Fish Eggs To Fry

Hatching Salmon And Trout In The Classroom

Oregon Department of Fish & Wildlife
Salmon-Trout Enhancement Program
PO Box 59
Portland, OR 97207

Fish Eggs To Fry

Hatching Salmon and Trout In The Classroom

An Oregon Department of Fish and Wildlife
Salmon-Trout Enhancement Program Publication
PO Box 59
Portland, OR 97207

WHAT DO FISH EGGS NEED TO SURVIVE?

Healthy streams provide the physical and chemical environment fish eggs need to survive.

Your classroom incubator . . .

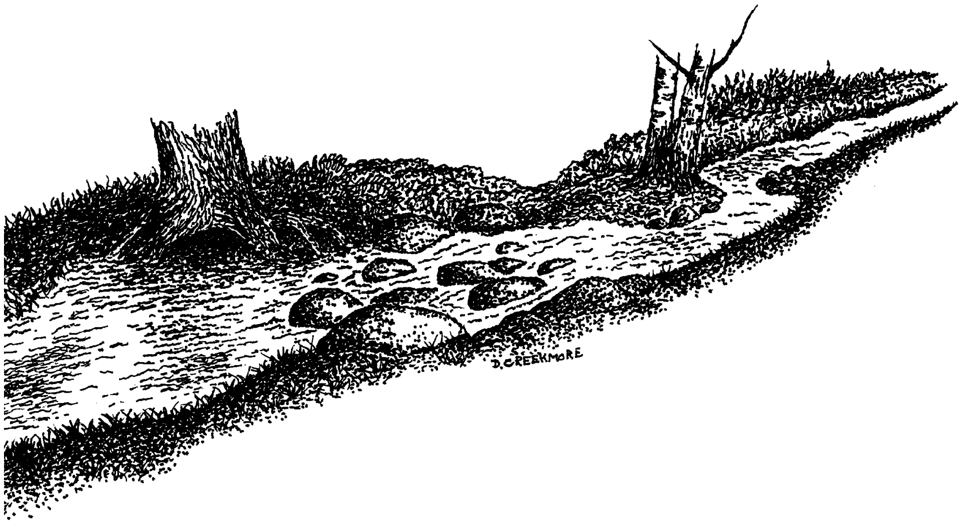
✔ provides an artificial, but protected, healthy habitat for rearing salmon or trout eggs to the fry stage, and

✔ gives students an opportunity to observe and participate in fish development and to understand the habitat needs of eggs and fry.

The following chart describes conditions necessary for egg and fry development, how nature provides for those requirements, and how the classroom incubator models those requirements.

EGG/FRY REQUIREMENTS	NATURAL HABITAT	AQUARIUM HABITAT
• **Limited light** (as eggs and alevin)	• Eggs are buried under the gravel in a redd.	• Styrofoam or other types of insulation protect aquarium from direct sunlight and harmful ultraviolet light in classroom (also helps keep water cool).
• **Cold water** (42° - 55° F)	• Snowmelt, water from underground sources, and shade from streamside plants help keep water cool.	• Refrigeration unit (or other water-cooling system) maintains desirable water temperature.
• **Oxygen** (7 - 12 ppm dissolved in water)	• Cold, rushing water gathers and holds oxygen from the air. Aquatic plants also produce oxygen.	• Aeration system adds oxygen and circulates it through an undergravel filter.

Continued on page 9.



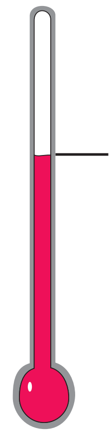
EGG/FRY REQUIREMENTS	NATURAL HABITAT	AQUARIUM HABITAT
• **Clean water** (contaminant-free)	• Clean water is stored and gradually released in a healthy, properly-functioning watershed. A healthy stream can absorb minimal human impacts. Human pollutants can harm streams. Bacteria and other organisms usually break down or eat naturally decaying matter in streams. Some pollutants are resistant to the natural processes of decay. Plants also absorb nitrates.	• Dechlorinated water • Undergravel filter, or some other method of filtration, removes wastes and encourages microorganisms in gravel which change harmful ammonia to harmless nitrates.
• **pH** (6.5 - 7.5)	• Runoff from nearby rock and soil types, parking lots, animal wastes, and decaying organic matter in the water all affect pH.	• Proper balance between acidity and alkalinity - optimum is 7.0 (a neutral solution).
• **Gravel**	• Rocks and gravel are washed into the stream and tumbled smooth by the water and other rocks. Spaces between the gravel are sediment-free.	• Clean gravel is placed into aquarium.
• **Food**	• Aquatic insects that live in the gravel or fall into the water and tiny zooplankton are food items for fry.	• Not provided in aquarium - unfed fry are released into an approved water body.
• **Protection** from predators.	• Eggs buried in the gravel are generally safe from birds and other predators. Fry have protective coloration and hide under rocks and other stream habitat.	• No predators in the aquarium.

Adapted from *A Manual For Classroom Incubation*, Public Involvement Program, Fisheries and Oceans, British Columbia, Canada and *Salmon and Trout Go To School*, Diane Higgins, McKinleyville, California.

CRITICAL WATER QUALITY ELEMENTS

✔ Temperature

Normal winter-spring water temperatures in Pacific Northwest streams may range from 32°F to approximately 60° F. Lower temperatures slow hatching rates significantly and increase the time the fish are in the vulnerable alevin stage. Higher temperatures speed up hatching rates, but also encourage growth of bacteria and fungi that may kill eggs or fry. The ideal controlled temperature range for classroom incubators is 48° F - 52° F. This allows rapid development, good sizes at hatch, a good feeding response upon release, and adequate oxygen supplies.



The ideal controlled tempera-ture for a classroom incubator is 48 - 52 ° F

Temperature affects ammonia and oxygen concentrations and fish metabolism. A sudden increase or decrease of 3 - 5 degrees within a 15-minute period, even within an acceptable temperature range, can create problems for both eggs and alevins. Eggs may develop coagulated yolk disease which prevents button-up and causes death. It also causes excessive fluid buildup or a stress response which damages the immune system. Immune system failure usually results in disease development within one or two weeks.

When doing water changes, make sure the new water is within 1 - 2 degrees as that in the incubator. Try to keep aquarium temperature adjustments to less than 3 or 4 degrees over a 24-hour period.

Use a standard aquarium thermometer to monitor water temperature or create a more sophisticated monitoring system with a maximum-minimum thermometer or a thermograph to track daily temperature fluctuations.

