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ABSTRACT

This color-coded guide was developed to assist teachers in helping interested students plan, build, stock, and run aquaculture facilities of varied sizes. The guide contains 15 instructional units, each of which includes some or all of the following basic components: objective sheet, suggested activities for the teacher, instructor supplements, transparency masters, information sheet, assignment sheets, assignment sheet answers, job sheets, practical tests, written test, and answers to written test. Units cover the following topics: introduction to aquaculture; the aquatic environment; fundamental fish biology; marketing; site selection; facility design and layout; water quality management; fish health management; commercial catfish production; commercial trout production; commercial baitfish production; commercial crayfish production; other commercial species; harvesting and hauling; and business management. All of the units focus on measurable and observable learning outcomes. They are designed for use in more than one lesson or class period of instruction. (KC)

Aquaculture

- Catfish
- Trout
- Crayfish
- Baitfish
- Recreational fish
- Ornamental fish
- Gators & others
- Pond culture
- Cage culture
- Raceway culture

MAVCC

Teacher Edition


North Dakota
South Dakota
Nebraska
Iowa
Colorado
Kansas
Missouri
Oklahoma
Arkansas
Texas
Louisiana

AQUACULTURE

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AQUACULTURE

TABLE OF CONTENTS

FOREWORD

Because American agriculture is increasingly subject to unstable markets and inroads from foreign competition, alternatives to agriculture are emerging to help the American farmer find new products and markets. Aquaculture is one of the exciting alternatives that promises economic rewards to those who take the time to plan and develop a fish farm or any other aquaculture project properly. That's what MAVCC's *Aquaculture* has as an ultimate objective: to help interested students plan, build, stock and run aquaculture facilities of varied sizes. Aquaculture projects require planning and management comparable to any other commercial endeavor. Much of the material in our text addresses the down-to-earth activities of selecting a site, evaluating soil types, selecting equipment, planning a facility, and managing water quality to promote good health and growth. *Aquaculture* is a good-sized text, almost bigger than a bread basket, but with the bigness comes a comprehensive text from which instructors and students may select materials that can be put to work locally.

As is typical with MAVCC's competency-based format, *Aquaculture* is chock full of hands-on assignment and job sheets that explain to students how to get things done. We think you'll enjoy the text—we feel that everyone will profit from it.

Ann Masters, Chairman
Board of Directors
Mid-America Vocational
Curriculum Consortium

Jim Steward
Executive Director
Mid-America Vocational
Curriculum Consortium

ACKNOWLEDGEMENTS

The Resource Committee which planned and approved materials for *Aquaculture* was professional in every sense of the word. Some committee members farm fish; other committee members are involved in the teaching and experimentation that helps others farm fish more profitably. Their collective knowledge is evident in each unit of the text. To the Resource Committee goes a thank you to every member:

Bill Binnian, President/General Manager, Mount Blanca Game Bird and Trout, Inc., Blanca, Colorado.

Glen Gebhart, Langston University Agricultural Research and Extension Department, Langston, University, Langston, Oklahoma.

Jim Gleim, Hatchery Biologist, Nebraska Game and Parks Commission, North Platte Hatchery, North Platte, Nebraska.

D. Leroy Gray, Extension Fisheries Specialist, University of Arkansas Co-op Extension Service, Little Rock, Arkansas.

Dr. Gary Jensen, Aquaculture Specialist, Louisiana Cooperative Extension Service, Louisiana State University Agricultural Center, Baton Rouge, Louisiana.

Jim Kahrs, Owner/Operator, Osage Catfishery, Osage Beach, Missouri.

Dr. Wallace Klussman, Professor, Department of Wildlife and Fishery Science, Texas A&M University, College Station, Texas.

It would be impossible to name everyone whose works in other books and published items have contributed significantly to MAVCC's effort to produce a comprehensive text. But it's worth a try.

A thank you to John Guidice, D. Leroy Gray, and J. Mayo Martin for their *Manual for Bait Fish Culture in the South*, a joint publication of the University of Arkansas Cooperative Extension Service and the U.S. Fish and Wildlife Service.

Another valuable reference is Jasper S. Lee's *Catfish Farming. A Reference Unit,* published by Mississippi State University, and we thank all associated with that publication.

Catfish Aquaculture: A Decision-Making Guidebook was published by the Louisiana Cooperative Extension Service at the Louisiana State University Agricultural Center, and to those who helped with that project, another thank you for providing a valuable resource.

We thank Claude E. Boyd and Frank Lichtkoppler for another valuable resource, *Water Quality Management in Pond Fish Culture.* The text was published by the International Center for Aquaculture, Agricultural Experiment Station at Auburn University, Auburn, Alabama, under the direction of R. Dennis Rouse.

To Larry Belusz we extend a thank you for materials used from his *Fish Farming Techniques.* That text was published as a joint effort by the Instructional Materials Laboratory, University of Missouri, Columbia, in cooperation with the Missouri Department to Elementary and Secondary Education, Jefferson City, Missouri.

Crawfish in the Classroom is only a five-page brochure, but we thank J. V. Huner of Southern University and J. E. Barr of the Louisiana Department of Education for an impressive effort and the good graphics.

Glenn L. Hoffman and Andrew J. Mitchell wrote *Some Parasites and Diseases of Warmwater Fishes*. This was published by the Fish Farming Experimental Station, U.S. Fish and Wildlife Service, Stuttgart, Arkansas. Although it is listed as Fish and Wildlife Leaflet 6, it had a book-size value to the MAVCC effort, and we thank Hoffman and Mitchell for a job well done.

A special thank you goes to Harry K. Dupree and Jay V. Huner for the *Third Report to the Fish Farmers* which they edited. The *Report* proved its value time and time again. Naturally, our thank you is extended to all the contributors to that marvelous book, and to the U.S. Fish and Wildlife Service for publishing the text.

Fish Hatchery Management published by the United States Department of the Interior, Fish and Wildlife Service, contributed vital information to the unit about trout production. Thanks to Robert G. Piper, Ivan B. McElwain, Leo E. Orme, Joseph P. McCraren, Laurie G. Fowler, John R. Leonard, and others who helped with that excellent text.

We thank the Nebraska Game and Parks Commission and the very cooperative people at *NEBRASKALand Magazine* for their well-illustrated publication, *The Fish Book*.

For their help with other stages of development, we thank Glen Gebhart for help with photographs and his technical expertise, Jim Gleim for special help with the trout farming unit, D. Leroy Gray for help with photographs and information in the baitfish unit, Gary Jensen for help with photographs and for finding Louisiana crawfish farmers willing to lend a hand, Wallace Klussman for materials on international aquaculture, and Jim Kahrs for a special fish farming text—all in Chinese.

Our final thank you goes to the many anonymous fish farmers whose failures and successes alike, in varied circumstances, have contributed to the solid body of references that have turned aquaculture into a disciplined activity.

Development of *Aquaculture* has been an adventure. We at MAVCC hope it serves well the instructors and students for whom it is designed.

AQUACULTURE

INSTRUCTIONAL / TASK ANALYSIS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)

UNIT I: INTRODUCTION TO AQUACULTURE

1. Terms and definitions
2. Facts about aquaculture
3. The historical background of aquaculture
4. Types of aquaculture environments
5. Types of aquaculture enterprises
6. Species of economic importance
7. Factors to consider before starting an aquaculture enterprise
8. Limiting factors in joint agriculture/aquaculture enterprises
9. Physical and fiscal risks associated with aquaculture
10. Advantages of aquaculture
11. Sources of information about aquaculture
12. Survey local aquaculturo production. (Assignment Sheet #1)
13. Visit a support facility and interview the operator(s). (Assignment Sheet #2)
14. Survey local market outlets for types of fish sold. (Assignment Sheet #3)
15. Interview a local producer. (Assignment Sheet #4)

JOB TRAINING: What the Worker Should be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)

UNIT II: THE AQUATIC ENVIRONMENT

1. Terms and definitions
2. Important variables affecting the ecological balance of a pond
3. Links in the aquatic food chain
4. The oxygen cycle in pond ecology
5. Factors affecting oxygen production in pond water
6. The effects of seasonal temperature changes on pond water
7. The positive roles of plankton and benthic organisms in pond ecology
8. The negative roles of plankton and benthic organisms in pond ecology
9. Problems concerning carbon dioxide in the aquatic environment
10. Problems concerning water acidity (pH) in pond ecology
11. Water alkalinity and hardness
12. Ammonia and ammonia byproducts in pond ecology
13. Hydrogen sulfide in the aquatic environment
14. Aquatic plants
15. Sources of water pollution
16. Collect pond plankton and examine under a microscope. (Assignment Sheet #1)
17. Observe the effects of sunlight on collected samples of pond water. (Assignment Sheet #2)
18. Seine a pond; examine findings and discuss the fish food chain. (Assignment Sheet #3)

11

JOB TRAINING: What the Worker Should be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
19. Collect a pond bottom sample;examine and discuss findings. (Assignment Sheet #4)	
20. Prepare a list of food sources a sample pond. offers its fish populations; identify benthic organisms and other elements in the food chain. (Assignment Sheet #5)	
21. Survey the aquatic plants and marginal ecology of a sample pond; discuss the ecological impact on fish populations and the aquatic environment. (Assignment Sheet #6)	

UNIT III: FUNDAMENTAL FISH BIOLOGY

	1. Terms and definitions
	2. External parts of a typical fish
	3. Basic external body features that permit fish to live in water
	4. Internal organs of a typical fish
	5. The functions of internal organs and systems of fishes
	6. Life cycles of fish
	7. Fish species
8. Dissect a fish, examine under a microscope, and identify internal organs. (Job Sheet #1)	
9. Kill, weigh, measure, and dress a catfish, and compare dressed and undressed measurements. (Job Sheet #2)	

UNIT IV: MARKETING

	1. Terms and definitions
	2. Processing plant markets
	3. Live haul markets
	4. Local markets: stores and restaurants
	5. Local retail markets
	6. The fee-fish market

JOB TRAINING: What the Worker Should be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	7. Economy of scale
	8. Factors to consider when exploring marketing alternatives
	9. Product forms
	10. Food processing cuts and forms
	11. Dressout percentages of processing cuts and forms
	12. On-site versus plant processing
	13. Disposal of processing waste
	14. Permits and regulations
15. Survey local markets. (Assignment Sheet #1)	
16. Skin and filet a catfish. (Job Sheet #1)	
17. Dress and package a trout. (Job Sheet #2)	

UNIT V: SITE SELECTION

	1. Terms and definitions
	2. Three basic site requirements
	3. Facts to consider when evaluating a site's potential water sources
	4. Steps in determining a site's water quality
	5. Pond type and site evaluation
	6. Steps in determining whether soil is suitable for pond construction
	7. Basic soil types
	8. Soil considerations in site selection
	9. Topographical considerations in site selection
	10. General facts to consider in site selection
	11. Site-specific factors that determine cost

JOB TRAINING: What the Worker Should be Able to Do (Psychomotor)		RELATED INFORMATION: What the Worker Should Know (Cognitive)
	12.	Laws, regulations, and permits required to develop a site for fish farming
13. Survey a site's potential as a fish farm. (Assignment Sheet #1)		
14. Evaluate a potential site's soil quality. (Assignment Sheet #2)		
15. Evaluate a potential site's water sources and quality. (Assignment Sheet #3)		
16. Complete a checklist to determine site's feasibility. (Assignment Sheet #4)		

UNIT VI: FACILITY DESIGN AND LAYOUT

	1.	Terms and definitions
	2.	Types of farm water enclosures
	3.	Facility requirements for food-fish production
	4.	Facility requirements for channel catfish fingerling production
	5.	Requirements for rainbow trout fingerling production
	6.	Facility requirements for fee-fish operation
	7.	Initial steps in planning an on-site processing facility
	8.	Facility and equipment requirements for an on-site processing facility
	9.	Factors to consider when planning pond size
	10.	Layout and design considerations
	11.	Advantages of small versus large pond
12. Estimate water requirements. (Assignment Sheet #1)		
13. Calculate common earth pond construction requirements. (Assignment Sheet #2)		

JOB TRAINING: What the Worker Should be Able to Do (Psychomotor)

RELATED INFORMATION: What the Worker Should Know (Cognitive)

14. Design and layout a pond. (Assignment Sheet #3)

15. Determine costs of local well drilling, earthmoving, and construction services. (Assignment Sheet #4)

16. Complete a feasibility study of a selected site by estimating construction. (Assignment Sheet #5)

17. Construct a cage for fish culture. (Job Sheet #1)

UNIT VII: WATER QUALITY MANAGEMENT

1. Terms and definitions
2. Compounds and elements and their chemical formulas and symbols
3. The importance of oxygen in water quality management
4. The role of temperature in oxygen management
5. Natural sources of water temperature variation and their effects
6. Types of thermometers for measuring water temperature
7. Facts about temperature management techniques
8. Causes of DO (dissolved oxygen) loss
9. Signs of DO deficiency
10. Facts about the prevention of DO depletion
11. Guidelines for measuring DO
12. DO measuring equipment and its description
13. Methods of correcting DO deficiency
14. Types of mechanical aerators
15. Facts about turbidity remedies

JOB TRAINING: What the Worker Should be Able to Do (Psychomotor)

RELATED INFORMATION: What the Worker Should Know (Cognitive)

16. The importance of nitrogen compounds in water quality management

17. pH and water quality

18. Methods of managing the pH cycle

19. The purposes of liming

20. General guidelines for water chemistry management

21. Aquatic plant control methods

22. Calculate dosages for chemical treatments. (Assignment Sheet #1)

23. Analyze facility aerator needs. (Assignment Sheet #2)

24. Use a Secchi disc to measure turbidity. (Job Sheet #1)

25. Use an 0_2 meter to measure DO (Job Sheet #2)

26. Use a water analysis kit to test water quality parameters. (Job Sheet #3)

27. Predict low DO levels, using Secchi disc, projection, and chart methods. (Job Sheet #4)

UNIT VIII: FISH HEALTH MANAGEMENT

1. Terms and definitions

2. Skin and tissue conditions

3. Severity of disease or condition

4. Behavior or appearance of sick fish

5. The role of stress in fish diseases

6. Common stressors of fish

7. Signs of stress and disease

8. Common pathogenic viruses

9. Common pathogenic bacteria

JOB TRAINING: What the Worker Should be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	10. Common pathogenic fungi
	11. Common pathogenic protozoan parasites
	12. Common pathogenic crustacean parasites
	13. Common pathogenic worm parasites
	14. General management measures for preventing disease outbreaks
	15. Basic hygiene for disease prevention and corrective management
	16. Treatment methods and their administration specifics
	17. General guidelines for treatment of fish diseases
	18. Regulations for chemical application in fish production
19. Solve problems related to common diseases and conditions of fish. (Assignment Sheet #1)	
20. Calculate treatment rates. (Assignment Sheet #2)	
21. Prepare a list of local, area or state specialists to contact in the event of a disease emergency. (Assignment Sheet #3)	
22. Report on the activities and precedures observed at a disease diagnostic laboratory. (Assignment Sheet #4)	
23. Complete record-keeping forms on fish health management practices. (Assignment Sheet #5)	
24. Prepare and package a speciman for shipment to a diagnostic laboratory. (Job Sheet #1)	

Unit IX: COMMERCIAL CATFISH PRODUCTION

	1. Terms and definitions
	2. The advantages of raising catfish

JOB TRAINING: What the Worker Should be Able to Do (Psychomotor)

RELATED INFORMATION: What the Worker Should Know (Cognitive)

3. The limitations of raising catfish
4. The phases of fingerling production
5. Guidelines for stocking broodfish
6. Managing broodfish in pens
7. Managing broodfish in open ponds
8. Egg, fry, and fingerling management
9. Stocking rates for fingerling grow-out
10. Guidelines for obtaining fingerlings for food-fish production
11. Size options for stocking fingerlings for food-fish production
12. Food-fish stocking rates
13. Types of commercial catfish feeds
14. Size and quality of catfish feed
15. Guidelines for feeding food fish
16. Producing catfish in cages
17. Advantages of cage culture
18. Limitations of cage culture
19. Tank and raceway culture of channel catfish

20. Keep daily, weekly, and monthly production records. (Assignment Sheet #1)
21. Calculate stocking rates. (Assignment Sheet #2)
22. Calculate FCR and estimate fish weights from feed records. (Assignment Sheet #3)
23. Calculate feed requirements and costs. (Assignment Sheet #4)
24. Make an anticipated loss projection. (Assignment Sheet #5)

JOB TRAINING: What the Worker Should be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
25. Perform pond sampling to estimate average fish weights and standing crop weight. (Job Sheet #1)	

UNIT X: COMMERCIAL TROUT PRODUCTION

JOB TRAINING	RELATED INFORMATION
	1. Terms and definitions
	2. Trout culture
	3. The external anatomy of a rainbow trout
	4. Basic water quality requirements
	5. Types of trout farming enterprises
	6. Phases of trout production
	7. Broodfish management
	8. Egg management
	9. Fry and fingerling management
	10. General guidelines for feeding different sized fish
	11. General management guidelines
	12. Types of impoundment and rearing units
	13. Raceway design
	14. Water use systems
	15. Typical stocking/loading rates
	16. Flow Index and Density Index
17. Keep trout production records. (Assignment Sheet #1)	
18. Calculate raceway carrying capacity based on flow and density indexes. (Assignment Sheet #2)	
19. Predict ammonia loads based on food consumption, fish load, and water flow rate. (Assignment Sheet #3)	
20. Artificially spawn trout broodfish. (Job Sheet #1)	

JOB TRAINING: What the Worker Should be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)

21. Inventory a raceway load. (Job Sheet #2)

XI: COMMERCIAL BAITFISH PRODUCTION

1. Terms and definitions
2. The baitfish industry
3. Marketing options
4. Factors affecting marketing success
5. Popular baitfish species
6. General characteristics of baitfish species
7. Guidelines for selection of broodstock
8. Reproductive and spawning characteristics of golden shiner, fathead minnow, and goldfish
9. Propagation methods
10. Methods of pond preparation for the propagation and rearing of baitfish
11. Predators and their control techniques
12. Propagation techniques and stocking rates for golden shiners and goldfish
13. Free-spawning and fry transfer methods of propagating fathead minnows
14. Fertilization techniques for plankton production
15. Feeding practices
16. Basic harvesting equipment needs
17. General guidelines for harvesting baitfish to holding troughs
18. Harvesting methods
19. Guidelines for maintaining baitfish in holding troughs

JOB TRAINING: What the Worker Should be Able to Do (Psychomotor)		RELATED INFORMATION: What the Worker Should Know (Cognitive)
	20.	Grading procedures and grading equipment
	21.	Guidelines for transporting fish to long-distance markets
	22.	Guidelines for transporting fish to short-distance markets
23. Survey baitfish dealers to evaluate local supply and demand. (Assignment Sheet #1)		
24. Visit a baitfish farm and report on the operation. (Assignment Sheet #2)		
25. Trap, count or weigh, and grade a sample of baitfish. (Job Sheet #1)		
26. Make a spawning mat. (Job Sheet #2)		
27. Bring baitfish eggs into hatching area and watch them hatch. (Job Sheet #3)		

XII: COMMERCIAL CRAYFISH PRODUCTION

	1.	Terms and definitions
	2.	Crayfish aquaculture
	3.	Crayfish body parts and their functions
	4.	Species selection
	5.	Red Swamp and White River crayfishes
	6.	The reproduction and life cycle of crayfish
	7.	Crayfish pond types
	8.	Open pond design
	9.	Open pond management cycle
	10.	Recirculating ponds
	11.	Water quality requirements for crayfish
	12.	Start-up stocking rates

JOB TRAINING: What the Worker Should be Able to Do (Psychomotor)

RELATED INFORMATION: What the Worker Should Know (Cognitive)

13. Feeds and feeding practices

14. Harvesting crayfish

15. Handling and shipping crayfish

16. Identify crayfish species and sexes. (Assignment Sheet #1)

17. Identify the external and internal parts of a crayfish. (Assignment Sheet #2)

18. Research techniques for soft-shell crayfish production, and report to the class. (Assignment Sheet #3)

19. Construct a crayfish trap. (Job Sheet #1)

XIII: OTHER COMMERCIAL SPECIES

1. Terms and definitions

2. The commercial culture of tilapia

3. Methods of managing tilapia to control overpopulation

4. The culture of largemouth bass

5. The culture of bluegill and hybrid sunfish

6. The culture of crappies

7. Description and uses of common and Chinese carps

8. The commercial production of striped and hybrid striped bass

9. Marine species that can be cultured in freshwater

10. The commercial production of alligators

11. The commercial production of bullfrogs

12. The commercial culture of hobby and ornamental fish

JOB TRAINING: What the Worker Should be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)

13. Interview local hobby and ornamental fish retailers to determine area supply and demand. (Assignment Sheet #1

14. Visit a facility that cultures a species discussed in this unit, and report on the operation. (Assignment Sheet #2)

XIV: HARVESTING AND HAULING

1. Terms and definitions
2. Advantages of total and partial harvest
3. Limitations of total and partial harvest
4. Guidelines for quality control
5. Correct uses of harvesting equipment
6. Correct uses of grading equipment
7. Pre-harvest guidelines
8. Harvesting techniques and procedures
9. Pond-to-shed transport procedures
10. Holding practices
11. Grading practices
12. Hauling equipment
13. Loading procedures and rates
14. Hauling and water quality
15. Chemicals, their correct descriptions and rates
16. Unloading procedures
17. Guidelines for the care of nets

18. Calculate loading rates. (Assignment Sheet #1)

19. Observe and report on a commercial harvest. (Assignment Sheet #2)

JOB TRAINING: What the Worker Should be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)

20. Survey your area and state for laws and regulations concerning interstate and intrastate shipping. (Assignment Sheet #3)

21. Check water temperature and other shipping parameters. (Job Sheet #1)

22. Grade fish. (Job Sheet #2)

23. Package fish in a plastic bag. (Job Sheet #3)

24. Disinfect fish transport tanks and equipment. (Job Sheet #4)

XV: BUSINESS MANAGEMENT

1. Terms and definitions
2. Reasons for keeping records
3. Basic kinds of records
4. Production credit and consumption credit
5. Guidelines for building and maintaining a good credit standing
6. The three C's of good credit
7. Factors that a lender looks for in a borrower
8. Factors that a borrower looks for in a lender
9. Indicators of good loan repayment ability
10. Indicators of poor loan repayment ability
11. Major types of credit extended by businesses
12. Types of loans issued by banks and other lending institutions
13. Sources of credit for aquacultural enterprises
14. Methods of computing interest
15. True annual interest rates

JOB TRAINING: What the Worker Should be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	16. Essential components of all budgets
	17. Budgeting principles
18. Prepare an equipment cost comparison report. (Assignment Sheet #1)	
19. Estimate fixed costs. (Assignment Sheet #2)	
20. Develop an enterprise budget to determine actual costs and expected returns. (Assignment Sheet #3)	
21. Develop a cash flow projection. (Assignment Sheet #4)	
22. Use a computer to evaluate an aquacultural operation. (Assignment Sheet #5)	
23. Interview a local lender and report on attitudes about aquaculture capital. (Assignment Sheet #6)	
24. Complete a checklist to determine individual potential in the aquaculture industry. (Assignment Sheet #7)	

USE OF THIS PUBLICATION

Instructional Units

Aquaculture contains fifteen units of instruction. Each instructional unit includes some or all of the basic components of a unit of instruction, performance objectives, suggested activities for teachers and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to the tests. Units are planned for more than one lesson or class period of instruction.

Careful study of each instructional unit by the teacher will help to determine.

A. The amount of material that can be covered in each class period
B. The skills which must be demonstrated

1. Supplies needed
2. Equipment needed
3. Amount of practice needed
4. Amount of class time needed for demonstrations

C. Supplementary materials such as pamphlets or filmstrips that must be ordered

D. Resource people who must be contacted

Objectives

Each unit of instruction is based on performance objectives. These objectives state the goals of the course, thus providing a sense of direction and accomplishment for the student.

Performance objectives are stated in two forms. unit objectives, stating the subject matter to be covered in a unit of instruction, and specific objectives, stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the intent of the objectives. A limited number of performance terms have been used in the objectives for this curriculum to assist in promoting the effectiveness of the communication among all individuals using the materials.

Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit.

Teachers should feel free to add objectives which will fit the material to the needs of the students and community. When teachers add objectives, they should remember to supply the needed information, assignment and/or job sheets, and criterion tests.

Suggested Activities for the Instructor

Each unit of instruction has a suggested activities section outlining steps to follow in accomplishing specific objectives. Duties of instructors will vary according to the particular unit, however, for best use of the material they should include the following. provide students with objective sheet, information sheet, assignment sheets, and job sheets, preview filmstrips, make transparencies, and arrange for resource materials and people, discus unit and specific objectives and information sheet, give test. Teachers are encouraged to use any additional instructional activities and teaching methods to aid students in accomplishing the objectives.

Information Sheets

Information sheets provide content essential for meeting the cognitive (knowledge) objectives in the unit. The teacher will find that the information sheets serve as an excellent guide for presenting the background knowledge necessary to develop the skill specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Students may take additional notes on the information sheets.

Transparency Masters

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheets. They are particularly effective when identification is necessary.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. They should be left on the screen only when topics shown are under discussion.

Assignment Sheets

Assignment sheets provide paper and pencil activities to aid the student in practicing and developing the knowledge necessary for skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided which may be used by the student and/or teacher for checking student progress.

Job Sheets

Job sheets are an important segment of each unit. The instructor should be able to demonstrate the skills outlined in the job sheets. Procedures outlined in the job sheets give direction to the skill being taught and allow both student and teacher to check student progress toward the accomplishment of the skill. Job sheets provide a ready outline for students to follow if they have missed a demonstration. Job sheets also furnish potential employers with a picture of the skills being taught and the performances which might reasonably be expected from a person who has had this training.

Practical Tests

Practical tests provide the instructor with an evaluation instrument for each of the job sheets.

Test and Evaluation

Written and performance tests have been constructed to measure student achievement of each objective listed in the unit of instruction. Individual test items may be pulled out and used as a short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz and will help the teacher spot difficulties encountered by students in their efforts to accomplish the unit objective. Test items for objectives added by the teacher should be constructed and added to the test.

Test Answers

Test answers are provided for each unit. These may be used by the teacher and/or student for checking student achievement of the objectives.

AQUACULTURE
Alphabetical List of References Used in Developing this Text

1. Avery, Jimmy L. "Production Practices of Commercial Catfish Farming," in *Proceedings of the Louisiana Aquaculture Conference, 1988,* Robert C. Reigh, ed. Baton Rouge, Louisiana: Louisiana State University Agricultural Center, 1988.

2. Beem, Marley. "Building Cages for Fish Farming," *Extension Extra.* 12002, F & F 9.1. South Dakota State University Cooperative Extension Service. May, 1987.

3. Beem, Marley and Glen Gebhart. "Cage Culture of Rainbow Trout," *Langston University Extension Facts.* Langston, Oklahoma: Langston University with support of the USDA/Cooperative State Research Service, n.d.

4. Beem, Marley, and Steven Anderson. *Catfish Farming.* Fact Sheet No. 9002. Stillwater, Oklahoma: Oklahoma State Cooperative Extension Service, n.d.

5. Beem, Marley, and Steven Anderson. "Catfish Farming," No. 9002.1 Stillwater, Oklahoma: Oklahoma Cooperation Extension Service/Oklahoma State University, n.d.

6. Belusz, Larry. *Fish Farming Techniques.* Columbia, Missouri: The Instructional Materials Laboratory, University of Missouri, 1987.

7. Black, Joe B. and Jay V. Huner. "Breeding Crayfish," *Carolina Tips*, Vol. 42, No. 4. Burlington, North Carolina, April 1, 1979.

8. Boyd, Claude E., et al. *Water Quality in Channel Catfish Ponds (A Report from the Water Quality Subcommittee of Regional Research Project S-168).* Southern Cooperative Series Bulletin 290. Mississippi State, Mississippi: Agricultural and Forestry Experiment Station, 1983.

9. Boyd, Claude E., and Frank Lichtkoppler. *Water Quality Management in Pond Fish Culture.* Auburn, Alabama: Auburn University International Center for Aquaculture, Agricultural Experiment Station, 1979.

10. Carroll, Cecil. *Cage Fish Farming Handbook.* El Reno, Oklahoma: Carroll's Fish Farm, 1987.

11. *Catfish Aquaculture: A Decision-Making Guidebook.* Baton Rouge, Louisiana: Louisiana Cooperative Extension Service, Louisiana State University Agricultural Center, 1987.

12. *Catfish Farming.* Washington D.C.: U.S. Government Printing Office, 1983.

13. Coche, A. G. *Soil and Freshwater Fish Culture.* Rome: Food and Agriculture Organization of the United Nations, 1985.

14. Coche, A. G., *Water for Freshwater Aquaculture.* Rome: Food and Agriculture Organization of the United Nations, 1981.

15. Cramer, Lawrence A. "Tax Tips for Aquaculture Investors and Producers," in *Proceedings of the Louisiana Aquaculture Conference, 1988,* Robert C. Reigh, ed. Baton Rouge, Louisiana, 1988.

16. "Crawfish in Louisiana," Agricultural Notes #86-001. Baton Rouge, Louisiana: Center for Small Farm Research, College of Agriculture, Southern University, n.d.

17. "Crawfish: Louisiana at Its Best," Pamphlet, Lafayette, Louisiana: Louisiana Crawfish Farmers Association, n.d.

18. Culley, Dr. Dudley D. "Water Quality and Soft-Shell Crawfish Production" Paper. Forestry, Wildlife, and Fisheries, [no pub., n.d.].

19. De La Bretonne, Lawrence W. Jr., and Robert P. Romaire. "Commercial Crawfish Cultivation Practices: A Review." *Journal of Shellfish Research,* Vol. 8, No. 1, 1989.

20. Dupree, Harry K., and Jay V. Huner. "Pond Culture Systems" in *Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington, D.C.: U.S. Fish and Wildlife Service, 1984.

21. Dupree, Harry K., and Jay V. Huner. "Pond Management" in *Third Report to the Fish Farmers. The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington, D.C.: Fish and Wildlife Service, 1984.

22. Dupree, Harry K., and Jay V. Huner. "Propagation of Black Bass, Sunfishes, Tilapias, Eels, and Hobby Fish," in *Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington, D.C.: U.S. Fish and Wildlife Service, 1984.

23. Dupree, Harry K., and Jay V. Huner. *Third Report to the Fish Farmers. The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington, D.C.: U.S. Fish and Wildlife Service, 1984.

24. Dupree, Harry K., and Jay V. Huner. "Transportation of Live Fish," in *Third Report to the Fish Farmers. The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington, DC: U.S. Fish and Wildlife Service, 1984.

25. Dupree, Harry K., and Jay V. Huner, "Warmwater Fish Farming. A Thriving Industry" in *Third Report to the Fish Farmers. The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington D.C.: U.S. Fish and Wildlife Service, 1984.

26. Fore, John. "Soft-Shell Crawfish," Pamphlet. Denham Springs, Louisiana: Louisiana Soft-Shell Crawfish Association, Louisiana Crawfish Promotion Board, and Louisiana Seafood Promotion and Marketing Board, n.d.

27. *Fritz Aquaculture Catalog 1987.* Dallas, Texas; Fritz Aquaculture, 1987.

28. Guidice, John J., D. Leroy Gray, and J. Mayo Martin. *Manual for Bait Fish Culture in the South.* Stuttgart, Arkansas: University of Arkansas Cooperative Extension Service and the U.S. Fish and Wildlife Service, 1982.

29. Garrard, Anthony B., Mary J. Fuller, and Mark E. Keenum. *Economic Analysis of Small-scale Processing for Mississippi Farm-Raised Catfish.* Mississippi Agricultural & Forestry Experiment Station, June 1988.

30. Hepher, Balfour and Yoei Pruginin. *Commercial Fish Farming.* New York: John Wiley & Sons, 1981.

31. Hoffman, Glenn L., and Andrew J. Mitchell. *Some Parasites and Diseases of Warmwater Fishes*, Fish and Wildlife Leaflet 6. Stuttgart, Arkansas: Fish Farming Experiment Station/U.S. Fish and Wildlife Service, 1986.

32. Huet Marcel. *Textbook of Fish Culture: Breeding and Cultivation of Fish.* Translated by Henry Kahn. Surrey, England: Fishing News Books Ltd., 1970.

33. Huner, Jay V., and Harry K. Dupree. "Methods and Economics of Channel Catfish Production, and Techniques for the Culture of Flathead Catfish and Other Catfishes," in *The Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research*, Harry K. Dupree and Jay V. Huner, eds. Washington, DC: U.S. Fish and Wildlife Service, 1984.

34. Huner, J. V., and Harry K. Dupree. "Propagation of Aquatic Animals Other than Fish: Crayfish, Prawns, Bullfrogs, and Alligators," in *Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington, D.C.: U.S. Fish and Wildlife Service, 1984.

35. Huner, J. V., and J. E. Barr. *Crawfish in the Classroom.* Baton Rouge: Louisiana Department of Education and Louisiana Sea Grant College Program, n.d.

36. Huner, J. V., and Vernon A. Pfister. "Feasibility of Stocking Juvenile Crawfish in Small Ponds," from review in *Crawfish Tales.* Baton Rouge, Louisiana: Center for Small Farm Research, College of Agriculture and Home Economics, Southern University, November 1987.

37. Huner, Jay V., Harry K. Dupree, and Donald C. Greenland. "Harvesting, Holding, and Grading Fish," in *Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research*, Harry K. Dupree and Jay V. Huner, eds. Washington, DC: U.S. Fish and Wildlife Service, 1984.

38. *Inland Aquaculture Engineering.* Rome. United Nations Development Program, Food and Agriculture Organization of the United Nations, 1984.

39. Jensen, Gary L. *Commercial Production of Farm-Raised Catfish.* Baton Rouge, Louisiana: Louisiana Cooperative Extension Service/Louisiana Agricultural Experiment Station, 1988.

40. Jensen, Gary L., and Joseph D. Bankston. *Guide to Oxygen Management and Aeration in Commercial Fish Ponds.* Baton Rouge, Louisiana: Louisiana Cooperative Extension Service/Louisiana State University Agricultural Center, 1988.

41 Jensen, Gary L. *Handbook for Common Calculations in Finfish Aquaculture.* Baton Rouge, Louisiana: Louisiana Cooperative Extension Service/Louisiana State University Agricultural Center, 1987.

42. Keenum, Mark E., and John E. Waldrop. *Cash Flow Analysis of Farm-Raised Catfish Production in Mississippi.* Mississippi Agricultural & Forestry Experiment Station, August 1988.

43 Killcreas, Dr. Wallace, et. al. *A Records Program for Catfish and Shrimp Production, Financial Data and Management Decisions for IBM PC and Compatible Microcomputers*. Mississippi Agricultural & Forestry Experiment Station, September 1985.

44. Kincaid, H. L., W. R. Bridges, A. E. Thomas, and M. J. Donahoo. "Rearing Capacity of Circular Containers of Different Sizes for Fry and Fingerling Rainbow Trout," *The Progressive Fish Culturist*, Vol. 38, No. 1, January 1976.

45. Klontz, George W., Philip C. Downey, and Richard L. Focht. *A Manual for Trout and Salmon Production*. Murray, Utah: Sterling H. Nelson and Sons, Inc., Murray Elevators Division, 1979, rev. 1985.

46. Lee, Jasper S. *Catfish Farming. A Reference Unit*. Jackson, Mississippi. Division of Vocational and Technical Education, Mississippi State Department of Education, 1971.

47. Marriage, L. Dean, Audrey E. Borell, and Paul M. Scheffer. *Trout Ponds for Recreation*. Washington, D.C.: U.S. Government Printing Office, 1976.

48. McLarney, William. *The Freshwater Aquaculture Book. A Handbook for Small Scale Fish Culture in North America*. Point Roberts, Washington. Hartley and Marks, Inc., 1984.

49. Meigs, Frank E., III. "Financing Options for Aquaculture," in *Proceedings of the Louisiana Aquaculture Conference, 1988,* Robert C. Reigh, ed. Baton Rouge, Louisiana, 1988.

50. Meyer, Fred P., J. W. Warren, and T. G. Carey. *A Guide to Integrated Fish Health Management in the Great Lakes Basin*. Ann Arbor, Michigan. Great Lakes Fishery Commission, 1983.

51. Meyer, Fred P. *Treatment Tips. How to Determine Chemical Treatments in Fish Farming*. Washington, DC: U.S. Government Printing Office, 1979.

52. Moore, Brenda Rogers. "Parasites and Diseases in Pond Fish" in *Third Report to the Fish Farmers. The Status of Warmwater Fish Farming and Progress in Fish Farming Research*. Washington, DC: U.S. Fish and Wildlife Service, 1984.

53. Morgan, Ann Haven. *Field Book of Ponds and Streams*. New York: G. P. Putnam's Sons, 1930.

54. Piper, Robert G., et. al., *Fish Hatchery Management*. Washington, D.C.. United States Department of the Interior, Fish and Wildlife Service, 1982.

55. Plumb, John A., ed. *Principal Diseases of Farm Raised Catfish*. Revised edition. Auburn University, Alabama: Alabama Agricultural Experiment Station, 1985.

56. *Pond Management in Oklahoma*. Oklahoma City. Fish Division, Oklahoma Department of Wildlife Conservation, 1984.

57. *Ponds—Planning, Design, Construction*. Handbook 590. Washington, D.C.. U.S. Department of Agriculture, Soil and Conservation Services, June 1982.

58. Post, George. *Textbook of Fish Health.* Neptune City, New Jersey: T.F.H. Publications, 1987.

59. Reigh, Robert C., ed. *Proceedings of the Louisiana Aquaculture Conference 1988.* Baton Rouge, Louisiana: Louisiana State University Agriculture Center, Louisiana Cooperative Extension Service, 1988.

60. Romaire, Robert P. "Overview of Harvest Technology Used in Commercial Crawfish Aquaculture." *Journal of Shellfish Research*, Vol. 8, No. 1, 1989.

61. Romaire, R. P., and C. E. Boyd. *Predicting Nighttime Oxygen Depletion in Catfish Ponds.* (Bulletin 505.) Auburn, Alabama: Alabama Experiment Station, Auburn University, n.d.

62. Sadler, Tom. "A Producer Looks at Catfish Farming," in *Proceedings of the Louisiana Aquaculture Conference, 1988.* Robert C. Reigh, ed. Baton Rouge, Louisiana: Louisiana State University Agriculture Center, Louisiana Cooperative Extension Service, 1988.

63. Saigo, Roy H., and Barbara Woodworth Saigo. *Botany. Principles and Applications.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1983.

64. Scheffer, Paul M. and L. Dean Marriage. *Trout Farming.* Leaflet 552. Washington, D.C.: U.S. Department of Agriculture, U.S. Government Printing Office, 1975.

65. Schnick, Rosalie A., Fred P. Meyer, and D. Leroy Gray. *A Guide to Approved Chemicals in Fish Production and Fishery Resource Management.* Little Rock, Arkansas: Arkansas Cooperative Extension Service/U.S. Fish and Wildlife Service, 1989.

66. Schubert, Dr. Gottfried. *Fish Diseases: A Complete Introduction.* Neptune City, New Jersey: T.F.H. Publications, Inc., 1987.

67. Sedgwick, S. Drummond. *Trout Farming Handbook.* London, England: Seeley, Service, & Co., 1978.

68 *Some Parasites and Diseases of Warmwater Fishes.* Fish and Wildlife Leaflet 6, Revision of Resource Publication 127. Stuttgart, Arkansas: Fish Farming Experimental Station, U.S. Fish and Wildlife Service, April 1976.

69. "Standard Cuts and Forms of Farm-Raised Catfish." Fact Sheet. Jackson, Mississippi: Catfish Farmers of America, n.d.

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

71. Steward, Jim, and Dr. Raleigh Jobes. *Farm & Ranch Business Management.* Moline, Illinois: Deere & Company, 1985.

72. Swift, Donald R. *Aquaculture Training Manual.* Surrey, England. Fishing News Books, Ltd., 1985.

73 *The Fish Book: NEBRASKAland Magazine.* Lincoln, Nebraska. Nebraska Game and Parks Commission, 1987.

74. Torrans, Les. *Blue Tilapia Culture in Arkansas.* Pine Bluff, Arkansas: University of Arkansas Cooperative Extension Service, 1988.

75. Van Ramshorst, Dr. J. D., ed. *Aquarium Encyclopedia of Tropical Freshwater Fish,* Tucson, Arizona, 1981.

76. Wellborn, Thomas L. Jr. *Catfish Farmer's Handbook.* Mississippi State University/Mississippi Cooperative Extension Service, 1987.

77. White, David, et. al. *WATERQ: A Microcomputer Program for Pond Water Management.* Mississippi Agricultural & Forestry Experiment Station, October 1988.

78. Williams, Kenneth. *Economic Evaluation of Small Scale Catfish Production.* Langston, Oklahoma: Langston University/Kerr Center for Sustainable Agriculture, 1987.

79. *World Book Encyclopedia.* Vol. 6, "Ecology," Vol. 7, "Fish," Vol. 15, "Pond," and Vol. 21, "Water." Chicago: World Book-Childcraft International, Inc., 1981.

AQUACULTURE

Tools, Equipment, and Materials Lists

Basic hand tools

Screwdriver
Awl
Rule
Wire cutters
Tin snips
Pliers
Shovel

Harvesting equipment

Ten-foot minnow seine
Hundred-foot seine with small mesh
Other seines as facilities demand
Hanging scales with 50-pound capacity graduated in ounces
Tripod or bar to hang scales from
Buckets
Dip nets
Fish food

Catfish cleaning equipment

Tub or vat to hold fish
Fish cleaning board with clip
Skinning hook
Skinning pliers
Gutting knife
Butcher knife or band saw
Filet knife

Cage and trap-building materials

Roll of 3-foot wide chicken wire or plastic-coated wire
Heavy duty fishing line (3 feet)
Large fishing weights
Large fishing bobber or buoy
Twenty feet of 16-gauge, plastic-coated welded wire 48-inches wide with a 1/2 inch by 1 inch mesh
Stainless steel C-clamps (36)
Five styrofoam squares, 12 x 6 x 6 inches
Plastic-coated bell wire (50 feet)
Plastic paint or rust-proof paint
Small paint brush
Strapping material
Cinder block & length of rope for anchor

Special equipment/instruments

Small open boat
Compass
Available aerator(s)
Dissolved oxygen meter
Water analysis kit

Record keeping supplies

Pen/pencil
Notebook
Graph paper

Miscellaneous equipment

Eyebolts
Supply of light rope
Corks or bottle stoppers

Processing materials

Running water and drain board
Dissection needles
Nine percent solution of sodium chloride
Tweezers with sharp points
Sharp knife
Small scissors with pointed blades
Spatula
Plastic freezer bag
Marking pen
Ice and ice bath container
Water brush
Rubber gloves and apron
Freezer for fish storage
Paper towels

Shipping materials

Transport box with styrofoam liner
Plastic bags of different sizes and weights
Supply of pure oxygen
Rubberbands
Crushed or artificial ice
Dry ice
Shipping labels
Supply of Formalin
Clean glass containers
Aluminum foil

Inspection/evaluation equipment

Plankton net or nylon stocking
Microscope, slide, and cover slips
Methyl cellulose to retard plankton movement
Eyedropper or pipette
Glass quart jars with screw-on lids (2)
Glass jars to use as specimen containers
Sieve with 2mm openings for soil testing
Plastic sheeting
Water thermometer

Secchi disc construction materials

Flat black and flat white paint that will adhere to metal
Foot square piece of sheet metal
Eyebolt
Lead weight with hole in center
Five feet of calibrated line

Trout production equipment

Spawning bench
Spawning pan
Anesthetic
Dip nets
Cotton gloves
Balance scale sensitive to 1 gram
Measuring cup
Feather for stirring
Trout incubator
Male and female broodfish
Live box 3′ x 3′ x 2′ high
Crowding screen
Measuring board graduated in millimeters
Metric balance beam
Spring scale

Baitfish production equipment

Lift seine/fulcrum and boom
16 percent protein bait feed
Scales
Buckets
Floating grader with appropriate bar space
Eight feet woven steel-welded wire with 2x4-inch mesh
Steel tape
One dozen hog rings
Quantity of Spanish moss, Astroturf or Spandex for spawning mat

INTRODUCTION TO AQUACULTURE
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss types of aquaculture enterprises and list factors to consider before starting an aquaculture operation. The student should also be able to complete a survey of local aquaculture production. These competencies will be evidenced by correctly completing the procedures outlined in the assignment sheets and by scoring a minimum of 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to introduction to aquaculture with their correct definitions.
2. Select facts about aquaculture.
3. Select facts about the historical background of aquaculture.
4. Match types of aquaculture environments with their descriptions.
5. Select facts about types of aquaculture enterprises.
6. Select from a list species of economic importance.
7. Complete statements about factors to consider before starting an aquacultural enterprise.
8. Select facts about limiting factors in joint aquaculture/agriculture operations.
9. Complete statements about physical and fiscal risks associated with aquaculture.
10. Complete statements about advantages of aquaculture.
11. List sources of information about aquaculture.
12. Survey local aquaculture production. (Assignment Sheet #1)
13. Visit a support facility and interview the operator(s). (Assignment Sheet #2)
14. Survey local market outlets for types of fish sold. (Assignment Sheet #3)
15. Interview a local producer. (Assignment Sheet #4)

INTRODUCTION TO AQUACULTURE
UNIT I

SUGGESTED ACTIVITIES

A. Read unit, make your own notes, and plan your teaching strategy.

B. Assist students in completing Assignment Sheet #4 by arranging for a local fish farmer to visit the class and talk about how he or she became interested in and got started in fish farming.

C. Contact a local support facility (processor, hauler, etc.) and prepare the operator for visits by the students as they complete Assignment Sheet #2.

D. During the first class period, introduce yourself, explain your class attendance and assignment rules, and provide your students with an overview of the course. Provide each student with a binder, or have students buy binders in which to keep their lesson components and homework assignments.

E. Provide students with objective sheet. Discuss unit and specific objectives.

F. Provide students with information sheet. Discuss each section of the information sheet, adding information from your experience and resources specific to the situations of the students in your class. Be sure to discuss local names for species introduced in Section VI.

G. Provide students with assignment sheets. Discuss assignment sheets and schedule due dates.

H. Give unit test. Critique in class.

AVAILABLE VIDEO MATERIALS

A. The American Association for Vocational Instructional Materials, AAVIM, has available a 30-minute VHS video entitled "Aquaculture: Farming the Water." The production focuses on all phases of catfish production and serves to reinforce and illustrate much of the material in this text. Cost of the tape is $43.95 which includes $4.00 for shipping and handling. Call 1-800-228-4689 for information or write to:

AAVIM
Ref: V-525
120 Engineering Center
Athens, GA 30602

SUGGESTED ACTIVITIES

B. The Clear Springs Trout Company of Buhl, Idaho is the largest trout producer in the world, and they have an excellent videotape that displays their impressive operation. Their facilities are located along the Snake River in the Magic Valley area of southern Idaho, and the operation includes everything from the management of broodfish to processing and delivery. The tape is especially recommended for Unit X of this text, "Commercial Trout Production." The video is VHS format and runs just over 15 minutes. Cost of the tape is minimal, and there is an educational discount for schools or organizations teaching aquaculture programs. Write for information to:

Clear Springs Trout Company
Attn: Marketing Department
P.O. Box 712
Buhl, Idaho 83316

REFERENCES USED IN DEVELOPING THIS UNIT

A. Belusz, Larry. *Fish Farming Techniques.* Columbia, Missouri: The Instructional Materials Laboratory, University of Missouri, 1987.

B. Dupree, Harry K., and Jay V. Huner. "Warmwater Fish Farming: A Thriving Industry" in *Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington D.C.: U.S. Fish and Wildlife Service, 1984.

C *Catfish Aquaculture: A Decision-making Guidebook.* Baton Rouge, Louisiana. Louisiana Cooperative Extension Service/Louisiana State University Agricultural Center, 1987.

D. Reigh Robert C., ed. *Proceedings of the Louisiana Aquaculture Conference, 1988.* Baton Rouge, Louisiana: Louisiana State University Agricultural Center, 1988.

INTRODUCTION TO AQUACULTURE
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. **Acclimate** — To gradually accustom fish to a different environment (different water temperature and water chemistry)

B. **Aeration** — Process of supplying additional oxygen to water; adjusting water chemistry

C. **Aquatic** — Growing or living in or upon water

D. **Fee-fish pond** — Pond stocked for sport fishing; the pond operator charges a fee for fishing

E. **Detritus** — Debris from plants and animals

F. **Levee** — Earth dike used to enclose water

G. **Marine** — Of the sea or ocean

H. **Noxious** — Harmful or undesirable

I. **Polyculture** — System where more than one kind of aquatic organism is grown in one pond or rearing unit

J. **Propagate** — To cause a plant or animal to reproduce; to raise or breed

K. **Turbidity** — Muddy or cloudy water caused by plankton or suspended particles of soil

L. **Intensive production** — Raising fish in densities higher than could be supported in the natural environment; requires feeding fish formulated feeds

M. **Extensive production** — Raising of fish in earthen ponds; the fish feed primarily on natural feeds

N. **Plankton** — Microscopic plants and animals

O. **Fry** — Stage of a fish's life from the time it hatches until it reaches 1 inch in length

P. **Fingerling** — Fish from 1 inch to 8 inches long

Q. **Stocker** — Fish 8 inches or over

R. **Hybrid** — Fish resulting from a cross between parents that are genetically unlike

INFORMATION SHEET

II. **Aquaculture**

A. Aquaculture is the commercial raising of animals and plants that live in water, it may also be referred to as *fish farming* or *fish culture*, though animals other than fish may be farmed.

(NOTE: Worldwide, fish farming produces at least 90 species of fish, 13 species of shrimps, prawns, and crayfishes, a wide variety of shellfish and marine plants, as well as such aquatic animals as frogs and alligators.)

B. Aquaculture and agriculture share a common goal: to increase stock or crop production above the level that would be produced naturally per unit of land or water area.

C. Aquaculture involves cultivation of water so that a marketable crop of fish or other commodity is efficiently and profitably produced.

D Aquaculture involves careful management of the conditions in which fish and other aquatic plants and animals grow.

III. **Historical background of aquaculture**

A. Aquaculture is about 3,000 years old and was first practiced in China and other Asian countries to feed fish-hungry populations.

B. While the majority of food fishes are still obtained by the capture of wild fishes, about 33 countries produce 90 percent of the farmed produce, with 75 percent grown in Asian countries.

(NOTE: Aquaculture is one of the most dynamic and promising forms of farming in the world. It produces 50 percent of fish consumed in Israel, 30 percent of fish consumed in China, 30 percent of fish consumed in India, and 1.8 percent of fish consumed in the U.S.)

C. Commercial food-fish farming in the U.S. began in the 1920s; before that, emphasis was on baitfish and ornamental fish production, as well as raising recreational species (largemouth bass, sunfish, catfish) for pond stocking.

D United States' aquaculturists now provide American consumers with nearly all their rainbow trout, channel catfish, and crayfish, and with 40 percent of the oysters they consume.

(NOTE: Channel catfish and trout are the major farmed fishes in the U.S., but crayfish and salmon production are increasing steadily. Louisiana leads in crayfish production; Mississippi is the major producer of catfish; and Idaho continues to produce most of our trout. Virginia, Louisiana, Maryland, Oregon, and Washington are the leading oyster-producing states.)

INFORMATION SHEET

IV. **Types of aquaculture environments**

A. **Warmwater aquaculture** — Commercial raising of stock that thrives in warm, often turbid, freshwater with temperatures between 70°F and 90°F.

(NOTE: With the exception of trout culture, this manual deals largely with warmwater aquaculture.)

EXAMPLES: Catfish, crayfish, carp, baitfish cultures; sport fishes

B. **Coldwater aquaculture** — Commercial raising of stock that thrives in cool, clear freshwater with temperatures 65°F and under.

EXAMPLES: Trout, salmon cultures

C. **Mariculture** — Commercial raising of stock that thrives in salt water of various temperatures; also called *marine aquaculture*.

EXAMPLES: Shrimp, oyster, seaweed cultures

V. **Types of aquacultural enterprises**

A. **Food-fish production** — Raising fingerlings or stocker fish until they reach a specific size and weight and can be sold for human consumption; while the owners of small enterprises may process and sell their product themselves, more often fish produced are sold to processing plants. (Figure 1)

EXAMPLE: FIGURE 1

B. **Broodfish production** — Raising and management of sexually mature, adult fish to produce eggs or seed stock; sold to fingerling producers.

C. **Fingerling production** — Raising fish used to stock food-fish and recreational ponds; requires the management of broodfish to produce young, the hatching of the eggs, and the care of the young until they reach market size.

INFORMATION SHEET

D. **Stocker production** — Raising fish to meet the demand for fish larger than fingerling size that will reach market size early in the growing season; this is the least common type of enterprise and is frequently included with fingerling production.

E. **Fee-fish production/operation** — Raising fish to be sold to fee-fish lakes near population centers or used for stocking farm fee-fish ponds; producers may market their own product by both stocking and operating the pond. (Figure 2)

EXAMPLE: FIGURE 2

F. **Baitfish production** — Raising minnows or other small fishes used by fishermen to catch wild fishes; producers may sell to a wholesaler, may deliver the product to retailers, or may raise, haul, and retail independently.

G. **Ornamental or hobby fish production** — Raising and propagating a variety of species of tropical or aquarium fishes for sale to wholesalers and retailers.

POINT OF INTEREST: Most domestically bred tropical fish are cultured at the more than 300 farms located near Tampa in central Florida, though hobby fish are also raised in most other states. Imported hobby fish are typically received by a wholesaler who acclimates, reconditions, or finishes rearing them for a time before shipping them to the retailer.

INFORMATION SHEET

VI. Species of economic importance

> POINT OF INTEREST: It is projected that the major warmwater species farmed during the next 10 years will continue to be channel catfish and crayfish; however, polyculture involving Chinese carps and the culture of tilapias, common carp, and Buffaloes will become increasingly important.

A. Baitfishes/feeder fishes

1. Fathead minnow
2. Golden shiner
3. Goldfish

B. Recreational fishes

1. Largemouth bass
2. Catfish
3. Bluegill sunfish
4. Crappie
5. Hybrid sunfish

C. Trout and salmon

1. Rainbow trout
2. Coho salmon
3. Atlantic salmon

D. Chinese carps

1. Silver carp
2. Bighead carp
3. Grass carp

E. Hybrids

1. Hybrid striped bass

   EXAMPLE: Striped bass (F) × white bass (M)

INFORMATION SHEET

2. Hybrid sunfish

   EXAMPLE: Green sunfish (F) × bluegili (M)

F. Crayfish

(NOTE: Crayfish are also called *crawfish* and *crawdads.*)

1. Red Swamp
2. White River

G. Catfish

1. Channel catfish
2. Blue catfish

VII. Factors to consider before starting an aquaculture enterprise

A. Capital

1. The amount of start-up money needed depends on the size and type of proposed aquaculture operation.
2. A planned budget must include money for feed, labor, stock, land (if not already owned), pond construction (if none exist), water supply development and pumping costs (if wells are needed), and additional equipment.
3. Any aquaculture enterprise diverts money and time from other farming operations.

B. Labor

1. The amount of labor required varies with the season, the production method, and the type of enterprise.

   EXAMPLES: Extensive versus intensive production; fingerling enterprise versus a fee-fish enterprise; harvesting in the summer heat versus harvesting in the fall.

2. Trained or skilled farm labor is often required to assist with pond treatment for disease or aquatic weed control, and to assist with facility upkeep and harvesting.
3. Routine monitoring of water quality requires round-the-clock attention in intensive production.

INFORMATION SHEET

C. Land

1. The amount of land required is determined by the type of operation and production method used.

   EXAMPLE: Raceways and tanks require less space but more water than pond systems. Fingerling producers require fewer acres and less water than do food-fish producers.

2. Sufficient acreage must be available to reduce the fixed per-unit costs of production for such things as water wells, boats, pumps, and motors.

3. If existing ponds are not available, the potential aquaculturist should investigate alternative uses of land needed for ponds, levees, access roads, and service areas to determine if greater profit can be obtained from other agricultural enterprises.

D. Water

1. A dependable source of clean, chemically suitable water is essential.

2. Water volume needs vary: for pond culture, 15 to 25 gallons per minute per surface acre are typically needed; raceway water supply should be capable of providing three changes per hour through each unit, and no less than one change per hour through the entire system.

3. An alternative water supply may be necessary to make up for evaporation and seepage in ponds, as well as to provide for normal household use, fire protection, irrigation or livestock watering.

4. A limited water supply means lower production unless the producer applies intensive management efforts to each unit of available water.

E. Equipment

1. Some fish farming equipment can be used for other crops, but other equipment is specialized to the aquaculture enterprise.

   EXAMPLES: Tractors, utility buildings, mowers, and compressors have obvious multiple uses; seines, fish cages, fish hauling tanks, and most aeration equipment are used only for aquaculture crops.

2. Multiple use of equipment spreads costs over several operations.

F. Markets

1. Appropriate markets must be located *before* the potential aquaculturist chooses or invests in an enterprise.

INFORMATION SHEET

2. Distance from the market and the number of producers in the area affect profitability of the enterprise.

   EXAMPLE: A large number of local growers in an area will flood the market, lowering the demand for and price of the product.

G. Legal requirements may restrict or prohibit an enterprise.

EXAMPLES: 1. There may be restrictions on the kinds of fish imported or raised.

2. You may be required to have a disease inspection certificate for certain species of fish.

3. You may be required to obtain permits to buy, sell, or grow certain fishes and aquatic plants.

4. You may be required to obtain your stock from a commercial source; stock captured from public waters may be prohibited for commercial purposes.

5. State and local sanitation, health, and grading requirements may be imposed.

6. Wildlife Conservation Laws prohibit the killing of some predators, such as egrets, herons, diving birds, pelicans; and a permit is required to hunt or trap others.

7. Laws protecting wetlands may penalize the producer who converts wetlands to farm use; permits are also required.

VIII. Some limiting factors in aquaculture/agriculture operations

A. Levees and ditches occupy much land, and few alternate uses of these structures exists.

B. Planting and harvesting schedules must be adjusted to both fish and field crops: One crop may be reduced if it cannot be sown (or stocked) or harvested during the optimum period.

C. Facility layout must be planned so that pesticides used on land crops do not drift or run off to pond cultures and kill fish.

D. Rotation of fish and field crops —

1. Pond and field sizes may be compromised: Desirable pond sizes are usually less than 50 acres, and desirable field sizes are generally 50 acres or larger.

2. A farmer should not plant certain crops that require pesticides that may later kill stocked fish.

INFORMATION SHEET

IX. **Physical and fiscal risks associated with aquaculture**

A. Stock loss may occur because of disease, poor water quality, or pesticide contamination of a pond.

(NOTE: Most fish diseases are stress related and are often triggered by poor water quality such as low oxygen levels. The fish farmer can lose an entire pond of fish overnight because of oxygen depletion. Small daily losses from parasitic or bacterial infections can also mount up and eat away profits. Poor quality feed can also trigger losses, especially with cage-raised fish.)

B. The amount of water available for both production purposes and for supplying emergency and supplementary needs may be undependable or limited.

C. Power failure may cause stock loss.

D. Poor quality stock may lead to disease or an unmarketable product.

E. The market may fluctuate or fail.

X. **Advantages of adding an aquaculture enterprise to an existing agriculture operation**

A. A start-up aquacultural enterprise can be added to an agricultural enterprise with existing pond for relatively little capital investment.

B. The addition of an aquaculture enterprise allows for multiple use of land and water.

1. Agricultural and aquacultural crops can be rotated or double cropped.

   EXAMPLES: Rotating crayfish and rice; double cropping fish and corn, milo, wheat, or soybeans

2. Badly eroded land or land from which the topsoil has been removed can be reclaimed by farming fish.

   (NOTE: Detritus from fish production adds organic material to the soil, as well as nitrogen, phosphate, and other essential plant growth elements. Several studies have shown that 2 or 3 years of fish production can improve land as much as 10 years of row crop production, and the cost is significantly less.)

3. The cost of an irrigation reservoir can be shared by both agriculture and aquaculture crops.

   (NOTE: In a properly constructed reservoir, extra water could be released by gravity flow to the surrounding fields. The higher income from fish production would enable the farmer to pay for the earthwork and pumps, and later return the field to row crop production.)

INFORMATION SHEET

4. Water from deep wells can usually be improved by running it through fish ponds because the temperature is raised and nutrients are added.

5. In some areas croplands that have been leveed for crop production and fish farming can be easily flooded during the winter to attract waterfowl; the farmer can then lease the land for wildlife hunting if desired to supplement income.

C. The addition of an aquaculture enterprise spreads the cost over several operations by multiple use of some equipment and machinery.

