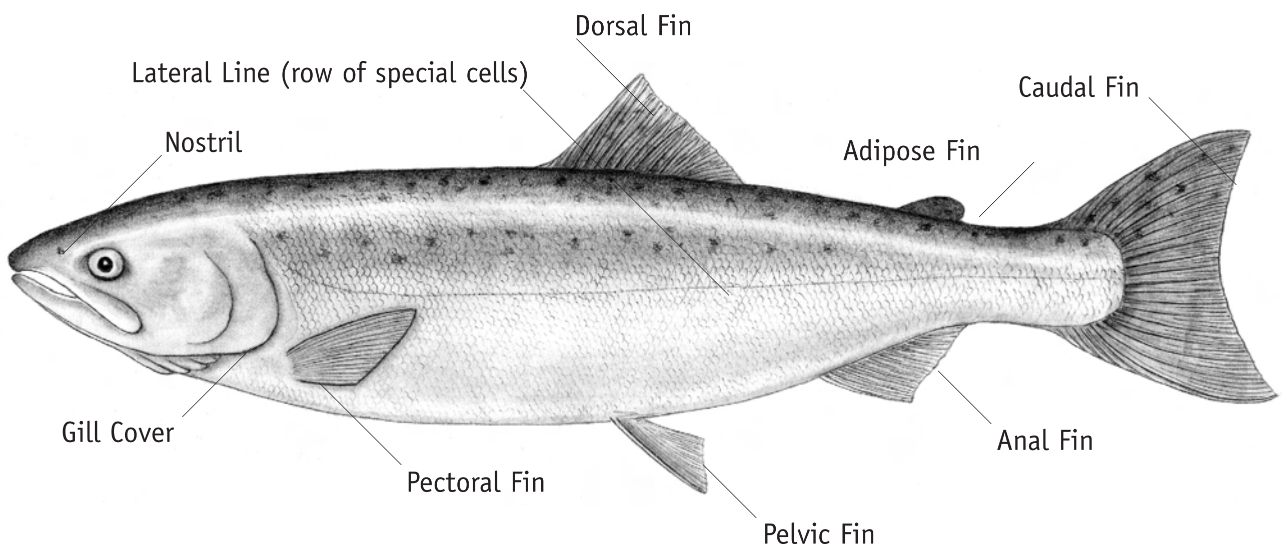
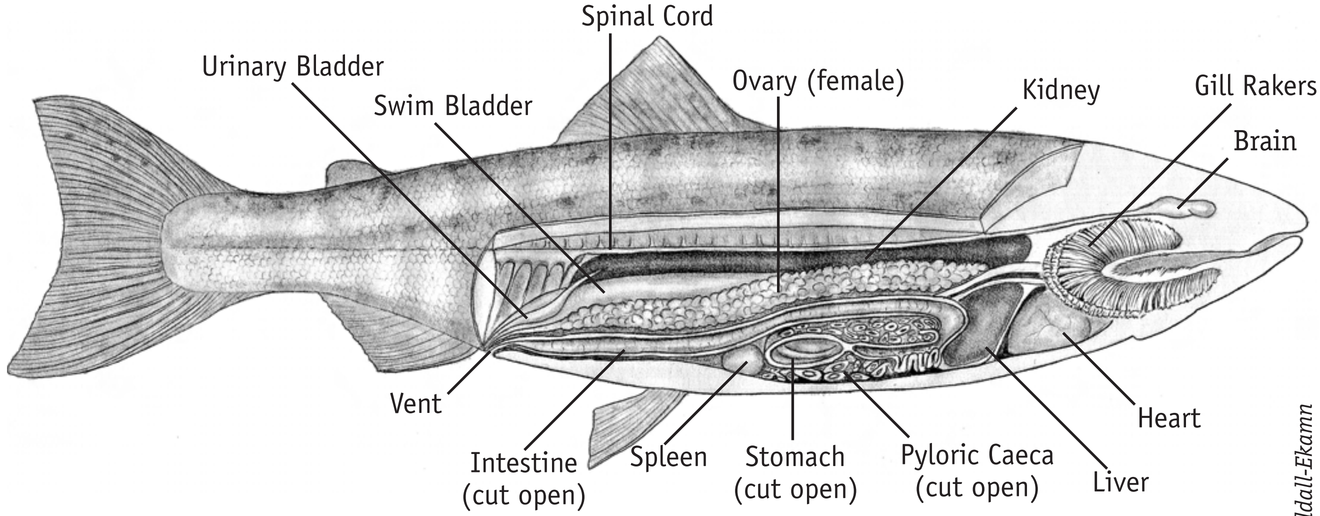


Illustration: Karen Uldall-Ekamn

HANDOUT 4.5

Salmon Internal Anatomy

female salmon



male salmon

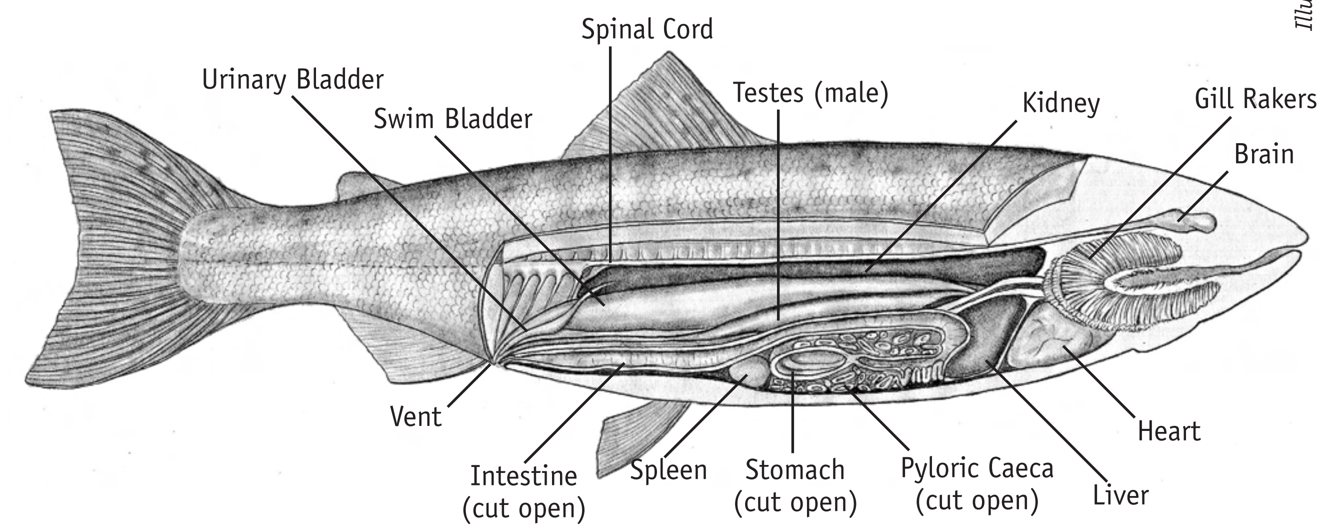
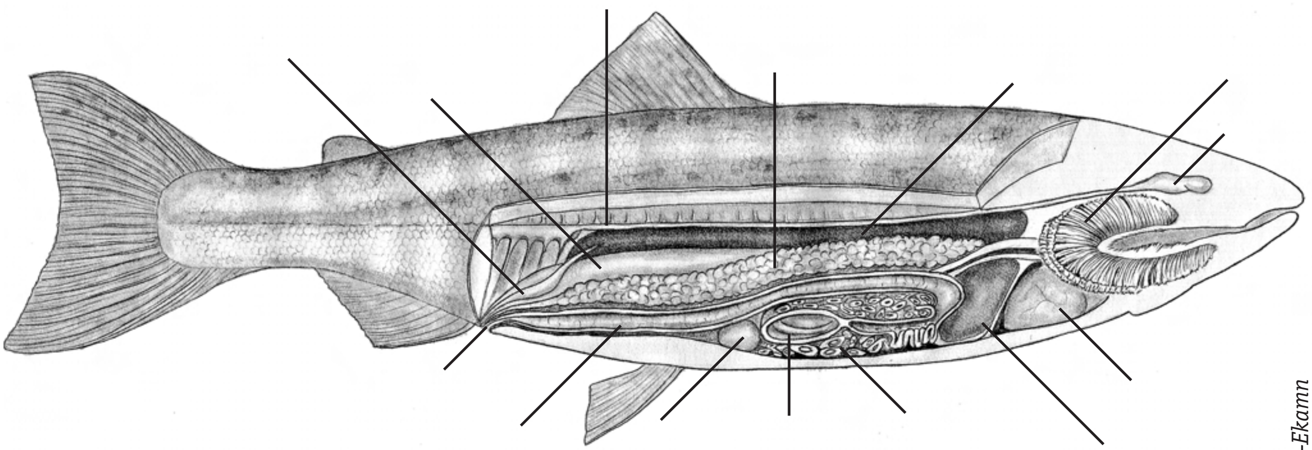


Illustration: Karen Uldall-Ekamn

Handout 4.5

Salmon Internal Anatomy

female salmon



male salmon

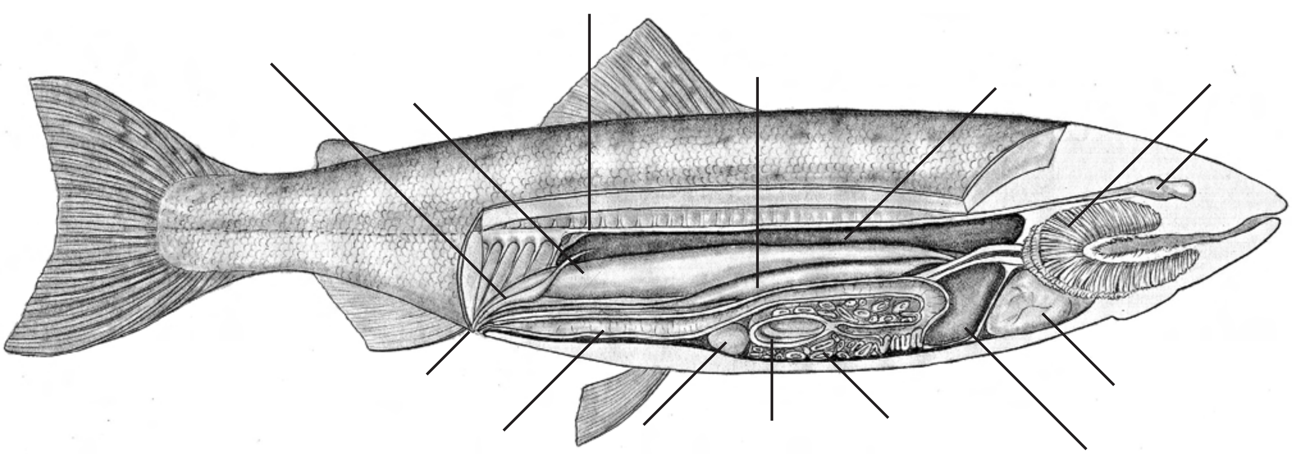
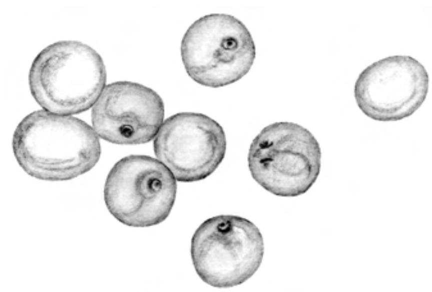


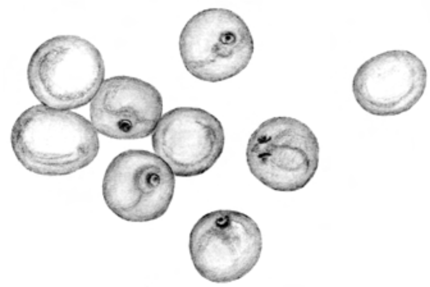
Illustration: Karen Uldall-Ekamn

UNIT 5

SALMON EGGS



Salmon Eggs



Overview

This unit gives students an opportunity to:

- discuss the ways in which animals reproduce;
- hatch an organism from an egg;
- study the role of temperature in egg development;
- create a chart of the salmon's life cycle;
- investigate the concept of parts per million (ppm);
- investigate the impact of pollution on salmon habitat and identify ways to reduce pollution
- review the concepts they learned in the unit.

Note that some activities begun here will continue through the life cycle units.

Key Concept

The egg contains a developing salmon. It is highly sensitive to disturbances in water quality, variations in temperature and pollution in its habitat.

Vocabulary

parts per million (ppm), concentration, molecule, oxygen, dissolved, impurities, pollutant, silt, Accumulated Thermal Unit (ATU), embryo, alevin.

Background Information

The information which follows can be used to supplement "Handout 5.1: Salmon Eggs".

Egg development

The development of salmon eggs, like the early development of most organisms, is a process of cell formation, division and differentiation.

An egg is fertilized when one sperm from the milt of the male salmon finds and enters a narrow canal in the egg. Sperm must enter the canal soon after the eggs are laid because the egg membrane reacts to the water and closes off the canal. After fertilization, the clear egg fluids concentrate over the surface of the yolk, forming a dome that becomes the blastodisc of cells after many cell divisions. The blastodisc eventually becomes the embryo.

After fertilization, egg development goes through three main phases:

- **Cleavage or cell division**. The first cell forms inside the fertilized egg on the cytoplasmic dome and within 10 to 25 hours, depending on the water temperature, it divides to form two cells. The cells continue to divide and begin to show some differentiation into tissues within four to eight days.
- **Epiboly or embryo development.** After four to eight days, the first bud of the tail begins to form and, a few days later the shape of the embryo becomes distinct, attached to the yolk within the egg.
- **Organogenesis or organ formation.** After a period varying from 12 to 30 days, the individual organs and body parts of the embryo become distinct, beginning with the tail. The heart begins to beat and blood vessels form over the yolk. After 22 to 50 days, the dark eyes are visible through the egg membrane and, after 60 to 120 days, the embryo has developed a backbone, fins and gills. It is ready to hatch from the egg.

As the embryo starts to grow, it moves within the egg. First the heart sac begins to contract, then the body begins to twitch. The developing pelvic and pectoral fins begin to twitch. Their fanning motion is essential to move oxygen, enzymes and fluids through the egg. The twitching movements also build up the muscles the embryo will use when it hatches.

As the embryo grows and becomes more active, it needs more oxygen. The oxygen that transfuses through the egg membrane becomes insufficient for the growing embryo. Scientists believe this insufficiency may trigger the embryo to release a chemical called a hatching enzyme, which digests the egg membrane. The movement of the embryo spreads the enzyme through the egg, further weakening the membrane. By stretching and pushing, the embryo breaks through the cell membrane, then slowly wiggles out of the egg, dragging the yolk sac with it. Embryos that have not wiggled enough inside the egg may not have weakened the membrane enough to tear or they may be able to push only their head through. These embryos may die in the egg without hatching.

Virtually all organisms, except one-celled ones, develop through a process of cell division and differentiation.

Introduction

Materials:
Pictures of adult animals with their offspring

Time required:
15 minutes

Suggested Activities

Choose activities from these suggestions that are appropriate for your class.

- Show pictures of adult animals with their offspring.
  Ask students to give examples of ways in which various animals produce their offspring or children.
  How does a chicken produce chicks? By hatching an egg. What about a frog? By hatching eggs. How does a cow have calves? By giving birth. What about a human? By giving birth to a baby.
- Ask students to describe the benefits and hazards of reproduction from eggs.
  Eggs provide a controlled environment and source of nutrition, especially if the parents will not be present. Eggs also allow the offspring to grow relatively large before they are born. However, eggs are generally immobile and difficult to protect from predators except by hiding.
- Explain that most animals, except mammals, reproduce by laying eggs outside of their bodies. In the unit's activities, we will study salmon eggs, their habitat and some hazards they face.

Classroom Incubation of Eggs

[experiment]

Depending on the ability of your students and class resources, you may prefer to do this activity as a class project or in small groups.

Materials:

- One copy of "Handout 5.1: Salmon Eggs" for each student
- Writing supplies

Time required:
Time for daily observations over several weeks plus one or more periods for class discussion

Level of conceptual difficulty:
Simple

Suggestions for assessment:
Review the students' recorded observations and class discussion to ensure that the students can observe and characterize changes in the life of an organism, and identify the elements essential to the organism's development.

Experiment

- Have students raise an organism with distinct life cycle stages, from an egg to an adult. Suitable organisms include: salmon eggs in an incubation tank, butterflies, snails, tadpoles.
    - Specific procedures and set-up needs will depend on the organism you choose. Refer to manuals such as *Fish Eggs to Fry* (Oregon Department of Fish and Wildlife Salmon-trout Enhancement Program, 2000) or general guides such as *A Year of Hands-on Science*, (Lynn Kepler, 1996, pages 32–39, 278–9). Monarch butterfly caterpillars and fertile chicken eggs are available from science supply stores.
- Have students set up and maintain the hatching environment, then observe and record the development of the organism from the egg, using notes, drawings, and either a still or video camera. Have them prepare a display or hypertext file summarizing the organism's development.

    Option: Have students raise similar organisms in environments with controlled variables and compare the outcomes. For example, they could raise tadpoles in water with different pH levels or temperatures.

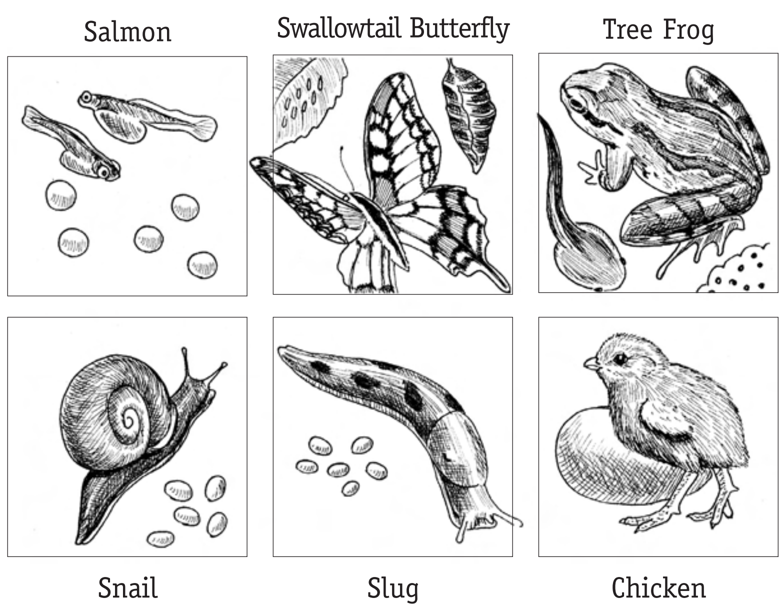
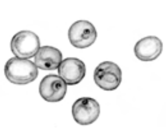


Illustration: Donald Gunn



Research/Discussion

- Have groups of students use "Handout 5.1: Salmon Eggs" or other resources to compare the common needs of the organism they raised with the needs of a salmon egg. Have a class discussion about the students' conclusions. If necessary, prompt them with questions, such as:
  - What changes did you observe in the organism?
    A salmon egg develops slowly at first, then develops organs, such as dark eyes that are visible through the cell wall. Eventually a small alevin pushes its way out.
  - Do other organisms you know go through similar stages?
    Most organisms move through several similar stages of development, although they may not be easily visible from outside the egg.
  - What changes might help the organism to survive better?
    Protection from disturbances or predators; constant temperature; a good supply of air.
  - What needs do salmon eggs have in common with other organisms?
    All need air, water and shelter. All organisms need a source of food, which is contained in an egg.
- Have students use "Handout 5.1: Salmon Eggs" to identify the habitat needs of salmon eggs *(e.g., water conditions, streambed, shelter, oxygen, nutrients, heat units)* and to learn how those conditions are met in the redd.

Summation

- Have students add information about salmon eggs to their habitat mural.

Salmon and ATUs

[math/simulation]

Materials:

- Math blocks or pennies (optional)

Time required:
Approximately 60 minutes

Level of conceptual difficulty:
Simple

Evidence for assessment:
Review the charts the students make to ensure that the students can identify various stages in the life of plants and animals, including salmon.

Introduction

- Ask students to suggest reasons for birds sitting on their eggs before they hatch, then explain that a bird's body provides heat, which eggs need to develop. Explain that in many species, including birds and fish, the amount of heat that eggs receive is the most important factor in determining when the eggs will hatch. The amount of heat is measured in units called accumulated thermal units (ATUs). Each species needs a different number of ATUs (about 450 degrees Centigrade for coho salmon; about 777 for chicken eggs at 70% relative humidity). While birds get most of the ATUs they need from their mother's body, salmon get the ATUs they need from the water that flows past them.

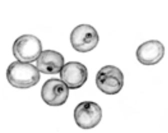
Simulation

- Explain that, in the simulation which follows, each student represents a redd with 2,500 coho salmon eggs in a stream. The eggs must receive 450 ATUs to hatch, but if they receive more than 18 or less than 2 ATUs in a day, they will die. Events taking place around them in their environment may also cause the eggs to die. Using the table below, have the class calculate the ATUs received by their salmon eggs.

  Note: You may wish to calculate a few examples with the class on a chalkboard. With younger students, you may prefer to have them manipulate tokens such as math blocks or pennies representing the ATUs the eggs receive. Ensure that the students understand that the ATUs suggested below are examples for the purpose of the simulation only, although they represent what could happen in an actual setting.

  - Read the daily temperature from the chart (page 104) to the class. Have each student note the temperature in a notebook, then calculate the ATUs the eggs in the redd receive.
  - Periodically ask the class to calculate the number of days until the eggs hatch if the temperature continues at that day's temperature. Students can use the formula:

$$\frac{450 - \text{ATUs to date}}{\text{current day's temperature}}$$



- Ask the class to predict when eyes will appear in the egg if they normally appear at 220 ATUs.
  Day 30
- Randomly add some events that affect the survival of the redds. Ensure that about 10 per cent survive to hatch.

  Events could include:

  - *Racoons discover redds and eat the eggs. One of every 10 redds is lost.*
  - *Disease hits some redds and kills the eggs. Two of every 10 redds are lost.*
  - *Off-road vehicles drive through the stream, crushing the eggs. One of every 20 redds is lost.*
  - *Construction or logging upstream releases silt into the stream, preventing oxygen from reaching the eggs. Two of every 10 redds are lost.*
  - *Small streams freeze solid, which destroys eggs. One of every 10 redds is lost.*
  - *High rainfall floods the stream and washes away the gravel and eggs. One of every 10 redds is lost.*
  - *Car oil seeps into the stream and poisons the water. One of every 20 redds is lost.*
  - *People remove streamside vegetation, raising the temperature to 20°C and killing juvenile salmon in the stream. Three of every 10 redds are lost.*
  - *Dogs playing in the stream dig up redds. One of every 20 redds is lost.*

Option: Have students determine scientifically ways of maximizing the eggs' chances of hatching on a given date. *Control the temperature to a level between 2°C and 14°C so the eggs receive 450 ATUs on the given date.*

Option: Have students calculate the average ATUs the eggs received per day (9) and use graph paper to graph the daily variations.

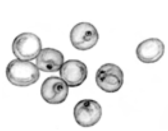
Discussion

- Discuss with the class the observations they drew from the data. If necessary, prompt them with questions, such as:
  - How consistent was the temperature?
    It varied from 4°C to 14°C, changing by from 0°C to 3°C per day.
  - When the temperature changed, what happened to the projected hatch out day?
    Higher temperatures made it sooner; lower temperatures made it later.
  - What events had the most impact on salmon survival?
    Logging, construction and disease.

  Option: Have students use data such as those in the table to create a computer simulation game or a desktop game that represents the development of an egg and its chances of survival.

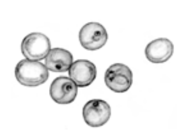
Research

- Have students measure the water temperature of a nearby salmon stream daily or weekly. A chart like the one below can help students estimate when salmon spawn, when eyes will appear in the eggs, when the eggs will hatch, etc.
- Conduct the research until the fry emerge from the gravel. Do some netting to see if fry have emerged. How accurate were the students' estimates of the emergence date? Ask the students what factors other than temperature may affect emergence?



Day Temp °C	ATUs	Days to hatch*	Notes	
Day 1	8	8	55	Eggs laid, very sensitive.
Day 2	8	16	54	
Day 3	8	24	53	
Day 4	9	33	46	
Day 5	9	42	45	
Day 6	10	52	40	
Day 7	9	61	43	`
Day 8	8	69	48	
Day 9	8	77	47	
Day 10	9	86	40	
Day 11	8	94	45	
Day 12	7	101	50	
Day 13	6	107	57	
Day 14	5	112	68	
Day 15	6	118	55	
Day 16	5	123	65	
Day 17	4	127	81	Low temperature warning.
Day 18	4	131	80	
Day 19	5	136	63	
Day 20	5	141	62	
Day 21	6	147	51	
Day 22	7	154	42	
Day 23	8	162	36	
Day 24	8	170	35	
Day 25	9	179	30	
Day 26	9	188	29	
Day 27	9	197	28	
Day 28	9	206	27	
Day 29	10	216	23	
Day 30	10	226	22	Eyes become visible
Day 31	11	237	19	
Day 32	11	248	18	
Day 33	12	260	16	
Day 34	12	272	15	
Day 35	13	285	13	
Day 36	13	298	12	
Day 37	14	312	10	High temperature warning.
Day 38	13	325	10	
Day 39	14	339	8	
Day 40	13	352	8	
Day 41	12	364	7	
Day 42	12	376	6	
Day 43	11	387	6	
Day 44	10	397	5	
Day 45	11	408	4	
Day 46	10	418	3	
Day 47	8	426	3	
Day 48	7	433	2	
Day 49	7	440	1	
Day 50	10	450	0	Hatch out

*If current day's temperature continues until hatch out.



Parts per Million

[investigation]

Materials:

- Approximately 20 sheets of 1-millimetre graph paper
- Copies of "Handout 5.2: Parts Per Million" for each student
- Writing supplies
- For each group of students:

- Eye dropper
- 5-ml measuring spoon
- 4-litre container
- 4 litres of water
- Food colourings

Time required:
One or two periods

Level of conceptual difficulty:
Moderate

Suggestions for assessment:
Review the students' worksheets and class discussion to ensure that the students can calculate and work with concentrations up to 1ppm.

Introduction

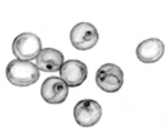
- Give each student a sheet of graph paper ruled in millimetres, and have them calculate the number of one-millimetre squares on each sheet. Have them calculate the number of sheets needed to have one million one-millimetre squares.
  (A typical sheet of graph paper has about 50,000 one-millimetre squares. Students will need approximately 20 sheets to make one million.)
  Have students tape or staple together enough sheets to make one million squares.

  Alternative: Have students measure the size of a small object, such as a penny or a marble. Have them calculate the area needed to line up one million similar objects. *(A square made up of one thousand objects by one thousand objects is equal to the area of one million objects.)*

- Have students use a tape measure to measure an equivalent area in the schoolyard and mark it with a string.
  For example, a penny is about 2 cm in diameter. An area of one million pennies would be 2,000 cm by 2,000 cm, or 20 m by 20 m.

Investigation

- Using the graph paper, have students draw a line around a row 1 square wide and 10 squares tall, i.e., 1 mm x 1 cm.
- Have them draw a line around a section 10 squares by 10 squares, i.e., 1 cm x 1 cm. Have them fill in 1 square and explain that it represents 1 in 100, or one part per hundred.
- Have them draw a line around a section 100 squares by 10 squares, i.e., 10 cm x 1 cm. Have them fill in 1 square and explain that it represents 1 in 1,000, or one part per thousand. Have students demonstrate a variety of other numbers, up to one part per million (e.g., 1 in 10,000 is 10 cm x 10 cm; 1 in 100,000 is 100 cm x 10 cm; 1 in 1,000,000 is 100 cm x 100 cm.)
- Explain that many organisms are very sensitive to chemicals in the air and water, including both essential chemicals and pollutants.



For example:

- *Humans need trace elements, including iron, copper, fluorine, iodine, selenium, zinc, chromium, cobalt, manganese and molybdenum; these are measured in parts per million.*
- *Human health can be damaged by chemicals, such as lead and mercury, and by some compounds, such as PCBs, even when exposure is only a few parts per million.*
- *Salmon are sensitive to certain chemicals in their water, such as chlorine, even when exposure is as low as a few parts per million. But they need oxygen in the water at a concentration of about 5 to 15 parts per million.*

■ Give students "Handout 5.2: Parts Per Million" and have them work in groups to fill in the worksheet. When they are finished, discuss their observations and conclusions.

Worksheet Answers:

1. *The number will depend on the size of the drops, but 5 ml will usually hold 50 to 80 drops.*
2. *A 10-ml container will hold 100 to 160 drops.*
3. *A 100-ml container will hold 1,000 to 1,600 drops.*
4. *A 1,000-ml (one-litre) container will hold 10,000 to 16,000 drops.*
5. *A 4-litre container will hold 40,000 to 64,000 drops.*
6. *The concentration of food colouring in the container will be between 1 part in 40,000 and 1 part in 64,000 (between approximately 25 and 15 ppm).*
7. *It would take 15 to 25 4-litre containers to hold 1,000,000 drops.*
8. *The food colouring is in the 4-litre container, but is so dilute that it is invisible.*
9. *Students' conclusions will vary, but may include the fact that 1 ppm is a very low concentration, and that a concentration of even 1 part in 50,000 is very difficult to detect.*

Water Quality Testing

[experiment]

Materials:

- Wire coat hanger
- Five sections of cheesecloth
- Five elastic bands or string
- Five one-litre jars
- One pollutant for each of five stations (See Variables listed in the Test column of the chart on page 116)
- Five containers for pollutants
- Ruler
- Litmus paper
- Copies of “Handout 5.3: Water Quality Testing” for each student

Time required:
Approximately two periods

Level of conceptual difficulty:
Simple to moderate

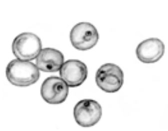
Suggestions for assessment:
Review students’ observation sheets and class discussion to ensure that the students can distinguish the effect of various contaminants on water, and can discuss their potential impact on aquatic organisms.

Preparation

- Place one-litre samples of tap water at each of five stations around the room. Label the samples and stations from 1 to 5. From the Variables listed in the chart in “Handout 5.3: Water Quality Testing” on page 116, choose a pollutant substance for each station.
- Place a ruler at Station 1 and litmus paper at Station 3.
- Bend the wire coat hanger to form a small square and place it at Station 5, with the sections of cheesecloth and elastic bands.
- Refer to the Chart on page 109, as needed, when discussing the experiment.