✔ Dissolved Oxygen

Dissolved oxygen is defined as the amount of oxygen, measured in parts per million (ppm), that will dissolve in water at a given temperature. Salmon and trout are very active fish and consume a lot of oxygen from the water. Cool water flowing over rocks and boulders normally maintains high dissolved oxygen levels in streams. Lakes and ponds rely on plant photosynthesis for addition of dissolved oxygen to their waters. Dissolved oxygen readings of 10 - 12 ppm are most desirable. The absolute minimum dissolved oxygen concentration for developing eggs and alevins is 8 ppm and 5 ppm for fry. At these levels you can expect negative effects on fish or eggs. Any decrease in dissolved oxygen below 5 - 8 ppm is critical.

Green or newly fertilized eggs have relatively low oxygen requirements as there is little biologically active tissue. Eggs are mostly yolk. As the embryo develops there is more active biological tissue and oxygen requirements increase accordingly. Increasing oxygen requirements continue right up to hatching. Shortly after hatching, alevins have lower oxygen requirements because the eggshell is a poor oxygen transfer membrane and because the fish can now use its gills to obtain the oxygen it needs.

Oxygen concentration has a negative relationship with temperature. Cooler water holds more oxygen. Conversely, warmer water holds less oxygen. As water temperature increases, a fish's metabolic rate increases and more oxygen is required. **Temperature limits oxygen availability**.

Many schools release fry in ponds and lakes to avoid conflicts with native fish in streams. Be aware that fish die-offs in shallow, warm ponds are a fairly common occurrence during hot summers. During a long period of warm sunshine, algae grow profusely. A summer storm can result in several days of cloudy weather. Lack of sunlight can cause a massive die-off of the algal bloom. As dead algae decompose, they use up the available oxygen supply. As the amount of dissolved oxygen drops to lethal levels, it can result in a subsequent die-off of fish and other aquatic organisms. Remind students that approved release sites provide the greatest opportunity for fry survival while still protecting native fish resources. As explained above, climatic and other habitat factors may reduce survival of their fry in even the best of conditions.

Eggs usually arrive in a small piece of wet burlap or wet paper toweling. The eggs must be kept cool and moist, but not sitting in water while in transport. Eggs transported in water quickly use up the available oxygen supply in the container and can suffocate.

Most of the oxygen in a classroom incubator is produced by aerators or water circulation across the surface, so a good flow from the powerhead is required. Use a dissolved oxygen test kit, available from most aquarium supply stores, to monitor dissolved oxygen.

✔ pH

pH (or the **p**ower of **H**ydrogen) is a measure of water acidity or alkalinity. pH values range from 1 to 14. Along this scale, any number less than 7 is acidic. Any number more than 7 is basic or alkaline. Pure, pH-balanced water has a pH of 7. A pH of 7 is neutral and ideal for most aquatic animals.

pH Poetry

For coffee it's 5, for tomatoes it's 4
While household ammonia is 11 or more.

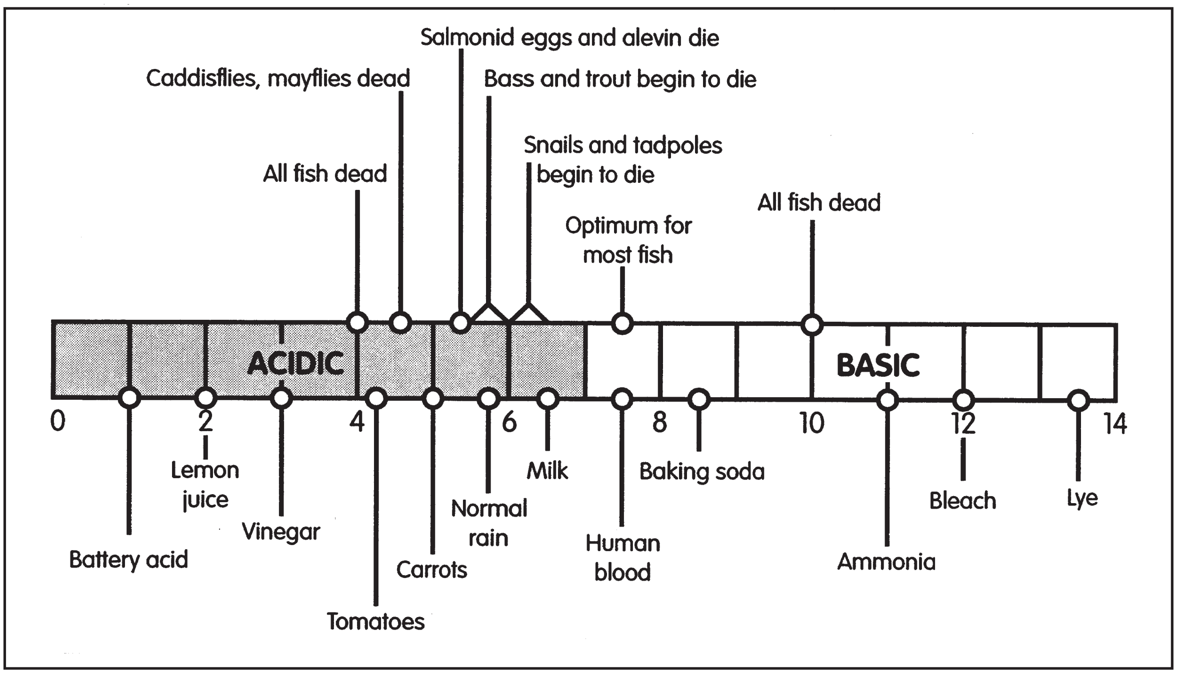
It's 7 for H_2O, if in a pure state
But rain water is 6 and sea water is 8.

It's basic at 10, quite acidic at 2
and well above 7 when litmus turns blue.
Some find it a puzzlement,
How about you?

Anonymous
Salmon Below The Surface
Dept. of Fisheries and Oceans
British Columbia, Canada

Any significant change in pH (dropping below 6.0 or rising above 8.0) is reason for concern. Fish take oxygen from the water through their gills and give off carbon dioxide. A simple chemical reaction occurs when carbon dioxide is expelled into water. It produces a weak acid called carbonic acid. Too many fry in a closed aquarium system can change the pH to dangerously low pH (high acid) levels. Complete a partial water change or add a basic chemical such as baking soda to correct the situation. Use extreme care when adding buffering agents like baking soda, to avoid a see-saw situation that may result in a water exchange anyway.

pH Scale



Source: The Stream Scene: Watersheds, Wildlife, and People, Bowers, Patty, et al., Oregon Department of Fish and Wildlife, 1999.