XI. Sources of information

(NOTE. Information is needed at different points in the development of a productive and profitable aquaculture program. Various publications, persons, and organizations can provide assistance. Time and money spent planning will return many dollars in the future operation of an aquaculture program. Below is a general listing of sources of information. For specific names and addresses, consult, *Third Report to the Fish Farmers*, published by the U.S. Department of Interior, Fish and Wildlife Service.)

A. Reference books, trade books, educational videotapes, government and other publications

B. Universities, colleges, and vocational programs

C. University and public libraries with computer programs

D. State and national fish farming associations

E. Agricultural experiment stations

F. Federal and state agencies

1. U.S. Department of Agriculture

2. U.S. Soil Conservation Service

3. U.S. Department of Commerce

4. National Marine Fisheries Service

5. U.S. Fish and Wildlife Service

6. County Cooperative Extension Service

7. State Geological Survey

8. Sea Grant

9. U.S. Corps of Engineers

INFORMATION SHEET

G. Regulatory agencies

   1. State fish and game departments
   2. State natural resources departments
   3. State and federal environmental protection agencies
   4. State health boards

H. Professional consultants

I. Fish farmers

J. Processors

K. Feed distributors

L. Merchandisers

INTRODUCTION TO AQUACULTURE
UNIT I

ASSIGNMENT SHEET #1 — SURVEY LOCAL AQUACULTURE PRODUCTION

Before making the decision to begin an aquacultural enterprise, you should take time to evaluate local aquaculture production. You may want to start by looking in the yellow pages of the phone directory to find listings of fish farmers, processors, haulers, etc. Talk to the county cooperative extension agent or state fish and game agency; get in touch with teachers or administrators at a nearby university, college, or vocational-technical school However you approach this assignment, put yourself in touch with the full scope of the aquaculture activity in your area by finding the answers to the following questions.

1. How many fish farmers are there in your area? ____________

2. What species are farmed in your area? ____________

   ____

3. What is the primary species farmed? ____________

4. What types of aquacultural enterprises (recreational, baitfish, food-fish, etc.) are represented in your area? ____________

   ____

5. Which of these enterprises is most prevalent? ____________

6. How many area suppliers are there for obtaining the species you plan to culture?

   ____

7. How many fish processors are there in your area? ____________

8. How far is the nearest processor from your proposed aquaculture enterprise?

   ____

9. How many live-fish haulers are there in your area? ____________

10. How many feed distributors are there in your area? ____________

11. Is feed available in bulk quantities? ____________

12. How many suppliers of aquaculture equipment? ____________

13. Are there fee-fish ponds in your area? ____________ How many? ____________

14. Are there laboratory facilities available for periodic feed analysis and disease diagnosis? ____________

ASSIGNMENT SHEET #1

15. How far are these facilities from your proposed aquaculture enterprise?

____

INTRODUCTION TO AQUACULTURE
UNIT I

ASSIGNMENT SHEET #2 — VISIT A SUPPORT FACILITY AND INTERVIEW THE OPERATOR(S)

For this assignment, visit one of the support facilities — hauler, processor, merchandiser, equipment supplier — located in Assignment Sheet #1. Interview the operator(s) to find out as much as possible about the services that the facility could provide to your proposed aquaculture enterprise. Use the questions below as an interview aid.

General

1. How long have you been in this business?
2. How many customers do you have locally?
3. What services do you provide, and what are the charges for these services?

Processors

1. How are prices established? Do you contract with your producers? What is your present per-pound price? How has this price fluctuated in the past 12 to 24 months?
2. What special considerations are required of the producer in terms of market size, weight, off-flavor testing, quality control?
3. How are the products packaged?
4. Who are your wholesale and retail markets? Are they live markets or fresh-killed markets?
5. What are your hours, slack periods, rush season, etc.?
6. Do you send a truck to pick up fish?
7. Do you have distance pick-up limits, and if so, what are they?

Haulers

1. What size are your hauling trucks and how are they equipped?
2. Do you use polyethylene bags or tanks?
3. What size trucks do you use? Pickup? 21/2 ton? Larger?
4. Do you use aerators or agitators to ensure adequate oxygen during transport?
5. Are your trucks equipped with a back-up power source?
6. What is the source of water for your tanks? How do you maintain water chemistry? Water temperature? Do you use an anti-bacterial in your haul water to prevent disease when transporting stockers?

ASSIGNMENT SHEET #2

7. How does your hauling procedure vary between summer and winter?

8. Are you bonded? How do you handle stock loss?

9. What special considerations must the producer take just prior to harvest? When to stop feeding? When to stop medications?

10. What are your charges per loaded mile?

11. Do you have minimum load limits?

12. Whom do you haul to?

INTRODUCTION TO AQUACULTURE
UNIT I

ASSIGNMENT SHEET #3 — SURVEY LOCAL MARKET OUTLETS FOR TYPES OF FISH SOLD

Before deciding what species you want to culture, it is wise to survey the local market outlets to determine the types of fish sold and to learn about consumer and customer demand in your market area. Where will your proposed enterprise fit in? Is there a market, a demand for the species you want to culture?

Check the following markets for species bought and sold:

1. Processors
2. Individuals (fresh use and freezer)
3. Restaurants
4. Grocery stores
5. Businesses (annual picnics or special events)
6. Ethnic groups (special holiday or yearly seasonal orders)
7. Church groups, fraternal orders, police (hold fish fries two or three times a year)
8. Taverns (selling food and liquor)
9. Farmer's markets (sold live or processed)
10. Fee-fish ponds
11. Sports groups
12. Other fish farming enterprises

Analyze your findings:

1. What are the most popular species sold in your area?
2. Is there a market for the species you plan to farm?
3. Is there a demand for the species you plan to farm?
4. Is the market "glutted"—too many producers for the demand?
5. Is there a demand for a species not widely marketed in your area?

INTRODUCTION TO AQUACULTURE
UNIT I

ASSIGNMENT SHEET #4 — INTERVIEW A LOCAL PRODUCER

Commercial fish farming is generally more complicated than the potential fish farmer first believes. The producer must be a combination business and sales person, as well as a biologist, lawyer, manager, and (possibly most of all) a hard worker.

Your instructor will invite a local producer to speak to the class. Interview the producer. Find out as much as you can about the producer's aquaculture operation and satisfaction with the enterprise and the species being cultured. Ask about all phases of the farming operation.

1. How did this producer become interested?
2. Is the enterprise used as supplementary or primary income?
3. What problems has the producer encountered in setting up proper facilities, buying stock, maintaining water chemistry, preventing disease, dealing with seasonal changes, harvesting, marketing the product?
4. About how much does the producer budget annually for feed?
5. What kinds and brands of equipment and feed does the producer use?
6. What facilities are needed?
7. How much investment was required?
8. What sources of technical information does the producer have?
9. What sources of financial assistance did/does the producer use?
10. How far is the producer from markets?
11. What legal regulations are involved?
12. Does the producer process on-site or use a processor?
13. What were the initial costs? The annual fixed costs?
14. What type of record keeping system does the producer use?
15. Has the producer had any problems with poaching?
16. Has the producer had any migratory bird problems?
17. How does the producer deal with diseases and stock losses?

INTRODUCTION TO AQUACULTURE
UNIT I

TEST

NAME__________________________________ SCORE ________________

1. Match terms related to introduction to aquaculture with their correct definitions. Write the correct numbers in the blanks.

_____a.	Harmful or undesirable	1.	Turbid
_____b.	Of the sea or ocean	2.	Propagate
_____c.	Earth dike used to enclose water	3.	Polyculture
_____d.	Muddy or cloudy water caused by plankton or suspended particles of soil	4.	Detritus
		5.	Fee-fish pond
_____e.	To cause a plant or animal to reproduce; to raise or breed	6.	Acclimate
_____f.	Growing or living in or upon water	7.	Aeration
_____g.	Debris from plants or animals	8.	Noxious
_____h.	Pond stocked for sport fishing; the pond operator charges a fee for fishing	9.	Marine
		10.	Levee
_____i.	To gradually accustom fish to a different environment (different water temperature or water chemistry)	11.	Aquatic
		12.	Intensive production
_____j.	Process of supplying additional oxygen to water; adjusting water chemistry	13.	Extensive production
_____k.	System in which more than one kind of aquatic organism is grown in one pond or rearing unit	14.	Plankton
		15.	Fry
_____l.	Microscopic plants and animals	16.	Fingerling
_____m.	Fish resulting from a cross between parents that are genetically unlike	17.	Stocker
		18.	Hybrid
_____n.	Fish from 1 inch to 8 inches long		
_____o.	Raising fish in densities higher than could be supported in the natural environment; requires feeding fish formulated feeds		

TEST

_____ p. Stage in a fish's life from the time it hatches until it reaches 1 inch in length

_____ q. Fish 8 inches or over

_____ r. Raising fish in earthen ponds; the fish feed primarily on natural feeds

2. Complete statements about aquaculture. Write the correct numbers in the blanks.

_____ a. Aquaculture is the _____ of animals and plants that live in water.

1. commercial raising
2. commercial fishing
3. commercial trapping
4. commercial processing

_____ b. Aquaculture may also be called _____.

1. aquarium culture
2. fish farming
3. fish culture
4. both 2 and 3

_____ c. Aquaculture and _____ share a common goal: to increase stock or crop production above the level that would be produced naturally per unit of land or water area.

1. monoculture
2. horticulture
3. agriculture
4. polyculture

_____ d. Aquaculture involves the cultivation of _____ so that a marketable crop of fish or other commodity is efficiently and profitably produced.

1. water
2. soil
3. desert land
4. mountain areas

_____ e. Aquaculture requires careful _____ of the conditions in which fish and other aquatic plants and animals grow.

1. assessment
2. management
3. estimation
4. evaluation

TEST

3. Select facts about the historical background of aquaculture. Write the correct numbers in the blanks.

_____a. What country first practiced aquaculture?

1) India
2) Japan
3) China

_____b. About how old is the practice of aquaculture?

1) 3,000 years
2) 4,000 years
3) 5,000 years

_____c. How are the majority of food fishes obtained?

1) Fish farming
2) Capture of wild fishes
3) Sport fishing

_____d. What percent of food fishes do the world's 33 fish-farming countries produce?

1) 75%
2) 90%
3) 53%

_____e. When did commercial food-fish farming begin in the United States?

1) 1920s
2) 1930s
3) 1940s

_____f. What was the aquacultural emphasis in the U.S. before food-fish farming became the primary enterprise?

1) Mariculture of oysters
2) Fee-fishing
3) Baitfish and ornamental fish

_____g. United States' aquaculturists now provide American consumers with nearly all of what three species of fish?

1) Coho salmon, blue catfish, bait minnows
2) Rainbow trout, channel catfish, crayfish
3) Largemouth bass, sunfish, Chinese carp

TEST

_____h. What percent of the oysters Americans consume is provided by aquacultural enterprises?

1) 20
2) 30
3) 40

4. Match types of aquaculture environments with their descriptions. Write the correct numbers in the blanks.

_____a. Commercial raising of stock that thrives in often turbid freshwater with temperatures between 70°F and 90°F.

_____b. Commercial raising of stock that thrives in salt water of various temperatures.

_____c. Commercial raising of stock that thrives in cool, clear freshwater with temperatures 65°F and under.

1. Coldwater aquaculture
2. Warmwater aquaculture
3. Mariculture

5. Select facts about types of aquaculture enterprises. Write the correct numbers in the blanks.

_____a. What is the typical market for large-scale producers of food fish?

1) Processing plants
2) Haulers
3) Retail markets

_____b. Which enterprises supply the food-fish producer with stock?

1) Broodfish producers
2) Fee-fish producers
3) Fingerling or stocker producers

_____c. Do broodfish producers breed fish?

1) Yes
2) No
3) Only for hybrid production

_____d. Which of the following enterprises does NOT generally buy fingerlings?

1) Food-fish producers
2) Fee-fish producers
3) Broodfish producers

TEST

_____e. How do fingerling farmers produce their product?

1) Buy fry and raise them in rearing ponds until they reach market size
2) Buy eggs, hatch eggs, and raise fry in rearing ponds until they reach marketable size
3) Manage broodfish, hatch eggs, and care for young until they reach market size

_____f. Which of the following is the primary use for stocker fish?

1) Stocking recreational ponds
2) Stocking farm ponds
3) Stocking ponds for fast grow-out/early market size

_____g. Stocker production is the least common type of fish farming enterprises. Which other aquaculture enterprise usually includes this enterprise?

1) Fee-fish production
2) Fingerling production
3) Food-fish production

_____h. What is fee-fish production?

1) The raising of fish for stocking fee-fish lakes or farm fee-fish ponds
2) The raising of fish on a commission or fee basis for a fingerling or stocker producer
3) The raising of fish for a set fee or contract negotiated in advance of the operation

_____i. What is the most common species raised by baitfish producers?

1) Crayfish
2) Minnows
3) Goldfish

_____j. Which of the following would be the most likely species raised by an ornamental or hobby fish producer?

1) Angelfish
2) Golden shiner
3) Orangespotted sunfish

TEST

6. Select from the following list species of economic importance. Write an "X" in the blank before each species of economic importance.

_____a. Common shiner

_____b. Fathead minnow

_____c. Golden shiner

_____d. Bigmouth shiner

_____e. Goldfish

_____f. Largemouth bass

_____g. Smallmouth bass

_____h. Channel catfish

_____i. Bluegill sunfish

_____j. Rock bass

_____k. Orangespotted sunfish

_____l. Bullhead

_____m. Blue catfish

_____n. Crappie

_____o. White perch

_____p. Hybrid striped bass

_____q. Hybrid sunfish

_____r. Brown trout

_____s. Sockeye salmon

_____t. Brook trout

_____u. Atlantic salmon

_____v. Rainbow trout

_____w. Coho Salmon

_____x. Chinese carp

_____y. Silver carp

_____z. Walleye pike

_____aa. Bighead carp

_____bb. Grass carp

_____cc. Red River crayfish

_____dd. Red Swamp crayfish

_____ee. Smallmouth Buffalo

_____ff. White River crayfish

_____gg. Gizzard shad

7. Complete statements about factors to consider before starting an aquaculture enterprise. Write the correct numbers in the blanks.

_____a. The amount of start-up money needed depends on the _____.

1) size and type of proposed aquaculture operation
2) season of the year that crop will be harvested
3) cooperation of the proposed lending institution

TEST

_____b. A _____ must include money for feed, labor, stock, land, pond construction, water supply development and pumping costs, and equipment.

1) weekly audit
2) planned budget
3) credit report

_____c. Any aquaculture enterprise diverts _____ from other farming operations.

1) money and time
2) hired labor
3) equipment

_____d. The amount of labor needed varies with the _____, the production method, and the type of enterprise.

1) water quality
2) processor
3) season

_____e. In intensive production, water is routinely monitored _____.

1) once a week
2) three times a day
3) round-the-clock

_____f. The amount of land required is determined in part by the type of operation and the _____.

1) production method used
2) species cultured
3) purity of water source

_____g. Sufficient acreage must be available to _____ the fixed per-unit costs of production for such things as water wells, boats, pumps, and motors.

1) complement
2) increase
3) reduce

_____h. Water volume typically needed for pond culture is _____ gallons per minute.

1) 10 to 15
2) 15 to 25
3) 20 to 35

TEST

_____i. Raceway water supply should be capable of providing _____ changes per hour through each unit, and no less than _____ change(s) per hour through the entire system.

1) 3; 1
2) 4; 2
3) 2; 1

_____j. _____ spreads costs over several operations, increasing the efficiency of the overall farm program by avoiding duplication.

1) Staggered stock purchase
2) Shared pond use
3) Multiple equipment use

_____k. _____ affect profitability of the enterprise.

1) Legal requirements and restrictions
2) Personal preference and self-satisfaction
3) Number of producers and distance from market

8. Select facts about limiting factors in joint aquaculture/agriculture operations. Write the correct numbers in the blanks.

_____a. What are the main disadvantages of the levees and ditches needed to contain water?

1) They do not have many alternate uses and they occupy much land.
2) They erode with wind and wave action and need periodic rebuilding.
3) They provide a habitat and shelter for aquatic animals that prey on fish.

_____b. How may planting and harvesting schedules limit aquaculture/agriculture operations?

1) They must be adjusted so that both agriculture and aquaculture crops can be sown (stocked) or harvested during the optimum period.
2) There may be insufficient farm labor to sow (stock) or harvest both aquaculture and agriculture crops.
3) Custom harvesting of both aquaculture and agriculture crops cannot be accomplished simultaneously because some of the same equipment must be used.

TEST

_____c. Farmer A says that when fish and field crops are rotated, the farmer cannot plant certain crops that require pesticides that will later kill stocked fish. Farmer B says that pond and field sizes will be compromised because field sizes generally require more acres than ponds.

Who is right?

1) Farmer A
2) Farmer B
3) Both A and B

9. Complete statements about physical and fiscal risks associated with aquaculture. Write the correct numbers in the blanks.

_____a. Stock loss may occur because of _____, or pesticide contamination of a pond.

1) pond size, shallow water
2) disease, poor water quality
3) aquatic plants, benthic organisms

_____b. The amount of water available for both production purposes and for supplying emergency and supplementary needs may be undependable or _____.

1) overabundant
2) unavailable
3) limited

_____c. _____ may cause stock loss.

1) Power failure
2) Aeration
3 Pond depth

_____d. Poor quality stock may lead to disease or _____.

1) an underpriced product
2) an off-flavor product
3) an unmarketable product

_____e. The market may _____.

1) expand or grow
2) stabilize
3) fluctuate or fail

TEST

10. Complete statements about the advantages of aquaculture. Write the correct number in each blank

_____a. A start-up aquacultural enterprise can be added to an agricultural enterprise with existing pond for _____ capital investment.

1) a major
2) relatively little
3) no

_____b. The addition of an aquaculture enterprise allows for multiple use of _____.

1) land and water
2) equipment and machinery
3) both 1 and 2

_____c. Agriculture and aquaculture crops can be _____.

1) grown simultaneously
2) rotated or double cropped
3) controlled with the same pesticides

_____d. Badly _____ land or land from which the _____ has been removed can be reclaimed by farming fish.

1) polluted; clay
2) dried out; subsoil
3) eroded; topsoil

_____e. The cost of an _____ can be shared by both agriculture and aquaculture crops.

1) irrigation reservoir
2) aeration system
3) overflow pipe

_____f. Water from deep wells can usually be improved by running it through fish ponds because the temperature is raised and _____ are added.

1) bacteria
2) parasites
3) nutrients

_____g In some areas, croplands that have been leveed for crop production and fish farming can be easily flooded during the winter to _____.

1) kill crop pests
2) attract waterfowl
3) create an ice-skating rink

TEST

11. List 8 sources of information about aquaculture.

    a. ____________________

    b. ____________________

    c. ____________________

    d. ____________________

    e. ____________________

    f. ____________________

    g. ____________________

    h. ____________________

(NOTE. If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

12. Survey local aquaculture production. (Assignment Sheet #1)

13. Visit a support facility and interview the operator(s). (Assignment Sheet #2)

14. Survey local market outlets for types of fish sold. (Assignment Sheet #3)

15. Interview a local producer. (Assignment Sheet #4)

INTRODUCTION AQUACULTURE
UNIT I

ANSWERS TO TEST

1.

a.	8	g.	4	m.	18
b.	9	h.	5	n.	16
c.	10	i.	6	o.	12
d.	1	j.	7	p.	15
e.	2	k.	3	q.	7
f.	11	l.	14	r.	13

2. a. 1
   b. 4
   c. 3
   d. 1
   e. 2

3. a. 3
   b. 1
   c. 2
   d. 2
   e. 1
   f. 3
   g. 2
   h. 3

4. a. 2
   b. 3
   c. 1

5. a. 1
   b. 3
   c. 2
   d. 3
   e. 3
   f. 3
   g. 2
   h. 1
   i. 2
   j. 1

6. b, c, e, f, h, i, m, n, p, q, u, v, w, x, y, aa, bb, dd, ff

ANSWERS TO TEST

7. a. 1
   b. 2
   c. 1
   d. 3
   e. 3
   f. 1
   g. 3
   h. 2
   i. 1
   j. 3
   k. 3

8. a. 1
   b. 1
   c. 3

9. a. 2
   b. 3
   c. 1
   d. 3
   e. 3

10. a. 2
    b. 1
    c. 2
    d. 3
    e. 1
    f. 3
    g. 2

11. Answer should include any eight of the following:

    a. Reference books, trade books, educational video tapes, government and other publications
    b. Universities, colleges, and vocational programs
    c. University and public libraries with computer programs
    d. State and national fish farming associations
    e. Agricultural experiment stations
    f. Federal and state agencies
    g. Regulatory agencies
    h. Professional consultants
    i. Fish farmers
    j. Processors
    k. Feed distributors
    l. Merchandisers

12-15. Evaluated to the satisfaction of the instructor

THE AQUATIC ENVIRONMENT
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss water chemistry and the roles of aquatic plants and animals in pond ecology. The student should also be able to identify plankton and benthic organisms as sources of aquatic food available for fish. These competencies will be evidenced by completing the assignment sheets and by scoring a minimum of 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with the aquatic environment with their correct definitions.
2. List important variables affecting the ecological balance of a pond.
3. Select facts about the links in the aquatic food chain.
4. Complete statements concerning the oxygen cycle in pond ecology.
5. List factors affecting oxygen production in pond water.
6. Select facts about the effects of seasonal temperature changes on pond water.
7. Select from a list true statements about the positive roles of plankton and benthic organisms in pond ecology.
8. Select from a list true statements about the negative roles of plankton and benthic organisms in pond ecology.
9. Solve problems concerning carbon dioxide in the aquatic environment.
10. Solve problems concerning water acidity (pH) in pond ecology.
11. Select from a list true statements about water alkalinity and hardness.
12. Solve problems concerning ammonia and ammonia byproducts in pond ecology.
13. Select facts about hydrogen sulfide in the aquatic environment.

OBJECTIVE SHEET

14. Match aquatic plants with their descriptions.

15. Complete statements about sources of water pollution.

16. Collect pond plankton and examine under a microscope. (Assignment Sheet #1)

17. Observe the effects of sunlight on collected samples of pond water. (Assignment Sheet #2)

18. Seine a pond; examine findings and discuss the fish food chain. (Assignment Sheet #3)

19. Collect a pond bottom sample, examine and discuss findings. (Assignment Sheet #4)

20. Prepare a list of food sources a sample pond offers its fish populations, identify benthic organisms and other elements in the food chain. (Assignment Sheet #5)

21. Survey the aquatic plants and marginal ecology of a sample pond; discuss the ecological impact on fish populations and the aquatic environment. (Assignment Sheet #6)

THE AQUATIC ENVIRONMENT
UNIT II

SUGGESTED ACTIVITIES

A. Read unit, make your own notes, and plan your teaching strategy.

B. Invite a marine biologist to speak to the class before students complete assignment sheets.

C. Make copies of Handouts #1-#3.

D. Make and review transparencies.

E. Review the assignment sheets carefully, and make changes that reflect or emphasize local or area conditions.

F. Provide students with objective sheet. Discuss unit and specific objectives.

G. Provide students with information sheet. Discuss information sheet, adding information from your experience and resources specific to the situations of the students in your class.

H. Demonstrate to students the proper method for setting up and using a microscope.

I. Provide students with assignment sheets. Discuss assignment sheets and schedule due dates.

J. Give unit test. Critique in class.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Belusz, Larry. *Fish Farming Techniques*. Columbia, Missouri: University of Missouri, The Instructional Materials Laboratory, 1987.

B. Dupree, Harry K., and Jay V. Huner, "Pond Management" in *Third Report to the Fish Farmers. The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington, D.C.: Fish and Wildlife Service, 1984.

C. Morgan, Ann Haven. *Field Book of Ponds and Streams*. New York: G.P. Putnam's Sons, 1930.

D. Plumb, John A., ed. *Principal Diseases of Farm Raised Catfish*. Revised edition. Auburn University, Alabama: Alabama Agricultural Experiment Station, 1985.

E. Saigo, Roy H., and Barbara Woodworth Saigo. *Botany. Principles and Applications.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1983.

F. Schubert, Dr. Gottfried. *Fish Diseases. A Complete Introduction*. Neptune City, New Jersey: T.F.H. Publications, Inc., 1987.

SUGGESTED ACTIVITIES

G. *Some Parasites and Diseases of Warmwater Fishes*. Fish and Wildlife Leaflet 6, Revision of Resource Publication 127. Stuttgart, Arkansas: Fish Farming Experimental Station, U.S. Fish and Wildlife Service, April 1976.

H. *The Fish Book, NEBRASKAland Magazine*. Lincoln, Nebraska: Nebraska Game and Parks Commission, 1987.

I. *World Book Encyclopedia*. Vol. 6, "Ecology," Vol. 15, "Pond," and Vol. 21, "Water." Chicago: World Book-Childcraft International, Inc., 1981.

THE AQUATIC ENVIRONMENT
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. **Population** — Group of the same species (kind) of organism that lives in an area

B. **Community** — Group of animal and plant populations living together in the same environment

EXAMPLE: Ponds may contain populations of bass, sunfish, and catfish; populations of different plant species; and populations of crayfish, insects, and other invertebrates. All of these populations make up a community.

C. **Ecosystem** — Communities of plants and animals and their climate, soil, and water environments

D. **Organic** — Related to or derived from living organisms

E. **Microbe** — Microscopic organism

EXAMPLES: Bacteria, fungi

F. **Detritus** — Organic debris

EXAMPLES: Dead plants, uneaten feed, feces, soil particles

G. **Phytoplankton** — Microscopic aquatic plants

EXAMPLES: Blue-green algae, green algae, diatoms, phytoflagellates (chlorophyll-producing organisms with a whip-like part for movement)

H. **Zooplankton** — Microscopic aquatic animals

EXAMPLES: Water fleas, copepods, and rotifers

I. **Benthos** — Organisms living on or in the bottom sediment of a pond

EXAMPLES: Insect larvae, true worms, clams, snails, microbes

J. **Fish food chain** — Transfer of energy from one living thing to another in the form of food

INFORMATION SHEET

K. **Photosynthesis** — Process by which plants use sunlight to produce organic substances—chiefly sugars and oxygen—from carbon dioxide and water

L. **Larva** — An insect or animal that at birth or hatching is unlike its parent and must change to another form before assuming adult characteristics

M. **Nymph** — The larva of various insects, especially dragonfly and mayfly larvae

N. **Stratification** — The layering of temperature and oxygen in a pond

O. **Thermocline** — Zone separating waters of varying densities

EXAMPLE: Warm water is less dense (lighter) than cool water

P. **ppm** — Parts per million; the addition of 1 pound of a substance to 999,999 pounds of water so that the dissolved substance and the water weigh a total of 1 million pounds

II. **Variables affecting the ecological balance of a pond**

> POINT OF INTEREST: No living thing—plant or animal—lives alone; each organism depends in some way upon certain other organisms and upon inorganic elements in the environment. The ecological balance of a pond depends on a large number of variables, the dozen most important of which are listed in this objective. Water chemistry and climate are the two most important variables for aquaculturists of both pond and container cultures.

A. Water source

B. Water chemistry

C. Water depth

D. Climate

EXAMPLES: Temperatures, length of daylight, intensity of sunlight, season of year

E. Size of pond (area covered with water)

F. Age of pond

G. Geographical and topographical location of pond

H. Plankton and benthic populations

INFORMATION SHEET

I. Fish populations

J. Algae and rooted plant populations

K. Predator and competitor populations

L. Soil type and composition

III. The **aquatic food chain** (Transparencies 1 and 2)

A. **Primary producers** (phytoplankton, algae, and other aquatic plants) form the first link in an aquatic food chain; through photosynthesis, plants use sunlight to make organic molecules or food energy.

EXAMPLE: Phytoplankton

B. **Primary consumers** (zooplankton, insect larvae, fry and other small organisms) cannot produce organic molecules from inorganic ones, so obtain their energy by eating primary producers and other primary consumers.

EXAMPLE: Zooplankton feed on phytoplankton

C. **Secondary consumers** (medium-sized fish, crayfish, reptiles, other vertebrates) eat the primary consumers.

EXAMPLE: Crayfish eat zooplankton

D. **Tertiary consumers** (larger fish, a bird, raccoon, man) may then eat the secondary consumer, and so the chain grows until the last consumer in the chain dies.

EXAMPLE: A bass eats the crayfish and later dies.

E **Decomposers** (microbes and benthic organisms) convert animal wastes and dead animals and plants into chemical substances that primary producers use to produce food, thus joining the first and last links in the food chain.

EXAMPLE: Microbes and other decomposers break down the dead bass and produce nutrients which the primary producer—phytoplankton—needs to produce food.

INFORMATION SHEET

IV. **Natural oxygen cycle in pond ecology**

A. Fish need oxygen to live, they take dissolved oxygen (DO) from the water and give off carbon dioxide as a waste product of respiration. (See Table 1 below.)

TABLE 1
Effects of DO on Fish

Dissolved Oxygen, ppm	
0	
	Small fish survive short exposure.
0.3	
	Lethal if exposure prolonged.
1.0	
2.0	
3.0	Fish survive, but growth is slow and disease outbreaks are likely with prolonged exposure.
4.0	
5.0	Desirable range

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B. While pond water absorbs some oxygen directly from the air, the major source of DO in fish culture ponds is from photosynthesis by aquatic plants—primarily phytoplankton. (See Table 2.)

(NOTE: The fast flowing water in raceway cultures is aerated as it flows and drops from one raceway unit to another. The amount of oxygen diffused and absorbed from the overlying air into an undisturbed pond is not significant, but wind and wave action increase aeration.)

INFORMATION SHEET

TABLE 2
Sources and ranges of DO gains and losses in ponds

Source	Range (ppm)
Gains	
Photosynthesis by phytoplankton	5-20
Diffusion	1-5
Losses	
Plankton respiration	5-15
Fish respiration	2-6
Respiration by organisms in the mud	1-3
Diffusion	1-5

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C. During daylight, phytoplankton take carbon dioxide gas from the water and produce oxygen; oxygen is also required for respiration.

D. When sunlight is not available for photosynthesis, no oxygen is produced, and carbon dioxide accumulates in the pond water through the respiratory process.

E. Therefore, at night and when it is overcast and dark, both fish and plants compete for the DO in the water.

V. **Factors affecting oxygen production in pond water**

A. Number of aquatic plants and phytoplankton in pond

B. Number, size, and species of fish (and other aquatic animals) in pond

C. Number of hours of daylight

D. Intensity of sunlight

(NOTE: Oxygen production begins slowly at sunrise, increases as the day progresses, peaks in mid-afternoon decreases with the lowering intensity of sunlight, and falls to zero at darkness.)

E. Water temperature

(NOTE: The higher the water temperature, the lower the amount of DO water can hold. See Table 3.)

INFORMATION SHEET

TABLE 3
Approximate Oxygen Solubility in Pure Water at Different Temperatures and 1 Atmosphere Pressure

Degrees F	Parts per Million (ppm)	Degrees F	Parts per Million (ppm)
32	14.1	64	9.2
40	12.5	70	8.6
46	11.5	76	8.2
52	10.5	82	7.7
58	9.8	88	7.4

F. Altitude and wind

G. Water depth

(NOTE: Oxygen production decreases with increasing water depth because the intensity of sunlight decreases as it passes downward through the water.)

H. Water clarity

(NOTE: Suspended microscopic plants and animals, silt, stains, detergent foams, dense mats of floating algae, and debris all reduce light penetration and thus oxygen production.)

I. Water source

(NOTE: Well water and spring water may be lacking in DO.)

J. Amount of detritus in pond

(NOTE. Excessive accumulations of organic matter in ponds—usually due to heavy feeding—deplete pond DO because oxygen in the sediment is used up in decomposition.)

INFORMATION SHEET

VI. Seasonal temperature changes and pond water

POINT OF INTEREST. The seasons of the year trigger a cycle of changes in water mostly brought about by changes in temperature that cause a layering effect and affect DO distribution in a pond. This cycle is caused because as water becomes cooler, it becomes denser [heavier] until it reaches greatest density at 39°F, but as it cools still further, it becomes less dense. If this unique characteristic of water were not true, ponds would begin freezing at the bottom.

A. Winter

1. The pond is frozen over, and water temperature just below the ice is 32°F.
2. Beneath the ice, dead plants and animals continue to decay, the process gradually removes oxygen from the water and increases other gases such as carbon dioxide, methane, and hydrogen sulfide.
3. If the pond surface is frozen for an extended period, the fish may die in what is commonly called *winterkill.*

B. Spring

1. As temperatures increase, the ice melts, and the pond water begins to warm.
2. As it warms from 32°F, it becomes denser (heavier) and begins to sink, setting up currents that cause the highly oxygenated surface water to mix with the stagnant waters below.
3. When the upper water reaches 39°F, the pond is uniform in temperature from top to bottom.
4. Spring winds create waves that mix the pond and oxygenate it from top to bottom while at the same time releasing harmful gases into the air; this process is called *spring overturn.*

C. Summer

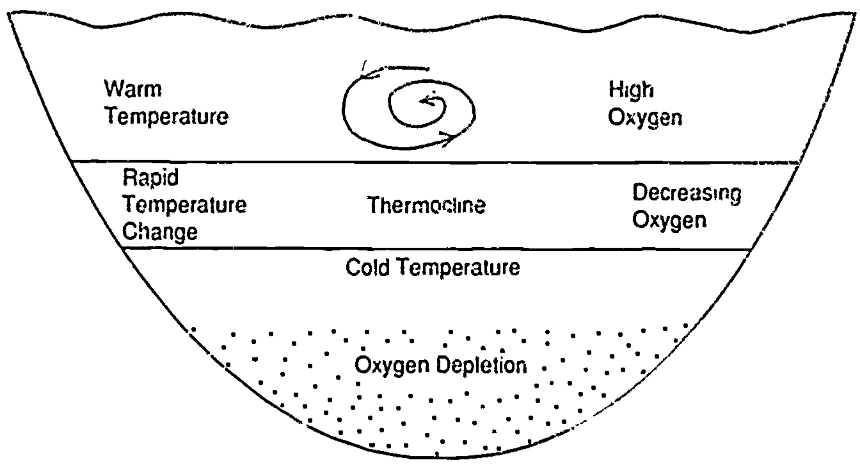
1. The surface water becomes warmer and lighter, making it harder to mix with the cooler, heavier water below.
2. Thermal stratification takes place: Warm surface water lies on top of the cooler, deeper water, preventing the mixing of upper and lower waters.

INFORMATION SHEET

3. Early in this process, lower depths have adequate DO, but as dead plants and animals sink to the bottom, oxygen is used in decomposition, and with no oxygen-rich surface waters to replenish the supply, an area of very low or no oxygen develops. (See Figure 1 below.)

(NOTE: Depending on the pond, the depth at which low oxygen develops can range from just a few to several feet deep, but the layering of temperature and oxygen is usually more pronounced in deep ponds.)

FIGURE 1



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D. Fall

1. Cooler weather causes surface waters to cool and become heavier; the cool water sinks, and the process of mixing starts over again.

2. By late fall the temperature reaches 39°F again from top to bottom, and the pond experiences the second overturn of the year, the *fall turnover*; thus the pond enters winter with a good supply of oxygen at all depths.

INFORMATION SHEET

VII. Positive roles of plankton and benthic organisms in pond ecology

A. Phytoplankton

1. Produce oxygen for fish and other organisms;

2. Serve as main source of food for zooplankton and some fish;

3. Produce blooms that help shade out unwanted rooted aquatic plants.

B. Zooplankton

1. Are a vital food source for fry of all species of fish;

2. Feed on phytoplankton and help keep it in balance.

C. Benthos

1. Convert dead plant and animal matter into inorganic nutrients recycled by plants into forms suitable for animals;

2. Supply food and essential vitamins and trace elements to fish;

3. Help control accumulations of organic matter in pond bottoms by converting to safe forms.

   (NOTE: If not converted to safe forms, organic matter decomposes and releases into the pond ammonia, carbon dioxide, hydrogen sulfide, soluble ferrous iron, and other compounds that in high concentrations may kill fish.)

VIII. Negative roles of plankton and benthic organisms in pond ecology

A. Plankton (phytoplankton and zooplankton)

1. May make the water so turbid that the sun cannot penetrate and DO cannot be produced;

2. May produce an off-flavor;

3. Compete with fish at night for available DO;

4. May die in numbers too great for conversion by decomposers and thus release noxious compounds into the water, cause high pH and low DO;

5. May be parasitic or disease causing;

6. May prey on eggs and fry.

INFORMATION SHEET

B. Benthic organisms

1. Compete with fish for food, DO, and space;

2. May serve as intermediate hosts for disease organisms;

3. May prey on eggs and fry;

   EXAMPLES: Snails and crayfish

4. May injure fish, leaving them susceptible to infections.

   EXAMPLES: Leeches attached to fish; crayfish injuring fish with their claws

IX. Carbon dioxide in the aquatic environment

A Besides being a waste product of respiration by plants and animals, carbon dioxide can be found naturally in all water.

(NOTE: Spring and well water usually have high levels of carbon dioxide, but may not contain oxygen.)

B Carbon dioxide reduces the ability of fish to extract oxygen from the water.

C Decomposition raises carbon dioxide levels, and photosynthesis lowers carbon dioxide levels; therefore, carbon dioxide levels rise and fall on a daily basis in relation to the amount of photosynthesis taking place.

(NOTE: A severe problem can occur after a die-off of phytoplankton because little photosynthesis takes place and carbon dioxide levels rise.)

D. Normal safe levels of carbon dioxide are in the range of 5 to 10 ppm in surface waters.

E. Fish can tolerate carbon dioxide levels as high as 20 ppm as long as DO levels remain high.

X. Water acidity (pH)

A. Water can act either as an acidic or basic solution depending on its pH.

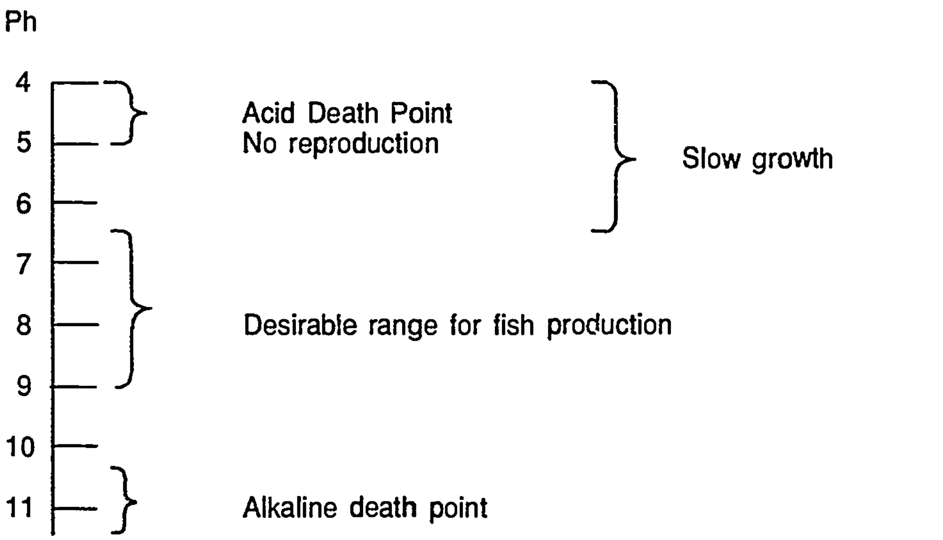
B. The pH scale ranges from 0 to 14, with pH 7 being neutral; therefore, water with a pH value less than 7 is acidic while water with a pH value above 7 is basic.

C. The acid and basic death points for fish are about 4 and 11 respectively. (See Table 4.)

INFORMATION SHEET

(NOTE: During afternoon hours, ponds with heavy algal blooms can reach pH levels above 11 for short periods of time without negative effects on fish.)

TABLE 4
Effects of pH on Fish

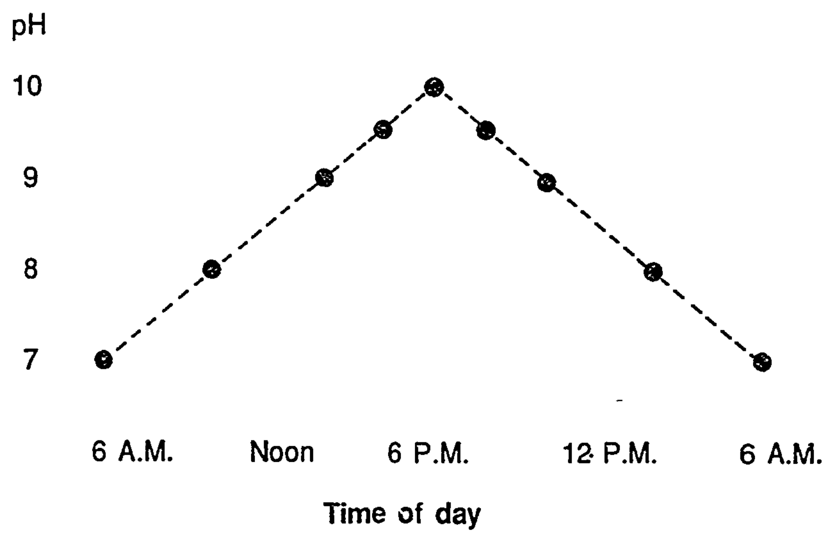


C. Water pH is influenced by the amount of carbon dioxide (an acidic substance) in solution.

D. Phytoplankton and rooted aquatic plants remove carbon dioxide during photosynthesis; thus, pH rises during the day (water becomes more basic) and falls at night (water becomes more acid) when the photosynthesis process is reversed. (See Table 5.)

INFORMATION SHEET

TABLE 5
Daily Rise and Fall of Pond pH



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XI. Water alkalinity and hardness

A. Alkalinity

1. Alkalinity is a measure of calcium carbonate and bicarbonate ions (both bases) in water to provide an idea of the resistance of that water to changes in pH.

2. Water with high alkalinity acts as buffer to changes in pH.

3. Water with high alkalinity has higher early morning pH levels because carbonate and bicarbonate ions buffer the effect of carbon dioxide (an acid) production by phytoplankton during the night.

B. Hardness

1. Hardness is a measure of the concentration of calcium and magnesium in water.

INFORMATION SHEET

2. Because the same rocks that produce carbonate and bicarbonate also provide calcium and magnesium, the values for alkalinity and hardness are often expressed as calcium carbonate equivalents.

3. As a rule, the best water for fish production has nearly equal values of total hardness and total alkalinity.

4. Fish grow reasonably well over a wide range of alkalinities and hardnesses, but values of 50-300 ppm are optimum.

XII. **Ammonia and ammonia byproducts in the aquatic environment** (Transparency #3)

A. Ammonia is present in water as a byproduct of fish metabolism and the breakdown of organic matter by bacteria.

B. Ammonia nitrogen occurs in water as ionized (NH_4) and un-ionized (NH_3); only NH_3 is toxic to fish.

C. Levels of NH_3 increase with increased temperature and pH; NH_3 becomes toxic at levels as low as 0.6 ppm.

D. Sublethal levels of NH_3 as low as 0.1 ppm reduce fish growth and cause gill damage in fishes.

E. Nitrite (NO_2) is a breakdown product of ammonia produced through oxidation by *Nitrosomonas* bacteria.

F. High levels of nitrite in fish blood hemoglobin reduce the ability of blood to carry oxygen and cause it to turn brown, signaling "brown blood" disease.

G. With brown blood disease, fish suffocate even when DO levels are considered safe.

(NOTE: Nitrite levels as low as 1.5 ppm have been found to be toxic under certain salinity. In pond cultures, the application of common salt (chloride) is effective in reversing the effects of nitrite toxicity.)

H. Nitrate (NO_3) is formed as a further breakdown product of ammonia by *Nitrobacter* bacteria.

I. Nitrate is the least toxic of the nitrogen compounds, fish can tolerate levels in excess of 500 ppm.

(NOTE. Nitrate is not usually a problem in normal pond ecology or commercial culture situations.)

INFORMATION SHEET

XIII. Hydrogen sulfide in the aquatic environment

A. Hydrogen sulfide accumulations can be toxic to fish.

B. Hydrogen sulfide accumulates in oxygen-deficient bottom sediments.

C. Accumulations of hydrogen sulfide can be identified by the presence of black sediments with a rotten-egg smell.

D. Concentrations are highest in summer and lowest in winter.

E. The application of lime may reduce the toxicity of hydrogen sulfide by raising the pH level.

F. Potassium permanganate can also be applied to a pond during harvesting to oxidize the hydrogen sulfide in the water.

XIV. Aquatic plants and their descriptions

> POINT OF INTEREST: There are many types of aquatic plants, but generally they can be divided into two distinct groups. algae and macrophytes. Algae are primitive plants without true roots, stems, or leaves. Macrophytes are vascular plants with true roots, stems, and leaves. Plants are further classified as free-floating, submergent, emergent, and marginal. All aquatic plants compete with fish for oxygen at night, and in excessive numbers may interfere with harvesting and draining of stocked ponds.

A. Planktonic algae

1. Are microscopic and are either single-celled or composed of branched or unbranched cell chains.

2. Are rootless forms of plant life that grow between the pond bottom and surface.

3. Are the chief producers of DO.

4. Are the "bloom" algae that may cause fish kills and off-flavor problems (blue-green algae) in stocked ponds.

B. Filamentous algae

1. Are visible to the naked eye as floating mats or hairlike strands attached to underwater objects.

2. Are primitive plants without roots, stems, or leaves, and are often called *moss* or *pond scum*.

INFORMATION SHEET

3. May completely cover a pond, preventing sunlight penetration and reducing photosynthesis by phytoplankton.

C. Macrophytic algae

EXAMPLE: Chara or muskgrass, a coarse plant with a strong musky odor often found encrusted with lime

1. Are large, branched plants attached to the pond bottom.
2. Are often confused with higher plants, which they resemble, but proper identification is necessary so that the correct chemical can be selected for control.

D. Free-floating macrophytes

EXAMPLES: Duckweed, watermeal

1. Are tiny green plants that float on the surface and superficially resemble algae, but have small leaves and roots that hang down into the water.
2. Often indicate water high in phosphorous, which in turn indicates ponds whose DO levels may vary widely.
3. Can cover a pond surface and thus prohibit sunlight penetration and reduce DO production.

E. Emergent macrophytes

EXAMPLES: Floating-leaf: Waterlilies, cowlilies
Above surface: Lotus, alligator weed

1. Are rooted in the pond bottom but have leaves that float on or extend above the water surface.
2. Some, like waterlilies, can grow in water 10 feet deep or more, and their leaves can completely cover a pond, thus prohibiting photosynthesis and DO production by phytoplankton.
3. Use nutrients from the soil and water that could be used by phytoplankton.

F. Submergent macrophytes

EXAMPLES: Hornwort, milfoil, coontail, najas, pondweed

1. Are rooted in the bottom and grow completely underwater, though some produce seed-heads that can be seen at the surface.

INFORMATION SHEET

2. Grow in dense underwater patches and can grow in water 5 feet deep or more.

3. Limit access of fish to food organisms produced on and in the pond bottom.

G. Marginal macrophytes

EXAMPLES: Cattails. flatsedges, bulrushes, waterprimrose, smartweed

1. Grow in very shallow water or wet soil along the edge of the pond.

2. Provide shelter for predators such as birds, snakes, frogs, turtles, and burrowing aquatic animals such as beaver and muskrats.

3. Can cause harvesting and pond management problems for the aquaculturist.

   EXAMPLE: Due to its dense surface growth that extends into the pond from the shoreline, waterprimrose can seriously affect pond management practices and hamper harvesting activities.

XV. Sources of water pollution

A. Industrial wastes

POINT OF INTEREST: In the United States, industries discharge three or four times as many pollutants into water as do all sewage systems in the country.

1. Industrial pollutants are high in chemicals and many are discharged directly into water systems.

2. Some industrial pollutants enter rivers, lakes and ponds in the form of *acid rain.*

   (NOTE: Acid rain is a pollutant formed when moisture in the air reacts with the nitrogen oxide and sulfur dioxide released by factories and power plants that burn coal or oil. This reaction produces nitric acid and sulfuric acids that fall to earth with rain and snow.)

3. Thermal pollution occurs when industries discharge heated water into lakes and streams.

B. Sewage

1. Nearly three-quarters of the sewage in the United States—human wastes, garbage, and water that has been used for bathing and laundering—is treated to turn it into less polluting substances; treatment plants discharge these substances directly into lakes or rivers or dispose of them on land.

INFORMATION SHEET

2. Of the remaining amount, about one-eighth is treated in septic tanks and disposed of on land.

3. The remaining one-eighth of sewage in the United States is disposed of untreated into waterways.

C. Agricultural chemicals and wastes:

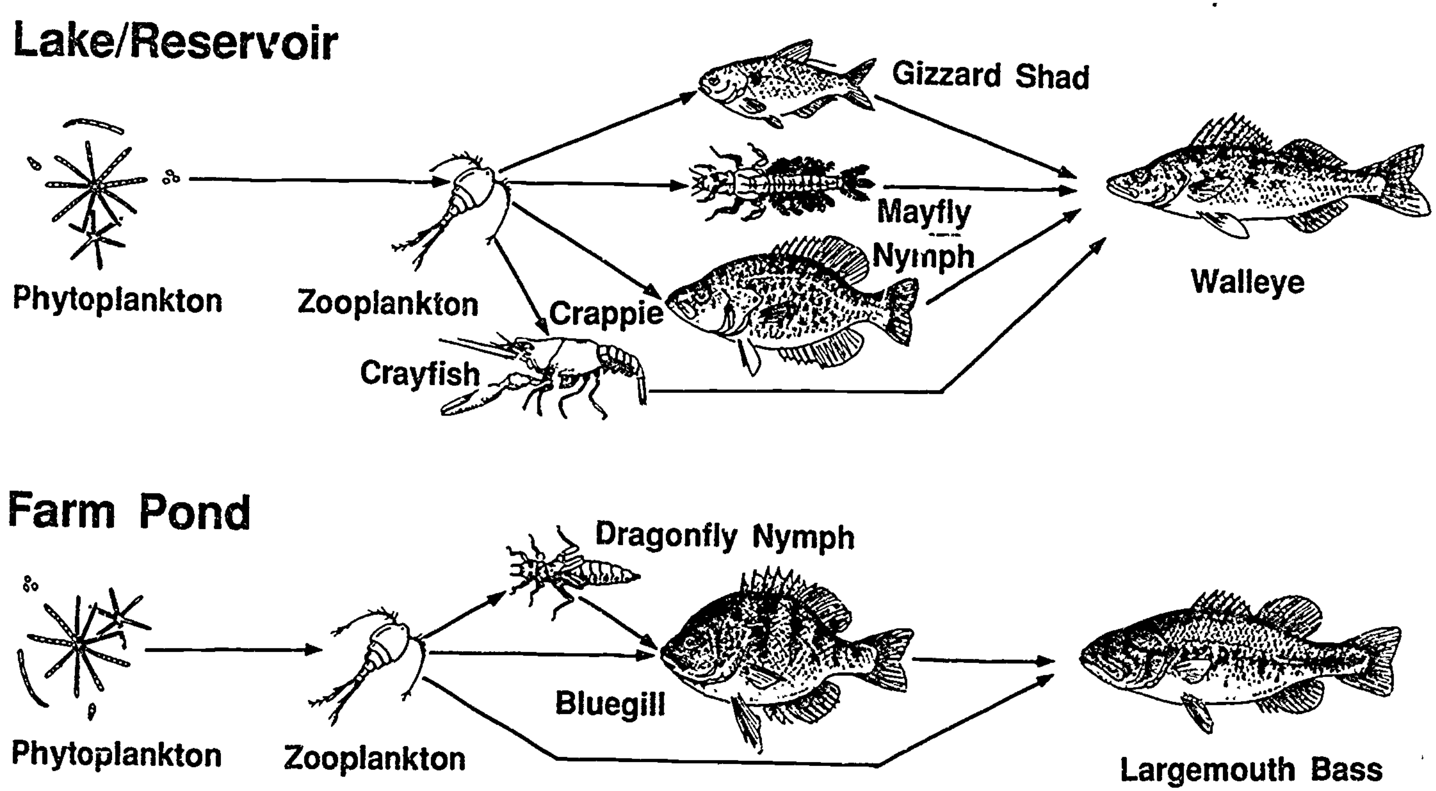
POINT OF INTEREST: Agricultural soil erosion [including soil, chemical herbicides, pesticides, and fertilizers] is the single greatest cause of water pollution in two-thirds of the river basins in the United States.

1. Rainwater flowing from farmland into ponds and streams carries chemical fertilizers and pesticides that have been put into the soil.

2. Wind carries sprayed pesticides and chemicals into ponds and waterways.

3. Cattle, hogs, sheep, and chickens raised on feedlots do not distribute their wastes over widespread pastureland; instead most of their wastes go into nearby streams and ponds during high runoff.

Aquatic Food Chain



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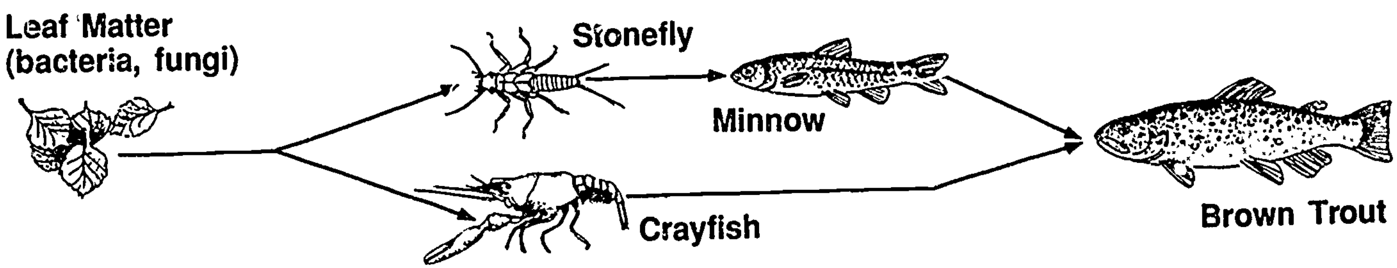
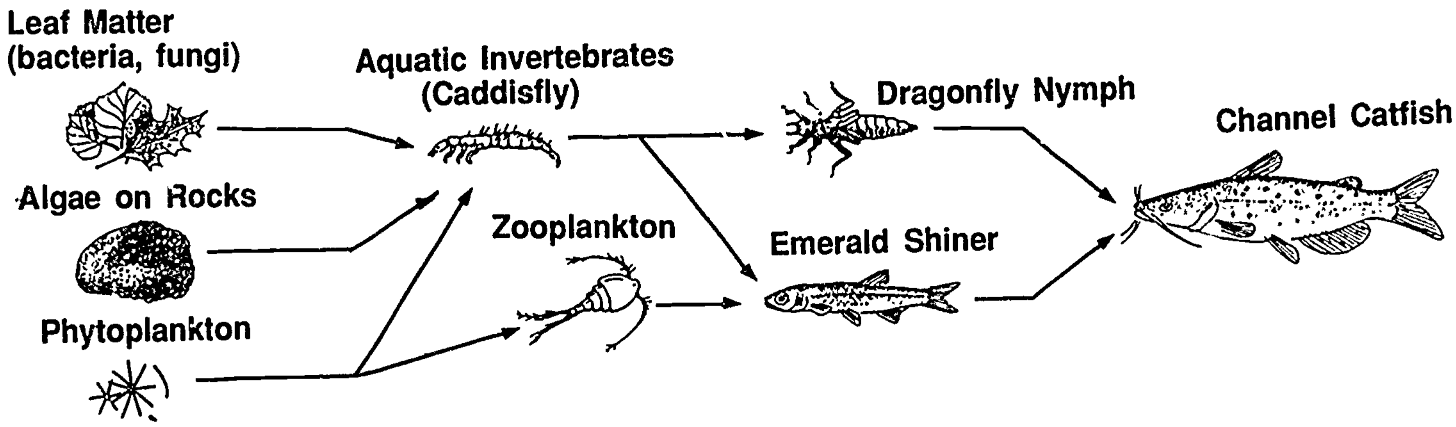
Aquatic Food Chain

Cold-Water Stream



Warm-Water Stream/River



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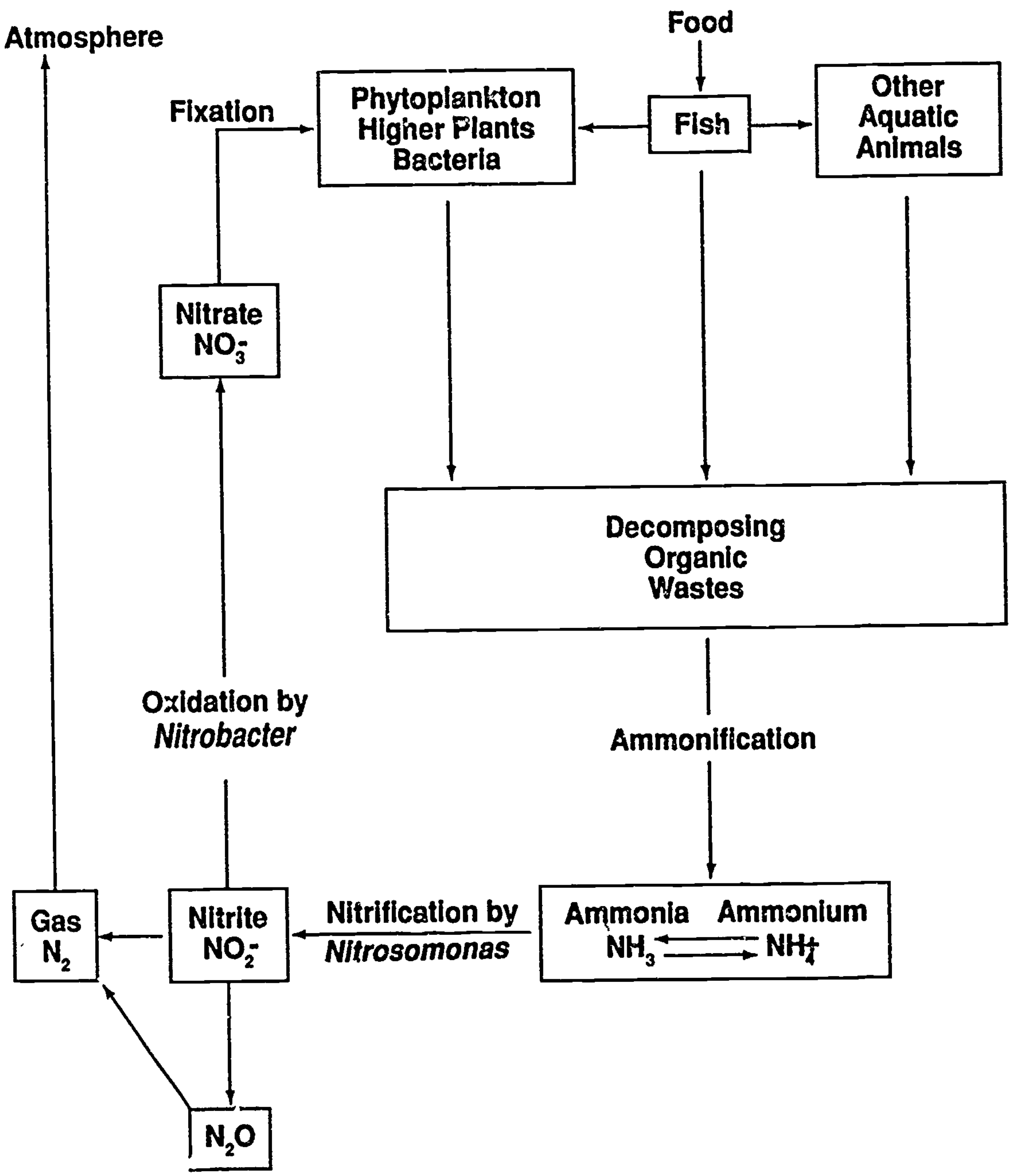
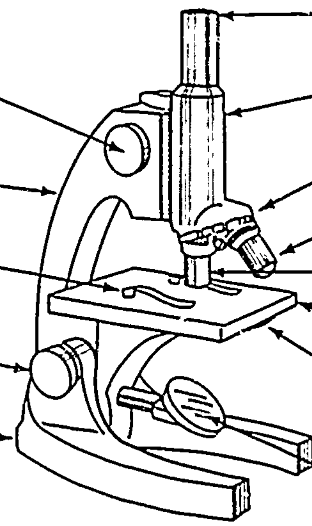
AQ-63

Nitrogen Cycle



THE AQUATIC ENVIRONMENT
UNIT II

HANDOUT #1 — HOW TO USE A COMPOUND MICROSCOPE



A. Set up microscope in best possible light, clean lenses and mirror with lens paper, and turn on lamp.

B. Prepare slide and insert under clips, centering field to be magnified over hole in stage.

(NOTE: Hold slide by its edges so as not to smear with fingers.)

C. Focus the low-power (LP) objective.

1. Turn nosepiece until LP objective (the shorter of the objectives) clicks into place over hole in stage.

2. Open diaphragm to its maximum circumference.

3. Turn mirror so that its flat side faces the underside of the stage.

4. Place one eye over ocular, taking care not to touch the eyepiece with your eyelashes.

(NOTE: Always keep both eyes open while using the microscope.)

