

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



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

Second Edition © 2000

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This material will be furnished in alternative format for people with disabilities if needed. Please call 503-872-5265 (voice) or 503-872-5259 (Portland TTY) to request.

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Fish Eggs To Fry is a blend of classroom incubator techniques and ideas shared among schools and aquatic education programs in Oregon, Alaska, California, Washington, and the Canadian province of British Columbia.

Portions of the following publications are adapted or referenced throughout this manual.

- Boye, Bob. 1989. *A Classroom — Community Salmon Enhancement Project, Student's Manual*. Centennial Salmon Project.
- Canada Department of Fisheries and Oceans, British Columbia Public Involvement Program. No date. *A Manual for Classroom Incubation*. Produced for the Salmonid Enhancement Program by Glover Business Communications Ltd.
- Higgins, Diane. 1996. *Salmon and Trout Go To School, An Instruction Manual For Hatching Salmon and Trout Eggs In Classroom Aquarium-Incubators*. California Department of Fish and Game and American Fisheries Society, Humboldt Chapter.
- Kraus, Fritz. 1999. *A Guide to Classroom Salmon Egg Incubation in Alaska*. Alaska Department of Fish and Game, Special Publication No. 99-2, Anchorage.

To supplement the water quality components of a classroom incubator project, additional information was obtained from the following publications.

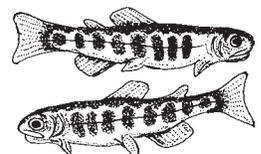
- Furnell, Don, PhD. Malaspina University-College, Nanaimo, British Columbia, *The Biofilter and Aspects of Salmonid Egg and Fry Biology*. Paper presented at Salmonid Enhancement Program's Workshop, May 17, 1997, Victoria, British Columbia.
- Torgerson, Larry O., PhD. No date. *Salmon Hatchery Water Testing Information*, No other information available.

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Tracy George, of Tracy George Graphics, Bend, Oregon, volunteered her time and talent to create most of the artwork for this publication. Gary Bloomfield, Jennifer Stone, Sharon Torvik, David Creekmore, Jamie Cannon, and ClickART Incredible Image Pak 25,000 also provided artwork.

Several generations of Oregon Department of Fish and Wildlife (ODFW) Salmon-Trout Enhancement Program (STEP) biologists provided key input and extensive review of the publication through all of its growing pains and developmental stages. We must also thank the numerous STEP volunteers who go into classrooms throughout Oregon to share their knowledge and commitment to fisheries resources with students. And, thank you to ODFW's Fish Division and the Sport Fish Restoration Program, without whose support this manual and its update would not have been possible.

Patty Bowers, Editor



INTRODUCTION

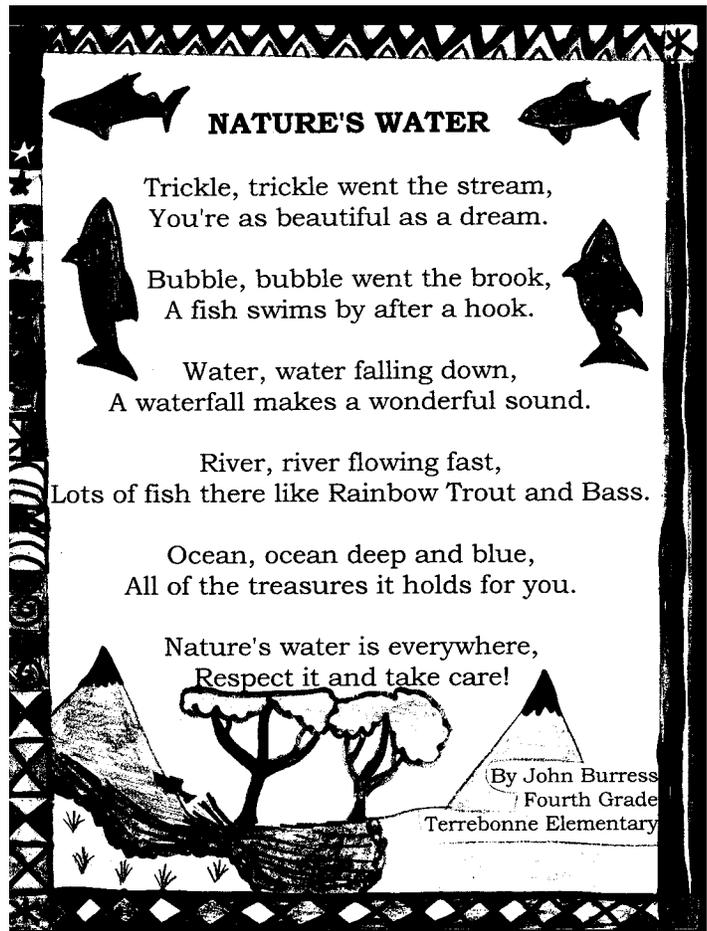
Hatching fish in a classroom is one of those magical activities that . . .

- catches kids' interest in the real world,
- facilitates learning in science and math, and
- can be the nucleus of learning activities in language arts, social studies, and fine arts at any grade level.

Caring daily for the fish as they develop from egg to fry fosters a sense of stewardship for wild things — and where wild things live. And best of all, it's easy, it's fun, and help is available.

This manual provides all the information you need—contact sources, incubator designs, how to monitor egg development, how to release the fry, ideas that connect the project to state education standards, and more!

Read on to discover how easy hatching fish in a classroom incubator can be!



Contributed by John's teacher, Cathy Cron, Terrebonne Elementary School, Terrebonne, Oregon.

This project is a way to motivate and involve 100% of my students — in the classroom and in the field. The students are so involved in every stage and you can see they truly care. I'm learning right along with my kids. Everything has come full circle.

Cathy Cron
Terrebonne Elementary School
Terrebonne, Oregon

Each day two different students put on their white lab coats and become ichthyologists. It is their job to take and record the temperature, test the water for pH, and check for dead eggs. They (the ichthyologists) then share their findings with the rest of the class. This hands-on science education activity helps me teach the state science benchmarks. Understanding life cycle, habitat, adaptations, organisms and their environments, recording and interpreting data are only a few of the benchmarks I was able to teach. We had quite a contest to see who could predict the day that our fish would start hatching. All in all, hatching fish has become an integral part of my science program.

Rayna Nordstrom
John Tuck Elementary School
Redmond, Oregon

This project becomes my students' life! They make sure that everyone who comes into the classroom checks out what's happening, which stage of development the eggs and fry are in, and what the TU's are. One student even expects his parents to postpone leaving for the holidays until we can release the fry.

Tori Anderson
Hines Elementary School
Hines, Oregon

The kids love it! This year's kids already know about it because last year's kids have talked about it so much. When the eggs are here their faces are full of excitement every day. One of the things the kids love to do best is to record what's happening in their journals — checking the progress, taking the temperature, and calculating the TUs. It's a great way to get kids excited about collecting data.

Gary Winter
Jewell Elementary School
Bend, Oregon

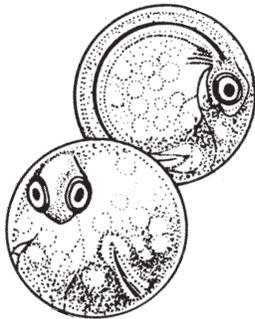
**Welcome To The
Oregon Department of Fish and Wildlife's**

CLASSROOM EGG INCUBATION PROGRAM

Fish egg incubation projects are a popular and valuable classroom education tool. Oregonians have long recognized the importance of the state's fisheries resources and the need for good fisheries education. Hatching fish eggs in a classroom setting helps students learn important concepts while developing caring attitudes about Oregon's native fish species and their habitats.

The classroom egg incubation program is coordinated through ODFW's **Salmon-Trout Enhancement Program (STEP)**. **STEP biologists**, and sometimes other ODFW biologists, serve as the primary local contacts for the program. Each June all local egg requests are funneled through the STEP biologists and the fish districts within a designated watershed. They then become part of the annual agency-wide egg allocation process which occurs each September. Consult pages 44-45 for phone numbers and locations, then call for more information.

Fish Eggs To Fry — part of a support system for the project — is a "how-to" guide:



- √ how to get involved
- √ how to set up the incubator
- √ how to care for the incubator, eggs, and fry
- √ how to predict hatching and release times
- √ how to release the fish
- √ how to troubleshoot
- √ how to record data
- √ how to design a cooling system
- √ how to integrate with state education standards, and
- √ how to locate related teaching resources.

STEP biologists, other ODFW biologists, and volunteers often assist with the classroom incubator program. The support system also includes two curriculum projects currently under development. *An Educator's Resource Guide For Hatching Salmon and Trout In The Classroom* will help you decide what level of involvement is best for your classroom. It tells you how to obtain related curricular resources and provides ideas for building effective lessons around the project. It also suggests how key curriculum resources can help your students meet state-wide education standards in science, math, English, social studies, and career-related learning. Using the workbook approach and creative activities found in *Why Wild? A Fish Genetics Primer For Students*, students can understand the overall concept of conserving Oregon's wild fish species and why their classroom incubator fry are only released in certain water bodies. Delivery of these packages is expected in 2001.

Fish Eggs To Fry describes a basic, easy-to-operate system for fish egg incubation. It is not the only system available. Refer to pages 53-57 for other ideas or develop creative ideas of your own.

Once involved with this project, it is often tempting to increase the number of eggs in your incubator. We commonly assume that "more is better." You can accomplish your teaching goals just as well with a few eggs as with 50,000. Program guidelines allow up to 500 eggs per school, but 200 or less is recommended, based on the size of the aquarium incubator. Just as in a natural environment, the number of eggs and fry an incubator "habitat" can support, its "carrying capacity," is determined by its size and other critical habitat components.



Remember — Your classroom incubator project is not part of a fish-stocking program. It is not intended to enhance existing fish populations or start new ones. Your objectives are to observe and participate in the development process of fish and understand fish habitat needs.

Other outdoor field activities, combined with the classroom egg incubation project, provide important long-term educational benefits. Consider angler education and watershed education (aquatic habitat typing, macroinvertebrate studies, water quality monitoring, and watershed mapping) as possibilities. Biological investigations also provide broad opportunities to incorporate chemistry, ecology, math, economics, writing, and social studies into your lessons. For example, encourage students to discuss the social and economic issues revolving around fisheries resources in Oregon today. For more information about ODFW's watershed and angler education programs, contact the Oregon Department of Fish and Wildlife's Aquatic Education program leader: 503-872-5264 x 5366.

Check with your STEP Biologist or project biologist to locate trained adult or student volunteers interested in helping with your project. Volunteers can help coordinate with your local ODFW contact person, set up the aquarium, deliver the eggs, provide suitable lessons for students, and help with the release. These volunteers are a valuable resource and a wealth of knowledge. Explore how they can fit into your program.

Direct questions regarding program feasibility, egg availability, or other information related to the incubator to your local program contact. See pages 44-45 for contact information.

Enjoy your project!



A Thought From The Past . . .

"The schools have been provided with glass specimen tubes showing the different stages of incubation, and some thirty-five schools in Portland are also furnished annually a few hundred eyed silver salmon eggs which are hatched in the schools as part of the nature study course."

Hugh Mitchell, Director of the Department of Fish Culture, Report of the Fish Commission of the State of Oregon, 1932.

HERE'S THE PROCESS . . .

Use the procedures below to initiate your classroom egg incubation project.

- Contact your local Oregon Department of Fish and Wildlife office for information about the classroom egg incubation project (pages 44-45).
- Review the criteria for egg incubation project participation and project approval (page 49). Prepare **Egg Request** form(s) for your project(s) (page 50) and forward to the nearest STEP biologist or other ODFW biologist assisting with the project. Eggs from different fish species are available at different times. Some are available in one area but not in others. Discuss what is available in your area with the project biologist prior to completing the egg request. Consider that delivery dates for some species of fish may require operation of the incubator during holiday periods. Although the time is often less, plan for six weeks from egg delivery to release. **Complete the Egg Request prior to June 1 for the next school year's project. Plan ahead!**
- The STEP biologist will track your request through the ODFW egg allocation process. You will receive notification about a month before the expected delivery or pick-up date. A copy of the approved Egg Request form with the **designated release site** information noted at the bottom is part of that package. Again, check with your ODFW contact so you know approximately when to expect the eggs to arrive.
- Obtain necessary equipment (see materials list on page 17). Assemble and operate the incubator at least a week prior to egg delivery so the biofilter can develop and to stabilize water chemistry and temperature.
- After receiving eggs, check aquarium daily and record egg or fry losses and other important information on the **Daily Progress Record** (see page 51).
- All fish from classroom incubator projects are released as unfed fry. When the yolk sacs on the sac fry are noticeably smaller, usually about two weeks before release, set a release date. (Release dates can be manipulated somewhat as described on page 28.) Review the release site information on the **Transportation/Release Site Permit** (found at the bottom of your copy of the egg request form). This form also serves as your transportation permit for release of the fry. Plan a visit to the site to address safety concerns and logistics before taking students to the release location.
- Release fry only at approved site(s). **Approved sites provide the greatest opportunity for fry survival while still protecting native fish resources.**
- Complete the **report of operations** form and forward to your local project biologist within 15 days after release of fry. It is also helpful to send a copy of the **daily progress record** at this time (see pages 51-52). The entire process, from egg request through final reporting, is part of ODFW's hatchery management system. **Your data becomes part of ODFW's statewide egg distribution and fry release tracking process. Ultimately, it helps protect fish health and the integrity of native fish stocks.**

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
<ul style="list-style-type: none"> • Limited light (as eggs and alevin) 	<ul style="list-style-type: none"> • Eggs are buried under the gravel in a redd. 	<ul style="list-style-type: none"> • Styrofoam or other types of insulation protect aquarium from direct sunlight and harmful ultraviolet light in classroom (also helps keep water cool).
<ul style="list-style-type: none"> • Cold water (42° - 55° F) 	<ul style="list-style-type: none"> • Snowmelt, water from underground sources, and shade from streamside plants help keep water cool. 	<ul style="list-style-type: none"> • Refrigeration unit (or other water-cooling system) maintains desirable water temperature.
<ul style="list-style-type: none"> • Oxygen (7 - 12 ppm dissolved in water) 	<ul style="list-style-type: none"> • Cold, rushing water gathers and holds oxygen from the air. Aquatic plants also produce oxygen. 	<ul style="list-style-type: none"> • Aeration system adds oxygen and circulates it through an undergravel filter.

Continued on page 9.



EGG/FRY REQUIREMENTS	NATURAL HABITAT	AQUARIUM HABITAT
<ul style="list-style-type: none"> • Clean water (contaminant-free) • pH (6.5 - 7.5) • Gravel • Food • Protection from predators. 	<ul style="list-style-type: none"> • 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. • Runoff from nearby rock and soil types, parking lots, animal wastes, and decaying organic matter in the water all affect pH. • Rocks and gravel are washed into the stream and tumbled smooth by the water and other rocks. Spaces between the gravel are sediment-free. • Aquatic insects that live in the gravel or fall into the water and tiny zooplankton are food items for fry. • 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. 	<ul style="list-style-type: none"> • Dechlorinated water • Undergravel filter, or some other method of filtration, removes wastes and encourages microorganisms in gravel which change harmful ammonia to harmless nitrates. • Proper balance between acidity and alkalinity - optimum is 7.0 (a neutral solution). • Clean gravel is placed into aquarium. • Not provided in aquarium - unfed fry are released into an approved water body. • 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.

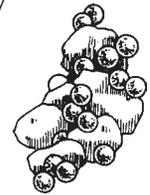
MORE ABOUT THE AQUARIUM

✓ **How large must the aquarium be?**

A 10-gallon aquarium will easily raise 200 eggs to be released as fry. If more eggs are incubated, use a correspondingly larger aquarium.

✓ **How much water circulation is necessary?**

A powerhead or a riser tube attached to an air pump creates sufficient circulation for egg incubation in a 10- or 20- gallon aquarium. Besides circulating the water, the powerhead helps keep the dissolved oxygen at an acceptable level. Water circulation moves waste products (ammonia) away from the eggs and brings freshly oxygenated water in contact with the eggs. Compare egg incubation in your aquarium to that of eggs buried in the gravel of a stream. Clear water flowing through clean, porous gravel provides adequate circulation and oxygenation for the eggs. Heavy siltation reduces circulation and oxygenation and may actually suffocate the eggs in the redd.



✓ **Where do the eggs go?**

Carefully place the eggs on the surface of the gravel to simulate eggs in a redd. Another option is to place some or all of the eggs in a floating tray. It is easier for students to remove dead eggs from a floating tray. You can make a floating egg tray from wood and fiberglass window screening or from a sieve (see pages 58-59 for instructions). Do not use copper nails or staples to attach screening to the wood. The tray must float deep enough in the water to provide adequate oxygenation and water circulation for the eggs.

✓ **Should the water be filtered?**

Although not absolutely necessary, a filter may reduce the need for frequent water changes. A charcoal filter removes some of the waste products and impurities from the aquarium. An undergravel filter works even better by trapping particles as the water is drawn down through the gravel. The microbial community that develops in the gravel layer functions as a biological filter, consuming the deadly ammonia that fish excrete and converting it to a harmless form of nitrogen. You may not need to change the water from the time you receive the eggs until the alevins have absorbed their yolk sacs, but it is likely that ammonia levels will rise in the aquarium following hatching. A change in pH indicates ammonia buildup. This often happens as the embryonic fluids are released and the egg shells begin to decompose. To correct this problem, it is recommended that from one-third to one-half of the water be changed at least once after hatching. Refill the aquarium with dechlorinated water which is the same temperature as the

water in the aquarium. A pH buffering product is also available from an aquarium supply store. Use extreme care when adding buffering agents to avoid a see-saw situation. An undergravel filter is generally sufficient for a 10-gallon aquarium. Use the two kinds of filters in combination if you wish.

✓ **How is the water cooled?**

Overhanging vegetation (trees, shrubs, and grasses), groundwater interaction, and other factors help keep the water in a stream cool. Use one of several options to cool the water in your aquarium. Some are more successful than others. A low-cost option is to use bottles of ice to cool the water. Although somewhat more labor intensive than other options, it is very effective. Another way is to place the aquarium on a shelf inside an operating refrigerator. A powerhead or air pump provides the oxygen and water circulation. Another good choice is a self-contained refrigeration unit which is either purchased or put together by a "do-it-yourselfer." Instructions for these and other ideas are found on pages 53-56.

✓ **What if all of the eggs or fry die?**

Students and adults working with trout and salmon often experience anxiety and some guilt each time an egg or fry dies. Compassion for living things is a positive human response. Deal with it in a straightforward way and use the experience as a teachable moment.

Trout and salmon species survive on the basis of mass reproduction. More eggs and young fish are produced than can possibly survive in a given habitat. In fact, an average of only 10 - 15 percent of the eggs hatch and survive to the fry stage. Many eggs, alevin, and fry die of natural causes under the gravel or in the stream, as they do in a school aquarium. The only difference is the remains are visible in the aquarium. Focus on the fitness of the surviving eggs or fry. Nature's plan dictates that only the most "fit" 1-2 percent of all salmon and trout that hatch survive to produce the next generation.

Eggs and alevins are vulnerable to many dangers. Predators eat fish eggs. Siltation or chemical pollutants choke off the oxygen supply needed by developing eggs. Flooding flushes eggs out of the gravel. Freezing temperatures kill eggs not adequately protected by water flow. Aquatic fungi that decompose dead eggs spread to infect healthy eggs nearby. Another fish may dig up a previously completed redd in a crowded stream, causing eggs to die from abrasion or wash downstream in the current. Accidents happen in the classroom, too. Someone may unplug the air supply or the pH may drop too low. If a few, or even all of your eggs or fry die, remind students that fish are sensitive to environmental conditions and it is difficult to raise them in an artificial environment.



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 temperature 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.

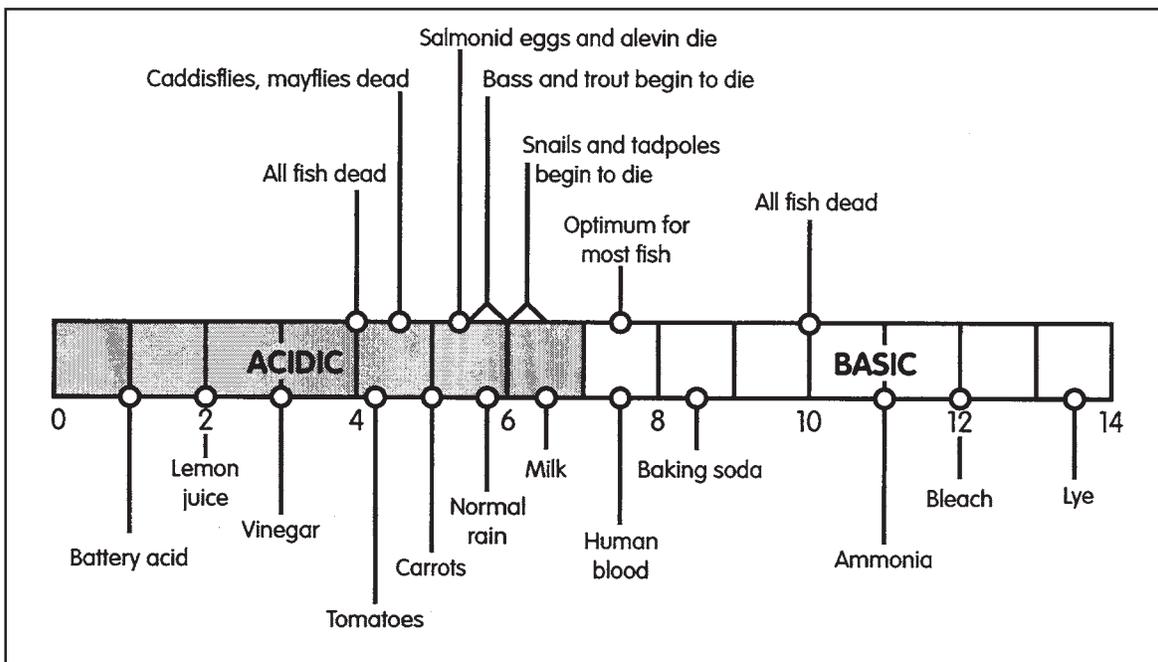
It's 7 for H₂O, if in a pure state
But rain water is 6 and sea water is 8.

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.

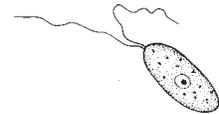
Bacterial Heterotrophs — consume microscopic food particles and feces. They release carbon dioxide and ammonia.

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.



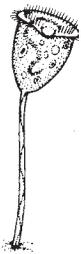
✓ Bacteria and other organisms are easily distributed through the air. They quickly recolonize the gravel as it is air dried.

✓ 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.

HERE'S WHAT YOU WILL NEED . . .

Materials List

Aquarium & Filter System

(items required depend on air circulation system chosen)

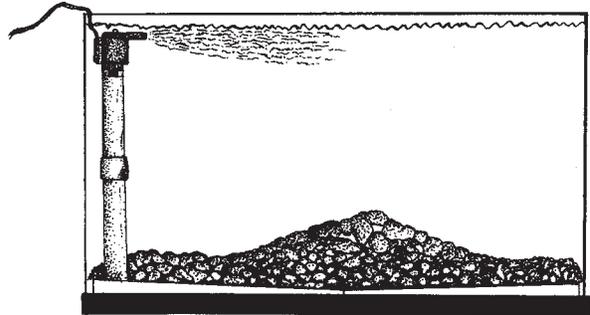
- * 10-gallon or larger aquarium
- * glass or plexiglass cover for top of aquarium
- * undergravel or other filter/1 or 2 riser tubes (with built-in charcoal filter units)
- * 2 air stones (only with pump)
- * 3-way (or simple T) gang valve (4-way if corner filter is used)
- * air pump or powerhead appropriate for aquarium size (air pump can be backup device)
- * corner filter, activated charcoal, filter floss (optional, but may not be adequate by itself)
- * air line tubing (only with pump)
- * enough pea-sized gravel (or standard aquarium gravel) to provide 2" layer over undergravel filter
- * a few handfuls of rounded rocks 1 1/2" to 3" in size

Cooling System

(items required depend on cooling system chosen)

- * 1 1/2" thick foil-faced (both sides) styrofoam or other insulation
- * duct tape
- * at least 4 frozen water bottles (if using low-cost cooling option or as emergency backup)
- * 4 plastic gallon milk jugs

- * refrigerator (inside dimension must be large enough to accommodate aquarium) or other cooling unit (see pages 54-56)



Tools

- * thermometer
- * egg tray (optional, pages 58-59)
- * small dipnet
- * "egg picker" (see page 30, or use a turkey baster)
- * pH, dissolved oxygen, and ammonia test kits (optional, but recommended)
- * dechlorination chemical

Other

- * several 5-gallon buckets with lids
- * battery-operated air pump with airstone and tubing to supply oxygen during fry transport
- * one-hand priming siphon hose
- * extension cord to reach power supply
- * daily progress record or other log for recording data
- * related curriculum and support resources (see pages 83-93)

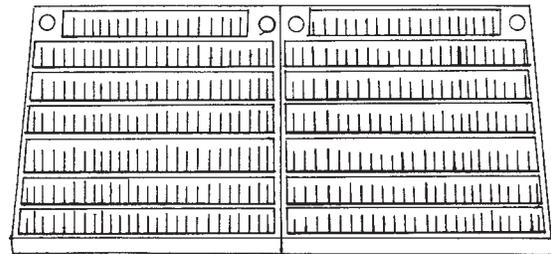
HOW TO ASSEMBLE YOUR AQUARIUM . . .