Acidic water (low pH) irritates gills, causes excess mucus production and reduces the gills' ability to exchange oxygen. Low pH also limits the fish's ability to regulate its blood salts, although adding calcium ions can reduce this effect.

Use litmus paper strips or a pH test kit available from aquarium supply stores to monitor pH.

✔ Ammonia

Proteins are essential to produce the powerful muscles salmon and trout use for swimming. Animal cells assemble their required proteins from amino acid building blocks found in foods. Ammonia is the result of the biological breakdown of proteins and is present in two forms: ammonium ions (NH_4^+) and ammonia (NH_3). The latter is highly toxic to fish. Even small amounts can be dangerous. A balance between the two is controlled by pH and the temperature of the water. At higher pH levels (>7) and temperatures, the toxic form increases its concentration. Total ammonia (the sum of both forms) should be less than 5 mg/liter and can be monitored with an ammonia test kit available from most aquarium supply stores.

In nature, ammonia (nitrogen) waste is not a problem. It is simply diluted into the stream where the nitrogen is reabsorbed by aquatic plants and plankton. In a closed aquarium ammonia (nitrogen) levels can build up very quickly, resulting in a fish kill. Because you will not feed fry during this project, nitrogen levels are easily manageable. The only time you should detect a noticeable difference is when the eggs hatch, releasing ammonia products found in the embryonic fluid into the aquarium.

High ammonia levels causes gill damage (clubbing) and anemia. It can kill both eggs and fry. A healthy, actively functioning biological community (biofilter), which develops in the undergravel filter, controls most of the ammonia. The biofilter breaks ammonia down initially into less toxic nitrites and finally to relatively nontoxic nitrates.

✔ Pollutants and Chlorine

Pollutants are generally not a problem if using dechlorinated tap or well water in classroom incubators. But surface waters can be polluted. Pollutants include metals, pesticides, hydrocarbons and phenols.

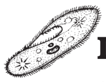
The greatest pollutant in tap water is chlorine. It is added as a sterilant for drinking water and swimming pools. The concentrations of chlorine in drinking water are toxic to fish and to the bacteria making up the aquarium's biofilter. Fortunately, chlorine is a very active element that changes readily to a gas or quickly attaches to other elements to form harmless chemicals. Once attached to another element chlorine is neutralized and no longer toxic. This is the premise behind water dechlorination.

Dechlorinate water by exposing a full bucket to the air for 24 hours or add dechlorinating tablets or solutions available from aquarium supply stores.

✔ Biofilter

The biological community (biofilter) that develops in the undergravel filter is perhaps the most important component of the classroom incubator system. Its main function is to oxidize the ammonia produced by eggs, alevin, and fry, first into less toxic nitrites and then into relatively nontoxic nitrates. The biofilter is a living community of organisms and has the same requirements as all living things. A biofilter consists of several kinds of specialized bacteria and tiny one-celled organisms like protozoans, rotifers, nematodes, and many others.

Four basic biological components make up the biofilter:



Large Macrophages — include protozoans (e.g. *Paramecium*, *Amoeba* sp.), rotifers, nematodes, and others who consume large food particles like fish feces. They release carbon dioxide and ammonia.

Bacterial Heterotrophs — consume microscopic food particles and feces. They release carbon dioxide and ammonia.

***Nitrobacter* species** — use ammonia as a food source and oxidize it to less toxic nitrites which are the food supply for other biofilter organisms.

***Nitrosomonas* species** — use nitrites as food and oxidize them to nitrates which fish can tolerate to relatively high levels.

Give the eggs and fry their best chance at success. **Set up the aquarium at least a week or more before the eggs arrive** to allow time for the biofilter to grow and develop. Students may ask how biofilter organisms get into the aquarium, especially after dechlorinating the water and disinfecting the entire setup. Several possibilities account for their presence.

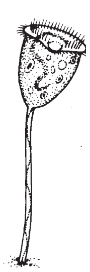
√ Bacteria and tiny one-celled organisms (called **microorganisms**) are found everywhere. They are very numerous, highly adaptable, and reproduce rapidly.

√ Bacteria and other organisms are easily distributed through the air. They quickly recolonize the gravel as it is air dried.

√ Airborne organisms colonize the exposed portions of the aquarium and enter the aquarium's water environment through its surface. This also applies to buckets of water left standing to dechlorinate.

√ Human hands easily transfer microorganisms to the aquarium and its water environment during setup and subsequent monitoring.

√ Introducing eyed eggs into their new aquarium environment adds another source of microorganisms.



√ Dormant stages of some microorganisms are not killed by weak bleach solutions. When fresh water is added, they emerge from their dormant state to live and reproduce.

Although disinfection techniques help reduce the potential for disease organisms in the aquarium, not all forms of bacteria and other one-celled organisms are bad. In fact, we rely on the organisms in the biofilter colonies to keep the aquarium healthy. Commercial products to introduce biofilter colonies are available from some aquarium suppliers.

CARING FOR THE EGGS AND THE INCUBATOR

Monitoring The Incubator

Monitor the aquarium incubator every day. Alleviate potential problems with early detection. Follow a few simple procedures to insure that everything runs smoothly.

Inspection

Do a "walk around" inspection of the incubator and associated equipment **at least twice daily**. First thing in the morning and just before leaving at the end of the day are best. Assign the task to individual students or rotate it among groups of students. Use the example incubator inspection record or students can design one of their own.

Temperature Measurements

Water temperature can indicate possible mechanical and biological problems. Temperature also determines the rate of development which can help you estimate hatch and release dates. Measure and record the temperature at least once daily or measure several times and record an average.