5. While looking into the ocular, move the lamp and mirror to obtain the best possible white light.

6. With your eyes level with the stage, turn the coarse adjustment knob (the larger knob) until the objective is 1/4 inch from the slide

HANDOUT #1

7. Return your eye to the ocular, and slowly raise the objective by turning the coarse adjustment toward you.

   (NOTE: Never turn the coarse adjustment away from you to focus down on the slide. The objective can smash the slide.)

8. If you cannot locate the object, repeat Steps 6 and 7.

9. Once you have the object in focus, turn the fine adjustment knob (the smaller knob) *very slowly* to sharpen the field.

D. Focus the high-power (HP) objective.

(NOTE: Always focus under low power first. Never focus with the coarse adjustment under HP. Use the fine adjustment only.)

1. Turn nosepiece until HP objective clicks into place over hole in stage.

2. With your eye at the ocular, turn the fine adjustment *very slowly* until the image is clear.

3. If you have trouble finding the object, start all over again by following all steps in LP focusing and then switching to HP.

E. Focus for depth of object.

1. Very gently turn the fine adjustment knob and observe the barrel movement.

2. Notice the small scale of lines near the fine adjustment knob.

3. Focus on the top of the object, and then observe the scale lines; record.

   Top-of-object scale lines: ______________________

4. Focus on the bottom of the object, and then observe the scale lines; record.

   Bottom-of-object scale lines: ______________________

5. Read barrel markings to learn the distance between each scale line.

6. Multiply this number times the distance you moved the fine adjustment knob (difference between Steps 3 and 4) to find the thickness of the specimen.

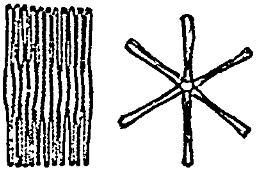
7. Multiply your answer by 1000 to convert milliliters to microns.

THE AQUATIC ENVIRONMENT
UNIT II

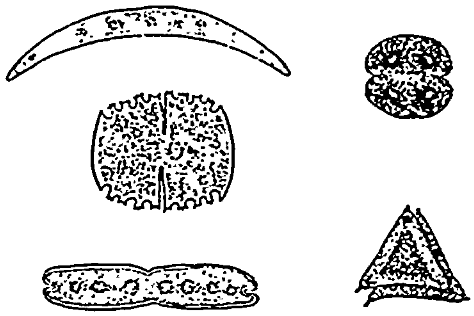
HANDOUT #2 — COMMON POND PLANKTON AND INSECT LIFE

MICROSCOPIC ALGAE

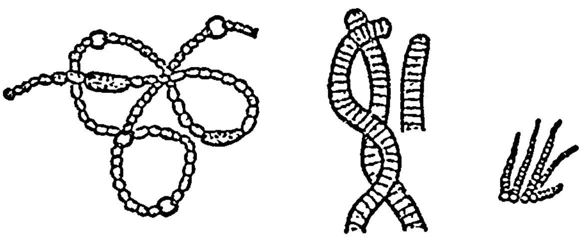
Diatoms (microscopic golden brown algae)



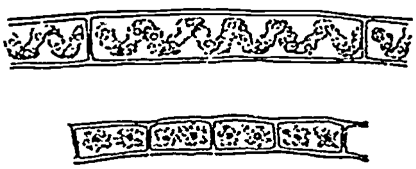
Desmoids (look like diatoms but are bright green)



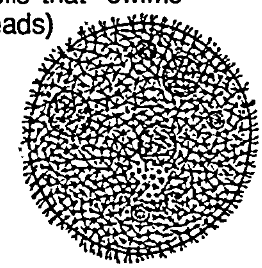
Blue-green algae



Filamentous green algae



Volvox (a sphere of hundreds of green algae cells that "swims" by lashing threads)



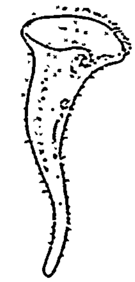
Euglena (animal-like, small green algae with a whip-like part for movement)

HANDOUT #2

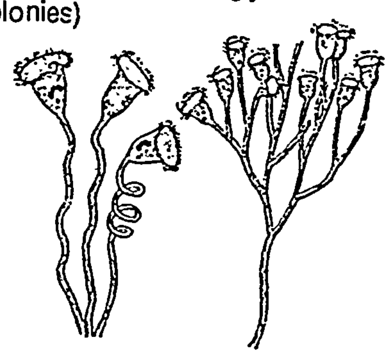
PROTOZOA (single-celled zooplankton)

Paramecium (can be seen with the naked eye as white, rapidly moving speck)

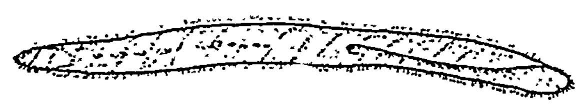
Stentor (transparent, blue-green or whitish, trumpet-shaped)



Bell animals (can be seen with the hand lens, either singly or in colonies)

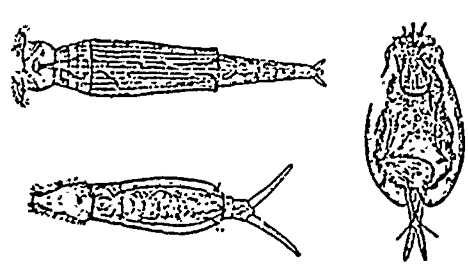


Spirostomum

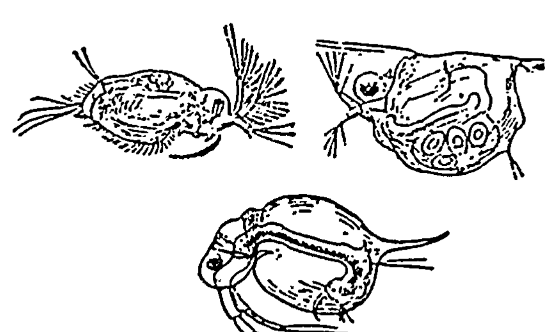


METAZOA (many-celled zooplankton)

Rotifers (an abundant and important member of the food chain)

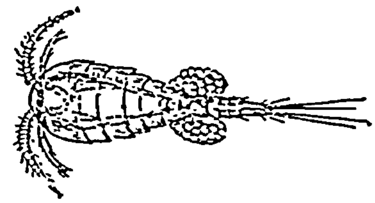


Water fleas (minute 10-legged crustaceans—members of the same family as crayfish)



HANDOUT #2

Cyclops (a copepod)

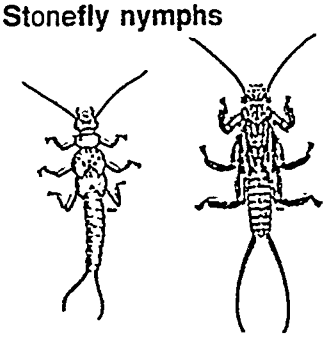


Fairy shrimp (1" long back-swimmers, transparent)

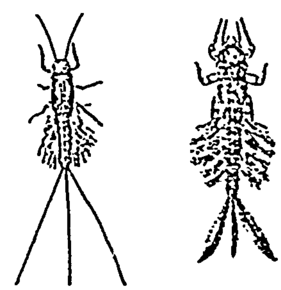
Nematodes (microscopic to 1/2" worms)

INSECTS AND WORMS

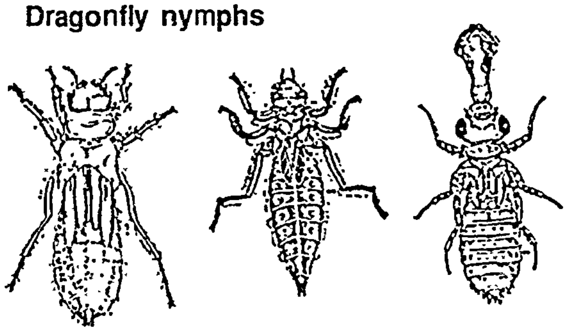
Stonefly nymphs



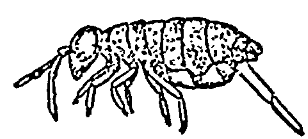
Mayfly nymphs



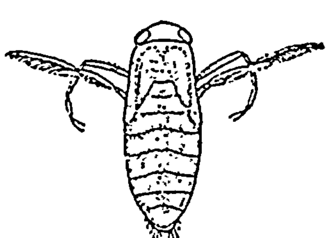
Dragonfly nymphs



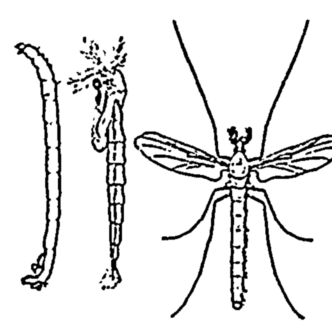
Water springtail



Waterboatman

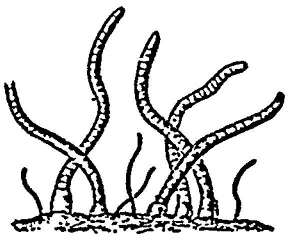


Midge (larva, pupa, adult)

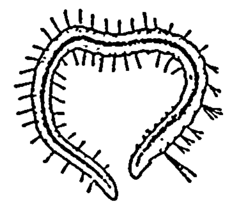


HANDOUT #2

Tubifex worms

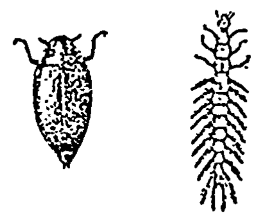


Bristleworm

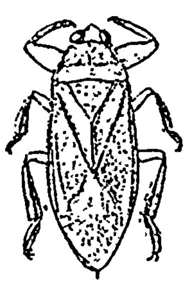


Leech

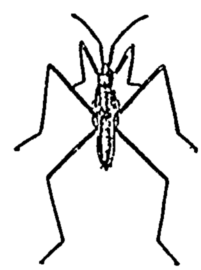
Whirligig beetle larva



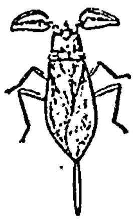
Giant waterbug



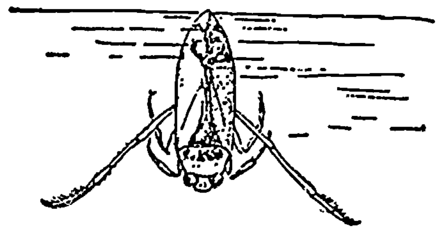
Water strider



Water scorpion (nonpoisonous to humans)



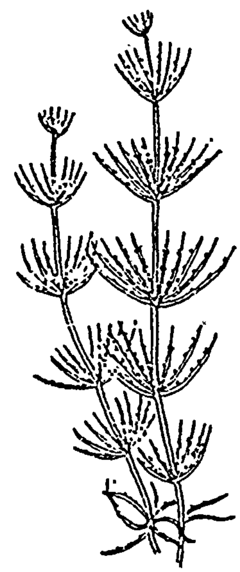
Backswimmer



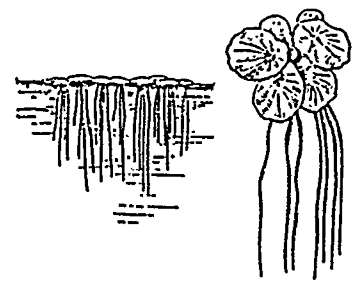
THE AQUATIC ENVIRONMENT
UNIT II

HANDOUT #3 — COMMON AQUATIC PLANTS

Chara (muskgrass)

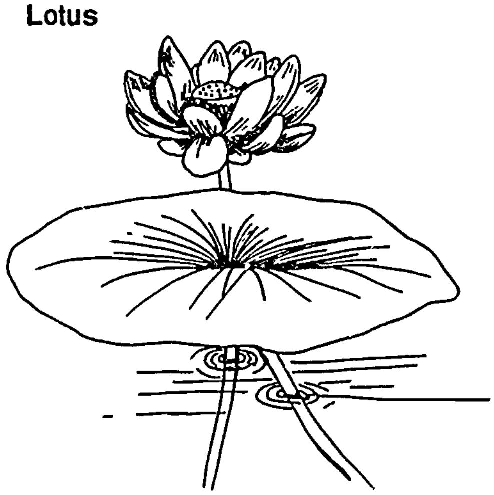


Duckweed

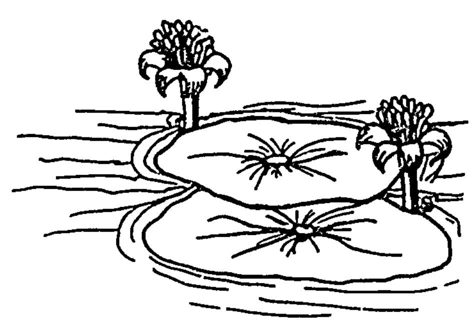


Waterlily

Lotus

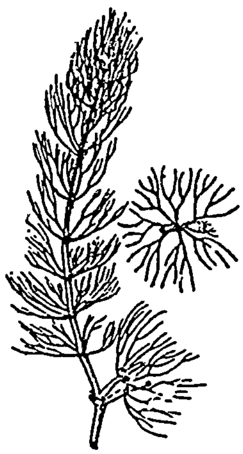


Watershield

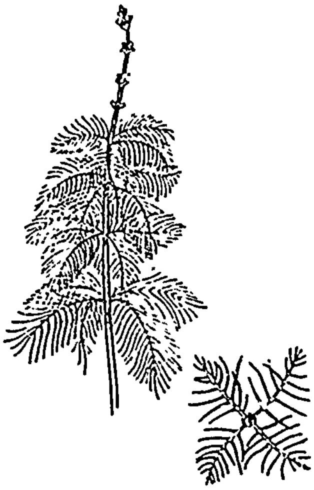


HANDOUT #3

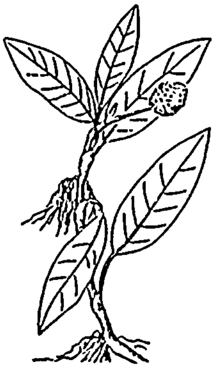
Hornwort



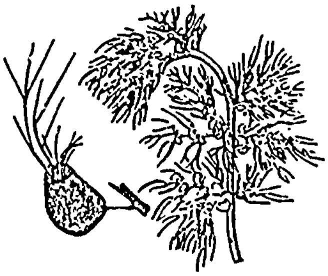
Milfoil



Water smartweed

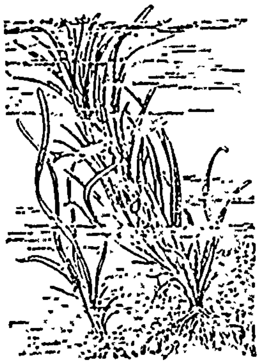


Bladderwort



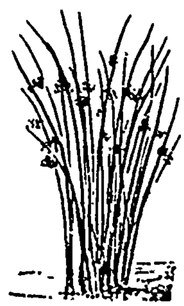
Cattail

Eelgrass



HANDOUT #3

Bulrush



Pondweed

THE AQUATIC ENVIRONMENT
UNIT II

ASSIGNMENT SHEET #1 — COLLECT POND PLANKTON AND EXAMINE UNDER A MICROSCOPE

This assignment sheet is designed to familiarize you with planktonic members of the food chain found in the water of earthen ponds. You will need to go into the field to collect specimens from an established pond, and then examine and discuss your findings in the classroom.

1. Gather the following equipment and materials

   a. Plankton net or nylon stocking

   b. Microscope, slides, and cover slips

   c. Methyl cellulose to retard plankton movement

      (NOTE: Zooplankton and some phytoplankton, such as the euglenas, can move so fast that they disappear from the viewing field if not placed in viscous [thick] methyl cellulose.)

   d. Eyedropper or pipette

   e. Clean 1-quart glass jar with screw-on lid

   f. Handout #2 to help you identify plankton

      (NOTE: If you do not know how to use a microscope, follow the instructions in Handout #1.)

   g. Magnifying glass

2. Collect a water sample from an established, stocked pond.

   a. Fill the clean glass jar with culture pond water.

   b. Pass plankton net or nylon stocking through water in pond several times.

   c. Release plankton from net into water in jar by inverting net and dipping up and down in jar.

3. Hold jar up to light and observe the larger protozoans and tiny multicellular organisms in your sample by staring intently into the water in the jar, you may also want to observe the organisms with a magnifying glass held to the side of the specimen container.

4. Return to the classroom and prepare slides.

   (NOTE. For best results, examine the pond water immediately or at most within an hour after collecting the sample.)

ASSIGNMENT SHEET #1

a. Using eyedropper or pipette, place a small drop of pond water on a slide.

b. Add a drop of methyl cellulose to the water drop to increase viscosity and slow plankton movement so that the organisms will stay within the field of the microscope.

c. Place cover slip over water drop.

5. Examine your prepared slides under the microscope at different levels of magnification.

6. Describe your findings, using Handout #2 as necessary to identify some basic types of plankton; try to distinguish between phytoplankton and zooplankton.

   (NOTE: Phytoplankton contain chlorophyll, a green substance.)

7. Sketch below some of the plankton observed.

THE AQUATIC ENVIRONMENT
UNIT II

ASSIGNMENT SHEET #2 — OBSERVE THE EFFECTS OF SUNLIGHT ON COLLECTED SAMPLES OF POND WATER

In this assignment sheet you wil' conduct an experiment to determine the effects of sunlight on the plankton populations in pond water. You will need to go into the field to collect water samples, and then you will conduct your experiment and evaluate your findings in the classroom. This activity will be accomplished over a period of three days.

1. Gather the following equipment and materials.

   a. Two one-quart glass specimen jars

   b. Microscope, slides, and slide covers

   c. Eyedropper or pipette

   d. Magnifying glass

2. Early in the morning on a sunny day, collect two samples of water from a stocked, aged pond that is in algal bloom.

   a. Submerge each jar about 1 foot.

   b. Invert the jars to release trapped air.

   c. Allow the jars to fill the water, and lift from pond, but do not place lids on the jars.

3. Place one specimen jar in a dark cupboard or closet for 36 hours.

4. Observe the color of the water in the second specimen jar (the one gathered from sunlit water), and record on the next page.

5. Smell the water in the second specimen jar, and record the odor on the next page.

6. Stare intently into the water and observe the density of the larger organisms present, you may want to use a magnifying glass to aid your observation.

7. Make slides of the water collected in the second specimen jar. Follow the procedure outlined in Assignment Sheet #1, but do not add methyl cellulose to alter the movement of the plankton.

ASSIGNMENT SHEET #2

8. Examine your slides under a microscope, and record your observations below.

WATER SAMPLE KEPT IN SUNLIGHT

Water color: ____

Water odor: ____

Approximate plankton density: _____ Dense _____ Moderate _____ Light

Plankton activity: _____ Rapid _____ Moderate _____ Slow _____ None

9. After 3 days, repeat the procedure in steps 1 through 6 on water from the specimen jar placed in the dark.

WATER SAMPLE KEPT IN DARK

Water color: ____

Water odor: ____

Approximate plankton density: _____ Dense _____ Moderate _____ Light

Plankton activity: _____ Rapid _____ Moderate _____ Slow _____ None

10. Compare the data obtained from both observations.

    a. Were there differences in water color? ____________ If yes, what conclusions can you draw about the cause of the color change?

    ____

    ____

    b. Were there differences in water odor? ____________________________

    ____

    ____

    If yes, what conclusions can you draw as to the cause of the odor change?

    ____

    ____

ASSIGNMENT SHEET #2

c. Which sample had the densest plankton populations? Why? ____________

____

____

d. In which sample were the plankton most active? Why? ____________

____

11. What conclusions can you draw about the effects of sunlight on the plankton in a water sample?

____

____

____

THE AQUATIC ENVIRONMENT
UNIT II

ASSIGNMENT SHEET #3 — SEINE A POND; EXAMINE FINDINGS, AND DISCUSS THE FISH FOOD CHAIN

In this assignment sheet, you will collect and classify mid-water members of the food chain found in an established pond. You will find it convenient to work with a partner to complete the assignment. After working together to seine a sample, one of you can classify and the other can record specimen types and numbers. After classifying your specimens, you will return to the classroom to evaluate your findings in terms of the food chain.

1. Gather the following equipment and materials.

   a. 10-foot minnow seine

   b. Handout #2

   c. Specimen containers

2. Work with your partner to seine an area of the same stocked pond observed in Assignment Sheets #1 and #2.

   (NOTE: Check to make sure that hand-seining is legal in the sample pond.)

3. Classify any fish caught as to species, size, and number; record below.

Species	Approx. Size (inches)	Number

4. Wet your hands and release any seined fish.

5. Record immediately on the chart on the next page any specimen, such as a frog or turtle, that cannot be confined in a specimen jar.

6. Sort the remaining contents of the seine into specimen jars; put plant specimens in one jar, larvae in another, insects such as water boatmen in another, snails in another, an so on.

7. Repeat the seining/sorting process at three or four places in the pond.

ASSIGNMENT SHEET #3

8. Record on the chart below the number and species in each of your specimen jars.

Specimen Type	Number

9. Release your specimens into the pond.

10 Return to the classroom and evaluate your findings in terms of the fish food chain:

a. How many types of food did you collect from the water of this pond?

b. Which food collected was most abundant?

c. What competitor specimens did you collect? (Those that would compete with the pond's fish population for food.)

d. What predator specimens did you collect?

e. Does the number of plant specimens collected indicate a weed control problem?

THE AQUATIC ENVIRONMENT
UNIT II

ASSIGNMENT SHEET #4 — COLLECT A POND BOTTOM SAMPLE; EXAMINE AND DISCUSS FINDINGS

This assignment sheet is designed to familiarize you with benthic members of the fish food chain commonly found on pond bottoms. You will need to collect some specimens at a pond, and then return to the classroom to evaluate your findings.

1. Gather the following equipment and materials.

   a. Bucket

   b. Sieve box

      (NOTE: A small sieve box can be made from common window screen.)

   c. Magnifying glass

   d. Specimen containers

2. Begin at the pond margin and collect three samples: the first from the shallow pond margin, the second from a depth of about 1 foot, and the last from a depth of about 2 or 3 feet.

3. Wade into the pond, and scoop as deeply into the pond bottom as conditions will allow.

4. Sift each sample through the sieve box.

5. Examine with the magnifying glass, describe and record your findings below.

Descriptions of Organisms Found	Number per Sample
Mollusks (clams, snails, etc.)	
Crustaceans (crayfish)	

ASSIGNMENT SHEET #4

Descriptions of Organisms Found	Number per Sample
Insects (larvae, nymphs, adults)	
Amphibians (frogs, salamanders)	
Snakes and turtles	
Worms	
Plants	
Man-made litter (glass, cans, discarded fishing equipment, etc.)	

6. Examine and describe the composition of the pond bottom. What is its primary composition? Clay? Organic debris? Sand? Stones/gravel?

   (NOTE: You can also place some pond bottom material in a glass jar filled with water. Shake jar vigorously and then observe the layers as the material settles out.)

7. Discuss the implications of your findings on the fish food chain and sound pond ecology.

   (NOTE: An interesting project is to collect some dried pond bottom (or edge) soil and place it in a large jar with water. In a moderately warm, well-lit place, this jar will soon become a miniature pond ecosystem as plants and animals revive from dormancy.)

THE AQUATIC ENVIRONMENT
UNIT II

ASSIGNMENT SHEET #5 — PREPARE A LIST OF FOOD SOURCES A SAMPLE POND OFFERS ITS FISH POPULATIONS; IDENTIFY BENTHIC ORGANISMS AND OTHER ELEMENTS IN THE FOOD CHAIN

1. Using the data that you collected in Assignment Sheets #1, #3 and #4, prepare a list of food sources that your sample pond offers its fish populations.

2. Identify benthic organisms, aquatic insects, and other elements in the food chain; list below.

TOTAL FOOD SOURCES FOR SAMPLE POND

Plankton

____
____
____
____

Algae

____
____
____
____

Rooted plants

____
____
____
____

Aquatic insects

____
____
____
____

Benthic organisms

____
____
____
____

Fish species

____
____
____
____

ASSIGNMENT SHEET #5

3. Other than plankton, which food source is most prevalent in the pond you sampled?

THE AQUATIC ENVIRONMENT
UNIT II

ASSIGNMENT SHEET #6 — SURVEY THE AQUATIC PLANTS AND MARGINAL ECOLOGY OF A SAMPLE POND; DISCUSS THE ECOLOGICAL IMPACT ON FISH POPULATIONS AND THE AQUATIC ENVIRONMENT

1. Walk around the margin of a sample pond; look for and record in a notebook any of the following:

    a. Types of marginal and aquatic plants

    b. Signs of burrowing predators such as muskrats, nutria, and beaver that damage pond edges and levees

    c. Signs (tracks or sightings) of predatory birds such as egrets, herons, pelicans, ducks, cormorants, and kingfishers

    d. Signs of competitors such as bullfrogs, otters, raccoons

    e. Trees and bushes that shade or overhang the water and drop leaves, adding to the organic debris on the pond bottom

    f. Turtles, tadpoles, frog eggs, frogs, salamanders, snakes

    g. Man-made litter

2. Note the location of the pond. Will it receive full-day sunshine? Is it near an agricultural endeavor that may cause run-off and pollution problems?

3. Note the size of the pond.

4. Determine the source of the pond's water.

5. Discuss the ecological impact of your findings on fish populations and the aquatic environment.

THE AQUATIC ENVIRONMENT
UNIT II

TEST

NAME____ SCORE__________

1. Match terms associated with the aquatic environment with their correct definitions. Write the correct numbers in the blanks.

_____a. Related to or derived from living organisms

_____b. Process by which plants use sunlight to produce organic substances—chiefly sugars and oxygen—from carbon dioxide and water

_____c. Microscopic aquatic animals

_____d. Zone separating waters of varying densities

_____e. Parts per million; the addition of 1 pound of a substance to 999,999 pounds of water so that the dissolved substance and the water weigh a total of 1 million pounds

_____f. Microscopic organism

_____g. Organic debris

_____h. Organisms living on or in the bottom sediment of a pond

_____i. An insect or animal that at birth or hatching is unlike its parent and must change to another form before assuming adult characteristics

_____j. Group of the same species (kind) of organism that lives in an area

_____k. Transfer of energy from one living thing to another in the form of food

_____l. Microscopic aquatic plants

1. Population
2. Community
3. Ecosystem
4. Organic
5. Microbe
6. Detritus
7. Phytoplankton
8. Zooplankton
9. Benthos
10. Fish food chain
11. Photosynthesis
12. Larva
13. Nymph
14. Stratification
15. Thermocline
16. ppm

TEST

_____m. The layering of temperature and oxygen in a pond

_____n. Communities of plants and animals and their climate, soil, and water environments

_____o. The larva of various insects, especially dragonfly and mayfly larvae

_____p. Group of animal and plant populations living together in the same environment

2. List 8 important variables affecting the ecological balance of a pond.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

   f. ______________________________

   g. ______________________________

   h. ______________________________

3. Select facts about the aquatic food chain. Write the correct numbers in the blanks.

_____a. Which organisms are the primary producers, forming the first link in the food chain?

1) Phytoplankton, algae, and other aquatic plants
2) Zooplankton, insect larvae, and other small organisms
3) Microbes and benthic organisms

_____b. What source of energy do primary producers use to produce food energy?

1) Primary consumers
2) Sunlight
3) Tertiary consumers

_____c. What are some examples of primary consumers?

1) Phytoplankton
2) Zooplankton
3) Microbes and benthic organisms

TEST

_____d. How do primary consumers obtain their energy?

1) By eating dead animals and plants
2) By eating secondary consumers
3) By eating primary producers and other primary consumers

_____e. What are some examples of secondary consumers?

1) Insect larvae, fry, zooplankton
2) Medium-sized fish, crayfish
3) Algae, phytoplankton

_____f. What is a tertiary consumer?

1) A larger fish, bird, or man that eats a secondary consumer
2) A microbe or benthic organism that eats a secondary consumer
3) A primary consumer that eats a primary producer

_____g. What role do microbes and benthic organisms play in the aquatic food chain?

1) They act as decomposers.
2) They act as primary producers.
3) They act as primary consumers.

_____h. How do decomposers join the first and last links in the food chain?

1) They provide the energy source for the primary producers.
2) They enrich the bottom sediment and provide chemicals needed by primary producers.
3) They provide the chlorophyll needed by algae and other aquatic plants.

4. Complete the following statements concerning the oxygen cycle in pond ecology. Write the correct numbers in the blanks.

_____a. Fish need oxygen to live; they take _____ from the water and give off _____ as a waste product of respiration.

1) carbon dioxide; dissolved oxygen (DO)
2) dissolved oxygen (DO); hydrogen sulfide
3) dissolved oxygen (DO); carbon dioxide

_____b. While pond water absorbs some oxygen from the air, the major source of DO in ponds is from _____ by aquatic plants.

1) photosynthesis
2) expiration
3) decomposition

TEST

_____c. During _____, phytoplankton take carbon dioxide gas from the water and produce _____.

1) daylight, oxygen
2) nighttime, hydrogen sulfide
3) nighttime, oxygen

_____d. When sunlight is not available for photosynthesis, phytoplankton and other aquatic plants use _____ for respiration.

1) carbon dioxide
2) oxygen
3) chlorophyll

_____e. Therefore, at night and when it is overcast and dark, both fish and plants _____ available DO in the water.

1) produce the
2) consume little
3) compete for

5. List 5 factors affecting oxygen production in pond water.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

6 Select facts about the affects of seasonal temperature changes on pond water. Write the correct numbers in the blanks.

_____a. If in winter a pond is frozen over for an extended period and the water temperature just below the ice is 32°F, how do decomposing plants and animals affect the water chemistry?

1) They gradually remove oxygen from the water and increase gases such as carbon dioxide, methane, and hydrogen sulfide.
2) They provide chemicals and nutrients for algae and aquatic plants.
3) They keep the water chemistry in balance by ridding the pond of dead organisms.

_____b. As spring temperatures warm the water, it becomes denser and begins to sink. At what temperature does this process begin?

1) 39°F
2) 0°F
3) 32°F

TEST

_____c. During the process described in b, which layer of water contains the most dissolved oxygen?

1) Surface
2) Middle
3) Lower

_____d. The spring pond is a uniform temperature from top to bottom. What minimum temperature must the water be?

1) 65°F
2) 39°F
3) 33°F

_____e. During which season would the aquaculturist be most likely to aerate (add oxygen to) a pond?

1) Summer
2) Spring
3) Fall

_____f. How does thermal stratification prevent the mixing of upper and lower pond waters?

1) The cooler water is denser and heavier, so sinks and cannot mix with the less dense, lighter water near the surface.
2) The warm water is denser and heavier, so sinks and cannot mix with the less dense, lighter water near the surface.
3) Cool dense water traps lighter warmer water beneath it.

_____g. In late summer in a deep and stratified pond, which fish would have the best supply of DO?

1) Bottom feeders
2) Surface feeders
3) Mid-depth feeders

_____h. During which two seasons does a pond have the best supply of DO at all depths?

1) Summer and winter
2) Spring and summer
3) Spring and fall

7. Select from a list true statements about the positive roles of plankton and benthic organisms in pond ecology. Write an "X" in the blank before each correct statement.

_____ a. Phytoplankton produce hydrogen dioxide for fish and other organisms

_____ b. Phytoplankton serve as the main source of food for zooplankton and some fish

TEST

_____ c. Phytoplankton produce blooms that increase oxygen production in rooted plants

_____ d. Zooplankton are a vital food source for fry and all species of fish

_____ e. Zooplankton feed on phytoplankton and help keep it in balance

_____ f. Benthos convert dead plant and animal matter into organic nutrients recycled by plants into forms suitable for animals

_____ g. Benthos supply food and essential vitamins and trace elements to fish

_____ h. Benthos help control accumulations of organic matter on pond bottoms by converting it to safe forms

8. Select from a list true statements about the negative roles of plankton and benthic organisms in pond ecology. Write an "X" in the blank before each correct statement.

_____ a. Plankton may make water so turbid that the sun cannot penetrate and DO cannot be produced.

_____ b. Plankton may produce an off-flavor.

_____ c. Plankton may compete with fish at night for available carbon dioxide.

_____ d. Plankton may die in numbers too great for conversion by decomposers, and thus release harmful compounds into the water and cause high pH and low DO.

_____ e. Plankton may be parasitic or disease causing.

_____ f. Plankton may prey on eggs and fry.

_____ g. Benthic organisms compete with fish for food, DO, and space.

_____ h. Benthic organisms may serve as intermediate hosts for disease organisms

_____ i. Benthic organisms may provide hiding places for eggs and fry

_____ j. Benthic organisms may injure fish, leaving them susceptible to infections

9. Solve problems concerning carbon dioxide in pond ecology.

a. You want to isolate a fish, so fill a holding tank with well water, acclimate the fish to the new water temperature, and release it into the tank. It immediately gasps at the surface and then dies. What water conditions probably caused the death?

____

____

TEST

b. It is 8:30 p.m. on an overcast summer evening. In the late afternoon of the same day, you experienced a die-off of phytoplankton. What level of carbon dioxide can you expect in your pond—high, average, low? Why?

___

c. You measure the level of carbon dioxide in your pond and find it to be 6 ppm in the surface waters. Is this a healthy level for your stock? Why or why not?

___

d. During the afternoon on a sunny, windy spring day, you measure the carbon dioxide levels in your pond. The CO_2 level is 19 ppm. Do you need to take emergency measures? Why or why not?

___

___

10. Solve problems concerning water acidity (pH) in pond ecology.

a. You have just tested your pond's pH level and are happy to find that it is neutral. What pH value did your test reveal?

___

b. You notice that the fish in one of your ponds have been experiencing slow growth. You suspect pH imbalance. Your suspicions are confirmed when you test the pond pH in the afternoon What pH range did your test reveal?

___

c. It is late afternoon on a sunny day, your pond is experiencing a heavy algal bloom, and you get a pH value readings of 11 and 9. Should you take emergency measures? Why or why not?

___

___

d. Through repeated pH testing, you find that your pond water is generally basic during the day and more acidic during the night. Why?

___

___

___

TEST

11. Select from a list true statements about water alkalinity and hardness. Write an "X" in the blank before each correct statement.

_____ a. Alkalinity is a measure of calcium carbonate and bicarbonate ions (both bases) in water to provide an idea of the resistance of that water to changes in pH

_____ b. Water with a low alkalinity acts as a buffer to changes in pH

_____ c. Water with high alkalinity has lower early morning pH levels because carbonate and bicarbonate ions increase the effect of carbon dioxide (an acid) production by phytoplankton during the night

_____ d. Hardness is a measure of the concentration of calcium and magnesium in water

_____ e. Because the same rocks that produce carbonate and bicarbonate also provide calcium and magnesium, and the values for alkalinity and hardness are often expressed as calcium carbonate equivalents

_____ f. As a rule, the best water for fish production has nearly equal values of total hardness and total alkalinity

_____ g. Fish grow reasonably well over a very narrow range of alkalinities and hardnesses, but values of 30-50 ppm are optimum

12. Solve problems concerning ammonia and ammonia byproducts in pond ecology.

a. In testing your tank culture water, you find a high level of ionized ammonia nitrogen (NH_4). Should you take emergency measures? Why or why not?

____

____

b. On a hot summer day, you test your tank culture water and find a pH value of 9 and an un-ionized ammonia nitrogen (NH_3) level of 0.5 ppm. Should you take emergency measures? Why or why not?

____

____

c. Should you be concerned when you find an NH_3 level of 0.1? Why or why not?

____

____

TEST

d. You have just experienced a fish kill. You test the water and find that it has a high DO content and a nitrite (NO_2) value of 1.5. You determine that the fish died of "brown blood disease." What caused this disease, and how did the disease cause the fish to die?

____

____

____

e. You test your pond culture and find the level of nitrate (NO_3) at 450 ppm. Should you take emergency measures? Why or Why not?

____

____

13. Select facts about hydrogen sulfide in the aquatic environment. Write the correct answers in the blanks.

_____a. Where do hydrogen sulfide build-ups occur in a pond?

1) In warm upper layers
2) In algae and aquatic plants
3) In bottom sediments

_____b. How can the fish farmer tell if a pond has an accumulation of hydrogen sulfide?

1) The water will be turbid
2) The sediment will smell like rotten eggs
3) The water will give a high nitrate reading

_____c. At what time of year are concentrations of hydrogen sulfide the highest?

1) Summer
2) Fall
3) Spring

_____d. What substance can be applied to raise pH and reduce the toxicity of hydrogen sulfide?

1) Lime
2) Potassium permanganate
3) Table salt

TEST

_____e. What chemical can be applied to the pond during harvesting to oxidize the hydrogen sulfide in the water?

1) Lime
2) Potassium permanganate
3) Table salt

14. Match aquatic plants with their descriptions. Write the correct numbers in the blanks.

_____ a. Are rooted in the bottom and grow completely underwater, though some produce seed-heads that can be seen at the surface; grow in dense underwater patches that can grow in water 5 feet deep or more; limit access of fish to food organisms produced on or in the pond bottom

_____ b. Grow in very shallow water or wet soil along the edge of the pond; provide shelter for predators; can cause harvesting and pond management problems for the aquaculturist

_____ c. Are microscopic and are either single-celled or composed of branched or unbranched cell chains; are rootless forms of plant life that grow between the pond surface and bottom; are chief producers of DO; are the "bloom" algae and may cause fish kills and off-flavor problems in stocked ponds

_____ d. Are large branched plants attached to the pond bottom; are often confused with higher plants, but proper identification is necessary so that the correct chemical can be selected for control

_____ e. Are rooted in the pond bottom but have leaves that float on or extend above the water surface; some, like waterlilies, can grow in water 10 feet deep or more, and their leaves can completely cover a pond, thus prohibiting photosynthesis and DO production by phytoplankton; use nutrients from the soil and water that could be used by phytoplankton

1. Planktonic algae
2. Filamentous algae
3. Macrophytic algae
4. Free-floating macrophytes
5. Emergent macrophytes
6. Submergent macrophytes
7. Marginal macrophytes

TEST

_____ f. Are visible to the naked eye as floating mats or hairlike strands attached to underwater objects; are primitive plants without roots, stems, or leaves, and are often called *moss* or *pond scum*; may completely cover a pond, preventing sunlight penetration and reducing photosynthesis by phytoplankton

_____ g. Are tiny green plants that float on the surface and superficially resemble algae, but have small leaves and roots that hang down into the water; often indicate water high in phosphorous, which in turn indicates ponds whose DO levels may vary widely; can cover pond surface and thus prohibit sunlight penetration and reduce DO production

15. Complete statements about sources of water pollution. Write the correct numbers in the blanks.

_____ a. Industrial pollutants are high in _____ and may be discharged directly into water systems.

1) nutrients
2) chemicals
3) buffers

_____ b. Some industrial pollutants enter rivers, lakes, and ponds in the form of _____.

1) distilled water
2) ionized chemicals
3) acid rain

_____ c. _____ pollution occurs when industries discharge heated water into lakes and streams.

1) Thermal
2) Therapeutic
3) Chemical

_____ d. Nearly _____ of the sewage in the United States is treated to turn it into less polluting substances; treatment plants discharge these substances directly into lakes or rivers or dispose of them on land.

1) one-eighth
2) one-half
3) three-quarters

TEST

_____ e. Of the remaining amount, about _____ is treated in septic tanks and disposed of on land.

1) one-eighth
2) one-half
3) three-quarters

_____ f. About _____ of the sewage in the United States is disposed of untreated into waterways.

1) one-eighth
2) one-half
3) three-quarters

_____ g. Rainwater flowing from farmland into ponds and streams carries _____ and _____ that have been put into the soil.

1) thermal wastes; carcinogens
2) chemical fertilizers; pesticides
3) topsoil; noxious plants

_____ h. Wind carries _____ pesticides and chemicals into ponds and waterways.

1) sprayed
2) mulched
3) organic

_____ i. During periods of high runoff, most of the wastes of cattle, hogs, sheep, and chickens raised on _____ go into nearby streams and ponds during high runoff.

1) small farms
2) concentrated feeds
3) feedlots

(NOTE: If the following activities have not been completed prior to the test, ask your 'nstructor when they should be completed.)

16. Collect pond plankton and observe under a microscope. (Assignment Sheet #1)

17. Observe the effects of sunlight on collected samples of pond water. (Assignment Sheet #2)

18. Seine a pond; examine findings and discuss the fish food chain. (Assignment Sheet #3)

19 Collect a pond bottom sample; examine and discuss findings. (Assignment Sheet #4)

2' Prepare a list of food sources a sample pond offers its fish populations, identify benthic organisms and other elements in the food chain. (Assignment Sheet #5)

TEST

21. Survey the aquatic plants and marginal ecology of a sample pond; discuss the ecological impact on fish populations and the aquatic environment. (Assignment Sheet #6)

THE AQUATIC ENVIRONMENT
UNIT II

ANSWERS TO TEST

1.
a.	4	i.	12
b.	11	j.	1
c.	8	k.	10
d.	15	l.	7
e.	16	m.	14
f.	5	n.	3
g.	6	o.	13
h.	9	p.	2

2. Answer should include any eight of the following

   a. Water source
   b. Water chemistry
   c. Water depth
   d. Climate
   e. Size of pond (area covered by water)
   f. Age of pond
   g. Geographical and topographical location of pond
   h. Plankton and benthic populations
   i. Fish populations
   j. Algae and rooted plant populations
   k. Predator and competitor populations
   l. Soil type and composition

3. a. 1
   b. 2
   c. 2
   d. 3
   e. 2
   f. 1
   g. 1
   h. 1

4. a. 3
   b. 1
   c. 1
   d. 2
   e. 3

ANSWERS TO TEST

5. Answer should include any five of the following

   a. Number of aquatic plants and phytoplankton in pond
   b. Number, size, and species of fish (and other aquatic animals) in pond
   c. Number of hours of daylight
   d. Intensity of sunlight
   e. Water temperature
   f. Altitude and wind
   g. Water depth
   h. Water clarity
   i. Water source
   j. Amount of detritus in pond

6. a. 1
   b. 3
   c. 1
   d. 2
   e. 1
   f. 1
   g. 2
   h. 3

7. b, d, e, f, g, h

8. a, b, d, e, f, g, h, j

9. a. The well water may be too high in carbon dioxide but contain no oxygen
   b. High; little photosynthesis takes place after a die-off of phytoplankton, and photosynthesis lowers carbon dioxide levels
   c. Yes; normal safe levels range from 5 to 10 ppm in surface waters
   d. No; oxygen levels are generally high in spring, and the day is windy, adding more aeration to the water. Fish can tolerate carbon dioxide levels as high as 20 ppm as long as DO levels remain high.

10. a. 7
    b. Range between 4 and 6
    c. While 11 is the basic death point for fish, ponds experiencing heavy algal blooms can reach pH levels above 11 for short periods of time without negative effects.
    d. When photosynthesis is taking place, the water is more basic than at night when photosynthesis is not taking place

11. a, d, e, f

ANSWERS TO TEST

12. a. No; ionized ammonia nitrogen is rarely toxic to fish
    b. Yes; un-ionized ammonia (NH_3) increases with increased temperature and pH; levels as low as 0.6 ppm are toxic
    c. Yes; sublethal levels as low as 0.1 ppm reduce fish growth and cause gill damage
    d. High levels of nitrite in fish blood hemoglobin reduce the ability of blood to carry oxygen; fish suffocate even when DO levels are considered safe
    e. No; nitrate is the least toxic of the nitrogen compounds; fish can tolerate levels in excess of 500 ppm

13. a. 3
    b. 2
    c. 1
    d. 1
    e. 2

14. a. 6
    b. 7
    c. 1
    d. 3
    e. 5
    f. 2
    g. 4

15. a. 2
    b. 3
    c. 1
    d. 3
    e. 1
    f. 1
    g. 2
    h. 1
    i. 3

16.-21. Evaluated to the satisfaction of the instructor

FUNDAMENTAL FISH BIOLOGY
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify species and basic anatomical parts of fishes. The student should also be able to discuss the functions of internal organs and the life cycle of a fish. These competencies will be evidenced by correctly completing the assignment and job sheets and by scoring a minimum of 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with fundamental fish biology with their correct definitions.
2. Label external parts of a typical fish.
3. Discuss basic external body features that enable fish to live in water.
4. Label internal organs of a typical fish.
5. Select true statements about the functions of internal organs and systems of fishes.
6. Match life cycles of fish with their correct descriptions.
7. Identify fish species.
8. Demonstrate the ability to:
    a. Dissect a fish, examine under a microscope, and identify internal organs. (Job Sheet #1)
    b. Kill, weigh, measure, and dress a catfish, and compare dressed and undressed measurements. (Job Sheet #2)

FUNDAMENTAL FISH BIOLOGY
UNIT III

SUGGESTED ACTIVITIES

A. Read unit, make your own notes, and plan your teaching strategy.

B. Make and review transparencies.

C. Provide students with objective sheet. Discuss unit and specific objectives.

D. Provide students with information sheet.

E. Discuss information sheet, providing as many examples as possible. Be sure to discuss local names for species illustrated in Section VII.

F. Provide students with job sheets and schedule due dates.

G. Discuss and demonstrate the procedures outlined in the job sheets. Provide students with Unit II, Handout #1—How to Use a Compound Microscope as necessary.

H. Give test. Critique in class.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Belusz, Larry. *Fish Farming Techniques.* Columbia Missouri. University of Missouri, The Instructional Materials Laboratory, 1987.

B. Dupree, Harry K, and Jay V. Huner, eds. *Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington, D.C.: Fish and Wildlife Service, 1984.

C. *The Fish Book* from *NEBRASKAland Magazine.* Nebraska Game and Parks Commission. Lincoln, Nebraska: Vol. 65, No. 1, January-February 1987.

D. Lee, Jasper S. *Catfish Farming: A Reference Unit.* Jackson, Mississippi: Mississippi Department of Education, Division of Vocational-Technical Education, 1971.

E. Piper, Robert G. et al. *Fish Hatchery Management.* Washington, D.C.: U.S. Department of the Interior Fish and Wildlife Service, 1982.

F. Schubert, Dr. Gottfried. *Fish Diseases: A Complete Introduction.* Neptune City, New Jersey: T.F.H. Publications, Inc., 1987.

G. Torrans, Les. *Blue Tilapia Culture in Arkansas.* Pine Bluff, Arkansas: University of Arkansas Cooperative Extension Service, 1988.

H. Van Ramshorst, Dr. J. D. *Aquarium Encyclopedia of Tropical Freshwater Fish.* Tucson, Arizona: H.P. Books, 1981.

SUGGESTED ACTIVITIES

I. *World Book Encyclopedia*. Vol. 7. "Fish." Chicago: World Book-Childcraft International, Inc., 1981.

FUNDAMENTAL FISH BIOLOGY
UNIT III

INFORMATION SHEET

I. Terms and definitions

A. **Species** — Narrowest scientific classification; a class of related organisms having common characteristics, capable of interbreeding, and sharing a common name

EXAMPLE: The species name for channel catfish is *Ictalurus punctatus.*

B. **Predator** — Animal that preys on, destroys, or eats other animals

C. **Vertebrate** — Organism with an inner skeleton and a segmented spinal column

EXAMPLES: Fish, alligator, man

D. **Invertebrate** — Organism with a hard outer skeleton and lacking a spinal column

EXAMPLES: Crayfish, shrimp, oyster

E. **Forage** — Food for animals taken by browsing or grazing, or the act of browsing or grazing to obtain food

F. **Parasite** — A plant or animal that lives on or in another species

EXAMPLES. Fungi, bacteria, protozoa, fish lice, intestinal worms, nematodes, flukes, "ich"

G. **Viscera** — The internal organs of the body, especially of the abdominal cavity

H. **Eviscerate** — To gut a fish; to remove the viscera

I. **Ventral** — Underside of the body where the belly is located

J. **Dress** — To clean and eviscerate for marketing or consumption

K. **Pigment** — The coloring matter in the cells of plants and animals

L. **Dorsal** — Top side of the body

M. **Lateral** — Side of the body

INFORMATION SHEET

II. External parts of a typical fish (Transparency #1)

A. Head

1. Mouth

2. Nostrils

   (NOTE: A fish's nostrils are not used for respiration as they are in other vertebrates. They are sensory organs used only for smelling.)

3. Operculum (gill cover)

4. Opercle tab

5. Nostrils (nares)

6. Barbels (catfish)

B. Trunk

1. Pectoral fin

2. Pelvic fin

   (NOTE: The pelvic fin is sometimes called the ventral fin.)

3. Pelvic or pectoral fin spine

4. Dorsal fin

5. Dorsal fin spine

6. Adipose fin

   (NOTE: This fleshy fin occurs in some species such as the catfish.)

C. Tail

1. Anal fin

2. Caudal (tail) fin

D. Lateral line

INFORMATION SHEET

III. Basic external body features that allow fish to live in water

A. **Shape** — Most fish have a streamlined body adapted for swimming and speed; fish have no neck so that the head blends smoothly into the trunk, which in turn narrows to the tail.

> POINTS OF INTEREST: Aside from this basic similarity, fish come in a variety of shapes. Many fast swimming fishes have a torpedo-like shape. Freshwater sunfish and some other midwater species are flattened from side to side. Many bottom-dwelling fishes, such as catfish and sturgeon, are flattened from top to bottom.

B. **Skin** — Fish have fairly tough skin that, like other vertebrates', contains blood vessels, nerves, and connective tissue, as well as certain special cells that produce mucus and pigment cells.

1. The slimy mucus produced by the mucous cells makes fish slippery and gives them their "fishy" smell; this mucous coating, called a *slimecoat*, provides an important protective barrier against disease organisms, and aids movement through the water.

   (NOTE: Fish should be handled with wet hands or net to reduce damage to the slimecoat.)

2. Pigment cells in the skin give fish what is called *protective coloration*, a coloration that matches that of their environment; many can also change their color to match color changes in their surroundings.

> POINT OF INTEREST: Many fish are light below and darker on top so that to predators looking up, they blend with the surface while to those looking down, they blend with the bottom. Some have stripes or speckles to help them blend better with weeds and shade patterns. Bright coloration may protect certain fish by confusing their enemies or by warning predators that they are poisonous.

C. **Scales** — Most jawed fish have an additional protective covering of scales, bony plates with rounded edges; scales protect the fish not so much against predators as against infections and foreign bodies.

(NOTE: If a fish loses some scales, they will grow back, but while they are absent, the fish will be more at risk from infection.)

INFORMATION SHEET

D. **Fins** — Fins are movable structures that help a fish swim and keep its balance; except for a few finless species, all modern fish have *rayed fins* in which fan-shaped rods called *rays* support a web of skin.

1. Median fins are the vertical fins on the fish's back, underside, or tail used to help the fish remain upright and to propel it through the water.

   EXAMPLES: Dorsal, anal, and caudal fins

2. Paired fins consist of two, identical fins, one on each side of the body; these fins are used primarily for stopping, turning and maneuvering.

   EXAMPLES: Pectoral and pelvic fins.

IV. Internal organs of a typical fish (Transparency #2)

A. Brain/spinal cord

B. Gill

C. Heart

D. Esophagus

E. Liver

F. Stomach

G. Intestine

H. Kidney

I. Sex organ (ovary or testes)

J. Swim bladder

K. Anus

L. Spleen

V. Functions of internal organs and systems in fish

A. Respiratory system

1. Unlike land animals, almost all fish get their oxygen from that dissolved in water.

2. Most fish have four *gills* enclosed in *gill chambers* on each side of the head.

3. Water enters a fish's *mouth* and is forced by the movement of the mouth and *gill covers* to flow out through the gills.

INFORMATION SHEET

4. As water passes over the two rows of *filaments* attached to each *gill arch*, blood flowing through tiny extensions on the filaments absorbs oxygen from the water and releases carbon dioxide into the water.

B. Circulatory system

1. Fish are cold-blooded organisms whose body temperature is regulated by water temperature.

2. A fish's *heart* consists of two main chambers—the atrium and ventricle.

3. Blood flows through *veins* to the atrium; it then passes to the ventricle.

4. Muscles in the ventricle pump the blood through *arteries* to the gills, where it receives oxygen and gives off carbon dioxide.

5. Arteries then carry this oxvgenated blood, plus food from the intestines, to body cells.

6. Blood also carries waste products away from the cells; the fish's *kidneys* remove the waste products from the blood, which then returns to he heart through the veins.

C. Digestive system

(NOTE: As in all vertebrates, a fish's digestive system changes food into materials that nourish the body cells, and eliminates unused materials.)

1. Most fish have a jawed *mouth* with an immovable *tongue* used only for tasting; mouths are different shapes and sizes reflecting the fish's eating habits and diet.

2. *Teeth*, in those species that have them, are used to seize prey and to tear off pieces of flesh; they are rooted in the jaw, but some fish may also have teeth on the roof of the mouth or on the tongue, and most have teeth in the *pharynx*, a short tube behind the mouth. These teeth are used to crush or grind food.

3. In all fish, food passes through the pharynx on its way to the *esophagus*, another tubelike organ that expands easily, allowing fish to swallow food whole.

4. From the esophagus, food passes into the *stomach* where it is partially digested.

   (NOTE: Not all fish have true stomachs.)

5. The digestive process is completed in the *intestines*, where digested food enters the bloodstream and waste products and undigested food pass out through the *anus*.

INFORMATION SHEET

D. Nervous system

1. The nervous system of fish, like that of other vertebrates, consists of a *spinal cord, brain*, and *nerves.*

2. A fish's nervous system is not as complex as that of other vertebrates.

3. The nervous system regulates the amount of gas in the swim bladder.

E. Reproductive system

1. The reproductive organs in fish are the *testes* in males and the *ovaries* in females.

2. The testes produce the male sex cells, or *sperm*, which are contained in a fluid called *milt*.

3. The ovaries produce the female sex cells, or *eggs*, which are also called *roe* or *spawn*.

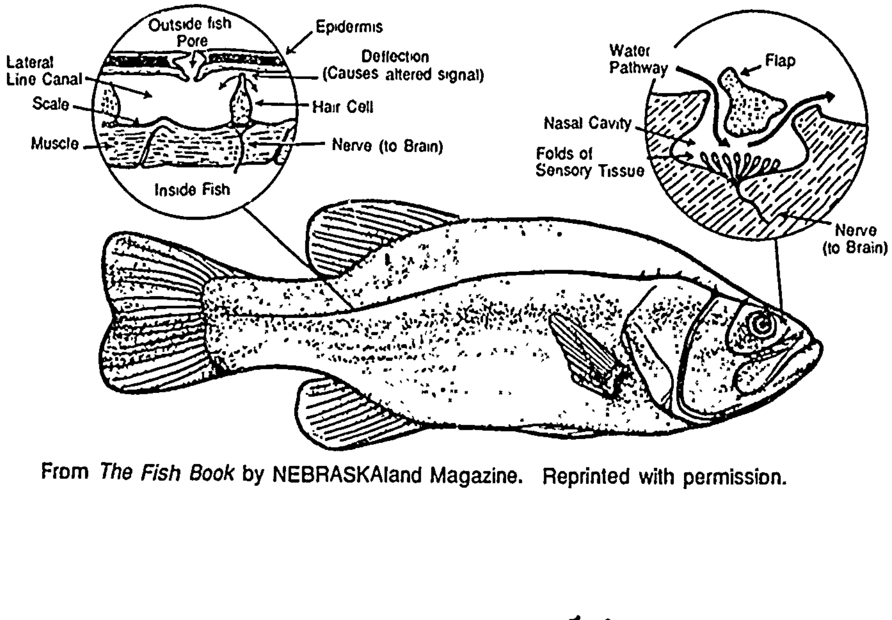
4. Most fish are *egg-layers*, releasing their sex cells into the water through an opening near the anus, but others are *live-bearers*; the males of these species have special structures for transferring sperm directly into the female.

F. Sensory organs

1. Nearly all fish have a special sensory organ called a *lateral line system* that enables them to react to the slightest pressure and temperature changes, allowing them to sense changes in water movement

   (NOTE: The lateral line can be seen both externally and internally. [See Figure 1 below.] It consists of a series of tubelike canals in the fish's skin. Vibrations enter the canals through pores and travel to sensory organs in the canals. Nerves connect these organs to the brain.)

FIGURE 1



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INFORMATION SHEET

2. A fish's *eyes* differ from those of land vertebrates in that most fish can see to the right and left at the same time, and most lack eyelids because water keeps the eyeballs moist and clean.

   (NOTE: A fish's ability to see both right and left at the same time, makes up, in part, for its inability to turn its head because it has no neck.)

3. Fish have no external ears or eardrums to receive sound vibrations, but all fish hear sounds produced in the water—and even on shore if they are loud enough—because sound waves are carried by body tissues to the pouches and tubelike sacs of their *internal ears*.

   (NOTE: Catfish have a very keen sense of hearing.)

4. The *organs of smell* in most fish consist of two pouches, one on each side of the snout; these pouches have a nostril at both the front and back, allowing water to pass through them and over tissue that is highly sensitive to odors.

   (NOTE: Many fish species, including catfish, have a highly developed sense of smell.)

G. Special organs

1. Below the backbone, most fish have a saclike *swim bladder* that provides buoyancy, enabling the fish to remain at a particular depth in the water; the fish's nervous system automatically regulates the amount of gas in the bladder.

   > POINT OF INTEREST: The stomach of a fish suddenly jerked from the bottom of a lake into the air may be forced out of the mouth. This is because the air bladder was under considerable pressure in deep water and rapidly expanded after the fish was pulled from the water. Some fish, such as the gar, can physically regulate the amount of air in the swim bladder. Also interesting is that many catfish use their swim bladders to produce sounds as well as to provide buoyancy. Some species communicate with these sounds.

2. The stomach and esophagus in some fish is enlarged into a *gizzard*, an organ that grinds food into small pieces before it is passed to the intestines.

3. Some fish that have no teeth, such as paddlefish, have comb-like *gill rakers* that strain plankton from the water pumped through the gills.

VI. **Life cycles of fish** (Transparency #3)

A. Every fish begins life as an egg; fish eggs are called **roe** or **spawn**.

B. In the egg, an undeveloped fish called an **embryo**, feeds on the yolk until ready to hatch.

INFORMATION SHEET

C. Newly hatched fish, called **larva** or **fry**, still draw their nourishment from the egg yolk in an attached yolk sac; because of this, they may also be called **sac fry** or **yolk sac fry.**

D. When the fry have used their supply of yolk and the yolk sac is absorbed, they can feed on the surface and forage for food on their own; these fry are called **swim-up fry** or **advanced fry.**

E. **Fingerlings** are the young of the year, juvenile fish resembling the parent fish, and used to stock food fish ponds.

F. **Yearlings** or **stockers** are fish held for a year or until they reach marketable size.

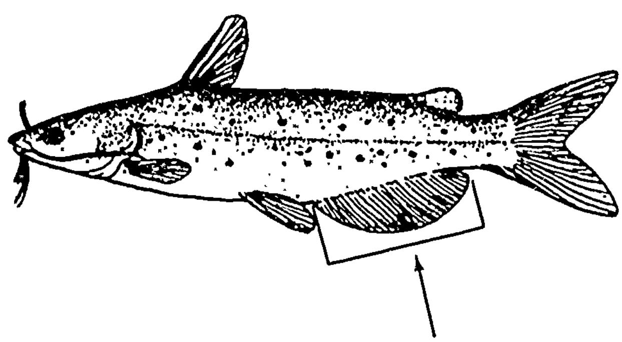
G. Sexually mature fish are called **adult spawners** or **broodfish**; generally the larger the species, the longer it takes to reach maturity.

VII. **Species identification** (Figures 2-17)

A. Channel catfish (*Ictalurus punctatus*)

(NOTE: The anal fin on the channel catfish has fewer than 30 rays, and the outer margin appears rounded. Spots on light colored young fish disappear with age. Adult colors range from olive and brown to dark blue.)

FIGURE 2

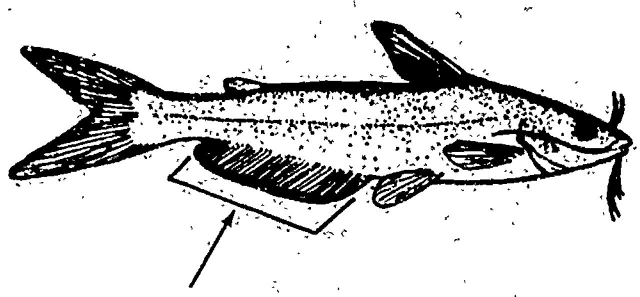


INFORMATION SHEET

B. Blue catfish (*Ictalurus furcatus*)

(NOTE: The anal fin distinguishes the blue from the channel catfish. The blue's fin has more than 30 rays, and the outer margin is straight. Color is silvery white to light blue.)

FIGURE 3



From Eddy and James C. Underhill, *How to Know the Freshwater Fishes*, 3rd ed. Copyright 1978. Wm. C. Brown Publishers, Dubuque, Iowa.

