# Trout

## AQUACULTURE CURRICULUM GUIDE

## YEAR TWO
## SPECIES MODULE

This is a project of the National Council for Agricultural Education, Alexandria, Virginia
with a grant from
United States Department of Agriculture

1995 Preliminary Edition

Send all comments to:
W. Wade Miller
201 Curtiss Hall
Department of Agricultural Education and Studies
Iowa State University
Ames, Iowa 50011-1050

This material is based upon work supported by the Cooperative State Research Service, U.S. Department of Agriculture, under Agreement No. 90-38816-5653.

Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

**Description:** The module consists of the following three problem areas:

**Module:** Trout

**Problem Areas:** Exploring Life Cycle of Trout
Discovering Opportunities in Trout Culture
Breeding, Raising, and Producing Trout

**Objectives:** The objectives for each problem area are given below:

A. Exploring Life Cycle of Trout
- list and discuss components of trout's natural habitat
- identify commercially important trout species
- list and discuss components of trout reproductive biology and spawning

B. Discovering Opportunities in Trout Culture
- discuss issues of world consumption and production of trout
- identify marketing channels used to link producers to consumers
- explain relationships between costs, returns, and yields

C. Breeding, Raising, and Producing Trout
- list and diagram 3 components of trout production operation
- diagram proposed hatchery, label its parts, and discuss why each was included
- describe differences between 3 types of containment systems
- list and discuss 6 factors affecting water supply and quality
- explain difference between wet and dry spawning; cite advantages of each
- explain 3 methods of egg taking
- discuss effects of direct light on eggs and sac fry
- list 3 methods of egg counting
- describe purpose of egg shocking
- list and discuss 4 methods of egg picking
- describe hatching eggs via troughs
- discuss advantages of hatching eggs with vertical flow incubator
- compare/contrast methods used in handling/shipping green eggs vs. eyed eggs
- describe sources from which producer may obtain various trout stock
- list 3 factors of farm hygiene
- explain purpose for grading fish
- explain difference between total length and fork length
- describe how to determine fish weight when transporting fish via large truck
- list factors affecting nutritional needs of trout
- explain difference between high density pellets and expanded pellets
- explain difference between processes that produce natural and artificial coloring of trout flesh
- define Food Conversion Ratio
- Define fish condition mathematically
- list 4 fish feeding methods
- define stocking density and the factors influencing it
- discuss how to transport live fish
- list classifications of fish disease and approaches to treatment

**Teaching Plan:**

**Module:** Trout - Section A

**Problem Area:** Exploring Life Cycle of Trout

**Goal:** The goal of this problem area is to explain and discuss various components of the life cycle of trout, as they relate to natural habitat, identification, and reproduction.

**Learning Objectives:** Upon completion of this problem area, students will be able to:

list and discuss components of trout's natural habitat
identify commercially important species of trout
list and discuss various components of trout reproductive biology and spawning

**Resources:** The following instructional resources are needed to complete this problem area:

**Essential:**

**The Trout and Salmon Handbook,** by Ade, R., Facts On File, New York, NY, 1989.

**Additional:**

**Trout Farming Manual** (2nd ed.), by Stevenson, J.P., Farnham, Surrey, England, Fishing News Books Limited, 1987.

**Salmon and Trout Farming**, by Laird, L.M. & Needham, T., Chichester, West Sussex, England, Ellis Horwood Limited, 1988.

## Content and Procedures

**Preparation (Interest Approach):**

To develop student interest in this module, photocopy this page of the unit and cut it along the two dashed lines, producing both a question sheet and an answer sheet. Select two students from the class, and give one the question sheet, and the other the answer sheet. Have the student with the question sheet interview the other student, who will be answering from the perspective of a trout. At the end of the activity emphasize the fact that all animals have their own habitats and life cycles, and stress the need to explore these as they pertain to trout.

---

Q1. What is your name?

Q2. What kind of dumb name is that?

Q3. Where do you live?

Q4. Why do you live in Oregon?

Q5. What is your favorite car of all time?

Q6. What is your favorite hobby?

Q7. What is your least favorite hobby?

---

A1. Charlie Salmonidae.

A2. My last name reflects my family background; besides, Charlie Tuna was already taken.

A3. I live in the McKenzie River, under Goodpasture Island Bridge, about 30 miles east of Eugene, Oregon. Most of my immediate family lives in the general vicinity, but some of my relatives also have a vacation home in the Pacific Ocean just off the Oregon coast.

A4. Oregon is one of the states in the U.S. that gives me the best quality of life. That is, my home is always very clean, highly oxygenated, and usually climate controlled for a wonderfully cool temperature.

A5. Plymouth Barracuda.

A6. Playing tag.

A7. Fishing.

**A. What is the natural adult habitat of trout?**

**Have students read pages 1, 3, 4, and 5 from *The Trout and Salmon Handbook* (TSH) and ask them to complete Worksheet: Section 1, TM A1.**

1. Trout are native to the cool oceans and fresh waters of the Northern Hemisphere.

2. What is commonly referred to as "trout" can be found belonging to one of several genera (e.g., *Salmo, Chars, Hucho,* and *Oncorhynchus*).

3. The greatest number of single species can be found in the Pacific basin.

4. Habitat requirements are pretty much the same for all species of trout.

5. Trout are pollution sensitive, requiring cool, pure, well-oxygenated water.

6. Successful spawning requires access to clean, gravelly, freshwater beds.

7. Trout are predominantly carnivorous and require that prey be appropriately sized during the various stages of the fish's development.

8. There is a great deal of variation and adaptation within the species.
   a. Any 2 fish from the same brood may develop and live very differently.
   b. Consequently, these differences coupled with specific local environmental conditions can, over time, establish new genetic strains.

9. One key in how any particular trout species may fare in a given location is how well it will relate to other rival salmonid species in the same location.
   a. Brown trout and brook trout do not do well together in the same stream.
   b. Rainbow trout and chinook may do well because one will occupy areas of faster water, and one will reside in slower water.

10. Young trout, immediately after hatching, are referred to as sac fry. Early on, they will remain deep in the gravel receiving nourishment from their yolk sacs.

11. The tiny fish will emerge from the gravel as fry, and will initially tend to school together.

12. The young fry will eat tiny creatures such as mayfly and midge larvae.

13. Within a few weeks the fry will become territorial with regard to their lairs and feeding stations. Since far more fish are born than what the stream can sustain, 90% of the fry will die within the first few months due to competition for territory.

14. One result of this territorial competition is that many fry will drift downstream, thus maximizing the available feeding areas along the stream and also invoking variability of size among the species throughout the stream.

15. The best feeding areas tend to be in alkaline parts of the stream because acidic waters, much like soil, tie up available nutrients which are important to the food chain.
    a. Waters with a chalk or limestone bottom tend to produce more pounds of fish.
    b. A greater range of food seems to be available in these areas.

16. Trout growth is seasonal in nature.
    a. In the winter months when the temperatures are cold, the fish become inactive, and food takes longer to digest. For all practical purposes, trout simply are maintaining themselves during this period.
    b. Growth usually takes place between April and November. Trout may triple their weight in a single growing season.

17. The oceans can also provide conditions conducive for excellent growth.
    a. Most species of trout can visit the oceans.
    b. Noted exceptions are taimen (*Hucho* sp.) and the North American lake trout.

18. Before entering the ocean, trout will lose their bright territorial colors in exchange for a silver layer of quanine which then designates them as smolt.

19. In the ocean, the territorial characteristic of the fish gives way toward the tendency of traveling together.

20. While in the ocean, trout tend to feed closer to the shore. By the time they return to their native streams, they have developed enough fat reserves to sustain them through the spawning process.

**B. How are commercially valuable members of the Salmonidae family classified (taxonomy and identification)?**

**Distribute TM A2, Worksheet : Section 2, and have students read pages 42-45, 58-61 and 90-95 from TSH and have them complete the activity.**

1. *Salvelinus fontinalis* (brook trout).
    a. Juvenile appearance of both male and females is about the same.
    b. Both have light spots on a darkened back, in addition to parr markings
    c. Adult hens develop a distinct puzzle-piece type mosaic on their back. Color may vary.
    d. Adult cocks develop very pronounced snouts and jaws. Colors are very exotic. Lower flanks possess a black line which separates the red sides from the white belly. There is a moderate hump at the shoulder. Both genders have large mouths.

2. *Salmo trutta* (brown trout).
    a. Juvenile male and female fish look very similar. They have an orange adipose fin and an unspotted tail. There are usually red spots along the lateral line that are surrounded by a pale halo.
    b. Adult males and females also look very similar. Males have more of a pointed head than do females and possess a slight hook on the jaw. The anal fin on the female is slightly concave, and the anal fin on the male is slightly convex

3. *Oncorhynchus mykiss* (rainbow trout).
   a. Juveniles possess oval-shaped parr marks along the lateral line. The dorsal fin and tail are marked with numerous small dark spots.
   b. Adult males and females look very similar. Males have a little longer upper jaw, and a little bit more pointed head.

**C. What is the reproductive biology of trout?**

**Show TM A3 and discuss the reproductive biology of trout. Discuss the role of milt and eggs.**

1. Reproductive organs are for the most part located similarly between males (gonads, testes) and females (ovaries).

2. In both cases the respective organs are located on either side of the body, above the intestinal tract. They run a significant distance of the total body length of the fish.

3. Eggs form in the ovaries of the female fish and are contained in a thin membrane. When the female is ripe the membrane ruptures; thus she voids the eggs out her vent.

4. Spermatozoa are developed in the gonads of the male fish.
   a. These are carried in a white seminal fluid called milt.
   b. This fluid will also pass out of the vent of the male when he is ripe and is actively spawning with a female.

5. In general, most salmonids spawn in a similar fashion.

**Distribute TM A4, Worksheet: Section 3, and have students read pages 6-7 from TSH and then complete the activity.**

   a. Males will tend to arrive at the spawning beds a little earlier than the females.
   b. They will lay claim to a certain territory and drive other fish off in an act of ritual combat.

6. Females will explore several sites before choosing one to be suitable. The female then begins cutting the nest by swiftly fanning her tail at the gravel, causing the gravel to be displaced by the hydraulic action, and thus creating a crater.

7. The female will test the depth of nest during the cutting procedure. The territorial male will continue to fight off intruders.

8. When the nest is ready, the female will lower the back portion of her body into it, open her mouth, and begin dropping her eggs.
   a. When the male sees this, he will quickly move in beside her, and open his mouth in anticipation of discharging his milt.
   b. Both fish together will begin to violently quiver as milt and eggs are simultaneously discharged together.

9. When spawning has been accomplished, the female will cover the eggs with gravel and then begin the process again on an adjacent site. This process may take several days. When it is over, the male may stay and guard the site from several days to several weeks.