1. Clean the aquarium, gravel, rocks, and previously used equipment.

- a. Thoroughly wash the aquarium, gravel, rocks, and any previously used equipment. This includes undergravel filter, riser tubes, powerhead, tubing, thermometer, nets, buckets, egg tray, egg picker and any other equipment that will contact the aquarium water. A 1:400 bleach rinse solution is recommended for disinfection. **Rinse with clean water several times, especially if detergents are used.** Thoroughly wash the gravel and rocks with clean water only.
- b. Completely fill the aquarium with water and let stand for a few days to check for leaks. Drain the aquarium.

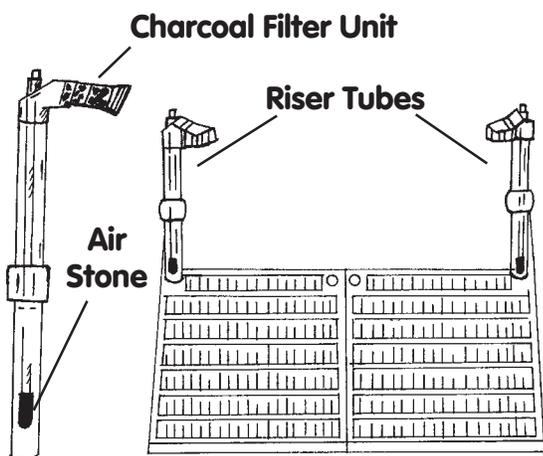
2. Assemble the undergravel filter system.

- a. Clip together the two undergravel filter plates according to package directions.
- b. Place the assembly in the aquarium.



Undergravel Filter Plates

3. Assemble the riser tubes.



Undergravel Filter With Riser Tubes

- a. Assemble riser tubes according to the package illustration. Cut to shorten if necessary.

Only one riser tube, minus its charcoal filter, is necessary when using a powerhead for water circulation.

- b. Place the riser tubes in the slots at the back of the undergravel filter, with the outflow opening in the tubes facing into the center of the tank. **Plug any unused slots in the undergravel filter.**

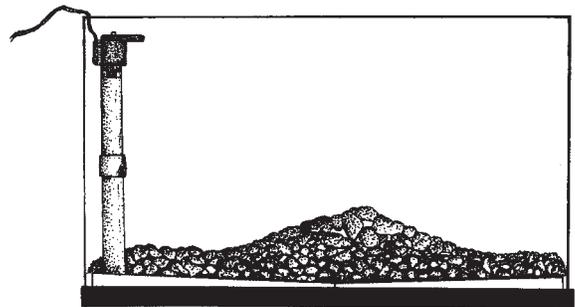
- c. If using an air pump, the top of the riser tubes should be approximately one inch below the top of the aquarium. **When using frozen water jugs, lower the riser tubes even more to allow for water displacement.**

4. Add the aquarium gravel.

- a. Rinse the gravel thoroughly to remove fine particles.
- b. Spread the gravel about two inches deep over the undergravel filter. Mound the gravel toward the front of the aquarium to simulate a redd.
- c. Make sure all access to the undergravel filter is covered to prevent alevins or fry from getting trapped under it.
- d. Add a corner filter if desired. Follow manufacturer's instructions for assembly. Change the filter floss as it becomes soiled.
- e. Add a few larger rocks near the front of the aquarium to simulate a cross-sectional view of a redd in the stream bottom.

5. Connect the air supply.

Several options are available for connecting an air supply to an aquarium. A powerhead (recommended) and an air pump are described here.



Aquarium Set-up With Powerhead

Powerhead:

- a. Fit the powerhead snugly into the riser tube and secure it to the tank. If the powerhead fits loosely, wrap black electrical tape around the powerhead intake before fitting it into the riser tube. Or, cut a small piece of one-inch (inside diameter) flexible Tygon tubing. Slide it over the top of the riser tube, leaving an extension. Then slip the powerhead intake tube securely into the Tygon tube extension.
- b. Follow manufacturer's instructions for proper water level once the powerhead is installed. Generally, the water level will be just above or slightly below the opening of the outflow tube. Some powerheads have a line marked on the outside of the unit to indicate proper water level.
- c. Once the unit is operating, adjust air flow for the size of the aquarium.

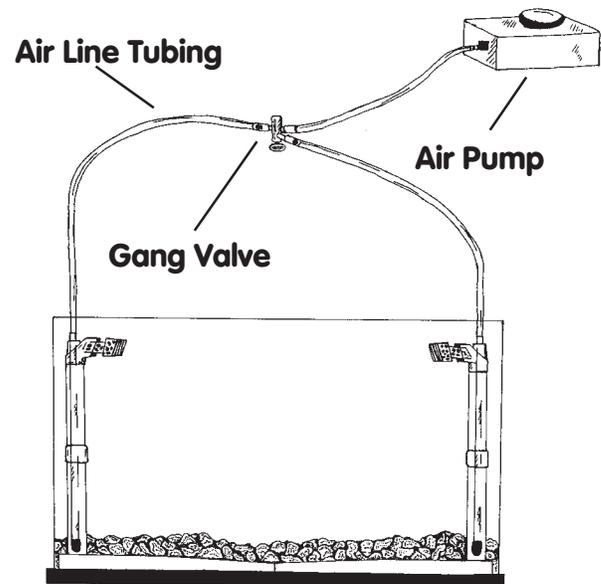
Air Pump:

- a. Cut three lengths of air line tubing and connect:
 - 1) gang valve to one riser tube
 - 2) gang valve to second riser tube
 - 3) air pump to gang valve

Note: If a corner filter is added, use a four-way gang valve.

- b. The air line is very important. It circulates water as well as oxygenating it. Circulation, caused by rising bubbles in the riser tubes, cools and filters the water.

- c. If the pump is not operated above the aquarium, an anti-backflow valve (between the gang valve and pump) will protect the pump from water damage in the event of a power failure.



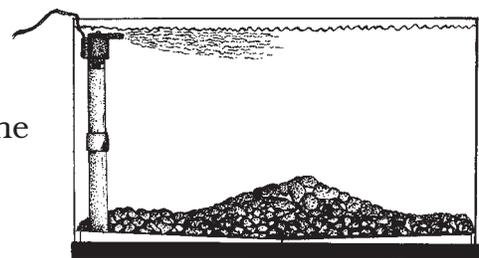
Aquarium Set-Up With Air Pump

SAFETY Reminder:

To avoid the possibility of the unit's plug (either air pump or powerhead) getting wet, position incubator to one side of the wall socket. Arrange a "drip loop" in the cord. The "drip loop" is that part of the cord that hangs **below the level of the socket**. If water travels along the cord, it will drip off at the loop, preventing it from coming into contact with the socket.

6. Fill the aquarium.

- a. Fill the aquarium with dechlorinated water so that its level is to the line indicated on the powerhead or one or two inches above the outflow from the riser tubes. If using tap water let it stand for 24 hours to dissipate the chlorine, or add dechlorinating chemicals to the water.



Aquarium Set-Up With Water

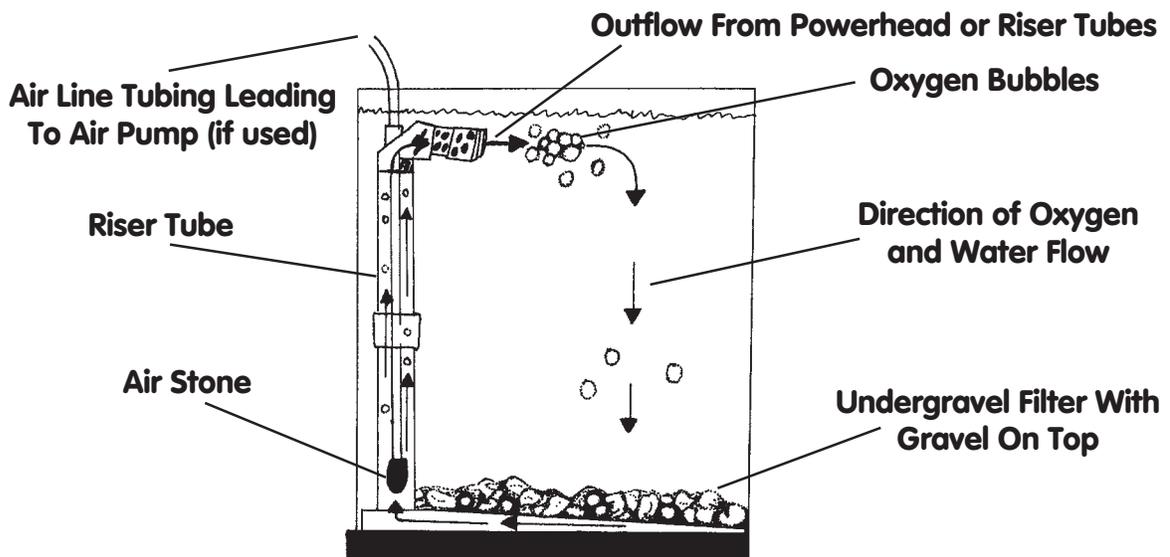
- b. An insulating cover helps keep the aquarium's water temperature between 42° and 55° F. Measure and cut foil-covered styrofoam insulation to fit over the glass on all four sides. Cut another piece for a cover. Connect the back and side pieces with duct tape or sticky-back Velcro. Tape all exposed foam edges. The cover must lay flat. Notch a small opening on the bottom side of the cover for the air line. To observe egg development with minimal disturbance, cut a viewing door in the front piece of

styrofoam. Use a piece of duct tape as a hinge. Metallic roll insulation also works well. Use sticky-back Velcro tabs to hook it together at the sides. The Velcro opens easily for viewing.

Note: Insulation is not necessary if aquarium is placed in a refrigerator or if using a chiller unit.

- c. Locate the aquarium in a quiet corner where it will receive little or no heat or bright light, unnecessary handling, or other disturbances such as bumping or jarring. If using a chiller unit, place it beside or below the aquarium. Connect the cooling device (or use the "low-cost" cooling unit described on page 55. If using a refrigerator or other enclosed cooling unit, place the aquarium setup on a shelf. Make sure all electrical connections are secure and safe.
- d. If possible, position the air pump higher than the gang valve to avoid water reversal and damage in the event of a power failure, or install an in-line anti-backflow valve.
- e. Connect the powerhead or air pump to a power supply and run continuously. The air supply helps circulate water through the undergravel filter and oxygen throughout the tank. Make sure the cooling and aeration system connections cannot easily be disconnected. Leave your phone number with the custodian. This person can be your best friend when it is time to install your aquarium and monitor its progress on weekends and after school. Explain your project and its objectives. Alert the custodians or other maintenance personnel that your project requires an uninterrupted power supply throughout the life of the project.

How Air And Water Circulate In The Aquarium

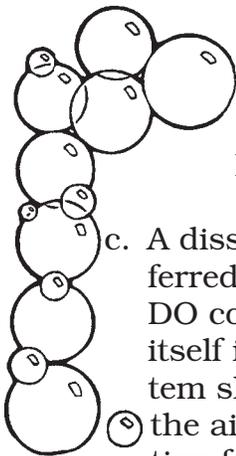


- f. If using a powerhead, adjust it so that bubbles (aeration) are evident and that water is circulating through the system. If using an air pump, check the gang valve or T-valve to make sure equal amounts of air flow to each of the riser tubes.

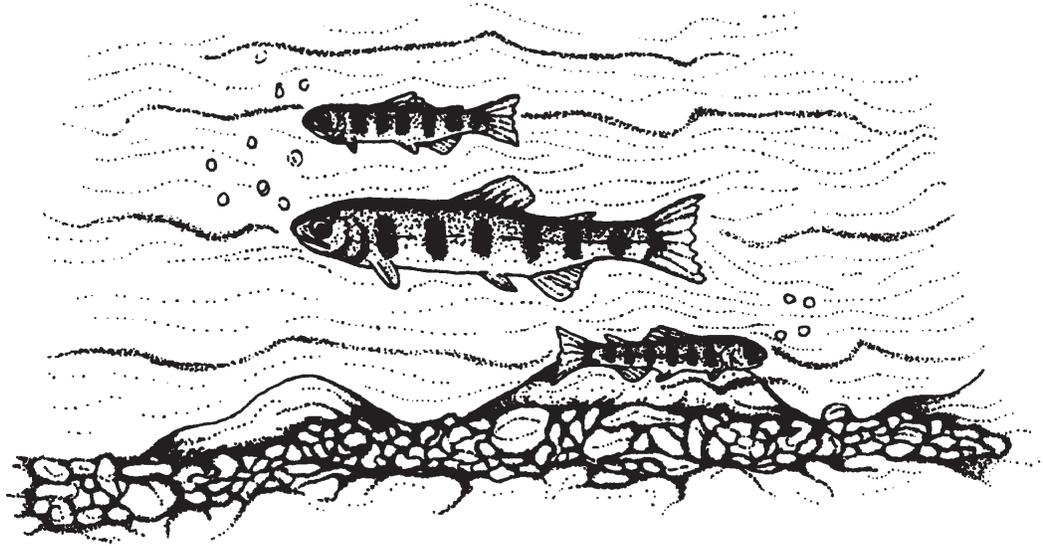
7. Monitor the system.

- a. Allow the system to operate for a week or longer prior to receiving eggs. Confirm that the system is operating properly by monitoring the temperature, dissolved oxygen, and pH (test kits are available at local aquarium supply stores). Be sure these water chemistry parameters are stable and match the guidelines described on pages 8 and 9 **BEFORE** the eggs arrive. Operation time prior to adding eggs also gives the biological filter a chance to develop.
- b. Stabilize the aquarium's temperature between 42° and 55° F by adjusting the cooling unit thermostat or temperature control of the refrigerator (if used). Avoid radical fluctuations in temperature over a short period of time. A rapid 10° F temperature change can shock and kill eggs. Never make water temperature adjustments prior to leaving for the day. Minor fluctuation is normally not a problem. Fluctuations are more frequent when using the low-cost cooling method described on page 53, but are still not usually harmful.

Optimum water temperature for egg and fry development is 50° F. Fish are cold-blooded animals. Their metabolic rate is affected by the surrounding water temperature. Egg development will occur considerably slower below 50°. Conversely, higher temperatures will speed it up. To better fit school vacations, hatching time can be manipulated somewhat with temperature regulation, but remember that egg and fry development will not occur when temperatures are too hot or too cold.



- c. A dissolved oxygen (DO) content of 12 parts per million (ppm) is preferred, but 7 - 12 ppm is acceptable. Use a water test kit to evaluate DO content. Although this is a valuable learning exercise, the testing itself is not critical to the project. A properly functioning air supply system should provide sufficient oxygen. If using an air pump, make sure the air stones are working properly, providing both oxygen and circulation for the tank.
- d. The pH range should fall between 6.5 - 7.5. The optimum pH is 7.0, with numbers below 7 in the acidic range and numbers above 7 in the alkaline or basic range. pH levels vary widely in the waters of the state; for example, normal pH values in southeastern Oregon may reach 8.0.



Other areas may commonly have pH values approaching 6.0. **If you choose to use buffering products to adjust the pH, do so cautiously. Remember, a change in pH value from one number to the next is a tenfold change in the acidity or alkalinity of the solution.** Use a water test kit or pH paper to measure pH. Carefully monitor pH when the eggs start hatching.

- e. Add small amounts of dechlorinated water to the aquarium as evaporation lowers the water level below the outflow of the powerhead or riser tubes. The water you add must be the same temperature as that in the aquarium. Keep a container of dechlorinated water at the correct temperature ready to add when necessary. Avoid disturbing eggs or fry when adding water.

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)	<input type="checkbox"/>
√ Powerhead or air pump plugged in	<input type="checkbox"/>
√ Powerhead or air supply operating properly	
- water at correct level	<input type="checkbox"/>
- even flow	<input type="checkbox"/>
- bubbles evident	<input type="checkbox"/>
√ Riser Tubes	
- below water level	<input type="checkbox"/>
√ Water	
- clean	<input type="checkbox"/>
- pH within acceptable range	<input type="checkbox"/>
√ Mortalities picked and recorded	<input type="checkbox"/>

Inspector's Signature:	_____

Record Keeping

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.

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

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.



Green Eggs In Gravel



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.

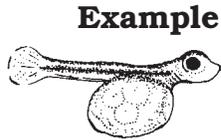
Placed in wet paper toweling or a small piece of wet burlap, the eggs must be kept cool and moist (but not sitting in water) while in transport. A small lunch cooler works well. Eggs are not transported in water as they quickly use up the available oxygen supply in the water. Avoid jarring or roughness 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.)

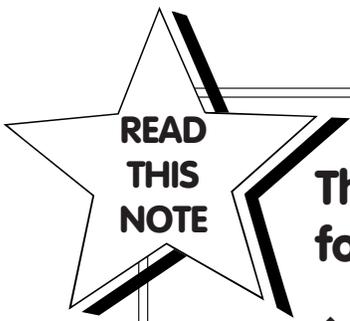
Species: <i>Rainbow</i>
TU's At Delivery <i>350</i>
TU's To Release <i>770</i>

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.**



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.

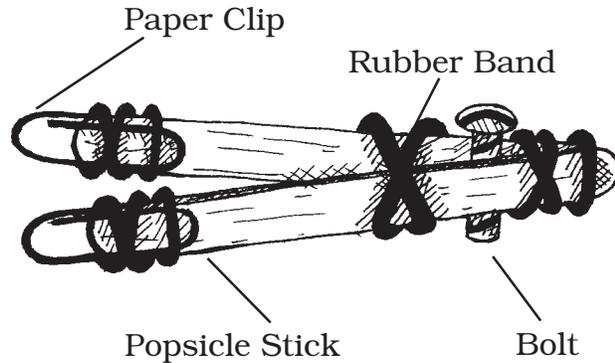
Approximate Development Rates In Cumulative Temperature Units (TU's)

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

Checking Eggs During Incubation

Check the incubator daily for dead eggs. Even if your incubator is working perfectly, some eggs may die. Live eggs are pink or orange in color. They change to a milky white color when dead. A fungus quickly forms on dead eggs as they begin to decay. Remove dead eggs to prevent the growth and spread of fungus to the other live eggs.

Use a turkey baster or make a simple tweezer-like tool for egg removal. Use a rubber band to attach a paper clip to a popsicle stick. Allow the paper clip to extend about one-half inch beyond the popsicle stick. Repeat with a second popsicle stick. Connect the two popsicle sticks with another rubber band on the end opposite the paper clips. Insert a small bolt (about 1/8 inch in diameter) between the two sticks. Place another rubber band below the bolt. Move the bolt up or down to adjust the tension. The arrangement should work like a set of tongs. Use the paper clip end loops to gently pick out any dead eggs.



Keep a count of all dead eggs removed and record on the **Daily Progress Record** (see example below and on page 51).



OREGON DEPARTMENT OF FISH AND WILDLIFE
Salmon-Trout Enhancement Program



DAILY PROGRESS RECORD
 STEP Egg Incubation Project
 Year 2000

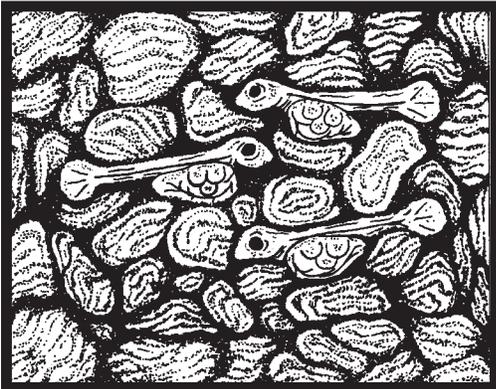
Participant Ochoco Elementary VO# 3546 # of Eggs Received 200
 Project Site Ochoco Elementary Rm 16 Species Rainbow Trout
 Hatchery of Origin Oak Springs
 Incubation Type: Classroom Incubator Hatchbox Other _____

* USE ADDITIONAL PAGES AS NEEDED Page _____ of _____

Date	Mortality	Water		TUs	Comments
		Eggs	Fry		
<u>3/20/00</u> (Received)				<u>54°</u>	
<u>3/21/00</u>	<u>4</u>			<u>54°</u>	
<u>3/22/00</u>	<u>5</u>			<u>54°</u>	
<u>3/24/00</u>		<u>2</u>		<u>55°</u>	<u>eggs hatched today</u>
				<u>56°</u>	<u>Checked ammonia</u>

Handling Alevins and Fry

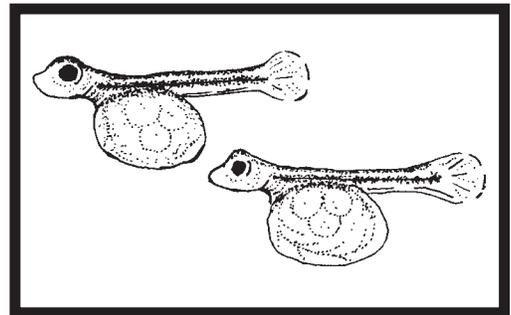
When the eggs are ready to hatch, the embryo produces an enzyme that dissolves the eggshell. During hatching a white foam usually appears on the water's surface. It may turn the water cloudy. The foam is caused by embryonic fluid released from the egg during hatching. Simply remove the foam from the 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

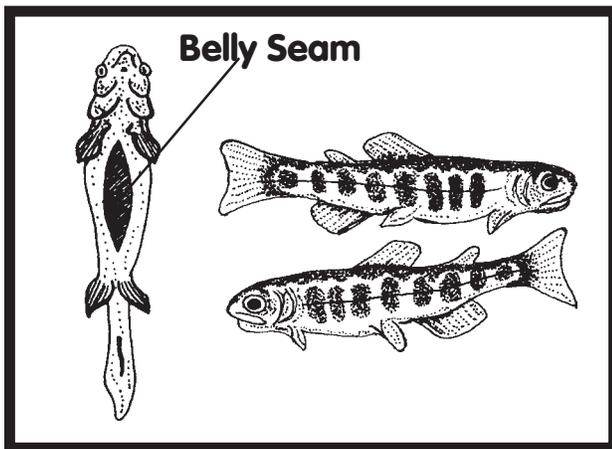
When the eggs hatch, the alevins (sometimes called sac-fry) will swim into the spaces in the gravel. They will remain there until their yolk sacs are consumed. Alevins are very fragile. Avoid handling them as the yolk sac is easily damaged. Any dead alevins should be removed and the numbers recorded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

lease 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.

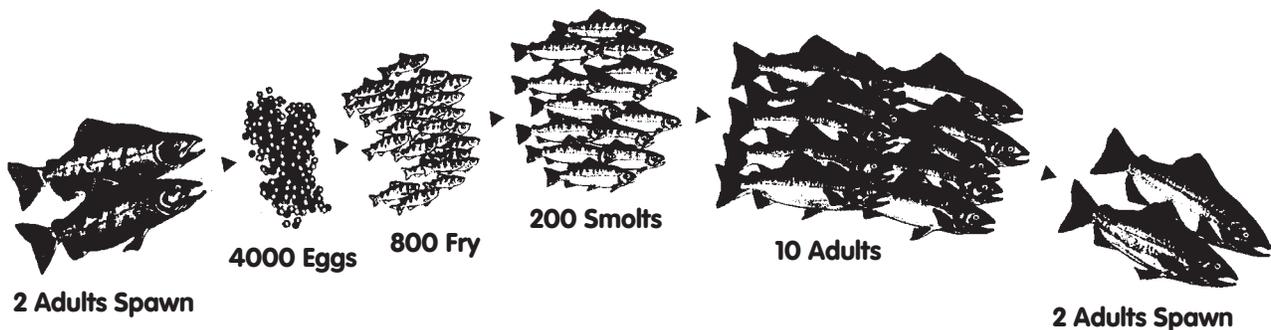


A good rule of thumb is when one-half to two-thirds of the fish have no visible yolk sac and the rest have a very small yolk sac, the fish are ready for release.

Preparing For Fry Release

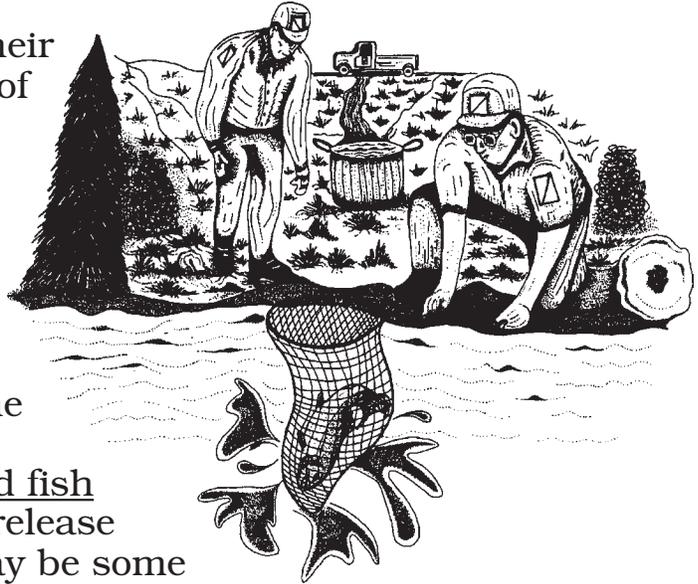
When most of the fry are actively swimming at or near the surface, prepare to release the fish. Begin acclimating the fry to surface light by opening the lid for longer time periods each day.