INCUBATOR INSPECTION RECORD

Date: ______________

Temperature (°F/°C): ______________

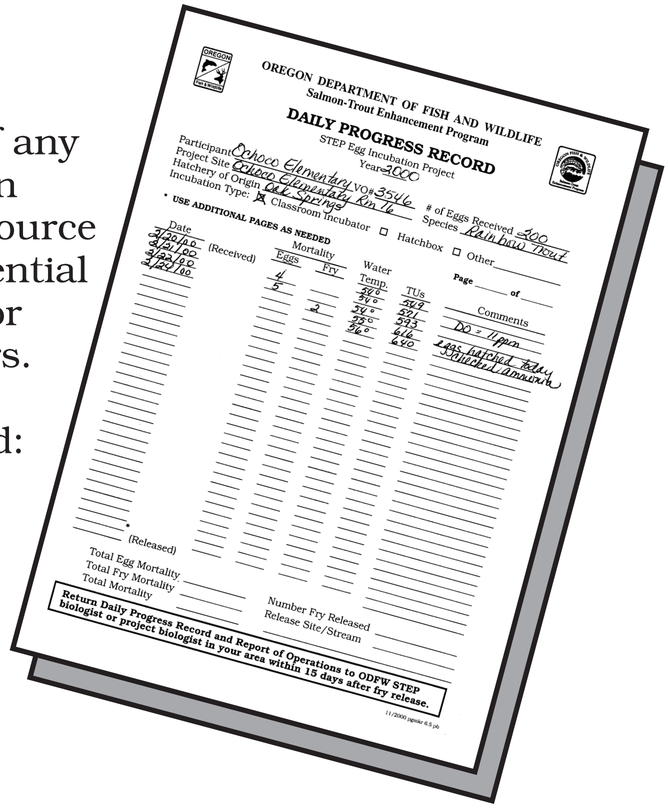
Thermal Units (TU's): ______________

- √ **Chiller unit plugged in (or frozen water jugs exchanged)** ☐
- √ **Powerhead or air pump plugged in** ☐
- √ **Powerhead or air supply operating properly**
  - **- water at correct level** ☐
  - **- even flow** ☐
  - **- bubbles evident** ☐
- √ **Riser Tubes**
  - **- below water level** ☐
- √ **Water**
  - **- clean** ☐
  - **- pH within acceptable range** ☐
- √ **Mortalities picked and recorded** ☐

Inspector's Signature:

____

Record Keeping


OREGON DEPARTMENT OF FISH AND WILDLIFE
Salmon-Trout Enhancement Program
DAILY PROGRESS RECORD
STEP Egg Incubation Project

Participant Ochoco Elementary VO# 3546 Year 2000
Project Site Ochoco Elementary Rm 16 # of Eggs Received 300
Hatchery of Origin Oak Springs Species Rainbow Trout
Incubation Type: ☒ Classroom Incubator ☐ Hatchbox ☐ Other
* USE ADDITIONAL PAGES AS NEEDED Page ___ of ___

Date		Mortality Eggs	Mortality Fry	Water Temp.	TUs	Comments
3/20/00	(Received)	4		48°	569	
3/21/00		5		47°	591	DO = 11ppm
3/22/00			2	54°	593	
3/23/00				55°	616	Eggs hatched today
3/24/00				56°	640	
	(Released)					

Total Egg Mortality ___ Total Fry Mortality ___ Total Mortality ___
Number Fry Released ___ Release Site/Stream ___

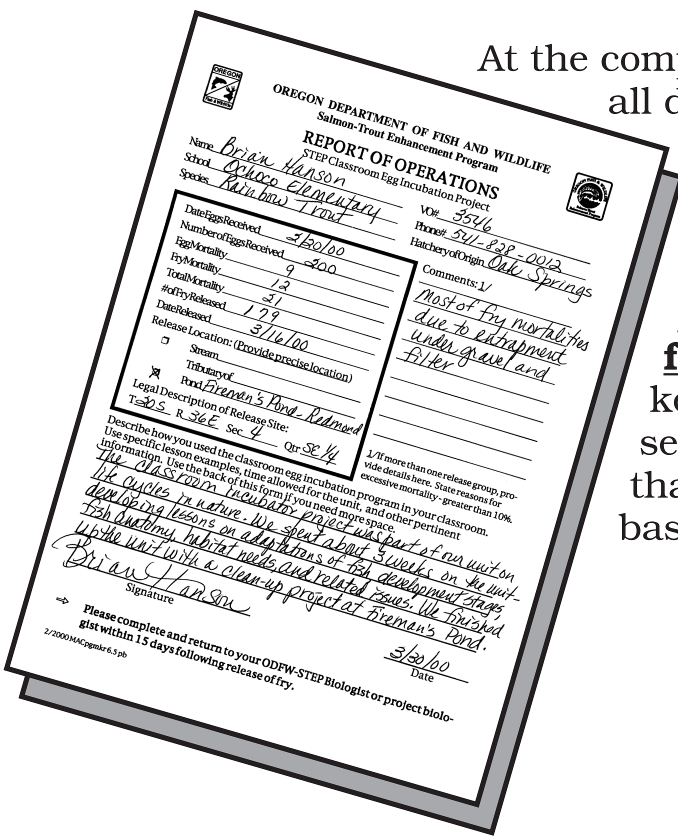
Return Daily Progress Record and Report of Operations to ODFW STEP biologist or project biologist in your area within 15 days after fry release.

Record keeping is a vital component of any incubation project and should be taken seriously. Records are an important source of information for troubleshooting potential problems, for class discussions, and for referencing experiences from past years.

Record EVERYTHING done or observed:

- √ egg numbers
- √ dates
- √ temperatures
- √ problems and solutions
- √ maintenance
- √ water quality measurements
- √ survival and mortality, and
- √ all observations (i.e., when eggs hatch or fry emerge).

Use the daily progress record (page 51) or students can design a form of their own.


OREGON DEPARTMENT OF FISH AND WILDLIFE
Salmon-Trout Enhancement Program
REPORT OF OPERATIONS
STEP Classroom Egg Incubation Project

Name Brian Hanson
School Ochoco Elementary VO# 3546
Species Rainbow Trout Phone# 541-828-0012
Hatchery of Origin Oak Springs

Date Eggs Received 3/20/00
Number of Eggs Received 200
Egg Mortality 9
Fry Mortality 12
Total Mortality 21
# of Fry Released 179
Date Released 3/16/00
Release Location: (Provide precise location)
☐ Stream
Tributary of
☒ Pond Freeman's Pond - Redmond
Legal Description of Release Site:
T 20S R 36E Sec 4 Qtr SE 1/4

Comments:1/ Most of fry mortalities due to entrapment under gravel and filter

1/If more than one release group, provide details here. State reasons for excessive mortality - greater than 10%.

Describe how you used the classroom egg incubation program in your classroom. Use specific lesson examples, time allowed for the unit, and other pertinent information. Use the back of this form if you need more space.
The classroom incubator project was part of our unit on life cycles in nature. We spent about 3 weeks on the unit developing lessons on adaptations of fish, development stages, fish anatomy, habitat needs, and related issues. We finished up the unit with a clean-up project at Freeman's Pond.