10. Some trout species will die following the spawning process and others will not.

11. Eggs will hatch out in a matter of weeks or months depending upon the water temperature.

**Review:**

Review by having students demonstrate their knowledge and understanding of the objectives for this problem area. Lead a discussion with students by asking questions that cause them to explain the content that goes with each objective.

**Application Activities:**

Application can be addressed in several ways. Worksheets filled out in the learning process may be reviewed together as a class project. The instructor may demonstrate singly, or as part of a total class activity, how to dissect a trout, and in so doing, identify key anatomical parts, particularly as they pertain to reproduction and feeding.

**Evaluation:**

Evaluation should focus on the extent to which students achieved the objectives of the problem area. The instructor can evaluate student performance from the worksheets the students turn in. The instructor can use the test provided to evaluate what the students have learned. Example exam questions are attached.

TM A1

# Worksheet: Section 1

Name:

Date:

Read page 1 and pages 3 to 5 from **The Trout and Salmon Handbook** and answer the following questions.

1. Describe the characteristics of the streams and rivers that trout prefer for their habitat.

2. List 3 genera that trout may belong to.

3. Where can the greatest single number of species of trout be found?

4. List several factors of water quality necessary for trout to survive in a stream:

5. Successful spawning (egg laying) requires what things?

6. What things describe the eating behavior of trout?

7. Describe in some detail the adaptability of trout to their local environment.

8. Describe in detail the relationship between the survival of any one species of trout in a stream, and whether or not it has to share the same space with other fish species.

9. What are freshly hatched fish called and what do they feed on?

10. What are the young fish called when they emerge from the gravel and what do they eat?

11. Describe in detail what factors are at work when the young fish become territorial.

12. Describe in detail how the pH of the water affects feeding.

13. Describe in detail the seasonal feeding habits of trout and how these pertain to their growth.

TM A1

14. Describe what happens to the coloring of sea-going trout when they migrate to the ocean.

15. When sea-going trout enter the ocean, what happens to their territorial nature?

16. Discuss in detail the feeding habits of sea-going trout and what implications this has for their spawning.

TM A2

# Worksheet: Section 2

Name:

Date:

Read pages 42-45, 58-61, and 90-95 from **The Trout and Salmon Handbook** and answer the following questions.

1. What is the scientific name of brook trout?

2. Describe the appearance of juvenile brook trout.

3. Describe the appearance of brook trout adult females.

4. Describe the appearance of brook trout adult males.

5. What is the scientific name of brown trout?

6. Describe the appearance of juvenile brown trout.

7. Describe the appearance of brown trout adult females.

8. Describe the appearance of brown trout adult males.

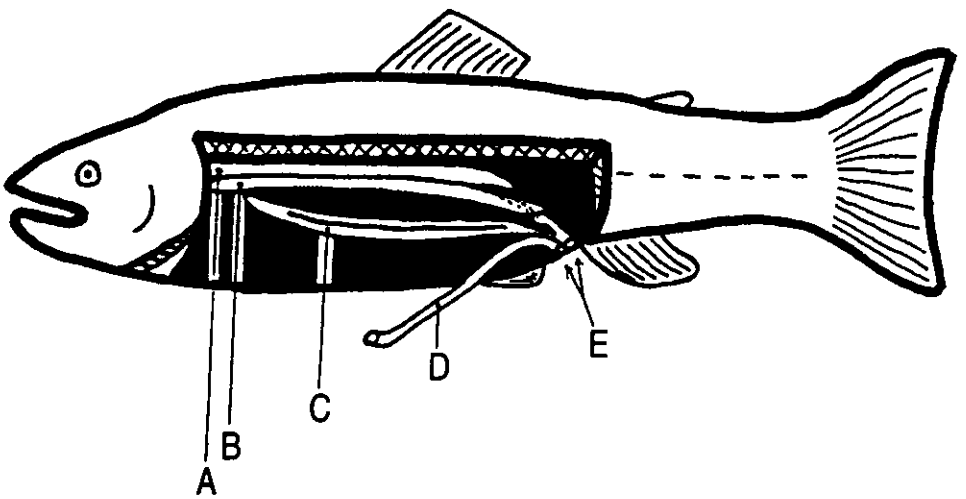
9. What is the scientific name of rainbow trout?

10. Describe the appearance of juvenile rainbow trout.

11. Describe the appearance of rainbow trout adult females:.

12. Describe the appearance of rainbow trout adult males.

# Trout Reproductive Anatomy




A. Kidney
B. Air bladder
C. Testes (also relative location of ovaries)
D. Intestine
E. Vents

TM A4

# Worksheet: Section 3

Name:

Date:

Read pages 10-15, 42-45, and 58-61 from **The Trout and Salmon Handbook** and answer the following questions.

1. What are the habits of male trout when they first arrive at the spawning beds?

2. What are the habits of female trout when they first arrive at the spawning beds?

3. Describe the process of a female cutting a nest and include what the male's role is in the process.

4. Describe in detail how spawning takes place after the nest is cut. Include the role of both the male and the female.

5. Discuss the issue of fish mortality after the entire spawning process has conclude,; including the factor of species.

Quiz for Section A

Name:

Date:

Quiz on Exploring the Life Cycle of Trout

For questions 1 to 6, circle the letter that best answers the question (1 pt. each):

1. What percentage of newly emerged fry will die within the first few months of their life?

   A. 30% C. 70%
   B. 50% D. 90%

2. Which rock material in streams will alter water pH in such a way so as to stimulate a better food supply for trout?

   A. Basalt C. Igneous
   B. Limestone D. Shale

3. Food eaten during the winter months requires how much time to digest relative to food eaten during the summer months?

   A. Less time C. The same amount of time
   B. More time D. Season is irrelevant

4. Which of the following color schemes is typical of ocean-going trout?

   A. Parr coloration C. Territorial coloration
   B. Vivid rainbow D. Silver tones

5. Adult male brown trout look very similar to females except that their anal fin is:

   A. Slightly convex C. Straight
   B. Slightly concave D. Very concave

6. The process of the female hydraulically creating a hole in the gravel bed as a place for her to lay her eggs is called:

   A. Cratering C. Cutting
   B. Hydraulic excavation D. Posterior erosion

Questions 7 and 8 (3 pt. each):

7. List three factors of water quality necessary for sustaining trout:

8. List three commercially important trout species by their common name:

For statements 9 to 13, fill in the blank with the most appropriate word (1 pt. each):

9. Trout are native to the _____ hemisphere.

10. The greatest number of different species of trout can be found in the _____region of the United States.

11. Young trout, immediately after hatching are referred to as _____.

12. Waters where the best feeding occurs tend to have a pH which is _____.

13. Spermatozoa are carried in a white fluid called _____.

For statements 14 to 25, circle a T if the statement is True or an F if the statement is False (1 pt. each):

14. T F Trout are predominantly herbivores.

15. T F Within trout's own natural habitat, it is very adaptable to varying local micro-environments.

16. T F In general, trout adapt easily to living in proximity with almost any other fish species.

17. T F Several -week-old fry are still much too young to become territorial.

18. T F Most growth in trout occurs between the months of December and March.

19. T F Trout which return to the ocean will be territorial.

20. T F Trout that remain in freshwater will be territorial.

21. T F The lower jaw of adult male trout tend to be more hook-shaped that those found on females.

22. T F Testes and ovaries of trout tend to be located in about the same place within the fish.

23. T F Testes in male trout are below the intestines.

24. T F Spawning habits differ widely between trout species.

25. T F Males will aid females in making the hole in the gravel for spawning.

Key for Quiz - Section A

1. D
2. B
3. B
4. D
5. A
6. C
7. cool, clean, well-oxygenated water
8. rainbow, chinook, brook, brown trout
9. Northern
10. Pacific Northwest
11. sac fry
12. alkaline (7.0)
13. milt
14. F
15. T
16. F
17. F
18. F
19. F
20. F
21. T
22. T
23. F
24. F
25. F

**Teaching Plan:**

**Module:** Trout - Section B

**Problem Area:** Discovering Opportunities in Trout Culture

**Goal:** To goal of this problem area is to learn the world demand for trout and what marketing opportunities avail themselves because of this demand.

**Learning Objectives:** Upon completion of this problem area, students will be able to:

discuss issues of world consumption and production of trout
identify marketing channels used to link producers to consumers
explain the relationships between cost, returns, and yields

**Resources:** The following instructional resources are needed to complete this problem area

**Essential:**

**Salmon and Trout Farming,** by Laird, L.M. & Needham, T., Chichester, West Sussex, England, Ellis Horwood Limited, 1988.

**Additional:**

**Trout Farming Manual** (2nd ed.), by Stevenson, J.P., Farnham, Surrey, England, Fishing News Books Limited, 1987.

## Contents and Procedures

**Preparation (Interest Approach):**

To develop student interest in this module, discuss the following scenario with your students. You have a foreign student from Europe (Hans) living with your family this school year. This student likes American food, but is also very fond of fish and seafood. Your family takes him out to dinner one night at a very good restaurant. There are several different fish dishes on the menu, but the one that sounds the best to Hans is trout almondine. Hans orders trout almondine and finds it to be fabulous. He can't get over how good it tastes. He begins to ask several questions about trout, such as where this trout came from.

Divide your students into groups of two people each and give them 5 minutes to decide what they would say to Hans. Have each group give its reply to the class. Through the discussion, emphasize that most trout served in restaurants are produced in an aquacultural environment. Emphasize that most trout production in the U.S. takes place in the Northwest and the Northeast. More than half of all trout production worldwide, however, takes place in Europe.

**Presentation:**

**A. What is the world consumption and production of trout?**

**Show TM B1 to cite reasons for increased consumer demand for fish.**

1. Consumer demand for fish for consumption has increased dramatically over the last decade:
   a. More married women in the work force.
   b. Increasing numbers of single-person house holds causing more demand for convenience foods.
   c. A more health-conscious society.

2. As of 1988 world production of trout was about 275,500 U.S. tons. Over half of this production was in Europe alone.

**Show TM B2 to present the magnitude of trout production worldwide.**

3. United Kingdom production of trout increased nearly 8 times between 1975 and 1986.

**B. What are the marketing channels from producer to consumer?**

**Use TM B3 to provide an overview of the main trout marketing channels. Use TM B4 to present common hatchery products.**

1. Hatchery products:
   a. Restocking for angling waters.
   b. Egg supplies.
   c. Fry and fingerling stock.
   d. Live or fresh catering.
   e. Freezing or smoking trades.
   f. Intermediary sales.

2. Restocking trade.

**Show TM B5 to present common restock markets.**

a. Waters of the state.
b. Private angling clubs.
c. "Put-and-Take" fisheries.
d. Riparian owners.
e. Private waters.