C. Black bullhead (*Ictalurus melas*)

(NOTE: The barbel colors help tell bullheads apart, and the more rounded tail helps tell them from catfish species. The black bullhead has black or grey barbels and 17 to 24 anal fin rays.)

FIGURE 4

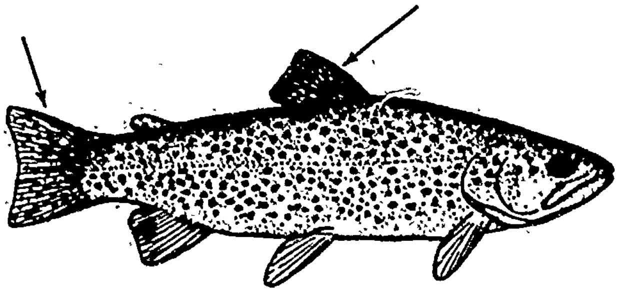
From Eddy and James C. Underhill, *How to Know the Freshwater Fishes*, 3rd ed. Copyright 1978. Wm. C. Brown Publishers, Dubuque, Iowa.

INFORMATION SHEET

D. Rainbow trout (*Oncorhynchus gairdneri*)

(NOTE: Small black spots cover the tail and dorsal fins of the rainbow trout. The pink lateral band that gives this fish its name varies in intensity, from faint in lake fish to a more brilliant color in stream fish.)

FIGURE 5

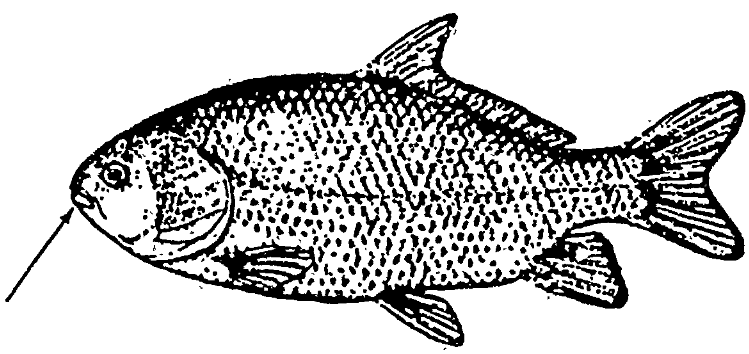


From Eddy and James C. Underhill, *How to Know the Freshwater Fishes*, 3rd ed.

E. Bigmouth buffalo (*Ictiobus cyprinellus*)

(NOTE: The bigmouth buffalo is a deep bodied, husky sucker that can top 30 pounds. Its mouth faces forward not down like other suckers. More than 10 dorsal rays separate suckers from the minnow family. Its main colors are olive, grey, and bronze.)

FIGURE 6



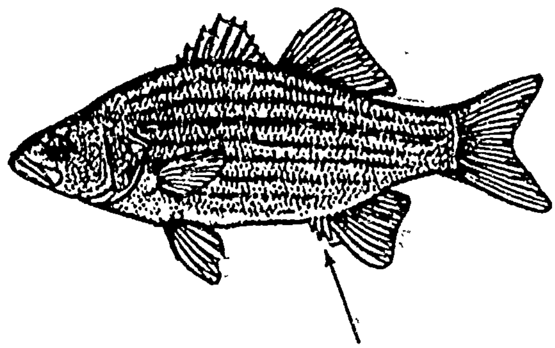
From Eddy and James C. Underhill, *How to Know the Freshwater Fishes*, 3rd ed.

INFORMATION SHEET

F. White bass (*Morone chrysops*)

(NOTE: The white bass has one tooth patch on the base of its tongue, broken horizontal lines on its sides, and its anal Fin spines are stair-stepped.)

FIGURE 7



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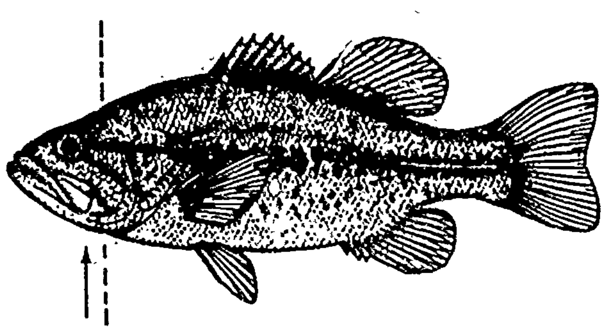
G. Largemouth bass (*Micropterus salmoides*)

(NOTE: Mouth size distinguishes this member of the sunfish family. In largemouth bass, the jaw extends beyond the eye; whereas in smallmouth bass, the jaw extends only to the rear margin of the eye and not beyond. Young largemouth bass and many adults have a distinct black lateral band.)

FIGURE 8



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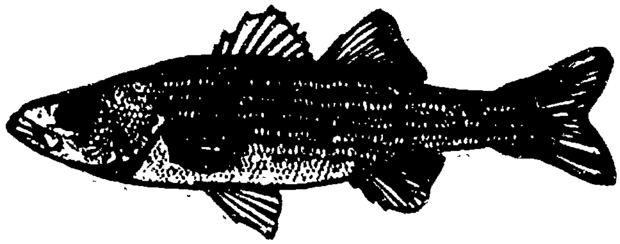
INFORMATION SHEET

H. Striped bass (*Morone saxatilis*)

(NOTE: Striped and white bass bear a superficial resemblance to each other. The striped bass, however, appears more streamlined than the white, and its horizontal lines are more distinct and unbroken. Also, stripers are large fish, capable of topping 50 pounds, but 5 pounds is tops for a white bass.)

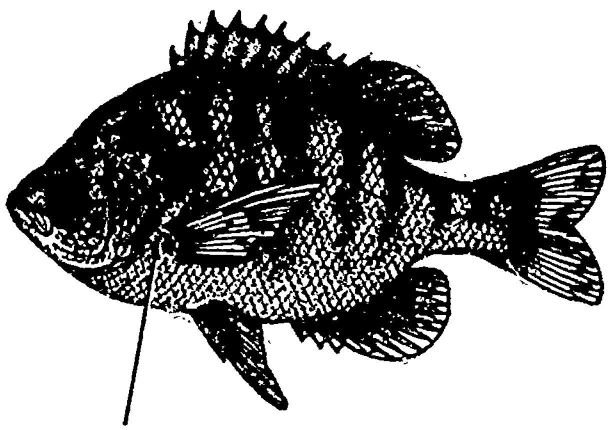
FIGURE 9



I. Bluegill (*Lepomis macrochirus*)

(NOTE: The backs of males of these sunfish are usually olive, and their sides are marked with dark, vertical bars. Orange breasts identify males guarding spawning beds. Females are drab, but both males and females have solid, dark blue gill cover tabs.)

FIGURE 10

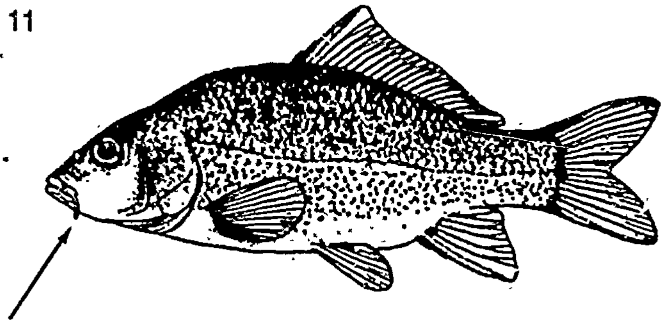


INFORMATION SHEET

J. Common carp (*Cyprinus carpio*)

(NOTE: A deep yellow body and toothless mouth with four barbels on the upper lip identify carp, members of the minnow family.)

FIGURE 11



From Eddy and James C. Underhill, *How to Know the Freshwater Fishes*, 3rd ed. Copyright 1978, Wm. C. Brown Publishers, Dubuque, Iowa. Reprinted by special permission.

K. Bighead carp (*Aristichthys nobilis*)

(NOTE: Dull grayish-brown in color, these Chinese carp have small scales and large heads. Their lateral lines are dark and clearly visible. These fish feed on detritus and zooplankton in nature but cultured fish accept pelleted feed.)

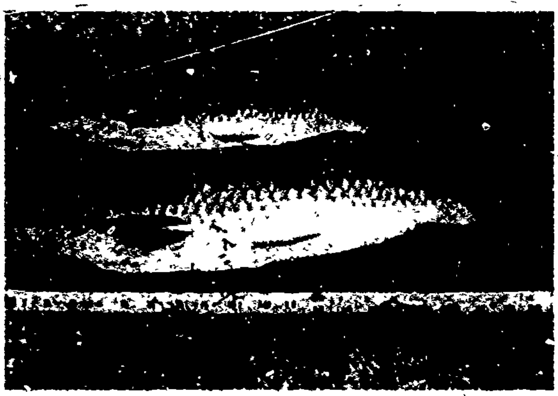
FIGURE 12

INFORMATION SHEET

L. Grass carp (*ctenopharyngodon idellas*)

(NOTE: These slim carp have large, dark-edged scales and dark fins. They feed on aquatic plants in nature but cultured fish accept pelleted feed.)

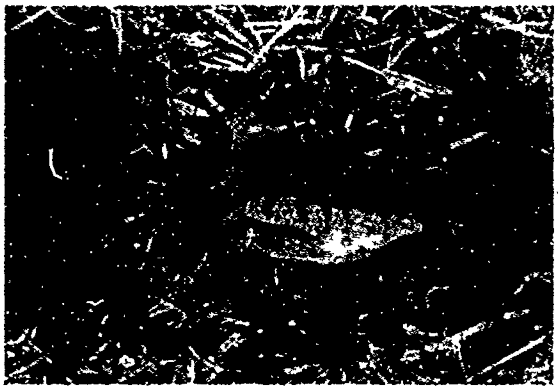
FIGURE 13



M. Blue tilapia (*Tilapea aurea*)

(NOTE: Young are difficult to distinguish from small sunfish, such as the green sunfish. However the dorsal fin of tilapia is longer than that of sunfish. Adult tilapia are blue to silver colored, with several dark, vertical bars on the sides. The paired fins may turn aqua-blue during the breeding season, giving the fish its common name. These fish are deep-bodied with a small head and small mouth.)

FIGURE 14

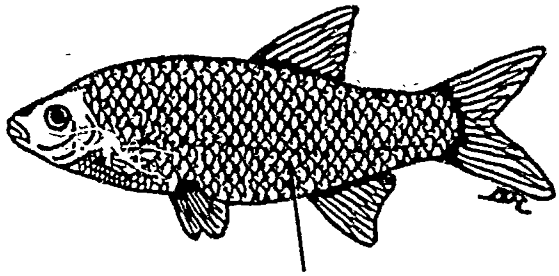


INFORMATION SHEET

N. Golden Shiner (*Notemigonus crysoleucas*)

(NOTE: A silvery gold color and deeply descending lateral line characterize this minnow, which is commercially raised and sold as a bait fish in many areas. One of the larger members of the minnow family, it will grow to over 8 inches.)

FIGURE 15

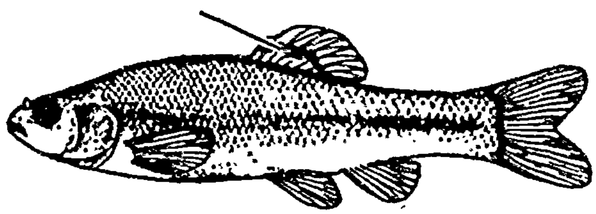


Drawing by Brenda Rodgers in *Manual for Bait Fish Culture in the South.* With permission.

O. Fathead minnow (*Pimephales promelas*)

(NOTE: These fish are characterized by their blunt snouts, olive color, and a horizontal bar across their dorsal fins. Like the golden shiner, they are raised and sold as bait fish. A small short-lived fish, they seldom reach 3 inches or 3 years.)

FIGURE 16



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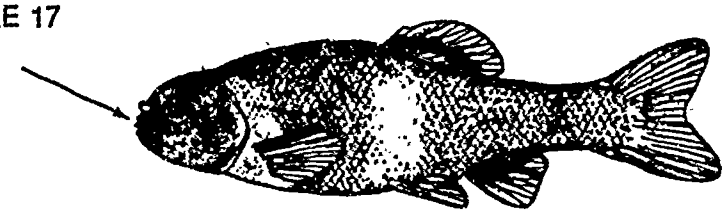
(NOTE: Male fathead minnows display grey and yellow spawning colors, develop humps on their heads and backs, and sport breeding tubercles. See Figure 17.)

FIGURE 17



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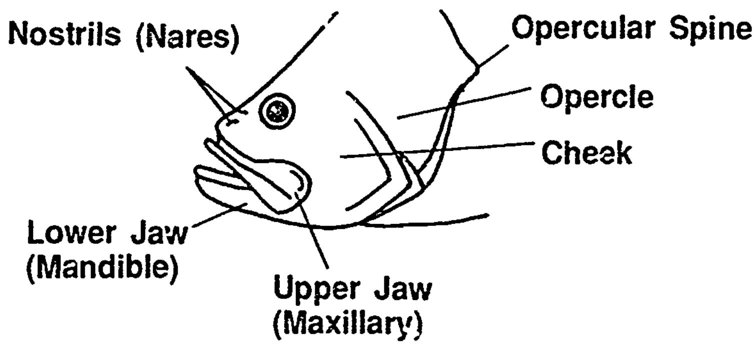
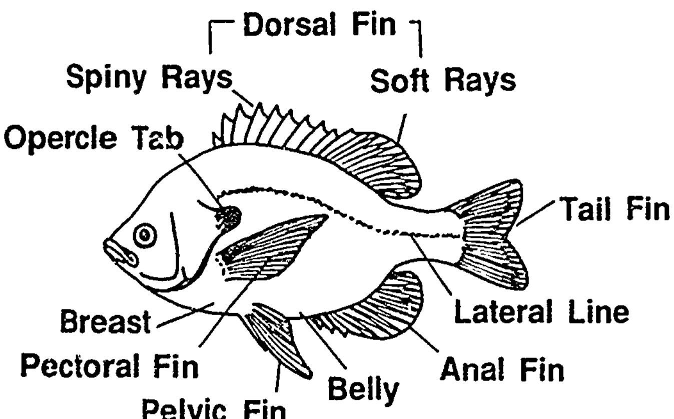
External Fish Anatomy

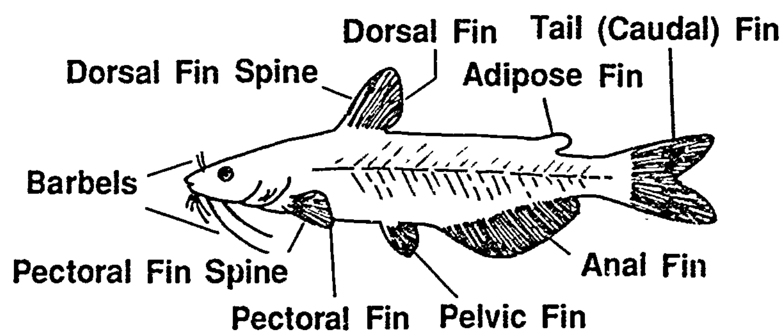
Head (Yellow Perch)



Spiny-Rayed Fish (Bluegill)



Soft-Rayed Fish (Channel Catfish)

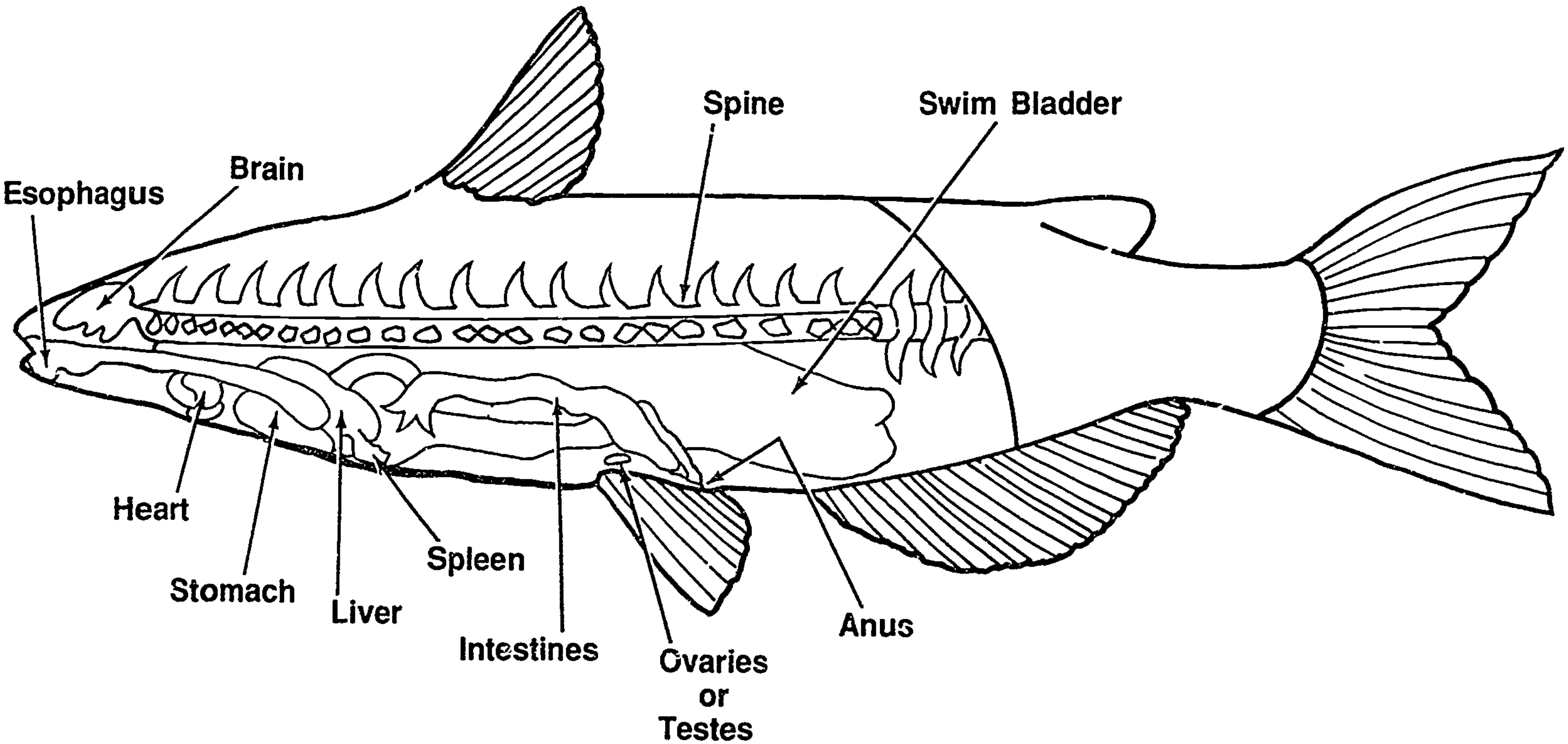


From *The Fish Book* by NEBRASKAland Magazine. With permission.

TM 1

AQ-129

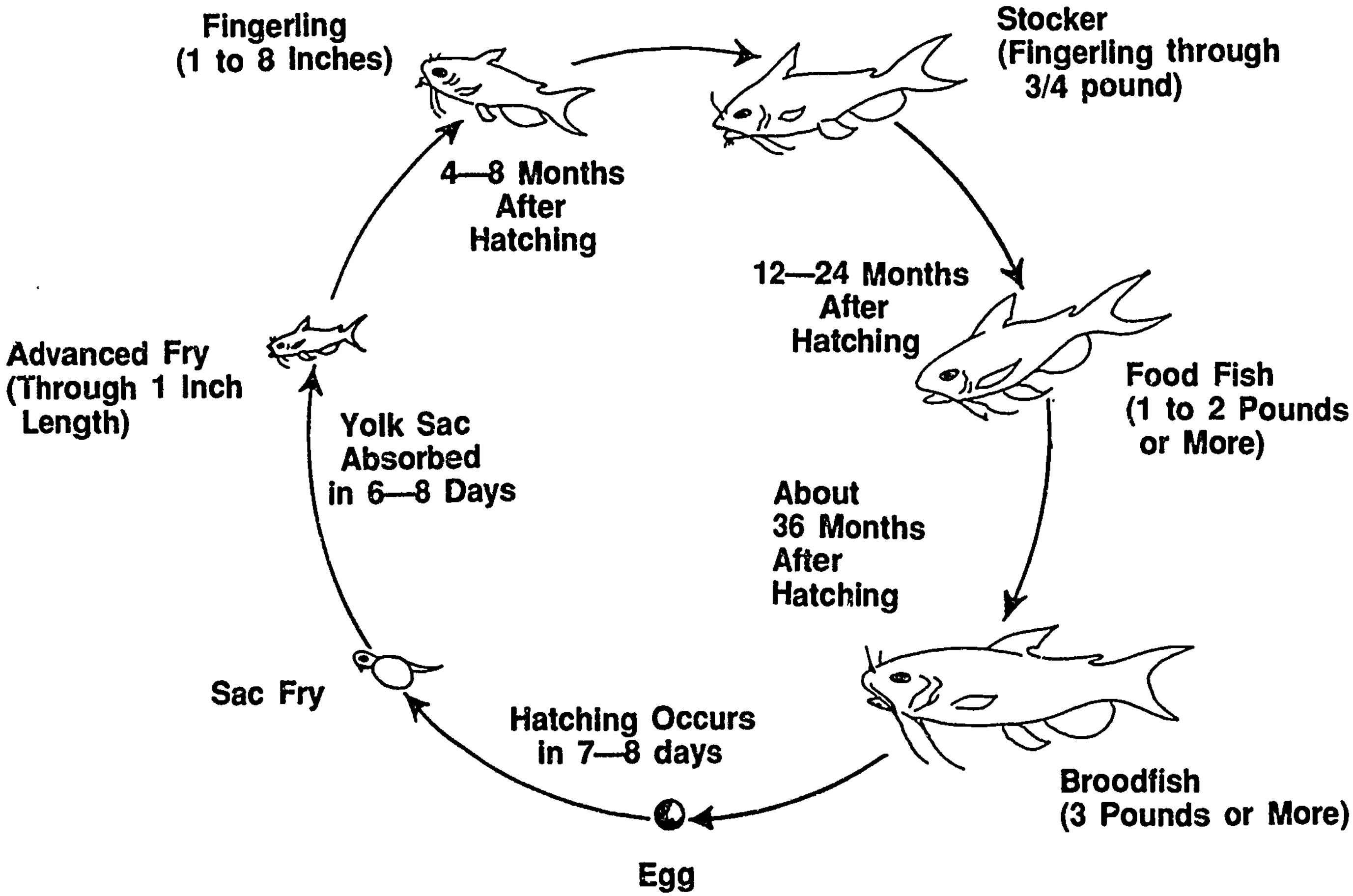
Internal Fish Anatomy



TM 2

AQ-131

Life Cycle of a Catfish



From *Catfish Farming* by Jasper Lee. With permission.

AQ-133

TM 3

FUNDAMENTAL FISH BIOLOGY
UNIT III

JOB SHEET #1 — DISSECT A FISH; EXAMINE UNDER A MICROSCOPE, AND IDENTIFY INTERNAL ORGANS

A. Tools and equipment

1. Tub to hold live specimen fish
2. Running water and drain board
3. Microscope and magnifying glass (multi-lens or ×3)
4. Slides and cover slips
5. Dissection needles

   (NOTE: Dissection needles are fine needles [sharp, blunt, or lancetlike] with a handle. They are used for probing, separating and holding down tissues and organs. You can make your own by inserting insect pins into suitable dowels.)

6. 9% solution of sodium chloride (9 grams of kitchen salt to 1 quart of water)
7. Eyedropper
8. Tweezers with sharp points
9. Sharp knife or strong pair of scissors (preferably right-angle scissors with one blunt and one sharp blade)
10. Small pair of scissors with two pointed blades
11. Fish skinning board with clip, or length of board to use as a dissecting surface
12. Spatula
13. Blotting paper or coarse paper towel

B. Routine #1 — Dissect fish; identify and examine organs and tissues.

1. Place a piece of damp blotting paper on the dissecting board.
2. Kill fish by cutting deeply through the spinal cord directly behind the head.

   (NOTE: Tissue breakdown after death is very rapid in fish. Do not kill the fish until you are set up and ready to dissect.)

JOB SHEET #1

3. Take a blood sample.

   a. Catch a drop of blood on a clean slide.

   b. Dilute with a smail drop of 9% sodium chloride solution.

   c. Cover with a cover slip and examine the blood cells under the microscope.

4. Place the fish on its side on the dissecting board.

5. Take a skin scraping.

   a. Collect skin deposits by scraping spatula gently over the skin, scraping toward the tail.

   b. Transfer sample to a slide, mix with a very small drop of tap water, and cover with a cover slip.

   c. Use a microscope to examine the scraping for parasites.

6. Take a gill scraping.

   a. Lift opercle and collect a gill scraping on a dissecting needle.

   b. Transfer sample to slide and make a wet mount as explained in 5b above.

   c. Use microscope to examine gill scrapings for parasites.

7. Cut away opercle and study the skin and gills; normal gills should be bright red; affected gills are faded and may look frayed.

   (NOTE: Because tissue breakdown is so rapid after death, the gills will become naturally pale 10 or 15 minutes after death.)

8. Examine the gill filaments with magnifying glass and microscope.

9. Examine a piece of fin under the microscope at low and medium powers.

10. Examine a healthy scale under the microscope.

11. Cut open the fish to expose its internal organs.

    a. Taking care not to damage the intestine, carefully insert tip of knife or one blade of the strong scissors into the anus, and cut along the medial line until reaching the gills.

       (NOTE: Clear fluid may be discharged.)

JOB SHEET #1

b. Now make a shallow cut from the anus upwards and toward the head, following the edge of the abdominal cavity until you reach the opercle.

(NOTE: Do not cut too deeply or you will damage the internal organs.)

c. Lift this triangular flap of abdominal wall up from the anal region, and with the spatula push back into the abdominal cavity any internal organs adhering to it.

d. Remove the flap by cutting between the first two cuts at the opercle.

e. If the incisions have caused a lot of bleeding — which means that they have been too deep — rinse the fish gently under running water.

☐ Have your instructor check your work.

C. Routine #2 — Identify and examine the internal organs.

1. Fill the abdominal cavity with clean water in order to make it easier to spread out the organs.

2. Identify each of the following organs, and then examine with the naked eye and with the magnifying glass.

(NOTE: You may want to refer to Transparency #2 for the approximate locations of the internal organs.)

a. Intestine (slit, make a slide from its contents, and examine under the microscope)

b. Spleen (move loops of intestine to reveal this small, bright red organ)

c. Stomach (open and examine contents)

d. Kidney (slice and look for renal tubes)

e. Ovary (if fish is female)

(NOTE: Sometimes large numbers of white spawn are found in the abdominal cavity. If sexually mature females do not discharge their spawn, the cells die and become white.)

f. Testes (if fish is male)

g. Liver

h. Swim bladder

i. Heart (snip out with pointed scissors and slice to expose the ventricle and atrium)

j. Esophagus

JOB SHEET #1

3. Open the skull by cutting from the left and right nostrils toward the back and connecting the two incisions at the front by cutting across between the nostrils.

4. Lift this strip of tissue to expose the brain; examine brain tissue under microscope.

☐ Have your instructor check your work.

5. Clean area and return tools and equipment to proper storage.

FUNDAMENTAL FISH BIOLOGY
UNIT III

JOB SHEET #2 — KILL, WEIGH, MEASURE, AND DRESS A CATFISH, AND COMPARE DRESSED AND UNDRESSED MEASUREMENTS

A. Tools and equipment

1. Vat or tub of catfish

   (NOTE: This job sheet covers the procedure for dressing a catfish. The procedure for other species may vary somewhat.)

2. Running water and drain board
3. Skinning hook
4. Gutting knife
5. Skinning pliers
6. Metal rule
7. Hanging scales

B. Procedure

1. Remove fish from tub, place on drain board, and measure from tip of snout to tip of tail; record this measurement.

   Length: ____________

2. Place fish on scales and record weight.

   Weight: ____________

3. Kill fish by cutting deeply through the spinal chord directly behind the head.
4. Hang fish by its head from skinning hook.
5. Cut or snip off dorsal and pectoral fins, taking care to avoid the spines.
6. Beginning just behind the opercle, cut through the skin all around the head.
7. Grasp edges of cut skin with skinning pliers, and strip off in a tailward direction, leaving ventral side of fish until last.
8. Cut out the dorsal fin as the back strip of skin is removed.

JOB SHEET #2

9. Strip the skin from the ventral side, slitting open the belly and removing the viscera and anal fin as the skin is pulled off.

10. Remove the head, cutting just behind the opercle.

    (NOTE: Commercial processing plants behead fish with a bandsaw.)

11. Wash fish and remove any skin, viscera, or fins that were not previously removed; the tail fin usually remains with the fish.

12. Place dressed fish on scales and record its weight.

    Dressed weight: ____________

13. Measure fish and record its dressed length.

    Dressed length: ____________

14. Determine amount of weight and length lost to dressing by subtracting the dressed weight and length from the undressed; record.

____________ Undressed length	____________ Undressed weight
____________ Dressed length	____________ Dressed weight
____________ Length loss	____________ Weight loss

(NOTE: The head, viscera, and skin are normally equal to 40 to 45 percent of a catfish. Catfish usually dress out at 55 to 60 percent of their live weight. The ideal size catfish for the retail market has a live weight of 1 to 1.5 pounds. This size usually yields a dressed fish weighing from 8 to 10 ounces.)

☐ Have your instructor check your work.

15. Clean area and return tools and equipment to proper storage.

FUNDAMENTAL FISH BIOLOGY
UNIT III

PRACTICAL TEST #1
JOB SHEET #1 — DISSECT A FISH, EXAMINE UNDER A MICROSCOPE AND IDENTIFY INTERNAL ORGANS

Student's Name________________________________ Date________

Evaluator's Name______________________________ Attempt No.____

When you are ready to perform Job Sheet #1, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to indicate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:		Yes	No
1. Assembled and used proper tools and equipment.	1.	☐	☐
2. Killed fish properly and timely.	2.	☐	☐
3. Took blood sample and scrapings.	3.	☐	☐
4. Made proper cuts to expose internal organs.	4.	☐	☐
5. Opened skull with proper cut.	5.	☐	☐
6. Examined brain tissue under microscope.	6.	☐	☐
7. Cleaned area and returned tools to storage.	7.	☐	☐

Evaluator's Comments ____

____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE. Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. [See performance evaluation key below.] If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:	Excellent	Acceptable	Fair	Unacceptable
Assembled and used proper tools and equipment	4	3	2	1
Followed procedures as outlined	4	3	2	1
Found and identified all nine organs	4	3	2	1
Worked safely	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

____

PERFORMANCE EVALUATION KEY

4 — **Skilled** — Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program.
2 — **Limited skill** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

FUNDAMENTAL FISH BIOLOGY
UNIT III

PRACTICAL TEST #2
JOB SHEET #2 — KILL, WEIGH, MEASURE, AND DRESS A CATFISH, AND COMPARE DRESSED AND UNDRESSED MEASUREMENTS

Student's Name________________________________ Date__________

Evaluator's Name________________________________ Attempt No.____

When you are ready to perform Job Sheet #2, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to indicate whether or not the student has satisfactorily achieved each step in this procedure. If the student unable to achieve this competency, have the student review the materials and try again.)

The student:		Yes	No
1. Killed fish properly.	1.	☐	☐
2. Measured undressed length and weight.	2.	☐	☐
3. Skinned fish and removed head properly.	3.	☐	☐
4. Cleaned, washed, and dressed fish.	4.	☐	☐
5. Measured dressed length and weight.	5.	☐	☐
6. Calculated amounts lost to dressing.	6.	☐	☐
7. Cleaned area and returned tools to storage.	7.	☐	☐

Evaluator's Comments ____

____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. [See performance evaluation key below.] If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:	Excellent	Acceptable	Fair	Unacceptable
Assembled and used proper tools and equipment	4	3	2	1
Followed procedures as outlined	4	3	2	1
Made proper calculations	4	3	2	1
Worked safely	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

____

PERFORMANCE EVALUATION KEY

4 — **Skilled** — Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program.
2 — **Limited skill** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

FUNDAMENTAL FISH BIOLOGY
UNIT III

TEST

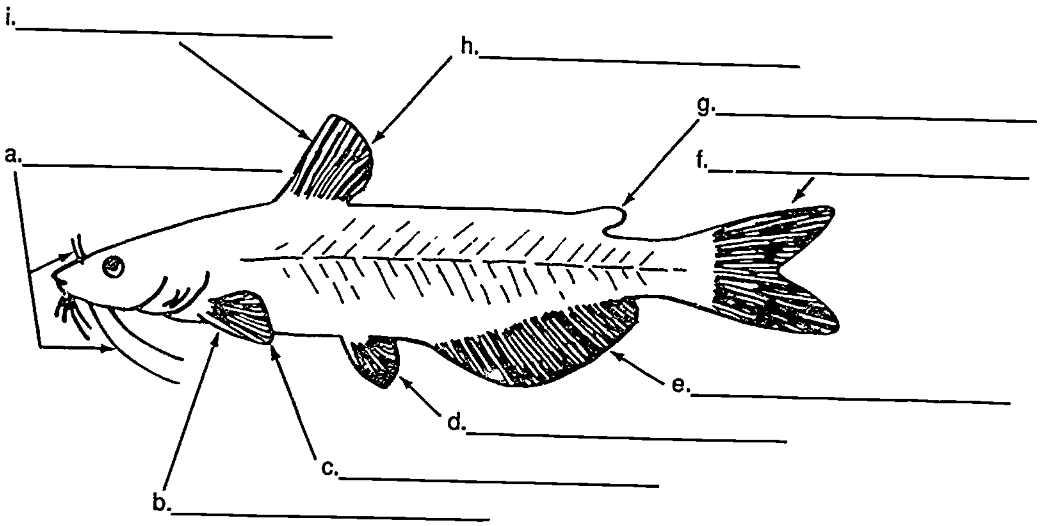
NAME____ SCORE__________

1. Match terms related to fundamental fish biology with their correct definitions. Write the correct numbers in the blanks.

_____ a. Narrowest scientific classification; a class of related organisms having common characteristics, capable of interbreeding, and sharing a common name	1.	Parasite
	2.	Pigment
	3.	Forage
_____ b. Animal that preys on, destroys, or eats other animals	4.	Species
	5.	Dress
_____ c. Organism with an inner skeleton and a segmented spinal column	6.	Invertebrate
_____ d. Organism with a hard outer skeleton and lacking a spinal column	7.	Predator
	8.	Ventral
_____ e. Food for animals taken by browsing or grazing, or the act of browsing or grazing to obtain food	9.	Viscera
	10.	Vertebrate
_____ f. A plant or animal that lives on or in another species	11.	Eviscerate
_____ g. The internal organs of the body, especially of the abdominal cavity	12.	Dorsal
	13.	Lateral
_____ h. To gut a fish; to remove the viscera		
_____ i. Underside of the body where the belly is located		
_____ j. To clean and eviscerate for marketing or consumption		
_____ k. The coloring matter in the cells of plants and animals		
_____ l. Side of the body		
_____ m. Top side of the body		

TEST

2. Label the external parts on the typical fish illustrated below.



3. Discuss external body features that enable fish to live in water. Answer the following questions.

   a. What is the basic body shape of most fish, and how does this shape equip fish to live in water?

   ____

   ____

   b. What is the mucous coating produced by the skin cells called, and what are its functions?

   ____

   ____

   c. How do the skin's pigment cells function as a protective device?

   ____

   ____

   d. What is the function of a fish's scales? ______________

   ____

TEST

e. What is the function of a fish's median fins? ______________________

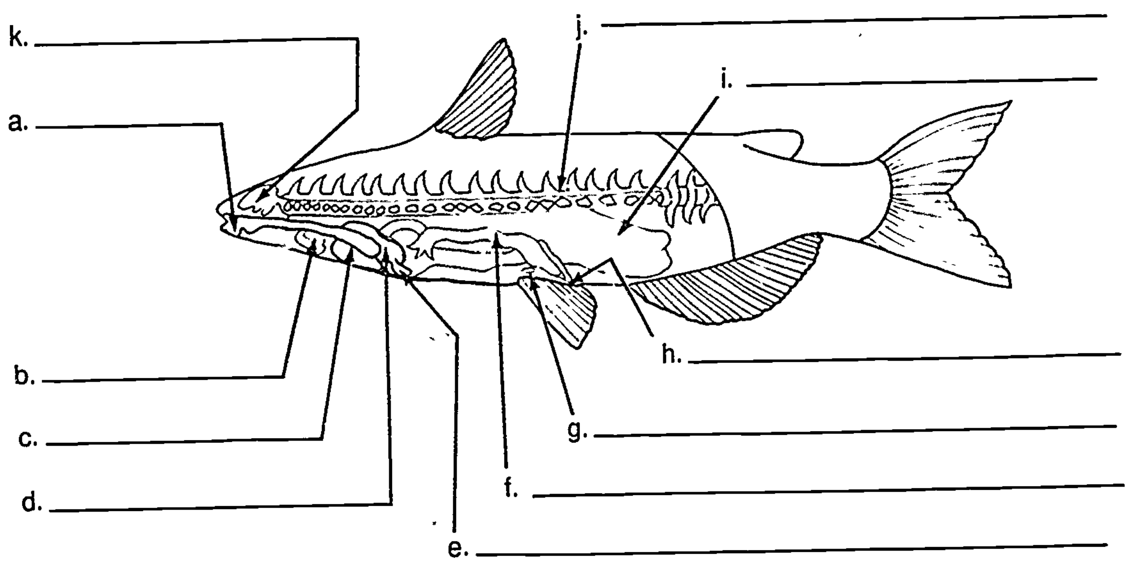
____

f. How many sets of paired fins does the typical fish have, and what are their functions?

____

____

4. Label the internal organs on the typical fish illustrated below.



5. Select true statements about the functions of internal organs and systems of fishes. Write an "X" before each statement that is true.

(NOTE: For a statement to be true, all parts of the statement must be true.)

a. Respiratory system

_____ 1) Unlike land animals, almost all fish get their oxygen from that dissolved in water

_____ 2) Most fish have two gills enclosed in gill slits on each side of the head

_____ 3) Water enters a fish's gill slits and is forced by the movement of the mouth and gill covers to flow through the gills

_____ 4) As water passes over the two rows of filaments attached to each gill arch, blood flowing through tiny extensions on the filaments absorbs oxygen from the water and releases carbon dioxide into the water

TEST

b. Circulatory system

_____ 1) Fish are cold-blooded organisms whose body temperature is regulated by water temperature

_____ 2) A fish's heart consists of two main chambers--the atrium and ventricle

_____ 3) Blood flows through the arteries to the atrium; it then passes to the ventricle

_____ 4) Muscles in the ventricle pump the blood through veins to the gills, where it receives oxygen and gives off carbon dioxide

_____ 5) Arteries carry oxygenated blood, plus food from the intestines, to body cells

_____ 6) Blood also carries waste products away from the cells; the fish's kidneys remove the waste products from the blood, which then returns to the heart through the veins

c. Digestive system

_____ 1) Most fish have a jawed mouth with a movable tongue used only for tasting; mouths are different shapes and sizes reflecting the fish's eating habits and diet.

_____ 2) Teeth, in those species that have them, are used to seize prey and to tear off pieces of flesh; they are rooted in the jaw, but some fish may also have teeth on the roof of he mouth or on the tongue, and most have teeth in the pharynx; these teeth are used to grind food

_____ 3) In all fish, food passes through the esophagus on its way to the pharynx, another tubelike organ that expands easily, allowing fish to swallow food whole

_____ 4) From the esophagus, food passes into the stomach where it is absorbed

_____ 5) The digestive process is completed in the intestines, where undigested food enters the bloodstream, and waste products and digested food pass out through the anus

d. Nervous system

_____ 1) The nervous system of a fish, like that of other vertebrates, consists of a spinal cord, brain, and nerves

_____ 2) A fish's nervous system is more complex than that of many other vertebrates

TEST

_____ 3) The nervous system regulates the amount of gas in the swim bladder

e. Reproductive system

_____ 1) The reproductive organs in fish are the testes in males and the ovaries in females

_____ 2) The testes produce the male sex cells, or milt, which are contained in a fluid called sperm

_____ 3) The ovaries produce the female sex cells, or eggs, which are also called roe or caviar

_____ 4) Most fish are egg-layers, releasing their sex cells into the water through an opening near the anus, but others are live-bearers; the males of these species have special structures for transferring sperm directly into the female

f. Sensory organs

_____ 1) Nearly all fish have a special sensory organ called a lateral line system that enables them to react to the slightest changes in dissolved oxygen in the water

_____ 2) Most fish can see to the right and left at the same time, and most lack eyelids because water keeps the eyeballs moist and clean

_____ 3) Fish have no external ears or eardrums to receive sound, so they sense sounds through their lateral line systems

_____ 4) The organs of smell in most fish consist of two pouches, one on either side of the snout; these pouches have a nostril at both the front and back, allowing water to pass through them and over tissue highly sensitive to odors

g. Special organs

_____ 1) Below the backbone, most fish have a saclike swim bladder that provides equilibrium, enabling the fish to remain upright in the water; the fish's respiratory system automatically regulates the amount of gas in the bladder

_____ 2) The stomach and esophagus in some fish is enlarged into a gizzard, an organ that grinds food into small pieces before it is passed to the intestine

_____ 3) Some fish that have no teeth have comblike gill rakers that strain plankton from water pumped through the gills

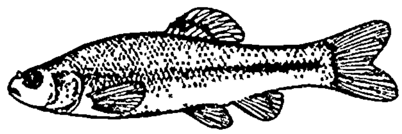
TEST

6. Match life cycles of fish with their correct descriptions. Write the correct numbers in the blanks.

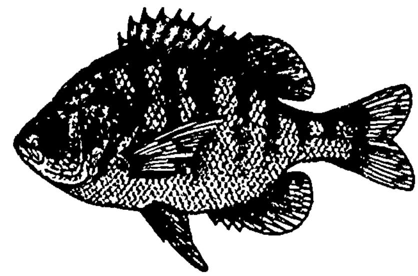
_____ a. Fry that have absorbed the yolk sac and can feed on the surface and forage for their own food	1.	Fingerlings
_____ b. Fish held for a year or until they reach marketable size	2.	Roe or spawn
_____ c. Newly hatched fish that draw their nourishment from the egg yolk in an attached sac	3.	Sac fry or yolk sac fry
_____ d. The egg from which every fish begins life	4.	Spawners or broodfish
_____ e. The undeveloped fish in the egg	5.	Embryo
_____ f. Sexually mature fish	6.	Swim-up fry; advanced fry
_____ g. The young fish of the year; juvenile fish resembling the parent fish and used to stock fish ponds	7.	Yearlings or stockers

TEST

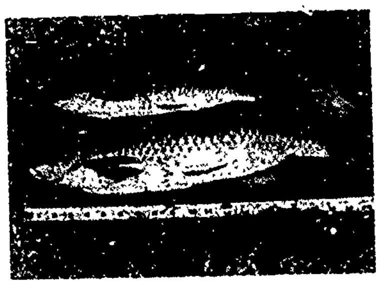
7. Identify the following species of fish. Write the common name below each drawing.



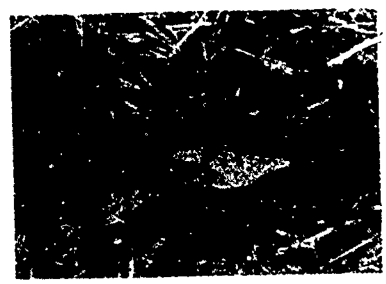
a. ______________________



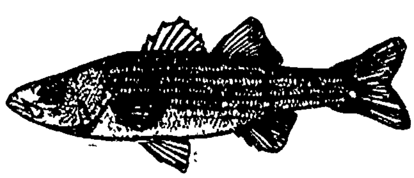
b. ______________________



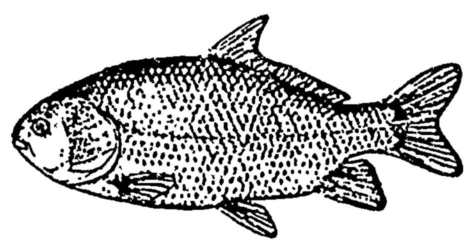
c. ______________________



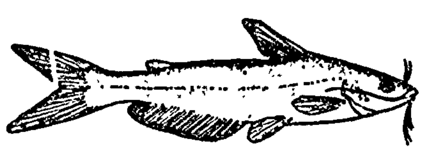
d. ______________________



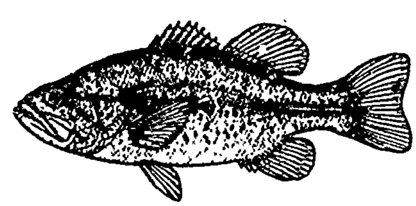
e. ______________________



f. ______________________

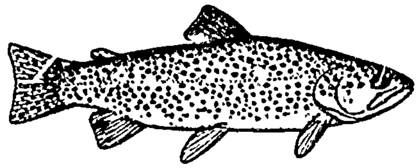


g. ______________________

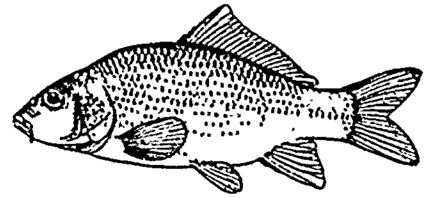


h. ______________________

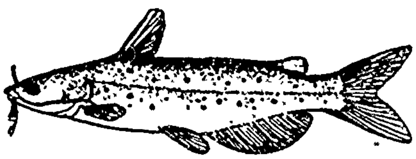
TEST



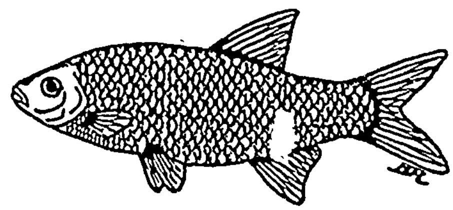
i. ____________________



j. ____________________

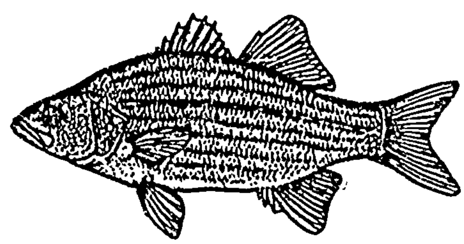


k. ____________________

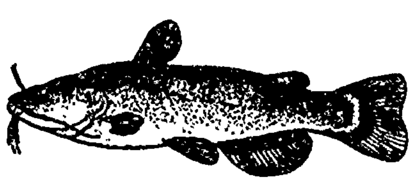


l. ____________________

m. ____________________



n. ____________________



o. ____________________

TEST

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

8. Demonstrate the ability to:

   a. Dissect a fish, examine under a microscope, and identify internal organs. (Job Sheet #1)

   b. Kill, weigh, measure, and dress a catfish, and compare dressed and undressed measurements. (Job Sheet #2)

FUNDAMENTAL FISH BIOLOGY
UNIT III

ANSWERS TO TEST

1.
- a. 4
- b. 7
- c. 10
- d. 6
- e. 3
- f. 1
- g. 9
- h. 11
- i. 8
- j. 5
- k. 2
- l. 13
- m. 12

2.
- a. Barbels
- b. Pectoral fin spine
- c. Pectoral fin
- d. Pelvic fin
- e. Anal fin
- f. Tail fin
- g. Adipose fin
- h. Dorsal fin
- i. Dorsal fin spine

3.
- a. Streamlined for swimming and speed
- b. Slimecoat; provides a protective barrier against disease and aids movement through water
- c. They provide coloration that lets the fish blend in with its environment
- d. Protection against predators, infection, and foreign bodies
- e. They help a fish stay upright in the water and also help propel the fish
- f. Two. They are used for stopping, turning, and maneuvering

4.
- a. Esophagus
- b. Heart
- c. Stomach
- d. Liver
- e. Spleen
- f. Intestines
- g. Ovaries or testes
- h. Anus
- i. Swim bladder
- j. Spine
- k. Brain

5.
- a. 1, 4
- b. 1, 2, 5, 6
- c. 2
- d. 1, 3
- e. 1, 4
- f. 2, 4
- g. 2, 3

ANSWERS TO TEST

6. a. 6
   b. 7
   c. 3
   d. 2
   e. 5
   f. 4
   g. 1

7. a. Fathead minnow
   b. Bluegill
   c. Grass carp
   d. Tilapea
   e. Striped bass
   f. Bigmouth buffalo
   g. Blue catfish
   h. Largemouth bass
   i. Rainbow trout
   j. Common carp
   k. Channel catfish
   l. Golden shiner
   m. Bighead carp
   n. White bass
   o. Black bullhead

8. a. Evaluated according to criteria in Practical Test #1

   b. Evaluated according to criteria in Practical Test #2

MARKETING
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify key markets and marketing strategies, complete a marketing flow chart, and process fish. These competencies will be evidenced by correctly completing procedures in the assignment and job sheets and by scoring a minimum of 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to marketing with their correct definitions.
2. Select true statements about processing plant markets.
3. Select true statements about live haul markets.
4. Select true statements about local markets: stores and restaurants.
5. Select true statements about local retail markets.
6. Select true statements about the fee-fish market.
7. Complete statements about economy of scale
8. List factors to consider when exploring marketing alternatives.
9. Complete statements about product forms.
10. Match food fish processing cuts and forms with their correct descriptions.
11. Match dressout percentages to processing cuts and forms.
12. Discuss on-site versus plant processing.
13. Select true statements about disposal of processing waste.
14. Complete statements concerning permits and regulations.
15. Survey local markets. (Assignment Sheet #1)

OBJECTIVE SHEET

16. Demonstrate the ability to:

    a. Skin and filet a catfish. (Job Sheet #1)

    b. Dress and package a trout. (Job Sheet #2)

MARKETING
UNIT IV

SUGGESTED ACTIVITIES

A. Invite local marketers to talk to the class about desired marketing forms and size, seasonal markets, and market strategies and prices.

B. Make transparency.

C. Provide students with objective sheet. Discuss unit and specific objectives.

D. Provide students with information sheet. Discuss information sheet, personalizing and localizing the information to fit your class profile.

E. Schedule and evaluate assignment sheet.

F. Gather equipment and materials needed for job sheets. Schedule, demonstrate, and evaluate job sheets.

G. Give written test.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Beem, Marley, and Steven Anderson. *Catfish Farming*. Fact Sheet No. 9002. Stillwater, Oklahoma: Oklahoma State Cooperative Extension Service, n.d.

B. Belusz, Larry. *Fish Farming Techniques*. Columbia, Missouri. The Instructional Materials Laboratory/University of Missouri, 1988.

C. *Catfish Aquaculture: A Decision-making Guidebook*. Baton Rouge, Louisiana: Louisiana Cooperative Extension Service/Louisiana State University Agricultural Center, 1987.

D. Huner, Jay V., and Harry K. Dupree. "Methods and Economics of Channel Catfish Production, and Techniques for the Culture of Flathead Catfish and Other Catfishes," in *The Third Report to the Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research*, Harry K. Dupree and Jay V. Huner, eds. Washington, DC: U.S. Fish and Wildlife Service, 1984.

E. Jensen, Gary L. *Commercial Production of Farm-Raised Catfish*. Baton Rouge, Louisiana. Louisiana Agricultural Experiment Station/Louisiana Cooperative Extension Service, 1988.

F. Reigh, Robert C., ed. *Proceedings of the Louisiana Aquaculture Conference, 1988*. Baton Rouge, Louisiana. Louisiana Cooperative Extension Service/Louisiana State University Agricultural Center, 1987.

SUGGESTED ACTIVITIES

G. Sedgwick, S. Drummond. *Trout Farming Handbook*. London, England: Seeley, Service, & Co., 1978.

H. "Standard Cuts and Forms of Farm-Raised Catfish." Fact Sheet. Jackson, Mississippi: Catfish Farmers of America, n.d.

I. Wellborn, Thomas L. Jr. *Catfish Farmer's Handbook*. Mississippi State University/Mississippi Cooperative Extension Service, 1987.

MARKETING
UNIT IV

INFORMATION SHEET

I. **Terms and definitions**

A. **Market** — Buyer of product

B. **Cryogenically frozen** — Frozen at very low temperatures

C. **Filet** — Boneless sides cf fish cut lengthwise away from the backbone

D. **Eviscerated** — Gutted; with internal organs removed

E. **Dressed** — Killed and prepared for food market

F. **Retail sales** — Sales of fish in small quantities directly to the consumer

G. **Wholesale sales** — Sales of fish in large quantities to buyer who then sells to distributor or retail market.

H. **Seed stock** — Larval fish or crustaceans; fry; small fingerlings

II. **Processing plant market** (Transparency 1)

A. Processing plants buy fish from the producer, and then dress, package, and sell the fish to appropriate markets. (Figure 1)

EXAMPLE: FIGURE 1

B. The major processing plants are in the catfish-producing areas of Mississippi and Alabama, but smaller plants are located in all the states in which fish are produced.

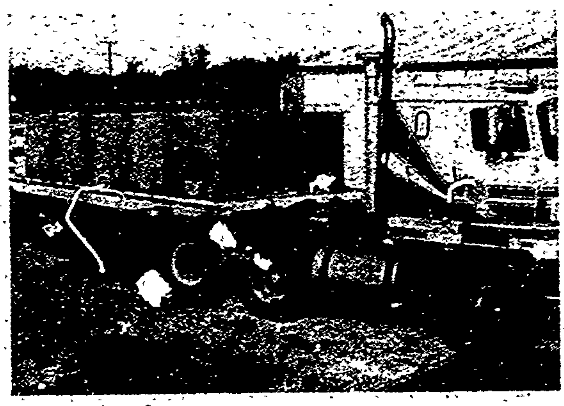
C. Plants often employ specialty harvesting crews and can provide transport trucks for hauling; harvesting costs range from 3 to 5 cents a pound, and hauling costs may range from 1 to 5 cents a pound.

INFORMATION SHEET

D. The minimum load is between 8,000 and 10,000 pounds of live weight, and many plants set a distance limit for their hauling services of no more than 50 miles one-way. (Figure 2)

(NOTE: These conditions mean that most hill-pond and small farmers will not be able to sell their fish to a processing plant because of the distance involved and the lack of enough fish.)

EXAMPLE: FIGURE 2



E. Arrangements with the plant to accept, harvest, and transport fish usually must be made well in advance—agreement 7 to 60 days before harvest is typical.

III. **Live haul market**

A. Live-fish haulers purchase fish from the producer and transport them predominately to the owners of fee-fishing lakes.

B. Live haulers only transport fish; they do not harvest or grade them.

C. Most haulers do not accept orders for small numbers of fish; a 5,000-pound to 8,000-pound minimum load is typical.

D. The fish must be in excellent condition so that they will survive the trip and can begin feeding in the fee-fishing pond.

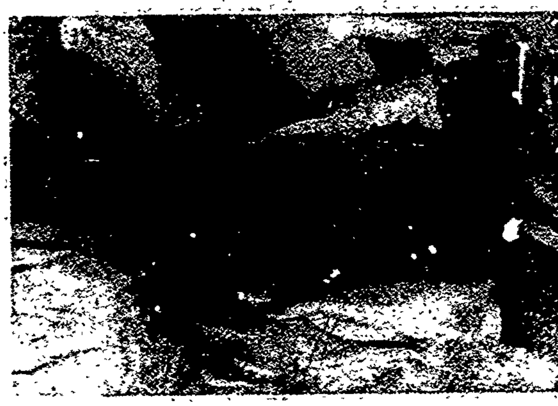
E. Live haulers often pay above-processor prices to obtain good quality fish.

INFORMATION SHEET

IV. **Local markets: stores and restaurants**

A. These markets are among the best for small enterprises, and for those located in areas beyond processing plant haul distances. (Figure 3).

EXAMPLE: FIGURE 3



B. Local stores and restaurants usually want fish weekly throughout the year, which means that the farmer must be able to harvest fish weekly by seining or trapping.

C. Many stores and restaurants will accept only dressed fish; therefore, the producer must be equipped to process the fish on the farm.

(NOTE: Some farmers may own a restaurant—such as a catfish specialty restaurant or a restaurant specializing in Cajun dishes—that becomes the principal outlet for their own fish.)

V. **Local retail markets**

EXAMPLES: Civic, church and other fund-raising groups and clubs; individuals; other fish farmers

A. Food fish can be live or dressed, and purchased on the farm or delivered; baitfish, crayfish, and hobby fish are generally delivered.

B. The producer may harvest food fish once or a few times a year and advertise by local radio and newspaper that fresh fish will be available on the farm at a certain date.

C. Food-fish may also be transported from the farm to nearby population centers and sold directly from the haul truck to the consumer; this method also requires advance advertising.

D. Fish farmers buy broodfish, eggs, fry, and fingerlings.

E. Depending on the location, area population, size of the operation, and number of competing producers in the area, this type of market ranges from excellent to poor.

INFORMATION SHEET

VI. Fee-fish market

A. In this market, the producer grows the fish in one or more ponds; the customer pays a fee for entering the site and trying to catch fish and usually pays an additional charge for the number of fish or pounds of fish caught.

EXAMPLE: In Louisiana in 1987, live weight prices for catfish from fee-fish ponds ranged from $1.00 to $1.75 per pound.

B. Some fee-fish producers also dress the fish caught for a modest charge.

C. Ponds may be open all year, only on certain days of the week, or only during certain periods; however, the fee-pond operator must be present whenever the pond is open for fishing. (Figure 4)

EXAMPLE: FIGURE 4

D. While the fee-fish market requires no harvesting, the operator may purchase stock from a producer, or a farmer may operate a fee-fish pond in addition to producing fingerlings or food-fish.

VII. Economy of scale

A. As a rule of thumb, production costs per pound of fish are usually lower for large farms than those for small farms

B. Unlike small farms, large farms can take advantage of discounts for bulk purchases of feed and seed stock.

C. Larger ponds are less expensive per acre to build than small ponds.

D. Large farms can sell wholesale to a processor or live-hauler while profits may be low or even negative if small farms sell to a processor or wholesale market.

E. Retail prices usually fluctuate more than wholesale prices and small farmers who must retail their products must advertise to be successful.

INFORMATION SHEET

F. These data do not mean that fish farming cannot be profitable for the small farmer: from a profit standpoint, what counts is the pounds of fish *marketed* each year, *not* the pounds of fish *produced*.

VIII. Factors to consider when exploring market alternatives

(NOTE: Marketing involves much more than the act of changing ownership of a product [selling]. Each producer must actively and creatively explore marketing alternatives.)

A. Market size (wholesale versus retail)

B. Area market distribution (Table 1)

(NOTE: Table 1 illustrates national market distribution. Producers should be aware of national market distribution, but of more immediate importance is the market distribution in the producer's locality or area.)

EXAMPLE: **TABLE 1: National Market Distribution for Sales of Food-Sized Channel Catfish in 1981***

Market	Quantity (thousands of pounds)	Percent of total
Processors	71,800	81
Live-haulers	5,921	7
Consumers	2,704	3
Fee and sport fishing	1,951	2
Other producers	1,812	2
Government agencies	49	Trace
Others	3,874	4

* Adapted from Table 4.8 in *Third Report*, 1984. From U.S. Department of Agriculture, 1982. "Aquaculture Outlook and Situation," U.S. Department of Agriculture Economic Research Service AS-3.

C. Local and area competition

D. Past and present market prices

E. Harvesting and transporting strategy

EXAMPLES: One-time or multiple harvest; custom harvest and hauling or producer harvest and hauling

F. Product forms and sizes desired in market area

EXAMPLE: Is there local demand for fingerlings? Hobby fish? Food fish?

G. On-site versus processing plant processing, packaging, and storing

INFORMATION SHEET

H. Processing form(s) desired in market area

EXAMPLES: Live, processed, fileted

I. Seasonal ups and downs

J. Advertising

IX. Product forms

(NOTE: Most fish are sold in all forms of their life stages. Crayfish may be sold in a softshell or hardshell stage. Most baitfish are sold in an adult life stage.)

A. **Eggs** — Fish eggs sell by the pound and the prices change annually, depending on the supply or success of the hatchery.

B. **Broodfish** — Some specialty markets exist for broodfish, especially if they are an improved or selected strain.

C. **Fry** — Fry are generally sold by the thousand, and fingerling fish longer than 1 inch are usually sold singly by the inch, up to about 8 inches; longer fish may be sold by the pound.

D. **Fingerlings** — Fingerlings or stocker fish are marketed primarily to commercial fish farmers and people who have recreational or farm ponds; a higher price is usually obtained than for wholesale sales to commercial farms.

E. **Food-fish** — Food fish are normally 3/4 to 2 pounds in weight and are sold by the pound to either a wholesale or retail market.

(NOTE: Fish over 4 pounds usually receive a lower price.)

F. **Crayfish** — Food crayfish are usually sorted by size and sold by the pound (softshell crayfish command a higher price than hardshell), and bait crayfish are sold by the piece.

G. **Baitfish** — Baitfish are usually graded by size, and may be sold by the pound at the wholesale level or the piece at the retail level.