Introduction

- Have the class describe water in a liquid state and list as many of its characteristics as they can.
  (For example, it is clear, neutral in taste and scent, inactive.)
- Have the class suggest ways to compare water from different sources to see if it is all the same.
- Have the class list pollutants that they think might affect the characteristics of water, and hypothesize about their effect on salmon living in the water.



Experiment

- Divide the class into five groups, and have each group work at one of the five stations. (With more advanced students, you may prefer to have the groups rotate through all five stations.)
- Give students copies of "Handout 5.3: Water Quality Testing" and have them work in small groups to conduct each of the tests in Part A, noting their observations on the sheet. Give them about five minutes at each station. (Tell them not to put any of the water samples in their mouth or eyes.)
- Have students report their observations to the class, while you record them on a large chart or chalkboard. Have the students compare their observations before and after adding the pollutants. Discuss the conclusions the students drew after completing Part A of the procedure. If necessary, prompt students with questions, such as:
  - What characteristics did the water have before adding the pollutant?
    Clear, neutral in scent, inactive, etc.
  - What happened to the water after each pollutant was added?
    Tests should give different results on each sample.

Discussion

- Have students, in small groups, use Part B of the handout to list the five polluting substances from Part A, then use their knowledge about the environment and salmon to hypothesize about the sources from which each enters the environment and their effects on salmon.
- Have the groups report to the class on the information they added to Part B. Prompt them, as needed, with information from Chart 5.4.
- Have the students write a short paragraph or draw a picture in the space provided, illustrating things people could do to prevent pollutants from entering salmon habitat and harming salmon.

Chart 5.4. Water quality testing: Pollutants and effects

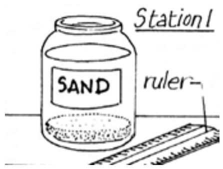
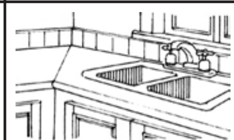
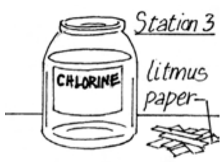
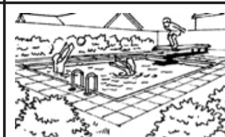
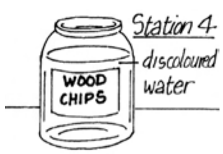
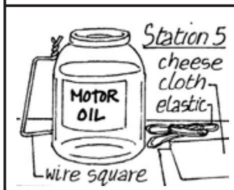
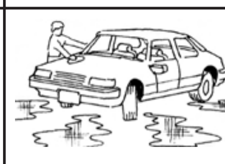
Experiment	Test	Substances	Cause	Pollution Source	Effect on Salmon
	Appearance: Turbidity Variables: Sand, soil, crushed concrete	• Sediment • suspended soil/gravel/ concrete or other particles	• land development • erosion • flooding • dredging activity • forestry activity		• damages gills • reduces light availableto algae and aquatic plants • smothers eggs • covers gravel substrate leaving less room for egg deposits • removes spawning habitat
	Smell Variables: Chlorine, bleach, soap	• chlorine • bleach • gasoline • soap/ detergent	• pools • hot tubs • drinking water • flushing fire hydrants • household drains		• biochemical death • damages/ obstructs sense of smell • smothers eggs/ gills • smothers other organisms (destroying salmon food source)
	Acidity/ Alkalinity Variables: salt, soap, lemon juice, vinegar, cola	• salts • metals • fertilizers • soap (alkaline) • leachates	• Exposed aggregate driveways (runoff pollutants) • Industrial effluent		• chemical change • disrupts balance of ecosystem • acid burns • damages gills, eyes, skin • changes internal water balance • fertilizers cause algal blooms, which depletes oxygen when the algae dies, and forces salmon away from the shore
	Appearance: Colour Variables: Leachate from "A Model Landfill" activity (Unit 6.5), motor oil, coffee, wood chips	• leachates • motor oil	• wood waste • landfills (percolates through soil) • lumber yards		• toxicity • destroys organisms • see acidity/ alkalinity
	Residue Variables: Lubricating oil, motor oil	• lubricating oil • motor oil • gasoline • antifreeze	• washing boats/ cars (runoff)		• toxicity • smothers eggs/ gills/ other organisms (destroying salmon food source)

Illustration: Donald Gunn

Review and Build on What You Know

Materials:
None

Time required:
20 minutes

Review

- Give students five minutes to review their notes and list at least six important ideas or facts about salmon eggs.
- Give students five minutes to share their lists in groups of four, and write on chart paper the four most important ideas agreed on by the group.
- Have the groups post their charts on the classroom wall, then lead a class discussion on the common ideas and differences recorded on the charts.

Summation

- Have students add their lists and any additional comments to a salmon science notebook or portfolio.
- Have students add information about salmon eggs to their salmon life cycle chart.
- Have students add information about salmon eggs to their salmon habitat mural.

SALMON EGGS

Wrap-Up

Extension Activities

- If your school has a classroom incubation tank, have students observe the eggs from the spawner when they are placed in the tank.
- If students are raising salmon in an incubation tank, have them calculate the number of ATUs the eggs receive daily and project the hatching date.
- Have students test and compare the physical and chemical characteristics of water from salmon streams in their local watershed and discuss its suitability for salmon eggs.
- Have students prepare a map showing the path water takes from a source to their home, including any purification or contamination sites along the route.
- Have students research what happens to wastes that enter the local sewage and stormwater drainage systems.
- Have students collect information on water quality in the following units to defend a position in favour of or against a project, such as a water diversion or sewage outflow, that would affect water conditions in a salmon spawning stream.

Suggestions for Assessment

- Have students write a letter to government or nongovernmental organizations describing the impact of pollutants on salmon and other organisms and recommending steps the organization could take to protect salmon and their habitat.
- Monitor student discussions of the class' habitat mural and life cycle chart to ensure that the students can identify the needs of salmon eggs, their habitat and threats.
- Monitor the discussion as students make and present their lists in the review activity to ensure that they can use factual information from the activities to support an opinion about salmon eggs.
- Have students write quiz questions about salmon eggs on one side of an index card and answers on the other. Have them quiz each other by asking the questions or using a *Jeopardy*-style format by giving the answers and asking for a question.
- Have students add their notes, experiment observations and other materials to a salmon science notebook or portfolio.
- Have students use "Appendix 2: Student Assessment Sheet" to review their group work and their own learning.

Home and Community Connections

- Have students describe to an adult practical steps they could take at home to reduce liquid pollutants and explain why the steps are useful.
- Suggest that the class begin a project to improve damaged salmon streams by arranging to place suitable gravel in appropriate locations where salmon can use it to bury their eggs. (For directions, refer to Unit Ten: Review: The Salmon Life Cycle, "Activity 5: Creating Positive Human Impacts".)

Salmon Incubation

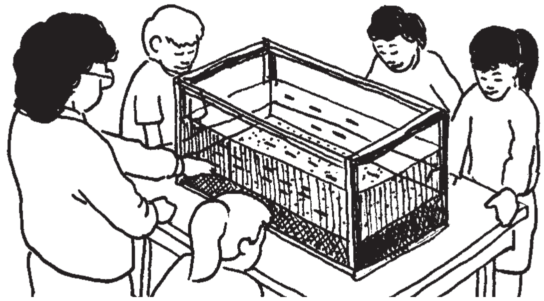


Illustration: Donald Gunn

If your school has an operating incubation tank,incubate salmon eggs and have students observe and record the results. For assistance, refer to "People and Connections That Can Help" on page vii of the Foreword.

➲ Have students use a thermometer to record the temperature of the water in the tank and keep a daily chart of the temperatures and ATUs. Have them graph and compare the readings and predict when the eggs will hatch.

Handout 5.1

Salmon Eggs

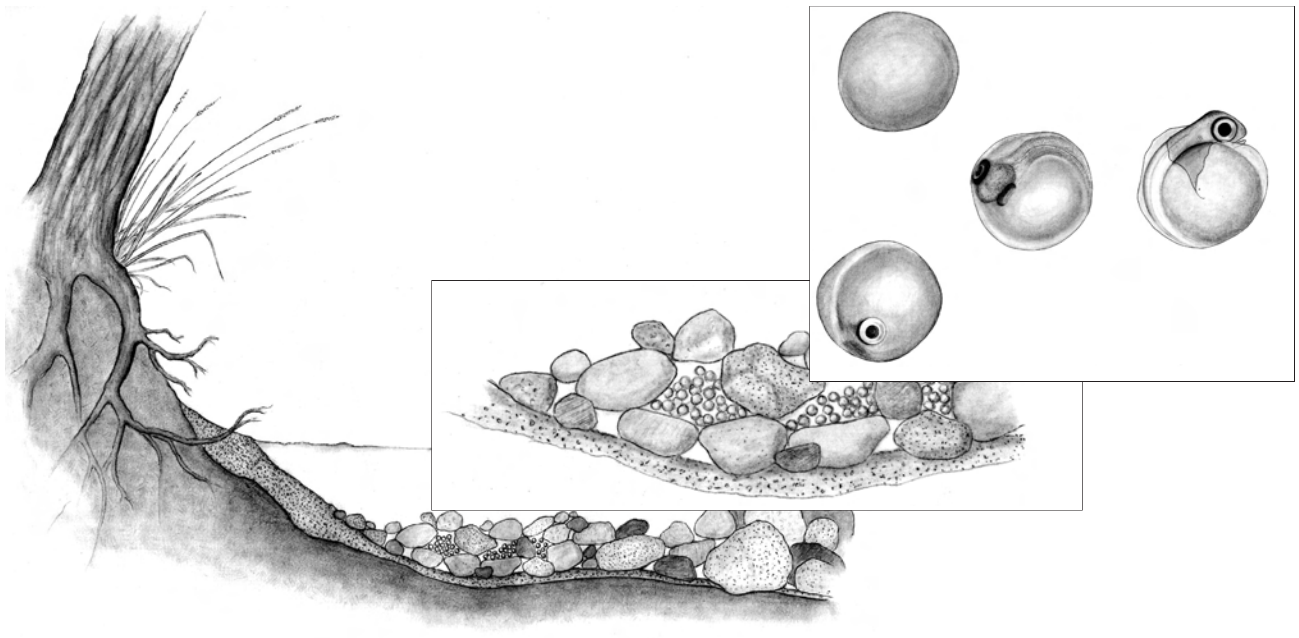


Illustration: Karen Uldall-Ekman

When adult salmon swim upstream to spawn in the fall, the female chooses a site in a stream with a gravel bed and plenty of flowing, fresh water. With her body, she digs a shallow depression called a redd, like a nest in the gravel.

Depending on the species and size, each female lays from 2,000 to 6,000 round, pinky-orange eggs, about 6 to 9 mm in diameter. Instead of a hard shell like a chicken, each egg has a soft, transparent wall. This wall, or membrane offers little protection against predators or other disturbances, so after the male fertilizes them the female covers the eggs with gravel. Birds, bears and raccoons eat the eggs if they can find them, and flooding, pollution and disease also destroy eggs.

Salmon eggs are very sensitive—only one in 10 survives to hatch. In the first days, even a slight disturbance of the streambed can be fatal. Changes in water level or temperature can kill many eggs; they are also very sensitive to pollution in the water. The eggs need pure, clean water, with little silt and a small amount of oxygen dissolved in the water.

Salmon begin to develop inside the egg. Because they are cold-blooded, the water temperature controls the rate at which the salmon develop. The ideal temperature for salmon eggs is from 5 to 9ºC. The eggs will die above 20ºC or below freezing. Eggs develop more slowly at lower temperatures. (See the box on ATUs.)

Handout 5.1

Salmon Eggs

Salmon biologists use **ATUs** to measure the heat an egg receives. ATU stands for Accumulated Thermal Unit. It is the total heat an egg receives over a period of time. To calculate ATUs, you add the water temperature each day to the total for the previous days. For example, if the water temperature is 8°C on the first day, the ATUs are 8. If the temperature is 8°C again on the second day, the ATUs are 16. If the temperature falls to 6°C on the third day, the ATUs are 22.

The ATUs control the time a salmon takes to develop. Coho salmon, for example, develop as outlined below. (Other salmon species have a slightly different schedule.)

Head and body
50 ATUs
(About 7 to 10 days)

Eyes begin to appear
220 ATUs
(About one month)

The salmon begins to move inside the egg
400 to 500 ATUs
(About two months)

The salmon hatches
700 to 800 ATUs
(About three months)

Inside the egg, the developing salmon feeds from a yolk sac. However, the embryo still needs to get oxygen from air dissolved in the water that flows through the gravel. Some oxygen can pass through the wall of the egg. However, if silt covers the gravel under which the egg is buried, oxygen cannot transfer through the egg membrane and the embryo can smother. The embryo can also die if the water flows too slowly and the dissolved oxygen cannot reach the egg.

As development progresses, the embryo begins to move and wiggle around. At a certain point, it releases a chemical that weakens the wall. The embryo breaks through and wiggles out. It will live the next stage of its life in the gravel as an alevin.

Handout 5.2

Parts per Million

Name ____

Water contains many chemicals in very low concentrations. When scientists measure low concentrations, they often state their results as parts per million. For example, if you have one molecule of a chemical mixed in one million molecules of water, the chemical's concentration is one part per million, or 1 ppm.

Salmon need free oxygen in water, that is, oxygen that is neither part of the water molecule itself nor part of any other compound. Salmon can breathe when the concentration of free oxygen is between 5 and 15 ppm. If the concentration drops to 3 ppm, the salmon will die. A difference of only 2 ppm of oxygen in water can determine whether a salmon lives or dies.

Use the following procedure to calculate the concentration of a substance in water.

Materials

- Eye dropper
- A 5-ml measuring spoon
- A 4-litre container
- 4 litres of water
- Food colouring

Procedure

1. Use an eye dropper to determine how many drops of water you can put in a 5-ml measuring spoon. ________
2. Calculate the number of drops it would take to fill a 10-ml container. ________
3. Calculate the number of drops it would take to fill a 100-ml container. ________
4. Calculate the number of drops it would take to fill a 1000-ml (one litre) container. ________
5. Fill the 4-litre container with water. Calculate the number of drops of water in it. ________
6. Add one drop of food colouring to the container. Calculate the concentration of food colouring in the container. _______________
7. Can you see the food colouring in the 4-litre container? _________
8. Estimate the number of 4-litre containers it would take to hold one million drops. ________
9. What conclusions can you draw from these observations? ______________________________________
   ____
   ____
   ____

HANDOUT 5.3

Water Quality Testing

Name ____

The physical and chemical properties of water affect organisms that live in it. Salmon and other organisms need some substances in water, such as dissolved oxygen. Some substances can be fatal, however. Pollution is a source of harmful substances. These tests let you compare the effect of certain pollutants on water quality.

Materials:

- 5 feathers
- 5 1-litre jars
- Sample substances, as provided at each station
- 5 containers for pollutants
- A ruler
- Litmus paper

Part A

Describe as many characteristics of the plain water sample as you can. ____________________________

____

____

Station	Test	Observations after adding pollutant
1	Appearance: Turbidity Add the polluting substance to the water sample. With a ruler, measure how much sediment settles on the bottom of the jar.	Sediment measured:___________ mm Observations:
2	Smell List as many words as possible to describe the scent of the water after adding the polluting substance. (Note: Scientists do not smell unknown substances. The substances in this test are safe to smell.)	Observations:

HANDOUT 5.3

Water Quality Testing

Station	Test	Observations after adding pollutant
3	Acidity /Alkalinity Add the polluting substance and use the litmus paper to test the pH of the water.*	Observations:
4	Appearance: Colour/ Texture Add some of the leachate from your landfill model (or other sources). Record the colour and texture of the water.	Observations:
5	Residue Pour the polluting substance in the water sample and shake it. Form a wire scoop (see illustration in chart on page 109), insert it in the water containing the polluting substance. Describe what remains on the cheesecloth and what remains in the water.	Observations:

**Note: Healthy water in salmon habitat ranges between 6.5 and 9 on the pH scale.*

What conclusions can you make about the effect of the pollutants on the water samples?

____

____

____

Handout 5.3

Water Quality Testing

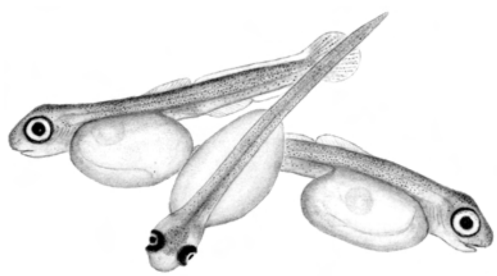
Part B

In small groups, list the five substances you tested in the correct column below. Using your knowledge of the environment and salmon, fill in the other two columns, listing sources from which the substances might enter the environment and their potential effects on salmon. (Leave room to add additional information after the class discussion.)

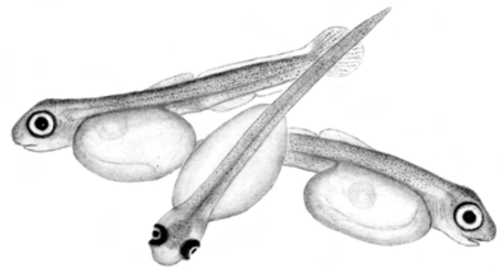
Substance	Sources (e.g. human activity)	Effect on Salmon

UNIT 6

SALMON ALEVINS



Salmon Alevins



Overview

This unit gives students an opportunity to:

- discuss what a newborn needs to survive;
- test the effect of temperature on the rate of growth and respiration in yeast;
- test the effect of water temperature on respiration in fish;
- discuss how people affect the temperature of stream water and ways of minimizing human impacts;
- construct a model of a waste landfill;
- review the concepts they learned in the unit.

Note that some activities begun here will continue through the life cycle units.

Key Concept

Salmon alevins receive food from their yolk sac but remain highly sensitive to changes in their environment, especially changes in water quality and temperature.

Vocabulary

embryo, temperature, energy, cold-blooded, warm-blooded, micro-organism, yeast, respiration, sensitive, landfill, compost, leachate, yolk sac

Background Information

In addition to the information in Handout 6.2, "Salmon Alevins," the following information may be useful.

Alevins can move about and swim, but their yolk sac makes them awkward and slow-moving. Since the bright colour of the yolk sac makes them very visible, they avoid light and live in spaces between the gravel. However, they are mobile, and they can move large distances through gravel if necessary. As long as there is water and enough space between the gravel pieces, they can avoid silt or find more oxygen-rich water.

Alevins begin to breathe through their gills when they hatch from the egg. Their rate of respiration can be estimated by observing the number of gill movements. As cold-blooded animals, their metabolic rate depends on the temperature of their environment, which also controls the rate of their respiration. As a result, they breathe more slowly, and grow more slowly, in colder water. At higher temperatures, they grow more rapidly, but their overall body growth is reduced because metabolic processes such as digestion and respiration are less efficient.

Alevins can flush small amounts of silt out of their gills, but their gills are very sensitive and their breathing is easily clogged. If necessary, they can secrete mucus to hold the silt, and cough out the mucus and silt.

Alevins depend entirely on their yolk sac for nourishment, except in the final days before the yolk sac becomes "buttoned up," when the alevin begin to catch bits of organic debris that float through the water. The yolk sac, containing a mixture of water, fats, protein and salts, contains enough nourishment for the alevin to live in the gravel for two to three months. As the yolk sac is absorbed, the alevins become more active, and move up through the gravel. When the sac is absorbed, they emerge from the gravel and migrate toward food sources. This usually coincides with the spring bloom of algae, aquatic insects and zooplankton in lakes and rivers.

Introduction

Materials:
None

Time required:
10 minutes

Suggested Activities

Choose activities from these suggestions that are appropriate for your class.

- Ask the class to list the things a newborn person or animal needs to grow and be healthy.
  Most need food to be supplied to them, often by a parent feeding them. They need a secure environment, where they will be protected from harm until they are able to look after themselves.
- Remind the class that salmon parents die before their eggs hatch, then ask if anyone can describe how newly hatched salmon meet these needs. Write their suggestions on chart paper and explain that the activities that follow will allow the students to test their ideas.

Energy and Growth

[experiment]

Depending on the abilities of your class, you may prefer to do this activity as a demonstration or have students do the experiment themselves.

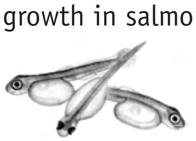
Materials:
For each group of students:

- 5 ml dry yeast
- 5 ml sugar
- 750 ml water
- Three small containers (test tubes or 500-ml clear plastic pop bottles)
- Funnel (optional)
- Measuring cup
- Measuring spoon
- Stirring sticks
- Three balloons (try to find balloons that blow up easily)
- Thermometer (optional)
- One copy of “Handout 6.1: Energy and Growth” for each student
- One copy of “Handout 6.2: Salmon Alevins” for each student
- Writing supplies

Time required:
60 to 90 minutes

Level of conceptual difficulty:
Simple

Suggestions for assessment:
Review the students’ written observation sheets and class discussion to ensure that the students describe the effect of external temperature on the rate of growth in salmon alevins and yeast.



Introduction

- Ask the class to compare the way their body feels when they are sitting quietly and the way it feels when they are being physically active. Ask if they can explain the difference.
  When they are more active, their body gets warm, they breathe harder and their heart pumps more. This happens because they are turning more of the food stored in their body into energy and producing more carbon dioxide, which they must expel by breathing harder.
- Explain that all animals turn food into energy and produce more carbon dioxide when they work harder. Salmon alevins and other cold-blooded animals convert food to energy at a rate determined mainly by water temperature. Although yeast is a different type of organism, it shows the effect of temperature on growth.

Experiment

- Give students a copy of “Handout 6.1: Energy and Growth” and have them work in small groups to carry out the activities. After 30 minutes, have them check the results and write their observations. Repeat the observations after an hour, if necessary, to see a visible difference.

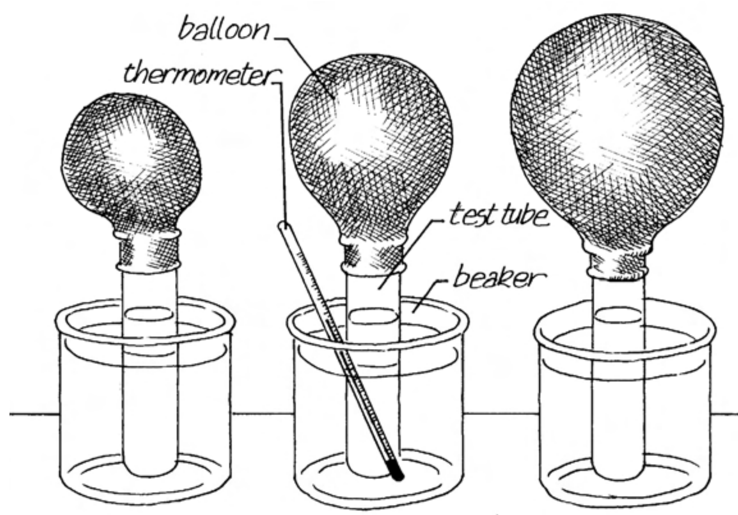


Illustration: Donald Gunn

1. Yeast, sugar in cold water
2. Yeast, sugar in tepid water
3. Yeast, sugar in warm water

Option: Have students grow yeast with different amounts of sugar in the mix. Have them record the effect of varying the amount of sugar available to the growing yeast. Ask what conclusions they can draw from their observations.

Discussion

- With the class, discuss the observations and conclusions the students recorded. If necessary, prompt them with questions, such as:
  - What happened inside the containers?
    The yeast consumed the sugar and produced carbon dioxide, which caused the bubbles and expanded the balloon.
  - What was the difference between the three bottles?
    The warm mixture produced more foam and a larger balloon than the control, while the cool mixture produced less foam and a smaller balloon.
  - What conclusions did you draw?
    The yeast grows faster and produces more carbon dioxide in the warm location.

Research/Discussion

- Have students, in small groups, read "Handout 6.2: Salmon Alevins", then list ways in which salmon alevins are similar to the yeast in the experiment and ways in which they are different. Have the groups report their conclusions to the class and discuss their observations. If necessary, prompt them with questions, such as:
  - How is the alevins' habitat similar to or different from the habitat in the bottle?
    Both are watery, but the bottle is enclosed, while alevins live in gravel in free-running streams or along lakeshores.
  - How are the food sources similar or different?
    The alevin carries its food in its yolk sac, while the yeast consumes sugar dissolved in the water.
  - How is their respiration similar or different?
    Both take oxygen from the water and produce carbon dioxide.
  - How is their rate of growth similar or different?
    Both are affected by the temperature of the environment.

Summation

- Have students add information on salmon alevins to the chart of the salmon's life cycle, which they began in Unit Five: Salmon Eggs.

Temperature and Respiration

[experiment]

Adapted from Jim Wiese, *Salmon Below the Surface*, pages 15-21.

Depending on the abilities of your class, you may prefer to do this activity as a demonstration or have students do the experiment themselves.

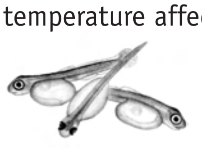
Materials For each group of students:

- One goldfish in a goldfish tank
- One thermometer
- One plastic bag (e.g., zip-lock sandwich bag) and twist wire to seal the bag
- Two large containers (e.g., a 4-litre milk carton with the top cut off)
- Crushed ice
- Hot water
- Watch or other timer
- One copy of "Handout 6.3: Temperature and Respiration" for each student
- Writing supplies

Time required:
60 to 90 minutes

Level of conceptual difficulty:
Simple

Suggestions for assessment:
Review the students' written observation sheets and class discussion to ensure that the students describe how external temperature affects respiration in fish.



Introduction

- Ask the class to describe how they respond to cold weather and to hot weather.
  People dress more warmly or lightly to maintain an even body temperature.
- Ask them to suggest ways in which animals respond to warm or cold weather.
  Warm-blooded animals, like people, can adjust their body temperature. Cold-blooded animals, like fish and reptiles, cannot, so their breathing and other bodily functions become slower in cold temperatures.

Experiment

- Explain that the following demonstration will show how fish, including salmon, adjust to changes in temperature. Give students a copy of "Handout 6.3: Temperature and Respiration" and have them carry out the procedures or observe you doing a class demonstration.

Discussion

- Discuss the students' observations and what they might mean for salmon in their natural habitat. If necessary, prompt them with questions, such as:
  - What changes did you observe?
    As the temperature went down, the number of mouth and gill movements declined.
  - What do the changes indicate about the fish's rate of respiration?
    Fish are affected by water temperature and have a slower respiration rate at lower temperatures.
  - Does warmer or cooler temperature harm the fish?
    The experiment does not give information to answer this question. However, other research shows that fish grow best at a specific temperature, usually between 7°C and 15°C for salmon. The careful changes in the experiment do not harm the goldfish.
  - What would happen to fish, such as salmon, in their natural environment if shade plants were cut down?
    Sunlight would warm the water and adversely affect the fish.

Changing Temperatures in the Environment

[discussion]

Materials:

- Art supplies

Time required:
Approximately 60 minutes in two periods

Level of conceptual difficulty:
Moderate

Suggestions for assessment:
Monitor the class discussion and the information students add to the salmon habitat mural to ensure that the students can identify ways in which humans change the temperature of a stream and ways of minimizing any changes that affect salmon.

Discussion

- Have the class brainstorm suggestions for creating a chart of natural and human-caused changes in the environment that could affect water temperature.
  For example, loss of streamside vegetation, disposal of water warmed in industrial processes, water diversion, dam construction, climate change.
- Discuss whether or not the items clearly fall into one category or the other.
  For example, a flood may be caused by natural occurrences or by human changes in the environment; species in the environment may be introduced by humans or by natural migration; natural rainwater may percolate through mine wastes causing acid leachate.
- Have students predict and discuss potential effects of these changes on salmon alevins.
- Discuss steps people can take to prevent damaging changes in water temperature and other conditions in spawning streams, and investigate their application in local streams.

Summation

- Have students add information about salmon alevins to their habitat mural.

A Model Landfill

[experiment]

Adapted from Jim Wiese, *Salmon Below the Surface*, pages 77-83.

Depending on the abilities of your class, you may prefer to do this activity as a demonstration or have students do the experiment in small groups. Instead of completing this activity as an independent experiment, you may prefer to use the final steps as a salmon studies wrap-up, as suggested in Unit Ten: Review: The Salmon Life Cycle. Students could also use leachate from the model in the water quality tests in Unit Five: Salmon Eggs.

Materials:

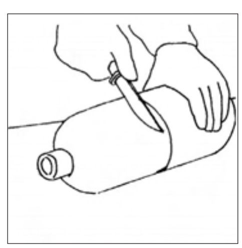
- Three clear, 2-litre plastic pop containers (remove the labels and cut the containers into two pieces, approximately 12 cm from the bottom)
- Three pieces of loosely woven fabric, such as cheesecloth, approximately 4 x 8 cm
- String or elastics
- Sand
- Garden soil
- Waste materials, including small pieces of paper, plastic, metal, food scraps, leaves, etc.
- Water
- Rubber gloves (optional)
- Hand garden tools or sticks
- Newspapers
- Litmus paper
- One copy of “Handout 6.4: A Model Landfill” for each student
- Writing supplies

Introduction

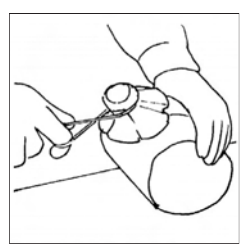
- Ask the class what happens to waste when it is thrown out.
  Some is recycled, some is incinerated, but some is buried in the ground, where it decomposes and eventually becomes part of the soil.
- Ask the class how waste buried in the ground can affect waterways.
  Rain falling on the soil percolates into the landfill, through the waste and through the ground. Eventually the rainwater seeps out into lakes, rivers and streams. It sometimes carries with it harmful substances from the landfill.

Experiment

- Explain that this demonstration will show how wastes in the ground can affect waterways.
  - Cover the neck-opening of the bottles with the folded cheesecloth and secure it in place with string or a rubber band.
  - Invert the top section of each container and place it on the bottom section.
  - Place 3 - 4 cm of sand in the inverted section of each container, then add 3 - 4 cm of garden soil.
  - Fill one container to about 2 cm from the top with garden soil and label it “Control”. Explain that this container will show what happens in soil that contains no waste.
  - Place 3 - 4 cm of mixed waste in one container, fill it to about 2 cm from the top with garden soil and label it “Landfill”. Explain that this container will show what happens in soil with mixed home and school waste in it.