3. Table trade.

**Show TM B6 to cite common products and farm considerations in table trade market.**

a. Portion-sized fish (6-9 oz).
b. Larger (2.5 lbs) fish for family consumption or the restaurant trade.
c. Small farms sell directly to processors, wholesalers, or to the direct market.
d. Some farms install their own freezing and cold storage facilities, and sometimes their own smokers to sell the fish under their own label.
e. Rainbow trout and brook trout are preferable.

4. Exports.

**Use TM B7 to show and discuss problem areas in the export market.**

a. This is an option, but duty and import taxes can be a problem.
b. These can vary according to the product, i.e., frozen vs. smoked.
c. Risks must be considered when exporting.
d. Disease control regulations must be considered.

5. Fee-fishing.

**Show TM B8 to list considerations in the fee-fishing (or rod-letting) market.**

a. This can be profitable on either a supplemental or full-time basis.
b. Anglers want to see a return for their money but they don't want to catch fish too easily.
c. Small to medium sized rainbow and brook trout will please most casual anglers.
d. Anglers, serious about their hobby, will be willing to pay more for larger (11-22 lbs) rainbow trout.
e. On larger rod-letting operations, a clubhouse may pay additional dividends.

**C. What are the costs-returns-yields in trout production?**

**Show TM B9 to illustrate possible economic returns using 2 very different methods of trout farming.**

1. These vary widely depending upon the scale of the operation.

2. Langston University in Oklahoma indicates that a small cage culture operation with access to water can see a net return of about $112 per cage every 6 months.

3. On the other hand, Washington State University indicates that an operation on 1 acre of ground with a 5-acre pond can net over $4,000 annually.
   a. Over $26,000 gross on over 17,000 lbs of fish produced annually.
   b. About $22,000 in costs were incurred annually.

**Review:**

Review the lesson by going through the objectives with your students. What are two marketing channels for trout hatcheries? What are two marketing channels for restocking trout? What does the term table trade mean? What does the term fee-fishing mean? Is it profitable to raise trout in an aquacultural environment? Explain why or why not.

**Application Activities:**

Application can be addressed in several ways. Have students find out where the trout comes from that the local grocery store stocks. Have students check the menu of local restaurants to determine if trout is on the menu. If it is, have them find out where the restaurants purchases their trout. Prepare a trout dish and have the students sample it.

**Evaluation:**

Evaluation should focus on the extent to which student achieved the objectives of the problem area. Examples include oral questioning and written reports. Example exam questions are attached.

TM B1

## Consumer Demand for Fish

- Has increased in the past 10 years
- More married women in work force
- Greater single-person households
- More health-conscious society

TM B2

# Trout Production Statistics

- World Production:
  275,000 U.S. tons in 1988
  50% of this was in Europe

- United Kingdom Production:
  Increased 8 times in 11 years

TM B3

# Marketing Channels

- Hatchery Products:
  Eggs
  Fingerlings

- Live Sales:
  Fingerlings: farms and angling waters
  Adults: fee-fishing, angling, and specialty markets

- Processed Fish Sales:
  Fresh
  Frozen
  Value-added (e.g., smoked)
  Exports

TM B4

# Hatchery Products

- Restocking for angling waters
- Egg supplies
- Fry and fingerling stock
- Sales of larger harvestable fish
- Sales to freezing or smoking trades
- Canned specialty items

TM B5

# Restock Markets

- Government-owned waters
- Private angling clubs
- Fee fishing
- Riparian owners
- Privately owned waters

TM B6

# Table Trade Market

- Portion-sized fish
- Larger Fish:
  For family consumption
  For the catering trade
- Small farms sell to processors or direct markets
- Larger farms have their own processing facilities
- Rainbow trout and brook trout are preferred

TM B7

# Export Market

- While an option, duty and import taxes can be a problem.
- Duty and import taxes vary according to the product.
- Risks must be considered in exporting.
- Disease control regulations must be considered.

TM B8

# Fee-Fishing Market

- Recommended as supplemental income
- Anglers want both success and challenge
- Stocking: about 300-375 fish/acre
- Small to medium fish will please most anglers
- Serious anglers will pay more for larger rainbow trout
- Larger operations may host a clubhouse

TM B9

# Costs-Returns-Yields

- Variables:
  Scale
  Type of operation
  Water volume
  Feed costs

- Cage Culture:
  May net $172/cage/6-month period

- Pond Farming (.5 acre):
  May net over $4,000 annually
  $26,000 in gross income
  $22,000 in total expenses

Quiz for Section B

Name:

Date:

Quiz on Discovering Opportunities in Trout Culture

For question 1, circle the letter that best answers the question (1 pt. each):

1. Which is not a market for the restocking trade?

   A. Government owned waters
   B. Private angling clubs
   C. Catering businesses
   D. Privately owned waters
   E. "Put-and-Take" fisheries

Questions 2 and 3 (3 pt. each ):

2. List 3 types of hatchery products:

3. List 3 markets for the restocking trade:

For statements 4 to 6, fill in the blank with the most appropriate word(s) (1 pt. each):

4. _____ is where a person pays for the opportunity to fish in someone's private fish pond.

5. _____ is one type of trout rearing process, and pond culture is another.

6. _____ produces over half of the world's production of trout.

For statements 7 to 11, circle a T if the statement is True or an False if the statement is False (1 pt. each):

7. T F Rainbow trout are preferred to brown trout in the table trade market.

8. T F Most small trout production farms need their own processing facilities in order to compete with the larger operations.

9. T F Import taxes and duties are a real problem in the export market.

10. T F There is a high overhead cost involved in raising trout.

11. T F U.S. fish production constitutes more than 50% of the world's production.

12. Write a paragraph discussing why consumer demand for fish has been steadily increasing over the last couple of decades. ( 5 pt.) :

Key for Quiz - Section B

1. C

2. Restocking for angling waters, egg supplies, fry/fingerling stock, live/fresh catering, freezing/smoking trades

3. Government-owned waters, private angling clubs, fee fishing, riparian owners, privately owned waters

4. Fee-fishing

5. Cage culture

6. Europe

7. T

8. F

9. T

10. F

11. F

12. More married women are working; more single-person homes that need convenience foods; more health-conscious society

**Teaching Plan:**

**Module:** Trout - Section C

**Problem Area:** Breeding, Raising, and Producing Trout

**Goal:** The goal of this problem area is to learn various stages of breeding, raising, and producing trout.

**Learning Objectives:** Upon completion of this problem area, students will be able to:

list and discuss 3 major components of trout production operation
diagram proposed hatchery, label its parts, and discuss why each was included
describe differences between 3 types of containment systems
list and discuss 6 factors affecting water supply and quality
explain difference between wet and dry spawning; cite advantages of each
explain 3 methods of egg taking
discuss effects of direct light on eggs and sac fry
list 3 methods of egg counting
describe purpose of egg shocking
list and discuss 4 methods of egg picking
describe hatching eggs via troughs
discuss the advantages of hatching eggs with vertical flow incubator
compare/contrast methods used in handling/shipping green eggs vs. eyed eggs
describe sources from which a producer may obtain various trout stock
list 3 factors of farm hygiene
explain purpose for grading fish
explain difference between total length and fork length
describe how to determine fish weight when transporting fish via large truck
list factors affecting nutritional needs of trout
explain the difference between high density pellets and expanded pellets
explain how natural and artificial coloring of trout flesh is produced
define Food Conversion Ratio
define fish condition mathematically
list 4 types of fish feeding methods
define stocking density and the factors influencing it
discuss how to transport live fish
list fish diseases and approaches to treatments

**Resources:** The following instructional resources are needed to complete this problem area:

**Essential:**

**Trout and Salmon Culture,** by Leitritz, E. & Lewis, R.C., Berkeley, CA, University of California, 1980.

**Trout Farming Manual,** by Stevenson, J.P., Farnham, Surrey, England, Fishing News Books Limited, 1980.

**Salmon and Trout Farming,** by Laird, L.M. & Needham, T., Chichester, West Sussex, England, Ellis Horwood Limited, 1988.

**Content and Procedures**

**Preparation (Interest Approach):**

To develop student interest in this module, present the students with the following situation. After receiving a B.S. degree in aquaculture at State University, you want to start a trout farm. You have decided to produce your own fry. Before you see your banker for a loan, you will need to prepare a business plan. One item in that plan is a drawing of your proposed trout farm facility.

What are the major structures you will want to show on your drawing? List them on a piece of paper. Ask the students what they have listed for their drawings. Discuss the similar and dissimilar items. Examples will include a hatchery or spawning house, a stock containment pond (tanks, raceways, etc.), and a source of water. Make the point that producing trout is no simple matter. It requires a lot of knowledge, skill, financing, facilities, and perseverance.

**Presentation:**

**A. What production facilities are needed to raise trout?**

**Show TM C1 to introduce the concept of needed facilities.**

1. The decisions of what facilities a producer deems as necessary for producing trout vary greatly, both within and between regions, countries, and continents.
2. In general, trout production requires a facility made up of a hatchery, a stock containment area, and a water supply.

**B. What are the requirements for a trout hatchery?**

**Show TM C2 to explain various provisions that must be accommodated when designing a hatchery.**

a. The hatchery may be built from a variety of materials, but concrete block is probably preferred because it is low cost, low maintenance, accommodates any design, and is impervious to insect and fungal damage.
b. The building should allow for good ventilation. Because light can damage eggs and young fry, windows and doors should be designed to occlude light.
c. Doors and windows should prevent the entry of flies. Doors should be of an adequate size to allow for the passage of large pieces of equipment.
d. The hatchery should provide enough space for sorting, weighing, and counting eggs and fry. It should also possess an area for cold storage.
e. There must be an area available for storage of fish feed. This area should be dry, well ventilated, and free of access by rodents and insects.
f. If one of the goals of the producer is to produce their own egg source through spawning, then an area for egg and milt collection must be designed into the facility.
g. By definition, a hatchery must possess an egg hatching area. This can be accomplished through one of two common methods: hatchery troughs or incubators. Both methods have their advantages. Hatchery troughs require much more space than do incubators.
h. This area should house an office and appropriate restroom facilities for the employees. Garage and/or shed facilities should be available to house large equipment and vehicles.

**C. What stock containment ponds are best suited for raising trout?**

**Show TM C3 to illustrate 3 common containment ponds. Show TM C4 to identify the advantages of using concrete raceway ponds.**

1. Concrete raceway ponds.
   a. Although there are a variety of ways to culture trout, using concrete ponds has a significant advantage.
   b. No weed growth or bank erosion.
   c. No structural maintenance.
   d. Fry can be moved directly from incubators to ponds without need for hatchery troughs.
   e. Good water circulation and good control for chemical flush of disease.
   f. Mechanical crowders can clean ponds, grade fish, and herd fish for truck loading or pumping.
   g. Easily assessable to transportation and easily adaptable to mechanical feeders.
   h. Small working area to simplify working conditions.
   i. Accommodates self-cleaning devices to dispose of solid waste.
   j. Simplifies bird control problems and overall management.