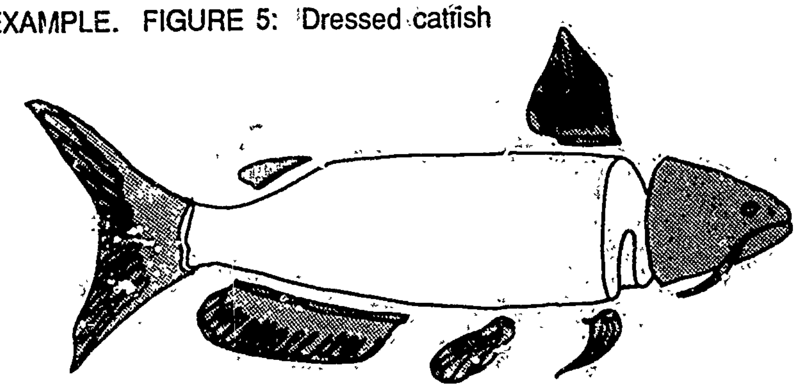
INFORMATION SHEET

X. Food-fish processing cuts and forms

(NOTE: Food fish may be sold live or processed. Processed food fish command the largest market, and may be sold fresh, cryogenically frozen, packed on ice, or—in the case of trout—smoked.)

A. **Dressed** — Dressed catfish are beheaded, eviscerated, and skinned (Figure 5); dressed trout are generally only scaled and eviscerated. (Figure 6)

EXAMPLE. FIGURE 5: Dressed catfish



EXAMPLE: FIGURE 6: Dressed trout filet and "in the round"

Courtesy Clear Springs Trout Company, Buhl, Idaho.

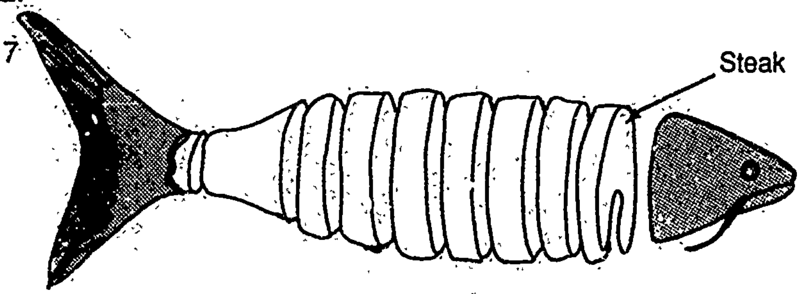
INFORMATION SHEET

B. **Steak cut** — Cross-section cuts from larger fish (Figure 7)

(NOTE: Large sea trout are often processed as steaks, but rainbow trout are rarely sold in steak form. Presently, catfish steaks are not very popular. The desired processing forms today run 60 percent filets, 35 percent whole, and only 5 percent steaks.)

EXAMPLE:

FIGURE 7

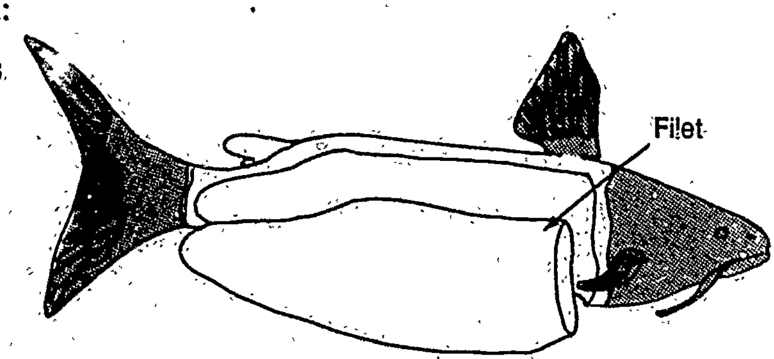


C. **Filet cut** — Boned side of the fish, cut lengthwise away from the backbone (Figure 8).

(NOTE: While rainbow trout have been traditionally processed "in the round," boneless butterfly trout filets are becoming increasingly popular.)

EXAMPLE:

FIGURE 8



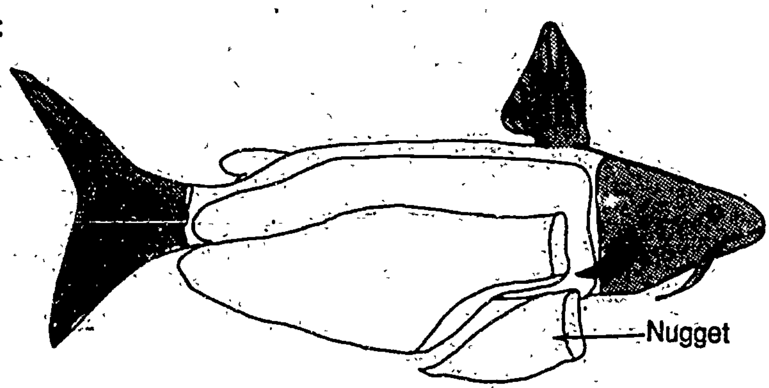
INFORMATION SHEET

D. **Nugget cut** — The belly flap off the filet (Figure 9)

(NOTE: Trout are not processed for nugget cuts.)

EXAMPLE:

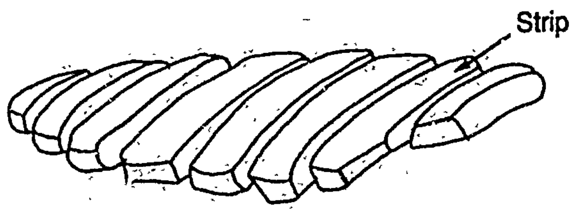
FIGURE 9



E. **Strip cut** — Smaller pieces of fish cut from filets. (Figure 10)

EXAMPLE:

FIGURE 10



XI. **Dressout percentages for catfish**

A. **Filet** — Usually averages about 42 percent of live weight; commonly marketed filet sizes are 3 to 5 ounces (3/4-pound fish), 5 to 7 ounces (1-pound fish), and 7 to 9 ounces (1½-pound fish).

B. **Shank and nugget** — About 83 percent and 17 percent of the regular filet, with the nugget averaging about 4 percent of the fish's live weight.

C. **Steaks** — Usually average about 75 percent of live weight, with steaks packaged by the pound, 6 to 8 per package.

D. **Dressed** — About 60 percent of live weight.

XII. **On-site versus plant processing**

A. Most large producers sell their fish crop to processing plants; this provides them with a secure market and saves harvesting and marketing time.

INFORMATION SHEET

B. Many small producers decide to process their own fish because the value-added return is so much greater than for sales to a processor or broker.

EXAMPLE: **Most profit**—Fish farmer to consumer
Less profit—Fish farmer to retailer to consumer
Least profit—Fish farmer to processor to broker to retailer to consumer

C. Modern processing plants are equipped with skinning machines, band saws for beheading fish, and state-of-the-art equipment for freezing, smoking, icing, and packaging the processed product. (Figures 11 and 12)

(NOTE: Filets are usually prepared by hand both at the processing plant and on-site because fileting machines are still being perfected, and those on the market are very expensive.)

EXAMPLE: FIGURE 11: A skinning machine with a high-speed rotating knife positioned in the table bed efficiently removes the skin from a catfish.

EXAMPLE: FIGURE 12: A bandsaw is used to behead fish and to cut fish into steaks.

INFORMATION SHEET

D. On-site processing is often done entirely by hand, though processing machinery is available if the size of the operation justifies it. (Figure 13)

(NOTE: A number of small producers in an area might consider a cooperative processing and marketing venture that would benefit all concerned. In this way they could share costs and assure an outlet for all fish raised.)

EXAMPLE: FIGURE 13: On-site processing, using hand labor to filet catfish.

E. Farmers who process, prepare, and package their own fish must be aware of state-mandated facility design requirements, and must be in compliance with local sanitary and waste disposal codes.

XIII. **Disposal of processing waste**

A. In some areas there is a market for frames (skeletons) that remain after the fish are fileted; among other uses, these are ground and used with other waste products in food for domestic pets.

B. Some processing plants market processed by-products that include viscera—sold to alligator producers, and heads—sold to commercial crab fishermen or crayfish producers.

C. For the most part, however, processing solid by-products are a liability to the processor, and traditional disposal methods have included trucking wastes to rendering plants and landfills.

D. Disposal of wastes is especially costly for major processing plants because the bulk of the processing waste is either dry rendered or made into silage.

1. **Dry rendering** units treat fish wastes with high temperatures to produce usable by-products, including high-grade fish oil and high-protein fish meal.

INFORMATION SHEET

2. Preparation of **fish silage** is a fairly new method of creating by-products from processed catfish wastes; typical by-products include fish meal and fish oil of higher protein than that produced by the rendering process, and high-protein concentrated silage that contains no bone.

   (NOTE: To produce silage, catfish wastes are ground up, heated, and treated with formic acid so that the skin and flesh are liquefied. The bones and much of the oil are then removed, and the silage is concentrated in a vacuum evaporator at 95°F.)

IV. **Permits and regulations**

A. Some states require commercial producers of fish and crayfish to obtain farming permits or licenses from the State Department of Wildlife and Fisheries.

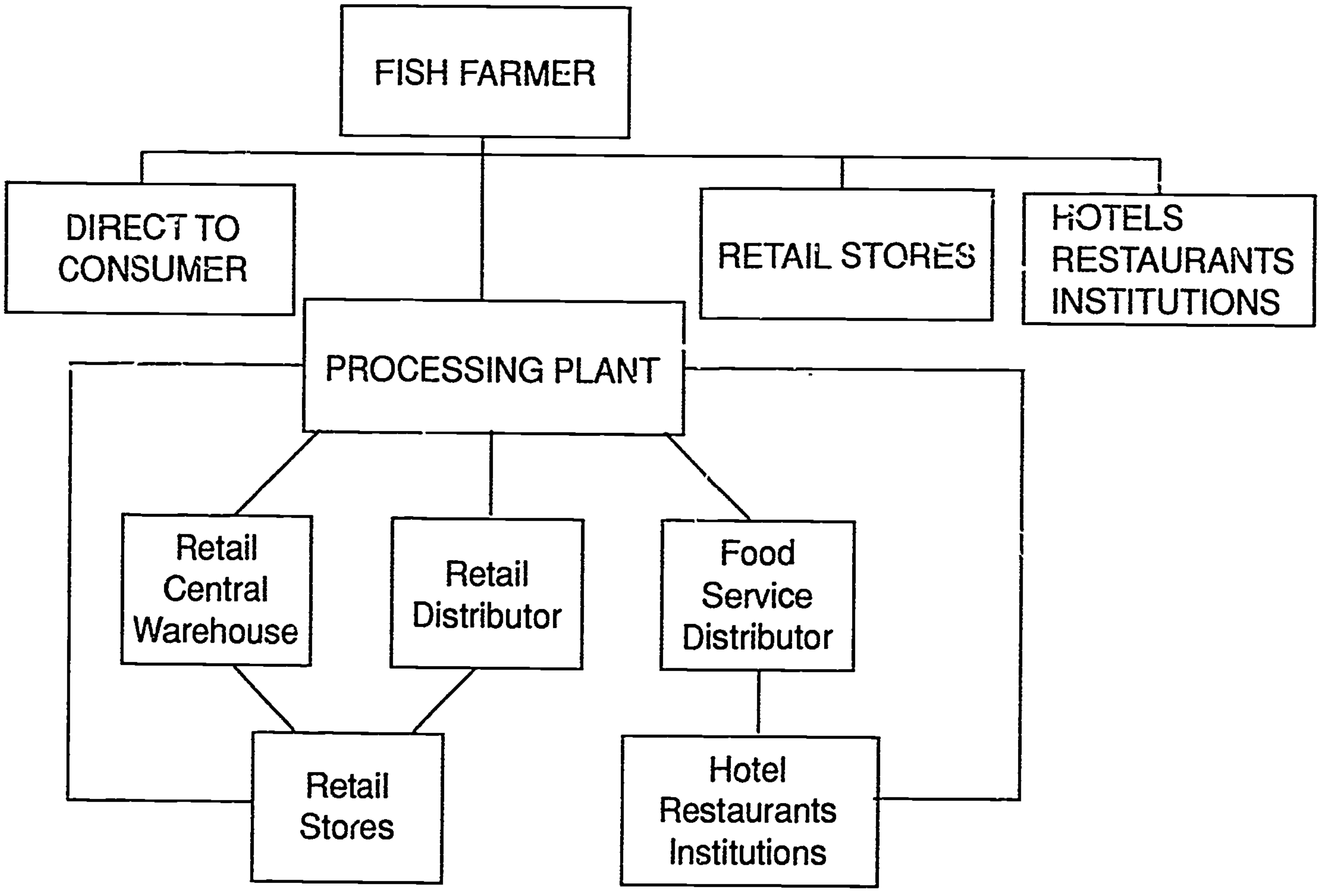
B. Some states may also require a commercial fish farmer's license, a wholesale/retail dealer's license, or a transport license for transportation over public roads and for sales taking place off the property.

C. While the federal government has no health, sanitation, or grading requirements for processed fish products at this time, states do have facility and sanitary requirements; permits are obtained from the county health and sanitation officer and from the state health office.

D. There are also laws regarding interstate and intrastate transportation of fish.

E. Laws and regulations may change from year to year, and vary from state to state, so it is wise to check with a representative of the appropriate agency or department when in doubt.

Marketing Flow Chart



Adapted from *Commercial Production of Farm-raised Catfish*, with permission.

MARKETING
UNIT IV

ASSIGNMENT SHEET #1 — SURVEY AREA MARKETS

In this assignment sheet, you will explore area markets to find where locally sold fish come from, who are the present and potential customers, what form, size, and species the customer desires, and the past and present market prices.

Visit individuals, organizations, churches, clubs, and groups that buy fish for family use, fish frys, and annual fund-raisers, dinners, and picnics. Visit area restaurants that include fish on their menus. Visit supermarkets, grocery stores, delicatessens, wholesalers, and retailers.

1. Which of these customers buy fish locally?
2. From whom do they buy their fish?
3. What species do they buy?
4. What product forms do they buy (steaks, filets, nuggets, etc.)?
5. What prepared forms do they prefer (fresh, fresh-frozen, iced, smoked, breaded, etc.)?
6. What sizes to they prefer?
7. What prices do they pay for the various processing and prepared forms?
8. How much fish (your product) do they use, and when do they use it? Do they buy heavily in the spring, summer, fall, or winter? Do they buy once a year or on a weekly or monthly basis?

Analyze the data you have collected and ask yourself the following questions.

1. How many producers are supplying the markets in my area?
2. If there are no area suppliers, why not?
3. Is there a demand for the species and enterprise I intend to undertake?

   (NOTE: Your product is of no value if you cannot sell it! You certainly would not start a baitfish enterprise in the middle of the desert, nor would you attempt to raise food crayfish in an area where few people consumed crayfish.)

4. If there are already producers in the area, is there enough market demand for more, or will I be competing for the same market?
5. Based on the present and past wholesale and retail prices of fish being sold in my area, can I price my product so that I can make a profit?

MARKETING
UNIT IV

JOB SHEET #1 — FILET AND PACKAGE A CATFISH

A. Equipment and materials

1. Tub containing live catfish
2. Running hot and cold water and dish detergent
3. Skinning hook
4. Skinning pliers
5. Gutting knife
6. Heavy-duty butcher knife or band saw
7. Filet knife
8. Scales
9. Plastic freezer bag
10. Freezer label/marking pen
11. Ice
12. Water brush
13. Rubber gloves and apron
14. Container for ice bath
15. Access to freezer

B. Procedure

1. Put on gloves and rubber apron.
2. Make an ice bath by placing about 1 gallon of water and 2 pounds of ice in a clean container.
3. Kill fish by cutting through backbone just behind head.
4. Hook fish by head to eye-level skinning hook.
5. Cut through skin just behind and on both sides of head.
6. Grasp flap of skin at head with skinning pliers and pull down on both sides.

JOB SHEET #1

7. Grasp remaining flap of skin at head and pull skin from belly flap.

8. Remove fish from skinning hook and lay on processing table.

9. Cut off head just behind opercles with heavy-duty butcher knife or a bandsaw if available.

10. Slit belly from anal opening to head area.

11. Gut fish, and use waterbrush to clean cavity.

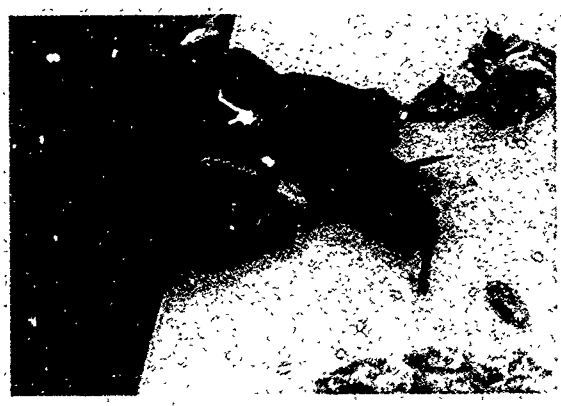
12. Lay the fish on one side with the head end pointing toward you.

13. Filet with filet knife. (Figure 1)

    a. Starting at backbone near head area, cut to and around the ribs and back to the backbone.

    b. Cut to and along backbone from head-end to tail, removing filet at tail.

FIGURE 1



14. Trim off pelvic flap and pelvic fins.

15. Turn fish over and repeat fileting process on other side.

16. Wash filets with waterbrush.

17. Place clean filets in ice bath for 15 to 30 minutes.

    (NOTE: The ice bath freshens the flesh and gives it body.)

18. Place the two filets in a plastic freezer bag, expel air from the bag, and seal.

19. Weigh the filets.

20. Label the package with the processing date and the weight.

JOB SHEET #1

21. Place the packaged filets in the freezer.
22. Discard fish waste in appropriate manner.
23. Clean all equipment and knives in hot, soapy water.
24. Dry equipment and return to proper storage.

MARKETING
UNIT IV

JOB SHEET #2 — PROCESS AND PACKAGE A TROUT

A. Equipment and materials

1. Tub containing live trout
2. Water brush
3. Hot and cold running water and dish detergent
4. Gutting knife
5. Plastic freezer bag
6. Freezer label/marking pen
7. Rubber gloves and apron
8. Clean container for ice bath
9. Access to freezer

B. Procedure

1. Prepare ice bath by putting about 1 gallon of water and 2 pounds of ice in a clean container.
2. Put on rubber gloves and apron.
3. Kill trout by cutting through backbone directly behind head.
4. Wash hard with waterbrush to remove scales.

   (NOTE: Trout scales are so tiny that all scales are not often removed.)
5. Slit belly from anal fin to underside of head.
6. Pull out entrails, and then reach further up and pull out gills; discard in proper receptacle.
7. Clean gut and gill cavities with water brush.
8. Place trout in ice bath for 15 to 30 minutes.
9. Place trout in freezer bag, expel air from bag, and seal.

JOB SHEET #2

(NOTE: Generally medium-sized trout are packaged two to a freezer bag. Large trout are packaged singly. Trout may also be fileted, and very large trout can be steak-cut.)

10. Weigh trout.

11. Label package with processing date and weight.

12. Place package in freezer.

13. Discard any fish waste in an appropriate manner.

14. Clean all equipment and knives in hot, soapy water.

15. Dry equipment and return to proper storage.

MARKETING
UNIT IV

PRACTICAL TEST #1

JOB SHEET #1 — FILET AND PACKAGE A CATFISH

Student's name ______________________________ Date ______________

Evaluator's name ______________________________ Attempt no. __________

Student instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:		Yes	No
1. Prepared ice bath.	1.	☐	☐
2. Skinned, beheaded, and gutted fish.	2.	☐	☐
3. Prepared filets and trimmed.	3.	☐	☐
4. Put filets in ice bath for proper length of time.	4.	☐	☐
5. Placed filets in air-free freezer bag.	5.	☐	☐
6. Weighed and labeled filets.	6.	☐	☐
7. Properly discarded waste and cleaned equipment.	7.	☐	☐

Evaluator's comments: ____

____

____

MARKETING
UNIT IV

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.

Criteria:

Preparation	Complete 4	Acceptable 3	Poor 2	Unacceptable 1
Skinning Process	Neat 4	Acceptable 3	Poor 2	Sloppy 1
Filet Preparation	Neat 4	Acceptable 3	Poor 2	Unacceptable 1
Packaging and Weighing	Complete 4	Acceptable 3	Fair 2	Unacceptable 1

EVALUATOR'S COMMENTS: ______________________________

PERFORMANCE EVALUATION KEY

4 — **Skilled** — Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program; limited additional training may be required.
2 — **Limited skill** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — is familiar with process, but is unable to perform jot

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

MARKETING
UNIT IV

PRACTICAL TEST #2

JOB SHEET #2—PROCESS AND PACKAGE A TROUT

Student's name ______________________ Date __________

Evaluator's name ______________________ Attempt no. __________

Student instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:		Yes	No
1. Prepared ice bath properly.	1.	☐	☐
2. Removed scales as required.	2.	☐	☐
3. Cleaned gut and gill cavities properly.	3.	☐	☐
4. Placed trout in ice bath.	4.	☐	☐
5. Packaged, weighed, and labeled trout.	5.	☐	☐
6. Cleaned equipment properly.	6.	☐	☐
7. Discarded waste properly and cleaned equipment.	7.	☐	☐

Evaluator's comments: ______________________

MARKETING
UNIT IV

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.

Criteria:				
Preparation	Complete 4	Acceptable 3	Poor 2	Unacceptable 1
Scrubbing and Gutting	Neat 4	Acceptable 3	Poor 2	Sloppy 1
Product Preparation	Neat 4	Acceptable 3	Poor 2	Unacceptable 1
Weighing and Labeling	Complete 4	Acceptable 3	Fair 2	Unacceptable 1

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — **Skilled** — Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program; limited additional training may be required.
2 — **Limited skill** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

MARKETING
UNIT IV

TEST

NAME ______________________________ SCORE __________

1. Match terms related to marketing with their correct definitions. Write the correct numbers in the blanks.

_____a.	Gutted; with internal organs removed	1. Market
_____b.	Frozen at very low temperatures	2. Cryogenically frozen
_____c.	Killed and prepared for the food market	3. Filet
		4. Eviscerated
_____d.	Buyer of product	5. Dressed
_____e.	Boneless sides of fish cut lengthwise away from backbone	6. Retail sales
_____f.	Sales of fish in large quantities to buyer who then sells to distributor or retailer	7. Wholesale sales
		8. Seed stock
_____g.	Larval fish or crustaceans; fry; small fingerlings	
_____h.	Sales of fish in small quantities directly to the consumer	

2. Select true statements about processing plant markets. Write the correct numbers in the blanks.

_____a. Which of the following is not a function of the processing plant market?

1) Buying fish from the producer
2) Dressing and packaging fish
3) Providing seed stock

_____b. In which of the following states are major processing plants located?

1) Oklahoma and Arkansas
2) Mississippi and Alabama
3) Florida and Louisiana

TEST

______c. Which of the following are typical charges for processing plants that provide harvesting and hauling services?

1) Harvesting costs at 3 to 5 cents a pound; hauling costs ranging from 1 to 5 cents a pound
2) Harvesting costs at 4 to 8 cents a pound; hauling costs ranging from 1 to 3 cents a pound
3) Harvesting costs at 1 to 3 cents a pound; hauling costs from 5 to 8 cents a pound

______d. What is the minimum live-weight load for typical processing plant hauling services?

1) 4,000 to 8,000 pounds
2) 2,000 to 12,000 pounds
3) 8,000 to 10,000 pounds

______e. What is the usual distance limit for processing plant hauling services?

1) 50 miles one-way
2) 75 miles one-way
3) 100 miles one-way

______f. Which of the following is typical of the length of lead time required by the processing plant for contracting harvesting and hauling services?

1) 7 to 60 days before harvest
2) 30 to 90 days before harvest
3) 3 to 7 days before harvest

3. Select true statements about live haul markets. Write the correct numbers in the blanks.

______a. Which of the following is the predominate destination of fish transported by live haulers?

1) Processing plants
2) Fee-fishing lakes
3) Retail markets

______b. Which of the following is a service provided by live haulers?

1) Harvesting
2) Grading
3) Transporting

______c. Which of the following is the typical minimum load for the live hauler?

1) 1,000 to 3,000 pounds
2) 2,000 to 4,000 pounds
3) 5,000 to 8,000 pounds

TEST

______d. Why must fish be in excellent condition for the live haul market?

1) So that they can be delivered to the processor live and be fresh-killed for dressing
2) So that they can withstand the acclimating and grading processes at the fish farmer's
3) So that they will survive the trip and can begin feeding in the fee-fishing pond

______e. When do live haulers generally purchase their fish?

1) In the fall after water temperatures have cooled enough for safe harvesting (typically mid-September to mid-November in the temperate southern states)
2) Only during sport fishing season (typically mid-April to mid-September in the temperate southern states)
3) In the early spring (mid-March to mid-May in the temperate southern states)

______f. Because of the short buying period, the farmer must often adjust production by doing which of the following?

1) Over-wintering fish
2) Alternating crop and fish harvests
3) Stocking in late fall

4. Select true statements about local markets: stores and restaurants. Write the correct numbers in the blanks.

______a. Which of the following would be LEAST likely to market to stores and restaurants?

1) Large enterprises
2) Small enterprises
3) Enterprises located in areas beyond processing plant haul distances

______b. How often must the farmer be able to harvest fish for this market?

1) Daily
2) Weekly
3) Monthly

______c. Why must the producer who markets to local stores and restaurants be prepared to process the fish on the farm?

1) Because many stores and restaurants will accept only dressed fish
2) Because it is the producer's responsibility to test for off-flavor
3) Because local and state laws often specify that fish must be processed before sale to restaurants and food stores

TEST

5. Select from a list true statements about local retail markets. Write an "X" in the blank before each correct statement.

______a. Food fish can be live or dressed, and purchased on the farm or delivered; baitfish, crayfish, and hobby fish are generally delivered.

______b. The producer may harvest food fish once or a few times a year and advertise by local radio and newspaper that fresh fish will be available of the farm at a certain date.

______c. Baitfish may also be transported from the farm to nearby population centers and sold directly from the haul truck to the consumer; this method also requires advance advertising.

______d. Other fish farmers buy broodfish, eggs, fry, and fingerlings.

______e. Depending on the location, area population, size of the operation, and number of competing producers in the area, this type of market ranges from fair to very poor.

6. Select from a list true statements about fee-fish markets. Write an "X" in the blank before each correct statement.

______a. In this market, the producer stocks one or more ponds, the customer pays a fee for entering the site and trying to catch fish, and usually is refunded the fee if no fish are caught.

______b. Some fee-fish producers also dress fish for a modest charge.

______c. Ponds may be open all year, only on certain days of the week, or only during certain periods; however, the fee-pond operator must be present whenever the pond is open for fishing.

______d. While the fee-fish market requires no harvesting, the operator may purchase stock from a producer, or a farmer may operate a fee-fish pond in addition to producing fingerlings or food-fish.

7. Complete statements about economy of scale. Write the correct number in the blanks.

______a. As a rule of thumb, production costs per pound of fish are usually ____ for large farms than those for small farms.

1) the same
2) lower
3) higher

TEST

______b. Unlike small farms, large farms can take advantage of ____ of feed and seed stock.

1) discounts for bulk purchases
2) seasonal sales
3) reduced amounts

______c. Larger ponds are ____ expensive per acre to build than small ponds.

1) more
2) less
3) as

______d. Large farms can sell wholesale to a processor or live-hauler, while profits may be ____ if small farms sell to a processor or wholesale market.

1) low or even negative
2) increased by 25 percent or more
3) even with investment costs

______e. ____ prices usually fluctuate more than ____ prices, and small farmers who must retail their products must advertise to be successful.

1) Market; credit
2) Wholesale; retail
3) Retail; wholesale

______f. These data do not mean that fish farming cannot be profitable for the ____ farmer: From a profit standpoint, what counts is the pounds of fish *marketed* each year, *not* the pounds of fish *produceo.*

1) extensive
2) large
3) small

8. List seven factors to consider when exploring market alternatives.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

TEST

9. Complete statements about product forms. Write the correct numbers in the blanks.

______a. Fish eggs sell by the ____ and the prices change annually, depending on the supply or the success of the hatchery.

1) hundred weight
2) unit
3) pound

______b. Some specialty markets exist for broodfish, especially if they are ____.

1) an improved or selected strain
2) sexually young
3) exotics

______c. Fry are generally sold by the ____, and fingerling fish longer than 1 inch are usually sold singly by the inch up to ____ inches; longer fish may be sold by the pound.

1) pound; 3
2) thousand; 8
3) thousand weight; 4

______d. Fingerlings or stocker fish are marketed primarily to commercial fish farmers and people who have recreational or farm ponds; a higher price is usually obtained ____.

1) than for wholesale sales to commercial farms
2) when selling wholesale to processors
3) when sales are made in the fall

______e. Food fish catfish and trout are normally ____ pounds in weight and are sold by the pound to either a wholesale or retail market.

1) 2 to 3
2) 2 1/2 to 2 3/4
3) 3/4 to 2

______f. Food crayfish are usually sorted size and sold by the ____ (softshell crayfish command a higher price than hardshell), and bait crayfish are sold by the ____.

1) piece; dozen
2) dozen; piece
3) pound; piece

______g. Baitfish are usually graded for size and may be sold by the ____ at the wholesale level or the _____ at the retail level.

1) thousand; container weight
2) dozen; piece
3) pound; piece

TEST

10. Match food fish processing cuts and forms with their correct descriptions. Write the correct numbers in the blanks.

______a.	The belly flap off the filet	1. Strip cut
______b.	Boned side of the fish, cut lengthwise away from the backbone	2. Nugget cut
______c.	Beheaded, eviscerated, and skinned (catfish), or scaled and eviscerated (trout)	3. Filet cut
______d.	Smaller pieces cut from filets	4. Steak cut
______e.	Cross-section cuts from larger fish	5. Dressed

11. Match catfish dressout percentages to processing cuts and forms. Write the correct numbers in the blanks.

______a.	About 83 percent and 17 percent of the regular filet	1. Filet
______b.	About 60 percent of live fish weight	2. Shank and nugget
______c.	Usually average about 75 percent of live weight, with those packaged by the pound, 6 to 8 to a package	3. Steaks
______d.	Usually averages about 42 percent of live weight; commonly marketed sizes are 3 to 5 ounces (2/4-pound fish), 5 to 7 ounces (1-pound fish), and 7 to 9 ounces (1 1/2-pound fish)	4. Dressed

12. Select from a list true statements about on-site versus plant processing. Write an "X" in the blank before each correct statement.

______a. Most small producers sell their fish to processing plants; this provides them with a secure market and saves harvesting and marketing time.

______b. Many large producers decide to process their own fish because the value-added return is so much greater than for sales to a processor or broker.

______c. Modern processing plants are equipped with skinning machines, band saws for beheading fish, and state-of-the-art equipment for freezing, smoking, icing, and packaging the processed product.

______d. On-site processing is often done entirely by hand, though processing machinery is available if the size of the operation justifies it.

TEST

13. Select from a list true statements about disposal of processing waste. Write an "X" in the blank before each correct statement.

______a. In some areas there is a market for frames (skeletons) that remain after fish are fileted; among other uses, these are ground and used with other waste products in food for domestic pets.

______b. Some processing plants market processed by-products that include viscera—sold to zoo keepers, and heads—sold to commercial crab fishermen and crayfish producers.

______c. For the most part, however, fish processing solid by-products are a liability to the processor, and traditional disposal methods have included trucking wastes to rendering plants and landfills.

______d. Disposal of wastes is inexpensive for major processing plants because the bulk of the processing waste is either dry rendered or made into silage.

______e. *Dry rendering* units treat fish wastes with quick freezing to produce usable byproducts, including high-grade fish oil and high-protein fish meal.

______f. Preparation of *fish silage* is a fairly new method of creating byproducts from processed catfish wastes; typical byproducts include fish meal and fish oil of higher protein that is produced by the rendering process, and high-protein concentrated silage that contains no bone.

14. Complete statements concerning permits and regulations. Write the correct numbers in the blanks.

______a. Some states require commercial producers of fish and crayfish to obtain farming permits from the ____.

1) State Department of Wildlife and Fisheries
2) U.S. Soil and Conservation Service
3) U.S. Department of Agriculture

______b. Some states may also require a ____ license, a wholesale/retail dealer's license, or a transport license for transportation over public roads and for sales taking place off the property.

1) fishing
2) conservation
3) commercial fish farmer's

TEST

_____c. While the federal government has no health, sanitation, or grading requirements for processed fish products, states do have facility and sanitary requirements; permits are obtained from the ____ and from the state health office.

1) county fish and wildlife ranger
2) county health officer
3) state department of wildlife management

_____d. There are also laws regarding ____ of fish.

1) feeding
2) interstate and intrastate transportation
3) market prices

_____e. Laws and regulations may change from year to year and vary from state to state, so it is wise to check with ____ when in doubt.

1) other fish farmers
2) the local game ranger
3) a representative of the appropriate agency or department

(NOTE: Test questions 15 and 16 list the assignment and job sheets. If they have not been completed, check with your instructor for scheduling dates and evaluation procedures.)

15. Survey local markets. (Assignment Sheet #1)

16. Demonstrate the ability to:

    a. Skin and filet a catfish. (Job Sheet #1)

    b. Dress and package a trout. (Job Sheet #2)

MARKETING
UNIT IV

ANSWERS TO TEST

1. a. 4 e. 3
   b. 2 f. 7
   c. 5 g. 8
   d. 1 h. 6

2. a. 3 d. 3
   b. 2 e. 1
   c. 1 f. 1

3. a. 2 d. 3
   b. 3 e. 2
   c. 3 f. 1

4. a. 1
   b. 2
   c. 1

5. a, b, d

6. b, c, d

7. a. 2 d. 1
   b. 1 e. 3
   c. 2 f. 3

8. Answer should include seven of the following:

   a. Market size (wholesale versus retail)
   b. Area market distribution
   c. Local and area competition
   d. Past and present market prices
   e. Harvesting and transporting strategy
   f. Product forms and sizes desired in market area
   g. On-site versus processing plant processing, packaging, and storing
   h. Processing forms desired in market area
   i. Seasonal ups and downs
   j. Advertising

ANSWERS TO TEST

9. a. 3
   b. 1
   c. 2
   d. 1
   e. 3
   f. 3
   g. 3

10. a. 2
    b. 3
    c. 5
    d. 1
    e. 4

11. a. 2
    b. 4
    c. 3
    d. 1

12. c, d

13. a, c, f

14. a. 1
    b. 3
    c. 2
    d. 2
    e. 3

15. Evaluated to the satisfaction of the instructor

16. a. Evaluated according to Practical Test #1
    b. Evaluated according to Practical Test #2

SITE SELECTION
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to evaluate a site for its fish farming potential. This competency will be evidenced by completing the assignment sheets and scoring a minimum of 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to site selection with their correct definitions.
2. List the three basic site requirements.
3. Select from a list facts to consider when evaluating a site's potential water sources.
4. List steps in determining a site's water quality.
5. Select facts about pond type and site evaluation.
6. Select from a list steps in determining whether soil is suitable for pond construction.
7. Match basic soil types to their characteristics.
8. Select facts about soil considerations in site selection.
9. Select facts about topographical considerations in site selection.
10. Select from a list general facts to consider in site selection.
11. List site-specific factors that determine costs.
12. Select from a list laws, regulations, and permits required to develop a site for fish farming.
13. Survey a site's potential as a fish farm. (Assignment Sheet #1)
14. Evaluate a potential site's soil quality. (Assignment Sheet #2)
15. Evaluate a potential site's water sources and quality. (Assignment Sheet #3)

OBJECTIVE SHEET

16. Complete a checklist to determine site's feasibility. (Assignment Sheet #4)

SITE SELECTION
UNIT V

SUGGESTED ACTIVITIES

A. Have available local soil, groundwater, and topographical maps to aid students in completing the assignment sheets and in selecting appropriate sites.

B. Invite a representative of the Soil Conservation Services, USDA, to speak to the class about the assistance that agency provides in site evaluation and layout.

C. Invite a representative of the Army Corps of Engineers to speak to the class about water use rules and regulations.

D. Invite a representative from a local well drilling company to visit the class and talk on the costs and processes of well drilling in the area.

E. Provide students with objective sheet. Discuss unit and specific objectives

F. Provide students with information sheet. Discuss information sheet, adapting and adding information specific to your state or locality.

EXAMPLES. Discuss soil types found in your area; provide students with local and state laws, regulations, and permit needs, and with specific addresses of agencies to contact.

G. Provide students with assignment sheets. Review assignment sheet information and schedule due dates.

H. If possible, have the class as a whole evaluate the potential of a mock site chosen by you. Discuss development potential and restrictions.

I. Have students complete assignment sheets. Evaluate and discuss in class.

J. Give test.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Coche, A. G. *Soil and Freshwater Fish Culture.* Rome: Food and Agriculture Organization of the United Nations, 1985.

B. Dupree, Harry K., and Jay V. Huner. *Third Report to Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington, D.C.: U.S. Fish and Wildlife Service, 1984.

SUGGESTED ACTIVITIES

C. Hepher, Balfour and Yoel Pruginin. *Commercial Fish Farming.* New York: John Wiley & Sons, 1981.

D. *Inland Aquaculture Engineering.* Rome: United Nations Development Program, Food and Agriculture Organization of the United Nations, 1984.

E. Jensen, Gary L. *Commercial Production of Farm-Raised Catfish.* Louisiana Agricultural Experiment Station, Louisiana Cooperative Extension Service, 1988.

F. Lee, Jasper S. *Catfis. Farming: A Reference Unit.* Jackson, Mississippi: Division of Vocational and Technical Education, Mississippi State Department of Education, 1971.

G. *Pond Management in Oklahoma.* Oklahoma City: Fish Division, Oklahoma Department of Wildlife Conservation, 1984.

H. *Ponds — Planning, Design, Construction.* Handbook 590. Washington, D.C.: U.S. Department of Agriculture, Soil and Conservation Services, June 1982.

I. Reigh, Robert C., ed. *Proceedings of the Louisiana Aquaculture Conference 1988.* Baton Rouge, Louisiana: Louisiana State University Agriculture Center, Louisiana Cooperative Extension Service, 1988.

J. Swift, Donald R. *Aquaculture Training Manual.* Surrey, England: Fishing News Books, Ltd., 1985.

SITE SELECTION
UNIT V

INFORMATION SHEET

I. Terms and definitions

A. **Friable** — Easily crumbled or crushed into powder

B. **Coherent** — Sticking together, as with soil particles

C. **Permeability** — Rate of penetration by liquids

(NOTE: Soils that are permeable can be penetrated by fluids. Soils or materials that are impermeable cannot be penetrated by fluids. Those that are semi-permeable resist fluid penetration.)

D. **Plasticity** — Capacity of soil to be bent without breaking and to remain bent after force is removed

E. **Water table** — Level below which the ground is saturated with water

F. **Substrata** — Subsoils

G. **Seepage** — To flow out slowly through the pond bottom material

H. **Drainage** — May refer to methods of draining a pond or to surface water runoff

I. **Wetland** — Area that is covered with standing water or is saturated most of the year, and that supports mainly water-loving plants

(NOTE: Wetlands are primary habitats and breeding grounds of many waterfowl. The conversion of wetlands to crop production—including fish crops—threatens waterfowl populations.)

J. **Aggregate** — Soil made of a mixture of mineral particles

K. **Infiltration** — To filter through small gaps or passages

L. **Runoff** — Rain that does not infiltrate the soil so flows to ponds, streams, and depressions

M. **Topography** — Surface features of a region; the lay of the land

N. **Sediment** — Matter that settles to the bottom of a liquid

O. **Flatland** — Area with not more than 3 percent slope

(NOTE: Flatlands used for pond or raceway sites need some slope for gravity drainage.)

INFORMATION SHEET

II. Basic site requirements

A. Adequate supply of good quality water

B. Subsoils that hold water

C. Suitable topography

III. Facts to consider when evaluating the site's potential water sources

A. Wells

1. Wells are the preferred water source, provided that enough water is available at an affordable energy cost.

2. If a well is to be the primary water source, adequate groundwater must exist in the proposed site before ponds or raceways are constructed.

3. The availability of groundwater varies with location, as do underground water-bearing formations.

   (NOTE: Groundwater maps of the area may be available from the U.S. Soil Conservation Service.)

4. A test bore well should be drilled to evaluate quality, quantity, and location of groundwater.

5. Well water is usually free of pollution, although some undesirable gases (hydrogen sulfide), minerals (iron), or chemicals (ammonia) may have to be removed.

6. Low oxygen is a problem with well water, but aeration will remedy this.

7. Wells are free of contamination by wild fish.

B. Spring water

1. Year-round availability must be evaluated by observing water flow from the spring(s), especially during fall when discharge is usually lowest.

2. Springs have a constant temperature and require no pumping costs to bring water to the surface.

3. Spring water is cool; continuous flow through a pond may make the pond water too cool for some warmwater species such as catfish, and a warming pond may be needed.

4. Spring water may be low in oxygen and require aeration, or it may be supersaturated with nitrogen gas and require investment in degassing equipment to avoid fish kills.

5. Because springs may contain wild fish, mechanical filtration is needed.

INFORMATION SHEET

C. Surface runoff

1. Surface runoff from a watershed is not a dependable supply of water; annual runoff is unpredictable, and the potential fish farmer must evaluate each of the numerous physical characteristics that affect water yield.

   EXAMPLES: Relief, soil infiltration, plant cover, surface storage; and amount, intensity, and duration of rainfall

2. The watershed area must be large enough to maintain water in the pond during drought, yet not so large that expensive overflow structures are needed to bypass runoff during storms.

3. An oversized watershed causes pond water to be changed too often, flushing out nutrients and animal life; washes too much silt into the pond; causes erosion of the spillway and dam; and may require a diversion canal.

4. Areas completely covered with grasses or woody vegetation make the best watersheds.

5. Properly grazed pastureland provides the second best watershed.

6. Heavily fertilized cultivated land provides the least desirable watershed cover; if used, it must be free of toxic insecticides and herbicides and should be protected from erosion by conservation measures.

   EXAMPLES: Terracing, contour tillage, strip cropping

7. Surface runoff is often used as a source of water for hill ponds and those that supplement rather than provide the principal farm income.

D. Surface water from rivers, reservoirs, lakes, bayous, canals

1. Water pumped from these sources is generally the least consistent and least desirable water supply

2. Agricultural, industrial, or municipal activities upstream or elsewhere may pollute the water with pesticides and other contaminants that can kill fish.

3. Silt loads are often heavy and can cause damage to fish or fill impoundments.

4. Surface water may contain fish eggs, wild fish and predatory species that may compete with the farmed species, amphibians and their eggs, and disease organisms.

5. Use surface water only if it can be managed economically; if surface water is used, a proper filter system is essential.

INFORMATION SHEET

IV. Steps in determining a site's water quality

A. Perform chemical analyses of water during site selection to determine whether the water quality is suitable for fish production.

B. Select a location where drainage from farms, feedlots, corrals, sewage lines, mine dumps, and similar areas cannot reach the pond.

C. Select a location free from industrial runoff or direct discharge of industrial waste into water source.

D. Note potential contaminating activities in the surrounding watershed.

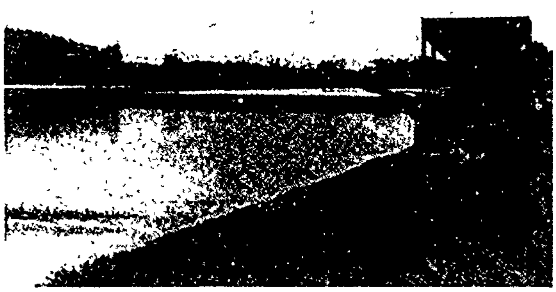
EXAMPLE: Adjacent land in row crop production receiving aerial pesticides that may drift with the wind and contaminate your pond or water source.

V. Pond type and site evaluation (Figures 1-3)

A. Levee (dike) ponds

EXAMPLE:

FIGURE 1



1. Most commercial ponds are earthen dike ponds built on flatlands.

2. Dike ponds have four raised levees, are usually rectangular, and have relatively level bottoms; maximum water depth is usually 4 to 8 feet.

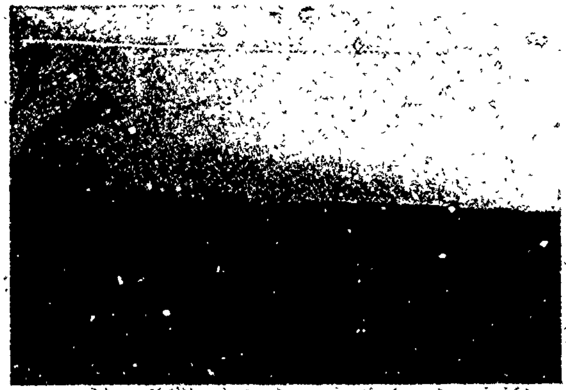
3. The chosen site should be large enough to enable the construction of the desired number of ponds for both present and future.

INFORMATION SHEET

B. Hill ponds

EXAMPLE:

FIGURE 2



1. Hill ponds are generally not as suitable for intensive culture as other pond types, but they may be profitable for cage culture or fee fishing.

2. Hill ponds are usually created by damming a gully or valley, have an irregular shape, have relatively steep bottom slope, and are 10 to 20 feet deep near the dam.

3. The type and condition of the watershed, and the ratio of watershed area to pond area are very important considerations in hill site selection.

4. Hill ponds, with their irregular shapes and bottom contours, are difficult to harvest except by complete draining, but skillful pond placement and construction can make harvesting efficient and ensure water supplies in all but the driest years.

5. Hill ponds are often built parallel to the contour of the hill.

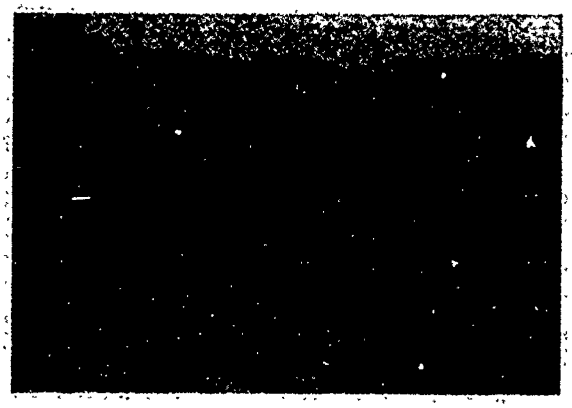
6. Drainage and overflow structures are necessary.

INFORMATION SHEET

C. Excavated ponds

EXAMPLE:

FIGURE 3



1. Excavated ponds are dug out below the soil surface; therefore it is important that the substrata have good water retention properties.

2. These ponds may be regular or irregular in shape, have relatively level bottoms, and a maximum water depth of 5 to 9 feet.

3. Surface runoff or springs generally serve as the water sources for these ponds.

4. These ponds usually have to be drained by pumping.

VI. **Steps in determining whether soil is suitable for pond construction**

A. Refer to soil maps of the area for information on the types of soils found on the proposed site.

B. Learn the characteristics of the different soil types, and look for soils with a slow infiltration rate and high runoff potential.

C. Perform simple preliminary visual and field tests to evaluate the suitability of the soil.

EXAMPLES: Checking color, odor, texture, permeability and so on as outlined in Assignment Sheet #2

D. After a tentative pond site has been chosen, contact the U.S. Soil Conservation Service to provide soil tests, soil analyses, and technical assistance in site layout.

INFORMATION SHEET

VII. Characteristics of basic soil types

A. **Sand** — Noncoherent visible particles of rock that when dry run through the fingers like water; these soils do not stick to tools, are easy to work with, and water circulates through them very easily.

B. **Inorganic silt** — Very fine, closely packed particles not visible to the eye; does not crack when dry or stick to tools when wet, is harder to work than sandy soils but easier than clayey soils, is less permeable than sand, and does not let water through as easily.

(NOTE: Inorganic silt has a smooth appearance just like clay, and is often mistaken for clay. However, it can be distinguished from clay in the field by using the Shaking Test outlined in Assignment Sheet #2. This distinction is very important because some silty soils become very unstable when wet, as, for example when used for dike construction and placed underwater. Clay, on the other hand, is a stable construction material.)

C. **Organic silt** — Particles of inorganic silt mixed with particles of organic matter; color varies from light to very dark grey, and this soil may have the odor of decaying organic matter.

D. **Inorganic clay** — Finest part of soil, with some particles not visible even under a microscope; absorbs water very slowly but will hold water once absorbed and will swell to more than double its volume; becomes very sticky when wet, and when it loses water it cracks and forms hard lumps; usually yellow, red, or white.

(NOTE: When clay soils are wet, they are often too sticky to work, and when they are dry, they are often too hard to work.)

E. **Organic clay** — Particles of inorganic clay mixed with organic matter; generally dark grey or black with a strong odor of decaying organic matter.

F. **Peat** — Wholly organic soil made of visible fragments of decayed plant material; color varies from light brown to black, and it has an odor of organic matter.

G. **Hardpan** — Very dense mineral soil of clay, sand, and gravel that has been cemented together to form a rock-like layer; it will not soften when wet, and a pick must be used to dig in it.

H. **Loam** — Rich, dark brown soil made of clay, sand, and organic matter; may be semi-impermeable to impermeable, depending on the proportion of clay.

VIII. Soil considerations in site selection

A. The best soils for fish culture are the sandy clay, silty clay loam, or clay loam soils with clay particles representing more than 50 percent of total dry weight.

B. A site may be considered suitable for a pond if the soil will ensure good water retention (clay or sand clay soils).

INFORMATION SHEET

C. If not enough clay is present, consider another site or the costs of trucking in clay to core (plate) the dam and pond basin.

D. A site may be considered unsuitable for dike ponds if it contains rock outcroppings or big surface stones, gravel beds or rocky soils, limestone or shale areas, sandstone soils, or organic soils such as peat.

E. Look for watershed soils with a slow infiltration rate: clay soils with a high swelling potential, soils with a high water table, soils with claypan at or near the surface, and shallow soils over impermeable rock.

F. After choosing a tentative site, learn the soil history, and then have the soil analyzed for possible pesticide residue if necessary.

> POINT OF INTEREST: The pesticides of greatest concern are chlorinated hydrocarbon residues, especially endrin and toxaphene. If cotton was grown on the proposed site any time after 1940, or if cotton was grown on adjacent land, these pesticides can remain in the top several inches of the soil. Contaminated soil will kill fish, however, it can be used for filling centers of levees or for outside slopes. The County Cooperative Extension Service Office can provide advice on procedures for collecting samples, and assist in providing soil sample containers and in contacting the state soil testing laboratory.

IX. Topographical considerations

A. Topography, particularly in hill ponds, often dictates the size, shape, and number of ponds possible.

B. Flatlands generally make the best sites for ponds.

C. The lay of the land determines the amount of dirt to be moved: generally, less dirt must be moved on flat land than on hilly, rolling land.

D. Often land that is considered marginal for field crops, or even wasteland, can be used.

E. Avoid sites in low-lying areas of floodplains: flooding can damage levees, ruin a fish crop, allow wild fish to enter a culture pond, and make draining difficult or impossible.

(NOTE: If an area is considered to be a "wetland," a Section 404 construction permit from the U.S. Army Corps of Engineers is required. See Information Sheet, Section XII for details.)

F. The topography around ponds should permit drainage by gravity flow during any season; if natural draws are absent, drainage ditches may have to be excavated.

G. Rivers, bayous, or drainage ditches should be at an elevation lower than that of the proposed drainpipe.

INFORMATION SHEET

H. Avoid damming creeks or large, deep draws: Ponds of this type usually become muddy, silt-in rapidly, develop unwanted fish populations, and lose valuable nutrients when they overflow; in addition, they are dangerous as their dams may blow out.

X. General facts to consider in site selection

A. If fish culture is to become the primary source of income, make sure that enough land is available for future expansion.

B. If water must be used elsewhere, such as for irrigation or fire protection, locate the pond site as close to the major water use as possible.

C. Beware of areas where natural phenomena—such as hurricanes or floods—occur regularly.

D. Evaluate access to the site from major roads and the condition of the roadways that will be used by heavy trucks.

E. Determine the location of the nearest power line and telephone line, and evaluate access costs.

F. Think about the site's proximity to available markets, feed suppliers, stock suppliers, and medical and chemical suppliers.

G. Choose a site on which the pond can be located to the best advantage of the prevailing wind direction

(NOTE: Wind-caused waves damage levees, shorelines, and dams, but construction of the long levee parallel to the direction of the prevailing wind increases wave action on the water surface and thus increases aeration and the mixing of the water, both of which are good for fish production.)

H. If possible, protect against theft and poaching by choosing a site where the ponds are visible.

XI. Site-specific factors that determine costs

(NOTE. In Unit VI, "Faculty Design and Layout," you will complete a feasibility study of the selected site, and estimate construction costs. In selecting a site, however, you must bear in mind the following factors that affect costs.)

A. Topography

EXAMPLE. Determines the cost of construction and the size and shape of the pond or raceway.

B. Depth to groundwater

EXAMPLE. The deeper the well, the more expensive the pumping and drilling costs.

INFORMATION SHEET

C. Location of energy source

EXAMPLE: If the power and telephone lines are near the site, access costs are lower.

D. Size and shape of ponds

EXAMPLE: Large, regularly shaped ponds are less expensive to construct on a per acre basis than some smaller ponds or hill ponds on steep slopes.

E. Size of farm

EXAMPLE: The principle of economy of scale: Investment costs per acre generally decrease as farm sizes increase; production and operating costs are usually higher for smaller farms that cannot benefit from discounted bulk purchases.

F. Enterprise chosen

EXAMPLE: Trout culture requires raceways; some enterprises require facilities other than ponds—hatching troughs, holding troughs, processing equipment.

G. Type of production method planned

EXAMPLES: Cage culture can be carried out in existing ponds of 1 acre with a minimum end depth of 8 feet; raceways or tanks require less acreage but different construction considerations and costs.

H. Type of soil

EXAMPLE: The cost is high to move peat soils or those high in organic matter.

I. Soil conditions

EXAMPLE: Soils containing pesticide residues cannot be used for pond bottom or dike construction, except as limited fill or on outside slopes.

J. Dirt to be moved and vegetation to be cleared

EXAMPLE: The more dirt moved and trees cleared, the higher the construction costs; the site selected should be one that requires the least amount of earthfill and clearing of trees and vegetation.

K. Whether land is owned or purchased

EXAMPLE: Flat land may be more expensive to purchase than hilly land, but hill ponds are usually more difficult to manage and less profitable.

INFORMATION SHEET

XII. Laws, regulations, and permits

(NOTE: Laws, regulations, and permits vary from state to state, and may change from year to year. If in doubt, check with a representative of the appropriate state or federal agency. Your County Cooperative Extension Service can also be of help.)

A. You may need to obtain a permit from the State Department of Natural Resources before drilling a well.

B. You will need a permit from the Army Corps of Engineers or the Environmental Protection Agency before diverting, damming, or altering the course of a river or stream.

C. You may need to secure a legal right-of-way if needed for access to market roadways.

D. Wells that pump over a certain capacity per day may be required to be registered with the State Department of Water Resources.

E. You may need a discharge permit from the Department of Environmental Quality (DEQ).

(NOTE: Regulations vary from state to state on the volume of allowable discharged water and the source of the discharged water. Processors, for instance, may need a permit for point-source discharge into state waters.)

F. You must notify the utility company and get permission to dig if above ground or underground cables or lines for power, natural gas, or water exist on the proposed site.

G. The Swampbuster Provision of the Food Security Act of 1985 discourages the conversion of wetlands for agricultural production, including fish culture.

1. If you convert wetlands to fish ponds without the necessary permits, you may lose your eligibility for certain USDA programs on all the land you farm, not just the wetlands.

2. When applying for USDA farm programs, applicants must certify that no crops (including fish) are being produced on any land that has been converted from wetlands since December 1985.

   (NOTE: Certification is obtained through county offices of the USDA Agricultural Stabilization and Conservation Services [ASCS].)

3. You need a permit to convert wetland to fish production; it can be obtained from the U.S. Army Corps of Engineers, Office of the District Engineer.

4. You must obtain a water quality certification permit by the EPA or state department of environmental quality before you will be issued a Section 404 construction permit.

INFORMATION SHEET

H. Know the local laws regarding poaching and trespassing. (Figure 4)

EXAMPLE: FIGURE 4

SITE SELECTION
UNIT V

ASSIGNMENT SHEET #1 — EVALUATE A SITE FOR ITS POTENTIAL AS A FISH FARM

To evaluate a site for a potential fish farm, you will have to walk the land and judge its suitability based on your requirements. It may be to your advantage to find more than one possible site and choose among them on the basis of your water requirements and the topography, soil, and vegetation present at each site. You should also take into consideration the site-specific cost factors outlined in Information Sheet, Section XI.

1. Begin your evaluation by drawing a small sketch map of the available and adjacent land. Locate all the major topographical features such as existing ponds and buildings, springs, swamps, gravel beds, rock outcroppings, hills, forest, grasslands, roads, railways, and power lines.

2. Eliminate from consideration areas with large surface stones, gravel beds, or rock outcroppings that are unsuitable for pond construction, eliminate also heavily forested areas.

3. Evaluate the remaining area for accessibility to power and water sources, and then sketch in proposed pond sites and locations of water supply.

4. Now make a field evaluation of the soil and watershed in the proposed site(s) (Assignment Sheets #2 and #3)

   (NOTE: Make your own quick soil analyses as outlined in Assignment Sheet #2, and then enlist the services of the U.S. Soil Conservation Services.)

5. Analyze the water quality of your proposed water sources (Assignment Sheet #3), and, if a well is to be one of your water sources, have a test bore well drilled to determine the quality, quantity, and location of groundwater.

   (NOTE: These are the actual steps taken by a prospective fish farmer, but for this exercise, you would not have an expensive test bore well drilled.)

6. Return to your sketch map and make any site location adjustments necessary as a result of your soil and water testing.

7. Now you are ready for the next step in the process, pond layout and design, which is explained in the following unit.

SITE SELECTION
UNIT V

ASSIGNMENT SHEET #2 — EVALUATE A POTENTIAL SITE'S SOIL QUALITY

A good understanding of soil and its characteristics is one of the most important of many factors that must be considered for successful site selection for freshwater fish farming.

To choose a successful site for fish farming, you must know your soil well. Before building your fish pond, you will need to test your soil to see if the texture, consistency, permeability, and saturation levels on the site you have selected are suitable for building a pond, supply canals, dikes, dams, or levees.

Survey the soil of your potential site by removing soil from different depths and conducting some of the following simple field tests.

A. <u>Quick field tests to determine soil texture</u>

1. **Shaking test (to differentiate clay from silt)**

   (NOTE: Silt and clay soils both have very smooth textures. It is important to be able to tell the difference between these two soils. When silt is used as a construction material for dams and dikes, it may not have enough plasticity, and when wet, it may become very unstable.)

   a. Take a sample of soil and wet it.

   b. Form a small patty about 1 1/2 inches thick and 3 inches in diameter.

   c. Place the patty, which will appear dull, in the palm of your hand, and shake it from side to side.

      — If its surface becomes shiny, it is silt.

      — If its surface remains dull, it is clay.

   d. Confirm this result by bending the patty between your fingers.

      — If the surface becomes dull again, it is silt.

   e. Put the patty aside and let it dry completely.

      — If it is brittle and dust comes off when rubbing it, it is silt.

      — If it is firm and dust does not come off when rubbing it, it is clay.

2. **Throw-the-ball test**

   a. Strain soil sample through a sieve with 2 mm openings to separate earth from larger particles.

   b. Moisten the strained fine earth.

ASSIGNMENT SHEET #2

c. Take a handful of the moist soil and squeeze it into a ball.

d. Throw the ball into the air about 2 feet and then catch it.

— If the ball falls apart, it is poor soil with too much sand in it for pond construction.

— If the ball sticks together, it is probably good soil with enough clay in it for pond construction.

3. **Squeeze-the-ball test**

a. Strain soil to separate fine earth from larger particles as in Step 1a above.

b. Take a handful of fine soil and wet it so that it begins to stick together without sticking to your hand.

c. Squeeze hard, and then open your hand.

☐ **Good** — Soil retains the shape of your hand.

☐ **Poor** — Soil does not retain the shape of your hand.

4. **Test for proportions of sand, silt, and clay.**

a. Place about 1 cup of soil in a clear glass bottle and fill the bottle with water.

b. Stir the water and soil well.

c. Put the bottle down and do not touch it for an hour.

d. At the end of an hour, the soil will have settled into layers: the bottom layer will be sand, the middle layer silt, and the top layer clay.