1. Cut bottles in half



2. Secure cloth on bottle top

3. Invert top, and sit on bottom. Add sand, soil.

Illustration: Donald Gunn

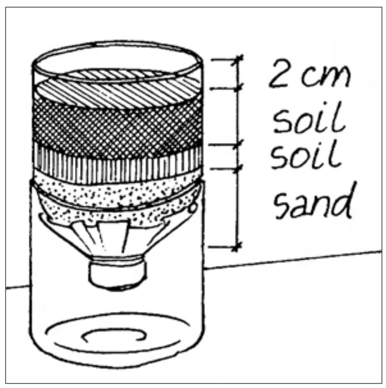
Time required:
Approximately 60 minutes to set up the demonstration in class; two to three observation sessions over four to six weeks; 60 to 90 minutes to examine the results and discuss

Level of conceptual difficulty:
Moderate to advanced

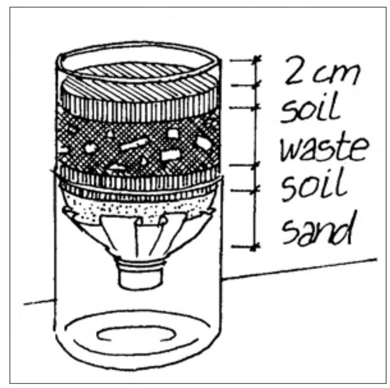
Suggestions for assessment:
Review the students' written observation sheets and class discussion to ensure that the students can explain how percolating water from waste landfills can affect salmon habitat.

- Place 3 - 4 cm of vegetation waste (leaves, fruit and vegetable wastes) in one container, fill it to about 2 cm from the top with garden soil and label it "Compost". Explain that this container will show what happens in soil that contains only plant waste.

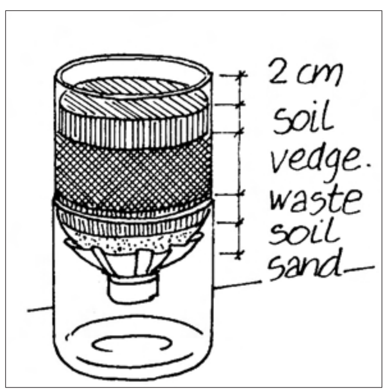
■ Ask students to predict what will happen to the waste in each container and to rain that falls in each container. *The plant and food waste will begin to decompose. Water will percolate through the top container into the bottom, carrying with it liquid leachate.*
Have the students write their predictions on the chart in "Handout 6.4: A Model Landfill" and describe or draw the experiment.



Control



Landfill



Compost

Illustrations: Donald Gunn

- Slowly add a small amount of water to each container, until it begins to come out the bottom. Mark the level of the different layers on the side of the container.
- Set the containers to one side, where they will be undisturbed but accessible, and leave them there for four to six weeks. Add a small amount of water to the containers about twice a week.
- Have the students repeat their observations every two weeks, noting the water that percolates from the bottom and the level of the layers.
- After four to six weeks, or as part of Unit Ten: Review: The Salmon Life Cycle, spread out newspapers and have the students use hand garden tools or sticks to dig up the containers. Have them compare the layers in the landfill and the compost with the control.
  Most of the plant and food waste should have decomposed into a dark layer, while the metal and plastic will remain as it was.
- Have the students compare the results with their predictions. Ask them why not all of the organic materials are fully decomposed.
  Larger, tougher masses take more time to break down.
- Have students observe the leachate that percolates from the bottom and use the litmus paper to test it for acidity.
  The leachate from the landfill and the compost will be black, thick and acidic. The leachate from the control should be less dark and less acidic.

Discussion

- Discuss with the class how each type of leachate would affect salmon. If necessary, prompt them with questions, such as:
  - Which leachate would be most like the forest conditions in a salmon stream?
    The control and the compost, although in forest conditions, water does not usually percolate through a large layer of compost at one time.
  - Which leachate would be most harmful to salmon?
    The landfill since it is more acidic. Also, it usually has other contaminants in it from the metals, plastics and other waste products.

- How can people protect salmon from the harmful effects of landfills?
  Reduce the total amount of waste; recycle as much plastic and metal as possible; keep rainwater out of landfills by covering them or building them in drier climates; control any leachate that comes out of landfills through controlled drainage.
- What can individuals do?
  Reduce the amount of waste and recycle at home and school.

Review and Build on What You Know

Materials:
None

Time required:
20 minutes

Review

- Give students five minutes to review their notes and list at least six important ideas or facts about salmon alevins.
- Give students five minutes to share their lists, in groups of four, and write on chart paper the four most important ideas on which the group agrees.
- Have the groups post their charts on the classroom wall, then lead a class discussion on the common ideas and differences recorded on the charts.

Summation

- Have students add their lists and any additional comments to a salmon science notebook or portfolio.
- Have students add information about salmon alevins to their salmon life cycle chart.
- Have students add information about salmon alevins to their salmon habitat mural.

Illustration: Donald Gunn

Vegetated stream bank

Stripped stream bank

Wrap-Up

Extension Activities

- Have students discuss the ethics of experiments involving live animals, as in the activity Temperature and Respiration on page 125 of Unit 6.
- If your class has access to a salmon incubator, have the students observe the alevins when they hatch and count the number of mouth and gill openings. Have them calculate the ATUs the alevins receive and project when the alevins will swim to the surface as fry.
- Have students research and compare the basic nutritional needs of humans and alevins.
- Have students research the difference between modern and old landfills.
- Have students research where landfills are located in their community or where their community's garbage goes, and identify any known impacts on the environment.

Evidence for Assessment

- Have students prepare a presentation, using appropriate graphics, to explain to a younger class how alevins live, the kind of environment they need, reasons young people should not harm the alevins' environment and ways of avoiding damage to spawning streams.
- Monitor the discussion as the students make and present their lists in the review activity to ensure that they can use factual information from the activities to support an opinion about the life of salmon alevins.
- Monitor student discussions of the class' habitat mural and life cycle chart to ensure that the students can identify the needs of salmon alevins, as well as their habitat and threats to it.
- Have students write quiz questions about salmon alevins on one side of an index card and answers on the other. Have them quiz each other by asking the questions or by using a *Jeopardy*-style format, by giving the answers and asking for a question.
- Have students add their notes, experiment observations and other materials to a Salmon science notebook or portfolio.
- Have students use "Appendix 2: Student Assessment Sheet" to review their group work and their own learning.

Home and Community Connections

- Have students ask an adult to visit the classroom to see the landfill demonstration or to take them to a local landfill and observe how wastes are managed.
- Suggest that the class begin a project to identify and remove any unnatural threats to salmon alevins in waterways in the community (e.g., silt or pollution entering salmon streams, people interfering with growing alevins). (For directions, refer to Unit Ten: Review: The Salmon Life Cycle, "Activity 5: Creating Positive Human Impacts".)

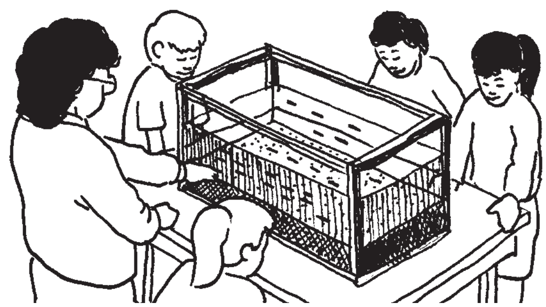
Salmon Incubation

If your school has an operating incubation tank, have students observe the alevins when they emerge and move about, and record their observations. Have them compare the size of the alevins' yolk sacs as they grow older. For assistance, refer to "People and Connections That Can Help" on page vii of the Foreword.

- Darken the room in which the tank is located and remove any protective materials from around the tank. Have students observe the normal activity of the alevins, and predict how they will react when a flashlight shines into the tank. Shine a flashlight into the tank and discuss why alevins avoid the light.

  Their colour makes them highly visible and they cannot swim quickly, so they move into the gravel to hide from predators.

- Have students observe the way in which alevins use their gills for respiration. Have them carefully remove a few alevins from the tank, place them in a small container of tank water and observe how the respiration rate changes as the water temperature rises. Have them return the alevins to the tank after 20 to 30 minutes.



Handout 6.1

Energy and Growth

Name ____

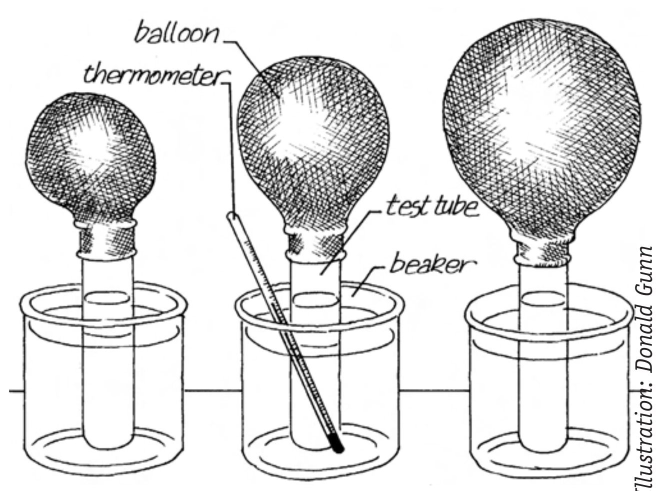
Temperature affects the rate at which plants and animals grow. Cold-blooded animals, such as fish and reptiles, and micro-organisms cannot control their body temperature by themselves. Instead, the surrounding environment controls their temperature and the temperature controls the amount of energy they use. This experiment shows how temperature affects yeast, a micro-organism that uses sugar for food.

Materials

- Dry yeast
- Sugar
- Water
- Three small containers
- Funnel
- Measuring cup
- Measuring spoon
- Stirring sticks
- Balloons
- Thermometer (optional)

Procedure

1. Use a thermometer or your hand to find three places in the classroom with different temperatures, one warm, one room temperature and one cool.
2. Mix 5 ml of dry yeast, 5 ml of sugar and 500 ml of water in the measuring cup. Stir them together until they are dissolved.
3. Carefully pour an equal amount of the mixture into the three containers. Label the containers with your name and a number. Fit a balloon tightly over the opening of the container.
4. Place one container in each of the locations you have chosen, and label them "Warm", "Cool" and "Control".



1. Yeast, sugar in cold water
2. Yeast, sugar in tepid water
3. Yeast, sugar in warm water

Handout 6.1

Energy and Growth

Observations

5. After about 30 minutes, check the containers and compare what you see happening in them. Write or draw your observations in the table below.

Warm	Cool	Control

Hypothesis

What do you think is happening in the bottle?______________________________

____

____

____

____

Conclusions

What conclusions can you make from your observations?______________________________

____

____

____

Handout 6.2

Salmon Alevins

Wiggling energetically, the salmon embryo in an egg breaks through the egg lining and makes its way out of its egg and into the gravel. For the next 30 to 50 days, it lives as an alevin (A-le-vin – the A can be pronounced like play or like cat) in the dark spaces between the stones in the gravel of its home stream. As with the egg, the rate of an alevin's development depends mainly on the water temperature, which should range from 5°C to 14°C.

The yolk sac, which remains attached to the alevin's belly, provides the food it needs. The sac shrinks as the alevin develops, gradually allowing it to move about more easily.

The alevin's respiration, or breathing, system also develops, allowing it to breathe through its gills. Clear, flowing water is still important, but an alevin can swim through spaces in the gravel away from gravel that is too silty. Also, an alevin can clear small amounts of silt from its gills, so it can live in water that has more silt than salmon eggs can accept.

Alevins need cold running water that is rich in oxygen and they need clean gravel with spaces in which they can hide. Threats include predators in the water, siltation, pollution, floods and other activities that can disturb the gravel. People can protect the alevins by keeping dirt or other pollutants out of the water and by staying out of stream gravel.

Because alevins keep the orange colour of the salmon egg and their yolk sac slows their movements, they are an easy target for predators. Alevins avoid light and live as much as 30 cm down in the gravel. However, as they grow stronger and their yolk sac grows smaller, they begin to move up to the surface of the gravel. They develop dark markings on their skin that help them hide on the streambed.

When the yolk sac is completely absorbed, or "buttoned up", alevins are about 2.5 cm long. In spring, when the water begins to warm and algae, insects and plankton grow in lakes and rivers, alevins emerge as fry to begin the next stage of their life.

Adapted from Jim Wiese,
Salmon Below the Surface, pp 35-36

Handout 6.3

Temperature and Respiration

Name ____

Fish and other cold-blooded animals cannot control their body temperature. Fish have the same temperature as the water in which they live.

Many body functions work properly only at a specific temperature. Because of this, some fish are very sensitive to water temperature. As eggs, salmon need a temperature between 5°C and 9°C. As alevins, they need a temperature between 5°C and 14°C. At later stages, salmon can live in warmer water, but they prefer water below 14°C.

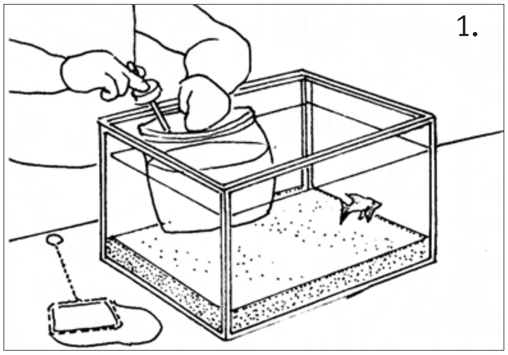
Water temperature affects fish respiration, or breathing. Fish breathe by opening their mouth to take a mouthful of water. They close their throat and force the water out their gills. The gills extract oxygen from the air that is dissolved in the water. You can tell how fast fish are breathing by counting the number of times they open and close their mouth and gills.

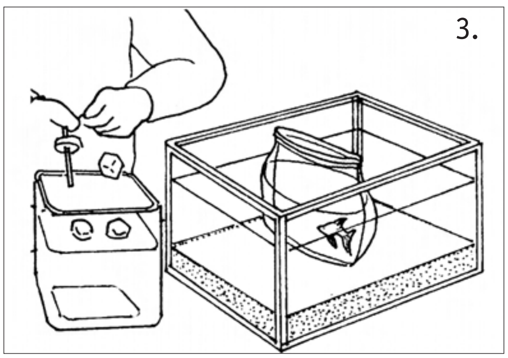
Materials

- One goldfish in a goldfish tank
- One thermometer
- One plastic bag (e.g., zip-lock sandwich bag) and twist wire to seal the bag
- Two large containers (e.g., a 4-litre milk carton with the top cut off)
- Crushed ice
- Hot water
- Watch or other timer
- Fish net

HANDOUT 6.3

Temperature and Respiration





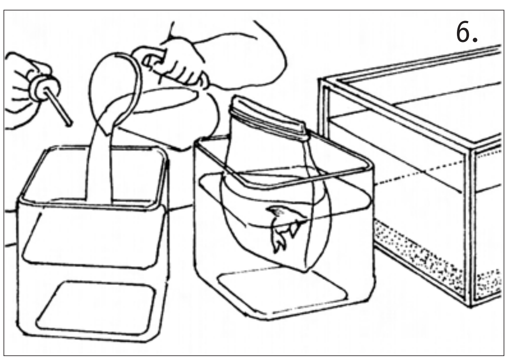


Illustration: Donald Gunn

Procedure

1. Fill a plastic bag with water from the tank. Use the thermometer to read the temperature of the water in the bag and record it on the observations chart. This will be the control temperature.

2. Use the net to transfer a goldfish to the bag, then seal the bag. Wait ten minutes for the fish to adjust to the environment of the bag.

3. While you wait, half fill the 4-litre container with water, then gradually add enough ice to cool the temperature of the water to 5ºC below the control temperature.

4. Count the number of times the goldfish in the bag opens and closes its mouth and gills in one minute. Record the number on the observations chart next to the control temperature.

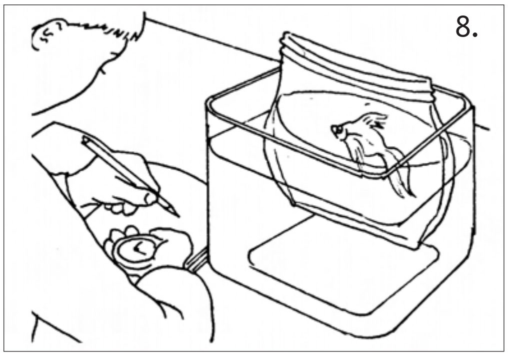
5. Place the bag containing the fish in the container of cooled water. Wait 10 minutes for the fish to adjust to the environment of the bag.

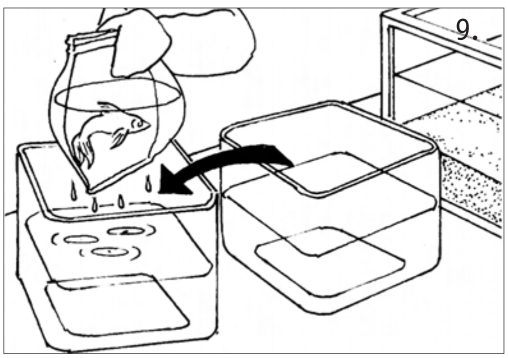
6. While you wait, half fill a second 4-litre container with water and add enough hot water to warm the temperature of the water to 5ºC above the control temperature.

7. Predict how the goldfish will react when the temperature of the water is lowered by 5ºC. Record your predictions on page 140.

Handout 6.3

Temperature and Respiration





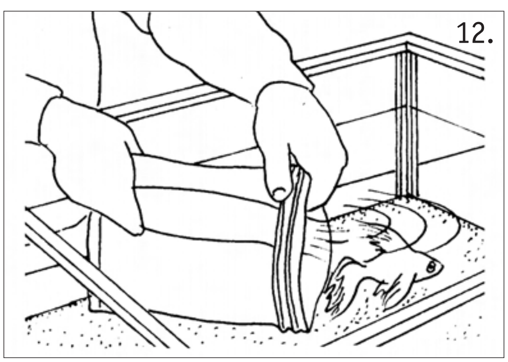


Illustration: Donald Gunn

8. Count the number of times the goldfish in the bag opens and closes its mouth and gills in one minute. Record the number on the chart next to the cool temperature. Remove the bag and let it return to the control temperature.

9. Place the bag containing the fish in the container of warmed water. Wait 10 minutes for the fish to adjust to the environment of the bag. While you wait, draw or describe the experiment procedure on page 140.

10. Predict how the goldfish will react when the temperature of the water is raised by 5°C. Record your predictions on page 140.

11. Count the number of times the goldfish in the bag opens and closes its mouth and gills in one minute. Record the number on the chart next to the warm temperature.

12. Place the bag containing the fish in the tank it came from until the temperature inside and out of the bag are the same. Release the fish from the bag.

13. Record your conclusions on page 140.

Handout 6.3

Temperature and Respiration

Draw or describe the experiment procedures here.

	Water Temperature in °C	Number of Mouth/Gill
Control Temperature		
Cooler Temperature		
Warmer Temperature		

Predictions

I predict that when the temperature is lowered, the goldfish will ________________________________

____

____

I predict that when the temperature is raised, the goldfish will________________________________

____

____

Conclusions

What conclusions can you make from your observations?________________________________

____

____

____

Handout 6.4

A Model Landfill

Name ______________________________

Procedure

Describe or draw the procedure used for this experiment.

Observations and predictions

Materials	**Prediction**	**Result After Digging**
Control		
Compost		
Landfill		

Observations after water is added: ______________________________

____

Observations after two weeks: ______________________________

____

Observations after four weeks: ______________________________

____

Observations after six weeks: ______________________________

____

UNIT 7

SALMON FRY

Salmon Fry

Overview

This unit gives students an opportunity to:

- discuss ways of distinguishing one animal from another;
- investigate the classification of animals as fish;
- read and discuss information on salmon fry;
- test ways in which air gives objects buoyancy in water;
- examine microscopic life in a sample of pond water;
- examine microscopic life in a sample of runoff water;
- review the concepts they learned in the unit.

Key Concept

Fry swim and search in their stream or lake habitat for aquatic organisms they can eat for food. Fry exhibit characteristics that classify them as fish.

Vocabulary

swim bladder, insect, nymph, larva (plural: larvae), plankton, Parr marks, predator, imprinting, classification, species, aquatic organism, cold-blooded, chum, chinook, sockeye, pink, coho, rainbow trout, steelhead trout, cutthroat trout, buoyant, buoyancy

Background Information

The information which follows can be used to supplement “Handout 7.1: Fish Classification”, “Handout 7.2: Salmon Fry” and “Handout 7.4: Aquatic Life”.

Classification in biology is the arrangement of organisms into a coherent scheme. Classification helps to organize the vast number of known plants and animals into categories that scientists can name, compare and contrast. Today, classification includes studying the relationships between organisms and attempting to show their evolutionary paths.

The naming of organisms and the categories in which they are classified follow predefined rules adopted by international science conventions. Pacific salmon are classified as:

Kingdom	=	Animal
Phylum	=	Chordata (animals with backbones)
Subphylum	=	Vertebrata (backbones are formed of linked segments)
Class	=	Osteichthyes (bony fishes)
Subclass	=	Octonopteryglic (fins have a ray-like structure)
Superorder	=	Telespondyli
Order	=	Isospondyli
Family	=	Salmonidae (salmon and its relatives, the trout, char and Dolly Varden)
Genus	=	Oncorhynchus (Pacific salmon)
Species	=	keta (chum), tshawytacha (chinook), nerka (sockeye), gorbusha (pink), coho (kisutch), mykiss (rainbow or steelhead trout)

Until recently, scientists classified rainbow trout and cutthroat trout separately from the Pacific salmon. New studies, however, have shown that rainbow trout is, in fact, a Pacific salmon and scientists now count six species of Pacific salmon. Steelhead trout are rainbow trout that migrate to sea and return to their home streams. Most older references do not yet reflect this classification – and some references classify cutthroat trout as salmon if they spend part of their life in the sea.

All salmonids (members of the Salmonidae family) have a well-developed adipose fin, a dorsal fin with 10 to 12 rays, an anal fin with more than 13 rays, strong teeth lining the mouth and tongue, and more than 100 small scales lining the body. Identifying characteristics of specific species are as follows (refer to "Handout 9.3: Species of Pacific Salmonids” for illustrations):

- **Sockeye** (Illustration A): small pupils, “glassy” eyes, no clear spots on the tail
- **Chum** (Illustration B): large pupils (1/2 of the eye), a slender tail, bars on either side of the body
- **Chinook** (Illustration C): black mouth and gums, spots on both halves of the tail, small spots on the body
- **Coho** (Illustration D): black mouth but white gums; spots only on the top half of the tail, spots half the size of the eye
- **Pink** (Illustration E): mouth is not black, large spots on body
- **Rainbow/Steelhead trout** (Illustration F): small head, mouth not past the eye, toothless tongue, anal fin has 13 rays

Cutthroat trout are salmonids, but not true salmon.

- **Cutthroat trout** (Illustration G): a large mouth, red slashes under the jaw, anal fin has 13 rays

For a comparison of the life history of Pacific salmon species, refer to Unit Ten: Review: The Salmon Life Cycle, “Background Information”.

Introduction

Materials:
None

Time required:
10 minutes

Suggested Activities

From these suggestions, choose activities that are appropriate for your class.

- Ask the class how they can tell one plant or animal from another.
  For example, body shape, colours and markings, features such as arms, legs, fins or tails.
- Explain that, when salmon become fry, they look more like other fish. They develop the streamlined fish shape, fins, tail, etc. that show they are fish. They also develop the features that allow people to identify different species, such as the location and shape of their fins, the markings on their skin.
- Explain that this unit focuses on how salmon live as fry and the features they share with other fish.

Illustration: Karen Uldall-Ekman

Fish Classification
[discussion]

Preparation:
Have students collect the photos they will need before the class. You may wish to have additional photos available for students who need them.

Materials For each student:
- Pictures of various organisms, including at least 10 different aquatic organisms and 10 different land organisms
- Copies of "Handout 7.1: Fish Classification"
- Writing supplies

Time required:
Approximately 60 minutes

Level of conceptual difficulty:
Moderate to advanced

Suggegstions for assessment:
Monitor the class discussion and review the diagrams and explanations the students make to ensure that the students can state and apply the elements of the definition of a fish.

Preparation

- Have students collect at least 20 pictures of various organisms, including at least 10 different aquatic organisms and 10 different land organisms. If necessary, suggest they download photos from Internet sites or photocopy photos from nature magazines, textbooks, etc.

Investigation

- Have students, in groups, sort through the pictures of various organisms and divide them into two categories based on the anatomy and other characteristics the organisms share.
  For example, body shape, body covering, type of limbs, environment.
- Have the students subdivide the categories into further pairs until there are only a few organisms in each category, each sharing characteristics with the others in the category.
- Have each student group present its categories to the class and explain what the members of the category had in common.

Discussion

- Ask the class to suggest reasons scientists would use a classification system to analyze species of life. Explain that scientists use the classification system to understand and describe the relationships between different organisms (and to their environment), to name them and organize data about them and their evolution.

Research/Discussion

- Have the class discuss and agree on a common definition for fish. Have them review "Handout 7.1: Fish Classification" in groups and compare their definition with the formal classification of fish as a cold-blooded animal with gills, fins and a flexible backbone.

  Option: Ask the class if humans or other animals they know would fit into any of the categories they made and, if not, to suggest a category that should be created for them.

Summation

- Have students use their knowledge of salmon to make a diagram or chart to prove that salmon are fish. List any additional information they would need if they do not currently have enough.

Salmon Fry

[discussion]

Materials:

- One copy of "Handout 7.2: Salmon Fry" for each student
- Writing supplies

Time required:
Approximately 60 minutes

Level of conceptual difficulty:
Simple

Suggestions for assessment:
Monitor class discussion and review the information the students add to the life cycle chart to ensure that the students can describe the features of a fry's life.

Discussion

- Draw a chart (two columns by five rows) on a chalkboard or flip chart paper. List the human life cycle stages (birth, infancy, childhood, adolescence, adulthood) in the first column. Ask students to brainstorm qualities for each stage and add these to the second column of the chart, as in the example below.

Infancy	• Dependent on parents (for food, changing, bathing, movement from place to place) • Learning about survival

- If necessary, prompt students with questions, such as:
  - What happens at the ________ stage of the human life cycle?
  - How long does each stage last?
  - What changes did you go through in your life as you changed from a ________ into a ________?
  - What do you think a human should know and be able to do by the end of ________ stage?
  - What qualities and traits does a human in the ________ stage have that a human in a ________ stage does not?

Research/Discussion

- Ask students to lay aside all pens, pencils, books, etc. Instruct them to assume a comfortable position and close their eyes. Explain that you are about to read a passage and that you would like them to listen very carefully while trying to imagine the scene. Wait until you see a general state of relaxation before you read the passage. (Remember to speak slowly and steadily, allowing students enough time to create rich mental images).

  Now that all of the nutrients in the yolk sac are used up, fry must search for their own food. As they drift downstream they find calm pools where they can feed on nymphs and the larvae of insects, such as, stonefly, mayfly, caddisfly and black fly. As other fry come near, they try to defend their feeding territory.

As fry travel through the stream, they remember the smell of the water. They smell the rocks and soil, plant life and other aquatic organisms in the streambed. These scents will help them find their way home when they return as adult spawners.

At this point in their life cycle, the fry must learn to hide from predators. Dark bars, called Parr marks, develop across their bodies. The bars help to camouflage the fry by allowing them to blend in with their surroundings. The fry must move very quickly in order to survive.

- Have students, in small groups, read "Handout 7.2: Salmon Fry" .
- As a class, list ways in which salmon fry are similar to human children, teenagers and adults. Discuss whether salmon fry are more like children, teenagers or adults. If necessary, prompt them with questions, such as:
    - How are fry similar to or different from human children?
      They are very small compared to adults; they begin to swim freely, but do not have the strength to swim against the current; they have little ability to protect themselves.
    - How are fry similar to or different from teenagers?
      They grow rapidly and start to move away from their birthplace; they must find their own food; they are more vulnerable to predators.
    - How are fry similar to or different from human adults?
      They defend a territory and hunt for their own food.
      Option: If students have not already done the simulation activity described in Unit Four: The Salmon Spawners, "The Salmon Spawner", have students carry out the simulation acting as salmon fry instead of spawners.

Summation

- Have students add information on salmon fry to the chart of the salmon's life cycle that they began in Unit Five: Salmon Eggs.

Buoyancy
[experiment]

Materials:
For each group of students:
- Plastic drinking straw
- A small container
- A balloon
- Waterproof tape
- A basin of water
- Scissors
- One copy of "Handout 7.3: Buoyancy" for each student
- Writing supplies
- Option: One copy of "Appendix 1: Science Experiment Sheet" for each student

Time required:
Approximately 60 minutes

Level of conceptual difficulty:
Simple

Suggestions for assessment:
Review the students' written observations and class discussion to ensure that the students can describe how a balloon can help fish achieve buoyancy in water.

Introduction

- Ask the class to predict what will happen if a container filled with water is placed in another container of water. *It will sink.*
- Ask the students to suggest ways to make the container float.

  Option: Have students use "Appendix 1: Science Experiment Sheet".

Experiment

- Have students, in groups, use "Handout 7.3: Buoyancy" to conduct a test for buoyancy.

  Option: Have students invent and test other ways in which a heavier-than-water object can achieve neutral buoyancy in water.

Discussion

- Have students discuss ways in which a submarine, a scuba diver, a fish and an amphibian could use the balloon method or another method to move in water. If necessary, prompt them with questions, such as:
  - Does the balloon help or prevent easy movement?
  - Does the balloon take up a practical amount of space?
  - Can the balloon be inflated, as needed, or must it remain inflated?
  - Where would the balloon fit?

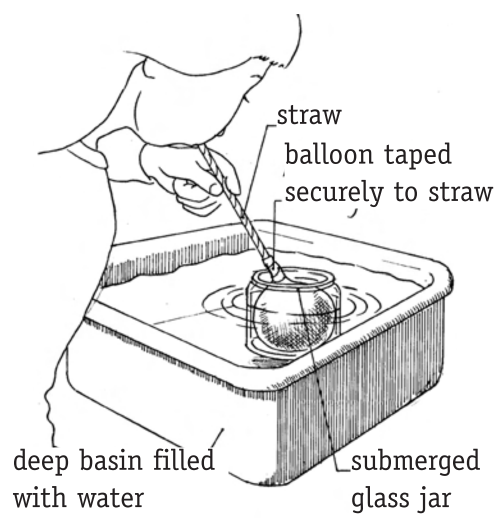


Illustration: Donald Gunn

Aquatic Life

[demonstration]

If feasible, you can do this activity as part of a field trip to a nearby stream or pond, or as a classroom activity.