2. Ponds or raceways.

**Show TM C5 to lshow a simple layout for concrete raceway ponds, and show TM A6 and list the advantages of having pond access inside the spawning section of the hatchery.**

   a. Can be 10 feet wide and 100 feet long, and may be set up in pairs with a 3-foot flume between them.
   b. Ponds can be connected end-to-end. This pond-flume network allows fish to be herded between any pond and the spawning house (hatchery) without ever having to be removed from the water.
   c. Doors on the spawning house can be lowered into water where ponds first enter the structure. This allows the spawning house to remain heated so that workers' hands will remain reasonably warm, allowing them to better probe the fish for egg and milt taking.

3. Circular ponds.

**Show TM C67 to list advantages of circular containment ponds.**

   a. May be made from metal, concrete, or fiberglass. They vary in size from small fry tanks to large broodstock ponds.
   b. Advantages: Less water is necessary, promote a uniform pattern of water circulation, fish are more evenly distributed, possess a center outlet which with the circular motion of the water promotes self-cleaning of the tank, and are better adapted to research work and conducting experiments.

4. Earthen ponds.

**Show TM C8 to discuss earthen ponds.**

   a. At one time, these were a very popular type of rearing pond in the U.S. This is not so much true now. European countries still widely use them due to their low cost.
   b. These ponds tend to possess some distinct disadvantages to the pond types mentioned above: They require a great deal of maintenance. Plants grow in the ponds and on the banks. Dikes must be reshaped annually. They have poor circulation.. Flush treatments for disease control are poor. The removal of solid waste is difficult.

**D. What are the water supply requirements?**

**Show TM C89 to discuss factors in choosing water supply when examining sites for potentially establishing a trout farm.Show TM C10 to discuss factors of dissolved oxygen in waters used by trout. Show TM C11 to show oxygen solubility equilibrium at various altitudes and water temperatures.**

1. No site should be purchased or facility built until a detailed knowledge of the water supply options is attained.

2. Necessary considerations should include:
   a. Seasonal fluctuation.
   b. Content analysis.
   c. Knowledge of any current or potential upstream polluters such as swimming pools, fertilized farmland, livestock waste, industrial waste, nitrogen supersaturation, etc.

3. Although rivers possess a large volume of water, they also tend toward pollution problems; and while small streams tend to offer high water quality, they may provide an inadequate sustained water supply.
   a. Data should be collected on the feasibility, costs, volume, and quality of well drilling as a possible alternative.
   b. Water temperature and pH must also be examined with regard to potential water supplies.

4. Dissolved oxygen.

   a. Studies show that the optimum oxygen content of water for trout production ranges between 5 and 9 ppm.
   b. An oxygen content that is less than 5 ppm makes respiration difficult for the fish, and an oxygen content of 3 ppm is considered lethal.
   c. 7 ppm seems to be an acceptable level of dissolved oxygen for trout.
   d. The solubility of oxygen for fresh water in equilibrium with the air changes both with increased altitude and with an increase in water temperature. For example:

   T = water temperature (°F)
   E = elevation in feet
   O = dissolved oxygen in ppm for fresh water in equilibrium with the air

| T | E | O |
|---|---|---|
| 40 | 0 | 13.0 |
| 40 | 5,000 1 | 0.8 |
| 40 | 10,000 | 9.0 |
| 55 | 0 | 10.6 |
| 55 | 5,000 | 8.9 |
| 55 | 10,000 | 7.3 |
| 70 | 0 | 9.0 |
| 70 | 5,000 | 6.1 |

   e. The amount of dissolved oxygen that a sample of water contains can be tested very easily using an inexpensive test kit or DO meter.

5. pH (H ion concentration).

**Show TM C12 to list considerations relative to water pH.**

   a. Studies show that trout prefer a water pH between 6.7 and 8.2. Since a neutral pH is 7.0, it can be seen that trout tend to prefer waters that are more alkaline in nature due to food availability.
   b. Streams that emanate from bogs or swamps tend to have a lower pH, and streams which run over rock with a high mineral content tend to possess a higher pH.

c. The pH level of a sample of water can be tested very easily using an inexpensive colorimetric test kit.

6. Carbon dioxide.

**Show TM C12 and discuss factors of carbon dioxide in water.**

a. All natural waters contain some amounts of carbon dioxide, with the quantity at equilibrium being about 2 ppm.
b. Low carbon dioxide is usually associated with high amounts of oxygen.
c. High amounts (>2 ppm) of carbon dioxide usually indicates that the water is either deficient of oxygen or polluted with some type of organic waste.

7. Alkalinity.

**Show TM C14 to discuss considerations of water alkalinity.**

a. Any alkalinity that is present in normal fresh waters is usually due to the presence of calcium and magnesium bicarbonates, and to a lesser degree with potassium or sodium bicarbonate.
b. Except in the case of pollution, the most caustic alkali form - hydroxide - is not usually found in normal fresh water.
c. Bicarbonates may be present in waters used for trout production in quantities ranging from just a few ppm up to 200 ppm without either end of the range posing a threat to fish life.
d. As noted under the pH section, trout tend to prefer waters which are slightly alkaline.
e. It should be noted that there is an interrelationship between carbon dioxide, pH, and alkalinity. If carbon dioxide is maintained at a normal level (2 ppm) then there is a fixed relationship between pH and alkalinity.

**E. How do galvanized pipes affect trout production?**

**Show TM C15 to discuss the effects of using galvanized pipe in aquaculture applications.**

1. Studies have shown that small quantities of copper, lead, or zinc are lethal to some varieties of trout.
2. Galvanized pipes are plated with zinc, and under certain conditions dictated by pH and temperature, some of the zinc can go into solution.
3. Cases of mass fish mortality have been documented with zinc levels in the affected water supply as little as .04 ppm. Lethal levels of zinc can go into solution from a single piece of galvanized pipe as short as 15 feet in length.

**F. How do trout spawn (egg production)?**

**Ask students to read pages 90-92 from the *Trout Farming Manual* (TFM) and pages 30-35 from the *Trout and Salmon Culture* (TSC). Students should complete the questions in TM C16.**

1. Broodstock.
   a. Broodstock are the male and female fish that will provide the eggs and milt for producing the next crop of fish.
   b. As previously discussed, they are housed in round or more preferably concrete raceway facilities; the latter providing direct access into the spawning house for egg and milt taking.
   c. Water flow should allow tank water temperatures not to exceed 54°F for 6 months before spawning, and the tank depth should allow the broodstock to escape direct sunlight.
   d. Some type of cording should be suspended a couple of yards above the water in order to protect the stock from bird access.
   e. Oxygen levels must be carefully monitored during warm seasons.

f. Females can be stripped of eggs as early as 2 years, but the egg quality is better if they are not taken until 3 years of age. If the females are treated gently during the stripping process, they may be returned to the ponds, thus allowing 1-2 more years worth of egg production. However, after this point, yields may begin to taper down.
g. Overall, the farmer should be attempting to always have a fresh set of 3-year-old females ready for stripping annually.
h. After stripping, they may be sold for other purposes.
i. Males may be stripped for milt several times with 3- or 4-day intervals between stripping. They should then be discarded after one productive season.

2. Stripping (eggs and milt).

**Have students read pages 93-100 from TFM and pages 26, 44-49, and 54-55 from TSC and then answers questions on TM C16.**

a. If concrete raceway containments are used, a crowding rack can be employed to herd the broodstock up toward the spawning house.
b. The fish are then dipped up out of the pond and are placed in an anesthetic solution for a short period of time.
c. Tricaine methane sulphonate (MS222) is the most common anesthetic used. It is mixed with water at a concentration between 15 and 300 ppm.
d. The anesthetic makes the fish much easier to handle, and since the fish do not fight or struggle, there is a much smaller risk of harming the fish or breaking the eggs.
e. Once anesthetized, the fish are sorted by sex and ripeness. Upon being stripped, the fish will regain their equilibrium quickly once they are returned to fresh water.
f. Since the vent where the eggs are expressed also discharges excretory materials t is advisable to not feed the fish 3 to 4 days before stripping to minimize contamination during the procedure.
g. There is some controversy as to whether egg stripping should be done dry or wet. Stripped eggs are emptied into a bowl which contains a quantity of water in the wet method. The bowl contains no water in the dry method. Thus the eggs reside only in ovarian fluid after expulsion.
h. It is generally believed that an expert stripper using the dry method can secure a higher degree of successful fertilization than by using the wet method.
i. It is believed that an egg will begin to swell in the water when using the wet method, and the micropyle (small openings in the egg for which the sperm are to enter) will begin to close reducing the time available for the sperm to enter the egg.
j. However, if any eggs are accidentally broken in the stripping process while using the dry method, the albumen from the broken egg(s) can lodge over the micropyles of the surrounding eggs, preventing the sperm from entering those eggs.
k. If the procedure is conducted in a bowl with a salt solution in it, the albumen will be held in suspension, and the egg micropyles will not be clogged. Suggested solution: 1 ounce of noniodized table salt to 1 gallon of water.
l. Stripping usually occurs in a ratio of one male for every one female. The males are very potent. One drop of milt will fertilize about 10,000 eggs.
m. Stripping males of milt is accomplished in the same way as extruding eggs from the female using the thumb and forefinger in applying pressure.
n. As has been discussed earlier, eggs and hatched sac fry must be protected from direct sunlight. Studies show that eggs expose to sunlight for more than 3 minutes at a time died.
o. Sac fry that hatched from eggs which were frequently exposed to indirect daylight were weaker, slower, smaller, more prone to mortality, and emerged to fry stage slower than did dark exposed sac fry.

3. Spawning methods.

   a. Two-person method: One person holds the fish with gloved hands, and the other person induces spawning by using his thumb and forefinger. Care is exercised not to place any pressure forward of the ventral fins because this could damage the heart and/or liver of the fish. No attempt should be made to completely strip the hen of all her eggs because breakage of the last eggs is likely.
   b. Single-handed method: The spawner holds the fish with an ungloved hand against the body, dorsal side up, and uses the gloved hand to hold the tail. The spawner then strokes the eggs from the fish into the bowl.
   c. Air method: One person holds the fish as in the two-person method. A second person inserts an 18 g x 1.5 inch needle 0.5 to 1 inch into the body cavity of the fish at a point of the hollow under a pelvic fin. About 2.5-3 lbs of air pressure is applied to the fish. When spawning is complete, the needle is removed and the excess air is expelled by hand. Experiments have shown that fewer eggs remain in the fish, the expelled eggs are cleaner, the egg shells are not broken, there is less chance of harming the fish, and the process is faster.