Brian Hanson
Signature
3/30/00
Date

Please complete and return to your ODFW-STEP Biologist or project biologist within 15 days following release of fry.

At the completion of the project, summarize all data and record the information on the Report of Operations form (page 52). Send the completed Report of Operations form to your ODFW project biologist **within fifteen days after release of the fry**. Your project biologist must keep records, too. The details you send are used to complete reports that become part of a statewide database of fry release information.

Monitoring Egg Development

Green Eggs In Gravel

At the hatchery, after eggs are taken from female fish and fertilized with milt (sperm) from the male fish, they are soaked in water for at least an hour. During this hardening process, the sticky eggs absorb the water and become firm. These eggs are called **green eggs**. Green eggs are very sensitive. Any rough handling, bumping, or jarring will kill eggs at this tender stage.

Eyed Eggs In Gravel

As the eggs develop, a recognizable set of eyes begins to form in the embryo. The eyes are clearly visible through the egg shell. Although still fragile, **eyed eggs** are stronger. Gentleness is advised as unnecessary handling can still reduce survival. The hatchery informs the project biologist when the eggs are "eyed- up" and ready for your classroom incubator.

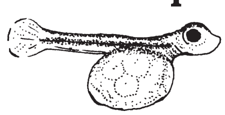
Generally, eyed eggs are delivered to the classroom by a biologist or volunteer, but sometimes the school must make arrangements for someone to pick them up at the hatchery. Placed in wet paper toweling or a small piece of wet burlap, the eggs must be kept cool and moist (but not sitting in water) while in transport. A small lunch cooler works well. Eggs are not transported in water as they quickly use up the available oxygen supply in the water. Avoid jarring or roughness during transport.

When the eggs arrive, carefully unwrap the toweling and allow the eggs to gently drift to the bottom near the front of the aquarium (or float the eggs in a small egg tray as described on pages 58-59). Do not expose the eggs to direct sunlight or fluorescent lighting. Fifteen minutes of prolonged exposure may kill eggs and fry. Remember, in nature the eggs are not exposed to light while buried in the gravel.

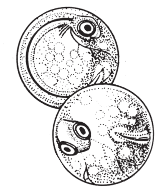
How To Predict A Hatching Date

By keeping daily temperature records, you can monitor egg development to predict approximate hatching dates.

Incubation time is measured in **temperature units (TU)**. A temperature unit is 1° Fahrenheit (F) above 32° F for 24 hours.



Example: Average temperature in a 24-hour period is 50° F. Subtracting 32 from 50 equals 18 (TU's) for that period. Over a 5-day period, 5 x 18 = 90 TU's will accumulate.



1. Take the water temperature at approximately the same time every day (or several times a day and average if you are using a system that does not maintain a constant temperature). Also average Friday and Monday temperatures to obtain temperature for Saturday and Sunday.
2. Record the temperature on a chart similar to the one below.
3. Calculate and record the number of temperature units accumulated each day. (See example on chart below.)
4. Add each day's temperature units to the **total** accumulated from the preceding days. (See example on chart below.)
5. Predict the **approximate** hatch and button-up dates using the information provided on page 29.

Date	Temperature (°F)	Daily Temperature Units (TUs)	Total Accumulated TUs
TUs at time of delivery	-----	-----	350
February 15	50	18	368
February 16	48	16	384
February 17	49	17	401
February 18	51	19	420
February 19	51	19	439
February 20	50	18	457

*** Average of Friday and Monday temperatures**

6. Sometimes the predicted fry release date does not match your school schedule. Hatch and release times can be manipulated somewhat by adjusting water temperature to better fit your timeline. **Remember, any temperature changes must be gradual and avoid temperature extremes**. Ask your students to complete the chart below to determine the best water temperature for your situation. Refer to the example to get started.

Water Temperature (° F)	Approximate # Days To Button-Up
40	
45	
50	
55	
60	

Species:

____

 # TU's At Delivery

____

 # TU's To Release

____

EXAMPLE:

(Note: Although this example is somewhat exaggerated, it clearly demonstrates how temperatures can affect development rates.)

Species:
Rainbow

 # TU's At Delivery
350

 # TU's To Release
770

If you receive rainbow trout eggs at 350 TU's on November 3 and you want to release the fry on December 15 before the holiday break, which temperature would best fit your needs?

To complete the calculations, fill in the details in the box as shown. The approximate number of TU's required for button-up are found in the chart on page 29. Ask the person who delivers the eggs for the species name and how many TU's accumulated at the hatchery. The delivery paperwork also has the information. Calculate the approximate number of days to button-up as shown below:

Calculations:

- √ November 3 to December 15 = 43 days
- √ Water temperature at 40° F equals 40° - 32° or 8 TU's/day
- √ Number of TU's required for development from delivery as eyed eggs to button-up equals 770 - 350 or 420 TU's
- √ 420 TU's divided by 8 TU's per day = **52.5 days**
- √ **This temperature would not work for your timeline. Use a warmer temperature or extend incubation beyond the break.**

READ THIS NOTE

The following table is an APPROXIMATE guideline for development rates. Variations occur:

- among different species of fish
- among stocks within the same species
- between different egg lots of the same stock
- because of water temperature differences at different hatcheries, and
- because of temperature fluctuations in your incubator.

A general rule of thumb is that the COLDER the water, the MORE temperature units are required to reach the various stages of development. Conversely, the WARMER the water, the FASTER the rate of development — up to the point where the water is too warm for fish to survive. Remember: Fish do not rely on mathematics to hatch. The development process is highly variable and it is easy to make calculation mistakes. Build a few extra days into your prediction schedule.