Materials:

- A large container (e.g., an ice cream bucket with a lid)
- 4 litres of stream or pond water, including bottom sediments and gravel
- A large frame (described under "Preparation")
- A fine screen (optional)
- A large basin (optional)
- A ladle or small container
- Egg cartons
- Plastic pipettes
- Turkey baster
- Several magnifying glasses
- One copy of "Handout 7.4: Aquatic Life" for each student
- Writing supplies

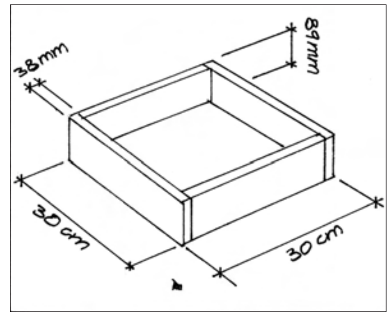
Time required:
Approximately 60 minutes in two periods

Level of conceptual difficulty:
Moderate

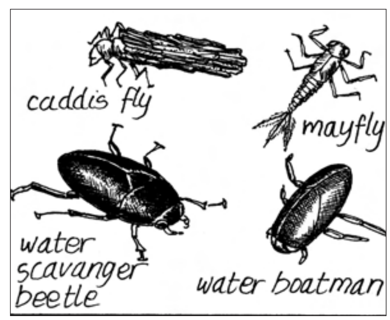
Suggestions for assessment:
Review the students' charts to ensure that the students can classify and identify various aquatic organisms and produce written descriptions of them.

Preparation

- Obtain a water sample from a nearby pond or stream, preferably on the day of the lesson. Scoop a bucket through the water and along the bottom of the pond to collect both water and sediment. Fill the bucket and seal the lid. Keep the bucket cool.



- Prepare a large frame by attaching 2x4's to the edge of a sheet of plywood. Lay the frame flat on the floor of the classroom and drape it with a sheet of white plastic film. With a large frame, the class can work together to identify organisms in the water sample.



Illustrations: Donald Gunn

- Alternatively, for a small-scale demonstration, prepare a screen by attaching nylon netting (e.g., screen door netting or pantyhose) to a wooden frame (approximately 30 x 30 cm).

Introduction

- Ask students to name or describe any kind of wild animals that live in streams and ponds. Ask which make good food for salmon fry. If necessary, prompt them with questions, such as:
  - What animals have you seen in ponds and streams or heard about in stories or on TV?
    Fish, frogs, salamanders, bugs, etc.
  - What animals live in water or on the surface of the water?
    Fish, insects, etc.
  - What kinds of animals live under the water in the mud?
    Insects, worms, etc.

Demonstration/Investigation

- Pour the water sample into the plastic-lined frame.

  Alternatively, arrange the screen over the empty basin, then have a student gently stir the pond water and pour a scoopful of water over the screen.
- Have students examine the screen or frame to find any organisms. Have them use the pipette or turkey baster to rinse any organisms, sort and transfer them to the egg cartons and cover them with a small amount of water. Warn students to handle specimens carefully to avoid injuring them.
- Have students repeat the process to isolate any organisms in the water sample.
- Have students, in groups, use “Handout 7.4: Aquatic Life” or another guide to aquatic organisms to identify as many organisms as they can. Have students count and record the number of each type of organism they find.
- Have students describe any organisms they find, noting colours, shape, size and features (e.g., legs, antennae, wings). Have students draw examples of each type of organism they find and label the ones they can identify.
- When student observations are complete, have students return the organisms to the water and, if possible, replace the water back in the location from which it came.

Option: Collect water samples from several different locations and have students compare the organisms from each.

Discussion

- Discuss with the class the observations they made. If necessary, prompt them with questions, such as:
    - How many organisms were you able to identify? How many were you unable to identify?
    - What types of features did the organisms have in common?
      Colour, shape, body form, etc.
    - Which features help the organisms live in a stream or pond?
      Protective colouration, tails for swimming, antennae or eyes, etc.
    - Which organisms do you think salmon fry might rely on as a source of food?
      Fry often eat stonefly nymphs, mayfly nymphs, caddisfly larvae, black fly larvae and land insects.
    - What factors would make salmon fry like or dislike the environment from which this water came?
      Presence of food sources, gravel, absence of silt, etc.

Runoff Life

[demonstration]

Materials:

- One copy of "Handout 7.4: Aquatic Life" for each student
- One copy of "Handout 7.5: Runoff Pollution" for each student
- Writing supplies

Time required:
Approximately 60 minutes in two periods

Level of conceptual difficulty:
Moderate

Suggestions for assessment:
Review the students' charts to ensure that the students can classify and identify various aquatic organisms and produce written descriptions of them.

Experiment

- Have students use turkey basters or small scoops to gather samples of stream or pond water at a point where runoff water from a street, parking lot or playground has directly entered the waterway. Then have the students carry out the procedure described under Demonstration/ Investigation in the activity, "Aquatic Life" on page 152, to compare the number and type of organisms in this runoff sample with the number and type found in the stream sample from the previous activity.

Discussion

- Have students read "Handout 7.5: Runoff Pollution" and discuss the differences between the runoff sample and the other samples. If necessary, prompt them with questions, such as:
  - How did the runoff water sample differ from the pond water?
    More or less silt, smell of water, oil on the surface, etc.
  - Which sample had a greater number of organisms? Which had a greater variety?
  - In which sample would salmon fry or other aquatic organisms prefer to live? Why?
    Ponds and streams have greater numbers and varieties of plant and animal life that fry can use for food and shelter. In addition, the supply and quality of water is more reliable and less polluted.
  - Where does the runoff water go?
    It soaks into nearby soil and flows into creeks, streams and drains, which sometimes flow into rivers, streams or seas.
  - What problems might be caused by runoff water from paved land?
    Instead of percolating into the ground, it tends to flow quickly, often flooding ditches and creeks with contaminated rainwater.
  - How does human development, especially in cities, affect aquatic life and the aquatic environment?
    It reduces the space for natural water, creates floods of polluted runoff, and reduces the variety and number of organisms.

- What steps might people take to reduce the impact of urban runoff?
  Reduce the need for roads, reduce car pollution, reduce runoff floods by building porous pavement that allows water to percolate into the soil, surround pavement with natural vegetation to absorb runoff, divert polluted water into ponds or wetlands where it can be treated, etc.

Option: Have students build small-scale models demonstrating how urban runoff water can be diverted or treated to reduce its impact on aquatic organisms.

Review and Build on What You Know

Materials:
None

Time required:
20 minutes plus more

Review

- Give students five minutes to review their notes and list at least six important ideas or facts about salmon fry.
- Give students five minutes to share their lists, in groups of four, and write on chart paper the four most important ideas agreed on by the group.
- Have the groups post their charts on the classroom wall, then lead a class discussion on the common ideas and differences recorded on the charts.

Summation

- Have students add their lists and any additional comments to a salmon science notebook or portfolio.
- Have students add information about salmon fry to their salmon life cycle chart.
- Have students add information about salmon fry to their salmon habitat mural.
- Have students inspect and record the condition of materials in the landfill models.

S A L M O N   F R Y

Wrap-Up

Extension Activities

- Arrange a field trip to conduct a systematic stream survey and identify plants, animals and environmental factors that make the site a good (or poor) habitat for salmon (e.g., running water, gravel, shade, food sources). See Unit Three: Salmon Habitat – On-Site Studies for a suggested procedure.
- Have students conduct a stream mapping or clean-up activity on a local stream. (Contact a local naturalist or Streamkeepers organization to find out about local projects and procedures to use.)
- Have students conduct a biodiversity survey of their home or school neighbourhood, or conduct a soil biodiversity survey. (See *Backyard Biodiversity*, pages 27 and 28.)
- Have students use a dichotomous key of salmon fry species to identify different types of salmon fry.
- Have students paint a picture of an underwater stream environment, then paint fry in different colours and patterns to identify the camouflage patterns that best allow fry to avoid detection by predators.

Suggestions for Assessment

- Have students draw a Venn diagram comparing fish with other species, then explain what distinguishes fish from other species.
- Monitor the discussion as students make and present their lists in the review activity to ensure that the students can use factual information from the activities to support an opinion about the life of salmon fry.
- Monitor student discussions of the class' habitat mural and life cycle chart to ensure that the students can identify the needs of salmon fry, as well as their habitat and threats to it.
- Have students write quiz questions about salmon fry on one side of an index card and answers on the other. Have them quiz each other by asking the questions or by using a *Jeopardy*-style format (giving the answers and asking for a question).
- Have students add their notes, experiment observations and other materials to a salmon science notebook or portfolio.
- Have students use "Appendix 2: Student Assessment Sheet" to review their group work and their own learning.

Home and Community Connections

- Have students visit a nearby stream or lake with an adult, identify a variety of aquatic organisms, and explain how the organisms contribute to salmon habitat.
- Suggest that the class begin a project to identify and remove any obstructions that make it difficult for migrating smolt to travel to the estuary, or suggest the class identify damaged estuary habitat and investigate how to restore it. (For directions, refer to the activity, "Creating Positive Human Impacts" in Unit Ten: Review: The Salmon Life Cycle.)

Handout 7.1

Fish Classification

Animals that live in water are called **aquatic organisms** (i.e., water animals). There are also aquatic plants, such as seaweeds and bullrushes.

Only some of the animals that live in water are **fish**. All fish have four things in common:

- **A flexible backbone**. This allows them to move and twist their body. Most fish have bony skeletons. Some, like sharks, have a stiff, but flexible, material called cartilage instead of bones.
- **Cold blood**. Fish cannot keep their body temperature steady, as people do. Their body is usually the same temperature as the water in which they live. If the water freezes or becomes too warm, the fish die. A rapid change of only a few degrees can kill fish.
- **Fins**. Fish use fins to control their movement through the water. Most fish have single fins along their top and/or bottom, and pairs of fins that work together on their sides. A fish's tail is its largest and most important fin because it acts as a rudder.
- **Gills**. Fish, like many other aquatic animals, use gills to breathe. Clusters of tiny blood vessels in an opening at the back of the mouth absorb oxygen from the water and give off carbon dioxide. Most fish die in the open air because they cannot remove oxygen from the air.

Other animals that live in water have only some of these characteristics. For example, whales have flexible backbones, but their blood is warm and they use lungs to breathe. Alligators have flexible backbones and cold blood, but they breathe with lungs. Eels are fish with modified fins.

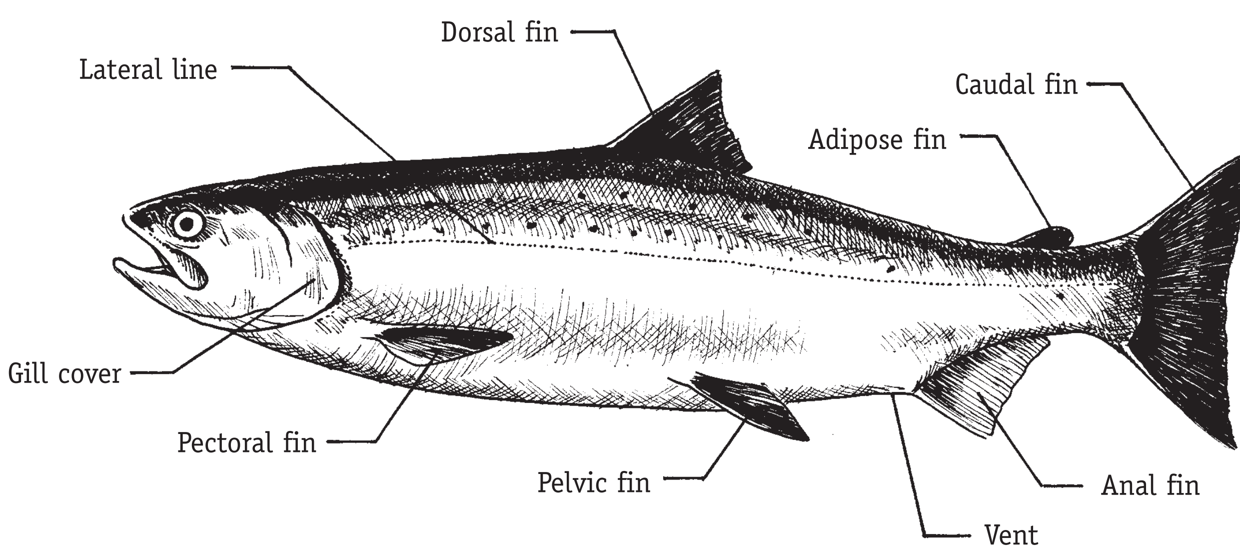
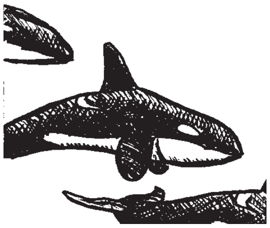


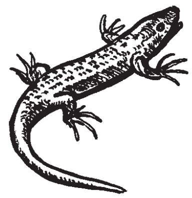
Illustration: Donald Gunn

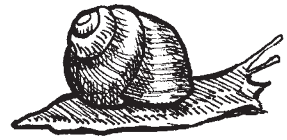
HANDOUT 7.1

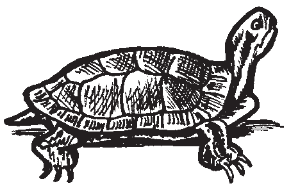
Fish Classification

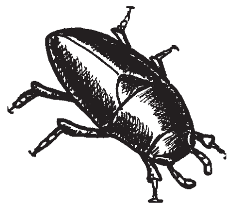

Orca (mammal)

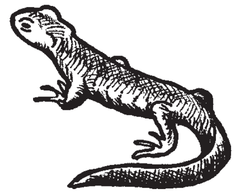

Sea Horse (fish)

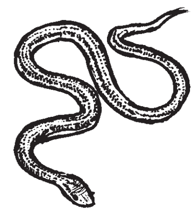

Alligator Lizard (reptile)

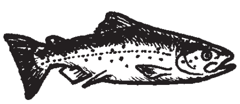

Snail (mollusk)

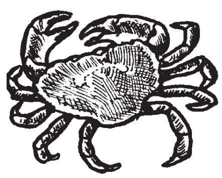

Turtle (reptile)

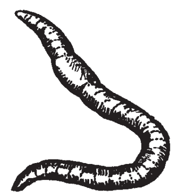

Diving Beetle (insect)

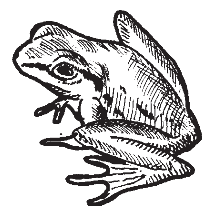

Newt (amphibian)

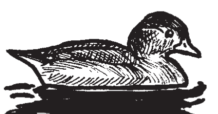

Garter Snake (reptile)

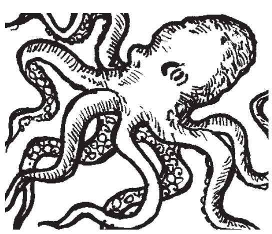

Trout (fish)

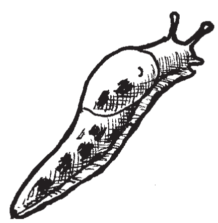

Crab (crustacean)


Earthworm (invertebrate)

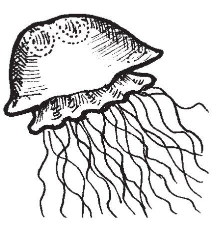

Tree Frog (amphibian)

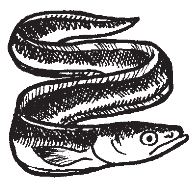

Duck (bird)

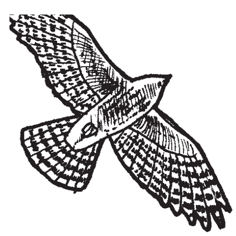

Octopus (mollusk)


Slug (mollusk)


Ant (insect)


Jellyfish (invertebrate)


Eel (fish)


Hawk (bird)


Shrew (mammal)

Illustrations: Donald Gunn

HANDOUT 7.1

Fish Classification

Scientists have identified about 22,000 different **species** or types of fish. About 1,150 species live in Canada. The differences between each species allow them to live in different environments. For example, some can tolerate warm water, while others prefer cold; some catch and eat smaller fish, while others eat plankton or water plants.

One group of fish is the family of salmonids, which includes the true salmon species and several related species, such as cutthroat trout and Dolly Varden. Six different species of true salmon live in the Pacific Ocean and the North American rivers that drain into it: chum, chinook, sockeye, pink and coho salmon, and rainbow trout. Each looks and acts a little different from the others.

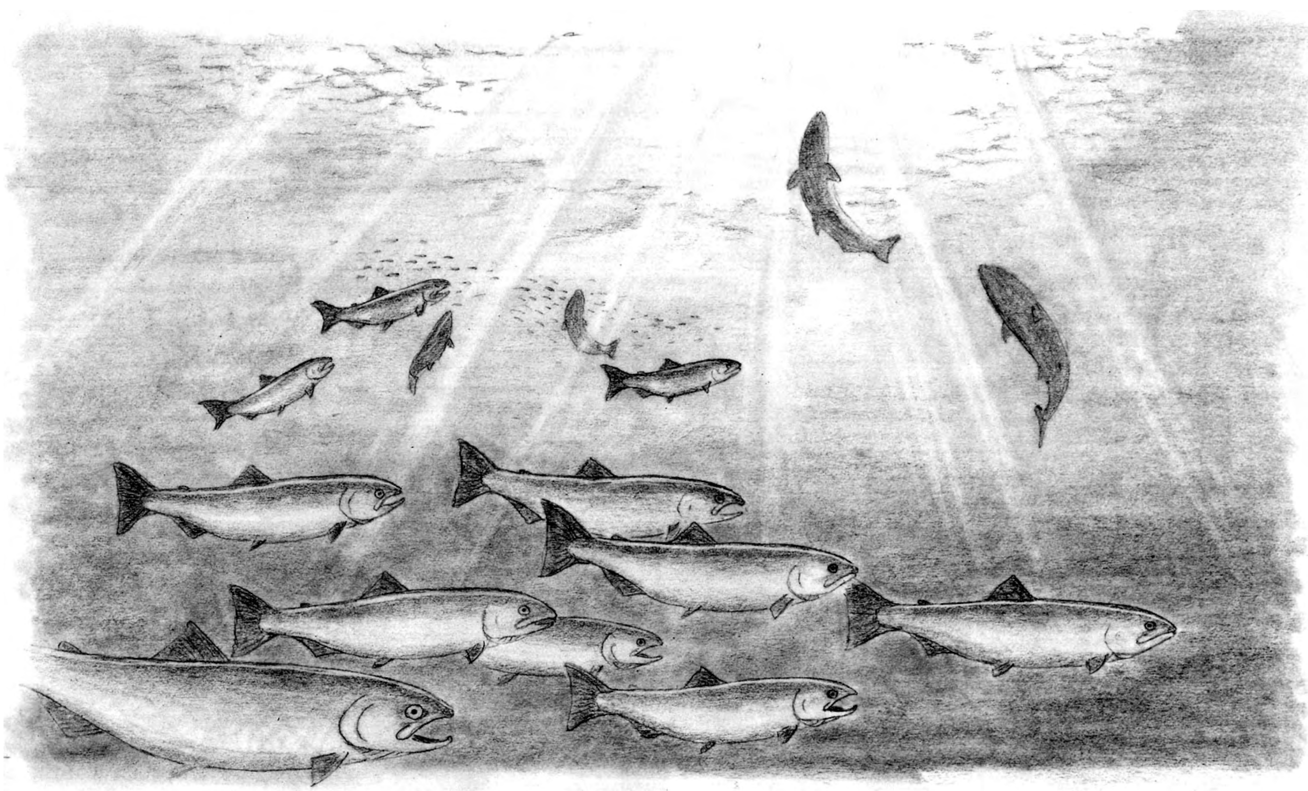


Illustration: Karen Uldall-Ekman

Handout 7.2

Salmon Fry

Alevin emerge from the gravel to begin the next stage of their life as "swim-up" fry, and then "free-swimming" fry.

Rapidly vibrating their tail, they push themselves up to the surface of the water and swallow a mouthful of air. The air is not for breathing, but to balance the weight of their body and allow them to float in water. It goes into a **swim bladder**, an organ like a balloon in their abdomen. They may have to take several gulps until they have enough air.

Fry are not strong enough to swim upstream, so they drift downstream until they find calm pools where they can feed. There, they defend a small feeding territory from other fry. Salmon fry eat the nymphs and larvae of insects such as stonefly, mayfly, caddisfly and black fly. They also eat plankton and some land insects that fall into the water. They grow from about 2.5 cm to between 4.5 and 5.5 cm during the summer.

Many salmon fry are eaten by predators, including birds and larger fish. To hide, salmon fry change their skin colour. They develop camouflage markings known as **Parr marks**, dark bars across their bodies. The mixture of light and dark helps them blend into the shadows on the stream bed so they are harder to see. They also dart very quickly from spot to spot.

Almost 90 per cent of all fry die from predators, disease or lack of food. They still need fresh flowing, cold water, with plenty of oxygen and shade to keep the water from getting too warm. People can help increase their survival by protecting their environment from pollution, flooding or blockages.

A crucial part of the salmon life cycle begins at the fry stage— **imprinting**. Salmon fry remember the smell of the water they grew up in. When they return as adults, they try to find the same spot. The rocks and soil in the stream bed, plant life and other aquatic organisms all create the scent that salmon return to. Changes in the environment of the stream can confuse the returning salmon, and prevent them from spawning.

Some salmon species spend just a few days in their home stream, but most spend one to three years.

- Pink and chum spend one to three months in fresh water.
- Chinook, coho and sockeye spend about one year.
- Rainbow trout spend two to three years.

Then, they begin to migrate downstream to the **estuary** where the river meets the ocean. Sometimes, dams or other blockages prevent salmon from travelling to the sea. They remain in lakes and rivers through their entire life cycle, but can continue to produce land-locked offspring.

Handout 7.3

Buoyancy

Name ____

Heavy objects sink when you put them in water. To float, they need **buoyancy** (pronounced BOY-an-cy). Buoyancy is the ability to float. The bodies of fish (and other animals) do not sink to the bottom of the water. They are **buoyant**. This experiment shows how heavy objects can be buoyant.

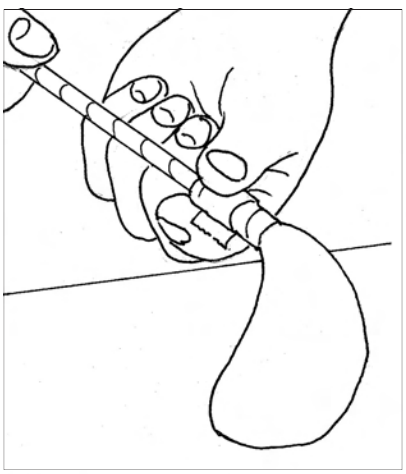
Materials

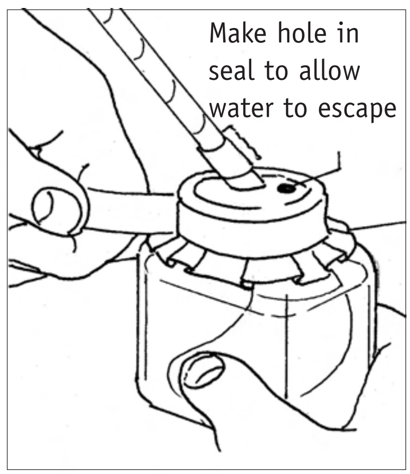
- Plastic drinking straw
- A small bottle with a narrow mouth
- A balloon
- Waterproof tape
- A basin of water

Hypothesis

A balloon can help an object float in water.

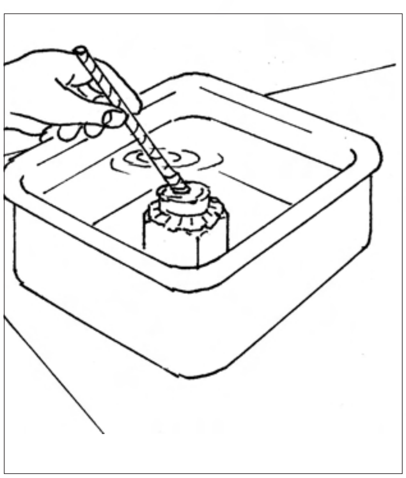
1. Tape balloon onto a drinking straw.

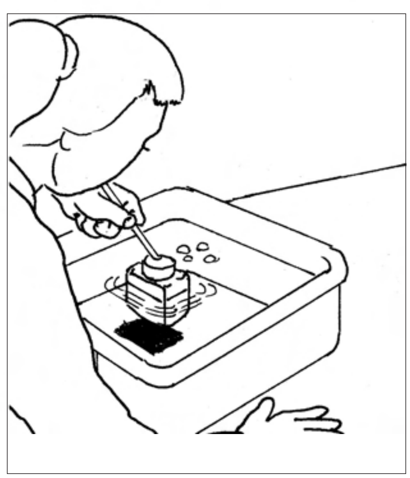




2. Insert straw/balloon through seal on small water-filled bottle.

3. Immerse bottle in a basin of water.





4. Blow gently through straw to inflate balloon.

Illustration: Donald Gunn

Handout 7.3

Buoyancy

Procedure

1. Tightly tie a balloon around the end of a drinking straw (but do not crush the straw).

2. Tape the straw to the mouth of the bottle so the balloon is inside.

3. Submerge the container in the basin of water. **Observations:** Describe what happens to the container.

____

____

4. Blow through the long straw into the container. **Observations:** Describe what happens to the container.________________________________

____

____

5. Suck the air out of the balloon. **Observations:** Describe what happens to the container.

____

____

____

6. See if you can keep enough air in the balloon so that it floats just below the surface of the water.

Observations: Describe what happens when you try to float the balloon just below the surface.

____

____

____

Conclusion

How do your observations support or question the hypothesis?________________

____

What conclusion can you make from your observations?________________

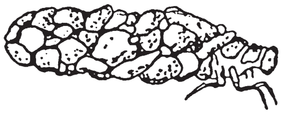
____

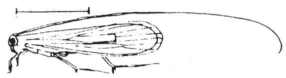
How could salmon and other fish make use of buoyancy? ________________

____

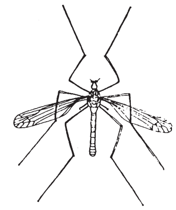
Handout 7.4

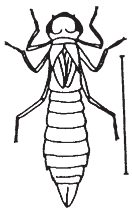
Aquatic Life

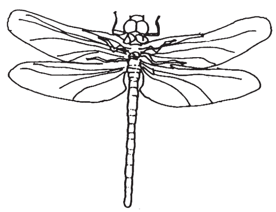

Caddisfly Larva

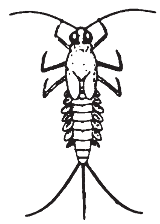

Adult Caddisfly

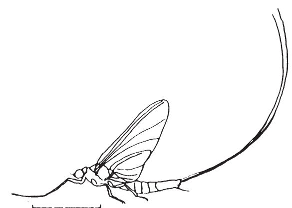

Cranefly Larva

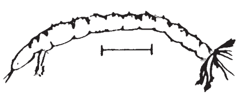

Adult Cranefly

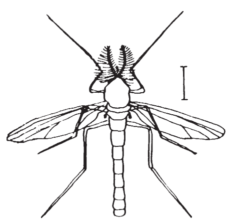

Dragonfly Nymph

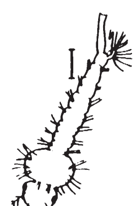

Adult Dragonfly

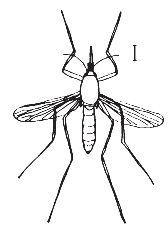

Mayfly Nymph

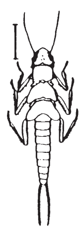

Adult Mayfly

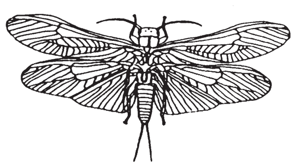

Midge Larva

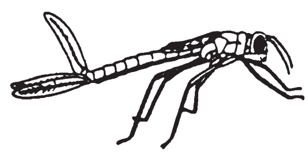

Adult Midge

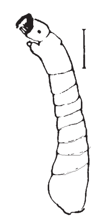

Mosquito Larva


Adult Mosquito

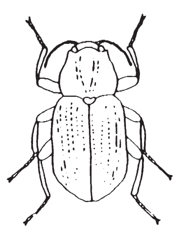

Stonefly Nymph

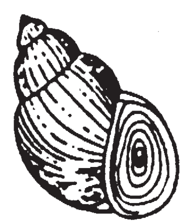

Adult Stonefly

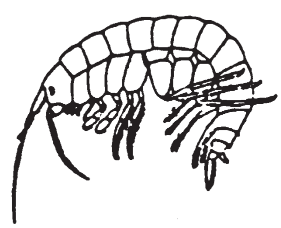

Damselfly Larva


Blackfly Larva


Leech


Riffle Beetle


Right-handed Snail


Scud

Handout 7.5

Runoff Pollution

Water pollution in British Columbia comes from many sources. Factories, farms, forest activities and boating activities can leave wastes in the water that is used by salmon.

People have changed their activities to reduce pollution, but some kinds of pollution are hard to stop. Runoff is an example.

In nature, when rain falls, most trickles into the soil and gradually moves toward lakes and streams. However, cities and buildings change that flow. Roads, sidewalks and parking lots do not absorb rainwater, nor can rain soak easily into hard-packed soil. Instead, rainwater flows across the surface to drains or puddles.

As rain flows across the surface, it can pick up dirt, chemicals and micro-organisms that are harmful to salmon. Harmful pollutants include:

- oil that drips from cars onto the street;
- air pollutants that settle on the ground;
- fertilizers and herbicides sprayed near the street;
- dirt kicked from a playground;
- paints and cleaners used on a parking lot;
- wastes that people dump onto the street.

When rain carries these pollutants into a drain, it often flows to nearby streams. The pollutants then flood into a water body, where they can harm salmon and other organisms. The dirt can harm their delicate gills. The chemicals can be poisonous. Chemicals also kill insects and micro-organisms that salmon need for food.

However, people can make a difference. Many schools mark road drains to remind people that wastes in the drain can harm nearby streams. Some people are planting vegetation to support loose soil that will absorb rainwater. New types of pavement allow water to drain through the surface into the soil below.