4. Egg handling.

**Have students read pages 55-64 from TSC and continue answering questions on TM C16.**

   a. After fertilization, the eggs should not be handled for about 20 minutes. From that point, until about 48 hours after fertilization, the eggs may be gently handled. The eggs should not be handled again until two eye spots develop inside the eggs.
   b. There may be many reasons for wanting to count eggs, ranging from fertility tests to commercial shipping. Three methods are the most popular: the California volumetric, Burrows displacement, and the Von Bayer.
   c. The California volumetric method uses several pieces of simple inexpensive equipment. The procedure basically takes a known quantity of eggs (in a 2-oz measuring cup) and then counts (on a counting board) how many eggs constitute 2 oz. Eggs can be manipulated on the counting board by using a trimmed turkey quill. A larger vessel may be used to load eggs into trays or shipping containers provided it is also calibrated in ounces, and a mathematical conversion is made.
   d. The Burrows displacement method involves 2 steps in the technique. First, it must be determined how many eggs are necessary on the average to displace 1 oz of water. Second, how much water is displaced by all of the eggs together. Again, only simple mathematical skills are necessary in making the conversions .
   e. The Von Bayer method requires acquiring a special trout egg measuring trough, which is 12 inches long. The sides of the trough move up and out from the bottom on 45° angles, with a total depth of 2 inches. The trough is specially calibrated on one side with the number of eggs in the trough, and is calibrated on the other side with the number of eggs per ounce. Once the number of eggs per ounce is determined through this method, simple mathematics calculate the numbers of larger weights of eggs.

5. Egg shocking.
   a. Egg shocking is a process that causes infertile eggs to rupture and discolor, while not permitting any damage to occur to the fertile eggs in the process.
   b. The farmer can simply use a pipet or suction bulb to pick up and remove eggs. This method is inexpensive, but the glass tube of either method must be frequently emptied of eggs.
   c. Creating a siphon will allow gravity to literally vacuum up the bad eggs. A powered suction machine will do the same thing.
   d. Another method which, while effective, can be cumbersome - the salt-flotation method, which uses the specific gravity of various concentrations of salt water solution to let good eggs sink and allow bad eggs to float. The bad eggs can then be skimmed off the surface of the salt water with a net.

e. Large numbers of eggs are better picked by means of a mechanical sorter. This machine uses a rotating disk mechanism to pick up all eggs under a vacuum identify infertile eggs for removal.
f. If infertile eggs are left with the fertile eggs, they can develop a fungus which will then spread to the fertile eggs. Egg shocking should only be done after the eggs have shown eye spots.
g. Egg shocking is performed by siphoning eggs from a container about 4 feet off the floor and allowing the eggs to flow through the hose and impact a bucket of water on the floor. This impact will rupture in yolk membrane in an infertile egg, but will not damage the fertile egg.

6. Egg picking.
   a. Egg picking is the process of removing the discolored infertile eggs once they can be identified. While removing a few eggs is not difficult, removing hundreds or thousands without damaging the viable eggs can be tedious.
   b. A simple pipet or suction bulb can be used to pick up and remove eggs. This method is inexpensive, but the glass tube of either method must be emptied frequently of eggs.
   c. Creating a siphon will allow gravity to vacuum up the bad eggs. A powered suction machine will do the dame thing.
   d. Another method that, while effective, can be cumbersome - the salt-floatation method, which uses the specific gravity of various concentrations of salt water solution to let good eggs sink and bad eggs float. The bad eggs are skimmed off the surface of the saltwater with a net.
   e. Large numbers of eggs are better picked via a mechanical sorter that uses a rotating disk mechanism to pick up all eggs under a vacuum and shine a light through all of them, one at a time. A photoelectric cell is activated by bad eggs, and an air jet blows them out. The cell activates on bad eggs (infertile) because they are opaque and light cannot pass through them. Good eggs pass through. This machine can process more than 100,000 eggs per hour.
   f. The need for egg picking can be eliminated altogether if a fungicide is routinely run past the eggs. This process must be done daily. The most common chemical used in this process is formalin.

7. Egg hatching.

**Have students read pages 65-70 and 78-79 from TSC and continue answering questions from TM C16.**

a. Hatchery troughs. Requires much more space than an incubator system, but is not as equipment intensive.
b. Several available layouts. However, individual troughs are usually 16 feet long, 16 inches wide, and 7.5 inches deep. The gradient is 1 inch in 16 feet. The water supply begins at the high end and drains down toward the low end.
c. The trough can contain about 64 gallons of water. 12-15 gallons of water is moved through each trough every minute. It is desirable to maintain a water oxygen level of 7 ppm.
d. Most modern troughs are made from aluminum alloys. However, before producers order any troughs they should have their water analyzed chemically. The trough manufacturer can help recommend the best alloy for any producer's given water situation.
e. Trough systems use wire mesh baskets to hold the eggs and are usually 24 inches long, 14.5 inches wide, and 6 inches deep. Five of them are able to fit end-to-end in each trough.
f. The baskets are often made out of copper, brass, or aluminum. The mesh baskets are woven at varying numbers of wires per inch based upon the type of trout is being hatched. For example, brook trout eggs require a mesh of 9 wires per inch, rainbow trout eggs require 7 wires per inch, and steelhead eggs require 6 wires per inch. Mesh size is important because it must hold the egg in the basket and also allow the hatched sac fry to slip through.
g. Egg baskets are separated by a metal division consisting of two plates. Water flows over the first plate and is forced downward by the second plate. This forces the water to flow through the baskets from the bottom up. This upward flow through the eggs allows for proper circulation.

8. Vertical flow incubators.
   a. Incubator systems can require specialized and expensive equipment. Advantages:
   b. Less space is required than for a trough system.
   c. Eggs are easily treated for fungus control.
   d. The need for egg picking is eliminated.
   e. A smaller amount of water is necessary.
   f. Water temperature may be controlled.
   g. Sac fry can be placed directly into tanks or concrete ponds without the need for troughs.
   h. A standard system consists of 16 trays and requires 3-10 gallons of water flow per minute, 5 is the average. Higher flows are required for eyed eggs and sac fry. This small amount of water flow lends itself both for temperature control and recirculation.
   i. Trays usually contain a basket that holds the eggs. Water flows from the top trays downward, but it enters each tray so as to move from the bottom up, thereby allowing for proper aeration. The trays have covered tops so that sac fry won't escape after they have hatched.
   j. Since egg picking is an impossibility with this system, the same formalin solution mentioned earlier is used in this operation as well.
   k. When the young sac fry are hatched, have consumed their yoke sacs, and are ready for feeding, they can then be moved to troughs, tanks, or ponds. Dead eggs can now be counted in the trays and discarded.
   l. California farmers average about 70 oz or 25,000 fry per tray.

9. Egg shipping.

**Have students read pages 70-73 from TSC and continue answering questions on TM C16.**

   a. Green eggs may be shipped up to the first 48 hours after fertilization. After this time, only eyed eggs may be shipped safely.
   b. Green eggs may be transported in 10-gallon milk cans for short distances. Eggs will swell as much as 20% during the early water hardening process.
   c. Therefore, if too many eggs are placed in a can for shipment, the bottom eggs can be crushed under the pressure from the expansion. A common practice is to suspend the eggs in the can at varying levels, with each level holding 50 oz of eggs. Mosquito netting is used to suspend the eggs.
   d. Eyed eggs can be shipped worldwide. Packed eggs should be moist, not allowed to dehydrate during shipping, kept cold so that they will not begin to hatch en route, and packed so that sudden impacts are minimized during shipment.
   e. Egg shocking and egg picking should have already taken place prior to packing.
   f. There are a variety of commercially prepared egg shipping containers on the market.
   g. Upon arrival, eggs should immediately be treated with an iodine solution so that viruses, molds, bacteria, and fungi are killed before placement in the producer's hatchery. This is an added preventative measure, and toxicity to humans is very low.
   h. The solution should be mixed at a ratio of 1 part iodine to 150 parts water. Mix 12.6 ml of chemical/1 gallon of water, or 4.25 fl. oz in 10 gallons of water.
   i. Green or eyed eggs should be immersed in the solution for 10 minutes and then rinsed with fresh water. No more than 25 oz of eggs should be exposed to each gallon of disinfectant.
   j. When the amber color of the solution fades to a light yellow, then the solution should be replaced with a fresh batch. Oxygen levels in the water should be monitored and soft-water considerations should be observed were alkalinity is less than 35 ppm.
   k. Be careful discarding the old solution. This water should not be reintroduced into the hatchery system. A concentration of 1 part Wescodyne in 20,000 parts water is harmful to fish.

**G. How are trout raised?**

**Have students read pages 41-42 from TFM and answer questions from TM C17.**

1. Stock.
   a. As may be surmised, farms which have no broodstock must buy their own eggs, and those without hatcheries must purchase their own fry, fingerlings, or growout stock.
   b. When purchasing new stock, it is imperative that they be obtained from a farm with a good reputation, and if possible with health certificates.
   c. It is wise to purchase all stock from at least two different suppliers. Thus, if the stock are diseased from one source (unbeknownst to the supplier) the producer is not completely destroyed economically.
   d. The producer should avoid doing business with suppliers who have a reputation for overcommitting their ability to supply and then end up purchasing from a separate source themselves to meet their commitments, leaving the producer with stock from multiple unknown sources, probably without health certificates.
   e. New supplies should not immediately be mixed with existing stock. Deliveries should be supervised to look for any possible problems with the new stock. The new stock should be emptied into fresh clean tanks, and should be quarantined for a short period in order to determine if there are any disease problems.

2. Hygiene.

**Have students read pages 42-44 from TFM and answer questions on TM C17.**

   a. Hygiene is the most important consideration in controlling diseases on the farm.
   b. Hatchery facilities and rearing areas should be treated separately, and equipment use on one should not be used on the other.
   c. Footwear of the producer should be different between the two facilities, or there should be a disinfectant bath for footwear before entry.
   d. Sick fish should be netted and examined for possible causes. Dead fish should be removed and a necropsy should be performed.
   e. Scrub out and disinfect any tanks that have held infected stock. Insure that tanks are well rinsed and flushed several times before reintroducing new stock.

3. Grading.

**Have students read pages 44-48 from TFM and then answer questions on TM C17.**

   a. A farmer does not want much size disparity existing in the tanks. But grading fish is time-consuming and always results in some stress and harm to fish. However, feed conversion efficiency improves.
   b. Unless underfed or overexposed to light, cannibalism is not much of a problem. However, larger fish will eat smaller fish.
   c. As noted, grading will harm some fish. Additionally, fish will not feed for some time after the experience. Grading is recommended once while fish are in fry tanks and then two or three times more while they are growing .
   d. Grading is accomplished through two major means. First (smaller operations) fish are crowded to one end of the holding facility netted out by hand, and run through a hand grader. Second, a crowder with adjustable grading bars can be used.
   e. Graded fish of similar size are then relocated together in new ponds for further feeding and growth.