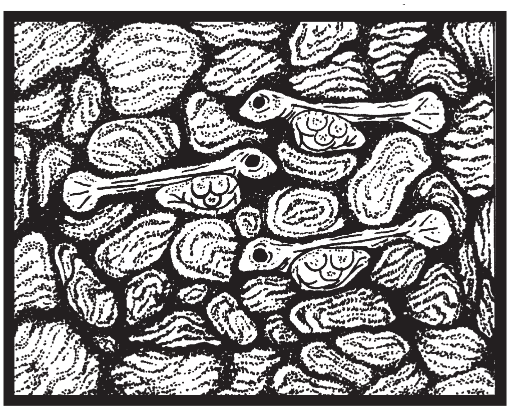
Approximate Development Rates

In Cumulative Temperature Units (TU's)

Species/Stocks	Avg. ° F At Hatchery Source	To Eyed Stage	To Hatch	To Fry Stage (Button-Up)
Spring Chinook	45 - 54	536 - 650	850 - 900	1650 - 1857
Fall Chinook	45 - 50	650 - 704	850 - 983	1590 - 1700
Coho	44 - 47	500	650 - 800	1300 - 1350
Summer Steelhead	48	375	550	950
Winter Steelhead	44 - 48	400 - 480	550 - 700	997 - 1120
Kokanee	50	600 - 650	900	1710
Rainbow Trout	54	305 - 315	600 - 625	750 - 775

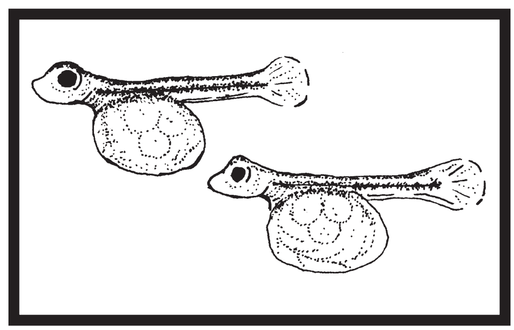
Handling Alevins and Fry

When the eggs are ready to hatch, the embryo produces an enzyme that dissolves the eggshell. During hatching a white foam usually appears on the water's surface. It may turn the water cloudy. The foam is caused by embryonic fluid released from the egg during hatching. Simply remove the foam from the surface with a spoon or dip net and the filter will do the rest. Check the pH carefully at this time. Remove any egg cases that develop fungus. **A one-half to two-thirds water change will improve water quality at this time**.

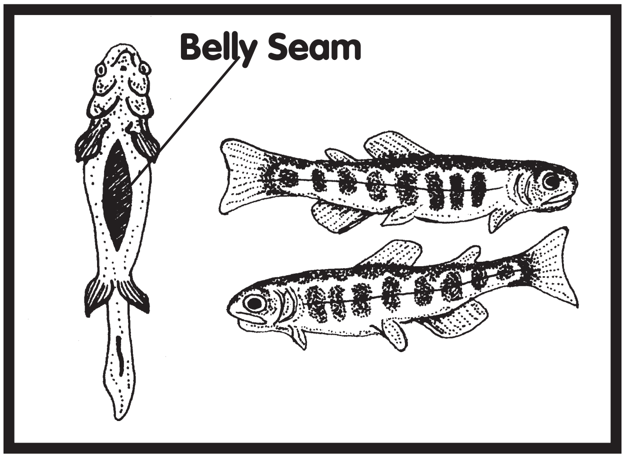

Alevins In Gravel

When the eggs hatch, the alevins (sometimes called sac-fry) will swim into the spaces in the gravel. They will remain there until their yolk sacs are consumed. Alevins are very fragile. Avoid handling them as the yolk sac is easily damaged. Any dead alevins should be removed and the numbers recorded in the "fry" column on the daily progress record. (See example on page 30.)

Check alevins frequently to observe the condition of the yolk sac. As the alevin develops, it absorbs nourishment from the yolk sac. The size of the yolk sac gradually diminishes. Watch the "seam" on the alevin's belly where the yolk sac is attached.


Sac Fry

When the belly seam is about **one millimeter** in width, a small amount of yolk is still present within the body cavity. This amount can sustain the fry for a short time. Place one or two fish in a small jar to closely observe the seam width. When the yolk is no longer visible from either the bottom or side views of the fish and the seam is one millimeter or less in width, the fish are called **buttoned-up** fry. As the yolk sac is absorbed, fry "swim up" to the surface and begin actively searching for food. This takes from five to seven days. Fry are then ready for release. **Do not feed the fry before release**.



Buttoned-Up Fry

Eggs from different females may be different sizes and may mature at different rates, so it is sometimes confusing as to when to release the fry. Inspecting the development stage of one or two fry may not accurately represent the majority of fry in the aquarium.

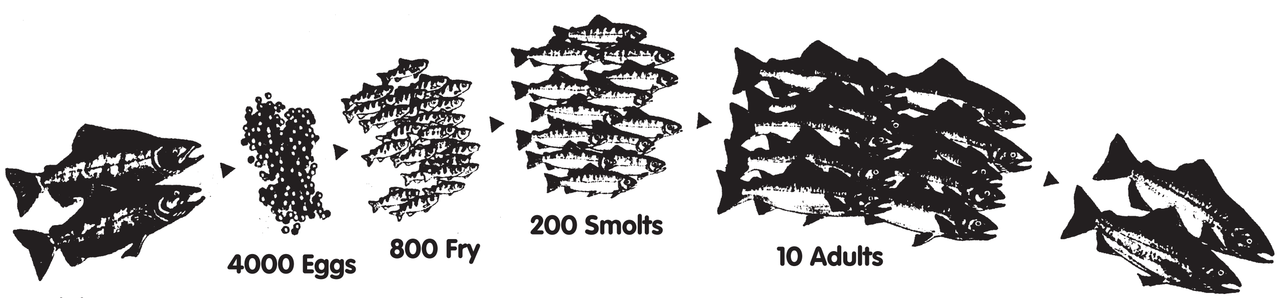
Survival time is short for fry released too early or too late. They must feed before they absorb all of the yolk sac or they will starve and die. It takes some time after release to find a quiet spot to rest and feed, so the fry must be out in the stream before the yolk sac is gone. If released too early, they use up energy swimming and exhaust themselves before they are ready to feed. If unsure about buttoning-up, consult with your ODFW project biologist.

A good rule of thumb is when one-half to two-thirds of the fish have no visible yolk sac and the rest have a very small yolk sac, the fish are ready for release.