Handout 7.5
Runoff Pollution

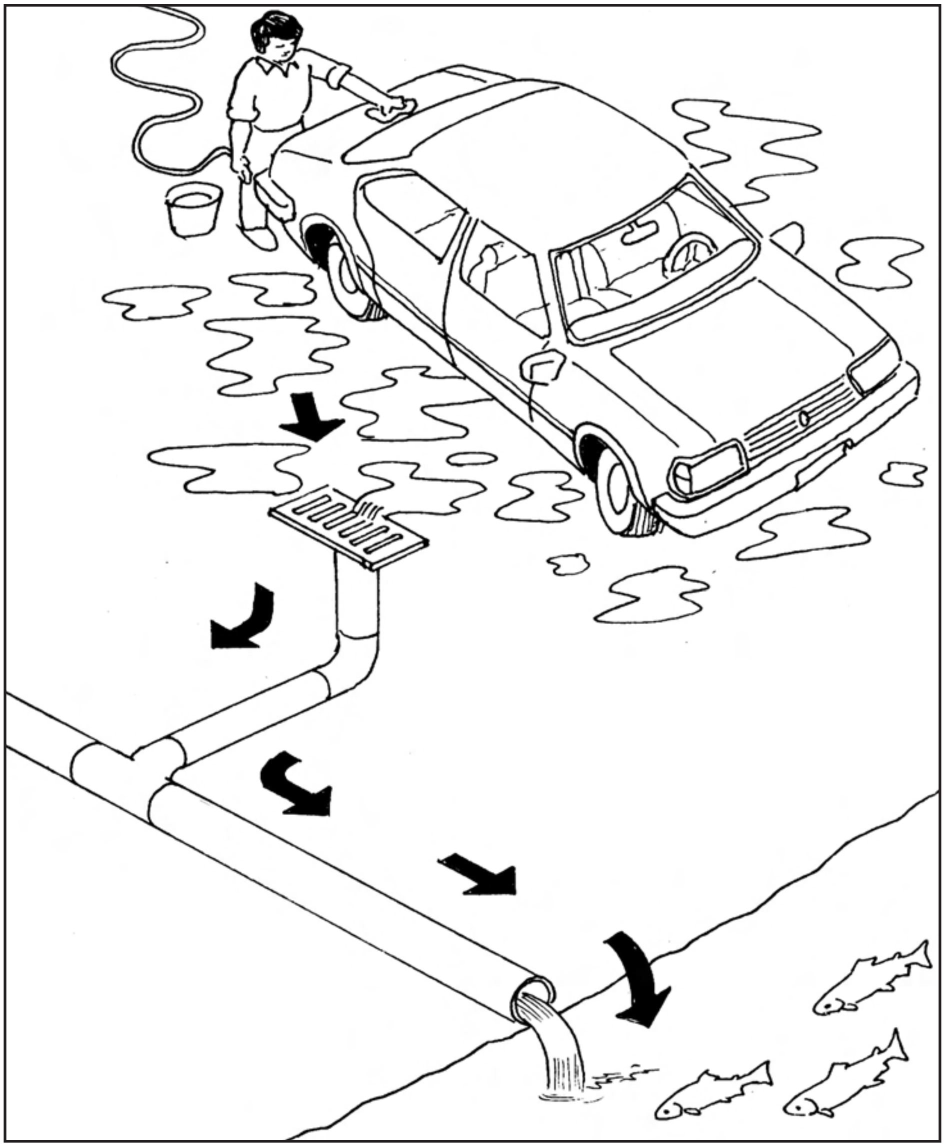
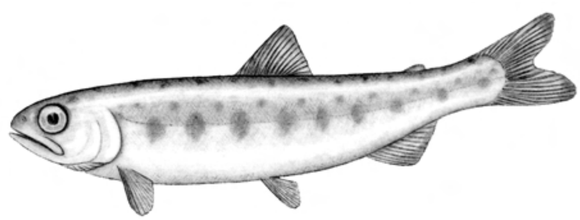


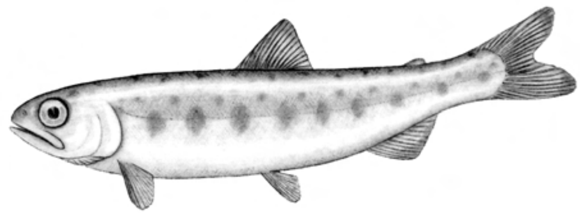
Illustration: Donald Gunn

UNIT 8

SALMON SMOLTS



Salmon Smolts



Overview

This unit gives students an opportunity to:

- discuss how salt water and fresh water mixes in an estuary;
- observe the reaction of animals to salt water;
- simulate the effect of salt water on cells;
- develop a simulation game representing salmon predators;
- research local estuaries lost to development;
- review the concepts they learned in the unit.

Key Concept

Smolts migrate to the estuary and adapt to salt water conditions, but face increasing hazards in the estuary.

Vocabulary

Smolt, adapt, excrete, membranes, cells, estuary, eelgrass, nutrient, predator

Background Information

The information which follows can be used to supplement "Handout 8.2: Salmon Smolts".

Smoltification

Salmon fry have only the physiological mechanisms needed for fresh water; they would die in salt water. They become smolts when they begin the process of adapting to salt water, a process called smoltification. The process begins in fresh water and continues in the estuary and the ocean.

Osmotic pressure forces fresh water into areas with a higher concentration of salt or other minerals. In fresh water, cells have a higher concentration of minerals and water moves from the environment into the cells. Salmon do not drink in fresh water. They get rid of excess water in their cells by excreting large amounts of weak urine.

In salty water, osmotic pressure draws water out of the cells and would lead to dehydration if the salmon did not compensate for the change in its environment. The salmon copes by drinking large amounts of salt water and excreting a concentrated urine. It also excretes excess salt in solution through the cell walls of its gills.

Smolts also develop silvery scales, which help slow the exchange of fluids through their skin and provide them with protective colouration in the bright waters of the estuary and the ocean.

Different species of salmon smoltify at different times.

- Chum and pink migrate within a few weeks of their emergence from the gravel. Chum fry are already prepared for salt water.
- Most sockeye spend one year in lakes before smoltifying and migrating to the ocean.
- Coho and some chinook stocks spend about one year in their home stream before migrating and smoltifying. Other chinook stocks spend 60-90 days in fresh water.
- Steelhead trout spend one to three years in fresh water before migrating to salt water.

Estuaries

An estuary is the mouth of a river, where its fresh water meets salt water and the river's current mixes with ocean tides. Material is deposited both by the rivers and tides, so estuaries provide a rich source of natural nutrients and are concentrated zones of food production. Most of the food production peaks in late spring, when the salmon are emigrating to the sea.

Most salmon species spend several months in an estuary, although scientists have only limited knowledge about this phase of salmon life. Here, salmon adapt to the saltwater environment and make large increases in their body weight. In the estuarine area, many animals (e.g., birds, snakes and larger fish) prey on salmon. However, the thick beds of vegetation (e.g., eelgrass and sedge) provide cover in which smolts can hide. Many other marine fish species grow through their juvenile stages in estuaries, while ocean species, such as herring, migrate to the estuary to spawn among the eelgrass beds.

The shallow, protected environment of estuaries makes good harbours and many large ports (e.g., Vancouver, Campbell River, Prince Rupert) are located in estuaries. The urbanization of these high-density population centres can destroy the ecological properties of the estuary. Developments include landfilling and dredging; pollution from urban sewage, solid waste, agricultural and industrial effluent, and hot water; and alteration of the salinity by changing the volume and the timing of the flow of fresh water.

Introduction

Materials:
None

Time required:
10 minutes

Suggested Activities

From these suggestions, choose activities that are appropriate for your class.

- Ask the class to describe what happens when a river meets the sea. If necessary, prompt them with questions, such as:
  - What happens to the seawater when river water flows in?
    River water mixes with seawater, diluting the saltiness of the seawater.
  - What happens to the river water and the silt and other materials it is carrying?
    The water warms and its velocity falls, causing it to deposit silt and floating debris at the river mouth.
  - What happens to the seabed when river water flows across it?
    The river water mixes up minerals and other nutrients lying on the seabed and circulates them in the water, causing rich plant growth.
  - How do fish, birds and other animals respond to the rich plant and aquatic insect growth?
    They grow rapidly as a result of eating the plants and other animals that feed off the plants.
  - How do animals respond if they do not like the salt water?
    Some avoid the salt water; some are able to adapt to it.
- Explain that, in the following activities, the students will look at ways in which salmon adapt to salt water in an estuary.

The Estuary

[experiment]

This experiment demonstrates that animals avoid salt water unless they are adapted to it, and leads to a discussion of ways in which salmon smolts adapt to the estuary environment. Depending on the abilities of your class, you may prefer to do this activity as a demonstration or have students do the experiment themselves.

Materials:

- A terrarium or large clear bottle (e.g., a clear two-litre pop bottle) lined with damp paper towels
- One or more snails (students can often collect snails on tree trunks or under leaves; if snails are not available, earthworms or mealworms will also work)
- Fresh lettuce
- A flat pan, such as a cookie tray
- Water
- Concentrated salt solution
- A straw or eye-dropper
- One copy of “Handout 8.1: Animals and Salt Water” for each student
- Writing supplies

Time required:
Approximately 60 minutes, plus time for observations before the experiment

Level of conceptual difficulty:
Moderate

Introduction

- Have students observe the snails in the terrarium and make notes of their normal behaviour. Have them feed the snails fresh lettuce and note their response.
- Have students hypothesize how the snails will react to salty water and write their hypothesis on “Handout 8.1: Animals and Salt Water”.

Experiment

- Have students place a snail at one end of the flat pan and the lettuce at the other end. Have them use the straw to make a line of plain water between the snail and the lettuce. Have them note, on the handout, the snail’s response to the water.
- Have students repeat the experiment using a concentrated salt solution instead of water between the snail and the lettuce. Warn students not to touch the snails with the salt solution. Have them note, on the handout, the snail’s response to the water. When finished, return the snails to the terrarium.

Discussion

- Ask the class whether or not their observations support their hypotheses. Discuss with the class the conclusions they can draw from the experiment about organisms and salt water.
  Some organisms, such as snails, avoid salt water.

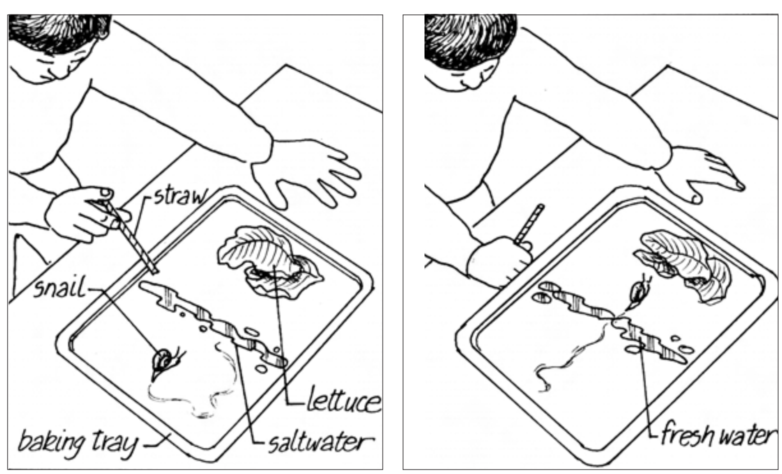


Illustration: Donald Gunn

Suggestions for assessment:
Review the students' observations and conclusions to ensure that the students can describe the snails' avoidance of salt water and discuss other organisms' responses to salt water.

If necessary, prompt them with questions, such as:

- How did the response of the snail to the salt water differ from its response to the fresh water?
  It avoids salt water, not fresh water.
- Why do you think the snail avoids salt water?
  Snail skin is very sensitive to salt and the salt can harm the snail.
- How does the response of the snail compare to other organisms, such as humans, birds and salmon?
  Most aquatic organisms prefer either salt or fresh water and do not live in both. Humans and some birds can briefly pass through both because their skin is less sensitive to salt, but they do not live in the water. Salmon do not avoid salt water as the snails do: salmon, and a few other fish, are able to move from one to the other at certain stages in their life by changing the way their body functions.

■ Have students write their conclusion about their hypothesis on the handout.

Smolts in Salt Water

[experiment]

Depending on the abilities of your class, you may prefer to do this activity as a demonstration or have students do the experiment themselves.

Materials:

- Two sealable plastic sandwich bags
- Enough water to fill the sandwich bags
- A basin to catch the water
- One copy of "Handout 8.2: Salmon Smolts" for each student
- Writing supplies

Time required:
Approximately 60 minutes

Level of conceptual difficulty:
Simple

Suggestions for assessment:
Monitor the class discussion and review the students' charts to ensure that the students can identify adaptations salmon undergo when they enter an estuary.

Experiment

- Fill two sandwich bags with water and have students describe them to the class.
  When full, the bags are fairly stiff.
- Have the class predict what will happen when some water is removed from one of the bags. Remove some water from one bag and have students compare the full bag with the partially full bag.
  The bag with less water is less stiff.

Discussion

- Explain that salt draws water through the skin of a body. (For older students, explain that salt draws water through the cell wall or membrane.) Have students predict the problem smolts face when they migrate to salt water. Have them predict the effect of reducing the amount of water in an organism's cells.
  The salty water will draw water out of the smolt's body. This would dehydrate the smolt's body, making its cells less stiff and changing the chemical balance in the cell fluids.
  Have the class suggest ways that the salmon can avoid the problem when they migrate from fresh water to salt water.
- Have students use "Handout 8.2: Salmon Smolts" to discuss how salmon smolts migrate to salty water and ways in which they cope with the changed environment. If necessary, prompt them with questions, such as:
  - In what ways is estuary water different from stream water?
    It is saltier; it is warmer and it contains more nutrients, food sources and predators.
  - What happens to the smolts' bodies, or cells, when they move into salty water?
    The salt draws water out of their cells.
  - How do smolts adapt to the changes in the water?
    They drink more salt water to keep their body full of water and they excrete the excess salt through their gills.
  - Why can't shipwreck survivors drink salt water? *People do not have gills or any other way to get rid of excess salt quickly enough, so it builds up and poisons them.*

- To what other changes must smolts adapt to when they enter an estuary?
  They eat different kinds of food and have to avoid different predators.

Summation

- Have students add information about salmon smolts to the chart of the salmon's life cycle, which they began in Unit Five: Salmon Eggs.

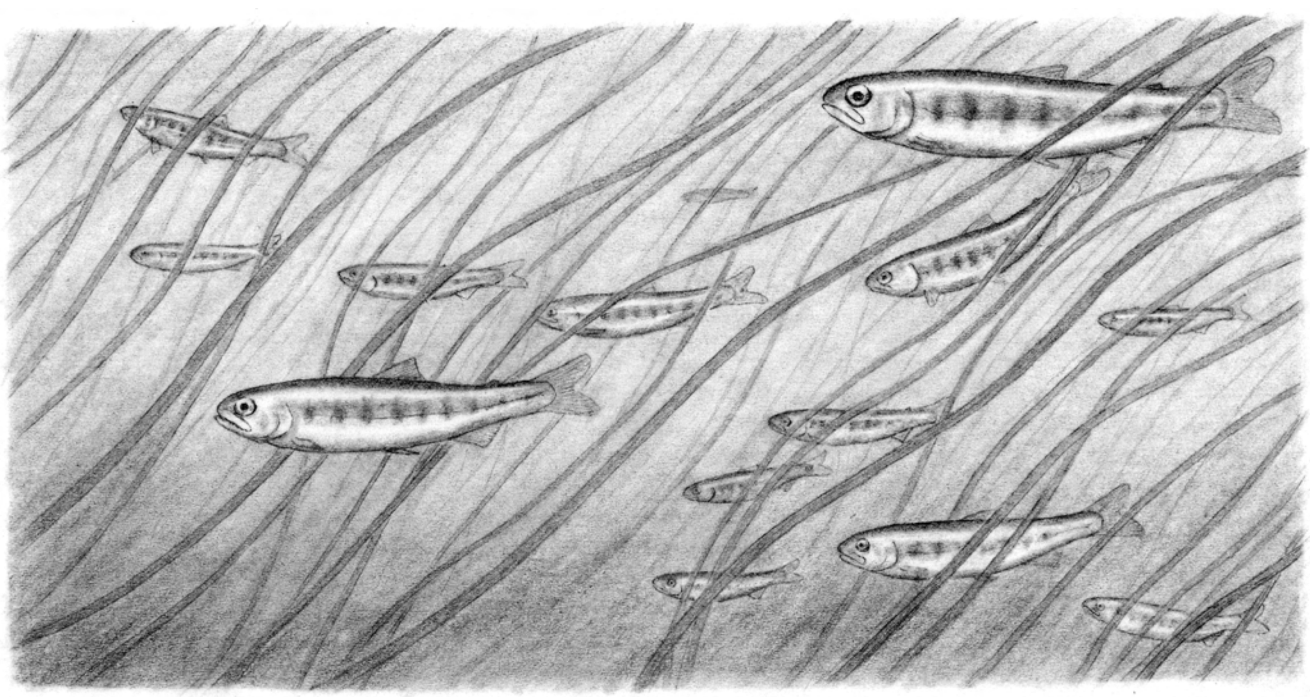


Illustration: Karen Uldall-Ekman

The Predator/ Prey Game

[discussion/simulation]

Materials:

- Gym supplies (optional)
- One copy of "Handout 8.3: The Predator/Prey Game" for each student
- Writing supplies

Time required:
Two 20-minute periods in class, plus an hour or more in a gym or open area

Level of conceptual difficulty:
Moderate to advanced

Suggestions for assessment:
Monitor the discussion of the games and review the students' game summaries to ensure that the students can identify the effect of predators on smolts in an estuary.

Introduction

- Have students, in small groups, list some advantages that salmon gain by migrating to the sea. Have the groups share their suggestions with the class.
  Food is more abundant in the sea; the salmon can grow larger and avoid predators more easily than in a small stream.
- Have the groups list some advantages that salmon gain by spending time in an estuary. Have the groups share their suggestions with the class.
  Food is abundant in an estuary; thick plant growth gives protection from predators; there is more room than in a small stream; the salmon can slowly adapt to saltier seawater.
- Have the groups list some hazards salmon face in an estuary, then share their suggestions with the class.
  Birds and other predators are attracted by the food sources in the estuary; it takes time and energy to adapt to the salty environment; estuaries can dry out both naturally and from human activities.

Simulation

- Have students, in groups of four or five, use "Handout 8.3: The Predator/Prey Game" to devise a simulation of salmon predators in an estuary.
- Have the class play the game that each group devises. If you have time, allow groups to modify their rules to make the games work better. Have students keep track of the number of surviving players under each group's rules and under any variations on the rules.

  Option: Have students with knowledge of computer gaming devise a simple computer game that represents salmon smolts hunting for food and avoiding predators in an estuary.

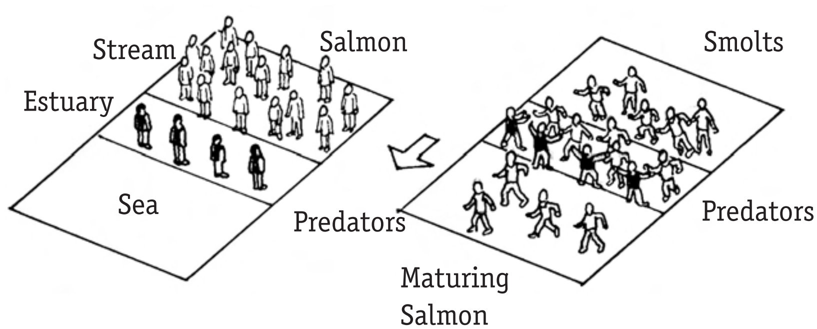


Illustration: Donald Gunn

Discussion

- Have the class plot the number of survivors from each game on a graph. Discuss the conclusions they can draw from their data. If necessary, prompt them with questions, such as:
  - Which game was most like real estuary conditions? Why?
  - What would have made the games more like real conditions?
  - How many smolts were needed to ensure that some made it through to the ocean?
    Usually many more smolts than predators.
  - What would be the effect of reducing the size of the estuary? Of changing the number of predators or smolts?
    Reducing the size of the estuary or increasing the number of predators usually results in fewer smolts surviving.
  - How can people use a game such as the predator/prey game to predict and manage their impacts on the environment?
    People can create a realistic simulation, then see what happens when changes are made.

Summation

- Have students summarize, in writing the results of their game and describe any changes they would make to create a more realistic model of a smolt's life in an estuary.

The Lost Estuary

[discussion/research]

Materials:

- Map showing locations of West Coast or world cities and rivers (Note: your local government agent may be able to help you to find maps, or visit http://home.gdbc.gov.bc.ca/catalog/Govt_Agent.htm)
- Topographical maps and road maps of the local municipal area
- Writing supplies

Time required:
60 to 90 minutes

Level of conceptual difficulty:
Moderate to advanced

Suggestions for assessment:
Monitor the class discussion and review the students' pro and con arguments to ensure that they can identify reasons for, and impacts of, human development in estuaries and describe ways to minimize the impacts.

Preparation

- Organize students in groups of five, then have them number themselves from 1-5. Explain that each person has been asked to sit on a committee and will represent a sector of the community about to settle in a currently undeveloped area. Development could potentially occur in two main locations:

  A. a mountainous region consisting mostly of forest and hillside; or

  B. a flat area, bordering an estuary and consisting mostly of wetland and shrubs, with some trees.

- Students #1-5 will take up to 10 minutes to brainstorm a list of pros and cons for each potential location, based on their sector's requirements for land. They should then take another 5 minutes each to report their list to the mayor (student #1) and council.
- Inform the #1 students that they have been appointed by the BC premier to be the first mayor of an undeveloped area. The mayor has been asked to consult with a committee of people (students 2-5) from various sectors to discuss the future of the proposed area. It is the mayor's responsibility to listen to and record the opinions of each sector representative regarding the pros and cons of each potential development location. The mayor will then count the total number of pros and cons for each location (based on the reports of each committee/sector representative) and report them to the rest of the class (the decision-making council).
- Inform the #2 students that they have been called upon to represent the agricultural industry (growing crops and raising livestock for food). To be successful in this sector, they will need to live on land that has access to water, good soil, space to grow food, pasture land for animals to graze, access to roads, good sun exposure and a favourable climate.
- Inform the #3 students that they have been called upon to represent the commercial fishing industry. To be successful in this sector, they will need to have access to land that has water, areas to dock and launch boats, places to store equipment, areas where fish can be processed (fish must get to the processing plant quickly to prevent spoilage).

- Inform the #4 students that they have been called upon to represent the housing development industry. To be successful in this sector, they will need to consider the interconnecting roads, close proximity to major amenities such as food and recreation, access to building materials (commonly shipped by boat, train or transport), access to household water and ways to treat storm/waste water.
- Inform the #5 students that they have been called upon to represent the tourism industry. To be successful in this sector, they will need to consider: outdoor recreation opportunities, scenic/wildlife views, historical buildings, special events, accommodation, and access to transportation (e.g., roads, airports, boats).

Discussion

- Have the mayor from each group report to the rest of the class the total number of pros and cons of both locations for each sector.
- Have the mayor share with the class some of the factors identified by their group that make estuaries attractive for human settlement.
  Estuaries often form protected harbours, the river allows transportation inland, they have fresh water for drinking, agriculture and industry, flat land allows construction and agriculture, etc.
- Have the class suggest factors that make estuaries problematic for human development.
  They may flood in the spring, water bodies may require bridges, they attract a wide variety of wildlife that is lost to development, etc.
- Have the groups list ways that human settlement affects the natural estuary environment, either positively or negatively, and ways in which it affects salmon.
  People fill or dyke estuaries for agriculture, housing and industry, divert or channel water to prevent floods, dredge shallows to improve shipping, hunt wildlife and catch fish, dump waste, sewage, rain runoff and other pollution run into the water. These activities affect salmon by reducing the size of the estuary and contaminating the water.
- Have students suggest potential consequences that may occur as a result of unchecked land use practices in estuary environments.

Unsafe drinking water, beach and shellfish closings, loss of habitat, fish and wildlife kills, and a host of other human health and natural resource problems.

- Have the groups share their lists with the class and create a class list or web of human impacts on estuaries.

Investigation

- Have the class look at a map of major West Coast or world cities and identify the ones that are built on a current or former estuary.
  Virtually all coastal cities are built on a river's mouth, and many inland cities are built on a lake estuary.

- Have students use local topographical maps to identify rivers, river courses and estuaries within local municipal boundaries. Have them compare the river and estuary locations with road maps to see which ones they can find and which ones have been diverted, channelled or buried in culverts.
  The local municipal or regional government engineering and planning departments will often have maps of waterways affected by civic works. In the Greater Vancouver Regional District, request a copy of Lost Streams of the Lower Mainland.

Summation

- With the class, discuss how people can protect estuary or river habitat that is threatened by urban development.
  Construct bridges over sensitive areas instead of dykes; build on higher land instead of on flood plains; do essential work in less sensitive seasons; restore buried or overdeveloped habitat; etc.

Review and Build on What You Know

Materials:
None

Time required:
20 minutes plus more

Review

- Give students five minutes to review their notes and list at least six important ideas or facts about salmon smolts.
- Give students five minutes to share their lists in groups of four, and write on chart paper the four most important ideas agreed on by the group.
- Have the groups post their charts on the classroom wall, then lead a class discussion on the common ideas and differences recorded on the charts.

Summation

- Have students add their lists and any additional comments to a salmon science notebook or portfolio.
- Have students add information about salmon smolts to their salmon life cycle chart.
- Have students add information about salmon smolts to their salmon habitat mural.
- Have students inspect and record the condition of materials in the landfill models.

Wrap-Up

Extension Activities

- Invite a retired municipal engineer or someone from a local historical society, drainage district or naturalist organization to describe to the class local rivers that have been diverted or buried in culverts to protect human development in the local area, and to discuss the new interest in restoring lost waterways.
- Have students use the procedure from the activity, "Aquatic Life" in Unit Seven: Salmon Fry, to compare the type of organisms found in water from a local estuary with the water they studied in Unit Seven.
- Have students prepare presentations on the best locations for humans to build settlements. Discuss the criteria that should be used to decide what "best" means.
- Have students take the role of contemporary planners and developers and work in small groups to develop a procedure for presenting, reviewing and approving development plans for natural areas. Have them use the resource *Stream Stewardship; A Guide For Planners and Developers* (available from www.stewardshipcentre.bc.ca) to describe some current procedures and options.

Suggestions for Assessment

- Have students draw an estuarine food web showing relationships between salmon predators and prey.
- Have students develop a dialogue expressing different points of view on estuarine development and backing up their points of view with evidence from the unit.
- Monitor the discussion as students make and present their lists in the review activity to ensure that they can use factual information from the activities to support an opinion about the life of salmon smolts.
- Have students write quiz questions about salmon smolts on one side of an index card and answers on the other. Have them quiz each other by asking the questions or by using a *Jeopardy*-style format (i.e., giving the answers and asking for a question).
- Monitor student discussions of the class' habitat mural and life cycle chart to ensure that the students can identify the needs of salmon smolts, as well as their habitat and threats to it.
- Have students add their notes, experiment observations and other materials to a salmon science notebook or portfolio.
- Have students use "Appendix 2: Student Assessment Sheet" to review their group work and their own learning.

Home and Community Connections

- Have students ask an adult to take them to visit a local estuary if there is one in the region.
- Suggest that the class begin a project to identify and remove any unnatural threats to salmon smolts in waterways in the community (e.g., silt or pollution entering salmon streams or people interfering with growing smolts). (For directions, refer to the activity "Creating Positive Human Impacts" in Unit Ten: Review: The Salmon Life Cycle.

Salmon Incubation

If you have a classroom salmon egg incubator, have students learn the names of its components, examine how it works and set it up for receiving salmon eggs. For assistance, refer to "People and Connections That Can Help" on page vii of the Foreword.

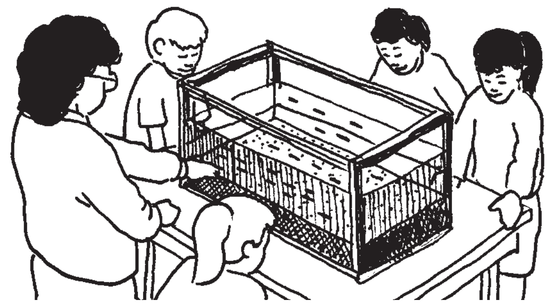


Illustration: Donald Gunn

➲ Have students use a shoebox to create a model of an incubation tank. Have them draw or cut out pictures of the tank's apparatus (filter, hoses, dechlorinator, etc.), then label and glue the pictures into the model. Have them add clean gravel to the box (or simulate gravel using foam chips or balls of paper). As you add eggs to the tank and watch them develop, have students use modelling clay to form eggs, alevins or fry and place them in the appropriate part of the box.

Handout 8.1
Animals and Salt Water

Name ____

Hypothesis ______________________________

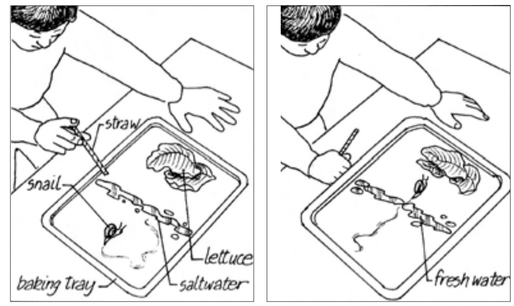


Illustration: Donald Gunn

Procedures

Write or draw the procedures you used in the experiment. ______________________

Observations

1. How did the snail react to the leaf and the line of water? ______________________

2. How did the snail react to the leaf and the salty water? ______________________

Conclusions

Do your observations support your hypothesis or not? Why? ______________________

Handout 8.2

Salmon Smolts

As salmon begin to mature, they leave their home stream to head to the ocean.

Most salmon species spend some time in the estuary of a river, where the fresh water mixes with the salt water. Here, they gradually get used to life in salty water, preparing for the time they will spend at sea. Some species spend up to a year in estuaries, while others leave almost immediately.

Salmon must adapt to the changes that salt water causes to their bodies. Salt water draws fresh water out of an organism's body. Saltwater fish, like salmon, survive by drinking salt water to replace the fresh water that is lost. However, too much salt is harmful. Saltwater animals develop a way to get rid of salt from their bodies before it harms them. Salmon excrete water and salt in their urine and they excrete excess salt through the fine membranes in their gills.

The appearance of smolts also changes as they prepare for ocean life. They lose the dark colours of the fry, which helped them hide in the shady water of a forest stream, and begin to take on the silvery colour of adult salmon. In an estuary, and in the open ocean, there is no shade – only the bright colour of sunlight reflecting on the waves. The smolts' silvery colour helps them hide in the silvery light at the surface of the ocean.

In an estuary, the mix of river and sea creates a nutrient-rich environment that supports plant and animal growth. Thick beds of eelgrass and sedge provide a home for insects and crustaceans, such as shrimps. Salmon smolts feast on these microscopic animals and on smaller fish that also live among the estuary plants. While in the estuary, smolts can grow from 4 or 5 cm in length to as much as 9 cm. They also add to the imprinted memories that help them find their way home after they migrate to the ocean.

However, estuaries are also home to many fish predators. Fish-eating birds, such as herons, stalk fish in the marshes, while hawks watch for them in the sky. Larger fish, snakes, seals and even orcas also prey on smolts.