4. Lengths.
   a. Grading also allows fish to be measured if desired. Two common measures are used:
   b. Total length is measured from the tip of the snout to the longest part of the tail when the fin rays are crowded together.

c. Fork length is measured from the tip of the snout to the innermost part of the "V" in the tail.
d. If stock are sold by length, it is very important for both parties to agree as to which definition of length they are using to buy and sell fish.

5. Weight.
   a. Grading fish also affords the producer an opportunity to take weight measurements on their stock. Sales too are often based upon weight.
   b If graded fish are pumped directly into a truck for transportation, then a 2-step procedure can be used. First, the number of fish being pumped into the truck must be counted. Second, the transportation bin should be first filled with an appropriate amount of water and weighed by itself, and then weighed again after the fish have been loaded.
   c. The tare weight subtracted from the gross weight will provide the net weight of the fish. The net weight of the fish divided by the number of fish loaded will yield the average weight per fish.

6. Feeding and nutrition.

**Have students read pages 48-55 from TFM and pages 210-215 from *Salmon and Trout Farming* (STF) and continue answering questions on TM C17.**

a. Fish must be carefully watched on a regular basis. So even if the fish are being fed on automated systems, they should be fed at least once a day by hand in order to observe their condition and behavior.
b. Because fish are cold-blooded creatures, their metabolism changes with temperature. If the water is too cold, they will be lethargic and will feed less. If the water is too warm, necessary enzymes will cease to function, and fish will die. Brown and rainbow trout feed best at temperatures of between 10 and 15°C .
c. The amount of exposure to daylight can also affect feeding to a small degree and should not be of concern unless fish are exposed to less than 6 hours of light during the day.
d. As is the case with most animals, fish require a diet which contains proteins, carbohydrates, fats, vitamins, minerals, and roughage.
e. Trout are carnivores and require 40-50% protein in their diet. Broodstock, prior to spawning, will need more protein.
f. Of the 20 or so naturally occurring amino acids that are the building blocks for proteins, 10 must be fed because they are unable to be formed from the breakdown products of other amino acids: arginine, histidine, iso-leucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. If these 10 are provided in the diet, then the fish can produce the rest.
g. Fish also use protein for energy production. Carbohydrates, however, should only constitute 8-10% of the trout diet.
h. The fat component of the trout diet must be made up of the unsaturated variety. Fats that belong to the linolenic, as well as the linoleic series, are essential. Linolenic acid should make up 1% of the trout diet.
i. In addition for providing trout a stored food energy supply, fat also insulates the body and protects vital organs. Too much fat, however, can be harmful to the fish, as well as promote poor dressout.
j. Mineral deficiencies in fish are not very common. Most waters provide enough mineral content to meet the needs of the fish. In truth, very little is known about the mineral needs of trout. Thus, what is included in prepared feeds is largely guesswork based upon the known needs of farm animals.
k. Most vitamins for trout must be provided in their diet. All of the known water-based vitamins are necessary for the fish, in addition to vitamins A, E, and K. Most prepared feeds contain enough of these.
1. The two most common types of fish feed are wet and dry. There are advantages and disadvantages to both, but the evidence seems to suggest that the pros to dry prepared fish food outnumber the cons.

m. There are two types of dry pelletized feeds: high density and expanded. Again, while there are pros and cons to both, the evidence seems to point to the fact that it is worth the extra investment in the expanded pellets as opposed to the high density pellets.
n. Market studies have shown that all things being equal, the public will select a pink piece of fish over a white or light pink-colored piece.
o. Sea-going trout acquire this pink color naturally by the carotenoid pigment astaxanthin, which is extracted from the crustacea that they eat. Europe has historically added additives to their feed to artificially replicate this characteristic. However, the U.S. FDA has not approved such an additive.
p. Other additives can include antibiotic drugs for the prevention and treatment of diseases such as furunculosis and vibriosis. Fish that have been treated with antibiotics are not to be sold until after a drug-specific amount of time has lapsed.
q. The size of pellets fed to trout depend upon the weight of the fish. Recommendations, feeding schedules, and blends of rations should be obtained from manufacturers.
r. The main objective in feeding is to provide the correct nutrients that will produce the largest gains in fish weight for the least cost. Thus gain in weight divided by weight of food equals the Food Conversion Ratio (FCR). The lower the number the better. Thus, 1:1.34 is better than 1:1.78.
s. In general, younger fish will have better FCRs than older fish.
t. Trout "condition" is based on the concept that the weight of the fish is proportional to the cube of its length. Thus: condition (K) should equal length if the weight of the fish in grams x 100 is divided by the (length of the fish in cm)$^3$. If the K of the fish is 1, the fish is in good condition. If the K is greater than 1, then the fish is too fat. And if the K of the fish is less than 1, then the fish is in poor condition. In trout specifically, an ideal K may be between 1.2 and 1.3.
u. There are a variety of ways in which to feed fish. The size of the operation and the preference of the producer will determine the best way:
v. Feeding by hand is labor intensive, but allows the producer to observe the condition of the fish daily.
w. Demand feeders do a very good job for fish that are large enough to activate them. The fish will quickly learn how to operate the triggering mechanism.
x. Larger operations may wish to use feeders that blow the feed over a large area by means of compressed air.
y. Time-activated automatic electric feeders can be used as well. These should be monitored so as to not under or over feed the fish.

7. Stocking density.

**Have the students read pages 56-57 from TFM and answer questions on TM C17. Present this information verbally and/or note for your own reference. Refer to the salmon module of this curriculum for more information.**

a. Stocking density largely depends on the dissolved oxygen content of the water. However, much experience is needed in order to carefully assess conditions surrounding this decision.
b. A pond containing clean fresh water that is fully saturated with oxygen at 15°C and exchanged 1.25 times/hour theoretically could sustain 25 kg/m$^3$. However, water temperature and oxygen content are the keys here.
c. Some experts suggest that stocking can be maintained at 50 kg/m$^3$ if water can be exchanged every 10-15 minutes.
d. Cage culture: Raising trout under a cage culture system is quite different from that which has been described here. In the U.S., very little cage culture is done at all in a marine environment. Most of what occurs, takes place in fresh water lakes or ponds.

## H. How are trout transported?

**Have the students read pages 150- 58 from TFM and answer question on TM C17.**

1. Communications between the consignors and the consignee are very important during this phase because the seller can be held responsible for mortalities that were actually caused by the buyer or transporter.

2. Methods of transporting trout:
   a. Plastic bag method: Fry and fingerlings can be shipped in plastic bags that are filled 1/3 with water, inflated with oxygen, and then sealed. The first bag should then be placed in a second one for added security.
   b. Insulated container method: Fish are transported in insulated containers with refrigeration and oxygenation equipment attached.
   c. Deliveries of larger fish, for short distances, in temperate climates can be done with few problems so long as oxygenation is provided.
   d. Refrigerated, oxygenated, and insulated tank units can be fitted to trucks or trailers.

3. Carrying capacities.
   a. Carrying capacity is very complicated to determine because it is dependent upon so many variables: temperature, water oxygen content, oxygen requirements of the fish, metabolism of the fish, time of containment, etc.
   b. Due to the influences of urine, feces, and carbon dioxide on the above, it is advisable to not feed the fish for a couple of days prior to transporting.
   c. In general, fingerlings can be carried in freshwater at a density of 0.15 kg per liter. Portion-sized fish can be carried at densities of about .25 kg per liter of freshwater. Water temperature should be kept at about 5°C, and the trip should not be longer than 12 hours.

## I. Trout diseases.

**Have students read pages 137-141 from TFM and answer questions from TM C17.**

1. Viral diseases.
   a. Infectious pancreatic necrosis (IPN): Usually affects young fry, but may also affect fingerlings up to 6 months old. Symptoms are swift increases in fish death, darkening of the skin, pop-eye, and erratic swimming. Disease can be carried by fish that are not showing signs and in or on eggs.
   b. Viral hemorrhagic septicaemia (VHS). Rainbow trout are the most susceptible. Usually seen in waters 6-12°C. Three stages of infection: acute, chronic, and nervous, marked by varying levels of increased darkening of the skin, paling of the gills, bloody patches, and popeye. Fish gather at the banks. Survivors become carriers for the rest of their lives. Egg infection is rare.
   c. Infectious hematopoietic necrosis (IHN). Limited to trout less than 1 year old. Transmission is similar to VHS. Symptoms: darkening of the skin, paling of the gills, popeye, abdominal swelling, trailing fecal casts from the vent, and small bloody patches near the base of the fins.
   d. Viral treatments: There are none. Prevention is paramount. Sick and dead fish should be buried with lime. A decrease in stock densities may help. Quality stock from a reputable source (with certificates) is recommended.

2. Bacterial diseases.
   a. Furunculosis: Affects all forms of salmonids in both fresh, and marine waters. Brown trout are more susceptible than rainbows. Outbreaks usually seen in warmer waters and in cases of overcrowding. Has two forms: acute, which has few external signs, and subacute. The subacute form will show bloody patches on the body and at the base of the fins, as well as the

development of large ulcers. Survivors become carriers of the and may induce another outbreak if water temperatures rise.

b. Vibriosis: Similar to furunculosis, affecting fish in marine cultures, but can affect fish in fresh water as well.

c. Bacterial treatments: Stocking density should be reduced immediately. The following antibiotic may be mixed with the feed at the mill. Sick fish will not eat, and thereby will not take, the drug Tetracycline: 75 mg/kg fish/day.

3. Protozoan diseases:
   a. Whirling disease: affects sac fry, fry, and fingerlings up to 6 months of age. Symptoms: spinal deformities, darkening of the skin, and swimming with a fast whirling motion. The organism persists in mud. Therefore, keep young stock in clean tanks or raceways until they are older than 6 months. Remove dead and sick fish and bury them in lime. Clean and disinfect tanks, and leave fallow for 2 weeks before reintroducing any new stock.
   b. Costiasis: affects rainbow, brook, and brown trout of all ages, and at all water temperatures. Symptoms: lying on the bottom, resting in slack water, lack of an appetite, and a bluish film covering the body. The parasite can be seen under x400 magnification on the body or gills.
   c. Treatment is accomplished by immersion in a formalin bath of 200 ppm for .5 to 1 hour. The solution must be constantly aerated, because formalin absorbs oxygen. If new infections continue to emerge, then the stock must be destroyed, and the facility disinfected.
   d. Ich (white spot): affects trout of all ages in waters at all temperatures. Symptoms: small white circular spots on the body surface, as well as irregular behavior. There is no treatment for individual fish, but repeated formalin treatments will help.