Approximate Survival Pattern For Pacific Salmon



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

- √ Students often express concern about the ability of their fish to survive once released. Use this as an opportunity to discuss potential threats to fry survival in a natural habitat. Help students understand the percentage of fry that survive to adult fish is determined by many factors. These include predation (by birds, other fish, and many other animals), pollution, unfavorable water temperatures, food availability, cover, living space, inadequate or excessive stream flows, excessive siltation, obstacles to migration, ocean environmental conditions, and competition with other fish (wild or hatchery).
- √ Although students will release their fry into a natural environment, it is important they understand this project is not part of a fish-stocking program. Reiterate the goals of your project to observe and participate in the development process of fish and to understand fish habitat needs.
- √ Help students understand their project is possible because of approval from the Oregon Department of Fish and Wildlife. ODFW has responsibility for managing the state's fish and wildlife resources. ODFW biologists choose release sites for your fish that provide the greatest opportunity for fry survival, yet protect the wild fish resources. That's why the release site chosen for your fish may be some distance from the school.
- √ Visit the release site prior to the release day. Evaluate the site for safe bus access, conditions along the edges of the water for safe student access, slow water areas with cover for fish release, and where students will create the least impact while releasing the fish. Make every effort to reduce the potential for accidents. Look for other possibilities to expand the lessons about good fish habitat — identifying plants along the edge of the water, collecting aquatic insects, and identifying habitat components within a stream (riffles, pools, cover, etc.).



- ✓ During very dry conditions the release site may not have water. Or it may be frozen over and access may be blocked by snow during fall release times. These are more good reasons to check the release site prior to the trip with students. In the case of ice, bring along an ice auger or other device for breaking through the ice. Enlist volunteers to help with this process. **Do not use an alternate site without approval from your ODFW project biologist.**
- ✓ Recruit parents or volunteers from local anglers' clubs or community organizations to help with release day activities.

Releasing The Fry

- ✓ **Release fish only in the approved release site shown on the Transportation/Release Site Permit found at the bottom of your approved egg request form (see example).** Show students the authorization form and discuss the reasons for its conditions. This is also a good time to discuss the impacts (spreading diseases and genetic interactions) when unauthorized people move fish or other aquatic organisms from one body of water to another. Have students read and discuss "Managing For Fish and Fishers" found on page 77 which discusses the value of wild fish populations, the role of hatcheries in Oregon's fisheries, and how the role of hatcheries is changing to complement wild fish populations.

OREGON DEPARTMENT OF FISH AND WILDLIFE
 Salmon-Trout Enhancement Program
 Classroom Egg Incubation Project
 Egg Request Application And Transport Permit

Name: Brian Hanson
 Address: 226 S. Cocheco Elementary
 City: Prineville State: OR Zip: 97754
 Work Phone: 541-822-0023 Home Phone: 541-666-6666 Fax: 541-822-0014
 Email: egghead@rivr.com

Species/Stock Requested: winter rainbow

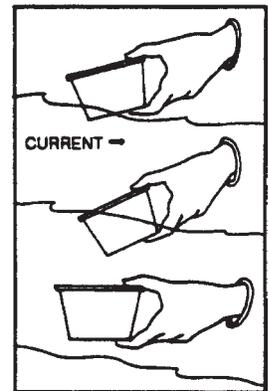
I agree to comply with the following permit conditions:
 1. Related fisheries lessons must focus on the project. Please describe on back of this form.
 2. Fish shall be handled only in the location shown on the permit.
 3. All fish from classroom incubation projects will be returned on school property.
 4. The fish shall be returned to the project biologist or project biologist if the location is shown on the permit.
 5. All fish shall be returned to the project biologist or project biologist if the location is shown on the permit.
 6. All fish shall be returned to the project biologist or project biologist if the location is shown on the permit.

Signature of Applicant: Brian Hanson

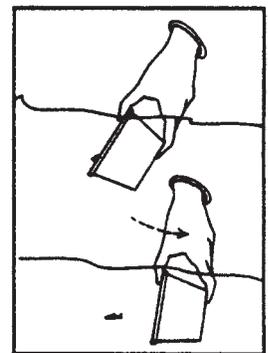
TRANSPORTATION/RELEASE SITE PERMIT: (ODFW will complete after approval.)
 The above participant is authorized to transport and release fish from a STEP egg incubation project only at the following location(s):
 Species: RB
 Location (s): Fireman's Pond - Redmond
 Authorized ODFW Representative: Ditty Bowers Date: 2/20/00
 * It is unlawful to transport and/or release fish in other than above designated location(s).

- √ If fish are transported in pails, buckets, or portable tankers, do not overload the containers. Use aeration to insure adequate oxygen supply. (Aeration may not be necessary for short trips.) Make sure the containers have lids so the fry do not splash out. Contact your project biologist for advice.
- √ Keep the fry as cool as possible during transport and avoid any rough handling. If the outside temperature is warm, small blocks of dechlorinated ice or ice cubes can be floated in the container to keep the water cool during transport.
- √ When you arrive at the release site, place the buckets in the water. Wait about 10 minutes for the temperature to equalize or slowly add water to the bucket, letting it sit for a few minutes after each addition. (*This is a good time to involve students. Hand out cups to each student and ask them, one at a time, to add a cup of release site water into the bucket. Repeat if needed.*) **Do not shock the fish. Use your thermometer to avoid temperature changes greater than 5° F.** While waiting, ask students to observe the area. Ask them to identify the conditions that help fish survive at this site and where they think the best release sites are located.

- √ Avoid releasing the fry in deep pools or other spots where large fish may wait to prey upon them. Shallow water without strong currents is best. Areas with too much wave action may wash fry onto the shore. Try to release the fry in an area with plenty of cover. Spread the fry out over as much distance as possible.



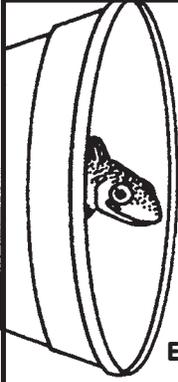
- √ When the water temperature is equalized, tip the bucket to allow some water to flow into it. Wait a few moments, then submerge the bucket and allow some of the fry to swim out. If possible, move to a nearby spot and release a few more fry. Continue until all fry are released. ***For effective student involvement, provide each student with a small cup. Clear plastic cups help students and others to easily see the fish. Fill the cup about half full of release site water and add one or two fry. (Adult volunteers enjoy helping with this***



Graphic courtesy of Canada Department of Fisheries and Oceans, Public Involvement Program, Salmonids In The Classroom — Stream Study and Fry Release, Intermediate.

part, too.) Remind students to allow a small amount of water to flow into the cup, then gradually submerge the cup and allow the fry to swim out. Encourage students to watch where the fish go and what they do, then write about their experience (poems, stories, journal entries).

- √ Releasing fry at night or during late evening may reduce bird and animal predation.
- √ Within 15 days after release, send a completed **Report Of Operations** form (page 52) to your ODFW project biologist, along with a copy of your Daily Progress Record (page 51). Don't forget to keep a copy for your records.



A Poem For The Fry

Goodbye, goodbye, we wish you goodbye.
We will miss you salmon fry!
Take care of yourself in Kanaka Creek
Watch out for dangers and enemies. Eak!
Predators, birds and bigger fish
Might make you their favorite dish.
So sneak away from those who lurk,
Eating, darting, growing in your "school" work.
We have raised you and fed you in our tank
So taking our advice can be your thanks.
We want to see you grow and survive.
Our wish is for you to stay alive.
Goodbye, goodbye, we wish you goodbye.
We will miss you, salmon fry!

This poem was read on the banks of Kanaka Creek, British Columbia, Canada, as a third grade class from Davie Jones Elementary released their classroom fry.

Cleaning And Storing Incubator Equipment

When the incubation process is complete, thoroughly clean and properly store all equipment. Cleaning is more effective if performed while the incubator is still wet.

- √ Empty the aquarium and remove the gravel.

- √ Clean the aquarium, powerhead, riser tubes, hoses, and filter plates with a mild detergent and a soft cloth. If desired, disinfect with a weak (1:400) bleach solution, but air drying should be sufficient, especially if the equipment is not used again for several months. **Rinse thoroughly with large amounts of water to remove any detergent or bleach residue.** Use a soft cloth and a baking soda paste for stubborn areas. **Rinse! Rinse! Rinse!**
- √ Vigorously wash aquarium gravel and other rocks or gravel with clean water ONLY. Another alternative is to boil the gravel in a large pot for 10 to 15 minutes. Allow the gravel to air dry to prevent the growth of mold. Spread the gravel in thin layers to speed up the drying process.
- √ After all equipment is thoroughly dry, reassemble and store in a clean, dry area. If using a chiller or other refrigeration unit, remove dust from the chiller fins.

Key Points To Remember

- √ Record daily temperatures to predict approximate “hatch” and “button-up” times through the accumulation of temperature units.
- √ Remove dead eggs or fry promptly. Keep accurate records of egg and fry mortality.
- √ Treat eggs and fry with care. They are fragile.
- √ When the belly seam is **one millimeter or less**, the fry are “buttoned-up”. Release fry 5 - 7 days after most of the fry are buttoned up and **only at approved site**. The approved site provides the greatest opportunity for fry survival while still protecting wild fish resources.
- √ Don't forget to submit your Report Of Operations in a timely manner (within 15 days of release).
- √ **This project is not part of a fish stocking program. The goals of your project are to observe and participate in the development process of fish and to understand fish habitat needs.**

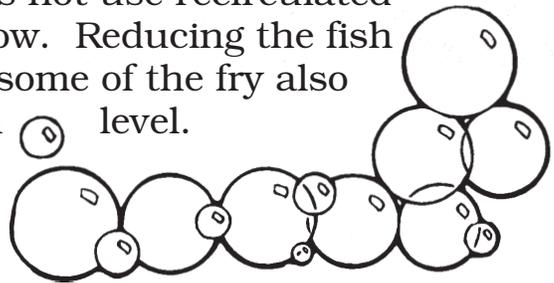
TROUBLESHOOTING

Dissolved Oxygen Problems:

Clue: fry gasping at the surface

Newly buttoned-up fry will come to the surface to gulp air and fill the swim bladder, but after that they should remain at mid-aquarium levels. If you see your fry all gathering at the surface, check oxygen concentration and consider decreasing the water temperature (gradually at about 1 degree per hour).

Eggs also use a surprising amount of oxygen. Check dissolved oxygen levels daily. Barring equipment failure, a properly maintained aquarium will supply sufficient oxygen levels. If the oxygen level falls below 7 ppm, promptly check the powerhead or air supply pump and water temperature. Add more oxygen with an additional or larger capacity pump if necessary or replace a defective one. Make sure all air lines are clear. If using a system that does not use recirculated water, you may need to increase the air flow. Reducing the fish population in the aquarium by releasing some of the fry also helps maintain a higher dissolved oxygen level.



pH Problems:

Clue: discolored eggs, eggs with eyes extending outside of the shell but rest of alevin is still inside the eggshell

Check pH level daily. Monitor the pH with an inexpensive test kit available from most aquarium supply stores. This kit is accurate to within a pH range of 0.2 and may be more useful than litmus paper. pH levels indicate the accumulation of egg hatching and fry waste products in the aquarium. As these various waste products increase, the pH drops, creating a more acidic water condition. If it falls below 6.5, the eggs or fry could die or be severely damaged. To correct this situation, change at least half the water. Use dechlorinated water the same temperature as that found in the aquarium.

Adjust the pH with white vinegar if pH values are too high (above 7.5) or baking soda if pH values are too low (below 6.5). Adding crushed oyster shell to the water can also adjust pH. Oyster shell is composed of calcium carbonate which dissolves into the water to increase pH. The oyster shell must be well-weathered with no organic material left which might decay. Wash well before crushing. Do not leave the oyster shell in the tank for long periods. Add it in a mesh bag suspended near the powerhead to increase dissolving. Monitor pH while the oyster shell is in the aquarium. When the pH reaches 7.5 remove the bag. Remember pH adjustment must be a gradual process. **Changing from one pH value to another is a tenfold change in magnitude and may be more than the eggs or fry can survive.** If pH levels continue to be a problem, check the water source. It may contain other dissolved materials which are causing the problem.

Ammonia Problems:

Clue: changes in pH measurements, compression of fins on the fry

An inexpensive, simple, but accurate ammonia test kit is available at most stores selling aquarium supplies. If ammonia levels rise to dangerous levels, a partial water change (one-third to one-half) is advised. Make sure the replacement water is dechlorinated and at the same temperature as that found in the aquarium. A buffering product, which can be placed in a corner of the aquarium, is also available at an aquarium supply store.

Disease Problems:

Clue: white cloudy eggs, purple eggs, white fuzz on eggs, fry that swim in circles, oily reddish spot in egg, discolored yolk, fry swimming on their sides

Diseases are transmitted to the eggs from the parents (vertically transmitted) or in the water or from other eggs or fry (horizontally transmitted). The hatchery makes every effort to provide healthy eggs. In an uncrowded incubator, disease is a rare problem. Generally, there is little that can be done with diseased eggs or fry in the classroom setting. These problems require consultation with your project biologist, fish pathology, or hatchery personnel. Do not release sick fry.

- * **white cloudy egg** - Dead egg. Remove as soon as possible to prevent fungus growth.
- * **purple egg** - Dead egg. Remove as soon as possible to prevent fungus growth.
- * **white fuzzy growth on egg or fry** - Fuzzy growth indicates the presence of fungus. Prompt removal of dead eggs, egg shells, or dead fry should prevent contamination of others. Your project biologist may recommend a specific treatment if fungus continues to be a problem.
- * **fry that swim in circles** - Deformed or injured fry.
- * **oily reddish spot in egg** - A ruptured yolk sac caused by excessive jostling or late shocking at the hatchery.
- * **discolored yolk, fry swimming on their sides** - Coagulated yolk is fairly common in classroom incubators, given the environment, focus and amount of activity the incubator receives. Some species may be more susceptible than others. Minimize handling, turbulence created by the water flow, and light exposure.

Mechanical Problems:

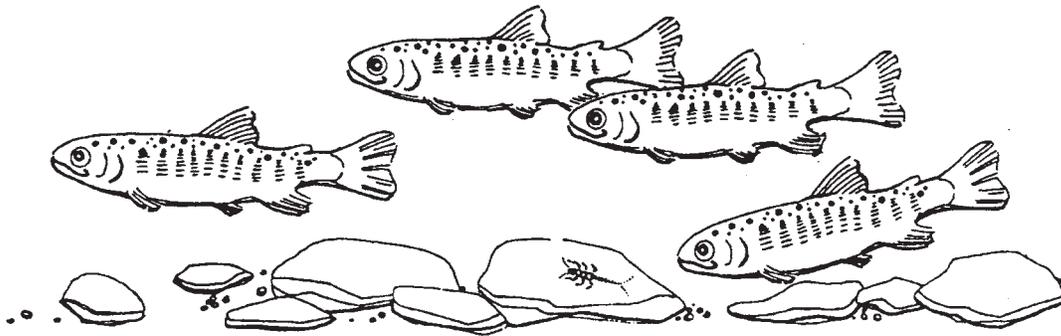
- * Most chiller systems are generally trouble and maintenance free, but mechanical difficulties can and do occur. Plan ahead in the event of equipment failure. Have emergency frozen water containers readily available.
- * If water temperature is steadily increasing, check to make sure the chiller unit or refrigerator is plugged in. If plugged in, is there a tripped breaker somewhere? Plug another electrical appliance into the outlet to see if it works. If plugged in and the outlet is working properly, reduce the temperature setting on the thermostat or in the refrigerator. If this fails to trigger the compressor, something is defective. Use frozen water containers to maintain the temperature in the aquarium until the problem is remedied. If water is freezing in the aquarium, the thermostat is probably defective. If the chiller runs constantly, but the coil is not cool to the touch, the refrigerant may have leaked out.
- * If water movement is not apparent or bubbles are not coming from the powerhead or air pump, the unit may be defective or clogged. First check to see if it is plugged in and that the outlet is functioning properly. If the pump is circulating, but not aerating, check for an air line blockage in the venturi tube (if applicable). Remove the tube and blow into it. If the pump is not

circulating, is it underwater? Is it air-locked in some fashion? Powerheads can become clogged with algal and slime growth and sometimes even an adventuresome fry that found its way into the riser tube. Unplug and remove the pump from the riser tube. Check the intake cone for debris, fish, or anything that may block flow into the pump. Sometimes it is necessary to take the powerhead apart and clean the magnet and impeller assembly inside the unit. The easiest solution is to have a backup powerhead or standard air pump and air stone available.

Miscellaneous Problems:

- * Some deformities (e.g. two heads) occur naturally.
- * Sac fry will naturally lay on the gravel after hatching. This is normal. **Do not release the fry at this stage.**
- * Check all connections between pump, gang valve, and riser tubes if water flow or aeration are interrupted. A power failure may cause these problems. **Plan for a backup system in the event of a power failure.** Check refrigeration unit if water temperatures raise or lower dramatically. Make sure the styrofoam cover and/or viewing door are replaced as too much direct sunlight can kill eggs and fry.
- * Frequent power failure problems occur on weekends or during holiday periods when no one is around to notice. Inform custodial staff and others in the school when your project will take place and how long it will last. Make sure they understand the necessity for an uninterrupted power supply throughout the project. Encourage their participation in the project to generate ownership and care when you or the students are not available to monitor the system. **Provide emergency contact numbers at the aquarium site in the event a problem is discovered.**
- * In a warm classroom, it is sometimes difficult to maintain the desired temperature. This may be caused by too much flow through the powerhead system. Reduce the amount of flow through the powerhead to give it more time to cool during circulation or find a way to lower the room's temperature.

- * Get to know the personnel at a nearby hatchery. They are experienced at troubleshooting and can be a valuable resource.
- * Certain filters (i.e. zeolite filters which remove waste ammonia) require more maintenance than others. Consult with a local aquarium supply store if you have questions.
- * *Diseases of Pacific Salmon: Their Prevention and Treatment* by James W. Wood, Washington Department of Fisheries, is a good reference. This book is available from the Mt. Hood Community College Bookstore in Portland, Oregon, or contact your project biologist or nearest hatchery.



Graphic courtesy of Canada Department of Fisheries and Oceans, Public Involvement Program, Salmonids In The Classroom — Stream Study and Fry Release, Intermediate.

ADDITIONAL RESOURCES

A. ODFW Contact Information

1. Oregon Department of Fish & Wildlife STEP Biologists
2. Oregon Department of Fish & Wildlife Regional & Watershed District Offices
3. Oregon Department of Fish & Wildlife Hatcheries
4. Maps of ODFW Watershed Districts, Offices, and Hatcheries

B. The Paper Trail

1. Egg Incubation Project — Criteria For Approval
2. Egg Request and Transportation/Release Site Permit
3. Daily Progress Record
4. Report of Operations

C. More Ideas

1. A "Low-Cost" Chiller Unit
2. A "Do-It-Yourself" Chiller Unit
3. "Pop-Machine" Chiller Unit
4. Self-Contained Chiller Units
5. Alternative Aeration Method
6. A Floating Wooden Egg Tray
7. A Floating Strainer Egg Tray

D. Related Information

1. Wild Trout Life Cycle
2. Wild Salmon and Steelhead Life Cycle
3. Hatchery Trout Life Cycle
4. Hatchery Salmon and Steelhead Life Cycle
5. Dimensions Of Fisheries Education
6. Applying Oregon's Academic Content Area Standards
7. Example Job Wheel For Students
8. Student Reading: Managing For Fish and Fisheries
9. Student Reading: Getting Fish Out Of And Into The Hatchery
10. Resources For Educators