In addition, people build cities and industries in estuaries. In some areas, less than 10% of the original estuary remains. With less room to mature, feed and adapt, fewer salmon survive to grow into adults in the ocean.

Handout 8.3

The Predator/Prey Game

Salmon face many new predators in an estuary, including herons and other sea birds, mammals, such as racoons and seals, and predatory fish. If they can avoid the predators, salmon smolts can triple their weight by feeding on the abundant food sources in the estuary.

Work in small groups to devise the rules for a game that your class can play to model the life of a salmon smolt in an estuary. For example, mark an area of the floor as the estuary. Have students pass through the estuary on their way to the ocean. Have some students act as different predators that hunt for salmon smolts. Create some safe places where smolts can hide and grow in the estuary.

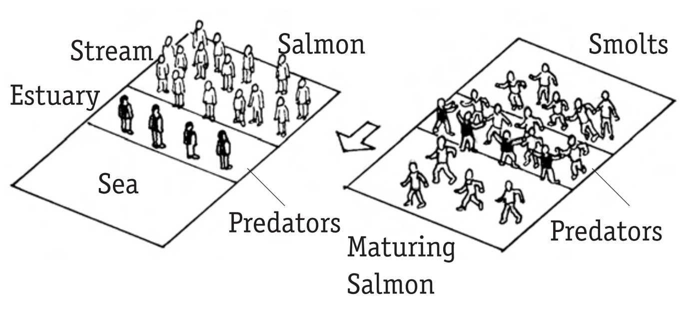
When you have worked out the rules, test them with your class in the gym or an open area. If you have time, try to modify your rules after you test the game to make it work better.

Your game must meet these conditions:

1. The whole class must be able to participate safely. (For example, predators catch smolts by tapping them on the shoulder.)
2. In the game, smolts must start at the river's mouth, spend time in an estuary, then swim to the ocean.
3. Predators in the estuary will try to catch smolts. Smolts will try to avoid predators.
4. Smolts will try to eat enough food to gain strength to begin their life in the ocean.

To make the game more interesting, try this:

1. Give smolts more "power" to survive if they have been feeding. (For example, smolts gain power by picking up paper shrimp from a container. A predator has to tag a smolt twice if the smolt has eaten a shrimp.)
2. Give different predators different "powers", that is, different ways to catch smolts. (For example, bird predators might tag a smolt above the waist, but fish predators tag a smolt below the knee.)
3. Imagine that, as the game goes on, construction makes the estuary smaller. (For example, the passage from the river to the ocean becomes one metre narrower with every passing minute.)



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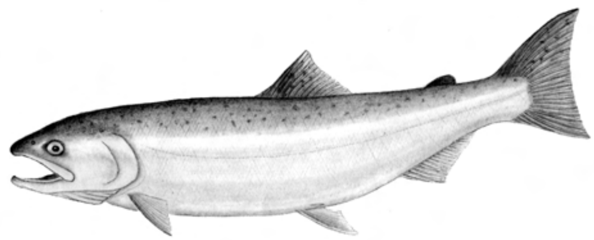
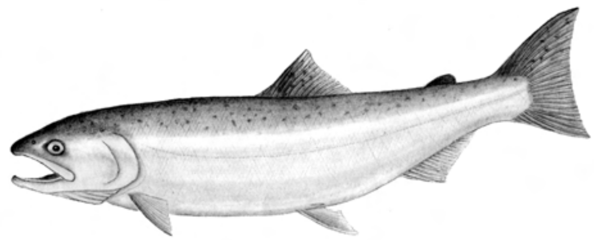
UNIT 9

ADULT SALMON



Adult Salmon



Overview

This unit gives students an opportunity to:

- discuss whether they like to eat salmon;
- watch or conduct a salmon dissection;
- identify species of salmon by categorizing their features;
- use various senses to navigate without a map;
- construct a three-dimensional map of the classroom;
- research various methods of fish harvesting and responsible fishing;
- review the concepts they learned in the unit.

Key Concept

Adult salmon migrate through the ocean and then return to their home rivers. People fish for salmon in different ways and for different reasons (recreational, commercial, native fisheries).

Vocabulary

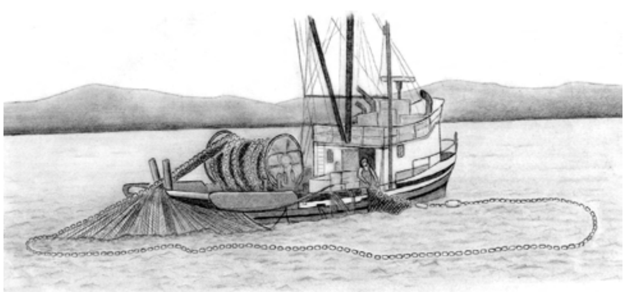
Salmonid, dichotomous key, species, isotherm, slime, scales, gills, gill rakers, milt, liver, bladder, kidney, lateral line, migration, mackerel, orca, plankton, herring, navigation, water pressure, salinity, magnetic direction, thermal, temperature, guidelines, principles, by-catch, zooplankton

Background Information

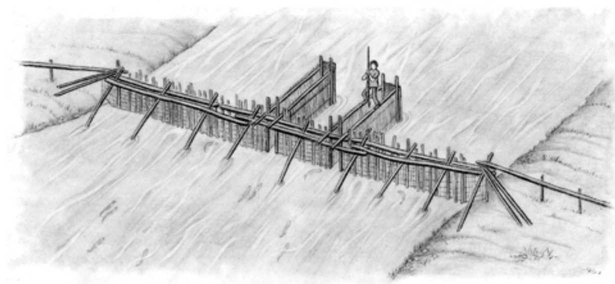
This background information can be useful for supplementing the material in "Handout 9.1: Pacific Salmonids", "Handout 9.2: Adult Salmon", "Handout 9.3: Species of Salmonids", "Handout 9.4: Salmon Navigation", "Handout 9.6: Salmon Harvesting", "Handout 9.7: A Code of Responsible Fishing for Canada".

Salmon harvesting and management have provoked many controversies on Canada's West Coast, with some questions similar to those in other world fisheries and some unique to the region.

A rapid increase in the number, size and efficiency of fishing vessels increased the catch of Pacific salmon in the 1970s, while habitat destruction on land reduced habitat quantity and quality and the ability of salmon to survive. A public enquiry in 1982 recommended that the number of commercial fish harvesting vessels be reduced to protect salmon stocks and to maintain their price. Fish harvesters supported many of the recommendations, but also requested protection for fishing communities, protection of fish habitat and a balanced reduction among all users of the fisheries resource, including non-Canadians, sport fishers and Aboriginal fishers. Policies to avoid risk to endangered stocks of salmon have led to intense conflicts over the fisheries resource.



The cost and trade-offs involved in protecting communities and fish habitat makes it difficult to meet these objectives quickly, although new laws and policies limit activities that threaten salmon habitat. Often, however, these approaches meet with resistance from others whose interests are affected, such as urban developers or forest companies.



Aboriginal fishers have legal rights to catch salmon for food, and in some instances also catch salmon commercially to support their communities. Sport fishing has grown to become a significant part of the tourism industry, and its supporters say that it generates more income for the economy than commercial fishing does, although sport fishers catch far fewer fish than commercial harvesters do.

A particularly complex issue has been the negotiation of controls on international fishing. While Canada's 200-mile territorial limit protects many salmon, except those caught in nets in the open ocean, Canada shares the right to control parts of the salmon fishery with the United States. Because salmon swim across international borders, rules about intercepting salmon originating from the other country cannot be enforced without cooperation. Canada and the U.S. signed the Pacific Salmon Treaty in 1985 to prevent overfishing provide for optimum production, and provide for

Illustrations: Karen Uldall-Ekman

each country to receive benefits equivalent to the production of salmon originating in their waters. Annexes to the treaty were re-negotiated in 1999. The Government of Canada, which controls the harvest of salmon, has adopted a policy of protecting the future of the salmon first, then meeting Canada's legal obligations to Aboriginal communities, and then balancing the remaining harvest among the other salmon users. To reduce the number of people trying to catch salmon, the Canadian government has also established programs to encourage commercial fish harvesters to voluntarily retire from the industry, and to provide financial compensation for those who do.

Note: While the policies and programs described here provide long-term direction for fishery managers, specifics can vary from year to year as circumstances change. For the most current information, refer to the Internet site for Fisheries and Oceans Canada, Pacific and Yukon Region (www.pac.dfo-mpo.gc.ca/) and the other sources listed in the Support Materials section. Current harvest statistics are available from the Salmon Market Database on the B.C. Salmon Marketing Board site (www.bcsalmon.ca/).

Introduction

Materials:
None

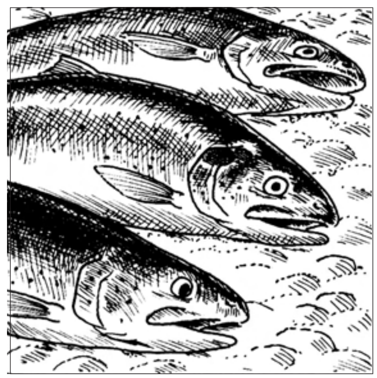
Time required:
10 minutes

Suggested Activities

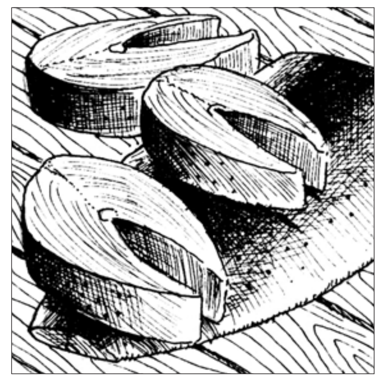
From these suggestions, choose activities that are appropriate for your class.

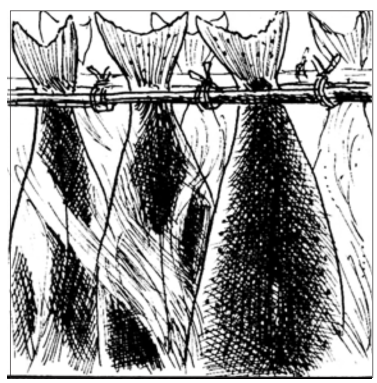
- Ask the class whether they like to eat salmon. Discuss some ways it can be prepared.
  Barbecued, baked, in sandwiches, in sushi, etc.
- Point out that, before anyone can eat salmon, the salmon have to grow into adults, and someone has to catch them. Explain that this unit is about adult salmon and how people catch them.

1. Whole Fresh



2. Steaks and Fillets





3. Smoked

4. Canned

Illustration: Donald Gunn

Species of Pacific Salmon

[simulation]

Materials:
- One copy of "Handout 9.1: Pacific Salmonids" for each student (or group)
- One copy of :Handout 9.2: Adult Salmon" for each student
- Writing supplies

Time required:
60 to 90 minutes

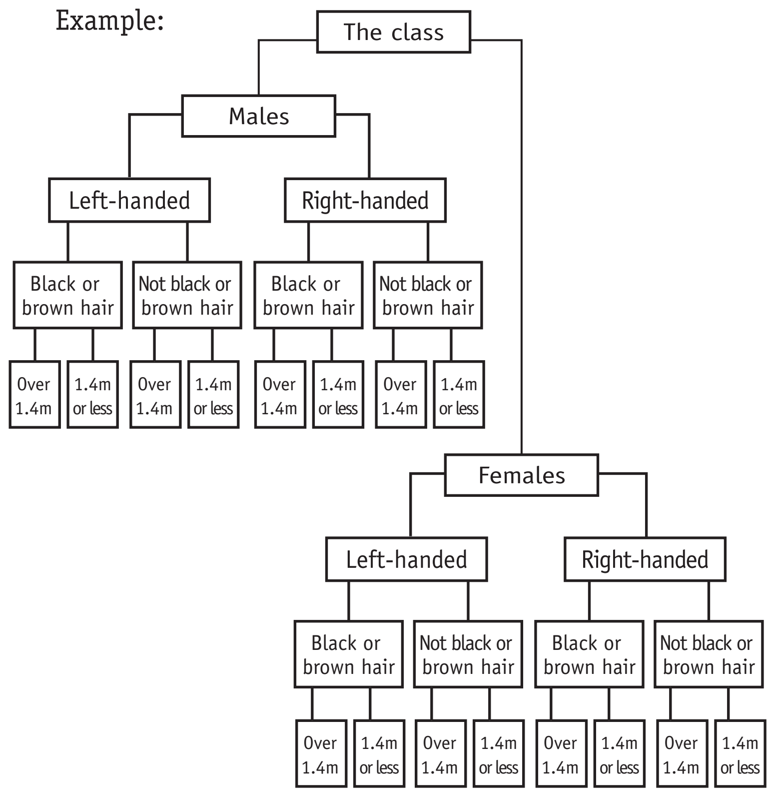
Level of conceptual difficulty:
Advanced

Suggestions for assessment:
Monitor the class discussion and review the charts the students make to ensure the students can use visible attributes to divide salmon into distinct species.

Introduction

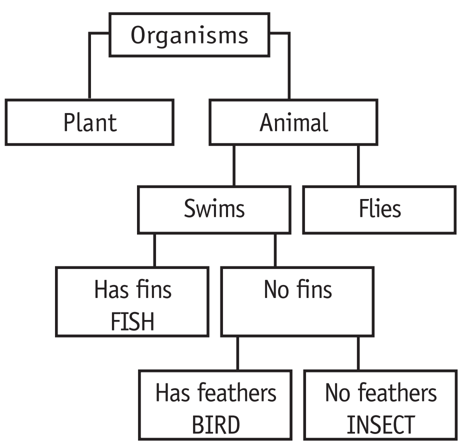
- Have the class create a dichotomous key of students in the classroom, by grouping students on the basis of questions that can have only one of two answers. Point out that each group divides into only two subgroups. Have the students physically move into the groups as they are created. As you create each group, write its description on the chalkboard in the form of a branching network.
  - Divide the class into two groups, males and females.
  - Divide each group into left-handed and right-handed students.
  - Divide each new group into those with black or brown hair and those with other colours.
  - Divide each new group into those over 1.4 metres tall, and those 1.4 metres or less.

Example:



DISCUSSION

- Discuss with the class how the groups were formed and how useful the categories are. If necessary, prompt them with questions, such as:
- Why does each group have only two subgroups?
  It simplifies dividing and makes membership clearer.
- How do the numbers of students in each group compare?
  Some pairs have similar numbers, while others are uneven.
- How useful are the categories? What might they be used for?
  Some, such as gender, could be useful, while others would rarely be needed. Gender might be useful for organizing gym classes; left-handedness might be useful to prevent people from bumping into each other; height might be useful to organize students for class pictures, etc.
- How could biologists use categories to organize their knowledge of plants and animals?
  They divide organisms into groups to identify how they are related to each other, and what their needs are.
- What categories would be useful for biologists?
  Plants vs. animals; plant-eating vs. meat-eating; male vs. female, aquatic vs. terrestrial, etc.



- Explain that the chart produced by the divisions is called a dichotomous key. A dichotomous key can be used to distinguish different types of Pacific salmon. Together with the class, create a dichotomous key for a simple group of organisms, e.g., Fish, Bird, Insect
  - Plant or animal: if animal, next question
  - Swims or Flies: if swims, next question; if flies, next question
  - (Swims) Has fins or no fins: if fins, fish; if no fins, next question (etc.)
  - (Flies) Has feathers or no feathers: if feathers, bird; if no feathers, next question (etc.)

Investigation

- Have students work in small groups or pairs to create a dichotomous key of Pacific salmonids using "Handout 9.1: Pacific Salmonids". Point out that cutthroat trout are not salmon, but are closely related.
- Have the groups compare their keys with "Handout 9.3: Species of Pacific Salmonids".

Adult Salmon

[discussion]

Materials:

- One copy of "Handout 9.2: Adult Salmon” for each student
- Writing supplies

Time required:
Approximately 60 minutes

Level of conceptual difficulty:
Simple

Suggestions for assessment:
Monitor class discussion and review the information the students add to the life cycle chart to ensure that they can describe the features of an adult salmon's life.

Research/Discussion

- Have students in small groups read "Handout 9.2: Adult Salmon” and list ways that food and predators affect the life of an adult salmon. Ask students to report to the class the factors their groups identified. If necessary, prompt them with questions, such as:

  - How does the availability of food affect the salmon?
    They follow schools of krill and herring on their migratory path. They grow to a large size when food is plentiful.

  - How do predators affect the salmon?
    Larger fish and mammals, such as killer whales and seals, eat salmon. Human fishers catch them in large numbers.

  - How is life in the ocean different from the salmon's earlier life?
    Salinity and water temperature are different. Food is often plentiful but it moves with the seasons. There are fewer hiding places than in a stream or estuary, but salmon can avoid most predators in the open ocean.

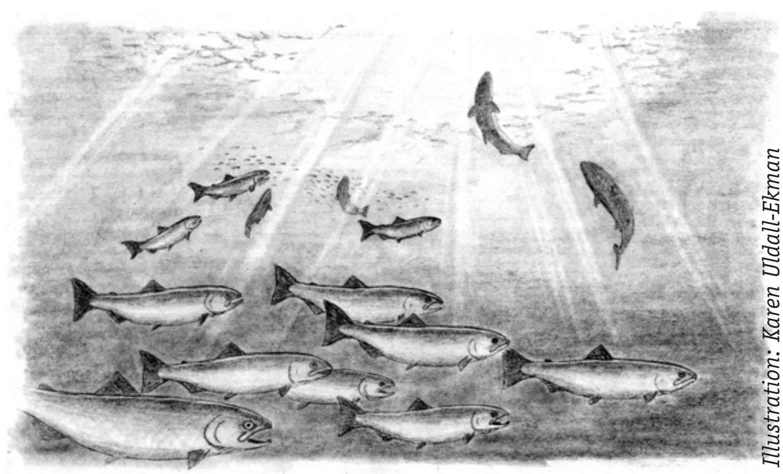


Illustration: Karen Uldall-Ekman

Summation

- Have students add information on adult salmon to the chart of the salmon's life cycle that they began in Unit Five: Salmon Eggs.

Navigating Without Landmarks

[experiment]

Materials:

- One copy of "Handout 9.4: Salmon Navigation” for each student
- Writing supplies

Time required:
Approximately 60 minutes in two periods

Level of conceptual difficulty:
Moderate to advanced

Suggestions for assessment:
Monitor the class discussion of navigation using the senses and how salmon navigate, and review their imaginary instructions for a salmon to ensure the students can describe how salmon navigate the ocean and return to their home river.

Introduction

- Discuss with the class how students find their way from one place to another without using a map. If necessary, prompt them with questions, such as:
    - How do you find your way home after school?
      By following a familiar route.
    - How do you know you are going in the right direction?
      By heading toward familiar landmarks, such as intersections, buildings, signs, etc.
    - How do you know when to turn?
      Watch for familiar landmarks, etc.
    - How do you know when you are there?
      By recognizing the destination.
    - Do you rely on any senses besides your vision?
      Humans rely mainly on vision.
    - How is this different from finding your way to a new place, like a new shop?
      In travelling somewhere new, you need a map or familiar landmark to which to relate.

Discussion

- Explain that salmon navigate through the ocean, without maps or familiar routes, by using all their senses. This activity demonstrates how to use a variety of senses to find an unfamiliar destination.
- Have the class suggest ways to navigate through an unfamiliar neighbourhood without using a map, using their senses of vision, hearing, smell and touch. If necessary, prompt them with questions, such as:
    - What kinds of things could you watch for?
      Vegetation, buildings, roads, sun and stars, etc.
    - What kinds of things could you smell?
      A bakery, a garbage container, a candy shop, a flower bed, etc.
    - What kinds of things could you listen for?
      A playground, a radio, a speaker system, a dog, etc.
    - What kinds of things could you feel?
      Carpet on the floor, grass, gravel, a hill, a rough wall, etc.

  Option: Have students navigate blindfolded, if it can be done safely in the school.

Experiment

(Note: It is strongly suggested that you try this activity in a nearby natural environment if time permits.)

- Have students write instructions for getting from one place to another in the school without naming the destination, and without using a map or names of rooms, teachers, etc. Have students use each of their senses (except taste) at least once in their instructions. *(For example, go down the hall toward the clock until you smell something cooking.)* Have other students attempt to follow the instructions and discuss their success with the class. If necessary, prompt them with questions, such as:
    - Who was able to follow the instructions to the destination?
    - Which directions were easy to follow? Which were difficult?
    - Which of your senses were easiest to use?
    - What was difficult about writing clear instructions?

Research/Discussion

- Have students, in groups, read "Handout 9.4: Salmon Navigation" and help each other clarify any parts they do not understand. Discuss with the class various hypotheses in the handout on how salmon navigate through the ocean. If necessary, prompt them with questions, such as:
    - Which salmon senses are most like human ones?
      Smell, temperature.
    - Which salmon landmarks are like those humans use?
      Sun, stars, scents.
    - Would other human senses help salmon find their way in the ocean?
      Not much since visibility is limited and sounds do not seem very distinct.
    - If salmon could draw a map, what would they put on it?

A Thermal Map

[experiment]

Adapted from Jim Wiese, *Salmon Below the Surface*, pages 67-74

Materials for each student or a large display version:

- One copy of a weather map showing isotherms

For each student or pair of students:

- One thermometer
- One ruler
- Tape
- Blank paper or three copies of an outline map of the classroom
- Coloured pencils or felts
- One copy of "Handout 9.5: A Classroom Thermal Map" for each student
- Writing supplies

Time required:
60 to 90 minutes

Level of conceptual difficulty:
Moderate

Suggestions for assessment:
Monitor the class discussion and review the students' maps and conclusions to ensure that the students can make an isotherm map from data, draw conclusions based on the map, and recognize ways in which salmon respond to temperature in the ocean.

Preparation

- To save time and ensure consistency, you may wish to draw an outline map of the classroom and make three copies for each student or pair of students.

Introduction

- Ask the class what maps show, and why.
  Land maps show roads, destinations, obstacles, elevations, etc. They show these because it is important for people to know where they are.
  Explain that special maps show other information that is important for other purposes.
- Ask the class what an ocean map for salmon would show.
  Locations, food sources, temperature, etc.
- Have students look at a weather map showing isotherms and discuss how they link areas of similar temperatures. Ask the class to suggest ways that scientists create the weather maps.
  They take temperature readings from various locations over land and water using weather balloons, ground stations, weather ships, etc., then plot them on maps and link places with similar values.
- Ask the class to suggest a way to make a temperature map of the classroom. Use thermometers to take temperature readings at fixed locations in the room and at different levels above the floor. (Hint: This may be easiest in winter when the heat is on or with an open window.)

Experiment

- Divide the students into six groups and have them follow the procedure in "Handout 9.5: A Classroom Thermal Map" to create an isotherm map of the classroom (i.e., readings at each level will be done by two groups). Model each step of the procedure as the class does it.

  Note: Depending on the time you have available, and the ability of your students, you may prefer to skip steps 6 and 7 in the procedure and make a single map instead of three maps.

  Option: Have students use a computer-graphing program to create a 3-D graph representing the room's isotherms.

  Option: If the school has a classroom salmon incubation tank, have students create isotherm maps of the incubation tank.

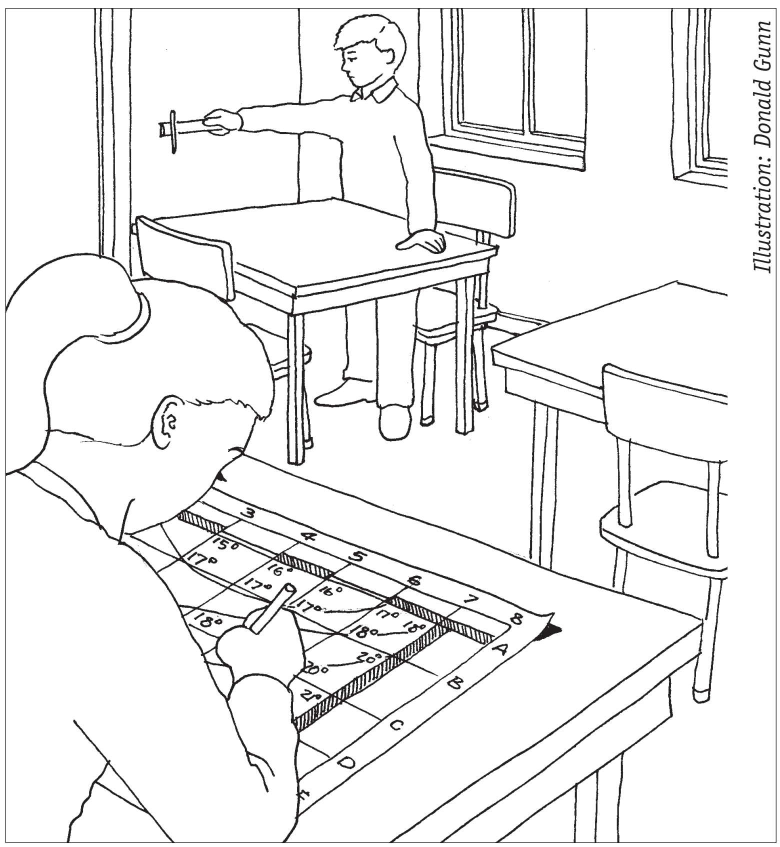


Illustration: Donald Gunn

Discussion

- Discuss with the class whether or not their data supported their hypothesis, and any other observations they draw from their data. If necessary, prompt them with questions, such as:

- What did the maps or the data show you that you did not know before the investigation?
  Temperature variations at different levels, sources of heat or cold drafts, the most comfortable place to sit, etc.
- What differences did you observe between the ceiling, middle and floor maps?
  Usually the temperatures will be warmer at the ceiling and cooler near the floor.
- How did the data compare with what your senses told you about the room?
- If you knew that animals preferred cool temperatures, how could you use isotherm maps to help locate them?

■ Discuss with the class how to make an isotherm map of the ocean, and what it might indicate about salmon. If necessary, prompt them with questions, such as:

- How could you adapt the procedure to make an isotherm map of the ocean?
  Take temperature measurements at various depths and locations to plot a 3-D ocean isotherm map.
- How would an ocean isotherm map differ from the classroom map or an atmospheric map?
  Water temperature changes less frequently and by smaller amounts, so the maps use smaller differences and do not change as quickly.
- How could people use ocean isotherm maps?
  To track ocean currents, and changes such as El Nino/La Nina; to predict climate changes that are affected by ocean temperature; to track fish populations that prefer certain temperatures, etc.
- How could you use an ocean isotherm map to keep track of salmon?
  Look for the temperatures they prefer to predict where they will be, and where they will go, or where their food species will be, etc.
- Salmon do not use isothermal maps. How do temperature differences in the ocean affect them?
  They are very sensitive to temperature changes, and seem to use temperature to tell when to migrate and where they are heading. Temperature differences also affect how fast they grow and the availability of food species.

Fishing

[research]

Materials:

- One copy of "Handout 9.6: Salmon Harvesting in B.C." for each student
- One copy of "Handout 9.7: A Code of Responsible Fishing for Canada" for each student
- Writing supplies

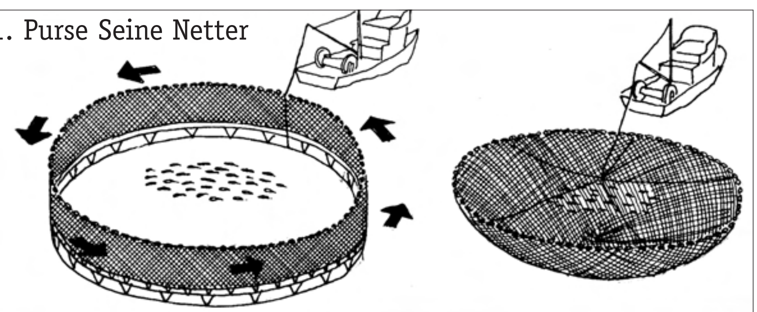
Time required:
In-class time to organize groups, give reports and discuss responsible fishing, plus time out of class for research

Level of conceptual difficulty:
Moderate

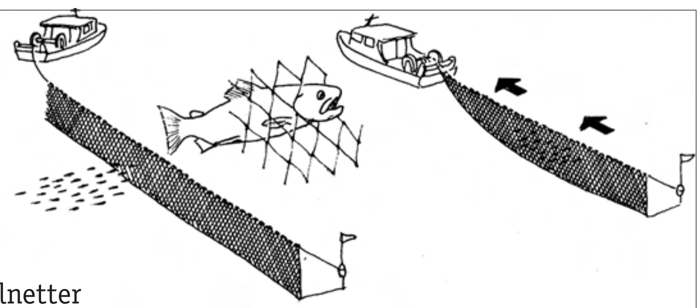
Suggestions for assessment:
Monitor the class discussion and review the students' written reports to ensure that the students can describe salmon harvesting methods and the issues involved in harvesting salmon responsibly.

Introduction

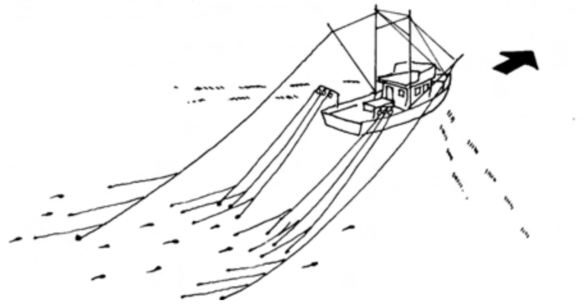
- Divide the class into five working groups and assign each group one of the following topics:
  - fish wheels in the Aboriginal salmon fishery;
  - sport fishing for Pacific salmon;
  - gillnet harvesting of Pacific salmon;
  - purse seine harvesting of Pacific salmon;
  - troll harvesting of Pacific salmon.
- Have each group brainstorm everything they know about their subject, then list the things they know and things they are not sure about. Have the groups briefly read their lists to the class. Have other students add any additional knowledge to the group reports, and add any other questions about which they want information.



1. Purse Seine Netter



2. Gillnetter



3. Troller

Illustration: Donald Gunn

Research/Discussion

- Have each group work together to research its topic, using "Handout 9.6: Salmon Harvesting in B.C.", Fisheries and Oceans Canada fact sheets on sport fishing, gillnetting, purse seining and trolling, and any other available sources of information. Have the students attempt to confirm their facts and find information about subjects about which they were uncertain.
- Have each group prepare an oral report of its findings to the class, using a poster display and any other appropriate media to assist their presentation. Have them construct a model showing the fishing method they researched.
- Ask the class to suggest reasons for the variation from year to year in the value of fish products shown in "Handout 9.6: Salmon Harvesting in B.C."
  Fish harvests vary as the number of fish change, the harvesting policies change, treaty rights of Canadian and U.S. fishers change, and market conditions change.