4. Parasitic worm (gyro). Fingerlings and young growers in medium water temperatures are susceptible. Symptoms: erratic behavior. Unhygienic conditions are usually the cause. Treatment is by means of a formalin bath.

5. Fungus disease (saprolegniasis). Introduced through wounds, skin diseases, or parasites, and may develop in waters of any temperature. Symptoms: fungal patches on the body surface that may be small or quite large. Severe cases will cause the fish to be listless and not feed and may eventually lead to death.

6. This list of diseases is hardly comprehensive, but is does provide information on the most common ailments of trout. The serious trout producer should acquire other references and resources specifically on this subject.

**Review:**

Use the objectives set forth in the beginning of this section to quiz the students orally on their knowledge and understanding of trout production. Have each student sketch the layout of a trout farm that they, in their own mind, believe to be good. Then have each student discuss his/her proposed layout with the class. If there is a trout farm in your area, arrange for a field trip. have the class members prepare a slide set, with script, about the farm.

**Evaluation:**

Evaluation should focus on the extent to which students achieved the objectives of the problem area . Example exam questions are attached. Information on two in-class activities is provided on the following pages.

**Dissolved Oxygen Activity:**

Obtain the appropriate number of test kits needed to accommodate your class. If you are unable to locate your own source for these kits, you may wish to contact the source listed below. There should be no more than three students assigned to one test kit.

Provide the students with a variety of water samples which may contain varying levels of dissolved oxygen. For example, tap water, water that students have oxygenated by blowing through a straw, water which has plants growing in it, water with a gold fish in it, etc. Have the students use the test kits to evaluate the amount of dissolved oxygen in each sample provided.

Dissolved Oxygen Test Kit Model OX-2P

Hach Chemical Co.
Main Office and Factory
P.O. Box 907
Ames, IA 50010

Hach Chemical Co.
Western Office, Sales-Service Center
P.O. Box 477
Laguna Beach, CA 92652

**pH Determination Activity**

Obtain the appropriate number of test kits needed to accommodate your class. If you are unable to locate your own source for these kits, you may wish to contact the source listed below. There should be no more than three students assigned to one test kit.

Provide the students with a variety of water samples which may possess varying levels of pH. For example, tap water, water which has plants growing in it, water with a gold fish in it, water from various streams or rivers, well water, etc. Have the students use the test kits to evaluate the pH level in each sample provided.

pHydrion

Micro Essential Laboratory
Brooklyn 10
New York, NY

TM C1

# Production Facilities

- Hatchery (with spawning house)
- Stock production facilities
- Water supply

TM C2

# Hatchery

- Suitable construction materials
- Appropriate doors and windows
- Provides for live fish processing and cold storage
- Provides for feed storage
- Provides for spawning practices
- Provides for egg hatching
- Administrative facilities

TM C3

# Stock Containment Ponds

Concrete raceway ponds

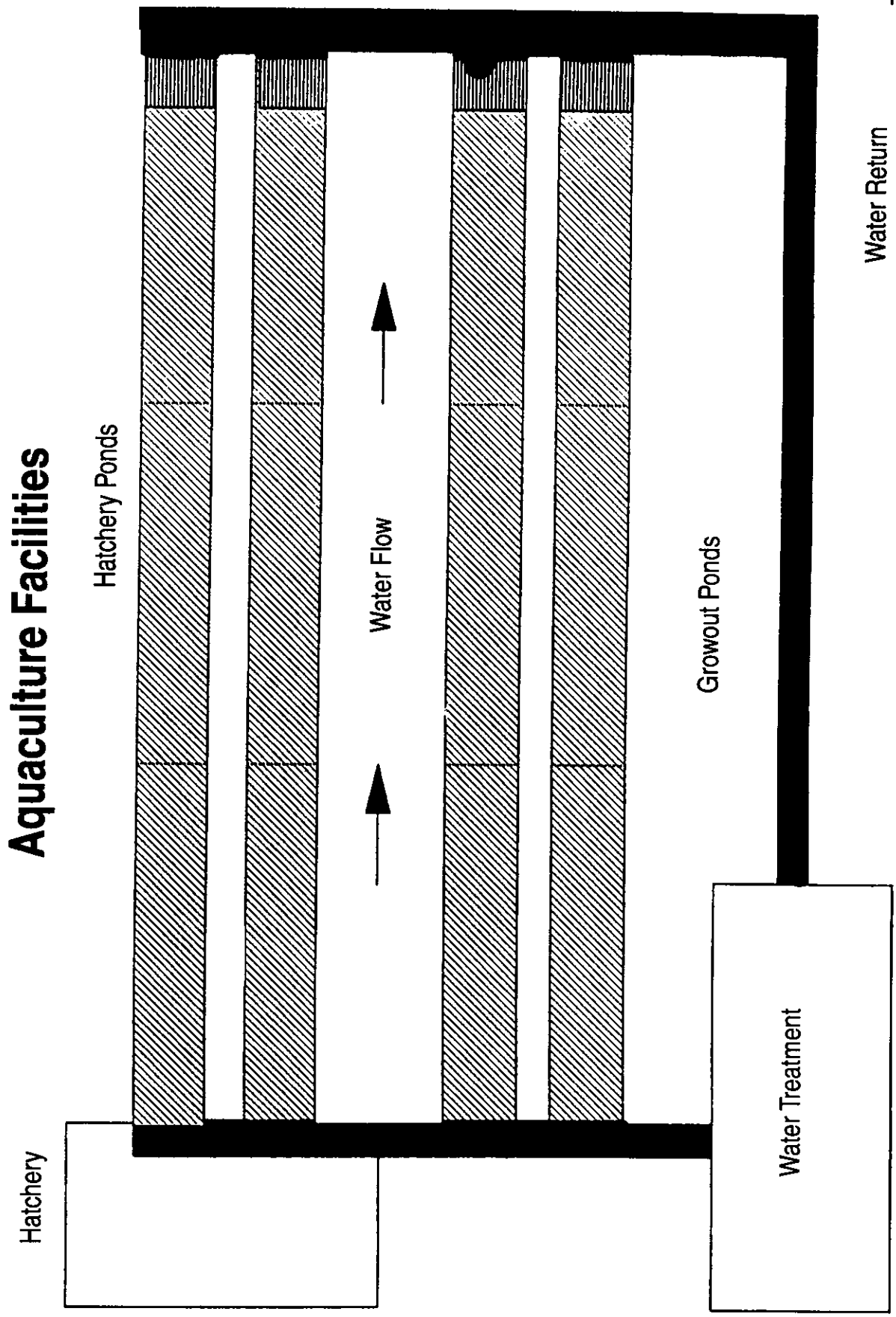
Circular tank ponds

Earthen ponds

TM C4

# Advantages of Concrete Raceway Ponds

- No weed growth
- No bank erosion
- No structural maintenance
- Direct fry stocking
- Good water circulation
- Good control of chemical flushes
- Ability to use mechanical crowders
- Easy access to transportation
- Easily adapts to automatic feeders
- Can use self-cleaning devices
- Simplifies bird control problems
- Simplifies overall management
- Fish are easier to observe


Aquaculture Facilities
Hatchery Ponds
Water Flow
Growout Ponds
Water Return
Hatchery
Water Treatment

TM C6

# Advantages to Pond Access Inside Spawning Area of the Hatchery

- Allows the facility to be heated
- Warm employees work more efficiently
- Warm hands can better probe the fish
- Overall, more efficient milt and egg taking

TM C7

# Advantages of Circular Tank Ponds

- Tanks vary in size and may be constructed from metal, concrete or fiberglass
- Operation needs less water overall
- Promotes uniform water circulation
- Fish are more evenly distributed
- Design promotes self-cleaning
- Better adapted to research and experimentation

TM C8

# Earthen Ponds

- Historically:
  Once very important because they were easy to make and low cost

- Current view:
  Require more maintenance
  Pose difficult plant control
  Must be reshaped annually
  Promote poor circulation
  Flush treatments are ineffective
  Solid waste removal is difficult

TM C9

# Water Supply Considerations

- Knowledge of available water is necessary before purchasing a site
- Seasonal fluctuations
- Analysis of water content
- Knowledge of potential upstream polluters (swimming pools, farms, fertilized land, forestry operations, industrial waste, etc. )
- Weigh rivers vs. streams vs. drilled wells using cost analysis
- Consider water temperatures and pH
- Fish disease

TM C10

# Dissolved Oxygen

- Range for trout: 5-9 ppm
- Levels <5 ppm are dangerous
- Levels ≤3 ppm are lethal
- A level of 7 ppm (or greater) is desired

TM C11

# Oxygen Solubility

- Altitude and temperature affect the solubility of oxygen in water.

| Temperature | Elevation | Oxygen (ppm) |
|---|---|---|
| 40 | 0 | 13.0 |
| 40 | 5,000 | 10.8 |
| 40 | 10,000 | 9.0 |
| 55 | 0 | 10.6 |
| 55 | 5,000 | 8.9 |
| 55 | 10,000 | 7.3 |
| 70 | 0 | 9.0 |
| 70 | 5,000 | 6.1 |

TM C12

# pH: H Ion Concentration

- Optimum trout level: 6.7-8.2 pH
- Streams emanating from bogs or swamps have a lower pH
- Rocky areas with a high soluble mineral content have a higher pH

TM C13

# Carbon Dioxide

- All waters possess some $CO_2$ content, with equilibrium being about 2 ppm.
- Low $CO_2$ is usually associated with a high oxygen level.
- A high amount (>2 ppm) indicates that the water is either polluted, has a low oxygen content, has a low pH, and/or a low alkalinity.

TM C14

# Alkalinity

- Any alkalinity is usually linked to:
  Calcium and/or magnesium
  Carbonates (to a large degree)
  Potassium and/or sodium bicarbonate (to a lesser degree)

- Except for pollution, hydroxide, the most caustic alkali, is usually not a problem in normal freshwater

- Bicarbonates ranging between a few to 200 ppm may be present in the water without any effect on trout

- Trout tend to prefer waters that are slightly alkaline.

- There is a relationship between pH, $CO_2$ content, and alkalinity

TM C15

# Galvanization

- Small quantities of copper, lead, or zinc are lethal to some species of fish.
- Galvanized pipes are plated with zinc that can go into solution under certain temperature and pH conditions.
- Documented cases exist of mass death in fish with zinc levels as little as .04 ppm. A 15-foot length of galvanized pipe can accomplish this.