E. Glossary

Oregon Department of Fish & Wildlife

Salmon-Trout Enhancement Program (STEP) Biologists

South Coast STEP Biologist

PO Box 642
Gold Beach, OR 97444
Phone: (541) 247-7605
Fax: (541) 247-2321

Eastern Oregon STEP Biologist

PO Box 8
Hines, OR 97738
Phone: (541) 573-6582
Fax: (541) 573-5306

Lower Willamette STEP Biologist

17330 SE Evelyn Street
Clackamas, OR 97015
Phone: (503) 657-2000 x 235
Fax: (503) 657-6808

Eastern Oregon STEP Biologist

61374 Parrell Road
Bend, OR 97702
Phone: (541) 388-6363
Fax: (541) 388-6049

North Coast STEP Biologist

4909 Third Street
Tillamook, OR 97141
Phone: (503) 842-2741
Fax: (503) 842-8385

Upper Rogue STEP Biologist

1495 E. Gregory Road
Central Point, OR 97502
Phone: (541) 826-8774
Fax: (541) 826-8776

Mid-Willamette STEP Biologist

7118 NE Vandenberg Ave
Corvallis, OR 97330-9446
Phone: (541) 757-4186
Fax: (541) 757-4252

Umpqua STEP Biologist

4192 N. Umpqua Hwy
Roseburg, OR 97470
Phone: (541) 440-3353
Fax: (541) 673-0372

Upper Willamette STEP Biologist

3150 E. Main St.
Springfield, OR 97478
Phone: (541) 726-3515 x 26
Fax: (541) 726-2505

Coos - Coquille STEP Biologist

PO Box 5430
Charleston, OR 97420
Phone: (541) 888-5515
Fax: (541) 888-6860

Central Coast STEP Biologist

2040 SE Marine Science Dr.
Newport, OR 97365
Phone: (541) 867-0300 x 253
Fax: (541) 867-0311

Siuslaw STEP Biologist

PO Box 352
Mapleton, OR 97453
Phone: (541) 268-9099
Fax: (541) 268-9098



Statewide STEP Coordinator

PO Box 59
Portland, OR 97207
Phone: (503) 872-5252 x 5429
Fax: (503) 872-5632



Oregon Department of Fish & Wildlife

Regional and Watershed District Offices

NORTHWEST REGION

Northwest Regional Office North Willamette Watershed District Office

17330 SE Evelyn Street
Clackamas, OR 97015
(503) 657-2000

South Willamette Watershed District Office

7118 NE Vandenberg Avenue
Corvallis, OR 97330
(541) 757-4186

North Coast Watershed District Office

4909 Third Street
Tillamook, OR 97141
(503) 842-2741

Astoria Field Office

2021 Marine Drive, Rm. 101
Astoria, OR 97103
(503) 338-0106

Newport Field Office

2040 Marine Science Center Drive
Newport, OR 97365
(541) 867-4741

Salem Field Office

4412 Silverton Road NE
Salem, OR 97305
(503) 378-6925

Sauvie Island Field Office

18330 NW Sauvie Island Road
Portland, OR 97231
(503) 621-3488

Springfield Field Office

3150 East Main
Springfield, OR 97478
(541) 726-3515

Corvallis Research Lab

28655 Highway 34
Corvallis, OR 97333
(541) 757-4263

SOUTHWEST REGION

Southwest Regional Office Umpqua Watershed District Office

4192 N. Umpqua Highway
Roseburg, OR 97470
(541) 440-3353

Rogue Watershed District Office

1495 E. Gregory Rd.
Central Point, OR 97502
(541) 826-8774

Charleston Field Office

PO Box 5430
63538 Boat Basin Drive
Charleston, OR 97420
(541) 888-5515

Gold Beach Field Office

PO Box 642
29907 Airport Way
Gold Beach, OR 97444
(541) 247-7605

NORTHEAST REGION

Northeast Regional Office Grand Ronde Watershed District Office

107 - 20th Street
LaGrande, OR 97850
(541) 963-2138

John Day Watershed District Office

73471 Mytinger Lane
Pendleton, OR 97801
(541) 276-2344

Baker City Field Office

2995 Hughes Lane
Baker City, OR 97814
(541) 523-5832

Enterprise Field Office

65495 Alder Slope Rd.
Enterprise, OR 97828
(541) 426-3279

Heppner Field Office

PO Box 363
430 Heppner-Lexington Hwy.
Heppner, OR 97836
(541) 676-5230

John Day Field Office

PO Box 9
John Day, OR 97845
(541) 575-1167

HIGH DESERT REGION

High Desert Regional Office Deschutes Watershed District Office

61374 Parrell Road
Bend, OR 97702
(541) 388-6363

Klamath Watershed District Office

1850 Miller Island Road W.
Klamath Falls, OR 97603
(541) 883-5732

Malheur Watershed District Office

PO Box 8
237 S. Hines Blvd.
Hines, OR 97738
(541) 573-6582

Lakeview Field Office

PO Box 1214
101 N. "D" St.
Lakeview, OR 97630
(541) 947-2950

Ontario Field Office

3814 Clark Blvd.
Ontario, OR 97914
(541) 889-6975

Prineville Field Office

2042 SE Paulina Hwy.
Prineville, OR 97754
(541) 447-5111

The Dalles Field Office

3701 West 13th
The Dalles, OR 97058
(541) 296-4628

HEADQUARTERS OFFICE

2501 SW 1st Avenue
Portland, OR 97201
(503) 872-5310



Oregon Department of Fish & Wildlife Hatcheries

Alesea Fish Hatchery

29050 Fish Hatchery Rd.
Philomath, OR 97370
(541) 487-7240

Bandon Fish Hatchery

55212 Fish Hatchery Road
Bandon, OR 97411
(541) 347-4278

Big Creek Fish Hatchery

Route 4, Box 594
Astoria, OR 97103
(503) 458-6512

Bonneville Fish Hatchery

70543 Herman Loop Road
Cascade Locks, OR 97014
(541) 374-8393

Butte Falls Fish Hatchery

580 Fish Lake Road
Butte Falls, OR 97522
(541) 865-3322

Cascade Fish Hatchery

74152 NE Eagle Creek Loop
Cascade Locks, OR 97014
(541) 374-8381

Cedar Creek Fish Hatchery

33465 Highway 22
Hebo, OR 97122
(503) 392-3485

Clackamas Fish Hatchery

24500 S. Entrance Road
Estacada, OR 97023
(503) 630-7210

Cole Rivers Fish Hatchery

200 Cole M. Rivers Drive
Trail, OR 97541
(541) 878-2235

Elk River Fish Hatchery

95163 Elk River Road
Port Orford, OR 97465
(541) 332-7025

Fall Creek Fish Hatchery

2418 E. Fall Creek Road
Alesea, OR 97324
(541) 487-4152

Fall River Fish Hatchery

15055 South Century Drive
Bend, OR 97707
(541) 593-1510

Gnat Creek Fish Hatchery

Rt. 2, Box 2198
Clatskanie, OR 97016
(503) 455-2234

Irrigon Fish Hatchery

Route 2, Box 149
Irrigon, OR 97844
(541) 922-5732

Klamath Fish Hatchery

46161 Hwy. 62
Chiloquin, OR 97624
(541) 381-2278

Klaskanine Fish Hatchery

Route 1, Box 764
Astoria, OR 97103
(503) 325-3653

Leaburg Fish Hatchery

90700 Fish Hatchery Road
Leaburg, OR 97489
(541) 896-3294

Lookingglass Fish Hatchery

Route 2, Box 89-D-B
Elgin, OR 97827
(541) 437-9723

Marion Forks Fish Hatchery

HC 73, Box 71
Idanha, OR 97350
(541) 854-3522

McKenzie River Fish Hatchery

43863 Greer Drive
Leaburg, OR 97489
(541) 896-3513

Nehalem Fish Hatchery

36751 Fish Hatchery Lane
Nehalem, OR 97131
(503) 368-6828

Oak Springs Fish Hatchery

85001 Oak Springs Road
Maupin, OR 97037
(541) 395-2546

Oxbow Fish Hatchery

Star Route, Box 750
Cascade Locks, OR 97014
(541) 374-8540

Roaring River Fish Hatchery

42279 Fish Hatchery Dr.
Scio, OR 97374
(503) 394-2496

Rock Creek Fish Hatchery

PO Box 197
425 McCarn Lane
Idleyld Park, OR 97447
(541) 496-3484

Round Butte Fish Hatchery

6825 SW Belmont Lane
Madras, OR 97741
(541) 475-6393

Salmon River Fish Hatchery

575 N. North Bank Road
Otis, OR 97368
(541) 994-8606

Sandy Fish Hatchery

39800 SE Fish Hatchery Road
Sandy, OR 97055
(503) 668-4222

South Santiam Fish Hatchery

43182 North River Drive
Sweet Home, OR 97386
(541) 367-3437

Trask Fish Hatchery

15020 Chance Road
Tillamook, OR 97141
(503) 842-4090

Umatilla Fish Hatchery

Rt. 2, Box 151
Irrigon, OR 97844
(541) 922-5659

Wallowa Fish Hatchery

Route 1, Box 278
Enterprise, OR 97828
(541) 426-4467

Willamette Fish Hatchery

76389 Fish Hatchery Road
Oakridge, OR 97463
(541) 782-2933

Wizard Falls Fish Hatchery

PO Box 130
Camp Sherman, OR 97730
(541) 595-6611



Oregon Department of Fish & Wildlife Watershed District Structure

Offices



10 0 10 20 Miles



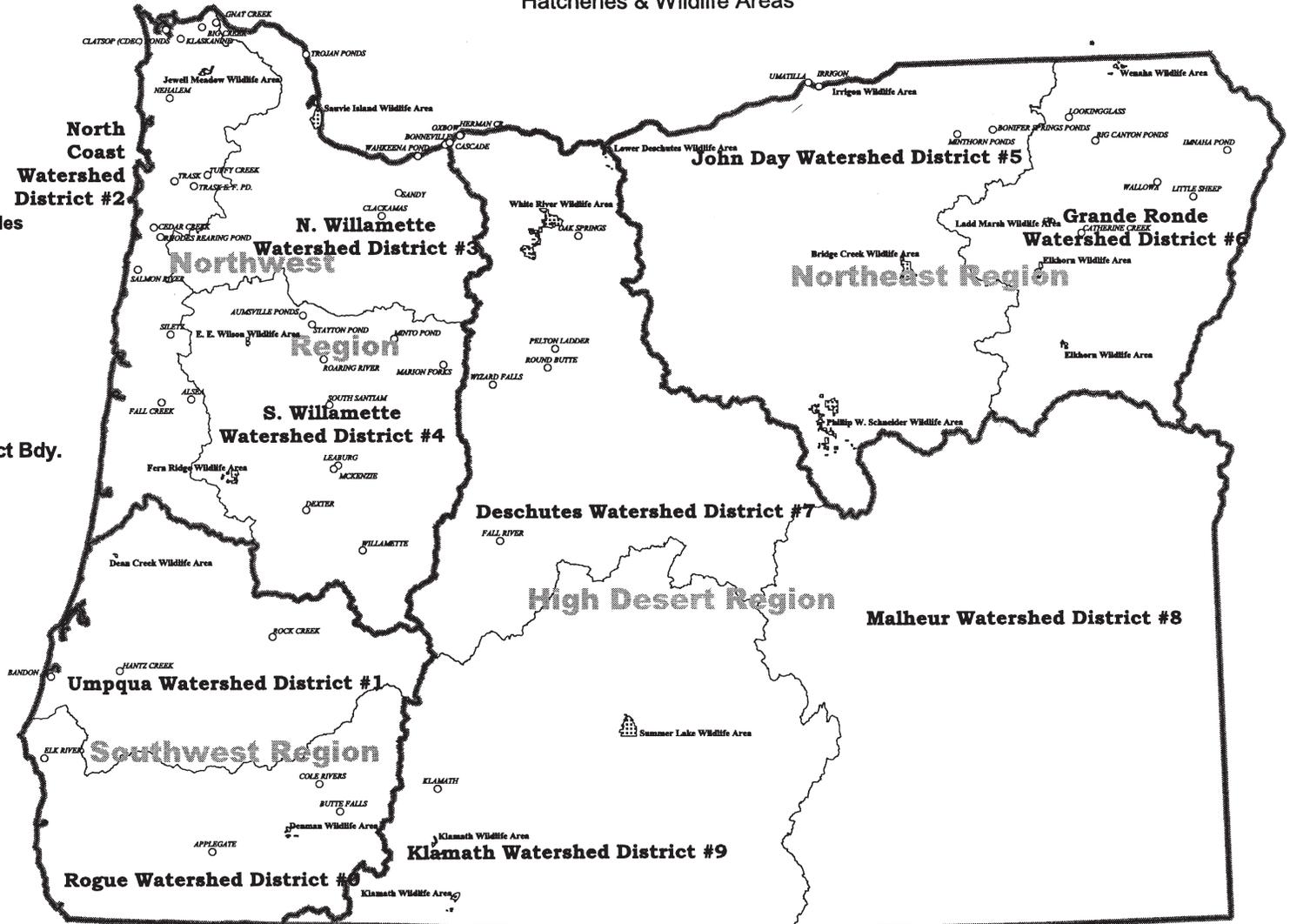
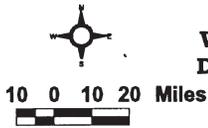
- ★ Headquarters
- △ Regional Office
- Watershed District Office
- Field Office
- ▭ Watershed District Bdy.
- ▭ Region Bdy.



01/04/00
M. Hill

Oregon Department of Fish & Wildlife Watershed District Structure

Hatcheries & Wildlife Areas



01/04/00
M. Hill



OREGON DEPARTMENT OF FISH AND WILDLIFE
Salmon-Trout Enhancement Program



CLASSROOM EGG INCUBATION PROJECT
Criteria For Participation And Project Approval

1. A Salmon-Trout Enhancement Program (STEP) classroom egg incubation project is designed solely for **educational purposes**. It is not part of a fish stocking program. It is not intended to enhance existing fish populations or start new ones. The objectives are to help students observe and participate in the development process of fish and to understand fish habitat needs.
2. The STEP Biologist, or ODFW project biologist, provides one copy of **Fish Eggs To Fry** to each project number. The project biologist serves as a technical advisor and conducts training sessions as necessary for classroom egg incubator operation.
3. Some form of lesson development must focus on the project. Your Oregon Department of Fish and Wildlife (ODFW) project biologist can offer suggestions for classroom activities.
4. Schools choose their own preferred classroom egg incubator design.
5. A **maximum of 500 eggs** per VO # (or project #) may be requested for a classroom egg incubation project. ODFW reserves the right to designate stock, numbers received, and release sites within policy guidelines.
6. **One VO# (project #) per school** - Maximum of 500 eggs can be split into as many aquariums as is feasible for the project coordinator to handle. One 200 egg setup per school is suggested. Schools may choose to rotate the aquarium incubator to other classrooms on subsequent years.
7. **One person at each school** is responsible for **coordinating** the project, including submission of all required STEP paperwork and reporting.
8. Egg loss, fry loss, # fry released, and release site records are **required** for each VO#. Fish are released only at site designated by ODFW staff.
9. Final project records must be in the project biologist's office **within fifteen days** following release of the fry.
10. Project biologists are not required to make repeated requests for final project records. **Participants who do not meet the requirements of the project within the designated time frame (or who release fish at an unauthorized site) may not have the opportunity to request eggs for future projects.**
11. All fish from classroom incubator projects are released as **unfed fry**.
12. Other organizations (agencies, civic groups, youth groups, etc.) may participate in an egg incubation project if the above criteria are met.



OREGON DEPARTMENT OF FISH AND WILDLIFE
Salmon-Trout Enhancement Program



Classroom Egg Incubation Project

Egg Request Application And Transport Permit

For ODFW Use Only:
 Stock _____
 # _____
 Year _____

_____ NEW _____ RENEWAL

— PLEASE PRINT CLEARLY —

Name _____ VO# _____

Name of School _____

Address _____

City _____ State _____ Zip _____

Work Phone _____ Home Phone _____ Fax _____

Email _____

(ODFW representative uses information above to coordinate egg delivery.)

Species/Stock Requested: _____
 (Complete one application/stock.)

RETURN TO:
 Nearest ODFW-STEP
 Biologist or ODFW
 District/Regional
 Office.

I agree to comply with the following permit conditions:

1. Related fisheries lessons must focus on the project. Please describe on back of this form.
2. Fish shall be hatched only at the location shown on the permit.
3. All fish from classroom incubator projects will be released as unfed fry.
4. The local ODFW-STEP or project biologist or District Fish Biologist must approve all release sites.
5. Fish shall be released only at the location(s) shown on the permit.
6. A written report of activities is required within 15 days following release of the fish.

 Signature of Applicant

 Date

NOTE: This is a request to receive eggs as available. The Oregon Department of Fish and Wildlife reserves the right to designate stock, numbers received and release site within policy guidelines. This form also serves as a fish transportation permit and must be in possession when eggs or fish are held or transported from the authorized source to the incubation or release site. You will receive an approved copy of this permit.

TRANSPORTATION/RELEASE SITE PERMIT: (ODFW will complete after approval.)

The above participant is authorized to transport and release fish from a STEP egg incubation project only at the following location(s):

Species: _____

Location (s): _____

Authorized ODFW Representative _____ Date _____

★ **It is unlawful to transport and/or release fish in other than above designated location(s) (OAR 635-09-140).**

11/2000 pgmkr 6.5 pb



OREGON DEPARTMENT OF FISH AND WILDLIFE
Salmon-Trout Enhancement Program



REPORT OF OPERATIONS

STEP Classroom Egg Incubation Project

Name _____ VO # _____
 School _____ Phone # _____
 Species _____ Hatchery of Origin _____

Date Eggs Received _____
Number of Eggs Received _____
Egg Mortality _____
Fry Mortality _____
Total Mortality _____
of Fry Released _____
Date Released _____
Release Location: (Provide precise location)
<input type="checkbox"/> Stream _____
Tributary of _____
<input type="checkbox"/> Pond _____
Legal Description of Release Site:
T _____ R _____ Sec _____ Qtr _____

Comments: 1/

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.

 Signature Date

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

A "Low-Cost" Chiller Unit

Materials

See list page 17 with the following changes/additions:

- * 20-gallon aquarium rather than 10-gallon
- * four 1-gallon recyclable plastic milk containers with twist lids
- * Alternative: 10- or 15-gallon aquarium with four 1-liter pop bottles

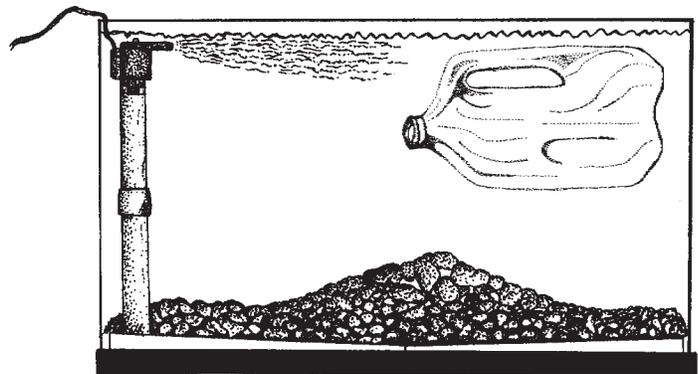
Procedure

Fill the four plastic containers with dechlorinated water. Allow room for expansion during freezing. Freeze the containers.

Follow instructions as outlined on pages 18-23, but adjust the water level to allow for water displacement by the frozen containers. Once the frozen containers are in place, adjust the outflow from the powerhead or riser tubes so it is below the water's surface.

The aquarium water is cooled by simply placing a gallon container of frozen water into the aquarium every morning Monday through Friday. The aquarium's insulation cover helps slow the thawing process in the frozen containers. The procedure on Friday afternoon is the most critical step. As late as possible on Friday afternoon, remove the frozen container and place **two** new ones into the aquarium for the weekend. This will keep your incubator cool until Monday morning.

Ask students to measure and record the water temperature before placing the frozen container in the aquarium in the morning and before leaving school in the afternoon. More temperature measurements are desirable. Average all temperatures for the day to determine the number of accumulated temperature units for that day.

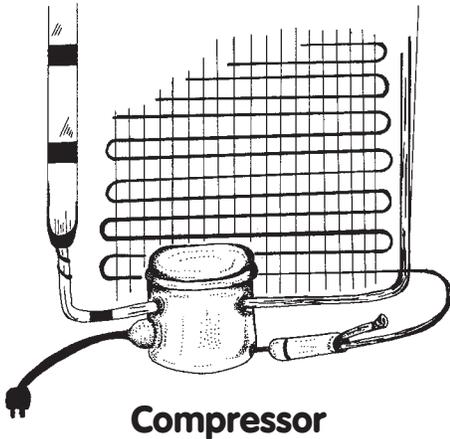


Powerhead Setup With Frozen Water Bottle

A "Do-It-Yourself" Chiller Unit

Materials

- * refrigerator compressor or chilling unit from drinking fountain
- * at least 5 ft. of 1/2" (outside diameter) stainless steel tubing
- * thermostat



Procedure

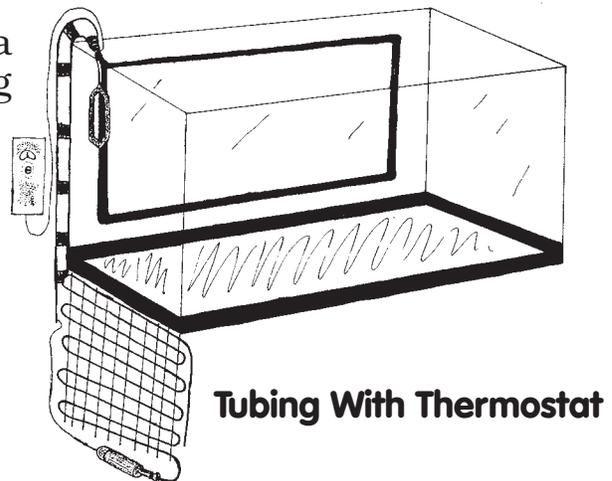
Use a hacksaw to remove the cooling coil that extends into the freezer compartment of an old refrigerator. **Before cutting the coil,** have the freon legally removed and recycled at a car air conditioner specialty shop or qualified appliance repair shop. Form the stainless steel tubing into a rectangular wand that fits into the back of the aquarium. Leave enough length to reach and connect to the compressor. Braze, solder, or joint the stainless steel tubing to

the compressor where the old coil was removed. If stainless steel is unavailable, copper tubing will work. **Coat copper tubing thoroughly with a waterproof epoxy paint.** If left unpainted, copper oxidizes and releases a toxin that kills eggs and fry.

Once everything is secured and the coil formed, have the entire unit recharged at a refrigerator or air conditioner shop.

The stainless steel cooling coil is immersed near the back of the aquarium. The coil may accumulate a small amount of ice during the cooling process. As the water warms, the ice melts and the process begins again.

Use painted copper tubing to connect the thermostat to the compressor. Immerse the thermostat probe 3-4 inches from the cooling coil. Adjust the thermostat to obtain the desired temperature.

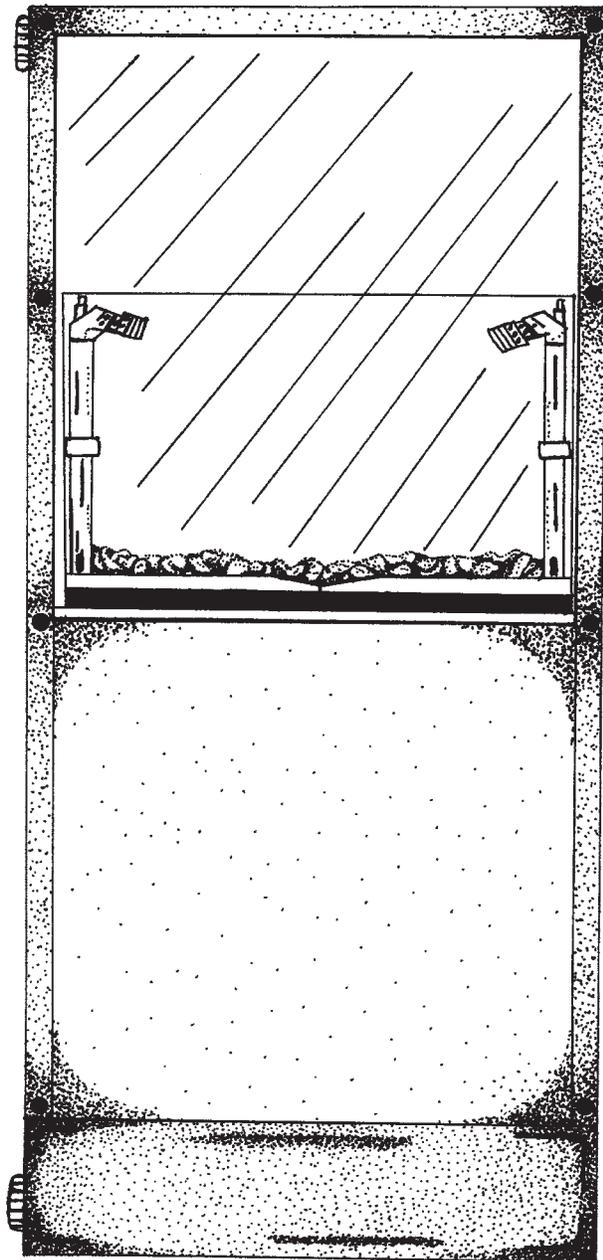


Tubing With Thermostat

"Pop-Machine" Chiller Unit

Materials

- * old pop machine (make sure chiller and thermostat work)
- * 1/2 inch - 3/4 inch piece of plywood for inside shelf
- * plexiglass
- * screws
- * glue



Procedure

Contact a local vending company about possible donation of an old pop machine.

Take out all of the inside shelves except the one just above the chiller unit. Make sure it is strong enough to hold the piece of plywood and a full aquarium. Attach brace supports if necessary. Cut the plywood to fit the inside dimensions of the machine. Place plywood on the shelf.

To make viewing easier, all the inside door parts can be removed and a piece of plexiglass attached to the outside of the door with glue and screws. Make sure the door seal is secure to keep the inside temperature constant. Put an opaque panel over the lower part of the door to hide the compressor, or encourage students to decorate the bottom panel.

Drill a hole through the back of the machine. Pass any electrical cords through this hole to the outlet.

Original idea contributed by Cheryl Butler, Cascade Middle School, Bend, Oregon.

Self-Contained Chiller Unit

Following is a partial list of sources for self-contained chiller units. Contact suppliers for current prices.

ODFW does not endorse any of the following products.

Taylor Refrigeration

6662 Apollo Road
Site-2 Comp-92 RR-6
Vernon, British Columbia
Canada V1T 6Y5

Phone: (520) 545-4906
Fax: (520) 545-5975

\$750 US currency + tariff (2%) and shipping

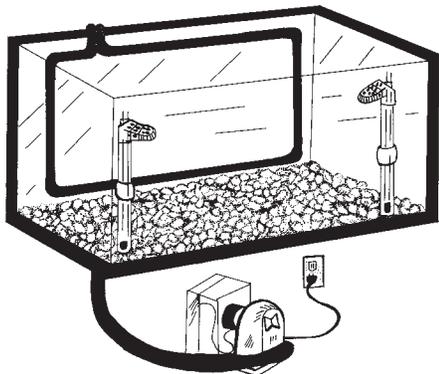
Glacier Corporation

2800 S. Main #K
Santa Ana, CA 92707

Phone: (714) 557-2826
Web site: www.glaciercorp.com

West Coast Aquatics 1/6 hp Micro Mini Chiller - \$649 + s/h (~\$40)

Discounts available to schools, Federation of Flyfishers and Trout Unlimited Chapters, and others associated with school programs.



Classic Aquariums, Inc.

10501 NE Hwy. 99
Vancouver, WA 98686

Phone: (503) 231-9577 or
(360) 573-5373
Fax: (360) 573-3347
Email: steve@classicaquariums.com
Web site: www.classicaquariums.com

West Coast Aquatics 1/5 hp Micro Mini Chiller - \$729 + s/h

West Coast Aquatics 1/6 h/p Micro Mini Chiller - \$618 + s/h

Shipping and handling charges only apply if out of Portland/Vancouver area

Aquarium Dynamics

15190 SE McLoughlin Blvd.
Milwaukie, OR 97267

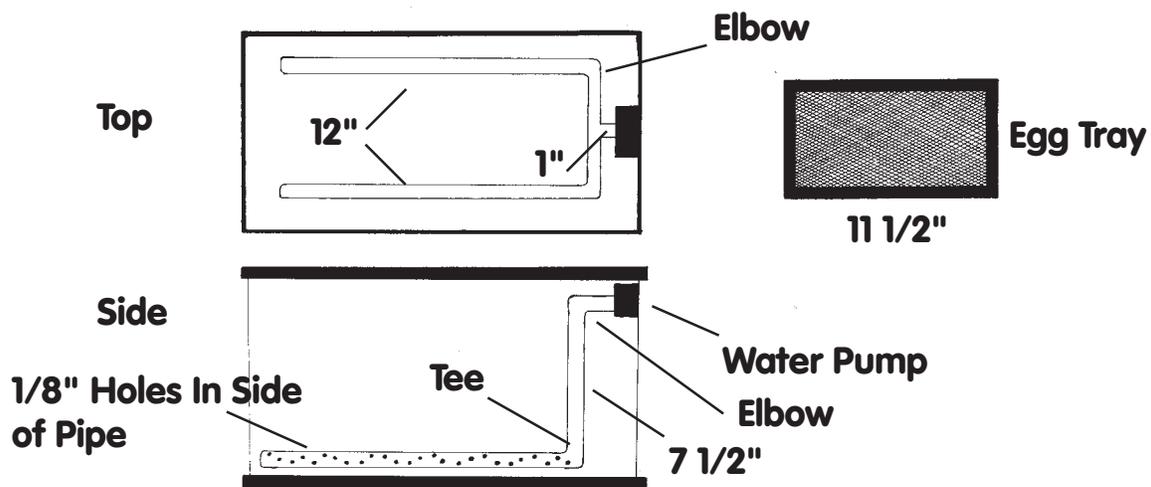
Phone: (503) 659-1280

West Coast Aquatics 1/6 hp Micro Mini Chiller - \$725.99 (includes s/h)

Alternative Aeration Method

Materials

- * 10-gallon aquarium
- * eight feet of 1/2" plastic pipe
- * six feet of 1/2" angle aluminum rod
- * three 1/2" plastic pipe elbows
- * one 1/2" plastic pipe tee
- * 6" x 11.5" plastic screen (1" x 1/8" rectangular mesh preferred)
- * powerhead with one gallon per minute flow
- * 1/2" diameter gravel
- * nine 1/2" plastic pipe plugs



Procedure

This setup fits into a standard size refrigerator. A water pump forces water through a 1/2" diameter plastic pipe to a pair of pipes at the bottom of the aquarium to create an upwelling flow. Several 1/8" holes are drilled in the sides of the bottom pipes. Once assembled the pipes are covered with approximately 2 inches of 1/2" gravel.