Research/Discussion

- Have students work in their groups to review "Handout 9.7: A Code of Responsible Fishing for Canada". Have them discuss what they would add to the code to ensure that the salmon fishers they researched can continue to catch salmon responsibly, while protecting salmon for future generations.
- Have each group report its conclusions to the class. Hold a class discussion about the need to balance a responsible harvest with the number of salmon in the ocean, lakes and streams. If necessary, prompt students with questions, such as:
  - If land-based activities, such as logging or mining, reduce the number of salmon that grow into adults, how should responsible fish harvesters respond?
    Should they reduce their harvest; maintain their harvest and ask logging and mining operators to change their practices; harvest as many salmon as they can before they are all gone?
  - If one type of fishing gear catches more salmon than others, how should responsible fisher harvesters respond?

Should they all switch to that type of gear; place strict limits on that type of gear; increase the total catch to allow everyone to continue fishing?

- If fishers from another country catch salmon from B.C. rivers in the ocean, how should responsible fish harvesters respond?
  Should they negotiate to divide the available harvest; send Coast Guard vessels to prevent them from catching B.C. fish; reduce their own harvest of B.C. salmon?

- If the number of fishers is so large that only a few of them can catch enough salmon to make a living, how should responsible fish harvesters respond?
  Should they increase their harvest so that all can make a living; pass laws preventing inefficient fishers from working; share the harvest equally among all fishers?

- If one group of fishers brings more income for each fish caught, how should responsible fish harvesters respond?
  Should sport fishers be allowed to catch more fish than commercial fishers if they contribute more to the economy?

Option: Have students work together to devise a balanced code of responsible conduct for sport fishing and then discuss it with local fishers.

Review and Build on What You Know

Materials:
None

Time required:
20 minutes

Review

- Give students five minutes to review their notes and list at least six important ideas or facts about adult salmon.
- Give students, in groups of four, five minutes to share their lists, and write on chart paper the four most important ideas agreed on by the group.
- Have the groups post their charts on the classroom wall, then lead a class discussion on the common ideas and differences visible on the charts.

Summation

- Have students add their lists and any additional comments to a salmon science notebook or portfolio.
- Have students add information about adult salmon to their salmon life cycle chart.
- Have students add information about adult salmon to their salmon habitat mural.

Wrap-Up

Extension Activities

- Have students glue the illustrations of Pacific salmon species to cards and challenge each other to recognize them by playing a game of Snap with the cards.
- Have students describe their own experiences in the sport, commercial or native fishery, or recount stories or "tall tales" they have heard from other fishers.
- Have students prepare a variety of salmon recipes and hold a class party in which they describe their favourite way to eat salmon.
- Have students arrange a field trip to a nearby salmon or trout fishing stream or commercial fishing operation, or have someone from the industry come to the class to talk about their work.
- Have students visit the cultural centre, band office or fishing site of a local First Nation to discuss traditional and modern methods of salmon harvesting and the role of salmon in the culture of the First Nation.
- Have students describe what a fisheries conservation officer does to manage the population and catch of Pacific salmon.
- Have students present information on the 1985 fisheries treaty between the United States and Canada from the Fisheries and Oceans Canada Internet site (http://www.dfo-mpo.gc.ca) or other Internet sites, and report to the class on the main issues.
- Have students research methods of aquaculture and identify the pros and cons of each.
- Have students research the effect of introducing non-native species into an environment. Have them evaluate the potential effect of introducing Atlantic salmon into Pacific waters.
- Have students research the extent of ocean pollution or global warming, using resources such as Environment Canada's factsheets on climate change in the Pacific and Yukon region (available from 1–800–667–7779), the Environment Canada Internet site (http://www.ec.gc.ca), or other Internet sites, magazine articles, books or videos.
- Have students write imaginary instructions for a salmon to return from the Aleutian Islands to a local river mouth, using only senses that a salmon could detect.

Suggestions for Assessment

- Have students label a black outline drawing of an adult salmon.
- Have students describe at least three ways by which salmon are thought to navigate through the ocean and back to their home stream or lake.
- Monitor the discussion as students make and present their lists in the review activity to ensure that the students can use factual information from the activities to support an opinion about the life of adult salmon.
- Have students write quiz questions about adult salmon on one side of an index card and answers on the other. Have them quiz each other by asking the questions or by using a *Jeopardy*-style format (i.e., giving the answers and asking for a question).

- Monitor student discussions of the class' habitat mural and life cycle chart to ensure that the students can identify the needs of adult salmon, as well as their habitat and threats to it.
- Have students add their notes, experiment observations and other materials to a salmon science notebook or portfolio.
- Have students use "Appendix 2: Student Assessment Sheet" to review their group work and their own learning.

Home and Community Connections

- Have students ask an adult to take them fishing, and discuss how to catch fish responsibly.
- Suggest that the class implement a project encouraging sport fishers to follow fishing regulations and to explain why it is important to do so. (For directions, refer to the activity, "Creating Positive Human Impacts" in Unit Ten: Review: The Salmon Life Cycle.)

Handout 9.1

Pacific Salmonids

A dichotomous (pronounced dye-COT-a-mus) key is a diagram that lets you tell one group from another by answering simple questions. The key helps scientists create categories which they can use to organize information. Others can use a dichotomous key to identify plants and animals they do not know. For example, field guides to birds or plants often use a dichotomous key to help people identify species they have not seen before.

One group of closely related animals is the Pacific salmonids (pronounced SAL-ma-nids). Salmonids are members of the Salmonidae family, which includes salmon, trout, char and whitefish. The Pacific salmonids include seven species: sockeye, chum, chinook, coho and pink salmon, steelhead trout and cutthroat trout. Steelhead trout are also called rainbow trout. Scientists used to think they were not salmon, but new studies show that they are. Cuthroat trout are not salmon, but they are members of the Salmonidae family.

Use the illustrations below to create a dichotomous key to the seven species of Pacific salmonids.

Use these steps to create the key:

1. Select a description that separates the illustrations into two groups (e.g., spots vs. no spots, or large eye pupil vs. small pupil).
2. Take each group and divide it into two more groups (e.g., large spots vs. small spots).
3. Continue to subdivide until each illustration is in a group that separates it from all the others.
4. If necessary, go back and change your groups to make the final groups distinct.
5. Create a chart showing how you divided the groups.
6. Have another group follow your chart to divide the illustrations. See if their final division is the same as yours.

Handout 9.2

Adult Salmon

After gaining weight in the estuary and adapting to the salt water, salmon travel along the coastline and then to the open ocean. Here they gain the full size, shape and colour of a mature salmon.

Most salmon spend the first part of their life in coastal waters, then migrate further out to sea. Each of the seven species of Pacific salmon has its own migration route and spends a different length of time in the ocean before returning home.

Young salmon can travel up to 20 km a day, while mature salmon can travel as much as 50 km a day. Salmon usually travel north in summer, often swimming as far as the Gulf of Alaska, and south in winter.

While at sea, salmon feed on a variety of smaller fish and zooplankton. The salmon can gain many kilograms, with mature adults reaching a few kilos to 20 kilos or more, depending on the species. Salmon are prey for seals and orcas, as well as for fish, such as tuna and cod.

The largest number of salmon is probably taken by human fishers. People catch salmon mainly in coastal waters as large schools return from their ocean travels, although some are also caught in huge ocean drift nets. B.C. residents catch millions of salmon each year and nonresidents also catch salmon heading for streams and lakes in B.C.

Recreational fishers catch many salmon using single fishing lines with lures and hooks. Aboriginal fishers use modern and traditional methods to catch fish, both in the ocean and in rivers and streams.

After spending from one to seven years at sea, depending on the species, salmon return to their home stream or lake. Mature salmon form large schools and find their way to the mouth of their home stream. They gather at the mouth of their home river before starting the difficult journey upstream.

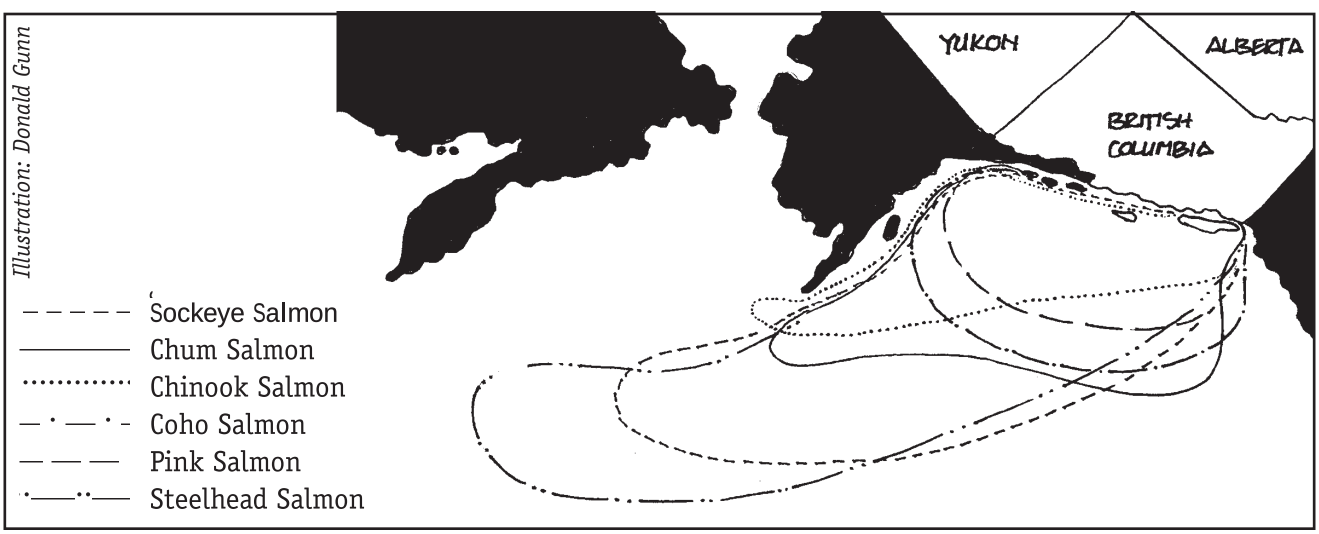
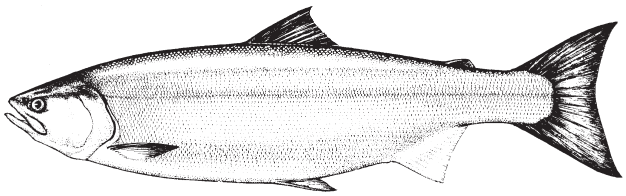


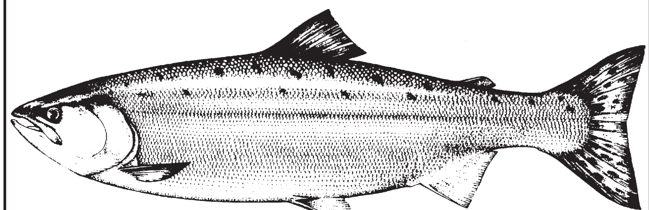
Illustration: Donald Gunn

Handout 9.3

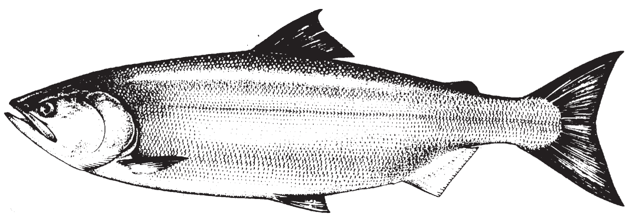
Species of Pacific Salmonids



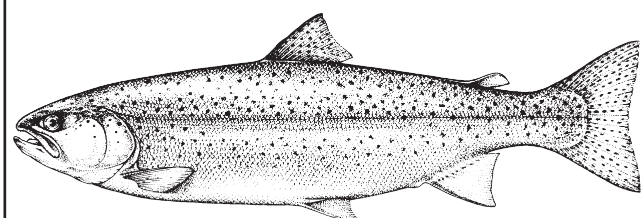
A. Sockeye



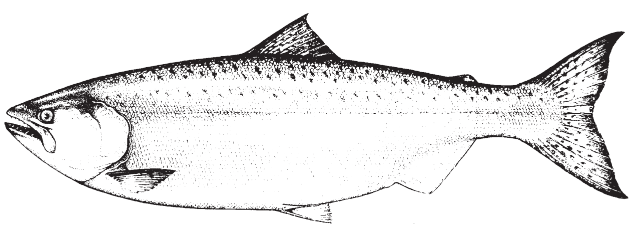
E. Pink



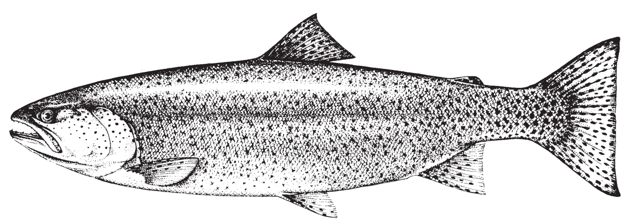
B. Chum



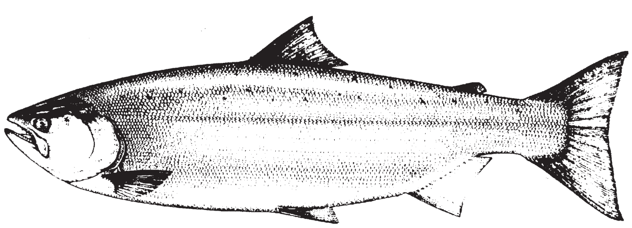
F. Steelhead



C. Chinook



G. Cutthroat



D. Coho

Handout 9.4

Salmon Navigation

B.C. sockeye and chum salmon travel as far as the Aleutian Islands off Alaska and the middle of the Pacific Ocean.

Salmon from different lakes and rivers mingle together in the ocean. They follow schools of plankton and smaller fish, such as herring. Although they follow a general pattern, their position can vary greatly from one year to the next.

Migrating salmon seem to know where their home stream is and how to return to it. When they are mature, all those that hatched at the same time in one stream or lake return together to the mouth of their home river. Then they begin their journey back upstream.

No one knows how salmon navigate through the ocean and find their way back. Scientists believe that salmon use a variety of ways to tell where they are and where they are going.

Possible navigational aids for salmon

Possibly salmon use different senses at different times, or rely on all of them together.

- **Water temperature.** Salmon generally head south in winter and north in summer, possibly following changes in the ocean temperature. They may also use temperature to tell where they are in the ocean and when to begin their migration.
- **Scents in the water.** Scientists know that salmon use their sense of smell to recognize their home river and to find their home stream or lake when they travel upstream. They may use similar scents to tell where they are in the ocean.
- **Water pressure and salinity.** The amount of salt in the ocean varies slightly in different places, and pressure can vary too. Salmon are very sensitive to these changes and may use them to tell one place from another.
- **Magnetic direction.** Salmon seem to be sensitive to the earth's magnetic poles. They may use the poles to help in getting their direction.
- **The sun and the North Star.** Salmon seem to have more trouble finding their way on overcast days. Some scientists think this is because they use the North Star or the sun to navigate.

Handout 9.5

A Classroom Thermal Map

The temperature varies from place to place. Some areas are warm, while others are cold. Temperature differences can be very important. Salmon bodies function faster in warmer water. They "live faster", but they may gain less weight and die sooner. Also, salmon predators, like tuna and mackerel, follow warm currents and kill more salmon when warm currents move north.

Even within a room you can record differences in temperature. If you take careful measurements and plot them on a map, you can make a thermal map showing the temperature in each area.

When you draw a line connecting the points with the same temperature, the line is called an isotherm. ("Iso" means equal; "therm" means temperature.) You can use the procedure below to make an isothermal map of your classroom. During the investigation, move as little as you can. Movement will create air currents that make it difficult to get accurate temperature readings.

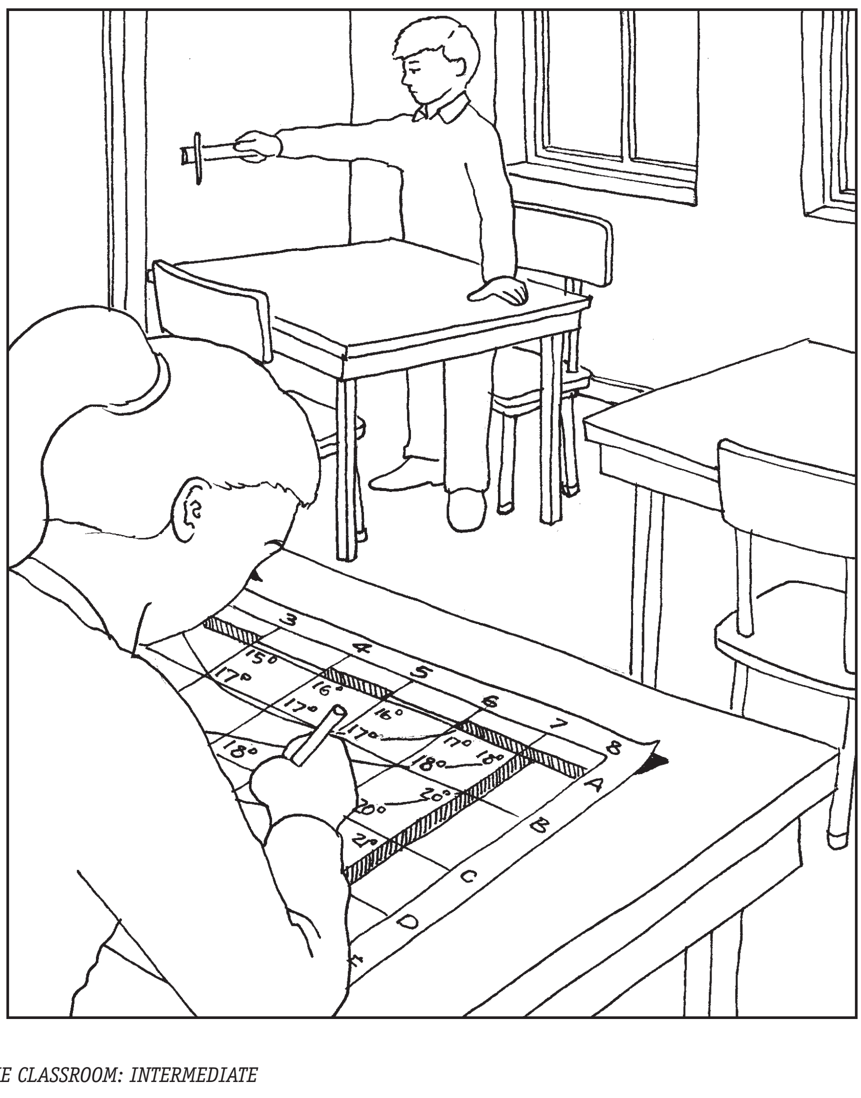


Illustration: Donald Gunn

Handout 9.5

A Classroom Thermal Map

1. Tape a thermometer to a ruler. Use the ruler as a handle so that your hand does not affect the temperature reading.
2. Make a map of the room, including walls, windows, doors, heating vents, desks, etc. (Your teacher may have a map you can use.)
3. Use your knowledge of the room to make a hypothesis about where the warmest and coolest parts of the room will be. Write your hypothesis on the next page.
4. Position yourself through the room in rows, giving each position a row number and letter. (For example, in the first row, the first position is A1, the one beside it is A2, the next is A3. In the second row, the first position is B1, the one beside it is B2, etc.) Draw each position on the map of the room.
5. Hold a thermometer above your head for two minutes. On the data form, record the temperature for each position in the classroom under the title "Ceiling Reading".
6. Hold a thermometer at waist level for two minutes. On the data form, record the temperature for each position in the classroom under the title "Waist Reading".
7. Hold a thermometer about one centimetre from the floor for two minutes. On the data form, record the temperature for each position in the classroom under the title "Floor Reading".
8. Transfer the data from the ceiling readings to the appropriate position on the classroom map. Then transfer the data from the waist readings and the floor readings onto separate maps.
9. Use coloured markers to connect the positions with similar temperature readings. The result will be an isothermal map of your classroom. With the three maps, you can compare the temperatures near the ceiling, middle and floor of the room.

HANDOUT 9.5

A Classroom Thermal Map

Name ____

Hypothesis

My hypothesis is that the warmest area of the classroom will be: ____________________

And the coolest areas of the classroom will be: ____________________

Data Form

Ceiling Reading

Position	1	2	3	4	5
A					
B					
C					

Waist Reading

Position	1	2	3	4	5
A					
B					
C					

Floor Reading

Position	1	2	3	4	5
A					
B					
C					

Conclusions

State whether or not the data support your hypothesis, and any other conclusions you can draw from the data. ____

____

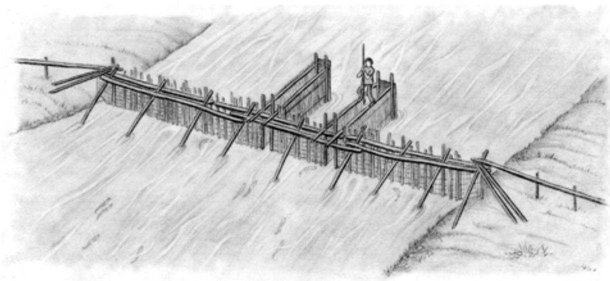
____

____

Handout 9.6

Salmon Harvesting in B.C.

Many people fish for salmon in British Columbia, both as a sport and as a way to make a living.



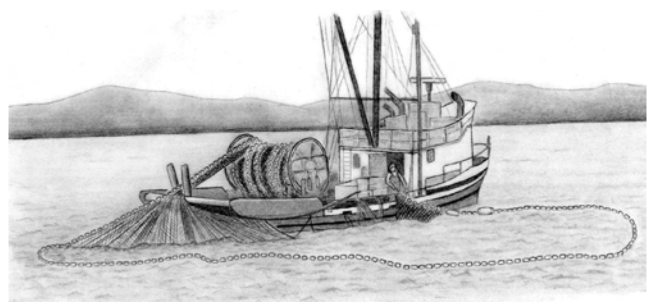
Aboriginal fishing

Canadian laws give Aboriginal people the right to catch salmon for food and ceremonial purposes using both modern and traditional methods. In some cases, agreements also allow them to sell their catch. Many Aboriginal people also fish commercially. About one third of all salmon licence holders are native and the fishing industry is the largest single source of jobs for B.C.'s Aboriginal peoples. Although some Aboriginal fishers use traditional methods, such as fish wheels, spears, hooks, dipnets and weirs, they take most of their catch using modern seine nets and gill nets.

Illustrations: Karen Uldall-Ekamn

Recreational fishing

Many British Columbians – as well as many tourists – love to fish for salmon. Besides individual sport fishers, the recreational fishery is also big business. Many charter and fishing lodge operations are located in the Gulf of Georgia and also in more remote places like the Queen Charlotte Islands.



Commercial fishing

Commercial fishers catch salmon and other fish for a living using long steel lines, gill nets and seine nets. (See separate information sheets.) The table on page 214 summarizes the number of fish caught in the commercial fishery.

Fish harvesters contribute to B.C.'s economy, but they also take many salmon before they can return to their spawning grounds.

Handout 9.6

Salmon Harvesting in B.C.

1997 and 1998 Salmon Catch

(Estimates, in numbers of salmon caught)

	Year	Chinook	Chum	Coho	Pink	Sockeye	Total
Gillnet	1997	50,000	670,000	40,000	700,000	3,710,000	5,170,000
	1998	20,000	1,080,000	2,982	180,000	790,000	2,072,982
Seine	1997	3,081	1,160,000	10,000	4,680,000	4,840,000	10,693,081
	1998	638	3,270,000	995	2,160,000	550,000	5,981,633
Troll	1997	140,000	40,000	160,000	1,100,000	2,110,000	3,550,000
	1998	120,000	100,000	0	50,000	410,000	680,000
TOTAL	1997	193,081	1,870,000	210,000	6,480,000	10,660,000	19,413,081
	1998	140,638	4,450,000	3,977	2,390,000	1,750,000	8,734,615

Source: B.C. Salmon Market database (http://www.bcsalmon.ca)

B.C. Nanufacturing Shipments

(Value in millions of dollars)

	1990	1991	1992	1993	1994	1995	1996	1997
Fish	784.5	709.7	634.6	689.8	862.8	793.7	949.1	914.6
All	25,329	23,259	24,839	27,142	31,048	35,040	33,933	34,671
As %	3.10%	3.05%	2.55%	2.54%	2.78%	2.27%	2.80%	2.64%

Source: B.C. Statistics

Handout 9.7

A Code of Responsible Fishing for Canada

Less than 100 years ago, many people thought that the number of salmon was so great that salmon would always survive. Since then, human activities have damaged lakes, streams, estuaries and even the ocean – places essential for salmon to live. At the same time, methods of catching fish improved, allowing people to catch more and more salmon every year. Today, in hundreds of B.C. lakes and streams, salmon no longer return to spawn.

Other countries and regions have faced a similar problem, both with salmon and with other fish species. In 1995, Canada and 79 other countries accepted a United Nations code of conduct for responsible fishing. In a series of meetings, fish harvesters from across Canada discussed how to meet the goal of responsible fishing locally. In 1998, they agreed to a code for responsible fishing operations for commercial fishers. Canada will also develop a code for recreational fishers.

The Canadian Code of Conduct for Responsible Fishing Operations identifies nine broad principles to protect fish while allowing a careful harvest. The code says that fish harvesters should:

- conserve and protect fish and their habitats for future generations;
- balance their fishing against the supply of fish and the economic needs of fishing communities;
- use gear that catches only the intended species;
- attempt to retrieve any lost gear that might trap or endanger fish;
- reduce the number of fish that go to waste (known as the by-catch);
- avoid polluting fishing grounds;
- look for solutions to fishing problems;
- share responsibility and cooperate with other fishers and regulators;
- educate the public and other fishers about fishing issues and ways of fishing wisely.

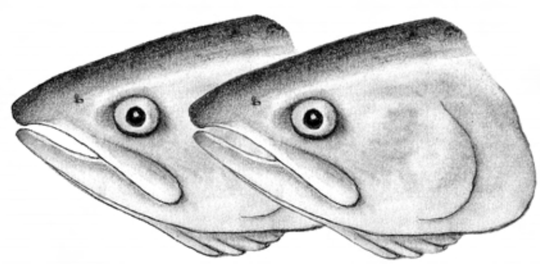
You can find current details from the Internet site of the Canadian Responsible Fisheries Board (www.responsiblefisheries.com).

What would you add to the code to ensure that salmon fishers can continue to catch salmon responsibly while protecting salmon for future generations? Consider the needs of fish harvesters, fishing communities and the fish themselves. Here are some suggestions:

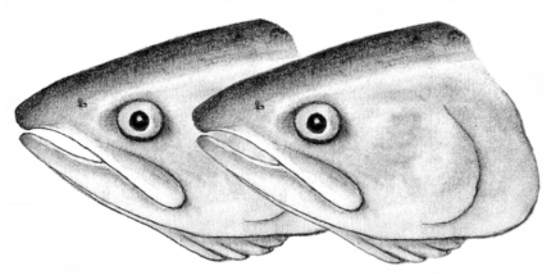
- Know the regulations about when and where salmon fishing is allowed and follow the regulations.
- Catch only the fish you need.
- Use lures and baits that will catch the kind of fish you want (e.g., use large baits so that only mature fish will bite them).
- Use fishhooks with no barb so you can release fish without harming them.
- Release any fish you catch that are too small or the wrong species.
- Handle all fish carefully so that you can release them safely.

UNIT 10

REVIEW: THE SALMON LIFE CYCLE



Review: The Salmon Life Cycle



Overview

This unit gives students an opportunity to:

- discuss what a life cycle is;
- review the stages of a salmon's life cycle and habitat;
- examine the material in their model landfill;
- calculate rates of salmon survival;
- prepare a plan for reducing human impact on salmon.

Key Concept

The stages in a salmon's life form a cycle, but each stage has specific needs and is vulnerable to disruption and mortality.

Vocabulary

Natural environment, built environment

Background Information

In addition to the information in "Handout 10.1: Salmon Survival" and the background information in Unit One: Building Knowledge: The Salmon Life Cycle, the information below may be useful.

Species comparison

	Coho *Oncorhynchus kisutch*	**Sockeye** *Oncorhynchus nerka*	**Pink** *Oncorhynchus gorbuscha*	**Chum** *Oncorhynchus keta*	**Chinook** *Oncorhynchus tsawytscha*	**Steelhead** *Oncorhynchus mykiss* (freshwater & anadromous populations)
Season when eggs hatch	Spring	Spring	Spring	Spring	Spring	Spring
Length of stay in fresh water	1 – 2 years 1 year is common	1 to 3 years	Virtually none; often straight to ocean	Virtually none; often straight to ocean	3 months to 1 year	1 – 3 years
Size at ocean migration	10 cm or more	Variable 6.5 to 12 cm	About 3.3 cm	2.8 to 5.5 cm	5 to 15 cm	5 to 23 cm
Length of ocean voyage	4 – 18 months	16 – 52 months	18 months	2 to 5 years	4 months to 5 years	1 to 3 years
***Age at return to fresh water**	During 2nd to 4th year	During 3rd to 5th years	During 2nd year	During 3rd to 5th years	During 2nd to 6th years	During 1st to 4th year
****Season/ month of return**	Late summer to January	Midsummer to late autumn	July to September	July to October	Spring to fall depending on run; some rivers support more than one run	Summer run and winter run; rivers support both
Size of adult	3 – 5 kg	1.5 – 3.5 kg	1.3 – 2.6 kg	3 – 5 kg	Up to 45 kg	3 – 15 kg
Number of eggs per female	2,000 – 3,000	2,000 – 4,500	1,200 – 2,000	2,000 – 3,000	2,000 – 17,000 (generally 5,000 – 6,000)	2,500 – 4,000
Preferred spawning grounds	Small streams	Near and in lake systems	Close to ocean	Above turbulent areas or upwellings	Very broad tolerances	Rivers, small streams

Note: Most information on the previous page is highly variable. All species of salmon adapt to some degree to their home streams, making it hard to produce concise data. This table is designed largely to compare the similarities and differences among the species.