TM C16

# Worksheet: Spawning (Egg Production)

Name:

Date:

Read pages 90-92 from the **Trout Farming Manual** (TFM) and pages 30-35 from the **Trout and Salmon Culture** (TSC) book and answer the following questions.

1. What are broodstock?

2. Describe a containment facility for broodstock. Include in your discussion water temperature, direct sunlight, bird access, oxygen levels, etc..

3. At what age might females be stripped and can they be reused? Explain your answer.

4. What factors are involved in the stripping of males?

Read pages 93-100 from the TFM and pages 26, 44-49, and 54-55 from the TSC then answer the following questions.

5 If broodstock are confined in concrete raceways, how might they be retrieved for purposes of stripping?

6. What is the trade name and scientific name of the most common anesthetic administered to the fish before stripping? Briefly explain why this practice is used.

7. By what criterion are anesthetized fish sorted?

8. How could a trout producer minimize the amount of feces that might be discharged during the stripping procedure?

9. Describe in detail the difference between wet and dry stripping. Include the advantages and disadvantages for both.

10. Describe the two-person method of egg taking.

11. Describe the single-handed method of egg taking.

12. Describe the air method of egg taking.

13. What is the ratio of males to females used in hand spawning?

TM C16

14. How is milt extracted from males?

15. Discuss the effects of direct light on eggs and alevins:

Read pages 55-64 from the TSC then answer the following questions.

16. Explain when eggs may and may not be handled in the first 48 hours after fertilization:

17. Describe the California volumetric method of egg counting:

18. Describe the Burrow's displacement method of egg counting:

19. Describe the Von Bayer method of egg counting:

20. What is the purpose of egg shocking?

21. Explain the process of egg shocking?

22. List 4 methods of egg picking:

23. Explain why egg picking is not necessary if Formula is used as a chemical treatment.

Read pages 65-70 and 78-79 from the TSC then answer the following questions.

24. Describe the dimensions of the typical hatchery trough.

25. What is the normal capacity of a hatchery trough, and what is the normal flow rate?

26. What are most hatchery troughs made from, and why is it important to have the hatchery water analyzed before buying the troughs?

27. What are the dimensions of trough egg baskets, and what are they made of?

28. Why do egg baskets have differing mesh sizes?

29. How does water flow through the egg baskets?

TM C16

Read pages 65-70 and 78-79 from the TSC then answer the following questions.

30. Describe the dimensions of the typical hatchery trough.

31. What is the normal capacity of a hatchery trough, and what is the normal flow rate?

32. What are most hatchery troughs made from, and why is it important to have the hatchery water analyzed before buying the troughs?

33. What are the dimensions of trough egg baskets, and what are they made of?

34. Why do egg baskets have differing mesh sizes?

35. How does water flow through the egg baskets?

36. List 5 advantages to vertical flow incubators:

37. Discuss the size, water capacity, and flow rate of a typical vertical flow incubator?

38. How is the issue of decay in infertile eggs dealt with when it comes to vertical flow incubators?

39. What kind of fry production can be expected when using vertical flow incubators?

Read pages 70-73 from the TSC then answer the following questions.

40. In the first few days, green eggs can be transported during what period of time?

41. Describe a method that might be used to transport green eggs for short distances.

42. Describe when eggs can be shipped safely for long distances, and what characteristic about the eggs signals when the eggs have reached this stage of development.

43. Describe what considerations must be taken when shipping eggs long distances.

44. Describe in detail the disinfecting process that should take place after a producer has received a shipment of eggs.

45. Discuss what concerns exist with regard to the used disinfecting solution:

TM C17

# Worksheet: Raising Trout

Name:

Date:

Read pages 41-42 from the TFM and answer the following questions.

1. If farms do not maintain their own broodstock, how do they replenish on-growing stock?

2. List 4 types of precautions and/or practices which should be implemented when a producer purchases stock from supplier(s)?

3. Upon receiving a shipment of stock, what precautions should be taken both to protect the new stock as well as the old stock?

Read pages 42-44 from the TFM and answer the following questions.

4. What is meant by hygiene around the facilities?

5. Compare and contrast hygiene as it relates to both the hatchery facility, and the rearing areas:

Read pages 44-48 from the and answer the following questions.

6. What are advantages to fish grading?

7. What are disadvantages to fish grading?

8. List and discuss 2 types of grading methods used in small or large operations:

9. Define total length as it pertains to fish measurement.

10. Define fork length as it pertains to fish measurement:

11. Explain the importance of fish length as it relates to contractual terms between buyers and sellers.

12. Explain the importance of fish weight as it relates to contractual terms between buyers and sellers.

13. Describe how fish weight is determined when using a large truck for transportation purposes:

TM C17

Read pages 48-55 from the TFM and pages 210-215 out of the Salmon and Trout Farming (STF)

14. Explain the importance of feeding fish once a day by hand.

15. Explain in detail the relationship that exists between the feeding habits of trout and the temperature of their water:

16. What is the relationship between the number of hours of daylight exposure and the feeding behavior of trout?

17. List 6 major components necessary in a trout diet.

18. What percentage of a trout feed ration needs to be made up of protein?

19 List 10 absolutely essential amino acids which must be incorporated into a trout feed ration:

20. What percentage of a trout feed ration should be made up of carbohydrates?

21. Describe the dietary importance of fat in a trout feed ration, and list two fat types which must be included.

22. Discuss the mineral needs of trout and how those needs are supplemented in addition to feed rations.

23. Discuss the vitamin needs of trout, and how feed rations can meet these needs.

24. Compare and contrast wet feeds versus dry feeds.

25 Compare and contrast high density pellets and expanded pellets and determine which probably has the most advantages.

26. What does market research show with regard to the coloration of trout meat?

27. What health concern has arisen with regard to canthaxanthin?

28. What other additives might be included in feed rations?

29. What is the best source of information with regard to what size pellets are appropriate at various stages of trout growth?

TM C17

30. Is an FCR of 1:1.78 better than an FCR of 1:1.37? Why?

31. If a producer determined that their stock averaged a trout condition (K) of .89, what would this tell them?

32. List briefly discuss 4 methods of feeding fish:

Read pages 56-57 from the TFM and answer the following questions.

33. What factors must be considered when addressing the issue of stocking density?

34. What has been suggested as an appropriate stocking density?

Read pages 150-158 from the TFM and answer the following questions.

35. Discuss the importance of good communications in the contractual arrangements for the transportation of fish.

36. List and discuss four methods of transporting varying quantities of varying sized fish:

37. Explain the importance of carrying density when transporting fish and provide examples of factors which affect carrying density.

38. Cite one recommended carrying density rule for transporting fingerlings, and one carrying density rule for transporting portion-sized fish:

Read pages 137-141 from the TFM and answer the following questions.

39. Discuss the virus, infectious pancreatic necrosis, and list symptoms to be watchful of.

40. Discuss the virus, viral hemorrhagic septicaemia, and list symptoms to be watchful of.

41. Discuss the virus, infectious hematopoietic necrosis and list symptoms to be watchful of.

42. What precautions and/or treatments are recommended for these viral infections?

43. Discuss the bacterial disease, furunculosis, and list symptoms to be watchful of.

44. Discuss the bacterial disease, vibriosis, and list symptoms to be watchful of.

45. What treatments are recommended for these bacterial infections? List one approved drug and its dosage.

46. For the following diseases;(l) determine whether they are protozoan, parasitic, or fungal; (2) describe the symptoms of each; and (3) discuss what treatment(s) is/are recommended:

Whirling disease:

Costiasis:

Ich (white spot):

Gyro:

Saprolegniasis:

Quiz for Section C

Name:

Date:

Quiz on Breeding, Raising, and Producing Trout

For questions 1 to 6, circle the letter that best answers the question (1 pt. each).

1. Which is not an accepted method of egg taking?

   A Air injection
   B. Hydraulic injection
   C. Single-handed
   D. Two-person

2. Which is not a standard method of egg picking?

   A. Pipet
   B. Freshwater electrolysis
   C. Siphon
   D. Mechanical sorting

3. Which of the following is a standard trout containment structure?

   A. Concrete raceway ponds
   B. Earthen ponds
   C. Both A B
   D. None of the above

4. In aquaculture, fish condition is determined by:

   A. Mathematics
   B. Coloration
   C. Weight
   D. Length

5. Which is not a classification of fish disease?

   A. Protozoan
   B. Parasitic
   C. Bacterial
   D. Predatorial

6. Which is a method of disease treatment:

   A. Flushing
   B. Hypodermic injection
   C. Both A B
   D. None of the above

Questions 7 and 8 (3 pt. each):

7. List 3 components of a complete trout production facility.

8. List 3 of the 6 factors that affect water supply and quality.

For statements 9 to 13, fill in the blank with the most appropriate word (1 pt. each):

9. _____is the process of causing infertile eggs to rupture and discolor so that they can be identified and removed.

10. The _____method of egg counting makes use of a counting board, a measuring cup, and a trimmed turkey quill.

11. _____length measures fish from the tip of their snout to the deepest part of the V-shape in their tail.

12. _____pellets, while more expensive, have other advantages which tend to justify the extra investment.

13. _____is defined as the amount of fish weight gained divided by the amount of feed weight fed.

For statements 14 to 23, circle a T if the statement is True or an F is the statement is False (1 pt. each):

14. T F Wet spawning requires that eggs and milt must be taken from the fish while the fish is under a water bath.

15. T F Direct sunlight over waters occupied by alevins stimulates vitamin D production in enhancing skin development.

16. T F While vertical flow incubators require more hatchery space than do trough systems, the other advantages of them out weigh this liability.

17. T F Eyed eggs an be transported much easier than green eggs.

18. T F It is desirable to have trough egg baskets made from galvanized steel so that they will not rust.

19. T F A producer, upon arriving to the production facility, should immediately change into a pair of rubber boots which should be worn only in the hatchery and the stock containment areas.

20. T F Under normal circumstances, protein should constitute 40% of the trout's feed ration.

21. T F One advantage to circular tank ponds is the fact that the natural water circulation tends to make them self-cleaning.

22. T F Plastic baggies can be used in certain fish transportation practices.

23. T F Stocking density refers to the thickness of fibers used in the nets designed for dipping fish out of containment ponds.

24. Diagram on the next page a proposed hatchery building and include and label all important parts (3 pt.).

Key for Quiz - Section C

1. B
2. B
3. A
4. A
5. D
6. A
7. Hatchery, stock production facilities, water supply
8. Seasonal fluctuations, analysis of water content, potential upstream polluters, cost analysis of rivers vs. streams vs. drilled wells, water temperature and pH, fish disease
9. Egg shocking
10. California volumetric
11. Fork
12. Expanded
13. Food Conversion Ratio
14. F
15. T
16. T
17. T
18. F
19. T
20. T
21, T
22. T
23. F
24. [See TM C5 for answer.]