A platform to hold the eggs is constructed of 1/2" angle aluminum. Plastic screen, preferably 1" x 1/8" mesh, is attached to the platform using rivets, screws, or bolts.

Fill the aquarium so the water level is above the intake of the water pump. Place the egg tray in the bottom of the aquarium. Once the eggs hatch, remove the egg tray.

A Floating Wooden Egg Tray

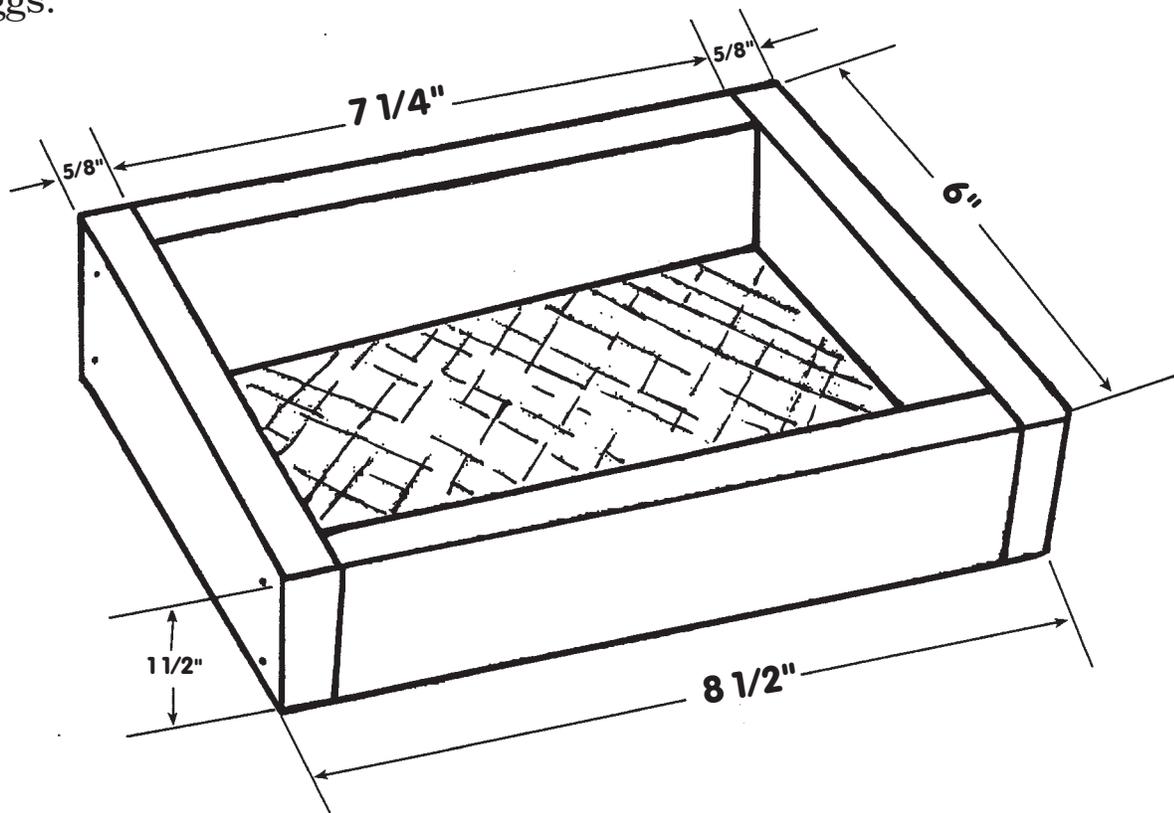
There are several different reasons to isolate all or part of the eyed eggs. The floating tray allows students to keep different species of eggs separate in the same aquarium, to experiment with different egg groups and provides a close-up view of developing eggs. Instructions for constructing two types of floating egg trays follow.

Materials

- * pine lumber $5/8"$ x $1\ 1/2"$ x $26\ 1/2"$ (cedar will bleed tannic acid, turning the water brown.)
- * $6"$ x $8\ 1/2"$ piece of fiberglass or vinyl screen and fasteners (tacks, hot glue, or staples)
- * eight $1"$ brads (do not use copper or galvanized products)
- * wood glue (Elmer's type)

Procedure

Cut wood to length — two pieces at $7\ 1/4"$ and two pieces at $6"$. Glue ends to sides. Secure with $1"$ brads. Attach screen to bottom with heavy staples, hot glue, or small tacks. Presoak tray before receiving eggs.



A Floating Strainer Egg Tray

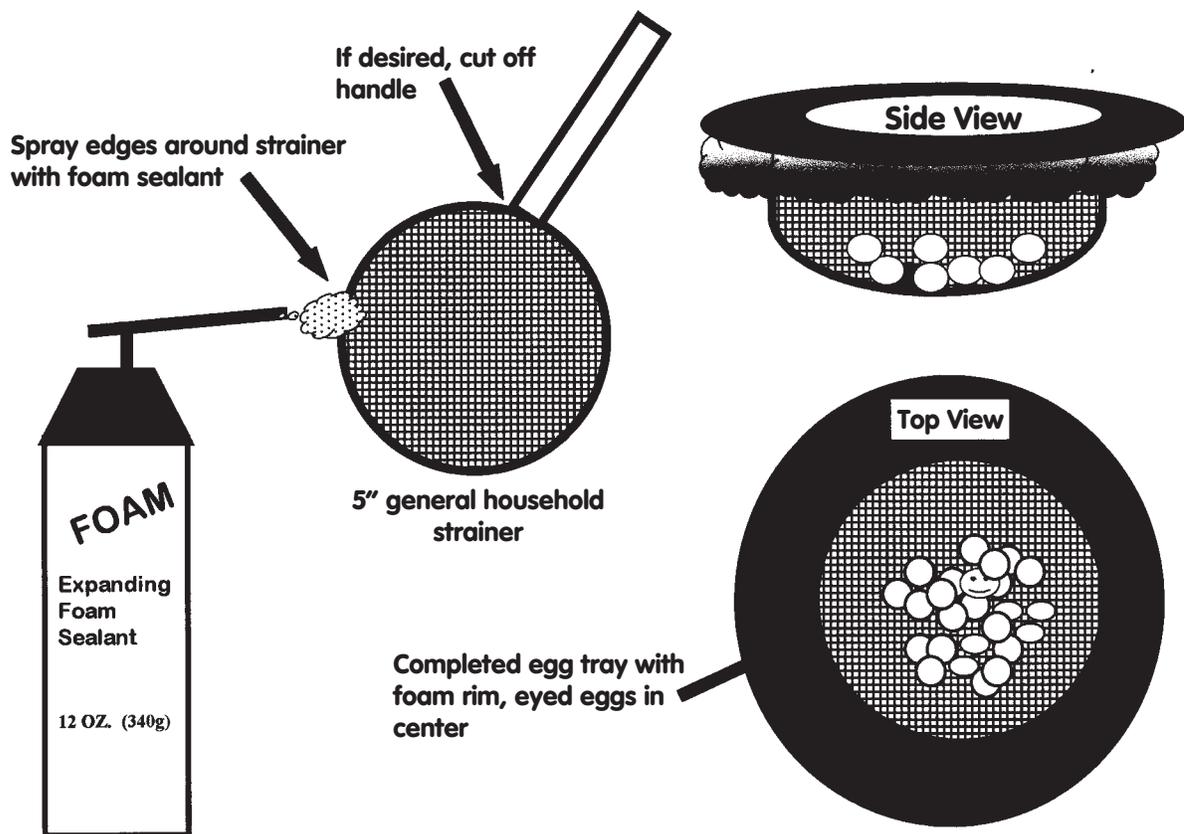
Materials

- * spray foam sealant
- * kitchen strainer or sieve (plastic or metal)

Procedure

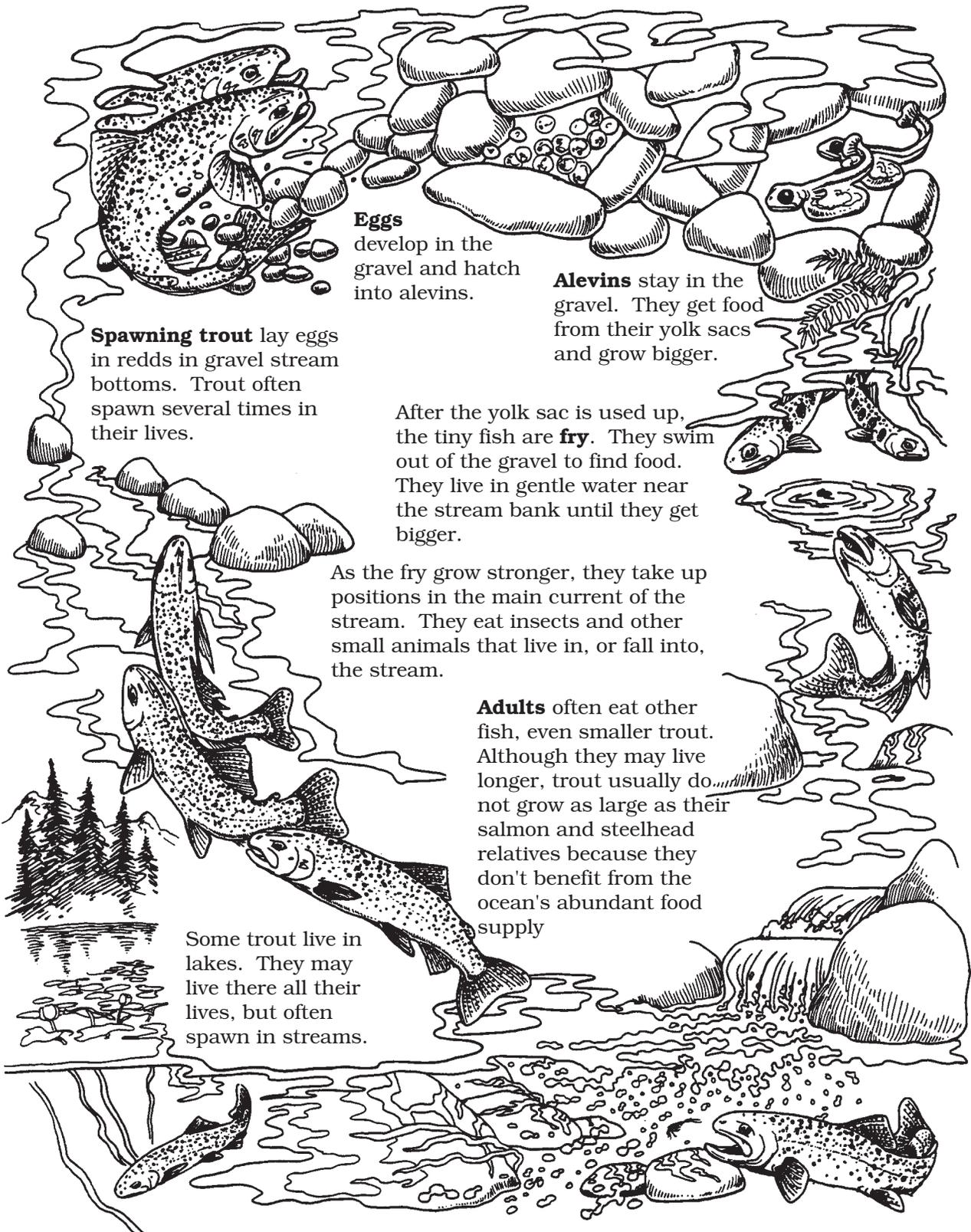
Either cut off or leave the handle of the strainer intact. Place strainer open side down on a flat surface covered with nonstick material (plastic, foil, or other product) Following sealant instructions carefully, apply a **very thin** bead of foam sealant around the rim. Avoid getting the product on your hands. Allow the sealant to dry. Remove the nonstick material and the egg tray is ready to use

Because the sealant expands greatly, it is important to use a fine bead and do not apply sealant too far below the rim. Both situations could interfere with free passage of water through the strainer.



Original idea contributed by Tony Stein, STEP Biologist, Newport, OR.

WILD TROUT LIFE CYCLE



Spawning trout lay eggs in redds in gravel stream bottoms. Trout often spawn several times in their lives.

Eggs develop in the gravel and hatch into alevins.

Alevins stay in the gravel. They get food from their yolk sacs and grow bigger.

After the yolk sac is used up, the tiny fish are **fry**. They swim out of the gravel to find food. They live in gentle water near the stream bank until they get bigger.

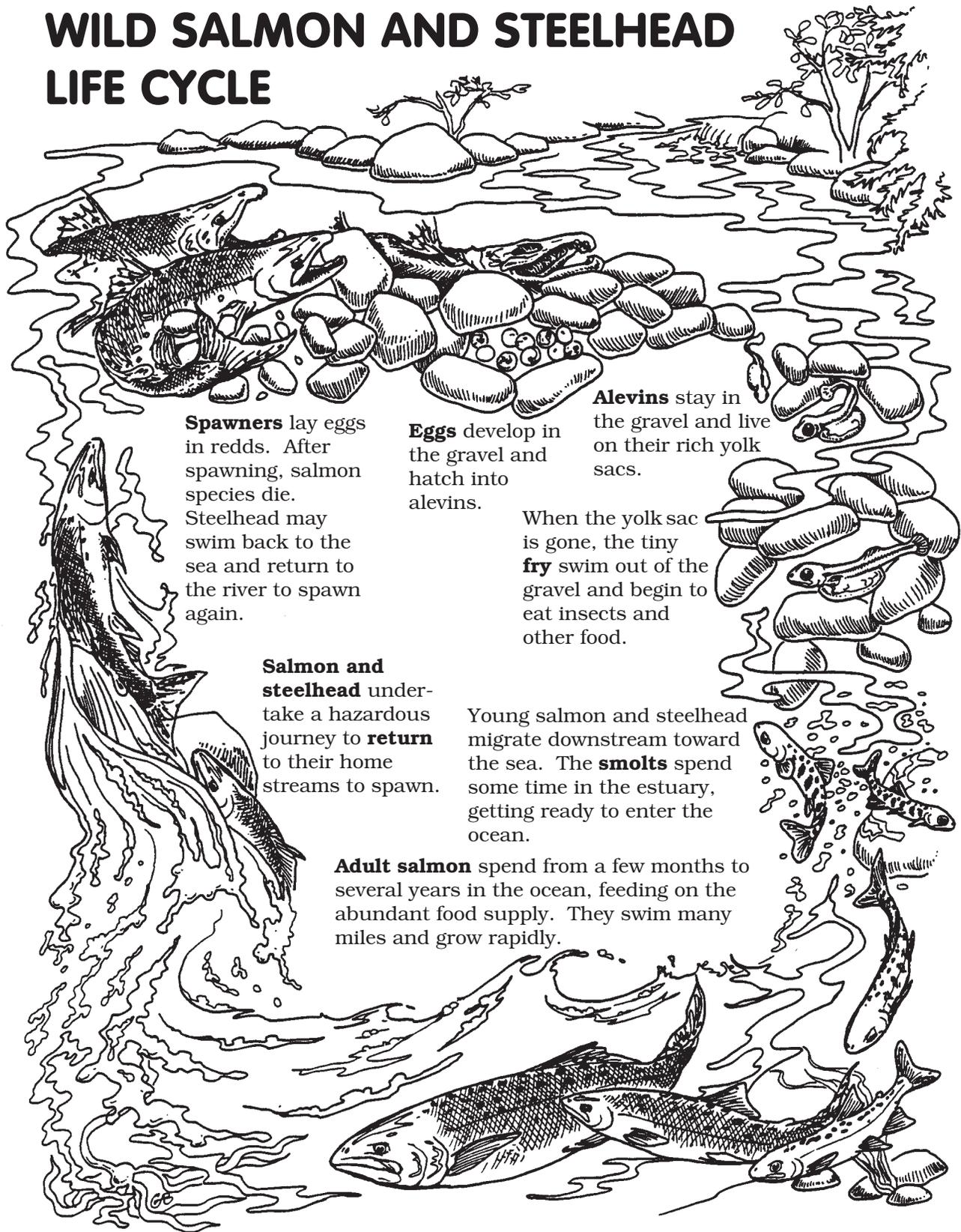
As the fry grow stronger, they take up positions in the main current of the stream. They eat insects and other small animals that live in, or fall into, the stream.

Adults often eat other fish, even smaller trout. Although they may live longer, trout usually do not grow as large as their salmon and steelhead relatives because they don't benefit from the ocean's abundant food supply

Some trout live in lakes. They may live there all their lives, but often spawn in streams.

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.

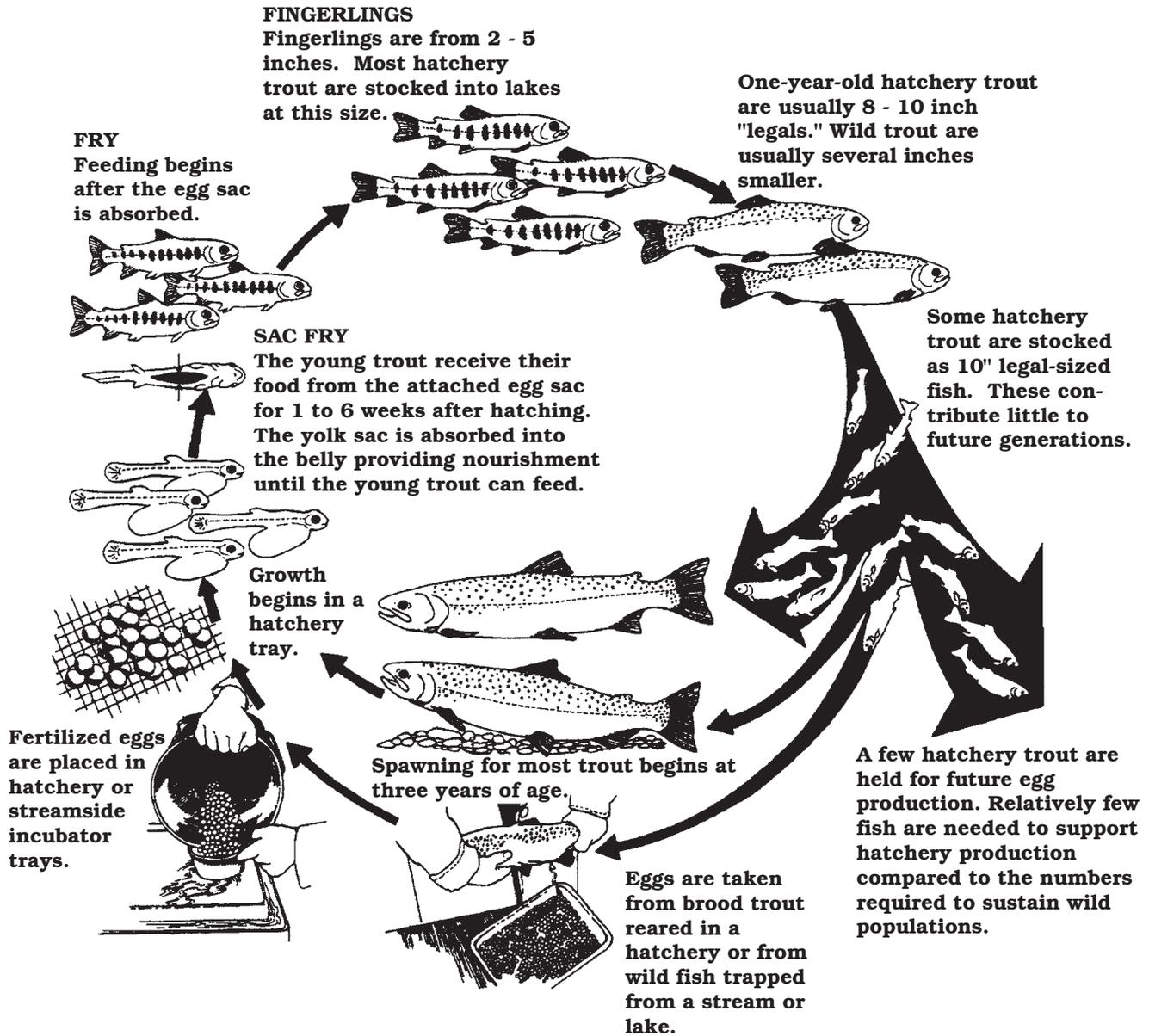
Salmon and steelhead undertake a hazardous journey to **return** to their home streams to spawn.

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.

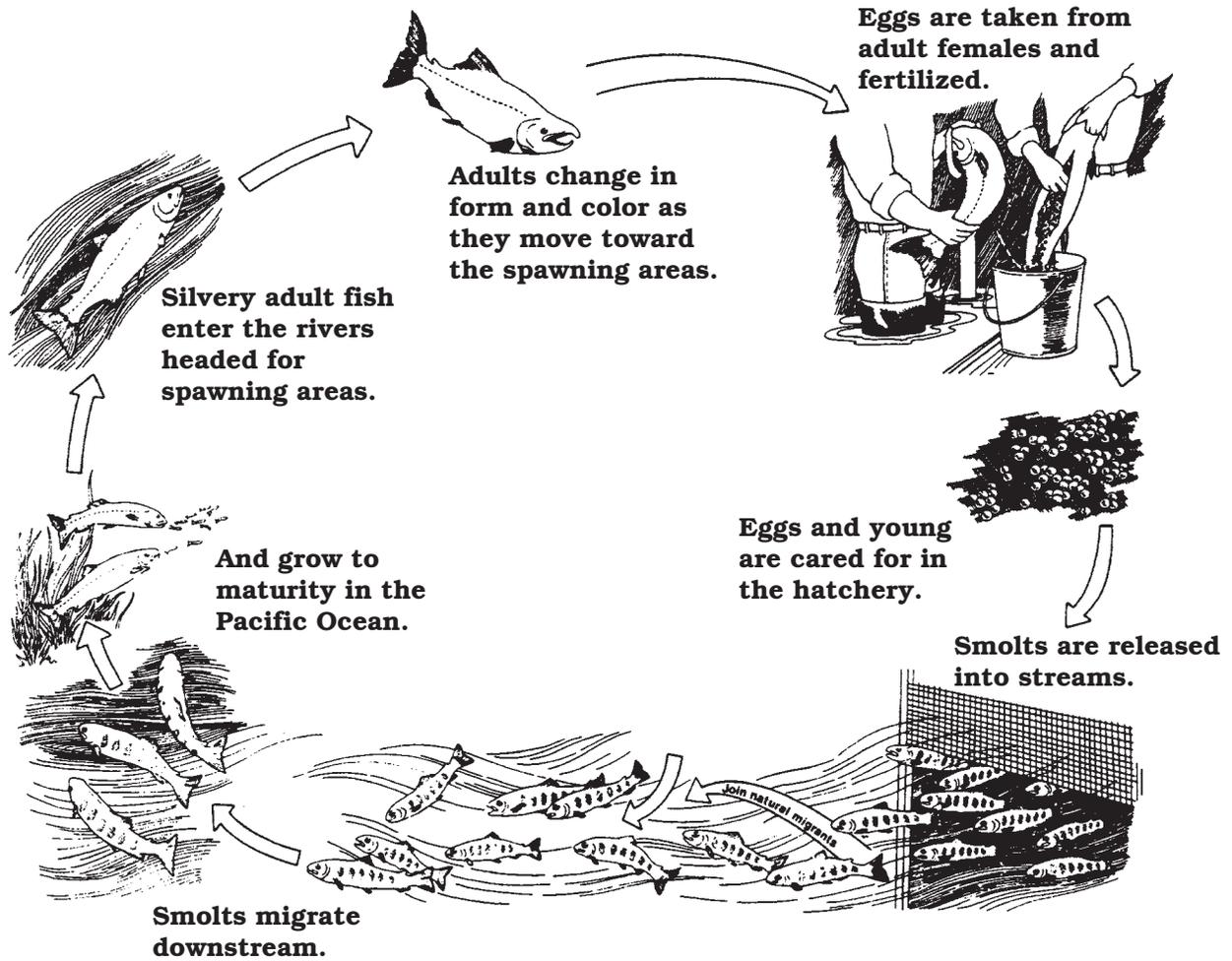
Adapted from original artwork by Gary Bloomfield, *Salmon and Trout Go To School, An Instruction Manual For Hatching Salmon and Trout Eggs In Classroom Aquarium-Incubators* by Diane Higgins, California Department of Fish and Game and American Fisheries Society, Humboldt Chapter, 1996.