Source: Species Comparison Table, Pacific Coast Salmon Fisheries, Creekside News (Haig-Brown Kingfisher Creek Restoration Project, Campbell River, 1998–99, http://www.tbc.gov.bc.ca/culture/schoolnet/pacific/habitat/fishtype.html)

** There are two methods for reporting the ages of salmon. The European method reports age using the number of winters the fish spent in fresh water and in the ocean, separated by a dot. The winter spent as an egg is not counted. A pink salmon, which spends 4 months incubating, goes to sea immediately on hatching and lives in the sea for 1 + years is reported as 0.1 (0 winters in freshwater, 1 winter at sea).*
The Gilbert-Rich method counts winters from spawning of the parents to capture and was developed to make it easier to calculate brood year (the calendar year the eggs were deposited). The pink salmon described above is termed a 21 (in its 2nd year, went to sea during its 1st year).

***The range of season/month of return for a stock depends on a number of factors, including latitude (northerly stocks tend to return earlier than southerly stocks), distance from ocean to spawning grounds (stock with farther to migrate tend to return earlier) and environmental conditions (seasonal fluctuations in water flow and temperature may restrict the use of spawning areas). You may also wish to review the return variations from area to area in the flow chart on page ix of the Introduction.*

Introduction

Materials:
None

Time required:
10 minutes

Suggested Activities

From these suggestions, choose activities that are appropriate for your class.

- Ask students to explain what a life cycle is and to give some examples.
  A life cycle is the series of stages through which an organism passes from birth to death, including the reproduction of a new generation.
- Have the class state the stages in the life cycle of a salmon.
  Egg, alevin, fry, smolt, adult, spawner.
- Explain that this unit gives students a chance to review the stages and conclude their salmon studies.

Salmon Life Cycle and Habitat Charts

[build-on-what-you know]

Materials:

- Student charts of salmon life cycle needs
- The salmon habitat mural created by the class
- Writing supplies

Time required:
Approximately 60 minutes

Level of conceptual difficulty:
Moderate

Suggestions for assessment:
Monitor the class discussion and review the students' oral and written reports to ensure that the students can accurately identify the main needs, threats and habitat at each stage of a salmon's life cycle.

Discussion

- Have the class discuss the similarities and differences at each stage of the salmon's life cycle and identify which factors remain constant. If necessary, prompt students with questions, such as:
  - How does the salmon's habitat change from one stage of its life to the next?
    Salmon move from a lake or stream, through rivers to an estuary, then to the open ocean, then back to their original lake or stream.
  - What elements are constant over several stages or throughout the salmon's life cycle?
    Need for clean water, reliable food sources, safe habitat.
  - What threats or dangers remain through several stages or throughout the salmon's life cycle?
    Pollution in water, habitat destruction by human activities, changes in water level or flow, natural predation, disease.
  - Which factors are affected by human activity?
    Habitat destruction and pollution.

Summation

- Have students use their charts to prepare individual reports summarizing the life cycle and habitat of a salmon.

  Option: Have small groups of students prepare a brief presentation of each stage in the salmon's life cycle, including information on the watershed, salmon habitat and salmon stewardship. Have them use the mural and any other available resources to make the presentation to another class or to an adult.

The Landfill Model

[experiment]

Materials:

- Model landfill, compost and soil pile begun in Unit Six: Salmon Alevins
- Litmus paper
- Student observations of changes in the models
- Spoons or small gardening tools
- Paper plates
- Newspapers and plastic garbage bags for waste
- Writing supplies

Time required:
Approximately 60 to 90 minutes

Level of conceptual difficulty:
Moderate to advanced

Suggestions for assessment:
Monitor class discussion and review the students' written reports to ensure that the students can compare the potential impacts of different forms of waste management on salmon habitat.

Investigation

- Have students use spoons or small gardening tools to dig carefully through the landfill, compost and soil pile models they began in Unit Six: Salmon Alevins. Have them measure the depth of the soil and any layers they can see, separate any solid materials onto paper plates, and record their observations.
- Have students observe the leachate at the bottom of the containers and record its colour, scent, texture, etc. Have them use litmus paper to test its acidity.
- Have students review the information they recorded as they monitored and dug up the landfills. Have them contribute their observations to a class chart describing changes through time in the condition of the landfill, compost and soil pile, and the leachate.

Discussion

- Have students discuss the impact of each model on salmon habitat. If necessary, prompt them with questions, such as:
  - What solid materials did you find in each model?
    The soil pile should have only minerals and rocks; the compost should have a thin layer of decomposed organic materials; the landfill should have a layer of mixed waste material.
  - How did the leachate from the three models compare?
    The soil pile and the compost should be relatively clear, but the compost will be more acidic and smelly. The landfill may be oily or acidic, depending on the materials used.
  - Where would leachate come from in nature?
    Rain percolating through the soil and into waterways.
  - How would leachate affect salmon?
    It could pollute the water with oils, acids and other materials, and harm them or force them to leave.
  - How can people reduce the leachate that harms salmon?
    Reduce the amount of waste, prevent rain from getting into landfills, drain leachate from landfills, etc.

Summation

- Have students use one of their previous experiment observations forms as a model to write a description of the landfill experiment, including their observations from "Handout 6.4: A Model Landfill" and a comparison of the impact on salmon habitat of the compost, the landfill and the control soil pile.

Salmon Survival

[experiment]

Materials:

- One copy of “Handout 10.1: Salmon Survival” for each student
- Calculators (optional)
- Computer graphing program (optional)
- Graph paper
- Coloured pencils
- Writing supplies

Time required:
Approximately 90 minutes

Level of conceptual difficulty:
Moderate

Suggestions for assessment:
Review the students’ charts to ensure that the students can describe salmon survival rates and discuss their implications.

Research/Discussion

- Have students use “Handout 10.1: Salmon Survival” to calculate the probability of survival at each stage of a salmon’s life cycle and to compare the survival of natural and hatchery salmon.
- With the class, review the student datasheets and discuss the conclusions students draw. If necessary, prompt them with questions, such as:
  - What is shown by the difference between the students’ graphs and the handout?
    Many more salmon survive when they are reared in hatcheries.
  - At which stage is the difference between the natural and the hatchery survival rate greatest?
    The difference is greatest at egg/alevin stage, and is reflected through the later stages.
  - If salmon lived at the hatchery survival rate, what would happen to the number of salmon?
    The number would increase if more spawners laid and fertilized eggs, until the number exceeded the capacity of their habitat. If more salmon survived than the habitat could support, more salmon would die. The larger number of survivors might also encourage higher predation
  - What would happen to the salmon if the number of survivors decreased following an outbreak of disease, habitat destruction or overfishing?
    Production might be limited by fewer spawners and the survivors might not produce enough offspring for the following generations to continue.
- Explain that B.C. residents currently produce, on average, 1.6 offspring for every pair of adults. Have students compare this reproduction rate with the reproduction rate for salmon *(2,500 eggs per adult pair of coho)*, and the significance of each in the environment. If necessary, prompt them with questions, such as:
  - How can B.C. residents survive if they produce fewer offspring than there are parents?
    The growth rate might decline but people choose to migrate to B.C. from other areas, so the total population increases by 2.3 per cent per year.

- If salmon produced fewer offspring than there are parents, what would happen to them?
  They would decline in numbers and possibly die out.
- Why is the reproduction rate among B.C. residents less meaningful than the reproduction rate among salmon?
  B.C. residents can migrate from other regions, live very long lives, consume large quantities of resources, etc. Human offspring have a very low rate of mortality compared to salmon offspring.

Creating Positive Human Impacts
[discussion]

Adapted from Bill Hammond, Florida Golf Coast University, *Water Stewardship*, pages 138 - 153.

Materials:
- A copy of "Handout 10.2: Creating Positive Human Impacts" for each student
- Writing supplies

Time required:
Approximately 90 minutes, plus time for community projects which students undertake

Level of conceptual difficulty:
Moderate to advanced

Suggestions for assessment:
Monitor class discussion and review the students' plans and reports to ensure that the students can analyze and describe the steps needed to take action to reduce human impacts on salmon habitat.
If students carry out a community environmental project, have them use the class or individual journals to write a reflective journal entry describing what they contributed to the project and what they learned from it. Review their oral contributions in the wrap-up celebration and their journals to ensure that the students can identify social, academic and environmental benefits from participating in the project.

Preparation

- Research any school policies that might apply when dealing with action in the community, and make appropriate arrangements with school administrators.
  Should students be advised to avoid propagandizing, should they be provided with a wide range of viewpoints to make informed choices, etc.?
- Determine the role you will play as teacher/facilitator if the class proceeds with an action project.
  Will it be your role to encourage independent thinking and action-skill development? Will you be actively involved?

Research/Discussion

- Have students in groups review their notes, observations, portfolios and other items from the salmon studies, list human impacts on salmon habitat and identify conditions that are healthy for salmon.
- Have the groups share their list of impacts with the class and identify ways that humans could make a more positive impact on salmon habitat and the local community environment at the following levels:
  - **Level 1:** Actions that produce a defined end product within a fairly short time.
    Habitat improvements, storm drain marking, developing educational tools, writing letters to the editor, government, etc.
  - **Level 2:** Actions that lead to ongoing or sustained environmental processes, even after the project designers have left.
    Recycling, composting and waste management programs, educational and awareness programs, habitat monitoring and reporting, etc.
  - **Level 3:** Actions that produce some level of policy change at the school, school district, city, province or federal level.
    Working with the media, governmental processes and the democratic system.
- Have students individually, or in groups, research environmental action projects that have been undertaken in local or other communities. Discuss the benefits of undertaking a class project to create positive human impacts in the local community.

- Ask the class if students want to carry out a project in the community to create positive human impacts.

  Option: Have students individually, or in groups, select one method for reducing human impact on salmon habitat and prepare a report listing steps they could take in school or at home to begin action on that step.

  Option: Have students research careers related to protecting salmon and the environment. Suggest that they contact local fisheries offices, waste management officers, naturalist associations, libraries, etc., to identify potential careers, the type of work involved and the training and preparation needed.

- Have the class read "Handout 10.2: Creating Positive Human Impacts", then hold a class discussion about the benefits of undertaking a class project to create positive human impacts in the local community.

- If the class chooses to undertake a community project, have students begin a class journal in which they can record their activities on the project, assess their success and document the progress of the project for future participants. (You may also wish students to keep individual journals on the project for use as an assessment tool. If so, explain to the class how they will be used and your expectations about what the journals should contain.)

- Have students contact local fisheries, naturalists, environmental managers, planners, community leaders, etc. to determine local issues that affect salmon or other components of the environment. If necessary, prompt them with questions, such as:

  - What are the causes of the problems? What are the symptoms?
  - What potential solutions have already been pursued? What is lacking?
  - What barriers exist to implementing potential approaches?

- As a class, brainstorm and evaluate a number of broad ideas for addressing an existing problem. If necessary, prompt students with questions, such as:

  - What are some potential cures or solutions?
  - What are the pros and cons to each solution?

Community Action

"A critical role in implementing action programs is coaching students to plan their broad visions or goals into a set of key steps, milestones, or critical sub-goal accomplishments. In this way, if the time constraints of the school setting or the political process delay the attainment of the ultimate goal, students will still have a positive sense of accomplishment, of partial closure, and a feeling that they indeed made a difference and can continue to make a difference if they persist."

— William Hammond,
Water Stewardship, p.142

- What are some actions that have already been taken?
- What are some ways that their class can make a positive impact on the issue?

■ Have the class choose an action project that they could initiate or add to. Have students individually, or in groups, analyze the situation by researching the background and context of the project they have chosen, using local community resources such as:

- newspaper reports,
- library references,
- environmental reports from local and regional authorities, and
- interviews with local experts.

■ Be sure students consider the viewpoints of all people who have a stake in the problem, as well as the impact that the proposed actions will have in both the short- and long-term.

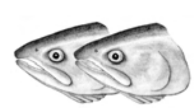
■ Have the class develop action ideas with specific steps they can take to complete the project. Have them create a chart outlining:

- a list of tasks,
- who will be responsible for each task,
- a due date for each task,
- how each task will be carried out.

■ Have the class list the names and locations of any additional material resources they will need or individuals with whom they will have to consult, involve and gain support to complete the tasks.

■ Have the class present its plan to the school administration and other community agencies that may be involved. Have the students discuss how they will carry out the project while meeting their other school requirements. Ensure that students obtain any approvals required before they start their project.

■ Have the class carry out the steps in its plan, with students reporting regularly to the whole class on their progress, including any problems they are facing and what they are learning from the experience. Have them add their reports to the class journal.



- When students have completed their work, have the class list any alternative strategies or follow-up activities that will be needed to sustain and continue the project.
- At the conclusion of the project, arrange a celebration of the class' successes at the site of the project, if feasible. Invite community members to join the celebration. Have the class use its journal and other appropriate media to describe the project, its achievements and steps remaining to be done. Have students take turns describing their contributions to the project and what they learned from it.

REVIEW: THE SALMON LIFE CYCLE

Wrap-Up

Extension Activities

- Have students write letters to the federal or provincial department of fisheries expressing their views on a subject that they have studied.
- Have students write a short story from the point of view of a salmon. Discuss what anthropomorphism is (viewing nonhuman events from a human perspective). Explain that anthropomorphism can be a powerful tool for understanding and is widely used in the conventions of folk tales. However, it is important to recognize clear differences between the entities of the wild as metaphors and as beings in their own right, with their own nonhuman qualities.
- Have students create a hypertext file, multimedia presentation, puppet show or readers' theatre representing the life cycle of a salmon.

Suggestions for Assessment

- Have students draw a food web representing the salmon's entire life cycle.
- Using information from the units and independent research, have students role play a scenario in which competing groups of people try to find the most appropriate way to protect a salmon spawning stream near a city. Have them compare and evaluate facts and arguments presented in a class debriefing. (Or have students use the Table Talk Resource Kit to prepare and discuss a role-play involving competing interests in a watershed.)
- Have students use the quiz questions they prepared on index cards in previous units about the stages of the salmon life cycle. Have them quiz each other by asking the questions or by using a *Jeopardy*-style format (i.e., giving the answers and asking for a question).
- Have students draw a cartoon storyline representing the life cycle of a salmon.
- Have students review their answers and explanations from the Introduction: Looking Ahead to Salmon Studies in Unit 1 and describe, how they would answer the questions now and how they would explain their answers.
- Have students add their notes, experiment observations and other materials to a salmon science notebook or portfolio. Have a conference with students, in which they discuss the materials in their portfolio and the significance of each in understanding the life cycle of a salmon.
- Have students use "Appendix 2: Student Assessment Sheet" to review their group work and their own learning.

Home and Community Connections

- Have students ask an adult to help them set up a home waste plan, including reduction, recycling and hazard waste management.

HANDOUT 10.1

Salmon Survival

A single pair of salmon produces thousands of fertile eggs, but the number of adult salmon that will survive depends on harvest levels and salmon habitat, especially ocean conditions.

After release, hatchery fish may not survive as well as wild ones, and they compete with wild populations for food and safe places to grow. Hatcheries cannot remedy the loss of fish habitat, but they remain tools that managers can use to help support endangered salmon populations.

The chart below shows the average number of salmon that survive at each stage of their life cycle, or the **survival rate**. (The chart uses average numbers for coho salmon. The numbers for other species of salmon are different, but they follow the same general pattern. The survival rate at each stage can vary considerably from the average.)

Wild coho salmon survival

Stage of development	Number	Deaths	Number of survivors	Survival rate	Causes of death
Eggs/Alevins	2,500	2,125	375	15%	• Unfertilized eggs • Gravel movement • Low oxygen in water • Drastic changes in water temperature • Pollution and/or sedimentation • Disease • Predators • Poor habitat conditions
Fry Eggs/Alevins	375	245	30		• Lack of adequate food or space • Predators (rainbow trout, doll var-den, char, grayling trout, sculpin, steelhead trout, ducks, merganser, tern, kingfisher) • River blockage or diversion along migration route • Pollution

This chart uses average numbers for coho salmon. The numbers for other species of salmon are different, but they follow the same general pattern.

Handout 10.1

Salmon Survival

Wild coho salmon survival (cont'd)

Stage of development	Number	Deaths	Number of survivors	Survival rate	Causes of death
Smolts	30	25.5	4.5		• Predators (other fish, killer whale)
Adults	4.5	2.5	2.0		• Harvesting (sport, commercial, Aboriginal food fishery) • Predators
Spawners	2	2	0		• Water levels too high or low • Predators (bears, otters, minks, birds) • Obstructions (dams, rock slides, log jams) • Diseases • Death after spawning

Fish hatcheries can greatly increase the number of salmon that survive the early stages. However, the smolts from hatcheries may not survive as well as wild smolts. Only a few grow to become adults and return to spawn in their home stream or lake.

The next chart shows the number of salmon that survive when the eggs are reared in a hatchery.

Hatchery coho salmon survival

Stage of development	Number	Deaths	Number of survivors	Survival rate	Causes of death
Eggs/Alevins	2,500	250	2,250		• Unfertilized eggs • Failure of hatchery systems • Disease
Fry	2,250	450	1,689		• Disease • Predators (otters, minks, birds)
Smolts	1,689	1,530	253		• Predators (other fish, killer whale)
Adults	253	162	111		• Harvesting (sport, commercial, Aboriginal food fishery) • Predators
Spawners	111	111	0		• Water levels too low or too high • Predators (bears, otters, minks, birds) • Obstructions (dams, rock slides, log jams) • Diseases • Death after spawning

Handout 10.1

Salmon Survival

Hatchery coho salmon survival

1. Use graph paper and coloured pencils or a computer graphing program to create a graph showing the number of survivors at each stage of a natural salmon cycle.
2. Add a graph showing the number of survivors at each stage of a hatchery salmon cycle.
3. What does the difference between the charts show? ______________________________

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____
____
____
____

4. The survival rate is the percentage of the original eggs that remains alive at each stage. You can calculate the survival rate for each stage using this formula:
   (number of survivors) / (number of eggs) x 100
   For example, the survival rate of natural eggs and alevins is 15% (375/2500 x 100).
5. Calculate the survival rate after each stage in the natural life cycle. Add it to the chart.
6. Calculate the survival rate after each stage in the hatchery life cycle. Add it to the chart.

____
____
____
____
____

7. At which stage is the difference between the natural and the hatchery survival rate greatest?
8. If salmon lived at the hatchery survival rate, what would happen to the number of salmon?

   Explain your answer. ______________________________

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____
____
____

HANDOUT 10.2

Creating Positive Human Impacts

A community project can be a great way to work together to protect the environment.

Good planning helps make a project a success. You can plan by taking steps like these:

- Find as much information as you can about your project. You can get information about local issues from newspaper stories, library references, environmental reports or by talking to local experts.
- Find out what other people have already done, if anything.
- List several solutions, with as many pros and cons as you can.
- List the steps you will have to take, including due dates and who will do them.
- List any resources you need, including tools, supplies and support from others.
- Keep records of what you are doing – and the results.
- Think beyond your project. You may need others to carry on for you after you are finished.

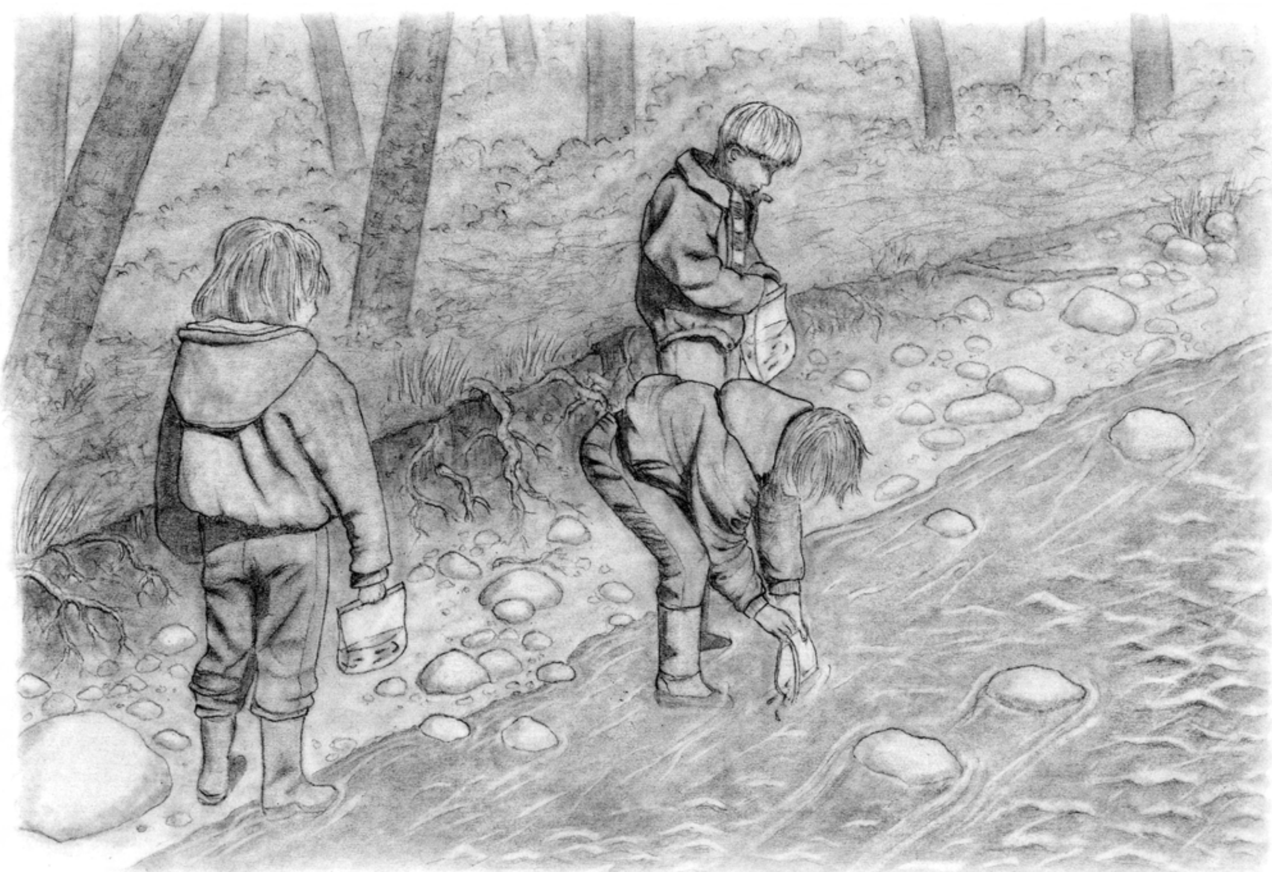

Illustration: Karen Uldall-Ekamn

APPENDICES

APPENDIX 1

Science Experiment Sheet

Name ______________________________

Date ______________________________

Experiment Title ______________________________

Hypothesis ______________________________

____

____

____

____

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Procedures ______________________________

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Observations ______________________________

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Conclusions ______________________________

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Appendix 2

Student Assessment Sheet, Attitudes and Communication

Students and teachers can use this form to assess their abilities to work together and communicate effectively through the salmon studies. Add comments below each question to give examples.

Name ____

- ❑ Does each student participate and take on responsibilities?

- ❑ Do students ensure that they all understand the task at hand before starting out?

- ❑ Do students express their own ideas and work together to resolve differences?

- ❑ Do students listen to one another when they are sharing information or opinions?

- ❑ Do students respect one another's ideas?

- ❑ Do students follow the steps as outlined?

- ❑ Do students observe and record data they need as they work?

- ❑ Do students use the vocabulary they have learned as they discuss their work among themselves?

These definitions refer to words in the context in which they are used in the *Salmonids in the Classroom: Intermediate* materials. They may have other meanings in other contexts.

Appendix 3

Glossary

The following definitions refer to words in the context in which they are used in the *Salmonids in the Classroom: Intermediate* materials. They may have other meanings in other contexts.

accumulated thermal unit (ATU)	a measure of the total heat received over a period of time
anadromous	fish or other animals that live their lives in the sea and migrate to a freshwater river to spawn
adapt	to become suited for changed conditions
alevin	a fish that has hatched and has a yolk sac attached
aquatic organism	a plant or animal that lives in water
amphipods	small crustaceans that become food for salmon in their fry, smolt and adult life cycle stages
atmosphere	the air that surrounds the earth
back-eddy	a water current that flows backward against the main current
bedrock	solid rock that lies below loose surface rocks and soil
bladder	a thin bag in the body that holds air or urine
boulder	rock pieces 30 cm or more cm across
built environment	the parts of the surroundings that are built by people
buoyancy	the ability to float or rise in water
buoyant	able to float or rise in water
by-catch	fish caught that are not the species that fishers intended to catch
carcass	the body of a dead animal
cell	tiny building blocks that make up the bodies of all living things
chinook	a species of Pacific salmon
chum	a species of Pacific salmon
classification	arranging things into similar groups
cobble	loose stones 10 to 30 cm across

Appendix 3
Glossary

coho	a species of Pacific salmon
cold-blooded	animals whose body temperature changes as the environment changes
compost	a mixture of decaying plant and animal material
concentration	the amount of a substance in a solution
copepods	small crustaceans that become food for salmon in their fry, smolt and adult life cycle stages
creek	water flowing in a narrow path, a small stream
cutthroat trout	a species of salmonid with both freshwater and anadromous populations
deforestation	clearing land of trees
dichotomous key	a chart that subdivides items of the natural world by two, through a series of choices that lead the user to the correct name of the given item
dissolved	mixed into a liquid such as water
dissolved oxygen	the concentration of oxygen in water. It is used as a measure of the water's ability to support aquatic life. Low concentrations do not support fish or similar organisms.
ecology	the science that studies how organisms relate to the environment in which they live
eelgrass	a plant with long, thin leaves that grows in salty water
embryo	a very young salmon in the egg or just after hatching
energy	the strength to live and be active
estuary	the mouth of a river where it mixes with the sea
euphausids	small crustaceans that become food for salmon in their fry, smolt and adult life cycle stages
evaporation	changing from a liquid to a vapour
excrete	to get rid of waste from the body
fertilize	to make eggs ready to grow by uniting egg and sperm

Appendix 3
Glossary

genetic diversity	the variability in the genetic make-up among a group of individuals in a population. Also called genetic variability.
genetic variation	change from one generation to the next; differences between organisms of one species that are inherited from the parents
gill rakers	the bony part inside a fish's throat that protects its gills from food and guides food into the throat
gill	the part of a fish's body that it uses to breathe under water
gravel	loose stones from 1-10 cm across
guideline	an ideal that is written down to guide others
habitat	where a plant or animal normally lives
herring	a small, silvery ocean fish
hydrologic cycle	a process in which water evaporates from the ocean, falls to earth as rain or snow and returns to the ocean in rivers and streams; the water cycle
imprinting	the way that salmon fry remember the scent of their home stream or lake
impurity	something that pollutes something else
insect	small animals with three pairs of legs and, usually, one or two pairs of wings
isotherm	a line on a map connecting places that have the same temperature
kidney	the part of an animal that separates waste and water from the blood
lake	a large body of fresh water
landfill	waste buried in the ground
larva	an insect after it hatches but before it becomes a pupa (plural: larvae)
lateral line	the part of an animal's body in a line along its side that it uses for sensing
leachate	liquid that flows through solid material and carries some of the material with it
life cycle	all the stages in a plant or animal's life

Appendix 3

Glossary

liver	the part of a fish's body that cleans the blood and secretes substances that help absorb food. It is essential for maintaining the proper level of blood chemicals and sugars.
mackerel	a predatory ocean fish
magnetic direction	direction following the earth's magnetic poles, as on a compass
membrane	a soft sheet of skin that covers a part of the body
micro-organism	living organisms too small to see without a microscope
migration	movement from one place to another
milt	the sperm cells of a male fish and the fluid in which they float
molecule	the smallest particle into which a substance can be divided and still keep the properties of the original substance; made up of two or more atoms
natural	the parts of the surroundings that are not built by people environment
navigation	finding a position or a direction of travel
nutrient	food that allows a plant or animal to live and grow
nymph	a stage between a larva and an adult through which some insects grow; similar to a wingless adult
orca	a marine mamal; a killer whale
oxygen	a gas in the air which plants and animals need to breathe
Parr marks	dark vertical bars on the sides of salmon fry
part per million (PPM)	for every particle of one substance there are one million particles of another substance
pH	a measure of the concentration of hydrogen ions in a solution, indicating neutrality (pH 7), acidity (less than pH 7), or alkalinity (greater than pH 7)
pink	a species of Pacific salmon
plankton	a group of microscopic organisms that live in water

Appendix 3
Glossary

pollutant	a byproduct of human activity which may cause harm to humans or other species
pond	a small body of still water
precautionary approach	recognizes that the absence of full scientific certainty shall not be used as a reason to postpone decisions where there is a risk of serious or irreversible harm
predator	an animal that catches and eats other animals
principle	a rule, especially a basic rule on which other rules are based
rainbow trout	a species of Pacific salmon that spends all its life in fresh water. The anadromous variant of this species is called steelhead trout.
redd	a stone nest in the gravel of a lake or stream for protecting eggs
respiration	breathing
riffle	an uneven area in a stream that makes the water form small waves or ripples
river	a large channel of water flowing to a sea or lake
runoff	water that drains away after a heavy rain or a spring thaw
salinity	saltiness
salmon	a type of fish that hatches in fresh water, swims to the ocean, then returns to its home stream or lake
salmonid	salmon and related fish such as trout and char
scales	small, hard, flat pieces that cover a fish's body like armour
sensitive	vulnerable to harm; able to perceive things easily
silt	very fine earth carried in water
slime	a slippery layer that covers fish
smolt	a young salmon that is getting ready to enter salt water
sockeye	a species of Pacific salmon

Appendix 3
Glossary

solar energy	energy that radiates from the sun
spawn	to produce, deposit and fertilize eggs
spawning ground	a stream or lake where salmon deposit eggs
species	a grouping of plants or animals; a group of plants or animals that can breed together and produce fertile offspring
steelhead trout	a species of Pacific salmon that does not always die after spawning; the freshwater variant of this species is called rainbow trout
stream	water flowing in a narrow channel
sustainability	meeting the needs of the present without compromising the ability of future generations to meet their own needs
sustainable development	development that meets the needs of the present without compromising the ability of future generations to meet their own needs
swim bladder	the part of a fish's body where a fish stores air to maintain buoyancy in water
temperature	the amount of heat or cold
thermal	something that has to do with heat (or cold)
transpiration	the process whereby plants give off moisture through the pores in their leaves
turbidity	a measure of water clarity; cloudiness or muddiness
velocity	speed
warm-blooded	animals that can keep their body at about the same temperature
waste	garbage; something that is thrown away or left over
water cycle	a process whereby water evaporates from the ocean, falls to earth as rain or snow and returns to the ocean in rivers and streams; the hydrologic cycle
water pressure	the weight of water on an object

Appendix 3
Glossary

watershed	the area that drains into one system of rivers and streams, including all the living things in it
yeast	a micro-organism that grows in liquids containing sugar
yolk sac	a thin bag containing egg yolk that grows on the belly of an alevin
zooplankton	an animal species of plankton