ASSIGNMENT SHEET #2

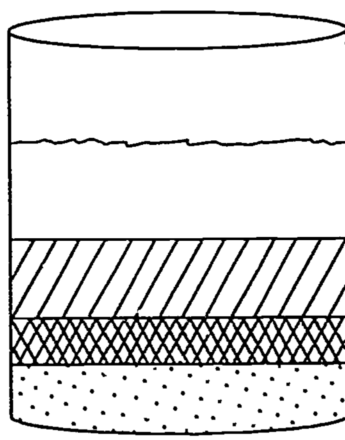
e. Measure the depths of each of the layers, and estimate the proportion of each. (Figure 1)

☐ **Poor** — High proportion of sand to clay

☐ **Fair** — High proportion of silt to clay

☐ **Good** — High proportion of clay to sand

FIGURE 1



B. <u>**Quick field tests to determine soil's consistency**</u>

(NOTE. Soil consistency is a measure of the soil's ability to hold together and to resist deformity and cracking. Wet soils suitable for pond construction should be sticky and plastic. Moist soils should be firm. Dry soils should be hard after air drying.)

1. **Field test for stickiness of wet soil**

   (NOTE: This test should be done when the soil is saturated with water. The best time is after a heavy rainfall.)

   a. Place a small amount of soil between your thumb and forefinger to see if it will stick to your fingers.

   b. Slowly open your fingers.

   c. Rate the stickiness and suitability for pond construction as follows:

   ☐ **Poor** — <u>Non-sticky</u> if no soil or practically no soil sticks to your fingers

ASSIGNMENT SHEET #2

☐ **Fair** — Slightly sticky if the soil begins to stick to your fingers but comes off one or the other cleanly and does not stretch when the fingers are opened

☐ **Good** — Sticky if soil sticks to both fingers and stretches a little before breaking when fingers are pulled apart

☐ **Best** — Very sticky if soil sticks firmly to both fingers and stretches when the fingers are opened

2. **Field test for plasticity of wet soil**

   a. Roll a small amount of wet soil between the palms of your hands until it forms a rope about 1/2" thick.

   b. Rate the soil's plasticity and suitability for pond construction as follows:

   ☐ **Poor** — Non-plastic if no rope can be formed

   ☐ **Fair** — Slightly plastic if rope can be formed but can be easily broken and returned to its former state

   ☐ **Good** — Plastic if rope can be formed but not re-formed after it is broken and returned to its original state

   ☐ **Best** — Very plastic if rope can be formed and not broken easily, and if rope can be re-formed several times

3. **Field test for moist soil consistency**

   (NOTE: Perform this test when the soil is moist but not wet. Test, for example, 24 hours after a good rainfall.)

   a. Try to crush a small amount of moist soil by pressing it between your thumb and forefinger.

   b. Rate moist soil consistency and suitability for pond construction as follows:

   ☐ **Very poor** — Loose if soil is noncoherent (will not stick together and is composed of single grains)

   ☐ **Poor** — Very friable if soil crushes easily under very gentle pressure but will stick together if pressed again

   ☐ **Fair** — Friable if soil crushes easily under gentle to moderate pressure

ASSIGNMENT SHEET #2

☐ **Good** — Firm if soil crushes under moderate pressure but resistance is noticeable

☐ **Best** — Very firm if soil crushes under strong pressure, but this is difficult to do between thumb and forefinger

4. **Field test for dry soil consistency**

(NOTE: Conduct test after soil has air dried.)

a. Try to break a small amount of dry soil by pressing it between your thumb and forefinger.

b. Rate dry soil consistency and suitability for pond construction as follows:

☐ **Very poor** — Loose if soil is noncoherent (single-grain structure)

☐ **Poor** — Soft if soil is very weakly coherent and friable, breaking to powder or individual grains after only slight pressure

☐ **Fair** — Slightly hard if soil resists light pressure, but can be broken easily between thumb and forefinger

☐ **Good** — Hard if soil resists moderate pressure, can barely be broken between thumb and forefinger, but can be broken in the hands without difficulty

☐ **Best** — Very hard if soil resists great pressure, cannot be broken between the thumb and forefinger, but can be broken in the hands with difficulty

C. **Field test to determine soil permeability**

1. Dig a hole as deep as your waist.
2. Early in the morning, fill it with water to the top.
3. In the evening, after some water has seeped into the soil, again fill the hole with water to the top.
4. Cover the hole with boards or leafy branches.
5. Check the water level the next morning; if most of the water is still in the hole, the soil permeability is suitable for building a pond at this location.
6. Repeat this test in several other locations as many times as necessary, according to the soil quality.

ASSIGNMENT SHEET #2

D. Field test for soil's resistance to water saturation

(NOTE: When you are selecting materials for embankment construction, it is very important to determine the ability of a soil to resist water saturation.)

1. Dig a 3-foot hole in the ground, line with a plastic sheet, and fill with water; or use a large metal drum filled with water.
2. Take a sample of soil and wet it well.
3. Kneed it with your hands until it becomes a stiff, plastic mass.
4. Make several balls about the size of an orange.
5. Place the balls in the hole or drum in still water about 3 to 5 feet deep.
6. Cover the pit with plastic anchored with rocks, or the drum with a cover.
7. Check the balls of soil every few hours at first, and later several times in a 24-hour period.
8. Rate the soil's resistance to saturation and its suitability for embankment construction as follows:

☐ **Not good** — The balls fall apart within a few hours

☐ **Good** — The balls do not fall apart but remain intact for at least 24 hours

This assignment sheet adapted from *Soil and Freshwater Fish Culture* by A. G. Coche. With permission.

SITE SELECTION
UNIT V

ASSIGNMENT SHEET #3 — EVALUATE A POTENTIAL SITE'S WATER QUALITY

A water supply for an aquaculture facility must have several characteristics to be considered "good." Oxygen content, temperature, pH, alkalinity, hardness, chlorides, and dissolved gases should all be within optimum ranges for the species you intend to raise. You must also check any potential water supply for pollution, especially from chemicals.

1. Trace to its source any stream or spring you are considering for a water source.

2. Note agricultural and industrial use on adjacent land and watersheds.

3. Learn the history of any watershed that could drain to your water source.

   (NOTE: Pay particular attention to any land on which cotton was grown since 1940, as this soil can hold residual chlorinated hydrocarbons that can be lethal to fish. Areas previously used for air strips; pesticide storage, disposal, or loading; and dip areas for livestock may also contain undesirable levels of chlorinated hydrocarbons.)

4. If you plan on using surface water from lakes, rivers, reservoirs, etc., note agricultural, municipal, and industrial activities that may pollute these sources.

5. If you plan on using well water, analyze the quality of the water to detect any problems with high iron content, heavy metals, nitrogen levels, or other possible contaminants.

   (NOTE: The U.S. Soil Conservation Service or you County Cooperative Extension Service can aid you in this analysis.)

6. After you have checked your water sources for pesticide contamination and pollution, use a multi-test water analysis kit (Hach Kit) to check your water source for the following variables. Check morning noon and night to get an overall idea.

   (NOTE: Specific directions for checking water parameters can be found in the unit titled "Water Quality." Water analysis kits are convenient and easy to use. They contain packets of reagents [chemicals] that are added to known volumes of water. You take readings by simply counting drops of chemical or noting obvious color changes.)

   a. Test water to determine amount of **dissolved oxygen**, and compare findings to lethal ranges in Table 1.

      (NOTE: The amount of DO in water fluctuates widely depending on a number of variables. For the purpose of site selection, you need only a rough estimate of DO content, especially in well water and some spring water, which may contain little or no DO.)

ASSIGNMENT SHEET #3

TABLE 1: Optimum and Lethal Levels of Dissolved Oxygen for Selected Fishes

Species	Optimum Level (ppm)	Lethal Level (ppm)
Bluegill	5.0	0.5 to 3.1
Channel catfish	5.0	0.8 to 2.0
Fathead minnow	5.0+	1.0
Golden shiner	5.0	1.4
Goldfish	5.0	0.1 to 2.0
Grass carp	5.0	0.2 to 0.6
Largemouth bass	5.0+	0.9 to 3.1
Rainbow trout	6.0	1.4 to 3.1

b. Check **temperature** of springs and well water, and compare to accepted ranges in Table 2; if temperature does not fall within the required range, plan site so that the cool water can be mixed with another water source or held in a warming pond until it meets species' temperature needs. If it is too warm, you will have to plan production only for cold seasons.

TABLE 2: Temperature Requirements for Selected Fishes

Species	Degree F Range	Degree F Optimum
Channel catfish	33 to 95	70 to 85
Largemouth bass	33 to 95	55 to 80
Bluegill	33 to 95	55 to 80
Hybrid striped bass	33 to 95	55 to 75
Golden shiner	33 to 90	50 to 80
Rainbow trout	33 to 78	50 to 60
Grass carp	33 to 95	65 to 85

c. Test **pH** to determine the water's acidity and alkalinity; an acceptable range is between 6.5 and 9.0, with the acid death point about 4 and the alkaline death point about 11.

d. Test water **hardness and alkalinity**; values of 50 to 300 ppm are optimum, but the best waters for fish production generally have about equal values of total hardness and total alkalinity.

e. Test **carbon dioxide** levels; normal safe levels range from 5 to 10 ppm in surface waters, though levels will vary in relation to amount of photosynthesis taking place.

ASSIGNMENT SHEET #3

f. Check **nitrite** levels, noting that levels as low as 1.5 ppm have been known to kill fish.

g. Check **chloride** levels; if levels are 20 ppm or less, you may encounter nitrite problems.

SITE SELECTION
UNIT V

ASSIGNMENT SHEET #4 — COMPLETE A CHECKLIST TO DETERMINE SITE'S FEASIBILITY

As a final step in the decision-making process, complete the following checklist to determine the feasibility of the proposed site. A majority of "yes" answers probably indicate that you have selected a site that will enable the successful construction of a fish farm.

Yes	No	
☐	☐	Do you already own land suitable for fish farming?
☐	☐	Do you already have suitable ponds or pond sites?
☐	☐	Will the subsoils on your land hold water adequately?
☐	☐	Is the soil of the proposed site free of insecticide and herbicide contamination?
☐	☐	Is the topography of the land suitable for economical construction of ponds of the desired size?
☐	☐	Is enough water available to fill ponds within a reasonable time and to replace water lost to seepage and evaporation?
☐	☐	Is there adequate groundwater available on the land at a reasonable cost and for future needs?
☐	☐	Is the water quality suitable for fish farming?
☐	☐	Is the pond area protected from hurricanes and flooding?
☐	☐	Are the drains in existing ponds or for ponds to be built large enough for rapid draining?
☐	☐	Do land elevations permit gravity draining?
☐	☐	Can you prevent wild fish from entering ponds?
☐	☐	Can you reach all ponds, regardless of the weather, for feeding, treating, and harvesting?
☐	☐	Will the pond bottom be suitable for dragging a seine for harvesting fish without snagging on stumps or other debris?
☐	☐	Is enough land available for future expansion if desired?

SITE SELECTION
UNIT V

TEST

NAME____ SCORE ____________

1. Match terms related to site selection with their correct definitions. Write the correct numbers in the blanks.

_____a.	Subsoils	1.	Friable
_____b.	Matter that settles to the bottom of a liquid	2.	Coherent
_____c.	Easily crumbled or crushed into powder	3.	Permeability
_____d.	To filter through small gaps or passages	4.	Plasticity
_____e.	Level below which the ground is saturated with water	5.	Water table
_____f.	Rate of penetration by liquids	6.	Substrata
_____g.	Rain that does not infiltrate the ground and so flows to ponds, streams and depressions	7.	Seepage
_____h.	To flow out slowly through the pond bottom material	8.	Drainage
_____i.	Sticking together, as with soil particles	9.	Wetland
_____j.	Capacity of soil to be bent without breaking and to remain bent after force is removed	10.	Aggregate
_____k.	Surface features of a region; the lay of the land	11.	Infiltration
_____l.	Area that is covered with standing water or is saturated most of the year, and that supports mainly water-loving plants	12.	Runoff
_____m.	Soil made of a mixture of mineral particles	13.	Topography
_____n.	May refer to methods of draining a pond or to surface water runoff	14.	Sediment
_____o.	Area with not more than 3 percent slope	15.	Flatland

TEST

2. List the three basic site requirements.

   a. ______________________________

   b. ______________________________

   c. ______________________________

3. Select from a list facts to consider when evaluating a site's potential water sources. Write an "X" beside each statement that is true.

   Wells

   _____a. Wells are the preferred water source, provided that enough water is available at an affordable energy cost.

   _____b. If a well is to be the primary water source, adequate rainfall must occur at the proposed site before ponds or raceways are constructed.

   _____c. The availability of groundwater varies with location, as do underground water-bearing formations.

   _____d. A test bore well should be drilled to evaluate quality, quantity, and location of inlet pipe.

   _____e. Well water is usually free of pollution, although some undesirable gases (hydrogen sulfide), minerals (iron), or chemicals (ammonia) may have to be removed.

   _____f. Low carbon dioxide is a problem with well water, but aeration will remedy this.

   _____g. Wells are free of contamination by wild fish.

   Spring water

   _____a. Year-round availability must be evaluated by observing rainfall, especially during the fall when discharge is usually lowest.

   _____b. Springs have a constant temperature, but require pumping to bring the water to the surface.

   _____c. Spring water is cool; continuous flow through a pond may make the pond water too cool for some warmwater species such as catfish, and a warming pond may be needed.

   _____d. Spring water may be low in oxygen and require aeration, or it may be supersaturated with nitrogen gas and require investment in degassing equipment to avoid fish kills.

   _____e. Because springs originate underground, they contain no wild fish.

TEST

Surface runoff

_____a. Surface runoff from a watershed is a dependable supply of water; annual runoff is predictable if the potential fish farmer evaluates the numerous physical characteristics that affect water yield.

_____b. The watershed must be large enough to maintain water in the pond during drought, yet not so large that expensive overflow structures are needed to bypass runoff during storms.

_____c. An oversized watershed causes pond water to be cnanged too often, flushing out nutrients and animal life; washes too much silt into the pond; causes erasion of the spillway and dam; and may require a diversion canal.

_____d. Properly grazed pastureland provides the best watershed.

_____e. Areas completely covered with grasses or woody vegetation make the second best watersheds.

_____f. Heavily fertilized cultivated land provides the least desirable watershed cover; if used, it must be free of toxic insecticides and herbicides and should be protected from erosion by conservation methods.

_____g. Surface runoff is often used as a source of water for dike ponds and those that provide the primary farm income.

Surface water from rivers, reservoirs, lakes, bayous, canals

_____a. Water pumped from these sources is generally the most consistent and most desirable water supply.

_____b. Agricultural, industrial, or municipal activities upstream or elsewhere may pollute the water with pesticides and other contaminants that can kill fish.

_____c. Silt loads are often heavy, adding to the nutrient level of the water.

_____d. Surface water may contain fish eggs, wild fish and predatory species that may compete with the farmed species, amphibians and their eggs, and disease organisms.

_____e. Use surface water only if it can be managed economically; if surface water is used, a proper filter system is essential.

TEST

4. List steps in determining a site's water quality.

   a. ____

   ____

   b. ____

   ____

   c. ____

   ____

   d. ____

   ____

5. Select facts about pond type and site evaluation. Write the correct numbers in the blanks.

   _____a. What is the topography for most commercial earthen dike ponds?

   1) Flatland
   2) Not over 6 percent slope
   3) Gully or valley

   _____b. What is the average water depth for dike ponds?

   1) 3 to 6 feet
   2) 10 to 20 feet
   3) 4 to 8 feet

   _____c. What type of culture is generally most profitable for hill ponds?

   1) Intensive
   2) Cage
   3) Raceway

   _____d. How are hill ponds constructed?

   1) Excavation
   2) Damming gully or valley
   3) Erecting levees

   _____e. What is the most important consideration in hill pond site selection?

   1) Type and condition of watershed
   2) Vegetation
   3) Size of pond

TEST

_____f. Why is it difficult to harvest hill ponds?

1) They are generally located in areas inaccessible to haul trucks.
2) They have steep banks.
3) They have irregular shapes and bottom contours.

_____g. How are excavated ponds constructed?

1) They are dug below the soil surface.
2) Levees are raised at the soil surface.
3) Gullies or valleys are dammed.

_____h. What purposes may excavated ponds fill in addition to those for aquaculture?

1) Reservoirs
2) Farm stock ponds
3) Both 1 and 2

_____i. What are the usual water sources for excavated ponds?

1) Wells
2) Surface water from rivers, reservoirs, lakes, bayous, canals
3) Surface runoff or springs

_____j. What type of pond usually must be drained by pumping?

1) Hill
2) Excavated
3) Levee

6. Select from a list steps in determining whether soil is suitable for pond construction. Write an "X" beside each statement that is true.

_____a. Refer to topographical maps for information on the types of soils found on the proposed site.

_____b. Learn the characteristics of the different soil types, and look for soils with a slow infiltration rate and a high runoff potential.

_____c. Perform preliminary excavation to evaluate the suitability of the soil.

_____d. After a tentative pond site has been chosen, contact the U.S. Soil Conservation Service to provide soil tests, soil analysis, and technical assistance in site layout.

TEST

7. Match basic soil types with their characteristics. Write the correct numbers in the blanks.

_____a.	Particles of inorganic clay mixed with organic matter; generally dark grey or black with a strong odor or decaying organic matter	1.	Sand
_____b.	Rich, dark brown soil made of clay, sand, and organic matter; may be semi-impermeable to impermeable, depending on the proportion of clay	2.	Inorganic silt
_____c.	Noncoherent visible particles of rock that when dry run through the fingers like water; these soils do not stick to tools, are easy to work with, and water circulates through them very easily.	3.	Organic silt
_____d.	Particles of inorganic silt mixed with particles of organic matter; color varies from light to very dark grey, and soil may have the odor of decaying matter	4.	Inorganic clay
_____e.	Wholly organic soil made of visible fragments of decayed plant material; color varies from light brown to black and soil has the odor of organic matter	5.	Organic clay
_____f.	Very fine closely packed particles not visible to the eye; does not crack when dry or stick to tools when wet, is harder to work than sandy soils but easier than clayey soils, is less permeable than sand, and does not let water through as easily	6.	Peat
_____g.	Very dense mineral soil of clay, sand, and gravel that has been cemented together to form a rock-like layer; it will not soften when wet, and a pick must be used to dig in it	7.	Hardpan
_____h.	Finest part of soil, with some particles not visible even under a microscope; absorbs water very slowly, but will hold water once absorbed and swell to more than double its volume; becomes very sticky when wet, and when it loses water it cracks and forms hard lumps; usually yellow, red, or white	8.	Loam

TEST

8. Select facts about soil considerations in site selection. Write the correct numbers in the blanks.

_____a. What are the best soils for fish culture?

1) Sandy clay, silty clay loam, clay loam
2) Peat loam, inorganic silt
3) Sandy loam, organic clay, silty peat

_____b. What soil quality makes a site suitable for a pond?

1) Fast infiltration rate
2) Good water retention
3) Permeable soil

_____c. What soil considerations make a site unsuitable for a dike pond?

1) Slow seepage, sandy clay or clay loam soils
2) Slow infiltration, silty clay loam soil
3) Rock outcroppings, sandstone or organic soils

_____d. What can be done if not enough clay is present at the pond site?

1) Soil in pond basin can be compacted over a 2 week period
2) Pond basin can be plated (cored) with trucked-in clay
3) Pond basin can be covered with 4 mil polyethylene

_____e. What is the primary soil characteristic to look for in watershed soils?

1) Good friability
2) Good permeability
3) Slow infiltration rate

_____f. After you have chosen a site, why is it important to learn the history of the soil?

1) Pesticide residues can remain in the soil.
2) The soil may not contain sufficient nutrients.
3) Soil may have been leached of important minerals.

9. Select facts about topographical considerations in site selection. Write the correct numbers in the blanks.

_____a. What type of ponds are most restricted by topography?

1) Levee
2) Excavated
3) Hill

TEST

_____b. What topography makes the best site for ponds?

1) Flatland
2) Wetland
3) Hill

_____c. What topography requires the least dirt to be moved?

1) Flatland
2) Wetland
3) Hill

_____d. Can wasteland and land considered marginal for field crops be used?

1) Yes
2) No
3) Only after expensive reclamation

_____e. What topographical area should be avoided?

1) Flatlands with slopes of 3 percent or under
2) Wetlands
3) Low-lying areas of floodplains

_____f. How does the topography around ponds affect drainage?

1) It doesn't affect drainage as drainage canals can be constructed.
2) It should permit drainage by gravity flow.
3) It should be higher than pond surface.

_____g. Where should the proposed drainpipe be situated in relation to existing waterways?

1) Lower than any rivers, bayous, or drainage ditches
2) Higher than any rivers, bayous, or drainage ditches
3) At same level as any rivers, bayous, or drainage ditches

_____h. Why should you avoid damming creeks and large, deep draws?

1) Dam may blow out
2) Silt-in rapidly
3) Both 1 and 2

10. Select from a list general facts to consider in site selection. Write an "X" in the blank before each true statement.

_____a. If fish culture is to become a primary source of income, make sure that enough land is available for expansion.

_____b. If water must be used elsewhere, such as for irrigation or fire protection, locate the pond site as close to the major water use as possible

TEST

_____c. Beware of areas where natural phenomena such as hurricanes, floods, or fog occur regularly

_____d. Apply for permits to access the site to major roads, and evaluate the condition of the roadways that will be used by heavy trucks

_____e. Locate power and telephone lines at least 1 mile from the pond site to avoid fish loss due to accidental electrical shock

_____f. Think about the site's proximity to available markets, feed suppliers, and medical and chemical supplies

_____g. Choose a pond site on which the pond can be located to the best advantage of the prevailing wind direction

_____h. If possible, protect against theft and poaching by choosing a site where the ponds are visible.

11. List seven site-specific factors that determine costs.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

12. Select from a list laws, regulations, and permits required to develop a site for fish farming. Write an "X" in the blank before each true statement.

_____a. You may need to obtain a permit from the State Department of Natural Resources before drilling a well.

_____b. You will need a permit from the U.S. Soil Conservation Service before diverting, damming, or altering the course of a spring.

_____c. You must secure legal right of way from the Department of Transportation for access to market roadways.

_____d. Wells that pump over a certain capacity per day may be required to be registered with the State Department of Water Resources.

_____e. You need a permit from the Environmental Protection Agency to discharge pond water over a certain capacity per day.

TEST

_____f. You must notify the utility company and get permission to dig if above ground or underground cables or lines for power, natural gas, or water exist on the proposed site.

_____g. The Provision of the Food Security Act of 1985 that discourages the conversion of wetlands for agricultural production, including fish culture, is called The Marshbuster.

_____h. If you convert wetlands to fish ponds without the necessary permits, you may lose your eligibility for certain USDA programs on all the land you farm.

_____i. You need a permit to convert wetland to fish production; it can be obtained from the U.S. Soil Conservation Service.

_____j. Know the local laws regarding poaching and trespassing.

_____k. You must obtain a water quality certification permit by the EPA or state department of environmental quality before you will be issued a Section 404 construction permit

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

13. Survey a site's potential as a fish farm. (Assignment Sheet #1)

14. Evaluate a potential site's soil quality. (Assignment Sheet #2)

15. Evaluate a potential site's water sources and quality. (Assignment Sheet #3)

16. Complete a checklist to determine a site's feasibility. (Assignment Sheet #4)

SITE SELECTION
UNIT V

ANSWERS TO TEST

1. a. 6
   b. 14
   c. 1
   d. 11
   e. 5
   f. 3
   g. 12
   h. 7
   i. 2
   j. 4
   k. 13
   l. 9
   m. 10
   n. 8
   o. 15

2. a. Adequate supply of good-quality water
   b. Subsoils that hold water
   c. Suitable topography

3. Wells
   a, c, e, g

   Spring water
   c, d

   Surface runoff
   b, c, f

   Surface water from rivers, reservoirs, lakes, bayous, canals
   b, d, e

4. a. Analyze the water during site selection to determine whether its quality is suitable for fish production.
   b. Select a location where drainage from farmsteads, feedlots, corrals, sewage lines, mine dumps, and similar areas cannot reach the pond.
   c. Select a location free from industrial runoff or direct discharge of industrial waster into water source.
   d. Note potential contaminating activities in the surrounding watershed.

5. a. 1
   b. 3
   c. 2
   d. 2
   e. 1
   f. 3
   g. 1
   h. 3
   i. 3
   j. 2

6. b, d

ANSWERS TO TEST

7. a. 5 e. 6
   b. 8 f. 2
   c. 1 g. 7
   d. 3 h. 4

8. a. 1 d. 2
   b. 2 e. 3
   c. 3 f. 1

9. a. 3 e. 3
   b. 1 f. 2
   c. 1 g. 2
   d. 1 h. 3

10. a, b, d, f, g, h

11. Answer should contain any seven of the following

    a. Topography
    b. Depth to groundwater
    c. Location of energy source
    d. Size and shape of ponds
    e. Size of farm
    f. Enterprise chosen
    g. Type of production method planned
    h. Type of soil
    i. Soil conditions
    j. Dirt to be moved and vegetation to be cleared
    k. Whether land is owned or purchased

12. a, d, f, h, j, k

13.-16. Evaluated to the satisfaction of the instructor

FACILITY DESIGN AND LAYOUT
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to design and lay out a pond for fish farming and estimate water, construction, and earthmoving costs for a typical enterprise. These competencies will be evidenced by correctly completing the procedures outlined in the assignment and job sheets, and by scoring a minimum of 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to facility design and layout with their correct definitions.
2. Match basic types of farm water enclosures with their characteristics.
3. List facility requirements for food-fish production.
4. List facility requirements for channel catfish fingerling production.
5. List facility requirements for rainbow trout fingerling production.
6. List facility requirements for fee-fish operation.
7. Arrange in order initial steps in planning an on-site processing facility.
8. List facility requirements for an on-site processing facility.
9. List factors to consider when planning pond size.
10. Complete statements about layout and design considerations.
11. Distinguish between advantages of small versus large ponds.
12. Estimate water requirements. (Assignment Sheet #1)
13. Calculate common earth pond construction requirements. (Assignment Sheet #2)
14. Design and lay out a pond. (Assignment Sheet #3)
15. Determine costs of local well drilling, earthmoving, and construction services. (Assignment Sheet #4)

OBJECTIVE SHEET

16. Complete a feasibility study of a selected site by estimating construction costs. (Assignment Sheet #5)

17. Demonstrate the ability to construct a cage for fish culture. (Job Sheet #1)

FACILITY DESIGN AND LAYOUT
UNIT VI

SUGGESTED ACTIVITIES

A. Schedule a member of the U.S. Soil Conservation Service to speak to the class on facility design, layout, and construction factors, particularly as related to Assignment Sheets #1-#3.

B. Make transparencies and set up overhead projector.

C. Gather equipment and materials necessary for completing the job sheet.

D. Read unit and prepare your teaching strategy.

E. At first class period, provide students with objective sheet. Discuss unit and specific objectives.

F. Provide students with information sheet and selected handouts. Discuss each section of the information sheet, providing supplemental information from your own experience and resources. Tailor the information to fit the situations of the individuals in the class.

G. Give unit test after presenting and discussing information sheet material.

H. Provide students with assignment and job sheets.

I. Discuss and schedule assignment sheets.

- The information necessary to calculate water volumes in Assignment Sheet #1 lends itself to mini hands-on sessions. Involve the students actively in this assignment. You may want to show the students an engineer's transit, for instance, and explain its operation. Then allow the students to use the transit, chaining, and pacing to measure an area. If you have a pond on your campus, allow the students to actually measure it to find its average depth. When discussing flow rates, have the students measure the flow rate of a classroom or facility spigot.

- Have your guest speaker from the U.S. Soil Conservation Service talk to the class about construction requirements before they complete Assignment Sheet #2.

- Assign and discuss Assignment Sheet #3 well in advance of its due date. This assignment requires planning and thoroughness. Students will take great pride in their finished layout and design plans. If there are a number of fish farms in your area, you might want to take the students to some of them so that they can compare the various layouts.

- After students have completed Assignment Sheets #4 and #5, have them discuss and compare their results with other members of the class.

J. Explain and demonstrate procedures in the job sheet.

SUGGESTED ACTIVITIES

K. Schedule job sheet completion and evaluation dates.

L. Evaluate job sheet performance with Practical Test #1.

M. Give written test.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Beem, Marley. "Building Cages for Fish Farming," *Extension Extra*. 12002, F & F 9.1. South Dakota State University Cooperative Extension Service. May, 1987.

B. Carroll, Cecil. *Cage Fish Farming Handbook*. El Reno, Oklahoma: Carroll's Fish Farm, 1987.

C. *Catfish Aquaculture: A Decision-making Guidebook*. Baton Rouge, Louisiana. Louisiana Cooperative Extension Service/Louisiana State University Agricultural Center, 1987.

D. *Catfish Farming*. Washington D.C.: U.S. Government Printing Office, 1983.

E. Coche, A.G. *Water for Freshwater Aquaculture*. Rome. Food and Agriculture Organization of the United Nations, 1981.

F. Dupree, Harry K., and Jay V. Huner. "Pond Culture Systems" in *Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research*. Washington, D.C.: U.S. Fish and Wildlife Service, 1984.

G. Jensen, Gary L. *Commercial Production of Farm-Raised Catfish*. Baton Route, Louisiana. Louisiana Cooperative Extension Service/Louisiana State Agricultural Center, 4/1988.

H. Jensen, Gary L. *Handbook for Common Calculations in Finfish Aquaculture*. Baton Rouge Louisiana. Louisiana Cooperative Extension Service/Louisiana Agricultural Center, 8/1988.

I. *Ponds—Planning, Design, Construction*. Agriculture Handbook No. 590. Washington, D.C.: United States Department of Agriculture/Soil Conservation Service, 1982.

J. Sedgwick, S. Drummond. *Trout Farming Handbook*. London. Seeley, Service & Co., 1973.

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

L. Wellborn, Thomas L. *Catfish Farmer's Handbook*. Mississippi State University/ U.S. Department of Agriculture, 1987.

FACILITY DESIGN AND LAYOUT
UNIT VI

INFORMATION SHEET

I. Terms and definitions

A. **Intensive production** — Raising of fish in densities higher than could be supported in the natural environment; requires feeding of formulated feeds

B. **Extensive production** — Raising of fish in low densities in ponds where the fish feed primarily on natural feeds

(NOTE: While with extensive production, per-unit production may be small, farmers using this method achieve substantial production in large bodies of water such as reservoirs.)

C. **Levee** — Earth dike used to enclose water

(NOTE: The main difference between a levee and a dam is that a dam lies perpendicular to the main axis of flow in the valley to be impounded.)

D. **Impound** — To gather and enclose water for fish pond or irrigation

E. **Overflow pipe** – Vertical pipe placed in tank so that top is at desired water height; water above this height drains from the tank

F. **Agitator** — Mechanism for stirring up and thus aerating water in hatching tanks and troughs

G. **Baffle** — Device such as a screen that interferes with water flow, thus stirring up and aerating the water

EXAMPLE: Baffles are used on the edges of egg trays in trout incubators to aerate the eggs.

H. **Seine** — Harvesting net

I. **Live car** — Seine attached to harvesting seine and used to crowd, grade, and hold fish in the pond

J. **Freeboard** — Distance between pond surface and top of levees or dam; generally between 1 and 2 feet

II. Characteristics of basic types of farm water enclosures

A. Earth ponds

1. **Impoundment pond** — Irregularly shaped basin created by damming water that would normally run off

2. **Excavated pond** — Regularly shaped basin on flat or gently sloping land created by removing earth and using it to build embankments or levees

INFORMATION SHEET

3. Levee pond — Usually square or rectangular enclosure constructed by building earth dikes (levees) to contain water; the pond bottom is above or nearly level with the surrounding soil

B. Fabricated ponds or rearing units

1. Circular concrete rearing unit — Medium-sized rearing unit into which water enters through a jet at the side and leaves through a center overflow pipe; the body of the water is kept in rotation; because the water is rapidly and continuously exchanged it is possible to culture very high densities of fish; typical diameter is 16 feet with a water depth of 4 feet

2. Rectangular concrete rearing unit — Small regular rearing unit typically 100 feet long, 40 feet wide, and 8 feet deep; used for fingerling or hobby fish or for holding pond

3. Raceway — Sloping series of narrow concrete units in which a frequent interchange of water is possible by maintaining a fast rate of water flow down the length of the units; a typical ratio of depth to width to length would be 1:3:30

(NOTE: Raceway systems are widely used for trout production. When they are used for catfish culture, they require more intensive management than earthen pond culture.)

C. Tanks, vats, and other enclosures

1. Holding tank or vat — Made of galvanized metal, concrete block, poured concrete, or fiberglass, these enclosures are used to grade fish into size classes, hold fish for sale, as temporary storage, and to segregate diseased fish for treatment; sizes vary, but 30 feet long by 4 feet wide by 3 feet deep is typical.

2. Hatching/fry trough — Made of marine plywood, metal, or fiberglass, these enclosures are typically 10, 12, or 15 feet long, 20 inches wide, and 10 inches or more deep; the water is kept in motion with agitators that circulate it among the fish eggs, which rest in the water on trays.

(NOTE: Paddlewheel agitators are used with catfish eggs as the fanning action imitates that of the male catfish. The trays in trout hatching troughs have baffles that ensure circulation among the eggs.)

3. Spawning pens — Used to confine spawning pairs, these 5 by 10 foot enclosures are made of heavy-duty vinyl-covered wire with a 2 inch mesh, and steel or treated wooden posts; they have no top or bottom, and are placed to extend from the pond bank into 2 feet of water, with their wire mesh sides embedded in the pond bottom.

INFORMATION SHEET

4. **Floating cages** — Floated in ponds and used for grow-out, these net units may be round, square, or rectangular; they are made of noncorrosive materials such as vinyl-covered wire, plastic and aluminum, and range in size from about 3 feet by 3 feet to 8 feet by 8 feet

   (NOTE: Sometimes large floating cages are called "pens.")

III. **Facility requirements for food-fish production**

A. Pond or raceway of appropriate size for present and future needs

B. Valves, screens, pumps, and other fixtures necessary for water control

C. Drainage system

D. Road system that allows for movement of vehicles when mowing, stocking, aerating, and harvesting

E. Small storage and utility buildings, feed storage bins

IV. **Facility requirements for channel catfish fingerling production**

NOTE: Fingerling producers frequently raise their own broodfish. Most of the facilities and equipment needed for broodfish production are interchangeable with food fish and fingerling production, though broodfish operations are generally not as large as fingerling or food fish operations.

A. Broodfish holding ponds of 1 acre or less to maintain broodfish between spawning seasons

B. Spawning pond of 1 to 5 acres, or spawning pens

C. Spawning nests

D. Hatching and fry troughs or fry ponds, depending on the method of hatching desired

E. Rearing ponds for growing fry into fingerlings

F. Holding vats of various sizes

G. Drainage, storage, and road systems as for food fish production

V. **Facility requirements for rainbow trout production**

A. Longitudinal raceway for holding broodfish

B. Divided raceway so that males and females can be separated when they near spawning condition

INFORMATION SHEET

C. Hatching trough with tray hatching system, or hatching jars, depending on preference

D. Small rearing troughs to handle fry to 2.5 inches

E. Raceways for rearing fish 2.5 inches and over

F. Settling basin for effluent that will settle out solids before release

G. Hatchery building with tank room, incubation room, some feed storage, and general storage

H. Garage and shop building

I. Feed storage building or bins

VI. Facility requirements for fee-fish operation

> NOTE: The requirements for fee-fish ponds vary somewhat from those required for food fish and fingerling production because the farmer is dealing with the public. Sport anglers like pleasant surroundings, and attractiveness is important. In addition to the facility requirements below, the operator must have good liability insurance and a reliable source of fish.

A. Drainable pond(s) in area with attractive vegetation and with shade available near the water

B. Drainage system

C. Fishing piers and platforms

D. All-weather parking facilities

E. Bait, tackle, food, and drink concession stands, if not using vending machines

F. Fish cleaning tables

G. Restrooms

VII. Steps in planning an on-site processing facility

> NOTE: At this time, the federal government has no health, sanitation, or grading requirements for processed fish products. States do, however, have sanitary requirements that a processor must meet.

A. Find out if your county has planning and zoning laws; if it does, you may need a minimum-sized parcel of land, or you may need to make legal notification of your plans to build a facility.

INFORMATION SHEET

B. Contact your county health and sanitation officer and discuss your plans to learn the specific requirements needed in the design of your facility.

C. Draw up plans (you don't need an architect) for the facility and send or take them to the state health office for approval.

D. Build your facility according to approved plans.

E. Receive final approval from state inspector.

VIII. Facility requirements for on-site processing

A. Enclosed structure with a concrete floor and wash-down walls

B. Lagoon for waste

C. Potable water system

D. Running water or aeration system

E. Three-basin sink and drain system

F. Covered light fixtures

G. Handwashing sink

IX. Pond size considerations

A. Slope and size of site available

B. Whether rotation of fish and land crops is planned

(NOTE: If crop rotation is anticipated, the area must be large enough to economically use machinery in harvesting the land crop such as soybeans or rice.)

C. The supply of good-quality water

D. Marketing demands and harvesting conditions

(NOTE: Is the equipment available to harvest a large quantity of fish at one time? Is there a market available for a large quantity of fish? A general rule of thumb is to have no ponds larger than can be harvested and processed in a relatively short time with the equipment available.)

E. The economics of construction

(NOTE: Large ponds cost less per acre to construct than smaller ones, yet while there is more surface area for aeration by wind, such water movement makes levee or dam erosion a serious problem with large ponds.)

INFORMATION SHEET

F. Management capabilities

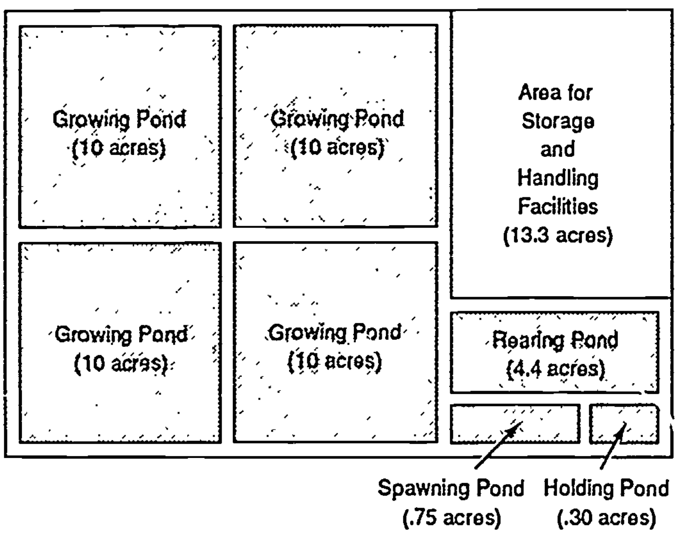
(NOTE: If parasites or diseases break out in a large pond, they are more difficult to control and the resulting losses can be large. Small ponds of 1 to 5 acres provide more flexibility for management, can be drained and refilled more quickly, allow for more gradual harvest, and allow for easier treatment of disease and parasites.)

X. Pond layout and design considerations

A. Lay out for maximum efficiency of production for the type of program to be followed.

EXAMPLES: In the layout of growing ponds, consideration should be given to the source of fingerlings—whether produced or purchased. Fingerling production requires three types of ponds: holding, spawning, and rearing. These ponds usually occupy only a small percentage of the total land in food-fish production. A portion of the acreage in ponds is occupied by the levees; therefore, the acreage of water in each pond is less than 10 acres. (Figure 1)

FIGURE 1



Food Fish Production	40.0	Acres
Rearing Pond	4.4	"
Spawning Pond	.75	"
Holding Pond	.30	"
Storage &Handling	13.3	"
TOTAL	58.75	Acres

INFORMATION SHEET

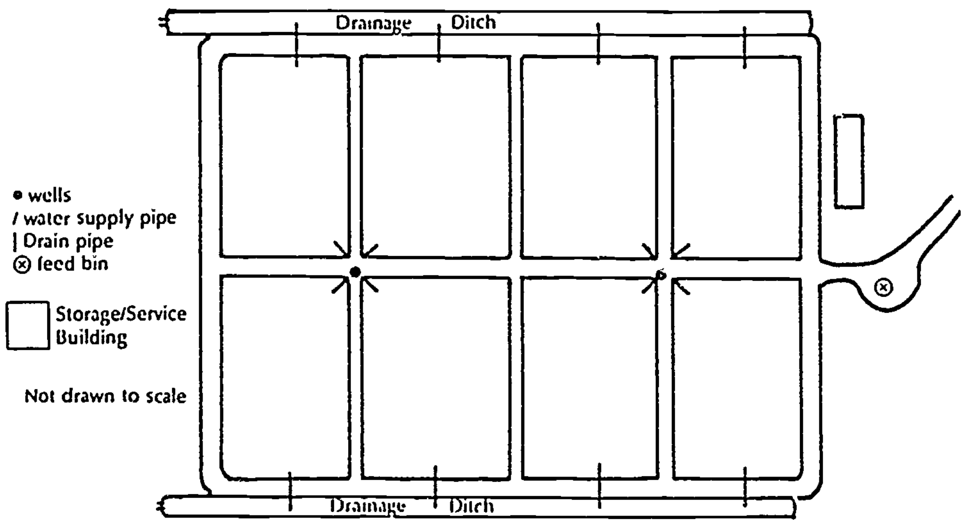
B. Shape pond to take into consideration the economics of construction and harvesting.

(NOTE: A square pond requires less levee than a rectangular pond for the same number of water acres, thus, it is more economical to construct. Economy of harvesting, however, usually favors rectangular ponds because less seine is required. Feeding from the dam is also facilitated by rectangular ponds. Impoundment ponds follow the contours of the land, and thus have irregular bottoms and shorelines that make harvesting difficult.)

C. If possible, construct ponds next to each other, so that both sides of the levee function to hold water, thus reducing costs of construction per acre of water.

D. Plan for maximum utilization of water supplies and drainage facilities. (Figure 2)

EXAMPLE: FIGURE 2: Typical Pond and Facility Layout for a Commercial Catfish Farm



From *Commercial Production of Farm-Raised Catfish* by Gary L. Jensen. With permission.

E. Locate the well head at a high elevation to avoid any flood water and to take advantage of gravity flow through the supply pipes.

F. Locate water lines at shallow end of pond where fish will be harvested and at end opposite drain.

G. Lay out water lines to minimize the length of pipe from the well head of each pond.

(NOTE. In order to minimize pipe length from the well head, wells are usually located where the levees of four ponds intersect. See Figure 2.)

INFORMATION SHEET

H. Lay out pond(s) to permit independent draining of each by gravity flow.

I. Building ponds in series conserves water and requires less construction; however, a parallel arrangement is usually best since when ponds are built in series whatever is in the upper ponds eventually finds its way into the lower ponds—including diseases, pollution, and unwanted organisms.

XI. Advantages of small versus large ponds

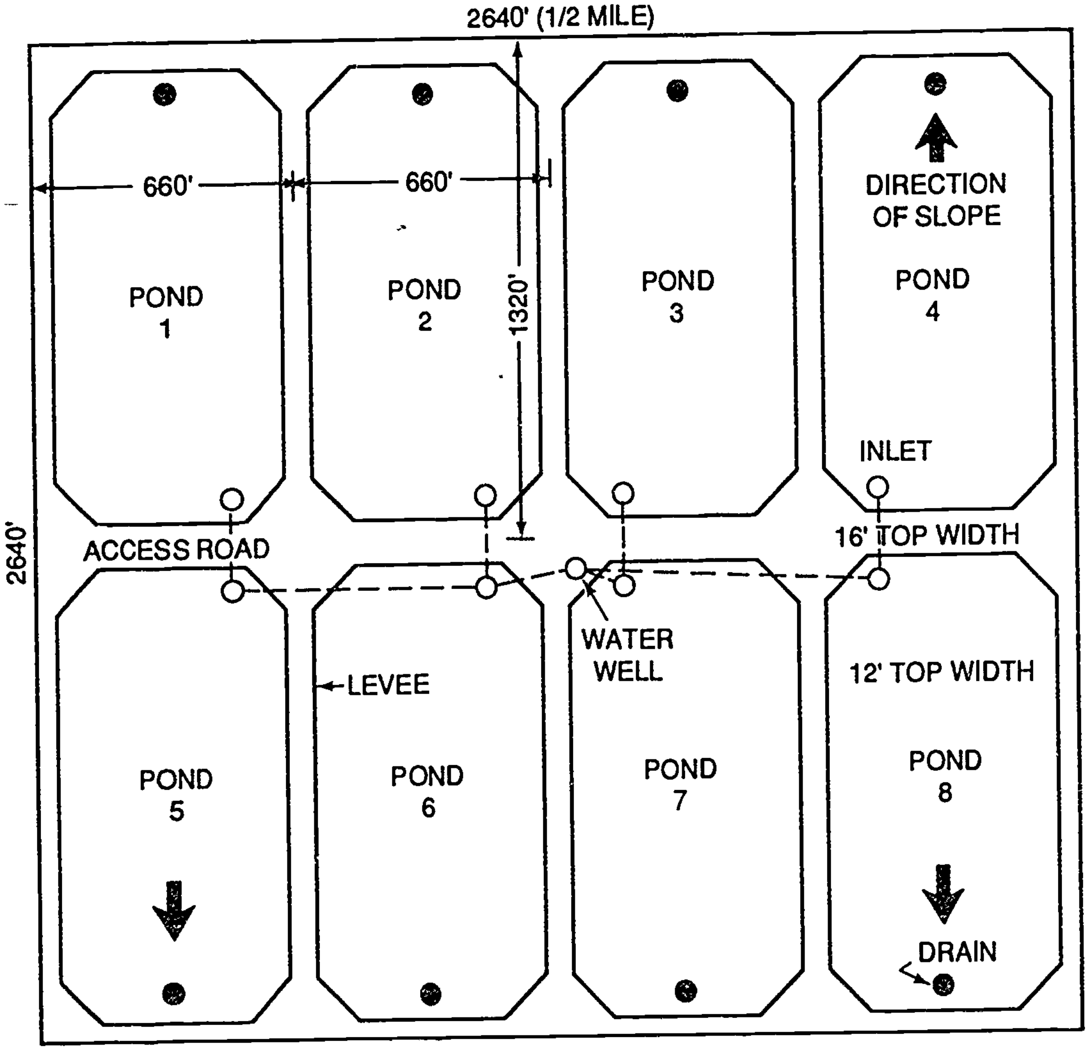
A. Small ponds

1. Are easier and quicker to harvest
2. Can be drained and refilled more quickly
3. Are easier to treat disease, apply fertilizer, feed fish, etc.
4. Result in less financial loss if stock is lost
5. Have banks that are less subject to wind erosion
6. Offer safety factors if several ponds are constructed and disease strikes one pond
7. Permit segregation of breeders, fish of different sizes, etc.
8. Permit more simultaneous experimentation

B. Large ponds

1. Require less construction cost per area since less soil must be moved to achieve equal surface area
2. Take up less space per area of water surface
3. Are more subject to wind aeration
4. Can be used to alternate fish and land crops, if levee pond

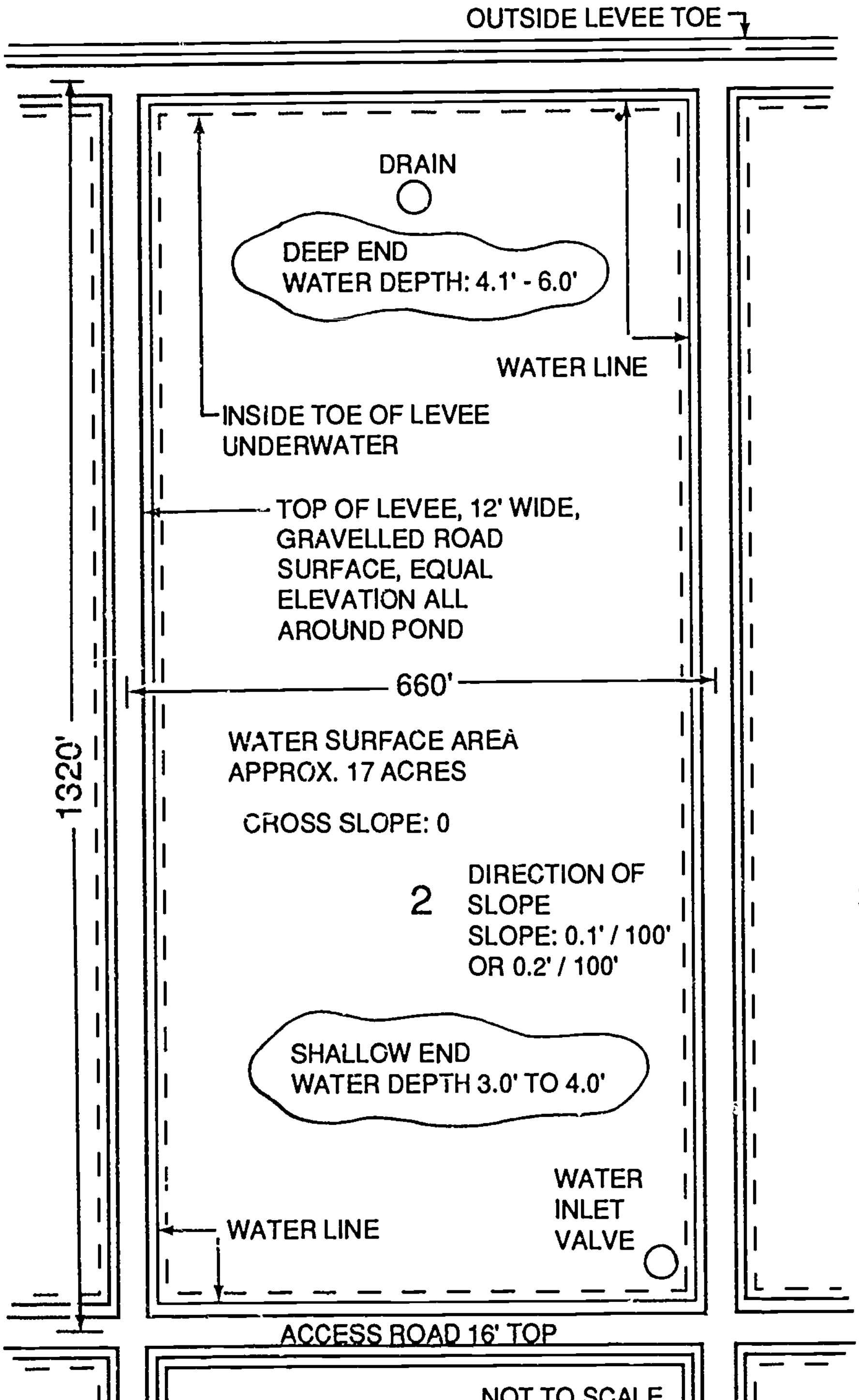
Typical Plot Plan 160-Acre Catfish Farm



NOT TO SCALE

From *Catfish Aquaculture* by Louisiana Cooperative Extension Service. With permission.

Pond Detail, 20 Acres



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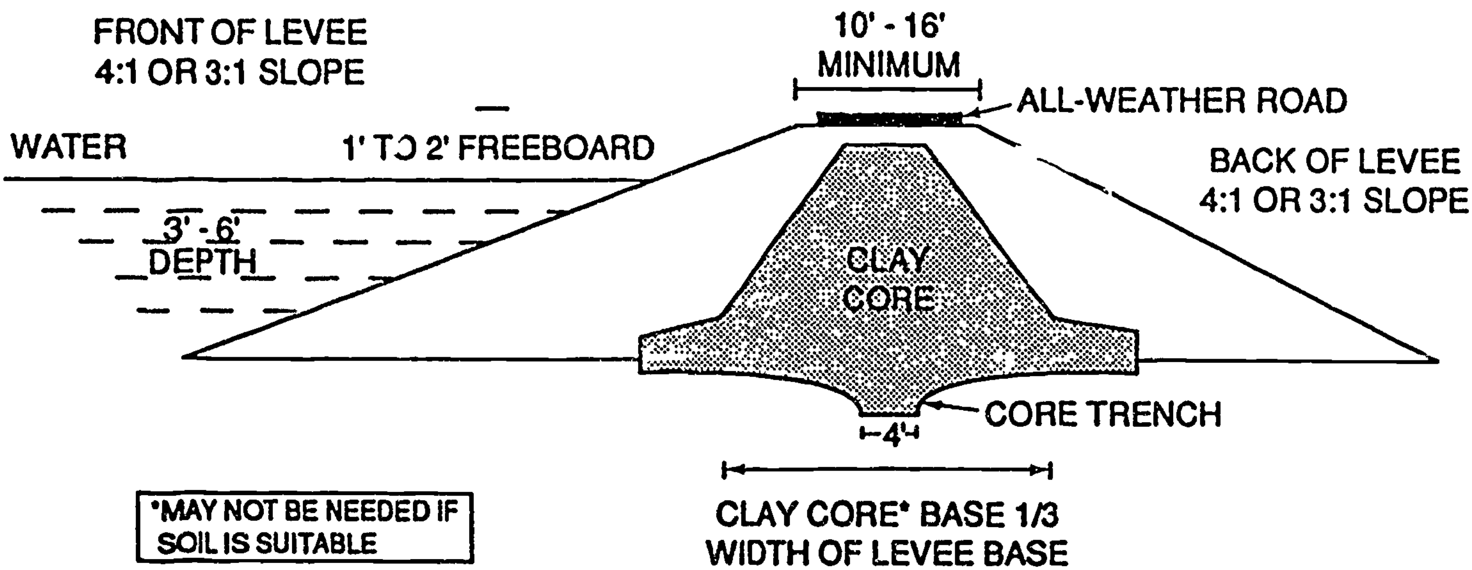
Cross Section of a Typical Levee



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FACILITY DESIGN AND LAYOUT
UNIT VI

HANDOUT #1 -- AQUACULTURE CONVERSION TABLES

TABLE 1: Miscellaneous Aquaculture Conversions

1 acre-foot	43,560 cubic feet
1 acre-foot	325,850 gallons
1 acre-foot of water	2,718,144 pounds
1 cubic-foot of water	62.4 pounds
1 gallon of water	8.34 pounds
1 gallon of water	3,785 grams
1 liter of water	1,000 grams
1 fluid ounce	29.57 grams
1 fluid ounce	1.043 ounces
1 grain per gallon	17.1 milligrams/liter
1 milliliter of water	1 gram
1 cubic meter of water	1 metric ton
1 quart of water	946 grams
1 teaspoon	4.9 milliliters
1 tablespoon	14.8 milliliters
1 cup	8 ounces
1 acre foot/day of water	226.3 gallons/minute
1 acre-inch/day of water	18.9 gallons/minute
1 acre-inch/hour of water	452.6 gallons/minute
1 second foot of water	448.8 gallons/minute
1 cubic foot/second of water	448.8 gallons/minute
1 foot of water	0.43 pounds/square inch
1 foot of water	0.88 inch of mercury (HG)
1 horsepower	550 foot-pounds/second
1 horsepower	745.7 watts
1 kilowatt	1,000 watts
1 kilowatt	1.34 horsepower
1 hectare	10,000 square meters
1 hectare	2.47 acres
1 acre	4,048 square meters

All tables in this handout from *Handbook for Common Calculations in Finfish Aquaculture* by Gary L. Jensen With permission.

HANDOUT #1

TABLE 2: Conversions for Units of Weight

FROM	TO: gm	kg	gr	oz	lb
gm	1	0.001	15.43	0.0353	0.0022
kg	1000	1	1.54×10^{4}	35.27	2.205
gr	0.0648	6.48×10^{-5}	1	0.0023	1.43×10^{-4}
oz	28.35	0.0284	437.5	1	0.0625
lb	453.6	0.4536	7000	16	1

gm = gram; kg = kilogram; gr = grain; oz = ounce; lb = pound

TABLE 3: Conversions for Units of Length

FROM	TO: cm	m	in.	ft.	yd.
cm	1	0.01	0.3937	0.0328	0.0109
m	100	1	39.37	3.281	1.0936
in.	2.540	0.0254	1	0.0833	0.0278
ft.	30.48	0.3048	12	1	0.3333
yd.	91.44	0.9144	36	3	1

cm = centimeter; m = meter; in. = inches; ft. = foot; yd. = yard

TABLE 4: Conversion for Units of Volume.

FROM	TO: cm^3	liter	m^3	$in.^3$	$ft.^3$	fl. oz.	fl. pt.	fl. qt.	gal
cm^3	1	0.001	1×10^{4}	0.0610	3.53×10^{5}	0.0338	0.00211	0.00106	2.64×10^{4}
liter	1000	1	0.001	60.98	0.0353	33.81	2.113	1.057	0.2642
m^3	1×10^{6}	1000	1	6.1×10^{4}	5.31	3.38×10^{4}	2113	1057	264.2
$in.^3$	16.39	0.0164	1.64×10^{5}	1	5.79×10^{4}	0.5541	0.0346	0.0173	0.0043
$ft.^3$	2.83×10^{4}	28.32	0.0283	1728	1	957.5	59.84	29.92	7.481
fl. oz.	29.57	0.0296	2.96×10^{5}	1.805	0.00104	1	0.0625	0.0313	0.0078
fl. pt.	473.2	0.4732	4.72×10^{4}	28.88	0.0167	16	1	0.5000	0.1250
fl. qt.	946.4	0.9463	9.46×10^{4}	57.75	0.0334	32	2	1	0.2500
gal.	3785	3.785	0.0038	231.0	0.1337	128	8	4	1

cm^3 = cubic centimeter = milliliter = ml; m^3 = cubic meter; $in.^3$ = cubic inch; $ft.^3$ = cubic foot; fl. oz. = fluid ounce, fl. pt. = fluid pint; fl. qt. = fluid quart; gal. = gallon

FACILITY DESIGN AND LAYOUT
UNIT VI

HANDOUT #2 — WATER REQUIREMENT AND EARTH CONSTRUCTION TABLES

TABLE 1: Water Flow Rates Equivalent to Acre-feet of Water per Day[1]

Flow Rate (gpm)	Acre-Feet Per Day
50	0.22
100	0.44
200	0.88
300	1.33
400	1.77
500	2.21
750	3.31
1,000	4.42
1,500	6.63
2,000	8.84
2,500	11.05
3,000	13.26
4.000	17.68
5,000	22.09

[1]Values are not corrected for precipitation, evaporation, and seepage.

TABLE 2: Guide to Recommended Well Casing Sizes for Various Pumping Rates

Anticipated Well Yield (gpm)	Nominal Size of Pump Bowls (Inches)	Smallest Size Well Casing (Inches)*	Optimum Size Well Casing (Inches)
150 to 400	6	8 ID	10 ID
350 to 650	8	10 ID	12 ID
600 to 900	10	12 ID	14 OD
850 to 1,300	12	14 OD	16 OD
1,200 to 1,800	14	16 OD	20 OD
1,600 to 3,000	16	20 OD	24 OD

*ID refers to inside diameter and OD refers to outside diameter. Consult with local water well drillers for specific recommendations for your area.

HANDOUT #2

TABLE 3: Estimated Pond Filling Time in Days at Different Pumping Rates[1]

Pond Size (acres)	Pumping Rate (gpm)					
	200	500	1,000	1,500	2,000	3,000
1	4.5	1.8	0.9	0.6	0.5	0.3
2	9	3.6	1.8	1.2	0.9	0.6
5	23	9	4.5	3	2.3	1.5
10	45	18	9	6	4.5	3
20	90	36	18	12	9	6

[1]Assume average water depth of 4 feet. Does not include losses or gains from rainfall, seepage or evaporation.

TABLE 4: Estimated Average Discharge Rates for Short Drainpipes in Fish Ponds of Various Sizes with Low Head Pressure[1]

Diameter of Pipe (Inches)	Approximate Discharge (gpm)
4	120
6	350
8	600
10	1,000
12	1,600
14	2,400

TABLE 5: Approximate Discharge Rates from Deep Wells of Various Sizes.

Well Size (Inches)	Maximum Discharge (gpm)
4	90
6	400
8	600
10	1,000
12	2,000

Tables 1-5 from *Handbook for Common Calculations in Finfish Aquaculture* by Gary L. Jensen. With permission.