HATCHERY TROUT LIFE CYCLE



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

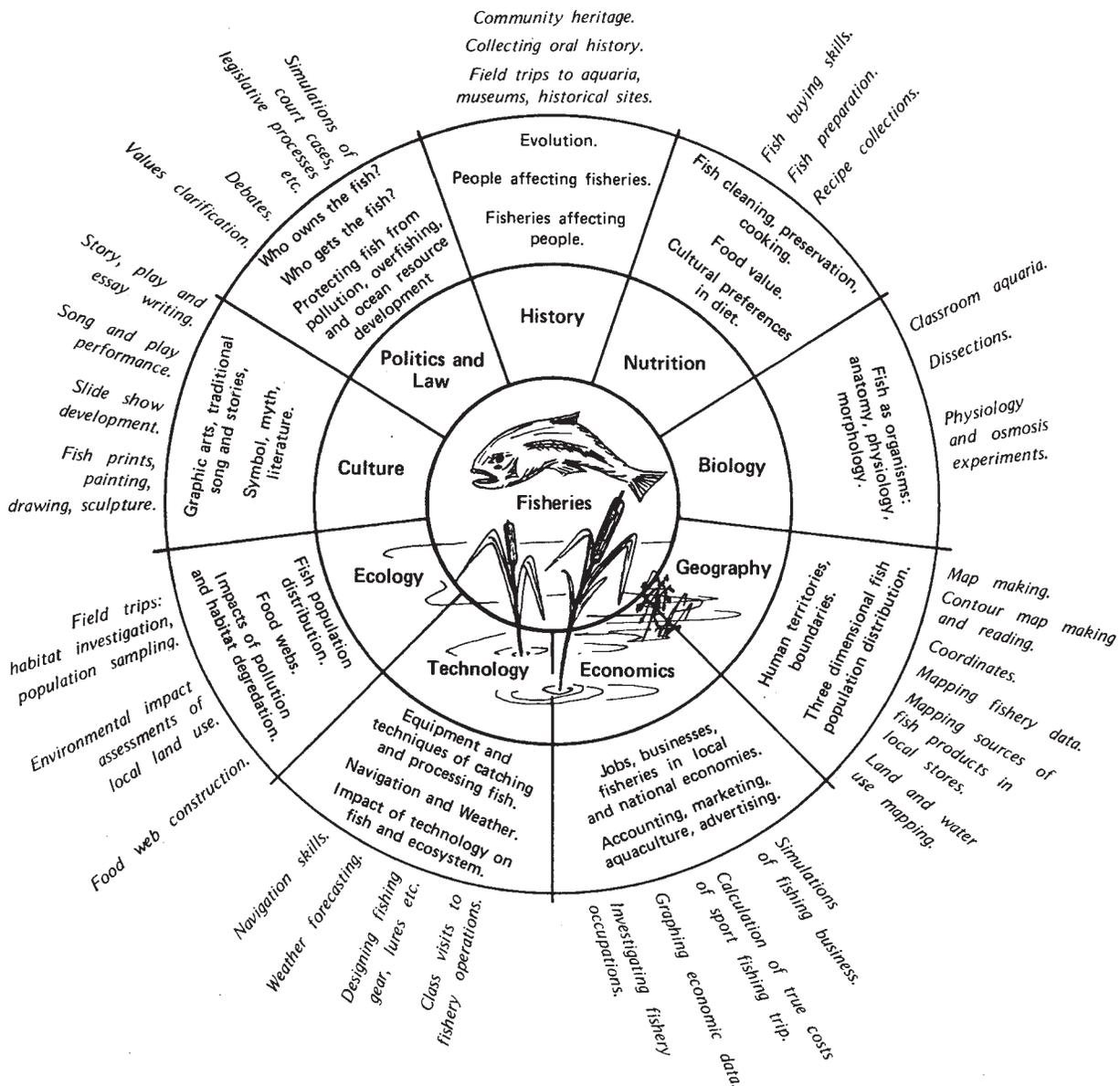
HATCHERY SALMON AND STEELHEAD LIFE CYCLE



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

DIMENSIONS OF FISHERIES EDUCATION

Suggested Activities For Integrating Fisheries Into Any Classroom



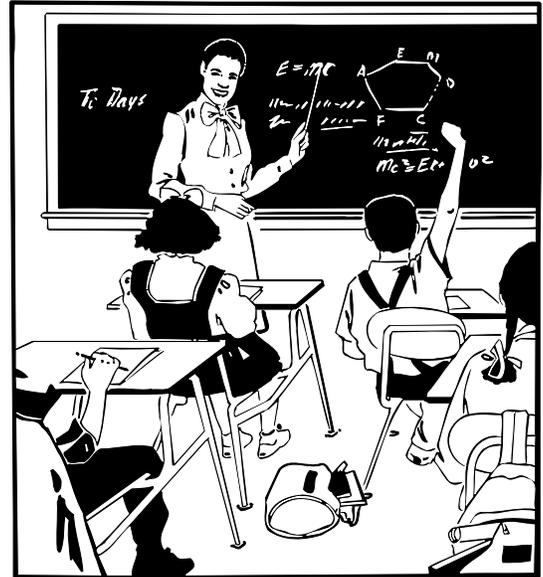
From "An Expanded Perspective Of Fisheries Education," *Current, The Journal Of Marine Education*, by Leslie Y. Lin, Augusto Q. Medina, and Wilfrid J. Rollman, with the Michigan Sea Grant College Program, Fall 1980.

"SEEING THE CONNECTIONS"

Applying Oregon's Academic Content Area Standards

Oregon has revised its educational standards to better prepare students for life in the 21st century. Standards-based education provides consistency for teaching and learning in Oregon. Within that framework, school districts are free to develop curriculum appropriate to the needs of their students.

Teachers today need resources and opportunities to help connect classroom lessons to real world events within the context of the new standards. Natural resource topics, based on fish, their habitats, and related watershed issues, provide a rich thematic tie to many of Oregon's academic content area standards across the disciplines. The classroom fish egg incubation project is a good way to develop the theme. See the diagram of page 64 for suggestions about integrating fisheries education into the classroom.



Standards-Based Education

Education standards are criteria to judge quality: the quality of what students know and can do in each academic content area.

Each academic content area standard is organized into one or more content or process strands. For example, the English content area has four strands: reading, literature, writing, and communication. In each strand, the items that comprise the broadest overview of what students should understand to be judged proficient are called **Common Curriculum Goals**. Common Curriculum Goals are designed as broad statements encompassing learning beyond the K-12 classroom. To guide the writing of instructional objectives aligned with these goals, **content standards** were developed which directly relate to student performance. Taken together, the content standards represent the complete set of learning outcomes Oregon students should attain. The standards do not prescribe a curriculum, but specify the criteria against which all instructional objectives in the academic content area are judged.

Common Curriculum Goals and content standards are applicable at all **benchmark** levels. Benchmarks are checkpoints during grades 3, 5, 8, and 10 at which a student's progress toward the **Certificate of Initial Mastery (CIM)** is formally measured. Specific instructional objectives at benchmarks 1, 2, 3, CIM, and the

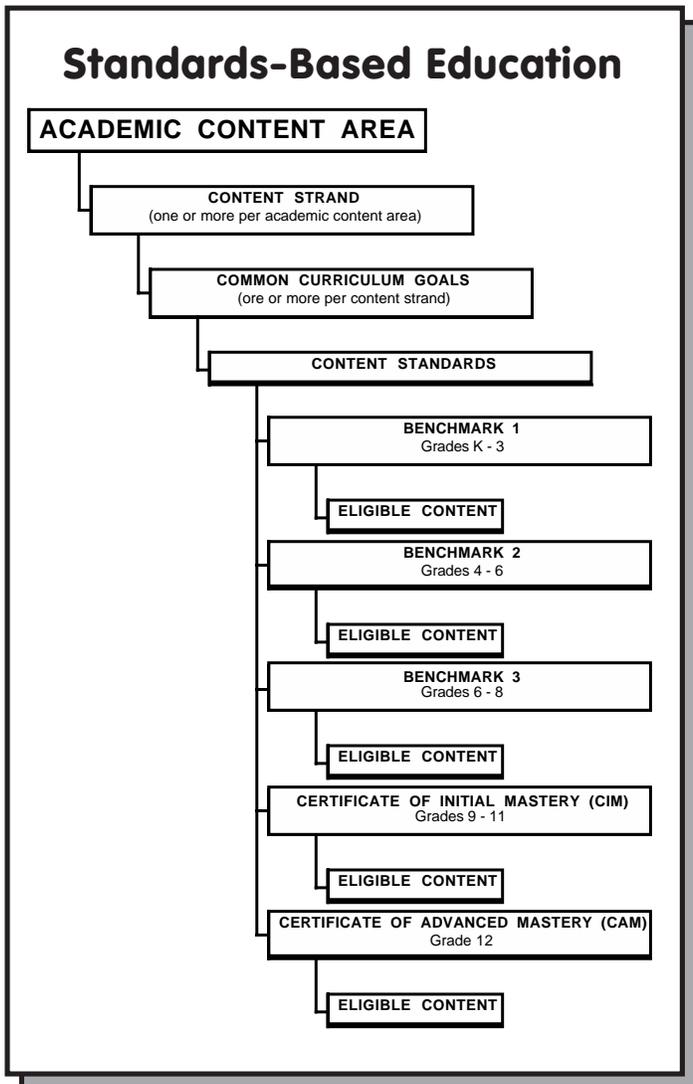
Certificate of Advanced Mastery (CAM) reflect the knowledge and skills students must demonstrate to achieve the standards. Under each benchmark are bulleted lists describing eligible content. **Eligible content** specifies elements of the benchmarks that may be assessed by state testing procedures and locally developed and scored student work samples.

Students receive a Certificate of Initial Mastery (CIM) when they achieve the state and district performance standards for grade 10. Students receive a Certificate of Advanced Mastery (CAM) when they achieve grade 12 academic benchmarks in the basic subject areas, achieve state-defined career-related learning standards,

focus on a broad career area of interest, and participate in career-related learning experiences in schools, workplaces, and/or the local community.

Oregon's content standards and benchmark levels provide teachers with guidance regarding what is essential for all students to learn in a specific academic content area. Educators determine when and how this content is delivered.

Pages 72 - 76 provide examples of various activities associated with a classroom fish egg incubation project. Refer to pages 67 - 71 for a list of each strand's most appropriate fish theme-related standards within a specific academic content area. Use these examples as a guide when developing lessons around the project. The suggestions may not be suitable for all ages of students. Individual teachers must identify what works best for them, their students, and the school environment.



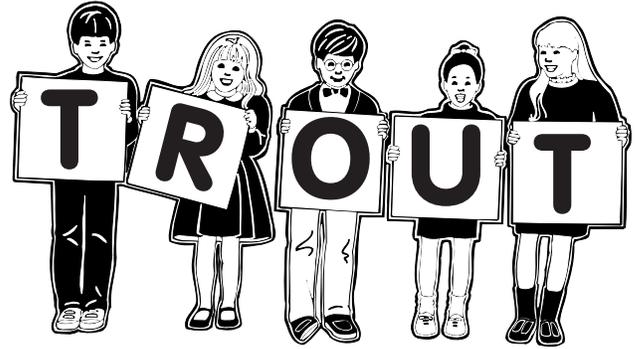
The ideas on pages 72 - 76 are best used with the most current benchmarks for each content standard. The Oregon Department of Education distributes the official *Teaching and Learning Standards* to Oregon schools, school districts, and education service districts. Obtain additional copies of *Teaching and Learning Standards* from the Oregon Department of Education, Office of Assessment and Evaluation, 255 Capitol St. NE, Salem, OR 97310-0203 or refer to their Web site, www.ode.state.or.us.

Academic Content Area Standards By Strand

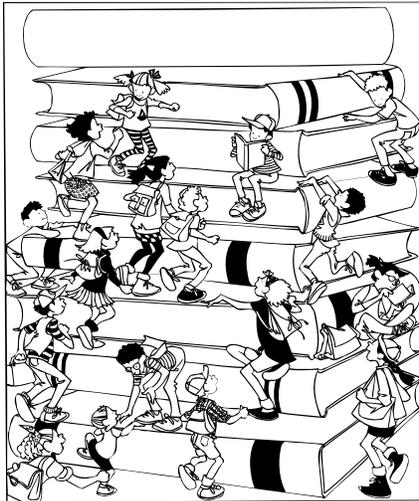
ENGLISH

Communication

1. Communicate knowledge of the topic including relevant examples, facts, anecdotes, and details.
2. Structure information in clear sequence, making connections, and transitions among ideas, sentences, and paragraphs.
3. Select words that are correct, functional, and appropriate to audience and purpose.
4. Use eye contact, speaking rate, volume, enunciation, oral fluency, vocal energy, and gestures to communicate ideas effectively when speaking.



Reading



1. Demonstrate literal comprehension of a variety of printed materials.
2. Demonstrate evaluative comprehension of a variety of printed materials.
3. Draw connections and explain relationships between reading selections and other texts, experiences, issues, and events.

Literature

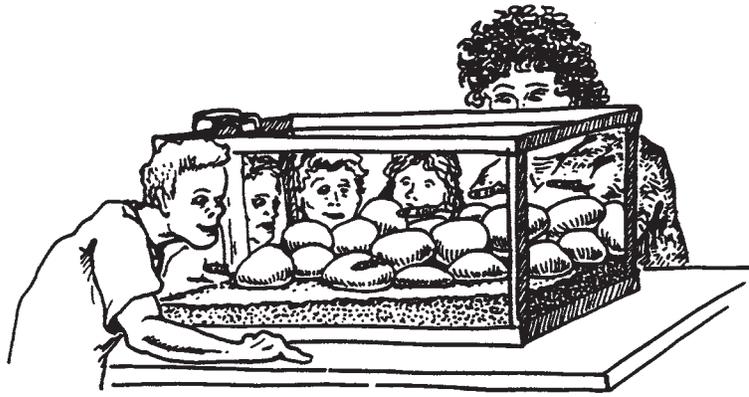
1. Understand how literature records, reflects, communicates, and influences human events.

SCIENCE

Scientific Inquiry

1. Formulate and express scientific questions and hypotheses to be investigated.
2. Design scientific investigations to address and explain questions and hypotheses.

3. Conduct procedures to collect, organize, and display scientific data.
4. Analyze scientific information to develop and present conclusions.



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.

Unifying Concepts and Processes

1. Use concepts and processes of change, constancy, and measurement.
2. Use concepts and processes of systems, order, and organization.
3. Use concepts and processes of evidence, models, and explanation.
4. Use concepts and processes of structure and function.

Physical Science

1. Describe chemical and physical changes.

Life Science

1. Describe the characteristics, structure, and function of organisms.
2. Describe the transmission of traits in living things.
3. Explain the interdependence of organisms in their natural environment.

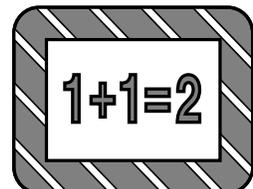
Science In Personal And Social Perspectives

1. Describe how daily choices of individuals, taken together, affect global resource cycles, ecosystems, and natural resource supplies.

MATHEMATICS

Calculations and Estimations

1. Compute with whole numbers, fractions, decimals, and integers, using paper and pencil, calculators, and computers.
2. Use estimation to solve problems and check accuracy of solutions.

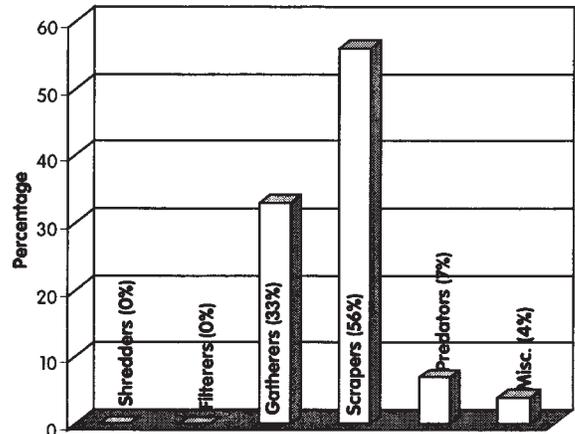


Measurement

1. Determine appropriate units, tools, and techniques to measure the degree of precision and accuracy desired in particular situations.
2. Apply direct methods of measurement in metric, U.S. customary, and other systems.
3. Apply indirect methods of measurement (e.g., formulas, estimates).

Statistics and Probability

1. Create charts, tables, and graphs, and use statistics to summarize data, draw inferences, and make predictions.



Mathematical Problem Solving

1. Represent patterns and mathematical relationships using symbols, graphs, numbers, and words.
2. Develop and apply problem-solving strategies accurately to solve problems.
3. Communicate solution process in an easily understood manner.
4. Review solutions to see if they are accurate and reasonable.

SOCIAL STUDIES

History

1. Understand and interpret relationships in history, including chronology, cause and effect, change, and continuity over time.
2. Understand and interpret events, issues, and developments in the history of one's family, local community, and culture.
3. Understand and interpret the history of the state of Oregon.

Geography

1. Locate places and explain geographic information or relationships by reading, interpreting, and preparing maps and other geographic representations.
2. Explain how humans and the physical environment impact and influence each other.

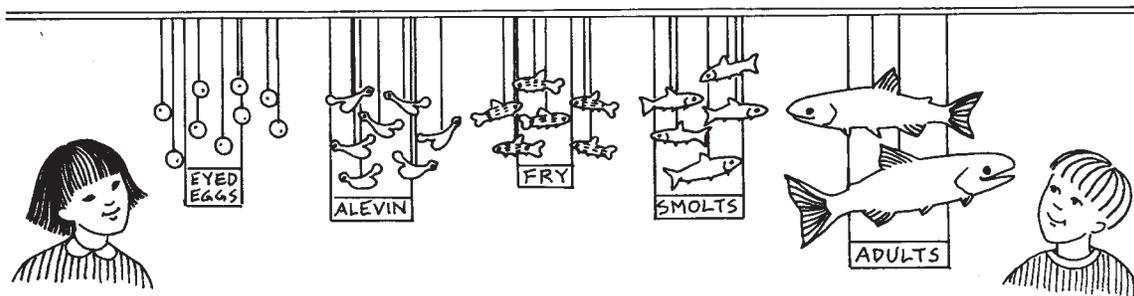
Social Science Analysis

1. Identify, research, and clarify an event, issue, problem, or phenomenon of significance to society.
2. Gather, use, and evaluate researched information to support analysis and conclusions.
3. Understand an event, issue, problem, or phenomenon from multiple perspectives.
4. Identify and analyze characteristics, causes, and consequences of an event, issue, problem, or phenomenon.
5. Identify, compare, and evaluate outcomes, responses, or solutions, then reach a supported conclusion.

THE ARTS

Create, Present, and Perform

1. Apply artistic elements and technical skills to create, present and/or perform works of art for a variety of audiences and purposes.
2. Communicate verbally and in writing about one's own artwork.



Original artwork by Jennifer Stone, Black Cat Graphics. *Update! New Activities and Current Teaching Strategies For Use With Salmonids In the Classroom*, by School District 41-Burnaby, B.C. Canada in partnership with the Salmonid Enhancement Program, Department of Fisheries and Oceans, British Columbia, Canada, 1993.

CAREER-RELATED LEARNING STANDARDS

Personal Management

1. Exhibit appropriate work ethic and behaviors in school, community, and workplace.

Problem Solving

1. Apply decision-making and problem-solving techniques in school, community, and workplace.

Communication

1. Demonstrate effective communication skills to give and receive information in school, community, and workplace.

Teamwork

1. Demonstrate effective teamwork in school, community and workplace.

Organization and Systems

1. Describe how individuals fit into organizations and systems.

Employment Foundations

1. Demonstrate both academic knowledge and technical skills required for successful employment within a career endorsement area.

Career Development

1. Demonstrate career development skills in planning for post high school experiences.



Suggestions To Help Students Achieve Benchmarks

Following are ideas for activities associated with the classroom egg incubation project. Each idea is associated with a specific strand within the major academic content area. Pages 67 - 71 refer to the associated content standards these ideas support. You must decide if these suggestions are suitable for your students and school environment and if they fit into the eligible content for the appropriate grade level benchmarks. A number of these suggestions may be suitable for assessment as student work samples.

ENGLISH

Writing

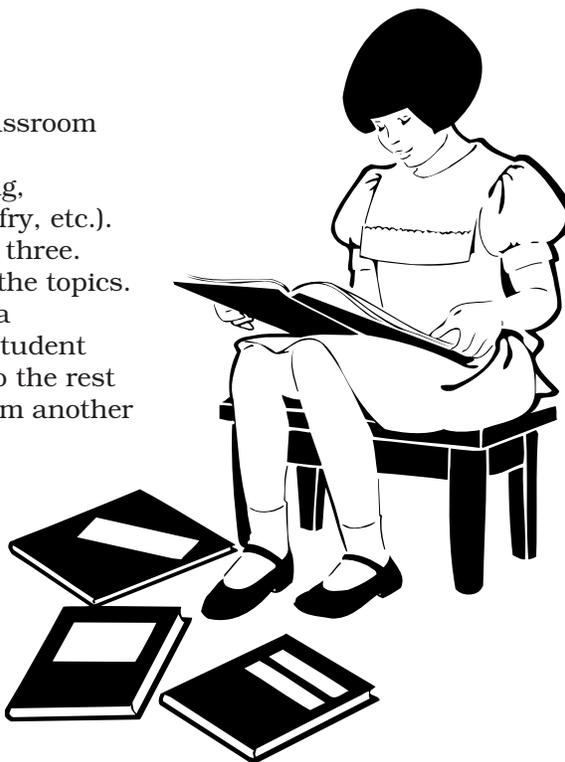
Ask students to keep a daily journal detailing the experience of hatching and releasing fish including setting up the aquarium, monitoring development, and releasing the fry. Include descriptions and drawings of the fish at the various stages as well as their habitats. Poetry, other creative writing assignments, and drawings provide an artistic aspect to an otherwise scientific journal.

Reading and Literature

Assign fish-related reading assignments from outside sources. Ask students to identify important issues and concepts about fish found in the reading, explore the historical significance of fish, recognize themes about fish that occur in literature (especially cultural stories), and recognize how authors express their ideas through fish analogies.

Communication

Make a list of topics related to the classroom egg incubation project (i.e., fish egg development, water quality monitoring, predicting hatch dates, releasing the fry, etc.). Divide students into groups of two or three. Ask student groups to choose one of the topics. Students then research and prepare a presentation about their topic. Ask student groups to deliver their presentation to the rest of the class or to visiting students from another class.



SCIENCE

Scientific Inquiry

Ask students to design and implement an experiment to test the effects of variable temperatures on the development rates of eggs and fry.

Unifying Concepts and Processes

Ask students to compare and contrast the life cycles of hatchery-reared and naturally-reproducing salmon and trout.

Ask students to diagram a typical food web that contains a salmon or trout.

Ask students to describe how the components of a classroom incubator model fish habitat found in nature.

Physical Science and Life Science

Set up a classroom incubator monitoring program which requires students to measure and record daily temperatures, and weekly dissolved oxygen and nitrogen levels in the incubator. Ask students to describe and explain the reasons for the changes they observe.

Ask students to label diagrams of both the external and internal structures of a salmonid, describe the function of each, and explain how the bodies of fish are adapted for life in water.

Explain the concept of "survival of the fittest." Ask students to describe how this concept applies to hatchery fish placed in a stream environment.

Ask students to design, illustrate, and label an ideal habitat for a salmon or trout.



Science in Personal and Social Perspectives

Ask students to describe how actions in their daily lives may affect the survival of salmon or trout in nearby streams.

MATHEMATICS

Calculations and Estimations

Calculate the approximate hatching and release dates if the fish eggs are received on February 16 and fry are released the day before Spring Break begins.

Measurement

Measure and record the temperature of the water in the aquarium incubator every day. Use this information to calculate hatching and release dates.

Statistics and Probability

Create a chart or table showing each day's water temperature measurement, daily temperature units, and accumulated temperature units.

Create a graph which shows the progress of the accumulated temperature units from the date the eggs arrived until the fry are released.

Science in Mathematical Problem Solving

Demonstrate and describe mathematically how water temperature affects development rates of eggs and fry.

SOCIAL STUDIES

History

Research and write a report describing the history of the salmon fishing industry in Oregon. Consider political, economic, social, and biological aspects throughout the report. Interview one or more individuals to add an oral history component to the report.

Geography

Produce a map showing chinook salmon distribution in Oregon. Highlight the watershed nearest you that supports chinook salmon. Describe any human impacts (both positive and negative) that may affect salmon in this watershed.

Social Science Analysis

Plan, research, and complete an in-depth research project about the salmon issue affecting the Northwest today. Include background information related to the issue, examine human activities and natural forces that affect salmon, discuss all the players connected to the issue, and describe restoration efforts undertaken by groups and individuals to deal with the issue.



THE ARTS

Create, Present, and Perform

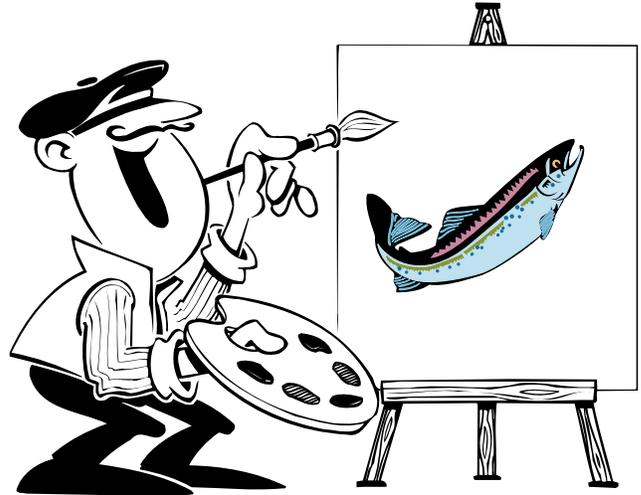
Create and display a series of banners illustrating the life stages of a salmon as if they were in a stream. Ask students to describe the life cycle as they accompany parents or other classroom visitors for a walk down the "stream."

Ask younger students to create and illustrate an alphabet book with words related to fish.

Ask students to write and perform a play about salmon.

Encourage students to create a mural depicting healthy stream habitat, complete with organisms who live in the habitat.

Ask students to write and perform a song about salmon or trout. Encourage musical accompaniment.