Preparing For Fry Release

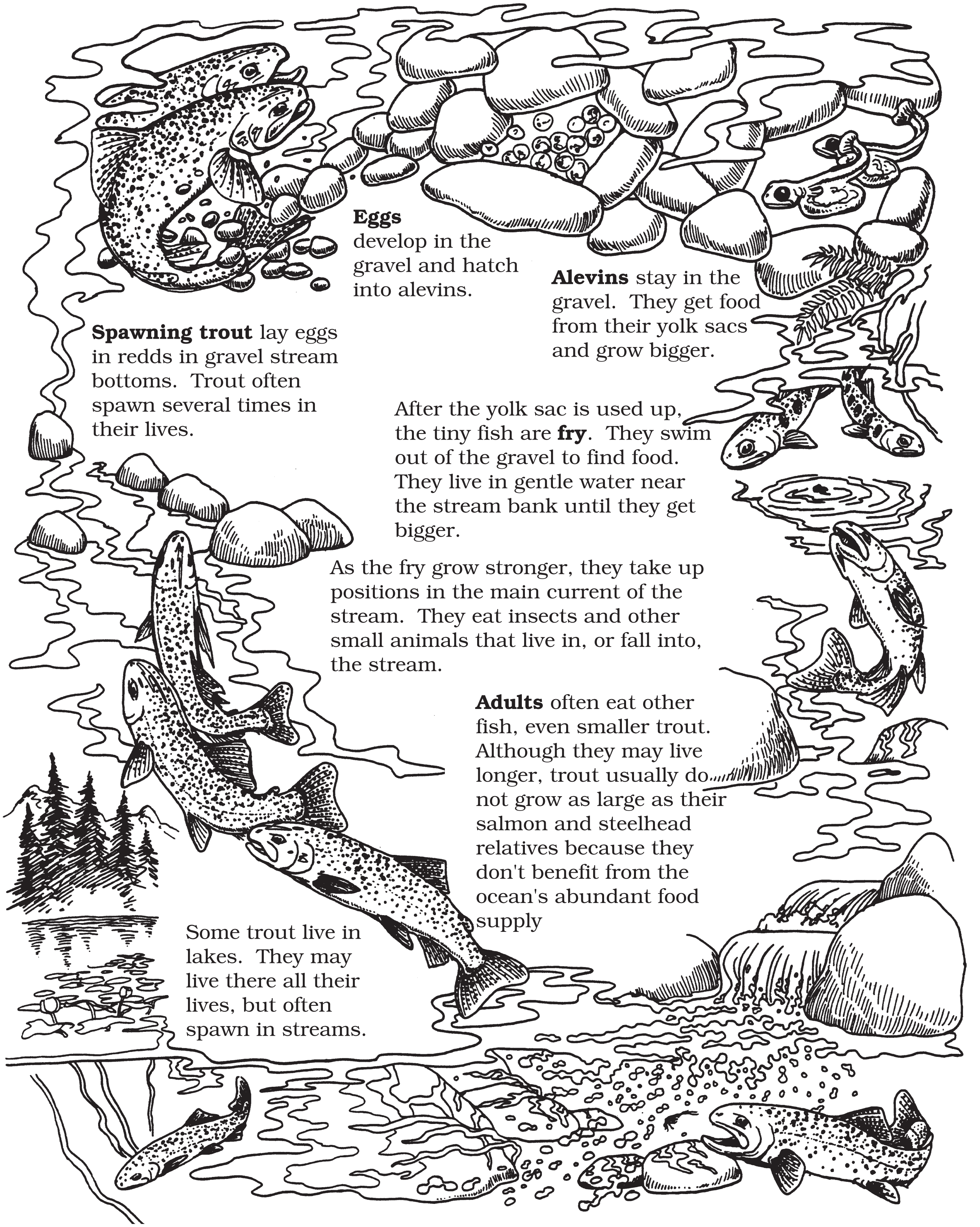
When most of the fry are actively swimming at or near the surface, prepare to release the fish. Begin acclimating the fry to surface light by opening the lid for longer time periods each day.

Approximate Survival Pattern For Pacific Salmon



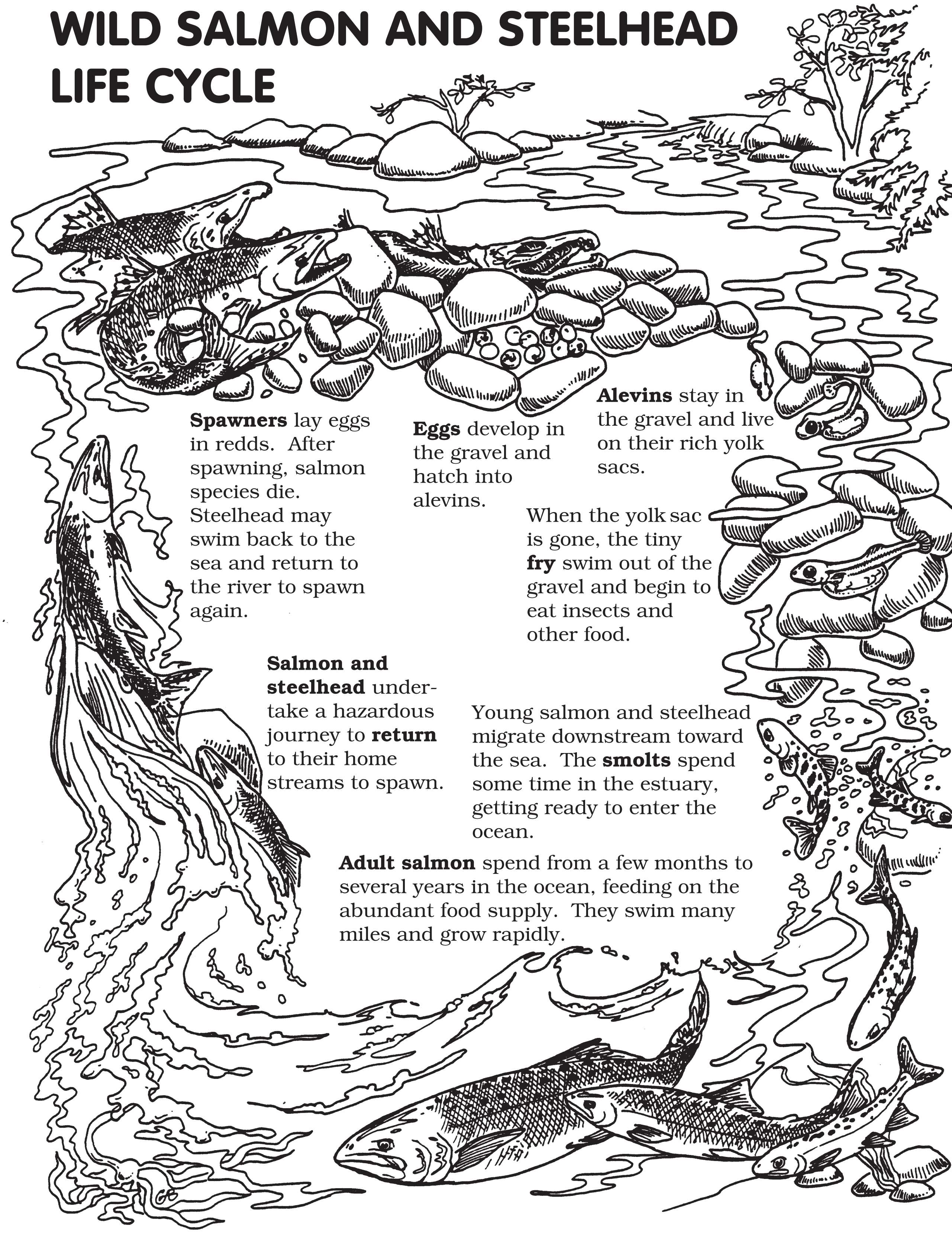
Original artwork, Pacific Salmon Foundation brochure, Vancouver, B.C., Canada.