HANDOUT #2

TABLE 6: Natural Soil Seepage Losses

Natural Soil Type	Seepage Losses (In./day)
Sand	1 to 10
Sandy loam	0.52 to 3
Loam	0.32 to 0.8
Clayey loam	0.1 to 0.5
Loamy clay	0.01 to 0.2
Clay	0.05 to 0.4

TABLE 7: Puddled Soil Seepage Losses

Puddled Soil Type	Seepage Losses (In./day)
Sandy loam	0.12 to 0.24
Loam	0.08 to 0.12
Clayey loam	0.04 to 0.08
Loamy clay	about 0.04
Clay	about 0.04

FACILITY DESIGN AND LAYOUT
UNIT VI

HANDOUT #3 — END AREAS AND FILL HEIGHTS

TABLE 1: End Areas (in Ft^2) of Embankment Sections for Different Side Slopes and Crown Widths[1]

	Side slopes					Crown width (ft)				
Fill Height (ft)	2.5:1 2 5:1 2:1 3:1	2.5:1 3:1 2:1 3.5:1	3.1 3.1 2.5:1 3.5:1	3.5:1 3.5:1 3:1 4:1	4:1 4:1 3:1 5:1	8	10	12	14	16
1.0	3	3	3	4	4	8	10	12	14	16
1.2	4	4	4	5	6	10	12	14	17	19
1.4	5	5	6	7	8	11	14	17	20	22
1.6	6	7	8	9	10	13	16	19	22	26
1.8	8	9	10	11	13	14	18	22	25	29
2.0	10	11	12	14	16	16	20	24	28	32
2.2	12	13	15	17	19	18	22	27	31	35
2.4	14	16	17	20	23	19	24	29	34	39
2.6	17	19	20	24	27	21	26	31	36	42
2.8	20	22	23	27	31	22	28	34	39	45
3.0	22	25	27	32	36	24	30	36	42	48
3.2	26	28	31	36	41	26	32	38	45	51
3.4	29	32	35	40	46	27	34	41	47	55
3.6	32	36	39	45	52	29	36	43	50	58
3.8	36	40	43	50	58	30	38	46	53	61
4.0	40	44	48	56	64	32	40	48	56	64
4.2	44	49	53	62	71	34	42	50	59	67
4.4	48	53	58	68	77	35	44	53	61	71
4.6	53	58	63	74	85	37	46	55	64	74
4.8	57	63	69	81	92	38	48	57	67	77
5.0	62	69	75	87	100	40	50	60	70	80
5.2	67	74	81	94	108	42	52	62	73	83
5.4	73	80	87	102	117	43	54	65	75	87
5.6	78	86	94	110	125	45	56	67	78	90
5.8	84	93	101	118	135	46	58	69	81	93
6.0	90	99	108	126	144	48	60	72	84	96
6.2	96	106	115	135	154	50	62	74	87	99
6.4	102	113	123	143	164	51	64	77	89	103
6.6	109	120	131	152	174	53	66	79	92	106
6.8	116	128	139	162	185	54	68	81	95	109
7.0	123	135	147	172	196	56	70	84	98	112
7.2	130	143	156	182	207	58	72	86	101	115
7.4	138	152	165	193	219	59	74	89	103	119
7.6	145	159	174	203	231	61	76	91	106	122
7.8	153	168	183	214	243	62	78	93	109	125
8.0	160	176	192	224	256	64	80	96	112	128
8.2	169	185	202	235	269	66	82	98	115	131
8.6	186	204	222	259	296	69	86	103	120	138
8.4	177	194	212	247	282	67	84	101	117	135
8.8	194	213	232	271	310	70	88	105	123	141
9.0	203	223	243	283	324	72	90	108	126	144
9.2	212	233	254	296	339	74	92	110	129	147
9.4	222	244	266	310	353	75	94	113	131	151
9.6	231	254	277	323	369	77	96	115	134	154
9.8	241	265	289	337	384	78	98	117	137	157
10.0	250	275	300	350	400	80	100	120	140	160
10.2	260	286	313	364	416		102	122	143	163
10.4	271	298	325	379	433		104	125	145	167
10.6	281	309	338	394	449		106	127	148	170
10.8	292	321	350	409	467		108	129	151	173
11.0	302	333	363	424	484		110	132	154	176
11.2	313	344	376	440	502		112	134	157	179
11.4	325	357	390	456	520		114	137	159	183
11.6	336	370	404	472	538		116	139	162	186
11.8	348	383	418	488	557		118	141	165	189
12.0	360	396	432	504	576		120	144	168	192
12.2	372	409	447	522	595		122	146	171	195

Continued on next page.

HANDOUT #3

TABLE 1 Continued

Fill Height (ft)	Side slopes					Crown width (ft)				
	2.5:1 / 2.5:1 / 2:1 / 3:1	2.5:1 / 3:1 / 2:1 / 3.5:1	3.1 / 3.1 / 2.5:1 / 3.5:1	3.5:1 / 3.5:1 / 3:1 / 4:1	4:1 / 4:1 / 3:1 / 5:1	8	10	12	14	16
12.4	385	424	462	539	615		124	149	173	199
12.6	397	437	477	557	635		126	151	176	202
12.8	410	451	492	574	655		128	153	179	205
13.0	422	465	507	592	676		130	156	182	208
13.2	436	479	523	610	697		132	158	185	211
13.4	449	494	539	629	718		134	161	187	215
13.6	463	509	555	648	740		136	163	190	218
13.8	476	523	571	667	762		138	166	193	221
14.0	490	539	588	686	784		140	168	196	224
14.2	505	555	605	706	807		142	170	199	227
14.4	519	570	622	726	829		144	173	202	230
14.6	534	586	639	746	853		146	175	204	234
14.8	548	602	657	767	876		148	178	207	237
15.0	563	619	675	788	900		150	180	210	240
15.2	578	635	693	809	924		152	182	213	243
15.4	594	653	711	830	949		154	185	216	246
15.6	609	669	730	852	973		156	187	218	250
15.8	625	687	749	874	999		158	190	221	253
16.0	640	704	768	896	1,024		160	192	224	256
16.2	656	722	787	919	1,050			194	227	259
16.4	673	740	807	942	1,076			197	230	262
16.6	689	758	827	965	1,102			199	232	266
16.8	706	776	847	988	1,129			202	235	269
17.0	723	795	867	1,012	1,156			204	238	272
17.2	740	814	888	1,036	1,183			206	241	275
17.4	757	833	909	1,060	1,211			209	244	278
17.6	774	852	930	1,084	1,239			211	246	282
17.8	792	871	951	1,109	1,267			214	249	285
18.0	810	891	972	1,134	1,296			216	252	288
18.2	828	911	994	1,160	1,325			218	255	291
18.4	846	931	1,016	1,186	1,354			221	258	294
18.6	865	951	1,038	1,212	1,384			223	260	298
18.8	884	972	1,060	1,238	1,414			226	263	301
19.0	903	993	1,083	1,264	1,444			228	266	304
19.2	922	1,014	1,106	1,291	1,475			230	269	307
19.4	941	1,035	1,129	1,318	1,505			233	272	310
19.6	960	1,056	1,152	1,345	1,537			235	274	314
19.8	980	1,078	1,176	1,372	1,568			238	277	317
20.0	1,000	1,100	1,200	1,400	1,600			240	280	320
20.2	1,020	1,122	1,224	1,428	1,632			242	283	323
20.4	1,040	1,144	1,248	1,457	1,665			245	286	326
20.6	1,061	1,167	1,273	1,486	1,697			247	288	330
20.8	1,082	1,190	1,298	1,515	1,731			250	291	333
21.0	1,103	1,213	1,323	1,544	1,764			252	294	336
21.2	1,124	1,236	1,348	1,574	1,798			254	297	339
21.4	1,145	1,254	1,374	1,604	1,832			257	300	342
21.6	1,166	1,283	1,400	1,634	1,866			259	302	346
21.8	1,188	1,307	1,426	1,664	1,901			262	305	349
22.0	1,210	1,331	1,452	1,694	1,936			264	308	352
22.2	1,232	1,356	1,479	1,725	1,971			266	311	355
22.4	1,254	1,380	1,506	1,756	2,007			269	314	358
22.6	1,277	1,405	1,533	1,788	2,043			271	316	362
22.8	1,300	1,430	1,560	1,820	2,079			274	319	365
23.0	1,323	1,455	1,587	1,852	2,116			276	322	368

[1]To find the end area for any fill height, add ft^2 given under staked side slopes to that under the top width for total section. Example: 6.4-foot fill, 3:1 front and back slopes, 14-foot top width — 123 plus 89, or 212 ft^2 for the section. Any combination of slopes that adds to 5, 6, 7 may be used. A combination of 3.5:1 front and 2.5:1 back gives the same results as 3:1 front and back.

HANDOUT #3

TABLE 2: Approximate Volume of Dirt to Fill a 1-Foot Length Section of Levee of Various Sizes on Flatland[1]

Levee Height (Feet)	Slopes Total 6:1[2]					Slopes Total 7:1[3]				
	Top Widths					Top Widths				
	12	14	16	18	20	12	14	16	18	20
5	5.00	5.37	5.74	6.11	6.48	5.46	5.83	6.20	6.57	6.94
5.2	5.32	5.70	6.09	6.47	6.86	5.82	6.20	6.59	6.97	7.36
5.4	5.64	6.04	6.44	6.84	7.24	6.18	6.58	6.98	7.38	7.78
5.6	5.97	6.39	6.80	7.22	7.63	6.55	6.97	7.38	7.80	8.21
5.8	6.32	6.75	7.17	7.60	8.03	6.94	7.37	7.80	8.23	8.66
6.0	6.67	7.11	7.56	8.00	8.44	7.33	7.78	8.22	8.67	9.11
6.2	7.03	7.49	7.95	8.40	8.86	7.74	8.20	8.66	9.12	9.58
6.4	7.40	7.87	8.34	8.82	9.29	8.15	8.63	9.10	9.58	10.05
6.6	7.77	8.26	8.75	9.24	9.73	8.58	9.07	9.56	10.05	10.54
6.8	8.16	8.66	9.17	9.67	10.17	9.02	9.52	10.02	10.53	11.03

[1]Values represent cubic yards of dirt per linear foot of the length of the levee.

[2]6:1 total slope equals a levee with inside and outside slopes each of 3:1.

[3]7:1 total slope equals a levee with a 3:1 slope on one side and a 4:1 slope on the other side.

From *Handbook for Common Calculations in Finfish Aquaculture* by Gary L. Jensen. With permission.

FACILITY DESIGN AND LAYOUT
UNIT VI

ASSIGNMENT SHEET #1 — ESTIMATE WATER REQUIREMENTS

Before you begin to design a pond, you will need to know whether your water supply is sufficient to fill the size pond you want to build, to fill the pond in a reasonable length of time, to compensate for seepage and evaporation losses, and to be able to operate your pond continuously throughout the year.

It is also helpful to measure the available water flow to estimate the number of days it will take to fill ponds of various sizes so that you will have some idea of the combination possible. You should also know how much water can be provided each day by the available water flow. This information will help you plan the number of ponds to be built, the number and size of the tanks and vats needed for holding and hatching, and will help you plan for future expansion.

This assignment sheet is divided into two parts. In the first part, you will be given information necessary to calculate water requirements. In the second part, you will be given some realistic situations to allow you to practice calculating these requirements.

PART I

MEASURING

Distance can be measured in any of the following ways:

Engineer's transit — using the transit to survey the area;

Chaining — using a field tape, making sure to reset it at the proper location when measuring a long distance, and keeping track of the number of times the tape length is repeated per side; or

Pacing — determining the number of strides or paces along a measured distance of 100 feet, dividing this by the average number of your paces in 100 feet and multiplying by 100 feet.

EXAMPLE. After pacing a measured 100 foot distance three times, you determine that your average was 41 paces or steps per 100 feet. The number of paces along one shoreline was 387 the first trial and 395 the second trial. What is the length of the shoreline in feet?

1. Find the average number of paces by adding each trial and dividing by the number of trials:

   387 paces + 395 paces = 782 paces

   $\frac{782}{2}$ = 391 average paces

ASSIGNMENT SHEET #1

2. Now substitute your known figures into the basic formula for measuring distances by pacing:

$$\frac{\text{Total Number of Paces in Unknown Distance}}{\text{Average Number of Your Paces in 100 Feet}} \times 100 \text{ ft} = \text{Distance in Feet}$$

$$\frac{391}{41} \times 100 \text{ ft} = 9.54 \times 100 \text{ ft} = 954 \text{ feet of shoreline.}$$

ESTIMATING POND SURFACE AREA

Square pond — Multiply two sides. (Surface Area = Side × Side)

Rectangular pond — Multiply length times width. (Surface Area = L × W)

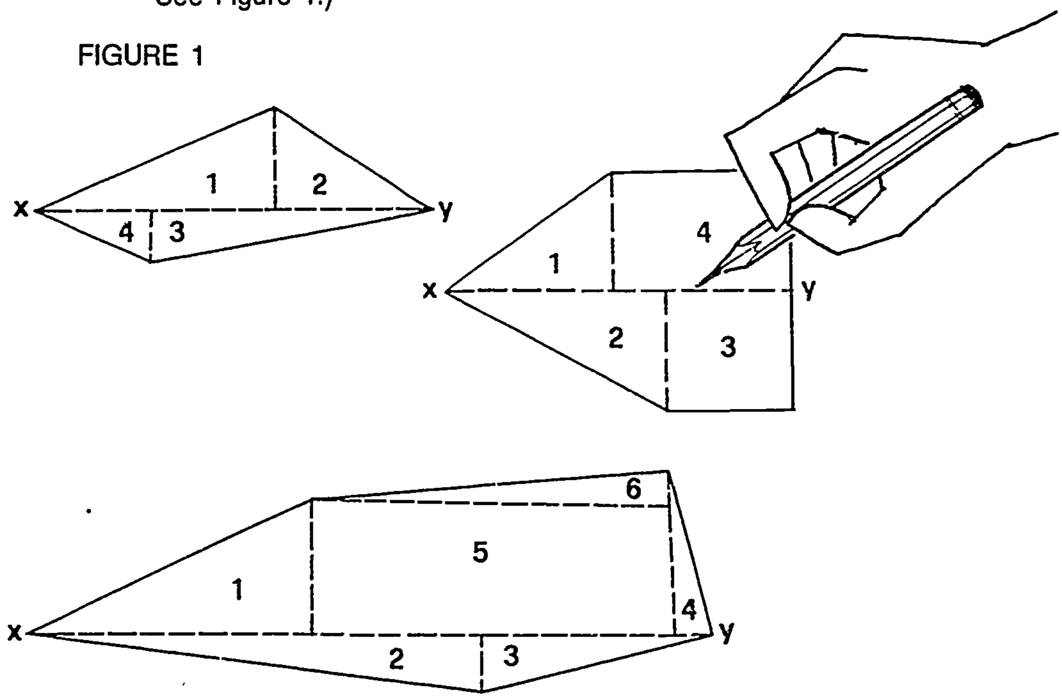
Irregular pond with straight sides — Divide pond into smaller areas that can be easily calculated, and then add these areas to find the total surface area.

1. Draw a plan of the surface area of the pond.

2. Divide the plan into squares, rectangles, and right (90 degree) triangles:

   (NOTE: When dividing the surface area of a large, irregular pond, it is helpful to create an xy axis the length of the plan. You can use this axis as a reference line along which to construct squares, rectangles, and triangles. See Figure 1.)

FIGURE 1



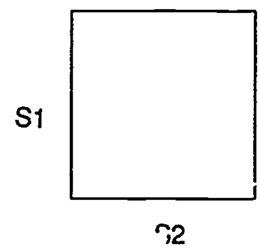
From *Water for Freshwater Aquaculture* by A. G. Coche. Used with permission.

ASSIGNMENT SHEET #1

3. Calculate the area of each shape, using accurate length, width, base, and height measurements.

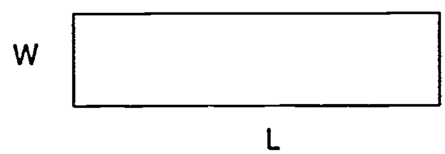
   —To find the area of a square, multiply two sides.

   Area = Side 1 × Side 2



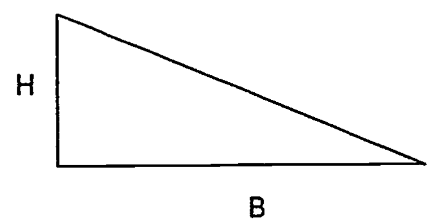
   —To find the area of a rectangle, multiply the length times the width.

   Area = Length (L) × Width (W)



   —To find the area of a right (90 degree) triangle, multiply the base by the height and divide by 2.

   $$\text{Area} = \frac{\text{Height (H) x Base (B)}}{2}$$



4. Add all calculated smaller areas to find the total surface area.

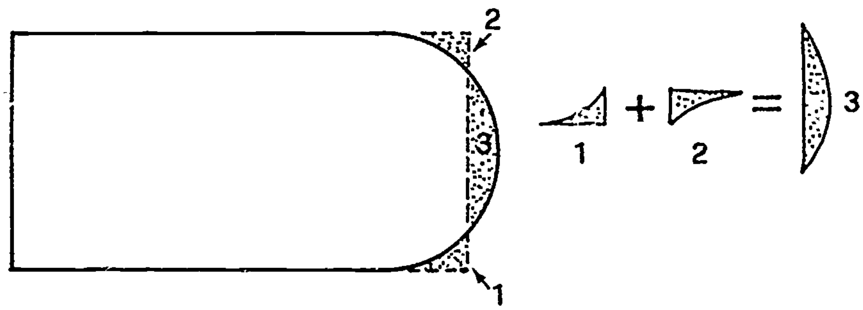
5. Use conversion table in Handout #1 to convert square feet to acres:

Irregular pond with curving side — Approximate the curved part.

1. Draw a line across the curved section of the pond so that the part outside the line is approximately the same as the part inside Figure 2:

ASSIGNMENT SHEET #1

FIGURE 2



From *Water for Freshwater Aquaculture* by A.G. Coche. Used with permission.

2. Calculate area or areas as you did for the irregular pond with straight sides.

   (NOTE: If the pond is very irregular, use surveying methods to accurately determine the pond's surface area.)

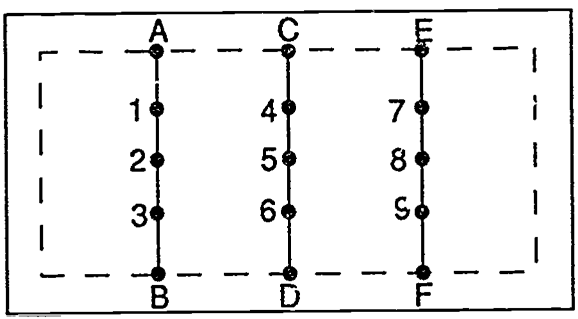
ESTIMATING WATER DEPTH

Empty small pond

1. Future water level is marked with strings stretched across pond and tied to stakes at AB, CD, and EF.

2. Measure depth at several places along each string, and calculate average water depth. Figure 3

   FIGURE 3



$$\text{Average Water Depth} = \frac{1 + 2 + 3 \ldots + 9}{9}$$

From *Water for Freshwater Aquaculture by A.G. Coche.* Used with permission.

Empty large pond

1. Set an engineer's transit at the elevation of the future water level or on the lip of the overflow pipe.

2. Move the Philadelphia level rod to different locations throughout the pond.

ASSIGNMENT SHEET #1

3. Add the height measurements, and divide the total by the number of measurement sites to determine the average depth.

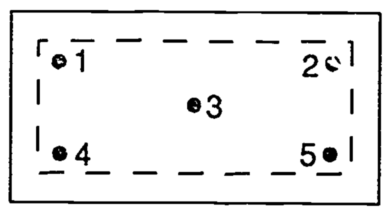
Full, small, regular pond with a constant bottom slope from one end to the other

1. Work in teams, with a long pole with yardsticks attached end to end.

2. Wade into the pond or use a boat, and take depth measurements at the five points shown in Figure 4.

3. Calculate the average of these measurements.

FIGURE 4



$$\text{Average Depth} = \frac{1 + 2 + 3 + 4 + 5}{5}$$

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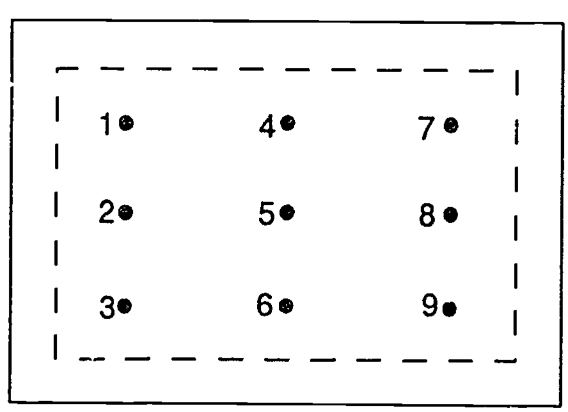
Full, large, regular-shaped pond with constant slope from one end to the other

1. Using same method outlined for small, regular ponds, measure depth at nine or more points as shown in Figure 5.

2. Calculate the average of these measurements.

FIGURE 5



$$\text{Average Depth} = \frac{1 + 2 + 3 + \ldots 9}{9}$$

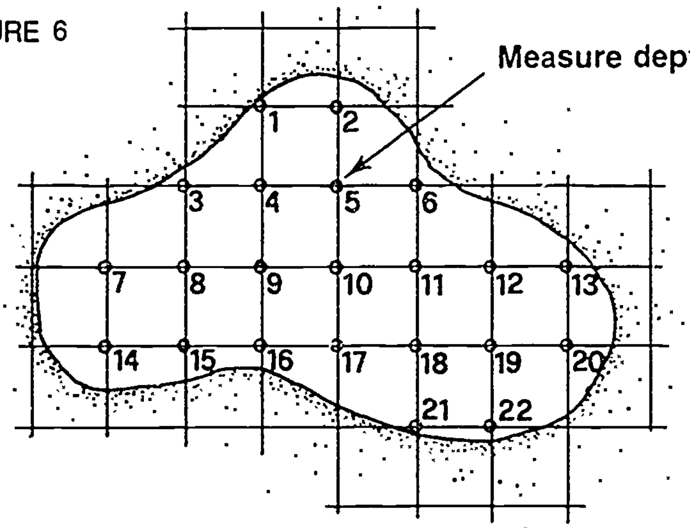
From *Water for Freshwater Aquaculture* by A.G. Coche. Used with permission.

ASSIGNMENT SHEET #1

Large filled pond with irregular shape and irregular bottom

1. Draw the approximate shape of the pond on a sheet of paper.
2. Create a grid pattern of 20 foot squares as shown in Figure 6.
3. Using the yardstick pole and a partner to record readings, measure the pond depth at each of the grid intersections.
4. Add all measurements and divide by number of intersections to find average depth.

FIGURE 6



$$\text{Average Water Depth} = \frac{1 + 2 + 3. . .+ 22}{22}$$

From *Water for Freshwater Aquaculture* by A.G. Coche. Used with permission.

CALCULATING WATER VOLUME

Ponds

1. Find the surface area of the pond.
2. Find the average water depth.
3. Multiply the surface area in square feet (ft^2) by the average water depth in feet (ft) to get the volume in cubic feet (ft^3)
4. Convert cubic feet to acre-feet or gallons, using conversion tables in Handout #1.

   (NOTE: The water volume in ponds is usually measured in units of acre-feet. If you refer to the conversion table in Handout #1, you will find that 1 acre-foot is equal to 43,560 cubic feet.)

ASSIGNMENT SHEET #1

Noncircular tanks, vats, troughs, and transport boxes

These enclosures are generally rectangular. To determine volume, you need to measure inside length of the enclosure, the inside width of the enclosure, and the average water depth.

Tank with overflow pipe and flat bottom

EXAMPLE: What is the volume of a tank 10 feet long, 2 feet wide, with an overflow pipe of 10 inches?

1. Convert to feet the water depth inch measurement.

   10 inches = $\frac{10}{12} \times 1$ foot = 0.83 feet

2. Determine tank volume in cubic feet by using the formula:

   Water Volume = Length × Width × Water Depth.

   = 10 ft × 2 ft × 0.83 ft

   = 16.6 ft^3

3. Use conversion tables in Handout #1 to convert cubic feet to gallons:

   16.6 ft^3 × 7.48 gal/ft^3 = 124.17 or about 124 gallons.

Trough or tank with overflow pipe and sloped bottom

EXAMPLE: A sloped-bottom tank has water depths of 3 feet at shallow end, 3 feet 4 inches in center, and 3 feet 8 inches at over-flow pipe. The tank is 50 feet long and 4 feet 6 inches wide. What is the volume of the tank?

1. Add the three depth measurements, convert inches to feet, and divide by 3 to find the average depth of the water:

   Average Water Depth = $\frac{3\text{ ft} + 3\text{ ft } 4\text{ in} + 3\text{ ft } 8\text{ in}}{3}$

   = $\frac{10\text{ ft}}{3}$

   = 3.33 ft.

2. Convert width of trough to a decimal so that all units are the same:

   4 ft 6 in = 4 1/2 ft = 4.5 ft

ASSIGNMENT SHEET #1

3. Substitute these numbers in the formula:

   Volume = Length × Width × Water Depth

   = 50 ft × 4.5 ft × 3.33 ft

   = 749.25 ft^3

4. Convert cubic feet to gallons, using conversion table in Handout #1:

   749.25 ft^3 × 7.48 gal/ft^3 = 5,604 gallons that tank will hold.

Circular Tank with Center Overflow Pipe

EXAMPLE. A circular tank has an 8 foot diameter and a 3 foot center overflow pipe. How much water can it hold?

1. Use the formula Volume = $\pi \times r^2 \times d$

   Where: π is a constant 3.14
   r (radius) equals 1/2 the diameter
   d equals water depth
   r^2 equals r times itself (r × r).

2. Substitute numbers into the formula:

   Volume = 3.14 × 16 ft^2 × 3 ft

   = 150.7 cu ft (ft^3).

3. Convert to gallons, using conversion tables in Handout #1:

   150.7 ft^3 × 7.48 gal/ft^3 = 1,127.23 gallons that tank can hold.

ESTIMATING FLOW RATES

Aquaculturists often need to adjust the supply of water discharged into a tank or pond. To do so, they need to know flow rates in order to know whether enough water is available for desired water exchanges in rearing troughs, vats, and raceways. The aquaculturist also needs to know flow rates so that filling times can be calculated.

Small Pipes

1. To determine flow rate, you will need at least two 1-gallon or 5-gallon containers and a stopwatch with a second hand.

2. Turn on your water source and place the container under the discharge pipe.

3. With your stopwatch, determine how long it takes for each container to fill.

ASSIGNMENT SHEET #1

4. Repeat this procedure, and then add the total times and divide by 4 (or the number of containers filled) to find the accurate flow rate in seconds for your water source:

1st container	=	43 sec
2nd container	=	44 sec
3rd container	=	42 sec
4th container	=	43 sec
	Total =	172

$\frac{172}{4}$ = 43 seconds, average flow rate.

5. Use the following formula to find the flow rate in gpm:

$$\frac{\text{Volume of Container in Gallons}}{\text{Total Seconds to Fill Container}} \times 60 \text{ Seconds/Minute} = \text{Flow Rate in gpm}$$

$$\frac{\text{5 gal container}}{\text{43 seconds}} \times 60 \text{ sec/min} = 6.97 \text{ or about 7 gallons per minute}$$

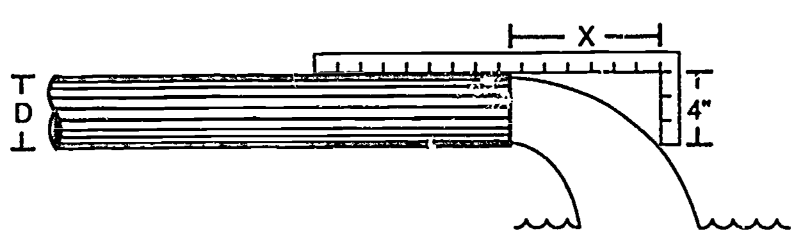
Large Pipes

1. Construct an L-shaped measuring instrument similar to that shown in Figure 1, making the short side 4 inches long and the long side any convenient length.

2. Mark both sides in inch increments.

3. With water flowing normally from a horizontal discharge pipe, place the long side of the L along the top of the discharge pipe as shown in Figure 1.

FIGURE 1



4. Slide the L along the pipe until the 4-inch length barely touches the water flow.

5. Note the distance (X) traveled by the flow of water before it drops 4 inches.

   EXAMPLE: 15 inches

6. Note the inside diameter of the pipe (D).

   EXAMPLE: 8 inches

ASSIGNMENT SHEET #1

7. Consult Table 1 below, finding the horizontal distance (X) in the left-hand column and then moving horizontally to the right, stopping under the column that shows the correct pipe diameter (8 inches). The discharge rate is 1160 gallons per minute.

TABLE 1

Horiz. Dist.(X) (Inches)	DISCHARGE RATE (Gallons per minute) Nominal Pipe Diameter 1	1¼	1½	2	2½	3	4	5	6	8	10	12	Average Velocity
4	5.7	9.8	13.3	22.0	31.3	48.5	83.5						2.1
5	7.1	12.2	16.6	27.5	39.0	61.0	104	163					2.4
6	8.5	14.7	20.0	33.0	47.0	73.0	125	195	285				3.1
7	10.0	17.1	23.2	38.5	55.0	85.0	146	228	334	580			3.7
8	11.3	19.6	26.5	44.0	62.5	97.5	166	260	380	669	1060		4.2
9	12.8	22.0	29.8	49.5	70.0	110	187	293	430	750	1190	1660	4.7
10	14.2	24.5	33.2	55.5	78.2	122	208	326	476	830	1330	1850	5.3
11	15.6	27.0	36.5	60.5	86.0	134	229	360	525	915	1460	2200	5.8
12	17.0	29.0	40.0	66.0	94.0	146	250	390	570	1003	1600	2220	6.2
13	18.5	31.5	43.0	71.5	102	158	270	425	620	1080	1730	2400	6.9
14	20.0	34.0	46.5	77.0	109	170	292	456	670	1160	1860	2590	7.4
15	21.3	36.3	50.0	82.5	117	183	312	490	710	1250	2000	2780	7.9
16	22.7	39.0	53.0	88.0	125	196	334	520	760	1330	2120	2960	8.4
17		41.5	56.5	93.0	133	207	355	550	810	1410	2260	3140	9.1
18			60.0	99.0	144	220	375	590	860	1500	2390	3330	9.7
19				110	148	232	395	620	910	1580	2520	3500	10.4
20					156	244	415	650	950	1660	2660	3700	10.6
21						256	435	685	1000	1750	2800		11.4
22							460	720	1050	1830	2920		11.8
23								750	1100	1910	3060		12.4
24									1140	2000	3200		13.0

Procedure, drawing, and table from Crisafulli Pump Co., Inc.

8. For other than standard pipes, the flow may be determined by using the following formula:

$$\text{gpm} = X1.28D^2$$

Where D = Inside pipe diameter

X = Horizontal open flow for drop of 4 inches

ESTIMATING FILLING TIMES

To determine water filling time, you must know the volume of water that a pond or tank can hold and the flow rate of the water. The water should flow at a uniform rate continuously from start to finish. You can figure flow rate as explained above, or you can use the chart in Handout #2 for approximate pond filling times at different pumping rates.

ASSIGNMENT SHEET #1

Fill Time

EXAMPLE. An 84 acre-foot pond is supplied with a steady flow of 1,500 gpm. How long will it take the pond to fill, assuming the soil is already moist?

1. Use the conversion table in Handout #1 to convert acre-feet to gallons:

   Pond Volume = 84 acre ft × 325,851 gal/acre ft = 27,371,484 gallons.

2. To find the number of minutes it will take to fill the pond, divide the gallon volume by the gpm of the water sources:

   $\frac{27,371,484}{1500 \text{ gpm}}$ = 18,247.65 or about 18,248 minutes to fill pond.

3. Divide the number of minutes by 60 to find the number of hours it will take to fill the pond:

   $\frac{18,248}{60}$ = 304 hours to fill pond.

4. Divide the number of hours by 24 to find the number of days it will take to fill the pond:

   $\frac{304}{24}$ = 12.66 or 12 days 16 hours.

5. You may also use the following formula to quickly compute days needed to fill:

   $\frac{\text{Pond Volume in Gallons}}{\text{gpm} \times 60 \text{ min/hr} \times 24 \text{ hr/day}}$ = Number of Days to Fill.

Water Exchange Rates

EXAMPLE. A trough contains 500 gallons of water with a flow rate of 23 gpm. How many water exchanges per hour are possible?

1. Divide the trough volume by the gpm to find the full time in minutes:

   $\frac{500}{23}$ = 21.7 minutes to fill trough.

2. Divide the number of minutes in an hour (60) by the number of fill minutes to find the number of exchanges in an hour:

   $\frac{60}{21.7}$ = 2.76 complete water exchanges in 1 hour.

ASSIGNMENT SHEET #1

ESTIMATING WATER LOSSES CAUSED BY SEEPAGE

Water lost vertically through the bottom of the pond, horizontally through the levees or dikes by infiltration, and through the drainage system of the pond is called *seepage water.*

If your levees or dikes are well built and well maintained, and if the drainage system is watertight, the amount of seepage water lost horizontally will be very small. You will need to calculate only vertical seepage.

Water seepage is greater from a new pond when it is filled for the first time. After the pond has been filled for some time, the water tends to break down the soil structure and the pores, or tiny spaces between the grains of soil, become sealed by organic matter that collects on the pond bottom. As a result, seepage decreases.

Seepage from Natural (Unpuddled) Soils

1. Determine the soil type of which your pond is built.

2. Determine the surface area of your pond in square feet.

   EXAMPLE: Assume that you have a 100 by 70 foot pond with a surface area of 7,000 square feet. The soil is clayey loam, and you want to determine the seepage losses in gallons over a 6-month (180 day) period.

3. Using Table 6 in Handout #2, find the average seepage loss per day:

   EXAMPLE: Clayey loam seepage losses are from 0.1 to 0.6 inch per day so the average loss will be 0.3 inch per day.

4. Convert the average daily seepage loss in inches to decimal feet:

   $\frac{0.3}{12} = 0.025$ feet

5. Now multiply the daily seepage loss in decimal feet by the surface area of the pond in square feet, and use the conversion tables to convert cubic feet to gallons:

   0.025 feet × 7,000 square feet = 175 cubic feet per day

   175 cubic feet × 7.481 gal/cu ft = 1,309 gallons per day.

6. Find the monthly loss by multiplying the number of gallons lost per day by the number of days in 6 months:

   1,309 gal/day × 180 days/six mo. = 235,560 gallons lost over 6 mo.

ASSIGNMENT SHEET #1

Determining Drainage Time

EXAMPLE: You have a pond 300 feet by 450 feet that has an average depth of 5.1 feet and is served by an 8-inch diameter drainpipe. How many days will it take to drain the pond?

1. Find the number of square feet of the pond:

   $300 \times 450 = 135{,}000$ square feet

2. Use the conversion chart in Handout #1 to convert square feet to acres:

   43,560 square feet = 1 acre

   $\frac{135{,}000}{43{,}560} = 3.09$ or 3.1 acre

3. Multiply number of acres times depth to find acre-feet:

   $3.1 \times 5.1 = 15.81$ acre-feet

4. Use Table 4 in Handout #2 to find approximate discharge rate for an 8-inch diameter drainpipe.

   8-inch diameter drainpipe = 600 gpm

5. Find the drain time in days by substituting these known values in the formula below:

$$\text{Drain Time in Days} = \frac{\text{Acre-feet Water} \times 325{,}851}{\text{Discharge gpm} \times 1440}$$

$$= \frac{15.81 \times 325{,}851}{600 \times 1440}$$

$$= \frac{5{,}151{,}704.3}{840{,}000}$$

$$= 6.1 \text{ days}$$

Seepage from Puddled Soils

One way to reduce seepage losses when constructing a pond is to break the soil structure on the pond bottom before it is filled with water. This is a common practice in irrigated rice fields and is called *puddling*.

The soil in the pond bottom is first saturated with water. When the soil has soaked into the pond bottom enough to permit working, the bottom is hoed, ploughed, or worked by any other means. Seepage losses are much less from puddled soils.

Calculate seepage losses from puddled soils in the same way you calculated losses from natural soils, but use the "Puddled Soil" table (Table 7) in Handout #2.

ASSIGNMENT SHEET #1

ESTIMATING WATER LOSSES BY EVAPORATION

Water that is lost to the air from the surface of a pond is called *evaporation*. The amount of water lost by evaporation depends largely on local climate conditions. High air temperatures, low humidity, strong winds and sunshine increase evaporation. Evaporation also depends on the amount of water surface area. The larger the pond, the more water will evaporate from its surface.

There are methods and formulas for computing evaporation loss, but because evaporation varies considerably with local conditions, you should obtain local evaporation rates from a meteorological station in your particular area. Usually you will be able to obtain average monthly evaporation rates, based on measurements made over several years in your area.

ASSIGNMENT SHEET #1

PART II

Practice computing water requirements by calculating the following problems. Use your calculator and any necessary tables from Handouts #1 and #2. Round your answers to the nearest whole number.

1. What is the volume of water in a pond that has a surface area of 17.5 acres and depths of 4.4 feet, 4.2 feet, 4.5 feet, and 4.6 feet?

   Acre-foot volume = ____________________

   Gallon volume = ____________________

2. Your water supply has a flow rate of 500 gpm, and fills your pond in 58 hours. How many acre-feet of water does your pond contain?

   Acre-foot volume = ____________________

3. A flat-bottomed trough is 15 feet long and 2 feet wide with a 10-inch high overflow pipe. How many gallons of water does the tank hold?

   Gallons = ____________________

4. One of your hatching tanks is 40 feet long and 3 feet 6 inches wide. The bottom is sloped with a depth at the shallow end of 3 feet; a middle depth of 3 feet 3 inches; and a depth at the drain of 3 feet 9 inches. How many gallons of water does the tank hold?

   Gallons = ____________________

5. What is the volume of a circular tank with a 5-foot overflow pipe and a diameter of 12 feet?

   Cubic feet = ____________________

   Gallons = ____________________

6. You want to construct four ponds in the same area and service all with 1 water well. The ponds vary in size—6 acres, 4.2 acres, 5.4 acres, and 4.5 acres. You want to be able to fill any pond within 6 days. The average water depth in each pond is 5 feet. What flow rate in gpm is required from your well to fill any one of your ponds in 6 days or less?

   HINT: Determine the volume of the largest pond first. If it can be filled in six days, then any of the smaller ponds will fill in six days or less.

   Flow rate = ____________________gpm

7. Using the gpm that you computed in problem 6, what would be the filling time in days for the smallest pond of 4.2 acres and 5 foot average depth?

   Number of days to fill = ____________________

ASSIGNMENT SHEET #1

8. You are planning a hatchery that will include 8 holding tanks, each 4 feet wide and 40 feet long. The average water depth in each tank is 3 feet 6 inches. Your water supply to these tanks must supply at least 2 complete water exchanges per hour in all tanks at the same time. You are also planning on installing 20 troughs, each 15 feet long and 2 feet wide, with an average depth of 1 foot. A flow rate of 5 gpm is required for each trough, and all may need water at the same time. What is the minimum flow rate in gpm needed for your facility?

   Minimum flow rate = ______________________ gpm

9. You have designed a pond that can hold 75 acre-feet of water. Your supply pipe provides a steady flow at 1,200 gpm. Assuming that the soil is already moist, how long will it take you to fill your pond?

   Fill time = ______________________ hours

   Fill time = ______________________ days

10. A 5 gallon container is filled in 45 seconds. What is the water flow rate of your supply pipe?

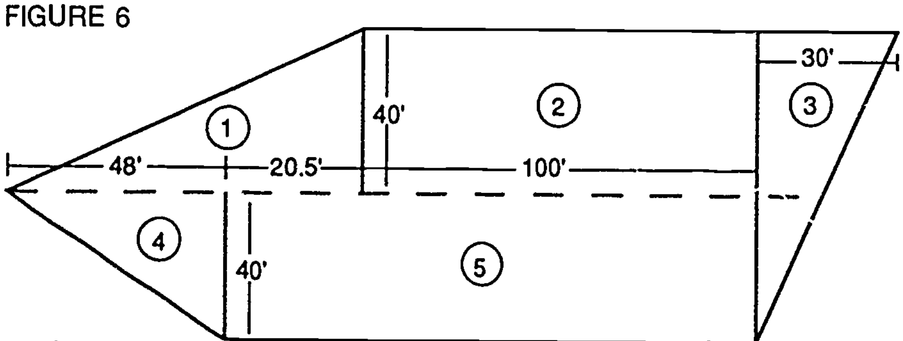
   Flow rate = ______________________ gpm

11. A 3 gallon container filled in 1 minute and 28 seconds. What is the flow rate of the supply pipe?

   Flow rate = ______________________ gpm

12. What is the total surface area of the straight-sided but irregularly shaped pond in Figure 6?

FIGURE 6



1 = ____________
2 = ____________
3 = ____________
4 = ____________
5 = ____________
Total = ____________

Surface area of pond = ____________ square feet
= ____________ acres

ASSIGNMENT SHEET #1

13. Your pond has a surface area of 14,500 square feet. The soil of the pond is loam. How many square feet of water are lost per day? How many gallons of water are needed to compensate for seepage losses during a 6-month (180-day) period? If the pond had been puddled, how many gallons would be needed to compensate for seepage loss during the 6-month period?

    Daily loss =______________________ square feet

    Seepage loss for unpuddled soil =______________________ gallons

    Seepage loss for puddled soil =______________________ gallons

14. You have a 17.5 acre pond with an average depth of 4.3 feet. It is drained with a 12-inch diameter drainpipe. How many days will it take to drain the pond?

    No. of days = ____

15. You have installed 4-inch drainpipe on your 3.4 acre pond that has an average depth of 6.4 feet. How many days will it take you to drain the pond?

    No. of days = ____

FACILITY DESIGN AND LAYOUT
UNIT VI

ASSIGNMENT SHEET #2 — CALCULATE COMMON EARTH POND CONSTRUCTION REQUIREMENTS

An important aspect of pond design and construction is the cost. The primary factor used by engineers to set a price is the volume of earthfill required. Therefore, you may find it useful to make your own estimate of the excavation, dam, or levee system.

Methods for calculating these volumes are explained in Part I of this assignment sheet. Part II will provide you with some realistic problems so that you can practice your calculations.

PART I

SIDE SLOPE

Once you have determined the surface area, depth, and water requirements for your pond, you need to determine the angle of the side slopes. For the most part, your soil characteristics determine the pond's side slope. Soil should not be stacked any higher than its natural repose. Usually the steepest feasible slope is 2:1, and 3:1 or 4:1 is more typical. Soils saturated with water at the time of excavation, and soft, sandy soils require even gentler slopes. A representative of the U.S. Soil Conservation Service can analyze your soil and recommend a suitable slide slope.

VOLUME OF EXCAVATION

With the correct side slope in mind, you can roughly calculate the amount of excavation necessary. This estimate determines the cost of the pond and is used as a basis for inviting bids and for making payment if work is to be done by a contractor.

EXAMPLE: You are planning a pond 200 feet long by 100 feet wide at the surface. The average water depth is to be 4.5 feet, and your inside slope will be a consistent 2:1.

1. Find the surface area (A) of the pond by multiplying length times width:

   A = 200 × 100

   = 20,000 square feet

2. Find the pond bottom area (C) in square feet:

   (NOTE: The side slope is 2:1, therefore, for every 2 feet extending horizontally into the water, there is a 1 foot increase in depth.)

   a. Multiply pond depth times horizontal slope to find the horizontal distance from the shoreline to the bottom of the excavation:

      4.5 feet depth × 2 foot horizontal slope = 9 feet

ASSIGNMENT SHEET #2

b. Double this shoreline-to-bottom distance to allow for two sides (or ends) of the pond, and you will find the difference between the top and bottom length or width of the excavation:

   9 feet × 2 = 18 feet

c. Subtract this figure from the top length and width to find the surface area of the pond bottom:

   $C = (200 - 18) \times (100 - 18)$

   $= 182 \times 82$

   = **14.924** square feet

3. Find area of excavation (B) at mid-depth by averaging the top and bottom surface areas:

$$B = \frac{20{,}000 + 14{,}924}{2}$$

$$= \mathbf{17{,}462}$$

4. Estimate total volume of excavation (V) by using the following formula:

$$V = \frac{A + 4B + C}{6} \times \frac{D}{27}$$

where V = Volume to be excavated in cubic yards
A = Surface area of pond in square feet
B = Area of excavation at mid-depth (½ D) in square feet
C = Pond bottom area in square feet
D = Average water depth of pond in square feet
27 = Constant to covert cubic feet to cubic yards

$$V = \frac{20{,}000 + (4)\ (17{,}462) + 14{,}924}{6} \times \frac{4.5}{27}$$

$$= \frac{20{,}000 + 69{,}848 + 14{,}294}{6} \times \frac{4.5}{27}$$

$$= \frac{104{,}772}{6} \times \frac{4.5}{27}$$

$$= 17{,}462 \times 0.16$$

= 2793.92 or about **2,794** cubic yards of soil to be excavated

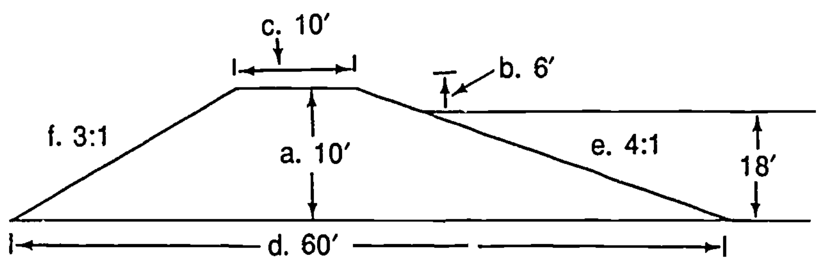
ASSIGNMENT SHEET #2

DIRT FILL FOR EMBANKMENT CONSTRUCTION

The amount of dirt required to build or fill a pond levee or dam can be estimated by knowing the cross-sectional area and length of the levee or dam. For long levees or dams with irregular heights, it is necessary to divide the dam into sections to determine the amount of dirt needed for each section. For levees or dams of uniform height, this step is not necessary. It is simpler to estimate the fill volume of levees than of dams, since the height of levees tends to be uniform from one end to the other.

Levees and dams are normally trapezoidal in cross section (Figure 1). The important dimensions are height at the crown, freeboard, width at crown, thickness or width at base, inside slope, and back slope.

FIGURE 1



a. Height at crown
b. Freeboard
c. Width at crown
d. Width at base
e. Outside slope
f. Inside slope

Levees or Dams of Uniform Height

EXAMPLE: Your pond plan requires a total levee length of 1,800 feet. You plan a top width of 16 feet, a water height of 4.5 feet, and a freeboard of 1.5 feet. The inside slope will be 3:1, and the outside slope will be 4:1. Dirt-moving costs are $.75 a cubic yard.

1. Find the cross-sectional area in square feet by using the following formula:

$$\text{Cross-sectional area} = H\left[T + \left(\frac{S1 + S2}{2}\right) H\right]$$

where T = Top width of levee in feet
H = Height of levee in feet
S1 = Pond side slope of levee
S2 = Outside slope of levee

(NOTE: If both slopes are the same, substitute the value of one slope (S) for $\frac{S1 + S2}{2}$.)

ASSIGNMENT SHEET #2

a. Find the average slope:

$$\frac{S}{2} = 1.55$$

b. Find the levee height by adding the desired water level to the freeboard:

4.5 foot water height + 1.5 foot freeboard = 6 foot levee height

c. Substitute these and other known dimensions into the formula:

$$\begin{aligned}\text{Cross-sectional area} &= 6\ [16 + (1.55)6] \\ &= 6\ [16 + 9.3] \\ &= 6\ [25.3] \\ &= \mathbf{151.8} \text{ square feet}\end{aligned}$$

2. Find the volume of dirt fill needed in cubic yards by using the following formula:

$$V\ (yd^3) = \frac{\text{Cross-sectional Area} \times \text{Levee Length}}{27}$$

$$= \frac{151.8 \times 1{,}800}{27}$$

$$= \frac{273{,}240}{27}$$

$$= \mathbf{10{,}120} \text{ cubic yards of earth fill}$$

3. Estimate earthmoving costs by multiplying the total cubic yards of dirt required by the cost per 1 cubic yard.

10,120 cubic yards × $.75/cu. yd. = **$7,590**

Levee or Dams of Uneven Heights

EXAMPLE: You want to build a dam 346 feet long by 12 feet wide at the crown, with identical inside and back slopes of 3:1 set across a natural valley. Dirt-moving costs are $.75 per cubic yard.

1. To estimate the volume of any unbuilt dam or levee of uneven height, you must construct a table like that in sample Table 1:

ASSIGNMENT SHEET #2

TABLE 1: Sample of Table to Be Constructed in Estimating Volume of Earthfill Needed for Unconstructed Dam*

Station	Ground elevation	Fill height[1] ft	End area[2] sq ft	Sum of end areas sq ft	Distance ft	Double volume[3] cu ft
0 + 50	35.0	0	0			
+ 68	32.7	2.3	44	44	18	792
1 + 00	25.9	9.1	357	401	32	12,832
+ 37	21.5	13.5	709	1,066	37	39,442
+ 53	20.0	15.0	855	1,564	16	25,024
+ 75	19.8	15.2	875	1,730	22	38,060
2 + 00	19.5	15.5	906	1,781	25	44,525
+ 19	20.3	14.7	824	1,730	19	32,870
+ 32	20.3	14.7	824	1,648	13	21,424
+ 36	18.8	16.2	981	1,805	4	7,220
+ 40	18.2	16.8	1,049	2,030	4	8,120
+ 43	18.5	16.5	1,015	2,064	3	6,192
+ 46	19.6	15.4	896	1,911	3	5,733
+ 59	19.8	15.2	875	1,771	13	23,023
3 + 00	20.8	14.2	775	1,650	41	67,650
+ 35	27.7	7.3	248	1,023	35	35,805
+ 60	31.6	3.4	76	324	25	8,100
3 + 96	35.0	0.0	0	76	36	2,736
					Total[3]	379,548

[1] Elevation of top of dam without allowance for settlement.
[2] End areas based on 12-foot top width and 3:1 slopes on both sides.
[3] Divide double volume in ft^3 by 54 to obtain volume in yd^3, e.g.,

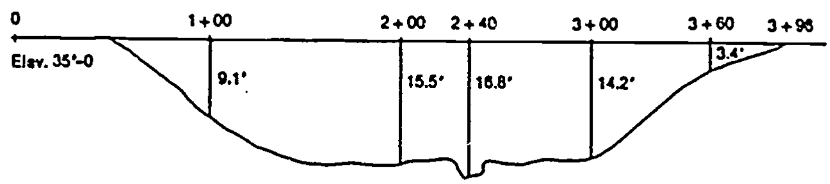
*Figures are based on Figure 2 on the following page and on dimensions in example.

ASSIGNMENT SHEET #2

2. Sketch a profile of the dam and determine the elevation at a number of points along the centerline of the space to be filled (Figure 2).

   (NOTE: A centerline survey can be made by an engineer, or you can survey the centerline by measuring abrupt elevation changes or measuring every 5 to 50 feet, depending on the steepness of the site. If you cannot obtain the actual elevation above sea level, designate the low point on the profile as zero elevation, and make further measurements as distances above that point.)

   FIGURE 2



3. Record these elevations in the second column of your table.

4 Find fill heights by subtracting each ground elevation from the top elevation of the dam; record fill heights in the third column of your table.

5. Find the cross-sectional end area in one of the following ways:

   a. Use section lengths and the general cross-sectional formula you used in determining levee cross-sectional area.

   b. Use Table 1 in Handout #3:

      EXAMPLE: Assume you want to find a cross-sectional end area at a 15-foot height —

      1) Find 15 foot fill height under first column in table.

         (NOTE: If your exact fill height doesn't appear on the table, use the next highest figure—15.6 for 15.5, for instance.)

      2) Now find the numbers at this fill height under the appropriate side slope (3:5:1/4:1) and crown width (16) columns—675 and 180.

      3) Add these two numbers to find an end area of 855 square feet at this point.

ASSIGNMENT SHEET #2

6. To find the total volume in cubic feet of fill between two points for which the end areas have been computed, add the two end areas (column 5 on your table) and multiply by the distance between the two points in feet; record in final column on your table.

   EXAMPLE: The volume of fill required between Station 1 + 53 and the next station, 1 + 75 is computed as follows:

   (855 sq. ft. + 875 sq. ft.) (22 feet) = 38,060 cubic feet

7. Now that your table is complete, add all the volumes in the last column, and divide by 54 to obtain the volume in cubic yards:

   $\frac{379,548}{54}$ = **7,029** cubic yards of fill dirt needed for dam

8. Now add a percentage for settling of the dam; if you do not have an engineer's estimate based on the type of soil in the dam and its foundation, 10 percent is a good approximation.

   .10 x 7,209 = 703 cubic yards

   7,209 + 703 = 7,732 cubic yards of fill dirt needed after adjustment

9. Multiply total cubic yards needed by cost per 1 cubic yard to estimate construction costs.

   7,732 x .75 = $5,799

ASSIGNMENT SHEET #2

PART II

Solve the following problems to practice calculating excavation and dirt fill volumes. Use Table 2 in Handout #3 as desired.

1. You are planning to construct a 432-foot long dam across a natural valley. The dam will be 16 feet wide at the crown with an inside slope of 3:5:1 and an outside slope of 4:1. Complete the columns on the measurement chart below. How many cubic yards of fill dirt will you need, including dirt to compensate for settling? What will the construction cost be if earth-moving costs are $.60 a cubic yard?

Station	Ground elevation	Fill height[1] ft	End area[2] sq ft	Sum of end areas sq ft	Distance ft	Double volume[3] cu ft
0 + 50	48.0					
+ 61	44.8				11	
1 + 00	40.5				39	
+ 50	34.5				50	
2 + 00	33.2				50	
+ 34	35.3				34	
+ 53	32.4				19	
3 + 00	32.0				47	
+ 48	35.5				48	
+ 76	39.6				28	
4 + 00	44.1				24	
+ 32	48.0				32	

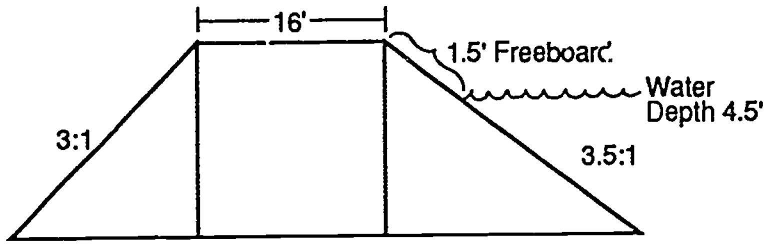
Cubic yards of fill dirt = ____________________

Cost of earth-moving = ____________________

2. Calculate the number of cubic yards of earth needed to fill the following levees, all of which are not of uniform height. Include dirt needed to compensate for settling, and calculate construction cost where indicated

ASSIGNMENT SHEET #2

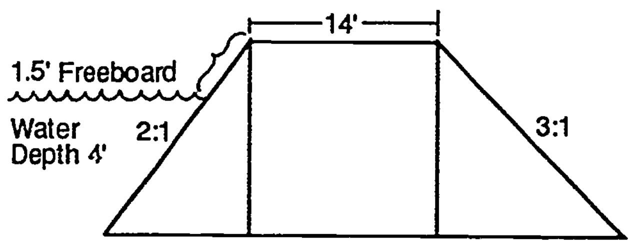
a. Length of levee = 1,500 feet
Construction cost = $.65 per cubic yard



Fill dirt required = ______________________ cubic yards

Construction cost = $______________________

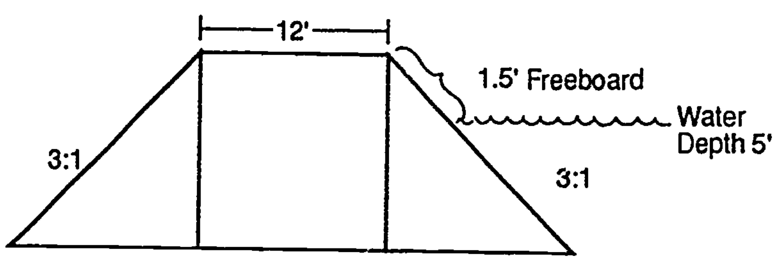
b. Total length of levee = 1,648
Construction cost = $.65 cubic yard



Fill dirt required = ______________________ cubic yards

Construction cost = $______________________

c. Total length of levee = 826 feet



Fill dirt required = ______________________ cubic yards

FACILITY DESIGN AND LAYOUT
UNIT VI

ASSIGNMENT SHEET #3 — DESIGN AND LAY OUT A POND

In this assignment sheet you will design and lay out on paper a pond or raceway system to fit your specific enterprise, topography, and needs.

1. Study layouts, designs, and specifications in literature supplied by your instructor, and in your library's source materials. Look also at the layouts in the transparencies, and at any other source materials that contain design and layout ideas. Use these designs and layouts as inspiration, but do not attempt to copy any one exactly. Because the topography of your land and your specific needs are unique, no two pond or raceway layouts will be exactly the same.

2. Draw a topographical map of the area of the proposed site, indicating hills, rock outcrops, streams, wooded areas, roads, buildings, etc. Indicate any areas that must be cleared to build the rearing unit (s).

3. Now sketch a map showing the proposed shape and layout of your pond(s) or raceway and facility. Label well or water source, piping, drainage, landscaping, and buildings, etc. Indicate all dimensions.

4. Complete a facility profile in which you list or explain the following information.

   a. Type of pond
   b. Purposes:
      Principal
      Secondary
   c. Production
   d. Species
   e. Water supply
   f. Topography
   g. Type of construction
   h. Access
   i. Use of surrounding land
   j. Pond surface area
   k. Pond depth
      Maximum
      Average
      Minimum
   l. Pond shape
   m. Embankment slopes
   n. Water inlet structure
   o. Water outlet structure
   p. Special features
   q. Comments

ASSIGNMENT SHEET #3

After you have completed your sketches, maps, and pond profile, use the knowledge gained in Assignment Sheets #1 and #2 to calculate all water requirements and earth-moving volumes. These figures will help you estimate costs in Assignment Sheet #5.

1. Water volume needed to fill pond
2. Water volumes needed to fill troughs and vats
3. Water flow rate
4. Estimated filling and water exchange times
5. Estimated discharge times
6. Estimated seepage and evaporation losses
7. Volume of excavation necessary
8. Volume of dirt fill for embankment construction

FACILITY DESIGN AND LAYOUT
UNIT VI

ASSIGNMENT SHEET #4 — DETERMINE COSTS OF LOCAL WELL DRILLING, EARTH-MOVING, AND CONSTRUCTION SERVICES

In this assignment sheet, you will compare costs of local well drilling, excavating, earth-moving, and construction services. In order to compare costs, you must first assess which aspects of the construction you are equipped to do yourself and which aspects you need to contract.

You must also consider what type(s) of excavation and earthmoving equipment is best suited for the job at hand. For example, if a dragline excavator is used, the length of the boom usually determines the maximum width of excavation that can be made with proper placement of waste material. Also, a dragline excavator leaves a borrow ditch inside the pond and compacts levees poorly and unevenly. Bulldozers cannot lift earth, and pushing earth over considerable distances can be costly. For large ponds, earth buckets and scrapers are used to build levees economically. Sheepsfoot rollers do a good job at compacting the soil layers, but frequent back and forth traffic by heavy equipment also works satisfactorily. Almost any type of heavy equipment can be used to construct a pond—from a backhoe to a tractor equipped with a bulldozer blade—but it is wise to select the equipment that can do the job most efficiently and economically.

The first place to turn is the U.S. Soil Conservation Service, which offers a variety of publications as well as free consultation service. Next, survey the services offered in your locality. List contractors and costs per unit below, and then calculate total costs based on the dimensions and needs of the facility you laid out in Assignment Sheet #3.

Service	Contractor	Cost/Unit	Total Cost
Soil survey			
Dam centerline survey			
Surveying & staking for construction			
Site clearing			
Excavation & earth moving			
Well drilling			
Levee and dam earth filling			
Landscaping			
Gravel placement			
Riprap placement			
Pipe placement			
Other			

FACILITY DESIGN AND LAYOUT
UNIT VI

ASSIGNMENT SHEET #5 — COMPLETE A FEASIBILITY STUDY FOR A SELECTED SITE BY ESTIMATING CONSTRUCTION COSTS

The investment requirements for pond construction vary depending on location, size of pond, type of enterprise, whether the land is owned or purchased, and whether there are existing ponds and facilities. Other factors include how much equipment is already owned and whether needed equipment is purchased used or new or is home-built. Some producers build their ponds, cages, or raceways to reduce costs. Others use family rather than hired labor.

Many construction costs are determined by site-specific factors such as topography, depth to groundwater, and size of ponds or wells. Also land prices can differ from one area to another. The costs of building ponds is determined by dirt-moving costs that vary with location and size of pond. Investment costs per acre generally decrease as farm size increases.

Because of the wide range of enterprises and investment requirements, use of the following estimation worksheet and tables as guidelines only. You will have to research and compare costs in your locality, and you will have to tailo the worksheet to fit your individual situation.

First determine a dollar amount for each line item that is appropriate for your layout plan. For a more detailed explanation, refer to the explanations that correspond by number to each line item. Put a zero for total cost if an item is not appropriate or required. Add line items that are required by your specific enterprise.

ESTIMATION WORK SHEET AND REFERENCE KEY

Reference Number	Item: Land	Cost
1	Land, total acres × cost/acre	______
	Land Total Cost:	______

1. Marginal land that drains poorly, or produces low crop yields, is often used for catfish farming. Figure about 85% to 90% of the land area will be water depending on size of ponds and levees; the rest will be levees, buildings or drainage.