CAREER-RELATED LEARNING

Career-Related Learning

Set the stage for the project with a realistic scenario. Provide students with a reason for planning the research, collecting the data, and presenting the results. Ask students to present their findings to an appropriate audience.

Any of the activities associated with the classroom incubator project are suitable for student work groups and teamwork concepts.

Create opportunities for students to work with individuals from both professional and non-professional organizations whose major focus is fish or fish management. Invite a representative to share with the class how they, as an individual, fit into their organization.

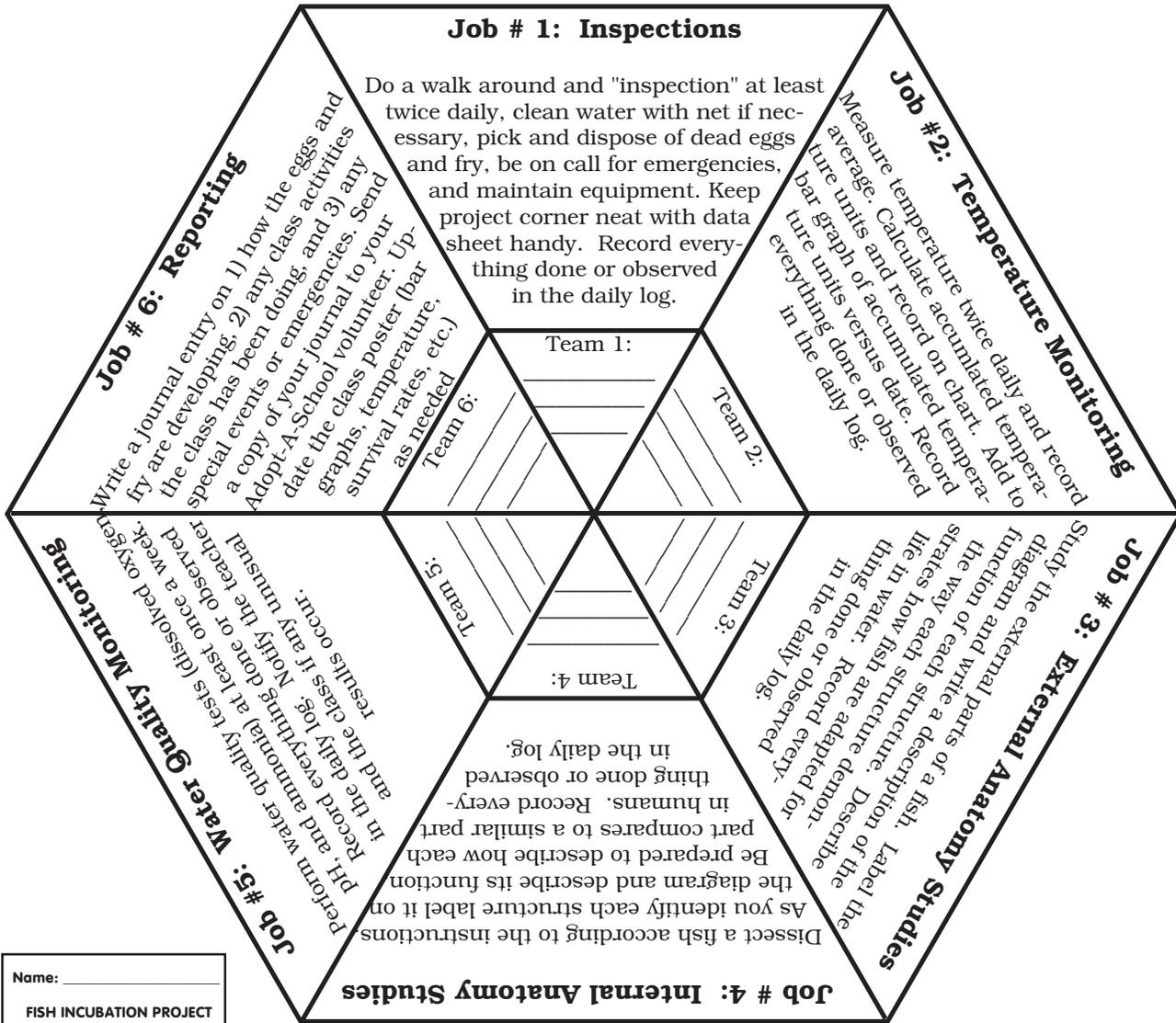
Identify the specific careers associated with the project. Ask students to research both the academic knowledge and technical skills required for employment in a fisheries career.

Note the significance of volunteer contributions to the project and the reasons why people volunteer. Ask students to volunteer to complete a project related to fisheries.

Ask students to identify how fisheries studies cross discipline boundaries.

Classroom Incubation Project

Example Job Wheel For Students



Name: _____

FISH INCUBATION PROJECT

Group # _____ Week # _____

Completed Job _____ /30 pts.
Did Fair Share _____ /30 pts.
Understood Job _____ /30 pts.
Attitude _____ /10 pts.

Total _____ /100 pts.

Comments: _____

- Each team is responsible for:
- reading the job wheel and descriptions
 - dividing the work equitably
 - getting the job done on time
 - arranging for substitutes if absent
 - working independently as a group

EXAMPLE ROTATION SCHEDULE						
JOB	1	2	3	4	5	6
Weeks of:	--- Teams ---					
Oct 7, 14	1	2	3	4	5	6
Oct 21, 28	6	1	2	3	4	5
Nov 4, 11	5	6	1	2	3	4
Nov 18, 25	4	5	6	1	2	3
Dec 2, 9	3	4	5	6	1	2
Dec 16, 23	2	3	4	5	6	1

Adapted from activity by Ben McLuckie, Hoonah City Schools, Hoonah, Alaska, 1997.

MANAGING FOR FISH AND FISHERS

Student Reading

Oregonians live in a special place — a place that allows us to share beautiful lakes, rivers, streams, and a vast ocean. We also inherit an obligation to pass on the quality of life and range of opportunities we enjoy to the next generation of people. But when it comes to fish and fisheries, we are beginning to see that we have not paid enough attention to making sure fish and the places they live will be here in the future.

For more than a century, people have cut off fish passage to spawning grounds, degraded water quality and quantity, and harvested too many fish from some populations. We built and operated fish hatcheries thinking we could make up for some of these actions. But we found that some of the hatcheries' goals and where we put the fish they produced didn't solve the fish conservation problem. Today we know that developing a hatchery "superstock" fish or increasing fish releases many times over is not the answer.

The answer is where it has always been — in Oregon's streams and rivers. It is here that steelhead, salmon, and trout have continued to live and reproduce in the natural environment, despite large odds against them. These survivors are our ticket to the fish future, because they carry in their genes the traits of fish that have survived. These wild fish are a precious resource, too valuable to lose.



Today fisheries scientists are refining their management programs. Wild fish, streams and rivers, and fish hatcheries are partners in the fish and fishing future.

What's Wild?

To be considered wild, a fish population must meet two tests:

1. It must be a naturally-spawned fish from any of the animal kingdom's group of fishes — the jawless fishes, sharks and rays, and the bony fishes, like salmon and trout.
2. It must be **indigenous**, or in other words, reproduce naturally and be directly descended from a population that was present in the same geographical area prior to the year 1800.

These fish are clearly the best fish for their native stream or river. If increased fish production is going to happen in these particular streams and rivers, it is the wild fish from that place that will make it happen.

Are there any wild fish populations left in Oregon? Yes! Efforts are underway to identify and nurture these wild populations. And even though earlier fish stocking changed the genetic makeup of some wild populations, the fish are surviving in their natural environments.

Fisheries Management and Hatcheries

So, where do hatcheries fit? One of the Oregon Department of Fish and Wildlife's goals is to maintain all wild fish populations for present and future generations of Oregonians. This means everything that affects fish must be considered in our fishery management programs. These include:

- √ wild fish conservation
- √ habitat protection and enhancement
- √ responsible hatchery operations and stocking
- √ responsible harvest management

Here's a short look at how these parts fit together.

Wild Fish Conservation

Oregon's goal is to conserve wild fish populations. We are also fixing culverts and roads that block fish who are migrating to their spawning areas. Oregonians are banding together to restore and protect fish habitat and to improve water quality for fish and biologists adjust fishing regulations when needed to protect wild fish populations.

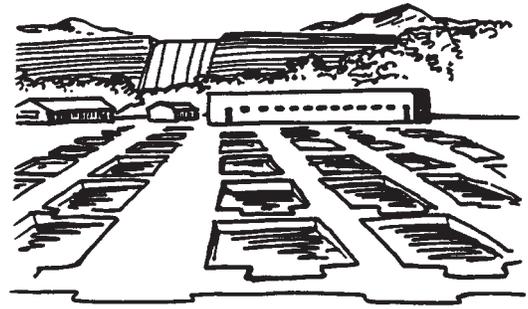
In some instances we are using "conservation hatcheries" to help rebuild wild stocks. Eggs are collected from wild fish and reared to maturity in specially designed hatcheries. We hope this can increase survival of small wild populations.

Habitat Protection and Enhancement

As information about habitat needs and availability is gathered, biologists, land and water managers, and even volunteers can expand the natural production capability of many lakes and streams. The end result is more fish!

Hatchery Operations and Stocking

A few people have concluded that being in favor of wild fish means being against hatcheries. And while some hatchery practices have not helped natural production, hatcheries have provided lots of harvest opportunities in our lakes, rivers, streams and seas. Hatcheries today have a changing role in fisheries management, and continue to be a vital part of fish conservation for the future.



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.

Examples of the changing role of hatcheries include:

- √ producing more fish stocks that are genetically similar to the fish populations already present in the watersheds where the hatchery fish will be released. This gives both wild and naturally-producing fish populations a chance to thrive. Doing this may mean making some changes in hatchery practices and stocking methods. For example, a fishery for hatchery-produced salmon in a coastal bay and watershed may be concentrated in the lower portion of the river system, while the upper portion of the river system is managed for wild populations.
- √ trapping excess hatchery fish not needed for egg-taking and reproduction and donating them to food banks, selling them for fish fertilizer, recycling them downstream so anglers have another opportunity to catch them, or placing fish carcasses in streams as a source of nutrients for juvenile fish and the food they eat. In the past, these fish were allowed to stray into wild populations. This “swamped” naturally-reproducing populations in the upper watershed with fish that were less fit to survive in the continually changing wild environment. Hatchery fish may also interbreed with wild fish that are better adapted to the stream. Scientists are now studying the results of this interbreeding.
- √ building ponds in the lower reaches of watersheds where hatchery smolts can “acclimate” to the lower river before they are released. This encourages returning adults to concentrate low in the system, leaving waters above open for natural production of locally-adapted fish stocks.
- √ exploring the role of hatcheries in conservation and recovery of wild fish populations.

Responsible Harvest Management

Managing how many fish are caught by sport and commercial fishermen is something the Department of Fish and Wildlife has been doing for many years. But today, there's a new twist — catch and release fishing. Simply put, anglers release any wild fish they catch, while keeping the hatchery fish.

Using the example of the coastal bay and upper watershed: since the fishery concentrates on marked hatchery fish that are produced for people to catch, fishing regulations in the lower part of the river system would allow some harvest. Anglers would release any wild fish, which are unmarked. The upper part of the river system would be more restrictive, even closed, since the idea is to protect the wild fish who live there. Differences in the timing of runs of both wild and hatchery fish could also be used to reduce harvest on wild fish, while increasing harvest on hatchery fish.

Go Slow And Get There Quicker

Hatchery programs are in transition. But changes cannot be made overnight and it may be a decade before they are complete. Well-thought-out approaches to hatchery operations, and careful study of the changes that are made, will pay off in the long run. And in the end, we will all benefit from a combination of hatchery-produced and naturally spawning fish.

Adapted from *The Fish Hatchery Next Door*, Bill Hastie, et al., Oregon Department of Fish and Wildlife Aquatic Education Program, Portland, Oregon, 1995.

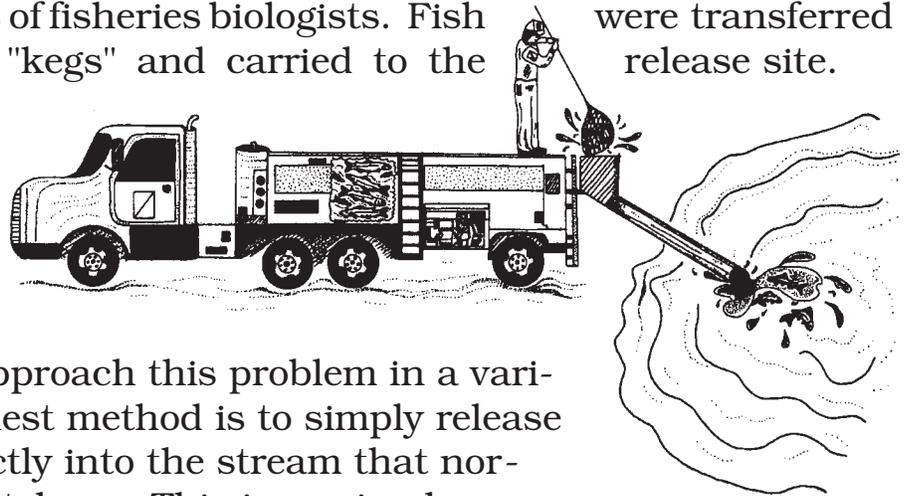
GETTING FISH OUT OF — AND INTO THE HATCHERY

Student Reading

Getting fish out of the hatchery and into the place you want them can be tricky business. For one thing you have to keep the fish in the water. For another, the place you want them may be miles from the hatchery. Finally, just having enough water to keep them in isn't enough. The water must be kept cool, as close to the temperature of the hatchery as possible. And the water must be kept well supplied with oxygen.

In days gone by, fish stocking depended on good horses or mules and even the strong backs of fisheries biologists. Fish were transferred to wooden or metal "kegs" and carried to the release site.

Many high mountain lakes saw fish for the first time through this method.



Today's hatcheries approach this problem in a variety of ways. The easiest method is to simply release the juvenile fish directly into the stream that normally flows by the hatchery. This is as simple as opening a valve to a holding pond, and "swoosh", the fish are gone. This stream is also where the hatchery may get its water for raising fish in the first place.

Another method involves placing the juvenile fish into tankers, called liberation trucks, and driving the fish to the release point. The trucks are equipped with large tanks that both cool and oxygenate the water. The fish are released by draining the tanks into a stream, or by using a hand-powered dip net to quickly take the fish from tank to stream. Stocking high altitude lakes that don't lend themselves to roads and trucks is more exciting, especially for the fish. Where appropriate, helicopters and planes are used to drop the fish into the lake. Surprisingly, the fish survive just fine.

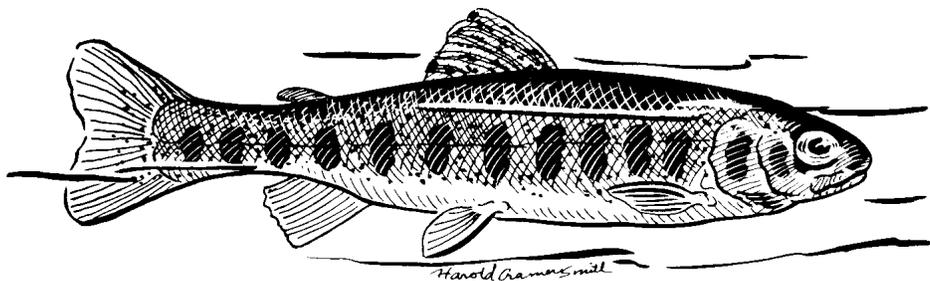
Occasionally, the Department of Fish and Wildlife still stocks some of these lakes. Horses, llamas, and volunteers often help carry the fish to the release sites.

Once the fish are out there in the world, they're on their own. They grow and learn, and many fall prey to a number of hazards.

Getting fish back to the hatchery involves three basic methods. The easiest one is to take advantage of the homing instinct of anadromous salmonids, also known as "letting the fish come to you." Hatchery fish come back to the hatchery outlet, their place of birth. The fish are then trapped or netted and held in a holding pond until they are ready to spawn.

To help rebuild wild stocks of fish, a hatchery obtains "broodstock" or adults from wild or naturally-producing fish populations to use as parents for producing hatchery fish. Brood fish are trapped, netted, or caught by volunteer anglers in a stream or lake and transported by truck (or carried) to the hatchery. The hatchery holds the brood fish in ponds at the hatchery site.

Finally, parent fish may be trapped and spawned on a stream or lake, and the fertilized eggs transported back to the hatchery to be raised in trays.



Adapted from *The Fish Hatchery Next Door*, Bill Hastie, et al., Oregon Department of Fish and Wildlife Aquatic Education Program, Portland, Oregon, 1995.

RESOURCES FOR EDUCATORS

Related Curricula and Reference Materials

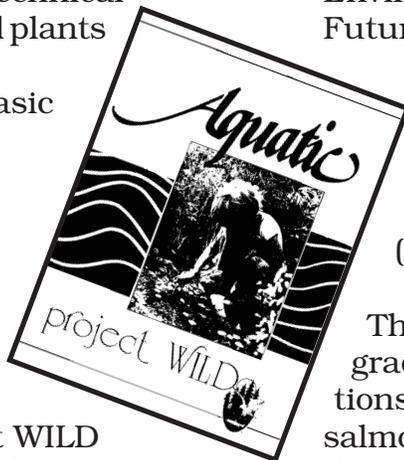
Adopting A Stream: A Northwest Primer: Steve Yates, \$9.95, University of Washington Press, PO Box 50096, Seattle, WA 98145-5096

Filled with information about aquatic habitat, water quality, and salmonids, this book tells how school, community, or sports groups can restore a nearby creek...and in the process learn much about biology, ecology, economics, and the effects of watershed activities on our streams.

Adopting A Wetland: A Northwest Guide: Steve Yates, \$5, Adopt-A-Stream Foundation, PO Box 5558, Everett, WA 98206

An ideal resource for schools, community groups, and individuals interested in restoring and/or protecting their neighborhood wetland areas. Information is in simple terms. Guide provides introduction to wetland plants, information on marsh life, wetland types and identification, their values and benefits, mitigation and legislative issues, developing an action plan, etc., as well as technical appendices on wetland plants and wildlife, scientific classification and a basic observation checklist.

Aquatic Project WILD: Aquatic Project WILD is available only through workshops. As of press time, no organization is sponsoring Aquatic Project WILD in Oregon. For an update on



Oregon availability, contact the national office at Council for Environmental Education, 5555 Morningside Drive, Ste. 212, Houston, TX 77005, (713) 520-1936, www.projectwild.org or Oregon Forestry Education Program, College of Forestry, Oregon State University, 146 Forest Research Laboratory, Corvallis, OR 97331-7404, (800) 554-6987, email: ofep@cof.orst.edu.

Developed by Western Regional Environmental Education Council. Contains many excellent, interdisciplinary water-related activities for grades K-12.

Aquatic Resources Education Curriculum: C. Boyd Pfeiffer and Mark Sosin, \$25 + \$4 s/h, Future Fisherman Foundation, 1033 N. Fairfax St., Suite 200, Alexandria, VA 22314. Call 703-519-9691 for order form or 847-364-1222 for credit card or purchase order.

Contains information about fishing techniques, water safety, and aquatic life. Units include A Fishing Primer; Becoming A Better Angler; Understanding Fish and Their Environment; Water Resources For Our Future; and Careers.

California's Salmon and Trout: Our Valuable Natural Heritage: \$20, Diane Higgins, 4649 Aster Avenue, McKinleyville, CA 95521 (707) 839-4987.

These materials were developed for grades K - 6. It is divided into sections dealing with biological aspects of salmon and trout and habitat needs of the various species.

Clean Water, Streams, and Fish: A Holistic View of Watersheds: Wendy Borton, et. al., \$12 + \$3 s/h, Washington State Office of Environmental Education, 2800 NE 200th, Seattle, WA 98155-1418 (206) 365-3893, <http://cifl.ospi.wednet.edu>.

Focuses on human dependence and human impact on water quality of the Northwest. Covers water quality, life cycle of salmon, stream ecology, and environmental/economic tradeoffs. It is specific to Washington State, but most is applicable elsewhere.

The Creek Book: UBC Press, \$10.95 + s/h, Raincoast Book Distribution, 8680 Cambie St., Vancouver, B.C. V6P 6M9, 1-800-663-5714.

Nice drawings and descriptions of plants and animals found in this ecosystem. Student worksheets included.

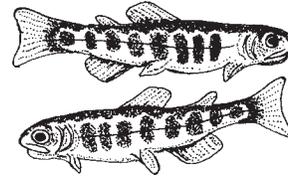
Discovering Salmon: A Learning and Activity Book: Nancy Field and Sally Machlis, \$4.95 +s/h, Dog-Eared Publications, PO Box 620863, Middleton, WI 53562-0863, (608) 831-1410 (phone and fax) or 1-888-DOG-EARS, <http://www.dog-eared.com>

Covers life cycle, different species of salmon, river geography, predators, and hatcheries. Elementary level.

Earth: The Water Planet: Jack Gartrell, et. al., \$18.50 + \$4.25 s/h, Special Publications, National Science Teachers Association, 1840 Wilson Blvd., Arlington, VA 22201-3000, 703-243-7100 or 1-800-722-6782, <http://www.nsta.org>

An excellent collection of elementary/middle school water activities. The book is divided into five sections: Groundwater; Reshaping the Surface of

the Earth; Raindrops Keep Falling On My Head; Water Water Everywhere; and Investigating the Physical Properties of Water. Each section includes readings and hands-on activities.



Field Identification of Coastal Juvenile Salmonids: WR Pollard, et. al., \$12.95 + s/h, Harbour Publishing, PO Box 219, Madeira Park, BC Canada V0N 2H0, (604) 883-2730.

A guidebook designed primarily for juvenile salmonid identification in Canadian waters, but has application throughout the Northwest.

Fish Eggs to Fry: Helping Kids Hatch Fish: Bowers, Patty, et. al., Oregon Department of Fish and Wildlife, STEP Coordinator, PO Box 59, Portland, OR 97207, (503) 872-5252, or call local STEP Biologist to obtain a copy.

This manual provides all the information an Oregon teacher would need to hatch salmon or trout eggs in a classroom incubator.

The Fish Hatchery Next Door: Hastie, Bill and Bowers, Patty, Oregon Department of Fish and Wildlife, PO Box 59, Portland, OR 97207, (503) 872-5264, or contact your local Oregon hatchery.

This package helps you create successful visits to a fish hatchery with students of all ages. Fish hatcheries play an important role in maintaining the balance between human demands and the needs of Oregon's diverse wildlife.

Fish in the Floodlights: BCTF Lesson Aids, #100-550 W. 6th Avenue, Vancouver, BC V5Z 4P2, (604) 871-2181.

Nine short dramas; ideal for theme units and integrated activities.

From Ridges to Rivers - 4-H Watershed

Project: Copies are available from all Oregon State University Extension Service county offices.

This is an interactive curriculum based on creek tables using diatomaceous earth. Additional support activities, such as Mud Milk Shakes and Aquifer in A Cup, encourage scientific inquiry.

Groundwater: A Vital Resource: Cedar Creek Learning Center, free, Citizen Action Office, Tennessee Valley Authority, 400 W. Summit Hill Drive, Knoxville, TN 37902.

A good collection of activities for grades 3-12 related to groundwater. Units include The Water Cycle; Water Distribution in Soils; Water Quality; and Community Impacts.

How to Catch and Identify the Gamefish of Oregon: E. A. Lusch, Frank Amato Publications, PO Box 02112, Portland, OR 97202.

A practical guide to fish identification for all interested individuals.

Investigating Aquatic Ecosystems: William A. Andrews, Prentice-Hall Canada, Inc., Scarborough, Ontario, 1987.

A textbook with an introduction to the basic principles of freshwater ecology. Includes field and laboratory studies and thought-provoking questions.

Leapfrogging Through Wetlands: Margaret Anderson, Nancy Field and Karen Stephenson, \$7.95 +s/h, Dog-Eared Publications, PO Box 620863, Middleton, WI 53562-0863, (608) 831-1410 (phone and fax) or 1-888-DOG-EARS, <http://www.dog-eared.com>.

This book helps young people understand the significance of wetlands in ecosystems throughout North America. Readers learn about the vast array of plant and animal life associated with wetlands. Educators will find this book an excellent companion for *WOW! The Wonders Of Wetlands* and *Project WET*.

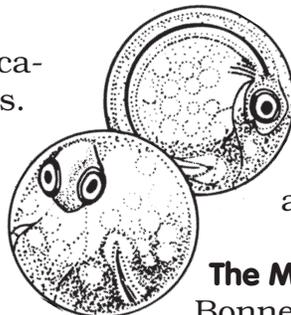
Learning to Love Streams: Izaak Walton League of America, 1401 Wilson Boulevard, Level B, Arlington, Virginia 22209.

Water quality and pollution materials.

Living in Water – An Aquatic Science Curriculum: (3rd edition) \$23.95 + \$4 s/h, Kendall Hunt, 4050 West Mark Drive, PO Box 1840, Dubuque, IA 52004-1840, 1-800-228-0810.

This is a basic hands-on aquatic science curriculum for grades 4 -6. The material provides extensive background on the basic principles and concepts of aquatic ecology: the solubility of water and its effects on the distribution of aquatic life, adaptations to aquatic environments, food web interactions, and the importance of aquatic research.