WILD TROUT LIFE CYCLE



Adapted from original artwork by Gary Bloomfield, *Salmon and Trout Go To School, An Instruction Manual For Hatching Salmon and Trout Eggs In Classroom Aquarium-Incubators* by Diane Higgins, California Department of Fish and Game and American Fisheries Society, Humboldt Chapter, 1996.

WILD SALMON AND STEELHEAD LIFE CYCLE



Spawners lay eggs in redds. After spawning, salmon species die. Steelhead may swim back to the sea and return to the river to spawn again.

Eggs develop in the gravel and hatch into alevins.

Alevins stay in the gravel and live on their rich yolk sacs.

When the yolk sac is gone, the tiny **fry** swim out of the gravel and begin to eat insects and other food.

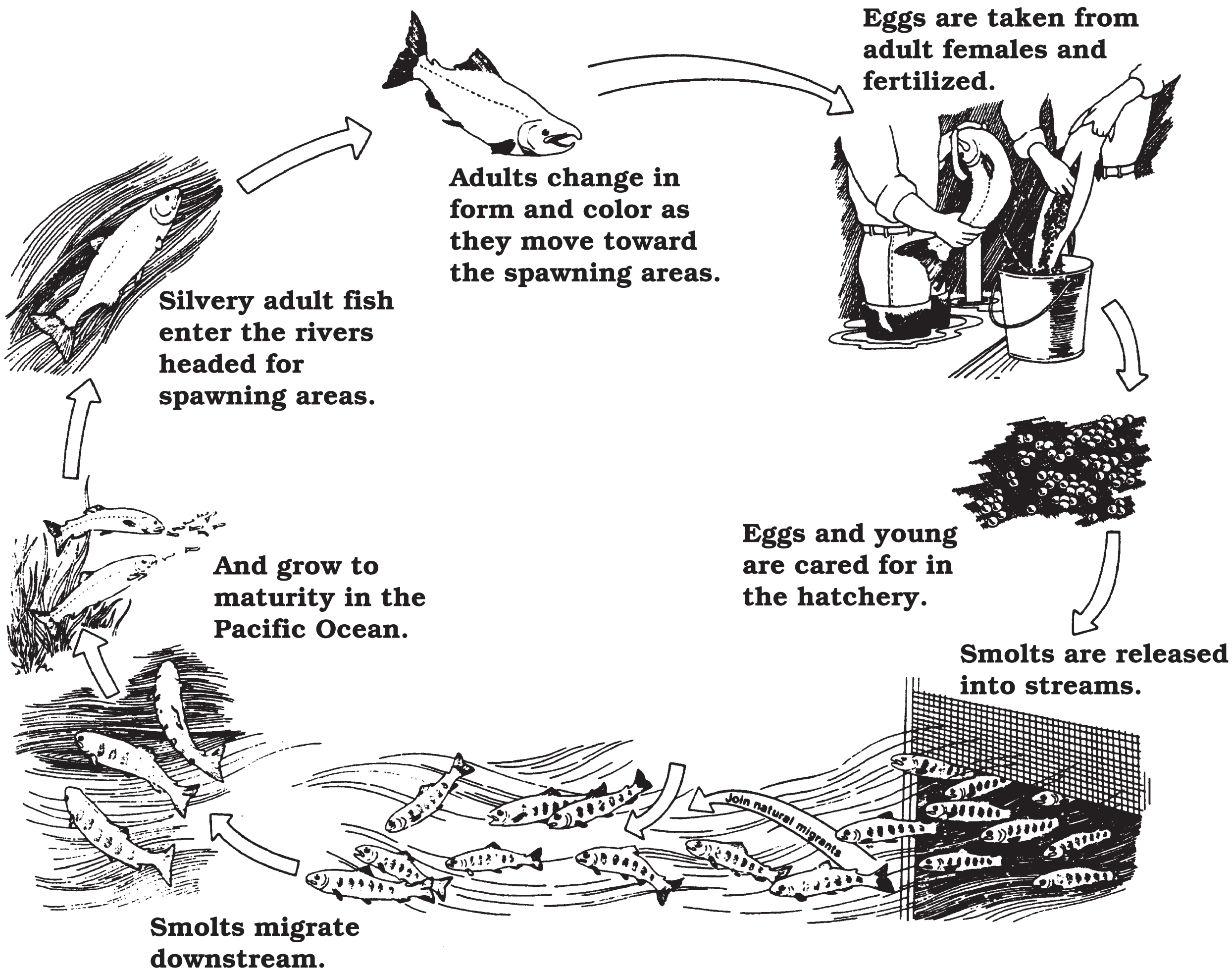
Young salmon and steelhead migrate downstream toward the sea. The **smolts** spend some time in the estuary, getting ready to enter the ocean.

Adult salmon spend from a few months to several years in the ocean, feeding on the abundant food supply. They swim many miles and grow rapidly.

Salmon and steelhead undertake a hazardous journey to **return** to their home streams to spawn.

Adapted from original artwork by Gary Bloomfield, *Salmon and Trout Go To School, An Instruction Manual For Hatching Salmon and Trout Eggs In Classroom Aquarium-Incubators* by Diane Higgins, California Department of Fish and Game and American Fisheries Society, Humboldt Chapter, 1996.

HATCHERY SALMON AND STEELHEAD LIFE CYCLE



Original artwork by Sharon Torvik, *The Fish Hatchery Next Door*, by Bill Hastie, et. al, Oregon Department of Fish and Wildlife, 1995.