The Magnificent Journey: Free, Bonneville Power Administration, Public Involvement Office, PO Box 12999, Portland, OR 97212, 1-800-425-8429, <http://www.bpa.gov/corporate/kr/ed/reslist/reslistx.shtml>



This is the life story of Onco, a chinook salmon from Idaho. Contains information about habitat and threats. Poster of salmon and steelhead included.

Make It Work! Rivers: The Hands-On Approach To Geography: Andrew Haslam, Two-Can Publishing Ltd, Chicago, IL 60661.

One of a four-part "Make-It-Work" series of books that use colorful realistic models and exercises to engage children in interactive hands-on projects. For ages 8 and older.

OBIS Ponds and Lakes: \$18.95, Delta Education, Inc., Box M, Nashua, NH 03061-6102, (603) 889-8899.

Eight activities explore aquatic sites, the plants and animals that live there, and their behaviors.

OBIS Streams and Rivers: \$18.95, Delta Education, Inc., Box M, Nashua, NH 03061-6102, (603) 889-8899.

Eight activities investigate aquatic life in streams and rivers. Specialized activities include feeding behaviors of crawdads and water striders, and the impact of a simulated oil spill.

Oregon Environmental Atlas: Carolyn Young, \$10, Portland State University, Media Publications, PO Box 1394, Portland, OR 97207.

Includes statewide information about Oregon landforms, surface water, ground water, water cycle, water uses, water quality, water pollutants, and related issues plus other environmental concerns such as air quality, solid and hazardous wastes, toxic issues, nuclear wastes, and noise pollution.

Our Water World - 4-H Marine Science Discovery Project: Copies are available from all Oregon State University Extension Service county offices.

Developed by the staff of Hatfield Marine Science Center and the 4-H Youth Development Program this curriculum is designed for grades 4-5. It includes activities about watersheds and ocean conditions that can affect salmon. The lessons are keyed to grade 5 science benchmarks.

Pacific Salmon and Steelhead Coloring Book: U.S. Fish and Wildlife Service, Fisheries Outreach Specialist, 911 NE 11th Ave., Portland, OR 97232, (503) 231-6874, <http://www.r1.fws.gov/publications/>.

This publication is a children's coloring book that helps students identify Pacific salmon and learn about a salmon's life cycle. It also discusses hazards and problems encountered by salmon during their life history.

The Pond Book: UBC Press, \$10.95 + s/h, Raincoast Book Distribution, 8680 Cambie St., Vancouver, B.C. V6P 6M9, 1-800-663-5714.

Contains drawings and descriptions of plants and animals found in the pond ecosystem. Some student worksheets included.

Project Learning Tree: Project Learning Tree materials are available only through workshops. Contact the Oregon PLT office, Oregon Forestry Education Program, College of Forestry, Oregon State University, 146 Forest Research Laboratory, Corvallis, OR 97331-7404, (800) 554-6987, <http://www/cof.orst.edu/cof/extended/ofep/>

PLT is an interdisciplinary, comprehensive environmental education program that uses the forest as a "window" into the natural world. The pre K - 8 activity guide is arranged into five major themes: diversity, interrelationships, systems, management and technology, and society and culture.

Project WET: The Watercourse, 201 Culbertson Hall, Montana State University, Bozeman, MT 59717-0057, (406) 994-5392, Contact Project WET coordinator for Oregon, The High Desert Museum, (541) 382-4754.

Project WET is an interdisciplinary water education program intended to supplement a school's existing curriculum. The goal of the program is to facilitate and promote the awareness, appreciation, knowledge, and stewardship of water resources through the development and dissemination of classroom-ready teaching aids.

Project WILD: Project WILD is available only through workshops. As of press time, no organization is sponsoring Project WILD in Oregon. For an update on Oregon availability, contact the national office at Council for Environmental Education, 5555 Morningside Drive, Ste. 212, Houston, TX 77005, (713) 520-1936, www.projectwild.org or Oregon Forestry Education Program, College of Forestry, Oregon State University, 146 Forest Research Laboratory, Corvallis, OR 97331-7404, (800) 554-6987, email: ofep@cof.orst.edu.



Contains a broad range of interdisciplinary activities focused on conservation and wildlife education.

Responsible Angling: The Oregon Angler Education Manual: Oregon Department of Fish and Wildlife, Aquatic and Angler Education Program, PO Box 59, Portland, OR 97207, (503) 872-5264.

The ODFW Aquatic and Angler Education course helps provide an awareness and understanding of the aquatic ecosystems that fish inhabit and the relationships these systems have to the sport of angling. Primary areas of instruction include conservation and stewardship, ethical conduct and responsibilities, water safety, and basic angling skills.

Rivers and Streams, Habitat Pac: \$5, National Institute for Urban Wildlife, 10921 Trotting Ridge Way, Columbia, MD 21044.

Includes teacher overviews, lesson plans, students worksheets and poster.

Rivers Curriculum Guide: \$23.95 each + s/h, Rivers Project Southern Illinois University, PO Box 2222, Edwardsville, IL 62026-2222, (618) 650-2000.

A series of six rivers-based units written by teachers participating in the Rivers Curriculum Project funded by the National Science Foundation. The units include biology, chemistry, earth science, geography, language arts, and mathematics.

Salmon A La Arte: An Arts-Based Science Curriculum: Roxallanne Medley, \$30 + s/h, 701 NW Madrona Way, Coupeville, WA 98239, (360) 678-3720, Email: rmedley@whidbey.net.

This curriculum is designed for students in grades 1 - 5. It teaches about salmon through a variety of arts-based activities.

Salmon Below The Surface: BCTF Lesson Aids, #100-550- W. 6th Avenue, Vancouver, BC, V5Z 4P2, (604) 871-2181.

Seven new science activities for use with *Salmonids in the Classroom, Intermediate*, also suitable for grades 8-10.

Salmon Kit: \$200, Pacific Science Center, 200 2nd Avenue N., Seattle, WA 98109.

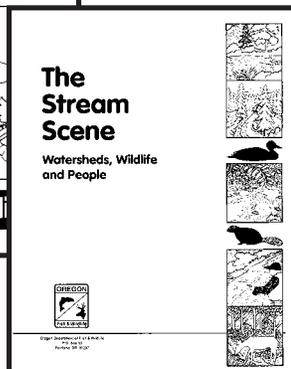
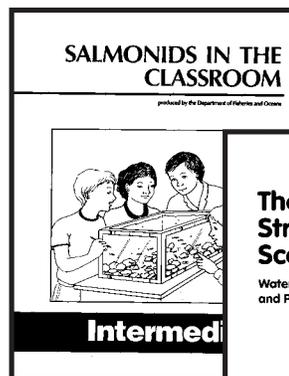
Includes 10 activities, 3 computer disks, filmstrips, slides, magnifying lenses, thermometers, laminated salmon cards, activity outlines and worksheets.

Salmonids in the Classroom – Primary Package (K-3):

includes video cassette and 8 life cycle posters, \$60 plus 20% surcharge for non-BCTF members, **Intermediate Package (4-7):**

includes video cassette, \$70.00 plus 20% surcharge for non-BCTF members, BCTF Lesson Aids, #100-550 W. 6th Avenue, Vancouver, BC, V5Z 4P2, (604) 871-2181.

Primary package studies salmonids through an illustrated story of Chucky Chum. Intermediate package has three units: life cycle, harvesting, and enhancement. Units cover biological aspects, salmonid habitat, the fishing experience, and salmonids in today's world. Ideas for all subject areas. Specific to British Columbia, but adaptable.



Save Our Streams: Izaak Walton League of America, 1401 Wilson Boulevard, Level B, Arlington, VA 22209.

This packet of materials on stream care and water quality includes background information, activities, teaching guide, and guidelines for how to adopt and monitor a stream.

Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods: Murdoch, Tom, et. al., \$29.95 + \$4.00 s/h, Adopt-A-Stream Foundation, 600-128th St SE, Everett, WA 98208, (425) 316-8592.

Information about how streams and their surrounding watersheds function, detailed methods for watershed inventory and stream monitoring for volunteers, tips on presenting data, and stories about Streamkeepers putting watershed inventory and stream monitoring information to use to protect and restore our nation's streams.

The Stream Scene: Watersheds, Wildlife, and People, Second Edition: Bowers, Patty, et al., 1999, \$32, Oregon Department of Fish & Wildlife, PO Box 59, Portland, OR 97207, (503) 872-5264.

This watershed education curriculum package targets students in grades 6-12. Units include The Water Cycle, Watersheds, Uplands, Riparian Areas, Hydrology: Water Quality; and Aquatic Organisms. This publication contains background information, student worksheets, field data sheets, correlations with state education standards, ideas for younger students, scientific inquiry experiences, and other resources.

Streamwalk Manual: US-EPA, Krista Rave, Eco-081, 1200 6th Ave, Seattle, WA 98101, (206) 553-6686.

A standardized, easy-to-use screening tool for monitoring stream corridor health. It is designed for use by lay people who are interested in learning more about their streams and rivers.

Update! BCTF Lesson Aids, #100-550 West 6th Avenue, Vancouver, BC V5Z 4P2, (604) 871-2181.

New and revised activities, handouts, and cooperative learning strategies for *Salmonids in the Classroom, Primary*.

Water Education: Distributed by the International Office for Water Education, Utah Water Research Laboratory, Utah State University, Logan, UT 84322-3200, (435) 797-3232.

Geared to grades K-6, the activities in this manual will help students develop a scientific attitude about water.

Watershed Uplands Scene: Catching the Rain: Ferschweiler, Kate, Horn, Kermit, and Hughes, Al, Environmental Education Association of Oregon, \$15, Oregon Watershed Enhancement Board, 775 Summer St. NE, Ste. 360, Salem, OR 97301-1290, (503) 986-0178

This package provides a model for students to learn fundamental concepts about their local watershed while developing information-gathering, problem-solving, group interaction, and public presentation skills. Unit 1 explores the biophysical aspects of a watershed – weather and climate, soils vegetation, and wildlife. Unit 2 introduces the human uses – urban, forestry, recreation, and agriculture, and Unit 3 provides an opportunity for students to

apply knowledge and skills learned in the previous section to local land-use management issues.

Wetland Walk Manual: US-EPA, Krista Rave, Eco-081, 1200 6th Avenue, Seattle, WA 98101, (206), 553-6686.

A standardized, easy-to-use screening tool for monitoring wetland health. It is designed to give citizens the opportunity to become partners in learning about wetlands and at the same time collect information and data that help identify trends in wetland health and location.

4-H Wetland Wonders: Virginia Thompson, Dave Price, Connie Reid, Oregon State University Extension Service, 5390 4-H Road NW, Salem, OR 97304, 503-371-7920.

This curriculum guide for grades 4 - 5 is focused on wetlands and water quality issues. Lessons begin with the water cycle and extend through watersheds, ground water, home water uses, and wetland plants, soils, and animals.

WOW! The Wonders of Wetlands: Kesselheim, Alan, et. al., Environmental Concern, Inc., \$15.95 plus shipping, The Watercourse, 201 Culbertson Hall, Montana State University, Bozeman, MT 59717-0057, (406) 994-5392.

This curriculum package is for all educators. It contains background material for those educators preparing wetland study units. It also contains material on organizing a wetlands field trip, making inexpensive sampling equipment, and getting involved in wetland enhancement and stewardship.



World Wide Web Sites

Because of the ever-changing nature of the Internet, the addresses of some sites mentioned in this section may change. If you are having trouble accessing a site with an address listed here, try using one of the many search engines that are available on the Web. Call up the search engine and enter the name of the site you want to find in the subject field. If the site still exists, it should appear in your list of results.

Alaska Aquatic Education Resources

www.state.ak.us/local/akpages/FISH.GAME/sportf/geninfo/aq_ed/aeindex.htm

Ideas and activities from Alaska's classroom incubation program.

Aquatic Invertebrates

http://education.lanl.gov/resources/ntep95/Aquatic_Insects/Waterbugs.html

Includes web pages for insect identification and classroom insect activities.

BC Salmon Page

<http://www.canfisco.com/bc-salm2.html>

The story of salmon in British Columbia.

BPA Resources

<http://www.bpa.gov/corporate/kr/ed/reslist/reslistx.shtml>

Try the salmon life cycle hexaflexagon.

Environmental Education Link

<http://eelink.net/classroomresources-directories.html>

Environmental education site with many links.

Hach Water Test Kits For Educators

<http://www.hach.com/Prod/paeduc.htm>

Good source of test kits for pH, dissolved oxygen, ammonia, and others.



Oregon Department of Fish and Wildlife

www.dfw.state.or.us

The Oregon Department of Fish and Wildlife website contains much information about the state's fish and wildlife resources. Refer to the Salmon-Trout Enhancement Program and aquatic and angler education links.

The Oregon Plan For Salmon And Watersheds

www.oregon-plan.org/

The Oregon Plan is the State of Oregon's effort to restore salmon, trout, and other aquatic resources to productive and sustainable levels.

Salmon Challenge

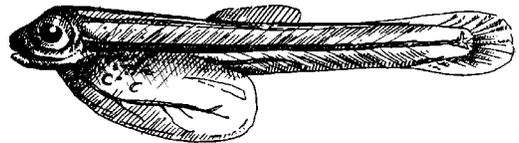
<http://dnr.metrokc.gov/wlr/waterres/salmonch.htm>

An interactive online voyage.

Stream Studies Page

[www.wsrv.xlas.Virginia.EDU/~sos-iwla/Stream Study/StreamStudyHomePage/StreamStudy.HTML](http://www.wsrv.xlas.Virginia.EDU/~sos-iwla/Stream%20Study/StreamStudyHomePage/StreamStudy.HTML)

Provides many resources about stream studies.



The Salmon Page

www.riverdale.k12.or.us/salmon.htm#k-12

A comprehensive salmon resource with many excellent links.

Trout In The Classroom Online

www.newberg.k12.or.us/ey/html/trout.html

This Oregon website is designed for educators and students involved in the classroom egg incubation program. It provides educators and students with quick access to resources designed to enrich the fish hatching experience.

Water Education Site

<http://www.uwex.edu/erc/ywc/sumlist.htm>

Includes a list of 100 curricula for educating youth about water.

Water Education Related Web Sites

<http://www.dnr.state.oh.us/odnr/water/educate/edulinks.html>

Contains links to many water education related websites.

Posters

Salmon Life Cycle Posters

Eight posters showing the life stages of a salmon, \$18 set plus 20% surcharge for non- BCTF members. Catalog available.

BCTF Lesson Aids
#100 – 550 W. 6th Avenue
Vancouver, BC V5Z 4P2
(604) 871-2181

Trout, Salmon, and Char of North America

\$10.95 plus shipping. Catalog available

Ed Lusch
Windsor/Nature Discovery LLC
1000 S. Bertelson #14
Eugene, OR 97402
1-800-635-4194

A Stream Continuum

Shipping and handling charges only (\$4) for educators. All others \$10 plus shipping and handling.

Oregon Chapter
American Fisheries Society
PO Box 722
Corvallis, OR 97339
(541) 753-0442

Pacific Salmon Life Cycle

Nominal fee for shipping and handling.

Education Coordinator
Alaska Department of Fish and Game
333 Raspberry Road
Anchorage, AK 99518
(907) 267-2265

Salmon Alphabet Poster

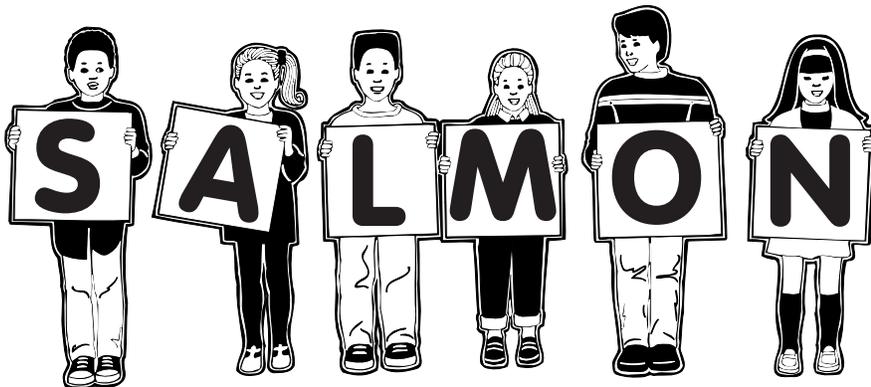
A full color poster, 48 x 80 cm, with illustrated salmon words from A to Z. \$10 plus 20% surcharge for non-BCTF members.

BCTF Lesson Aids
#100 – 550 W. 6th Avenue
Vancouver, BC V5Z 4P2
(604) 871-2181

Pacific Salmon Of North America Poster

This poster features color illustrations of all five Pacific salmon and the steelhead. Two sizes, \$16.99 or \$14.99 plus \$5.00 shipping and handling.

Timothy Colman, Publisher
Good Nature Publishing Company
1904 Third Avenue #415
Seattle, WA 98101
1-800-631-3086
www.goodnaturepublishing.com



Miscellaneous Props

Stuffed Dissection Fish

An excellent fabric likeness of a coho salmon. All internal parts are attached with velcro and easily removed. Excellent resource for fish dissections with any salmonid species. \$275 Canadian plus shipping.

Pacific Seam Works
3731 Winston Cr.
Victoria, BC V8X 1S2
(250) 388-3730
corrine@pinc.com

Games

Upstream Racers – An Educational Board Game

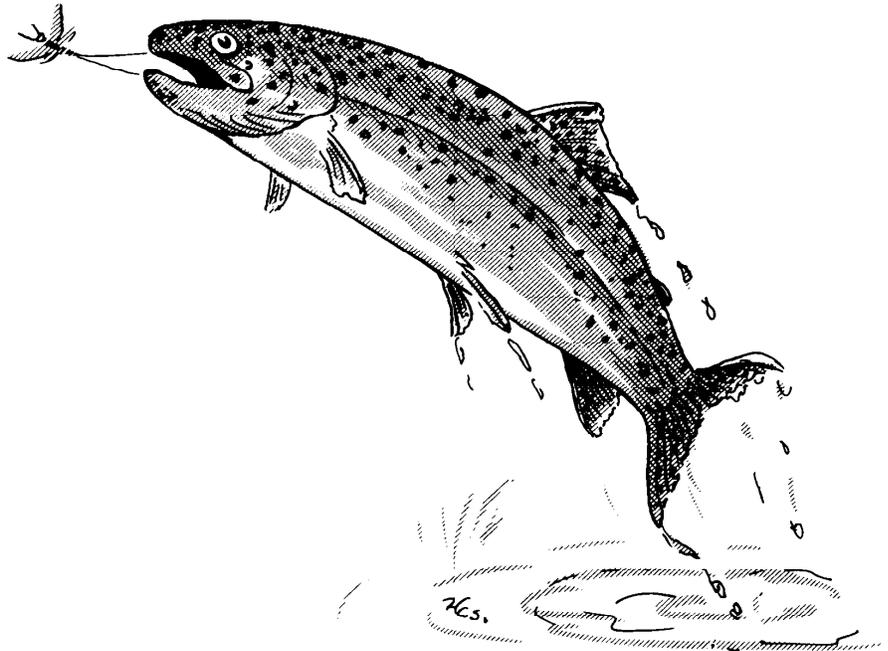
Includes a colorful game board, rules, die, pawns and predator capture canisters plus 20 pages of related learning activities. \$18 plus 20% surcharge for non-BCTF members.

BCTF Lesson Aids
#100 – 550 W. 6th Avenue
Vancouver, BC V5Z 4P2
(604) 871-2181

Puppets

Five, well-made stylized sock puppets of the salmon life cycle stages (egg, alevin, fry, adult, spawner) \$45 plus 20% surcharge for non-BCTF members.

BCTF Lesson Aids
#100 – 550 W. 6th Avenue
Vancouver, BC V5Z 4P2
(604) 871-2181



Glossary

aeration: To supply the water with air.

alevin: Newly-hatched fry which still have the yolk sac attached.

air pump: Provides aeration for the classroom incubator.

ammonia: Common waste product of eggs and fry, occurs as NH₃.



bacterial heterotrophs: Bacteria in the biofilter which consume microscopic food particles and wastes.

biological filter (or biofilter): Microorganisms which develop in the gravel layer above the undergravel filter; consume the deadly ammonia that fish excrete and convert it to a harmless form of nitrogen.

brood stock: Sexually mature fish from which eggs and milt are taken.

brood year: Year eggs are produced.

button-up: The stage of fry development when the belly seam closes as the yolk sac is consumed; fry at this stage are sometimes called "swim-up-fry."



coagulated yolk: Condition found in sac fry, characterized by discolored yolk and abnormal swimming behavior; caused by various stress and other factors including rough handling or light exposure.



daily progress record: Form used to document number of egg and fry mortalities during the incubation period.

designated fish release site: Specific site(s) approved for release of fry; approval required from STEP biologist or district biologist and contingent upon statewide guidelines and management goals outlined in basin plans.

dissolved oxygen (DO): Amount of oxygen dissolved in water; measured in parts per million (ppm); 7 - 12 ppm is optimum for fish survival.

DO: Dissolved oxygen concentration.



egg: Mature female sex cell, ovum

egg request: Application form which specifies the number and type of eggs requested by the classroom incubator operator; must be approved by the STEP biologist prior to project initiation.

eyed egg: A partially developed egg that shows the embryo's eyes; somewhat less sensitive to light or shock than a green egg.



fitness: Relative ability of an organism to survive and transmit its hereditary characteristics to the next generation.

fry: Young fish which have left the gravel to seek food, yolk sac is no longer present.



gang valve: A tool used to divert output from an air pump in several directions.

green eggs: Newly spawned eggs, very tender at this stage of development and highly susceptible to damage or death.



habitat: An area that provides an organism's needs for food, water, and shelter - it's home.

hatchery: A facility at which eggs are collected and incubated, hatched, and reared for release and harvest.

hatchery fish: A fish spawned, incubated, and/or reared under artificial conditions.



incubation period: Period from fertilization of the egg until beginning of active feeding by fry.

incubator: Device for artificial rearing of fish from fertilization of the egg to release of fry.

indigenous: Fish population that reproduces naturally and is directly descended from population present in the same geographical area prior to 1800.



macrophage: Larger microorganisms like protozoans, rotifers, and nematodes in the biofilter who consume large food particles and wastes.

metabolism: Vital processes which make new body tissues and excrete waste materials.

microorganisms: One-celled organisms like protozoans, bacteria, and others.

milt: Sperm-carrying fluid from male fish.



nitrobacter: One of the biological components of the biofilter. *Nitrobacter* species oxidize ammonia to less toxic nitrites which supplies food for *Nitrosomonas* bacterial species.

nitrosomonas: One of the biological components of the biofilter. *Nitrosomonas* bacteria use nitrites as food and oxidize them to nitrates which fish can tolerate.



ODFW: Oregon Department of Fish and Wildlife, agency responsible for management of Oregon's fishery resources.

Ovum: Female sex cell.



parts per million (ppm): One part of a substance by weight contained in one million parts of a solution; equal to milligrams/liter (mg/l).

pH: Measure of acidity or alkalinity of a solution ranging from 0 to 14; values above 7 are alkaline, below 7 are acid; a pH of 6.5 - 7.5 is required for egg and fry survival.

picking: Removal of dead eggs or fry from tray or gravel.



redd: A nest dug in the gravel by a female fish during spawning; the eggs incubate in the gravel until hatching.

report of operations: Form used to summarize the results of a classroom incubator project; includes egg and fry mortalities, release information, and other comments about the project.

riser tubes: Extensions of the undergravel filter, provide water circulation and aeration in the classroom incubator.



sac-fry: An alevin, a newly hatched fish with the yolk sac still attached.

salmonid: A fish in the salmon or trout family.

smolt: Juvenile salmon or steelhead that has physically changed to prepare for life in saltwater.

spawning: In fish, the act of laying and fertilizing eggs.

spawning survey: Evaluation of a particular stream for evidence of spawning fish; redds, fish carcasses, and live fish are counted.

sperm: Male sex cell.

STEP: Salmon-Trout Enhancement Program, a volunteer program within the Oregon Department of Fish and Wildlife (ODFW).

STEP biologist: One of several ODFW biologists assigned to work with volunteers on salmon and trout restoration and enhancement projects, including classroom egg incubation projects.

stress factor: Any factor which adversely influences the capability of a fish to perform normal functions.



temperature: One of the key habitat components in the classroom incubator; temperatures of 42° - 55° F are required for egg or fry survival.



temperature unit (TU): A measurement unit of accumulated temperature, 1° Fahrenheit (F) above 32° F for 24 hours equals 1 TU ; used to predict when a fish egg will hatch.

tender stage: Period of early development during which the embryo is highly sensitive to shock, from a few hours after fertilization to the time eyes become evident in the embryo; also called "green".

TUs: Temperature units; used to predict when a fish egg will hatch.



undergravel filter: Filter plate placed beneath the gravel in an aquarium; acts as a biological filter to remove waste products of eggs and fry from the water.



VO #: Volunteer operator #, tracking number assigned to an egg incubation project by the STEP biologist.



water hardening: Process of water absorption by eggs, occurs shortly after fertilization; eggs are very tender after water-hardening to the time they "eye-up".

wild fish: A naturally produced fish from any of the animal kingdom's group of fishes which is directly descended from a population present in the same geographical area prior to 1800.

yolk sac: Sac attached to a newly hatched fish which contains a balanced diet for its early growth.



Our mission is to protect and enhance Oregon's fish and wildlife and their habitats for use and enjoyment by present and future generations.