ASSIGNMENT SHEET #5

Reference Number	Item: **Pond Construction**	Cost
2	Land clearing, acres × cost/acre	______
3	Dirt moving, cubic yards × cost/cubic yard	______
4	Drain structure, units × cost/unit	______
5	Water supply line/valve, units × cost/unit	______
6	Ground cover, acres × cost/acre	______
7	Gravel or shellrock, cubic yards × cost/cubic yard	______
8	Drainage ditch, cubic yards × cost/cubic yard	______
9	Water well and casing, units × cost/unit	______
10	Pump and engine, units × cost/unit	______
11	Power source and installation, units × cost/unit	______
	Pond Construction Total Cost:	______

2. Land with trees or other obstacles needs to be cleared before ponds are constructed.

3. Dirt moving costs vary with location and condition of soil at the construction site. In flatland areas with large levees, about 6.2 cubic yards of dirt are moved per linear foot of levee. The actual amount depends on the dimensions of the levee.

4. Each pond should have a drain structure that permits pond draining in several days. Drains should be designed to prevent entry of wild fish and can be located either inside or outside of the pond. Various designs are suitable. The structure should be screened and fitted with a valve as needed.

5. Water supply lines should be large enougn to carry the desired flow and be straight as possible. The discharge water should be aerated before it enters the pond.

6. Unprotected areas of the levees should be covered with vegetation to minimize erosion and stabilize the soil. The vegetation should be suited for your area and may require lime and fertilizer.

7. Gravel or other material should be spread on at least the main levees where traffic is heaviest and fish are harvested. The road surface should be at least six inches thick to permit all-weather access.

8. An outside drainage canal is recommended on one side of the pond(s) to carry discharge water away from the pond area. The size and cost of the canal depend on the slope of the land and volume of water that drains at one time. Underground main drain lines are also used instead of open canals.

ASSIGNMENT SHEET #5

9. A water supply from a pumped well is recommended for intensive catfish production. Water can be added when needed. The well should be located to serve as many ponds as possible, that is, one well per four or more ponds. Adequate water should be available to fill the largest pond in about 10 days or less. This is equal to at least 25 gpm per acre-foot of water in the largest pond. Wells of 1,500 to 2,000 gpm capacity normally serve four ponds of 15 acres each with an average depth of four feet. For watershed or hill ponds, an adequate watershed area to pond area ratio is needed for ponds to fill between winter and spring.

10. Depth and size of the well and desired discharge will determine the size of pump and motor. Pump and motor should be properly selected for maximum pumping efficiency and economy of operation.

11. Power is required to operate wells and aerators. The availability and cost of single or three-phase electricity vary with location. Determine installation fees to run lines to your ponds, and estimate the operating costs. In areas without electricity, diesel-electric generators or diesel engines are used as a power source. Evaluate your power alternatives, and compare ownership and operating costs.

This assignment sheet is adapted from the Louisiana Agricultural Experiment Station and Louisiana Cooperative Extension book *Commercial Production of Farm-Raised Catfish* by Gary L. Jensen. With permission.

FACILITY DESIGN AND LAYOUT
UNIT VI

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet 1

Part II

1. 77 acre-feet
   25 million gallons
2. 5.34 or 5 acre-feet
3. 186 gallons
4. 3,487 gallons
5. 565.2 or 565 cubic feet
   4,228 gallons
6. 1,131 gpm
7. 4.2 days to fill pond
8. 1,217 gpm
9. 339 hours
   14.2 days
10. 2.85 or 3 gpm
11. 2.04 or 2 gpm
12. 15,140 square feet
    0.35 acres
13. 725 square feet per day
    130,500 gallons unpuddled
    20,880 gallons puddled
14. 10.6 days
15. 39.4 days

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #2

PART II

1. 10.428 cubic yards
   $6,257

Station	Ground elev.	Fill Height	End Area sq. ft.	Sum of end areas sq. ft.	Distance ft.	Double vol. in cu. ft.
0 + 50	40.0	0.0	00			
+ 61	44.8	3.2	87	87	11	957
1 + 00	40.5	7.5	325	412	39	16,068
+ 50	34.5	13.5	866	1191	50	59,550
2 + 00	33.2	14.8	1004	1870	50	93,500
+ 34	5.3	12.7	779	1783	34	60,622
+ 53	32.4	15.6	1102	1881	19	35,739
3 + 00	32.0	16.0	1152	2254	47	105,938
+ 48	35.5	12.5	759	1911	48	91,728
+ 76	39.6	8.4	382	1141	28	31,948
4 + 00	44.1	3.9	120	502	24	12,048
+ 32	48.0	0.0	000	120	32	3,840
					Total =	511,938

2. a. 11,933 cubic yards
   $ 7,756

   b. 9,500 cubic yards
   $6,175

   c. 6,393 cubic yards

Assignment Sheets #3 - #5 — Evaluated to the satisfaction of the instructor

FACILITY DESIGN AND LAYOUT
UNIT VI

JOB SHEET #1 — CONSTRUCT A CAGE FOR FISH CULTURE

A. Equipment and materials

1. Twenty feet of 16-gauge, plastic-coated welded wire, 48-inches wide with a mesh of 1/2 inch by 1 inch
2. Three dozen stainless steel C-rings and C-ring pliers
3. Pair of tinsnips
4. Five styrofoam squares 12 x 6 x 6 inches
5. Plastic-coated 1/8 inch feeding mesh 1 foot wide and 11 and 1/4 feet long
6. Plastic paint or rust-proof paint and small brush
7. Strapping material
8. Plastic-coated bell wire, 50 feet
9. Cinder block and length of rope for an anchor

B. Procedure (Figure 1)

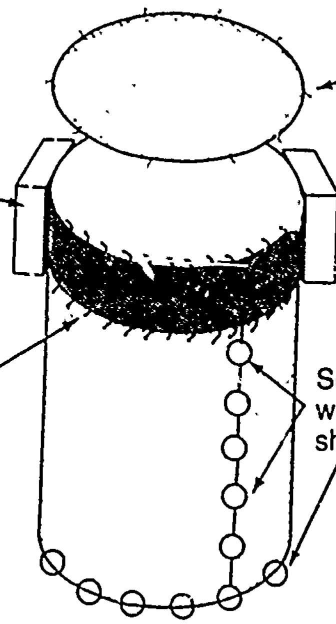
1. Cut the wire mesh into a piece 11¼ feet long.
2. Form the mesh into a cylinder with a 4 to 6 inch overlap where the ends meet.
3. Space C-rings 1 to 2 inches apart along the length of the joint.
4. Clamp C-rings from inside the cylinder so that any sharp edges will point to the outside to avoid injury to fish and people working inside the cage.
5. Place either end of the cylinder on an area of the remaining welded wire, and cut to size the two pieces needed to form the top and bottom of the cage.
6. Attach the bottom of the cage with C-rings, working from the inside out so all sharp points will be outside.
7. Cut the fine-wire feeding mesh into a piece 11¼ feet long and 1 foot wide.
8. Place the feeding mesh around the extreme upper part of the cage on the inside, fit it around the sides of the cage and attach it by twisting pieces of bell wire at 6 to 8 inch intervals at the top and bottom edges of the feeding mesh. (See Figure 1.)

JOB SHEET #1

9 Place the five styrofoam squares at even intervals around the top edge of the cage and secure them with pieces of bell wire or strapping.

(NOTE: Strapping is recommended because it will not cut the styrofoam like bell wire does.)

FIGURE 1



Courtesy Langston University Agricultural Research

10. Attach the top of the cage with bell wire, but secure only one side of the top so that it can be easily lifted for stocking fish, and can be fully secured when it is placed in use.

11. Use the plastic or rust-proof paint to coat any cut edges of the wire or mesh to assure that cut spots will not rust.

12. Tie a cinder block with an appropriate length of rope to anchor the cage near shore or an access dock.

(CAUTION: Take care not to bend the cage during construction or use because an ill-fitting top will cause a volume loss in the cage.)

FACILITY DESIGN AND LAYOUT
UNIT VI

PRACTICAL TEST #1
JOB SHEET #1 — CONSTRUCT A CAGE FOR FISH CULTURE

Student's Name________________________________ Date____________

Evaluator's Name________________________________ Attempt No.______

When you are ready to perform Job Sheet #2, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to indicate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	Yes	No
1. Gathered correct equipment and materials.	☐	☐
2. Measured materials correctly.	☐	☐
3. Cut materials accurately.	☐	☐
4. Constructed cage properly.	☐	☐
5. Returned equipment and materials to proper storage.	☐	☐

EVALUATOR'S COMMENTS ____

____

____

JOB SHEET #1 PRACTICAL TEST
PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:

Equipment and Materials	Properly selected and properly used 4	Properly selected and acceptably used 3	Poorly selected and/or used 2	Improperly selected and/or used 1
Construction Procedure	Well followed 4	Acceptably followed 3	Poorly followed 2	Improperly followed 1
Cage Dimensions	Accurate 4	Almost all accurate 3	Somewhat accurate 2	Inaccurate 1
Floatability	Excellent 4	Good 3	Fair 2	Poor 1
Usability	Excellent 4	Good 3	Fair 2	Unusable 1

EVALUATOR'S COMMENTS:____

PERFORMANCE EVALUATION KEY

4 — **Skilled** — Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program.
2 — **Limited skill** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR'S NOTE: If an average score is needed to complete a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

FACILITY DESIGN AND LAYOUT
UNIT VI

TEST

NAME________________________ SCORE____________

1. Match terms related to facility design and layout with their correct definitions. Write the correct numbers in the blanks.

_____a. Distance between pond surface and top of levees or dam; generally between 1 and 2 feet

_____b. Earth dike used to enclose water

_____c. Mechanism for stirring up and thus aerating water in hatching tanks and troughs

_____d. To gather and enclose water for fish pond or irrigation

_____e. Harvesting net

_____f. Raising of fish in densities higher than could be supported in the natural environment; requires feeding of formulated feeds

_____g. Vertical pipe placed in a tank so that top is at desired water height; water above this height drains from the tank

_____h. Raising of fish in low densities in ponds where the fish feed primarily on natural feeds

_____i. Device such as a screen that interferes with water flow, thus stirring up and aerating the water

_____j. Seine attached to harvesting seine and used to crowd, grade, and hold fish in the pond

1. Baffle
2. Seine
3. Overflow pipe
4. Intensive production
5. Extensive production
6. Freeboard
7. Levee
8. Live car
9. Agitator
10. Impound

TEST

2. Match basic types of farm water enclosures with their characteristics. Write the correct numbers in the blanks.

Earth ponds

_____a. Usually square or rectangular enclosure constructed by building earth dikes to contain water; the pond bottom is above or nearly level with the surrounding soil

_____b. Irregularly shaped basin created by damming water that would normally run off

_____c. Regularly shaped basin on flat or gently sloping land created by removing earth and using it to build embankments or levees

1. Excavated pond
2. Levee pond
3. Impoundment pond

Fabricated ponds or rearing units

_____d. Small regular rearing unit typically 100 feet long, 40 feet wide and 8 feet deep; used for fingerling or hobby fish or for holding pond

_____e. Sloping series of narrow concrete units in which a frequent interchange of water is possible by maintaining a fast rate of water flow down the length of the units; a typical ratio of depth to width to length would be 1:3:30

_____f. Medium-sized rearing unit into which water enters through a jet at the side and leaves through a center overflow pipe; the body of the water is kept in rotation; because the water is rapidly and continuously exchanged, it is possible to keep very high densities of fish; typical diameter is 16 feet with a water depth of 4 feet

4. Circular concrete rearing unit
5. Rectangular concrete rearing unit
6. Raceway

TEST

Tanks, vats, and other enclosures

______g.	Used to confine spawning pairs, these 5 by 10 foot enclosures are made of heavy-duty vinyl-covered wire with a 2-inch mesh, and steel or treated wooden posts	7. Holding tank or vat
______h.	Floated in ponds and used for grow-out, these net units may be round, square, or rectangular; they are made of noncorrosive materials such as vinyl-covered wire, plastic, and aluminum and range in size from 3 by 3 feet to 8 by 8 feet	8. Hatching/fry trough
______i.	Made of galvanized metal, concrete block, poured concrete, or fiberglass, these enclosures are used to grade fish into size classes, hold fish for sale, as temporary storage, and to segregate diseased fish for treatment; sizes vary but 30 feet long by 4 feet wide by 3 feet deep is typical	9. Spawning pens
______j.	Made of marine plywood, metal, or fiberglass, these enclosures are typically 10, 12, or 15 feet long, 20 inches wide, and 10 inches or more deep; the water is kept in motion with agitators that circulate it among the fish eggs, which rest in the water on trays	10. Floating cages

3. List four facility requirements for food-fish production.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

TEST

4. List five facility requirements for channel catfish fingerling production.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

5. List six facility requirements for rainbow trout fingerling production.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

   f. ______________________________

6. List 6 facility requirements for fee-fish operation.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

   f. ______________________________

7 Arrange is order initial steps in planning an on-site processing facility. Write a "1" before the first step, a "2" before the second step, and so on.

______a. Draw up plans (you don't need an architect) for the facility and send or take them to the state health office for approval.

______b. Contact your county health and sanitation officer and discuss your plans to learn the specific requirements needed in the design of your facility.

______c. Find out if your county has planning and zoning laws and make legal notification of your plans to build a facility if necessary.

TEST

______d. Receive final approval from state inspector.

______e. Build your facility according to approved plans.

8. List five facility requirements for an on-site processing facility.

   a. ________________________________

   b. ________________________________

   c. ________________________________

   d. ________________________________

   e. ________________________________

9. List factors to consider when planning pond size.

   a. ________________________________

   b. ________________________________

   c. ________________________________

   d. ________________________________

   e. ________________________________

   f. ________________________________

10. Complete statements about layout and design considerations. Write the correct numbers in the blanks.

______a. Lay out pond for ______ for the type of program to be followed.

1) maximum efficiency of production
2) maximum profit
3) maximum amount of excavation

______b. ______ to take into consideration the economics of construction and harvesting.

1) Select dam width
2) Choose equipment
3) Shape pond

______c. If possible, construct ponds ______ to reduce costs of construction per acre of water.

1) close to land crops
2) next to each other
3) near the processing facility

TEST

______d. Plan for ______ of water supplies and drainage facilities.

1) maximum utilization
2) minimum utilization
3) supplementary use

______e. Locate the ______ at a high elevation to avoid any flood water and to take advantage of gravity flow through the supply pipes.

1) outlet pipe
2) well head
3) drainage canal

______f. Locate water lines at the ______ end of pond where fish will be harvested, and at end opposite ______.

1) deep; drain
2) shallow; inflow pipe
3) shallow; drain

______g. Lay out water lines to minimize ______ from the well head of each pond.

1) the length of pipe
2) the water pressure
3) number of connections

______h. Lay out pond(s) to permit independent draining of each by ______.

1) gravity flow
2) pumping
3) overflow pipe

______i. Building ponds ______ conserves water and requires less construction; however a(n) ______ arrangement is usually best.

1) parallel; in series
2) in series; circular
3) in series; parallel

11. Distinguish between advantages of small versus large ponds. Write an "S" in the blanks before advantages of small ponds, and an "L" in the blanks before large pond advantages.

______a. Are easier and quicker to harvest

______b. Permit segregation of breeders, fish of different sizes, etc.

______c. Take up less space per area of water surface

______d. Are more subject to wind aeration

TEST

______e. Can be drained and refilled more quickly

______f. Offer safety factors if several ponds are constructed and disease strikes one pond

______g. Can be used to alternate fish and land crops

______h. Have banks that are less subject to wind erosion

______i. Result in less financial loss if stock is lost

______j. Require less construction cost per area since less soil must be moved to achieve equal surface area

______k. Permit more simultaneous experimentation

______l. Are easier to treat disease, apply fertilizer, feed fish, etc.

(NOTE. If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

12. Estimate water requirements. (Assignment Sheet #1)

13. Calculate common earth pond construction requirements. (Assignment Sheet #2)

14. Design and lay out a pond. (Assignment Sheet #3)

15. Determine costs of local well drilling, earthmoving, and construction services. (Assignment Sheet #4)

16. Complete a feasibility study of a selected site by estimating construction costs. (Assignment Sheet #5)

17. Demonstrate the ability to construct a cage for fish culture. (Job Sheet #1)

FACILITY DESIGN AND LAYOUT
UNIT VI

ANSWERS TO TEST

1.	a.	6	f.	4
	b.	7	g.	3
	c.	9	h.	5
	d.	10	i.	1
	e.	2	j.	8

2.	a.	2	f.	4
	b.	3	g.	9
	c.	1	h.	10
	d.	5	i.	7
	e.	6	j.	8

3. Answer should include any four of the following

   a. Pond or raceway of appropriate size for present and future needs
   b. Valves, screens, pumps, and other fixtures necessary for water control
   c. Drainage system
   d. Road system that allows for movement of vehicles when mowing, stocking, aerating, and harvesting
   e. Small storage and utility buildings and feed storage bins

4. Answer should include any five of the following

   a. Broodfish holding ponds of 1 acre or less to maintain broodfish between spawning seasons
   b. Spawning pond of 1 to 5 acres, or spawning pens
   c. Spawning nests
   d. Hatching and fry troughs or fry ponds, depending on method of hatching desired
   e. Rearing ponds for growing fry into fingerlings
   f. Holding vats of various sizes
   g. Drainage, storage, and road systems as for food-fish production

5. Answer should include any six of the following

   a. Longitudinal earthen raceway for broodfish
   b. Divided raceway for separating males and females when they near spawning condition
   c. Hatching trough with tray hatching system, or hatching jars
   d. Small rearing troughs to handle fry to 2.5 inches
   e. Raceways for rearing fish 2.5 inches or over
   f. Settling basin

ANSWERS TO TEST

g. Hatching building with tank room, incubation room, some feed storage, and general storage
h. Garage and shop building
i. Feed storage building or bins

6. Answer should include any six of the following

   a. Drainable pond(s) in area with attractive vegetation and with shade available near the water
   b. Drainage system
   c. Fishing piers and platforms
   d. All-weather parking facilities
   e. Bait, tackle, food, and drink concession stands, if not using vending machines
   f. Fish cleaning tables
   g. Restrooms

7. a. 3
   b. 2
   c. 1
   d. 5
   e. 4

8. Answer should include any five of the following
   a. Enclosed structure with concrete floor and wash-down walls
   b. Lagoon for waste
   c. Potable water system
   d. Running water or aeration system
   e. Three-basin sink and drain system
   f. Covered light fixtures
   g. Handwashing sink

9. a. Slope and size of site available
   b. Whether rotation of fish and land crops is planned
   c. The supply of good-quality water
   d. Marketing demands and harvesting conditions
   e. The economics of construction
   f. Management capabilities

10.

a.	1	f.	3
b.	3	g.	1
c.	2	h.	1
d.	1	i.	3
e.	2		

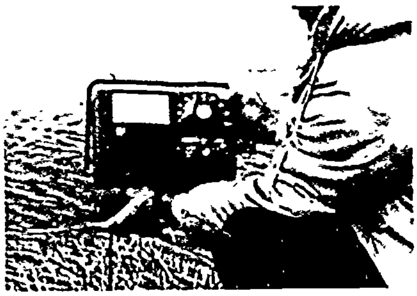
ANSWERS TO TEST

11.

a.	S	g.	L
b.	S	h.	S
c.	L	i.	S
d.	L	j.	L
e.	S	k.	S
f.	S	l.	S

12-16. Evaluated to the satisfaction of the instructor

17. Evaluated according to criteria in Practical Test #1



WATER QUALITY MANAGEMENT
UNIT VII

UNIT OBJECTIVE

After completion of this unit, the student should be able to monitor and test for water quality problems and correct or prevent those problems through proper management. These competencies will be evidenced by correctly completing the procedures in the assignment and job sheets and by scoring a minimum of 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to water quality management with their definitions.
2. Match compounds and elements with their chemical formulas and symbols.
3. Discuss the importance of oxygen in water quality management.
4. Discuss the role of temperature in oxygen management.
5. Match natural sources of water temperature variation with their effects.
6. Match types of thermometers for measuring water temperature with their descriptions.
7. Select facts about temperature management techniques.
8. List causes of DO loss.
9. List signs of DO deficiency.
10. Select facts about the prevention of DO depletion.
11. Select from a list guidelines for measuring DO.
12. Match DO measuring equipment with its descriptions.
13. Select from a list true statements about methods of correcting DO deficiency.
14. Identify types of mechanical aerators.

OBJECTIVE SHEET

15. Select facts about turbidity remedies.

16. Complete statements about the importance of nitrogen compounds in water quality management.

17. Complete statements about pH and water quality.

18. Select from a list methods of managing the pH cycle.

19. List the purposes of liming.

20. Select from a list general guidelines for water chemistry management.

21. Match aquatic plant control methods with their descriptions .

22. Calculate dosages for chemical treatments. (Assignment Sheet #1)

23. Analyze facility aerator needs. (Assignment Sheet #2)

24. Demonstrate the ability to:

    a. Use a Secchi disc to measure turbidity. (Job Sheet #1)

    b. Use an 0_2 meter to measure DO. (Job Sheet #2)

    c. Use a water analysis kit to test water quality parameters. (Job Sheet #3)

    d. Predict low DO levels, using Secchi disc, projection, and chart methods. (Job Sheet #4)

WATER QUALITY MANAGEMENT
UNIT VII

SUGGESTED ACTIVITIES

A. Obtain copies of *Guide to Oxygen Management and Aeration in Commercial Fish Ponds* for each of your students so that they may complete Job Sheet #3. If this is impractical or costly, make a copy available through your school library.

B. Make transparency.

C. Make copies of Handout #1 so that students may complete assignment sheets.

D. Provide students with objective sheet. Discuss unit and specific objectives.

E. Provide students with information sheet. Discuss information sheet, adapting and adding information specific to your state or locality.

F. Provide students with assignment sheets. Explain assignment sheets, and work additional problems relevant to the situations in your class.

G. Schedule job sheets and complete practical and product test forms.

H. Give written test.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Belusz, Larry. *Fish Farming Techniques*. Columbia, Missouri: University of Missouri, The Instructional Materials Laboratory, 1987.

B. Boyd, Claude E., et al. *Water Quality in Channel Catfish Ponds (A Report from the Water Quality Subcommittee of Regional Research Project S-168)*. Southern Cooperative Series Bulletin 290. Mississippi State, Mississippi: Agricultural and Forestry Experiment Station, 1983.

C. Boyd, Claude E., and Frank Lichtkoppler. *Water Quality Management in Pond Fish Culture*. Auburn, Alabama. Auburn University International Center for Aquaculture, Agricultural Experiment Station, 1979.

D. Dupree, Harry K., and Jay V. Huner, eds. *Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research*. Washington, D.C.: U.S. Fish and Wildlife Service, 1984.

E. *Fritz Aquaculture Catalog 1987*. Dallas, Texas: Fritz Aquaculture, 1987.

F. Jensen, Gary L., and Joseph D. Bankston. *Guide to Oxygen Management and Aeration in Commercial Fish Ponds*. Baton Rouge, Louisiana: Louisiana State University Agricultural Center, 1988.

SUGGESTED ACTIVITIES

G. McLarney, William. *The Freshwater Aquaculture Book. A Handbook for Small Scale Fish Culture in North America*. Point Roberts, Washington. Hartley and Marks, Inc., 1984.

H. Piper, Robert G., et al *Fish Hatchery Management*. Washington, D.C.: United States Department of the Interior, Fish and Wildlife Service, 1982.

I. *Pond Management in Oklahoma*. Oklahoma City: Fish Division, Oklahoma Department of Wildlife Conservation, 1984.

J. Reigh, Robert C., ed. *Proceedings of the Louisiana Aquaculture Conference 1988*. Baton Rouge, Louisiana: Louisiana Cooperative Extension Service, 1988.

K. Romaire, R. P., and C. E. Boyd. *Predicting Nightime Oxygen Depletion in Catfish Ponds*. Auburn, Alabama: Alabama Experiment Station, Auburn University, Bulletin 505, n. d.

WATER QUALITY MANAGEMENT
UNIT VII

INFORMATION SHEET

I. Terms and definitions

A. **Oxidation** — The union of a substance with oxygen resulting in an increased positive or decreased negative valence or ion

EXAMPLE. When oxygen combines with ferrous iron (Fe++) it gains a positive ion. Its ionized form, ferric iron (Fe+++), in sufficient quantities can clog the gills of young fishes.

B. **Turbidity** — Muddy or cloudy water caused by suspended particles of soil or plankton

C. **Sediment** — Matter that settles to the bottom of the pond

D. **Aerobes** — Organisms that can live and grow only where free oxygen is present

EXAMPLES: Man, fishes, aerobic bacteria

E. **Anaerobes** — Organisms that can live and grow where there is no free oxygen.

EXAMPLE: Anaerobic bacteria

F. **Toxicity** — Poisonous

G. **Mortality** — Death, particularly death from disease or on a large scale

H. **Alkalinity** — Measure of pH buffering capacity

I. **Buffer** — Any substance in a solution that tends to stabilize the hydrogen ion concentration by neutralizing any added acid or alkali

EXAMPLE: Lime is used to buffer or stabilize pH.

J. **Turbulence** — Swirling agitation of water

K. **Precipitate** — To separate out from a solution

L. **Salinity** — Measure of salt in water

M. **Secchi disc** — Instrument used to measure light penetration and thus turbidity

N. **B.O.D.** — Biochemical oxygen demand; based on total mass (biomass) and not on individual numbers of stock

O. **Supersaturation** — Greater than normal solubility of a chemical (oxygen, nitrogen) as a result of unusual temperatures or pressures

INFORMATION SHEET

P. **Effluent** — Water discharge from a rearing unit

Q. **Oxygen transfer efficiency** — A measure of the percent of the total oxygen used that a device is able to put into solution

II. Chemical formulas and symbols for compounds and elements

> POINT OF INTEREST: So far, twenty chemical elements have been shown to be important in aquatic ecosystems. Quality water management requires the aquaculturist to know the symbols and formulas for various chemical compounds and elements that will be encountered often on labels and in the literature outlining detection, prevention, and correction measures.

A. **DO** — Dissolved oxygen

B. **O_2** — Oxygen gas

C. **N_2** — Nitrogen gas

D. **NH_3** — Ammonia

E. **NH_4** — Ammonium

F. **NO_2** — Nitrite

G. **NO_3** — Nitrate

H. **H_2S** — Hydrogen sulfide

I. **Fe_2** — Ferrous iron

J. **Fe_3** — Ferric iron

K. **$CaCO_3$** — Lime (calcium carbonate)

L. **$Ca(HCO_3)_2$** — Calcium bicarbonate

M. **CaO** — Quicklime

N. **$Ca(OH)_2$** — Hydrated lime

O. **CO_2** — Carbon dioxide

P. **$NaHCO_3$** — Sodium bicorbonate

Q. **H_2Co_3** — Carbonic acid

R. **$KMnO_4$** — Potassium permanganate

S. **Ca** — Calcium

INFORMATION SHEET

T. Zn — Zinc

U. Pb — Lead

V. Cu — Copper

III. Importance of oxygen in water quality management

A. Of the many dissolved substances natural water contains, oxygen, nitrogen compounds, pH, alkalines, hydrogen sulfide, carbon dioxide, and iron are those most important to water quality management.

B. To the aquaculturist and aquatic animal alike, dissolved oxygen (DO) is the most important chemical part of natural water.

C. Dissolved oxygen is not the oxygen in H_2O, which is bound to two hydrogen molecules; instead it is pure gaseous oxygen (O_2) in the same form as is found in the air.

D. All aquatic animals and plants need a certain minimal amount of DO to survive. dawn DO readings in warmwater systems should ideally be maintained at above 4 ppm.

E. Water quality management is not as simple as maintaining a certain minimum DO to ensure survival, the aquaculturist is interested in maximizing growth, and at minimum DO levels, fish may survive yet fail to grow at all.

F. It is possible to have too much DO, but such cases are rare, and the aquaculturist can generally proceed on the rule of thumb that "more DO is better than less."

G. The primary natural source of oxygen in the atmosphere is photosynthesis--the process by which green plants convert carbon dioxide (CO_2), water (H_2O), and solar energy to sugars, with oxygen (O_2) as a by-product

H. In raceways and troughs, oxygen is supplied by continuously flowing fresh water; a raceway's production capability is regulated by the amount of available DO in the inflow water.

(NOTE: The available DO in the trout water is typically greater than 5 to 6 ppm. Five ppm is the minimum acceptable level.)

IV. Temperature and oxygen management

A. The temperature of water affects the amount of oxygen that can be dissolved in it: the higher the water temperature the less oxygen it will hold.

B High temperatures cause increased transpiration in plants and increased decay of organic materials, thus reducing DO levels.

INFORMATION SHEET

V. Effects of natural sources of water temperature variation

A. **Solar radiation** — Heats water and also causes evaporation, which reduces depth and volume, thus accelerating the rate of heating; shade moderates these effects.

B. **Air temperature** — Affects the water below it by changing its temperature—though water changes temperature more slowly than air; the larger the water surface in contact with the air, the more rapidly the water heats or cools; creates seasonal water temperature variations that may be limiting.

C. **Water depth**

1. Causes shallow bodies of water to warm and cool more rapidly than deeper bodies of water

2. May cause deep water to stratify with the colder, denser water sinking to the bottom

D. **Color of water and bottom** — Affects heat absorption; dark water and colorless water over a dark bottom absorb heat faster than their opposites.

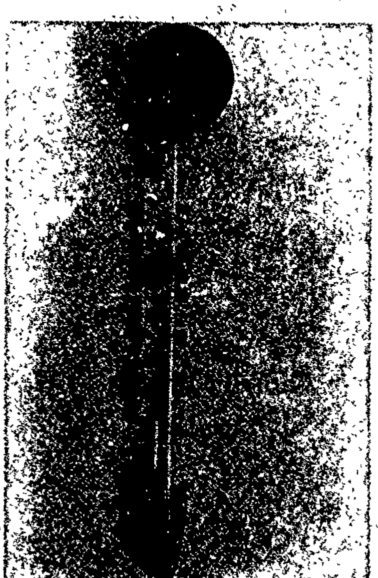
(NOTE: Turbidity, which colors while reducing transparency, may concentrate solar heating in the surface layer.)

E. **Circulation** — Gravity-induced flow, and wind-induced waves may cause cooling currents that serve to equalize pond temperatures.

VI. Types of thermometers for measuring water temperature (Figures 1-5)

A. **Aquarium thermometer** — Variously designed to float, clip to tank or trough walls, or to rest upright on bottom, this type thermometer is handy for small enclosures.

EXAMPLE: FIGURE 1



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B. **Fisherman's thermometer** — A highly portable thermometer in a rugged case so it cannot be easily broken, this thermometer usually has a top eyelet to add weight and to provide space for attaching a cord so that the thermometer can be handily dropped to different water levels.

EXAMPLE: FIGURE 2

C. **Maximum-minimum thermometer** — Designed to record highest and lowest temperatures over a specified period, this thermometer is useful in monitoring daily temperature variations.

EXAMPLE: FIGURE 3

INFORMATION SHEET

D. **Electronic probe thermometer** — Designed to measure air, liquids, surfaces, and semi-solid materials, this battery-powered digital-display thermometer is easy to read and practical for quick and consistent measurements.

EXAMPLE: FIGURE 4

VII. Temperature management techniques

A. It is difficult and costly to manage water temperature, so aquaculturists are often limited to culturing only species that thrive within specified ranges of their local temperature extremes.

POINT OF INTEREST: Some cage farmers in the South Central United States find it possible to raise warmwater species, such as catfish, in the spring and summer, and cool-water species, such as trout, in the fall and winter.

B. Water that is too cold can be warmed in warming ponds—shallow ponds through which the water passes before reaching the main pond.

C. Water that is too warm, can be cooled by removing some warm water and adding an equal amount of cool water.

D. Water that is too warm can also be cooled naturally by wind action and by laying out ponds and raceways so that they will be partially shaded for some period of the day.

E. In very small ponds or in tanks, water can be heated mechanically, though this process is expensive and impractical for larger facilities.

VIII. Causes of DO loss

A. **Respiration by aerobes** is the primary cause of DO loss; all animals and aerobic bacteria respire by oxidizing O_2 to CO_2.

INFORMATION SHEET

B. **High temperatures** cause DO loss by increasing the respiration rate and thus demand, while at the same time reducing the amount of O_2 that water will hold.

C. **Oxidation of organic matter** as it is decomposing, dead organisms, uneaten feed, and organic pollutants reduces the water's DO level.

D. **Oxidation of inorganic substances** also causes a loss of DO.

EXAMPLE: Ferrous iron (Fe_2) is oxidized to ferric iron (Fe_3) by the DO in water and uses oxygen in the process.

E. **Diffusion**, the release of O_2 into the air from the water surface, also causes DO loss, but occurs only when the water is supersaturated.

(NOTE. Diffusion losses can be significant if aeration devices are used when the water is supersaturated with O_2 in the afternoon or when strong wind occurs during this time.)

IX. Signs of DO deficiency

A. Fish not eating food and acting more sluggish than usual;

B. Fish gasping (piping) for air at water surface;

C. Fish grouped near water inflow pipe;

D. Other aquatic animals such as crayfish and snails crawling out of the water in numbers;

E. Fish-eating birds gathering at pond, especially in the morning;

(NOTE. This behavior often means dead or stressed fish are near the surface of the pond.)

F. Turbidity caused by heavy plankton die-offs;

(NOTE: A brown or yellow turbidity or a detergent-like odor are signs that a plankton system is experiencing low DO. Emergency aeration measures should be taken.)

G. Repeated outbreaks of stress-related disease and parasites;

H. Slow growth.

X. Guidelines for preventing DO depletion through water management

A. Avoid overstocking.

B. Avoid overfeeding.

C. Avoid over-fertilizing; it causes organic pollution.

INFORMATION SHEET

D. Control plant growth, remembering that in the absence of sunlight aquatic green plants compete with crop species for available DO.

E. Monitor temperature, and routinely measure DO levels. (Job Sheets #2 and #3)

F. Keep the water in circulation, and provide routine supplemental aeration. (Assignment Sheet #3)

G. Monitor turbidity that interferes with sunlight penetration and thus prevents photosynthesis. (Job Sheet #1)

H. Attempt to predict when DO will fall below minimum acceptable levels, so that you can take preventive action before DO depletion occurs. (Job Sheet #4)

XI. Guidelines for measuring DO

A. Measure DO daily, so that measurements can be used as a preventive rather than a diagnostic tool.

B. Take measurements at dawn, when DO is at its daily low point just before photosynthesis begins; at dusk, after a full day of DO production, and two hours later to see how fast the DO level is declining.

(NOTE: The difference between the DO concentration at dawn and dusk represents *net DO production*, while the difference between dusk and dawn represents *DO demand.* If demand increases and production does not increase proportionally, a depletion can occur. On the other hand, if net production is reduced, the following day's demand may reduce DO to critically low levels.)

C. Measure DO levels throughout the night during hot, cloudy weather, during intensive feeding or fertilization programs, or at any time when there is a sudden increase in B.O.D. and DO is apt to fall to critically low levels.

D. Measure DO at least 6 inches below the surface and at a variety of locations and depths because DO is generally highest at the surface and around inflows and aerators and lowest at the bottom.

(NOTE: *Never* take DO readings near inflowing waters, aeration equipment, immediately next to the bank, in scums of floating algae, nor right at the pond surface or bottom. Such measurements will be inaccurate, showing false highs and lows.)

E. The best places to measure DO in a trout raceway are near the head of the rearing unit and in its effluent; the difference between the two readings is the net DO used.

F. The best time to measure DO in trout rearing units is approximately 1 hour after feeding when the fishes' metabolism is high and they are using the most DO.

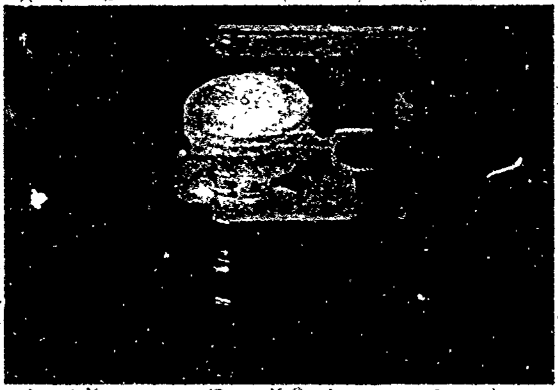
INFORMATION SHEET

XII. DO measuring equipment (Figures 5 and 6)

A. **Colorimetric test kit** — Inexpensive and not very accurate, this method depends on discriminating among colors that indicate O_2 levels.

B. **Titration test kit** — Inexpensive and more precise, but also more time consuming, this method requires collecting water samples and analyzing them chemically.

EXAMPLE: Figure 5



C. **Battery operated meters** — Expensive, but highly accurate and convenient, this method requires inserting a probe at various locations and recording instant electronic readings.

(NOTE: Most oxygen meters today include a thermometer, and some can be set to compensate for variables such as temperature, salinity, and altitude. Meters may cost from $500 to over $1,000 and may break down. A colorimetric or titration kit should be kept on hand in case of breakdown.)

EXAMPLE: Figure 6

INFORMATION SHEET

XIII. Methods of correcting DO deficiency

POINT OF INTEREST: The addition of oxygen through the diffusion and absorption of pure oxygen gas (0_2) is now becoming more economically feasible in raceway and tank culture. There are a variety of methods, each with its own transfer efficiency. Bulk liquid oxygen tanks or oxygen generators are the preferred sources for extended use.

A. Add oxygen to water through mechanical aeration.

(NOTE: This is the most effective method of quickly increasing DO levels.)

B. Reduce the demand for oxygen.

1. Reduce the fish population.
2. Remove excess vegetation.
3. Remove excess organic sediment with siphon or pump.
4. Draw off the most polluted water and replace it with new, oxygenated water.

C. Alter physical or chemical factors related to O_2 supply and use.

1. Increase pond volume by adding clean water to reduce quantity of organic material relative to total volume
2. Add an oxidizing agent so that organic material is "burned up" quickly.

EXAMPLE: Add (hydrated lime, $Ca(OH)_2$) at a rate of 30 to 50 pounds per acre.

(NOTE: This process does not affect DO, but removes CO_2, a competing gas in the water. It requires that the water be well buffered. It is a temporary solution only and will not solve the basic problem.)

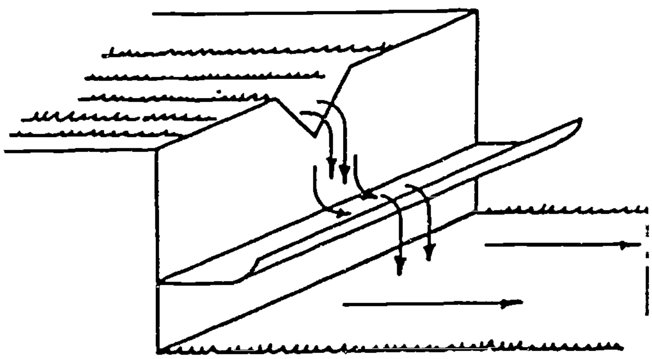
XIV. Types of aerators (Figures 7-14)

A. Gravity aerator — System in which water falling through the air is broken into drops, greatly increasing its surface area; further aeration is provided with the turbulence created when the falling water strikes the pond surface.

(NOTE. Gravity aeration is especially useful if the water supply is located at a higher elevation than the pond, since the energy used is free. The degree of oxygenation is directly proportional to the distance of the fall, though it can be increased by allowing the water to be broken up further by passing through baffles, screens, or over steps as in raceway aeration.)

INFORMATION SHEET

FIGURE 7



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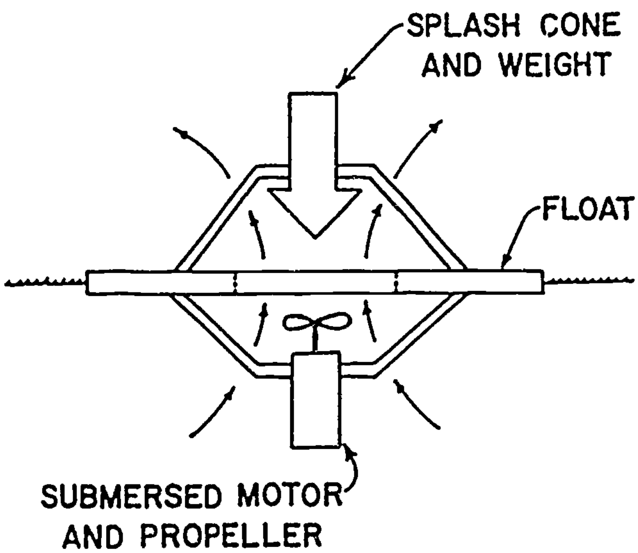
B. **Surface aerator** — Device that increases the surface area of water and exposes it to the air by using a rotor or paddlewheel to break up and agitate the water surface.

(NOTE: Surface aerators are used for small ponds. Some surface aerators pick up water and spray it across the water surface, while others merely increase turbulence and waves. Motors may be above or below the water, but those above water may freeze in the winter.)

FIGURE 8



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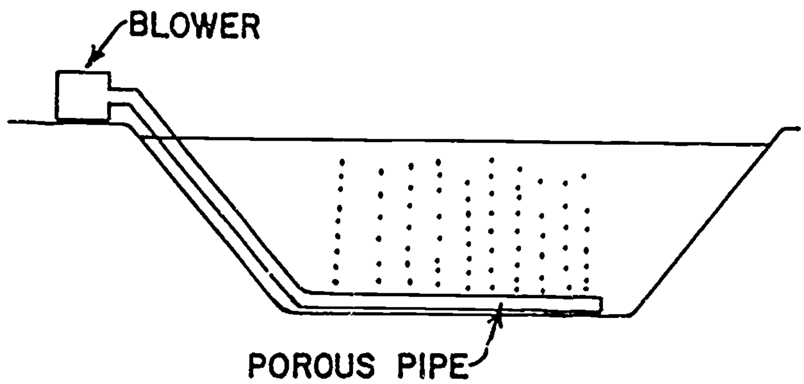
C. **Diffused air aerator** — Device that uses a compressor or blower to introduce air bubbles into the water; the smaller the bubble and the further it travels before reaching the surface, the more oxygenated the water.

(NOTE: Diffused air aerators are used in the winter to maintain open water. They are not efficient in shallow ponds.)

FIGURE 9



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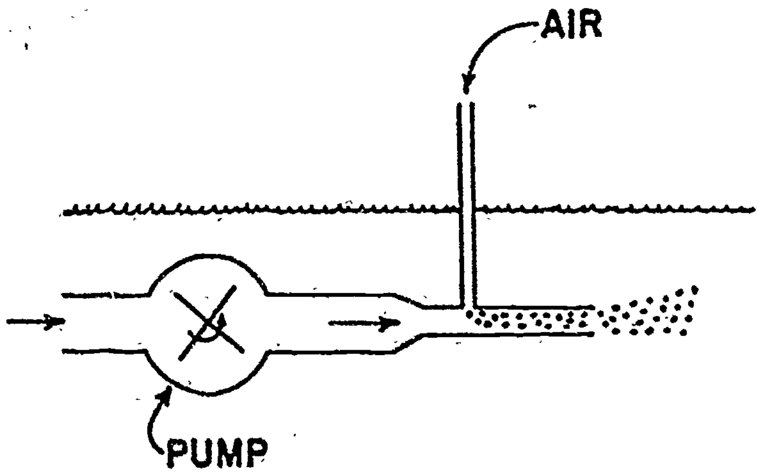
D. **Venturi aerator** — Device that sucks air into the water so that bubbles are formed; a rotor may be added to the motor to create additional turbulence.

(NOTE: Venturi aerators are used for small ponds.)

FIGURE 10



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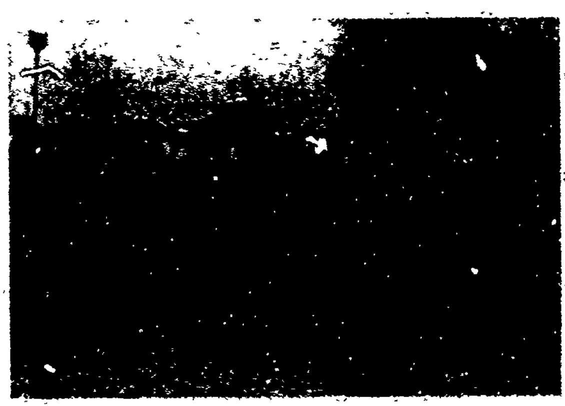
E. **Pump sprayer** — Device with suction, lift, or turbine pump that pumps water through discharge slits on a sprayer pipe.

(NOTE: Pump sprayers typically have no gear reduction. This means less risk of mechanical failures. These aerators do not erode the pond bottom.)

FIGURE 11—Aquaculture workshop participants watching sprayer pipe demonstration.

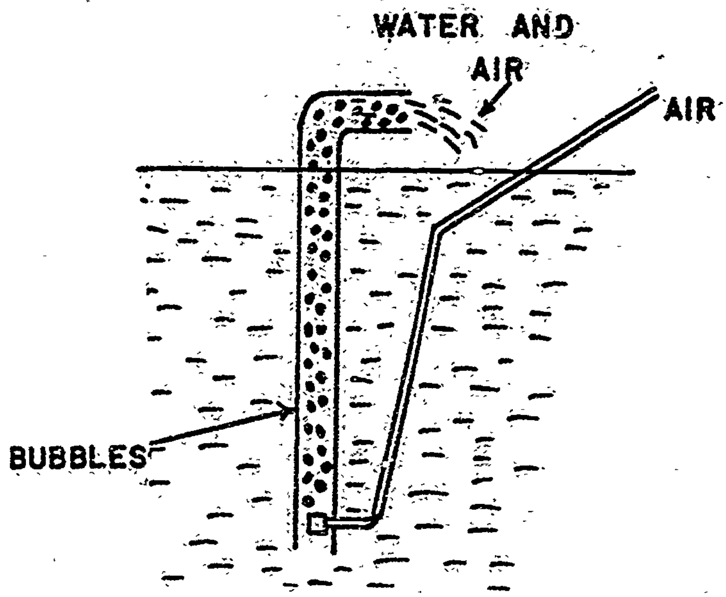


INFORMATION SHEET

F. **Air-lift pump aerator** — Device composed of an open-ended pipe or tube into which air is released at the submerged end; air bubbles rising through the tube both pump and oxygenate the water.

(NOTE: The air-lift pump aerator is used for small ponds.)

FIGURE 12



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G. **Paddlewheel aerator** — Device having fins or paddles attached to a rotating drum; breaks up and agitates the water surface.

(NOTE: Paddlewheel aerators have been used on catfish farms for many years. They can be powered by tractor PTO's or be self-powered.)

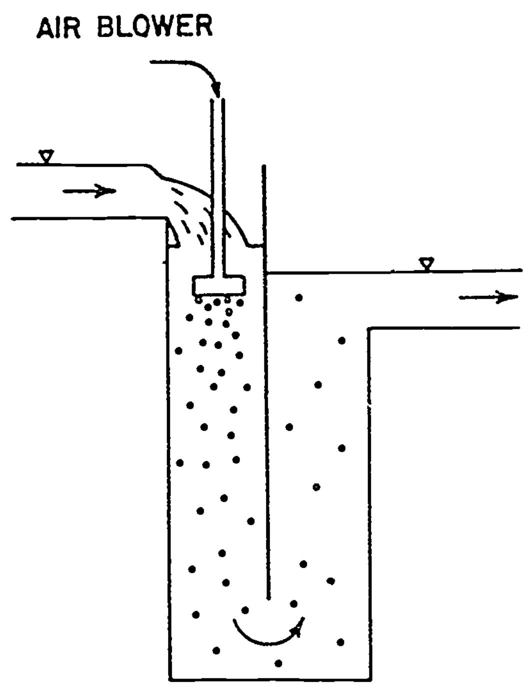
FIGURE 13

INFORMATION SHEET

H. **U-tube aerator** — Highly efficient, deeply submerged device that combines diffuser aeration with running water by pumping water over a bubbler in one leg, trapping it momentarily in the bottom, and releasing it via the other leg.

(NOTE: Because U-tube aerators hold the bubbles longer and provide for prolonged contact of the bubbles with the water before surfacing, this aerator is capable of producing supersaturation. This type aerator is also difficult and expensive to construct and works best at water depths that are impractical in fish farming. It is used with liquid oxygen in some intensive systems.)

FIGURE 14



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XV. Turbidity remedies

(NOTE. Turbidity remedies are based on acidifying the water so that positive electrical charges on suspended particles become negative, causing the particles to precipitate out and settle on the bottom. The farmer must watch for swing back. Some particles may not settle out. The usual procedure is to employ the remedy and then wait two days and sample again. There are both long-term and short-term remedies.)

A. Silt turbidity

1. Add gypsum incrementally at a rate of 100 to 1,000 pounds per acre until precipitation occurs.

INFORMATION SHEET

2. Add alum incrementally at a rate of 15 to 25 pounds per acre until precipitation occurs.

   (NOTE: Alum treatment is less expensive than gypsum, but a possible side effect is the reduction of the availability of phosphorus.)

3. Scatter old hay in shallow water at a rate of 7 to 10 bales per acre.

B. Organic turbidity — Broadcast 440 pounds of agricultural lime ($CaCo_3$) per acre while monitcring pH so that it never exceeds 9.5.

   (NOTE: Agricultural lime is often applied just before, during, or after manuring to nrevent excessive turbidity from organic fertilizing.)

XVI. **Importance of nitrogen compounds in water quality management** (Transparency #1)

A. Because air contains 78 percent nitrogen gas (N_2) and only about 21 percent oxygen gas (O_2), there is more dissolved nitrogen than DO in water.

B. Nitrogen gas is a problem in water quality management in spring and pumped well water when the surrounding water becomes supersaturated with N_2; the blood of nearby fish can become supersaturated with N_2, leading to the same gas bubble disease that occurs with O_2 supersaturation.

C. The real importance of nitrogen in water quality management, lies primarily in understanding its intermediate forms, all of which are pollutants that can become toxic to aquatic animals.

D. Organic waste is the main source of all nitrogen compounds normally found dissolved in water.

E. As organic waste decomposes, most of the nitrogen in it is converted to un-ionized ammonia (NH_3) and ionized ammonia (NH_4), which in turn are reduced by *Nitrosomonas* bacteria to nitrite (NO_2), which is then oxidized to nitrate (NO_3) by *Nitrobacter* bacteria. (Transparency 1)

F. Un-ionized ammonia and nitrite are the most harmful intermediate forms of nitrogen.

G. Un-ionized ammonia (NH_3) is potentially the most dangerous intermediate form of nitrogen; even very small concentrations call for remedial action.

   EXAMPLES: Concentrations of as little as 0.1 ppm endanger catfish.
   Concentrations of 0.0125 ppm cause reduced growth and gill damage in trout.

H. Ionized ammonia (NH_4) is 75 to 100 times less toxic than un-ionized ammonia.

INFORMATION SHEET

I. Un-ionized and ionized ammonia in solution exist in equilibrium with each other and are measured as total ammonia (NH_4 + NH_3), the proportion of the two substances in equilibrium is determined by pH, and temperature.

(NOTE: This fact is *very* important in managing water quality. Beginning intensive aquaculturists often measure total ammonia and then interpret the results *without* allowing for pH-related differences in ionization. At acid or neutral pH, ammonia makes up a very small amount of the total, yet at a high basic pH, it may predominate. See Table 1.)

TABLE 1: Percentage of Total Ammonia in Relationship to Water Temperature and pH

	Temperature in F							
pH	32	41	50	59	68	77	86	95
6.0	0.008	0.01	0.02	0.03	0.04	0.06	0.08	0.1
6.2	0.01	0.02	0.03	0.04	0.06	0.09	0.1	0.2
6.4	0.02	0.03	0.04	0.07	0.1	0.1	0.2	0.3
6.6	0.03	0.05	0.07	0.1	0.2	0.3	0.3	0.4
6.8	0.05	0.08	0.1	0.2	0.3	0.4	0.5	0.7
7.0	0.08	0.1	0.2	0.3	0.4	0.6	0.8	1.1
7.2	0.1	0.2	0.3	0.4	0.6	0.9	1.3	1.8
7.4	0.2	0.3	0.5	0.7	1.0	1.4	2.0	2.8
7.6	0.3	0.5	0.7	1.1	1.6	2.2	3.1	4.3
7.8	0.5	0.8	1.2	1.7	2.5	3.5	4.8	6.7
8.0	0.8	1.2	1.8	2.7	3.8	5.4	7.5	10.2
8.2	1.3	1.9	2.9	4.1	5.9	8.3	11.3	15.2
8.4	2.0	3.0	4.5	6.4	9.1	12.5	16.9	22.1
8.6	3.2	4.7	6.9	9.8	13.7	18.4	24.3	31.0
8.8	5.0	7.3	10.5	14.7	20.1	26.4	33.7	41.6
9.0	7.7	11.1	15.7	21.4	28.5	36.2	44.7	53.0
9.2	11.6	16.5	22.8	30.2	38.7	47.4	56.1	64.2
9.4	17.2	23.9	31.8	40.7	50.0	58.8	67.0	73.9
9.6	24.8	33.2	42.5	52.1	61.3	69.3	76.3	81.8
9.8	34.3	44.1	54.0	63.2	71.5	78.2	83.6	87.7
10.0	48.3	55.5	65.0	73.2	79.9	85.0	89.0	91.9

J. Any system in which nitrite (NO_2) is detectable by normal methods is suspect: a concentration of as little as 0.5 ppm can be critical, depending on species and amount of chlorides in the water.

K. Nitrate (NO_3) acts as a fertilizer, being the form of inorganic nitrogen most useful to higher plants and many bacteria; however, over-fertilizing with synthetic nitrogenous fertilizer can cause nitrate pollution, but toxic levels of nitrate are 50 to 100 times those of nitrite.

L. Generally ammonia, nitrite, and nitrate pollution and toxicity are problems only in intensive cultures and closed systems.

INFORMATION SHEET

XVII. pH and water quality

A. The pH of water is influenced by the amount of carbon dioxide (CO_2) in solution; most natural bodies of freshwater have a pH between 6 and 9.

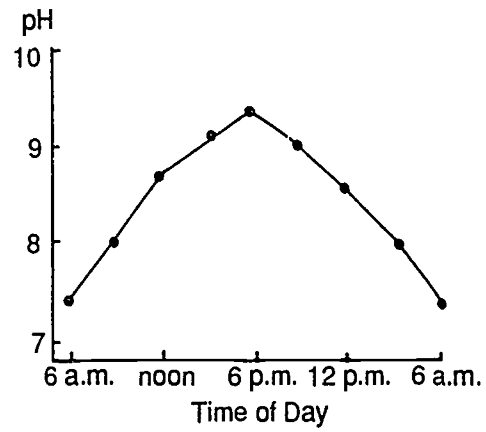
B. The acid and basic death points for fishes are about 4 and 11 respectively, though critical pH levels vary slightly for different species.

EXAMPLES: Critical basic pH levels are 9.2 for trout, 10.8 for common carp.

C. Respiration raises CO_2 and thus lowers pH; therefore, intensive aquacultural enterprises are more susceptible to pH fluctuations than extensive enterprises.

D. Photosynthesis lowers CO_2 and thus raises pH; therefore, pH will rise during daylight hours and fall in the absence of daylight. (Figure 15)

EXAMPLE: FIGURE 15



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E. Aquaculturists use calcium carbonates (limes) to buffer pH and control fluctuations; sodium bicarbonate $NaHCO_3$ is used in tanks.

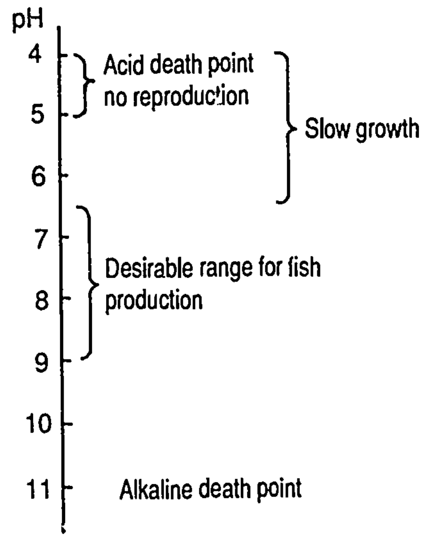
F. Calcium-poor waters diluted by heavy rain or snowmelt may become very acidic.

INFORMATION SHEET

XVIII. Managing the pH cycle

A. Aquaculturists should try to maintain a pH between 6.5 (slightly acidic) and 9.0 (somewhat basic). (Figure 16)

EXAMPLE: FIGURE 16



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B. Though it is important to maintain water at an optimal pH for your species, it is more important to prevent sudden fluctuations that shock and stress the stock.

C. Determine pH at start-up and then check morning, afternoon, and evening once a month in extensive enterprises with satisfactory growth, and once a week for intensive enterprises.

D. Monitor pH during any kind of fertilizer or chemical treatments.

E. The two basic preventive management techniques are avoiding organic overloading and adding calcium carbonate.

F. If pH is too high or too low and remains so, it can be adjusted by liming or pumping in well-buffered well water.

XIX. Purposes of liming

A. Raising the pH of the water

B. Raising the pH of the mud, upon which the effectiveness of phosphorus fertilizers depends

C. Buffering or stabilizing pH

INFORMATION SHEET

D. Increasing alkalinity of water by making more calcium available

(NOTE: It is advisable to check alkalinity whenever you suspect pH fluctuations, when setting up pH buffers, or when liming. Alkalinity should also be measured at start-up.)

E. Accelerating the decomposition and mineralization of organic matter, making it available without depleting DO

F. Killing many fish parasites without harming the fish

G. Precipitating out excessive suspended organic material

H. Increasing the amount of carbon available for photosynthesis by increasing the amount of bicarbonate in the system

XX. General guidelines for water chemistry management

A. Get baseline data on temperature, DO, pH, alkalinity, hardness, and chlorides before you start, and check your water supply — particularly if it is a well or groundwater — for hydrogen sulfide and iron.

(NOTE: Hydrogen sulfide is a very toxic substance produced by the decomposition of organic materials in an anaerobic state. It can be detected by its rotten-egg smell.)

B. Before you start, find the closest person who can help you if you encounter a problem you cannot diagnose or treat — perhaps an experienced fish farmer, country extension agent, or someone in a university.

C. Know your water and the variables and chemicals that affect it.

D. Give priority to DO management.

E. Monitor chemistry and appropriate variables, keep complete and accurate records and do not wait until there is a problem to do chemical testing. (Job Sheet #3)

F. Always know what is going into your water, and do not add any substance without considering the possible effects on all important chemical parameters.

G. Perform chemical tests after any change in the system.

H. Avoid organic overloading by being cautious with feed and fertilizer, and avoid it from the start by choosing the least intensive system that will satisfy your needs.

I. Monitor your stock's growth; it is the biomass, not the number of fish, that determines B.O.D. and volume of wastes.

INFORMATION SHEET

J. Do everything you can in terms of diet and disease control to keep your stock healthy and to keep the water free of harmful disease-producing organisms.

XXI. Aquatic plant control and water quality management

A. Biological methods

1. Fertilizer

   a. Controls the growth of vascular plants (macrophytes) by creating plankton turbidity, which shades pond bottom and prevents photosynthesis;

   b. Is most effective on ponds with no areas shallower than 2 feet;

   c. May create DO depletion if plankton die off.

2. Grass carps

   a. Eat tremendous quantities of vascular plants when stocked 10 to 40 per acre;

   b. Grow rapidly to several pounds and may injure farm species when seined;

   c. Cannot legally be stocked in many states as they are an Asian exotic fish.

3. Manual control — Cutting, pulling, or raking of rooted plants.

   EXAMPLE: Small stand of cattails

B. Chemical control methods

1. Herbicide

   EXAMPLES: Casoron, copper (from copper carbonate), 2,4-D, endothall.

   a. Used to control macrophytes;

   b. Administered according to label instructions and cautions;

   c. Harmless to fish in recommended concentrations;

   d. Has no residual toxicity, so macrophytes will regrow and require repeated applications;

   e. Decaying macrophytes may lead to DO depletion.

INFORMATION SHEET

2. Natural algicide

EXAMPLES: Cooper sulfate, kelated copper compounds (buffered compounds)

a. Used to control phytoplankton;

b. Administered by dissolving in water and distributing over pond surface;

(NOTE: Copper sulfate crystals are often placed in a burlap bag and towed behind a boat until dissolved. Crystals may also be placed in a mesh bag and left to gradually dissolve. Powdered copper sulfate can be sprinkled directly on the pond surface, and is often used locally to spot-treat algae scums.)

c. Will kill fish if administered in doses of 0.5 to 1.0 ppm to waters with alkalinity below 20 ppm;

(NOTE: Dosage rates are dependent on alkalinity levels. It is generally believed that 50 ppm total alkalinity is the minimum level needed before copper sulfate algicides can be used at their level of effectiveness.)

d. Has no residual toxicity, so phytoplankton will resume growth and require repeated applications;

e. Rapidly decaying phytoplankton may lead to DO depletion.

3. Synthetic algicide

EXAMPLES: Simazine, Dichlone

a. Is extremely toxic to phytoplankton;

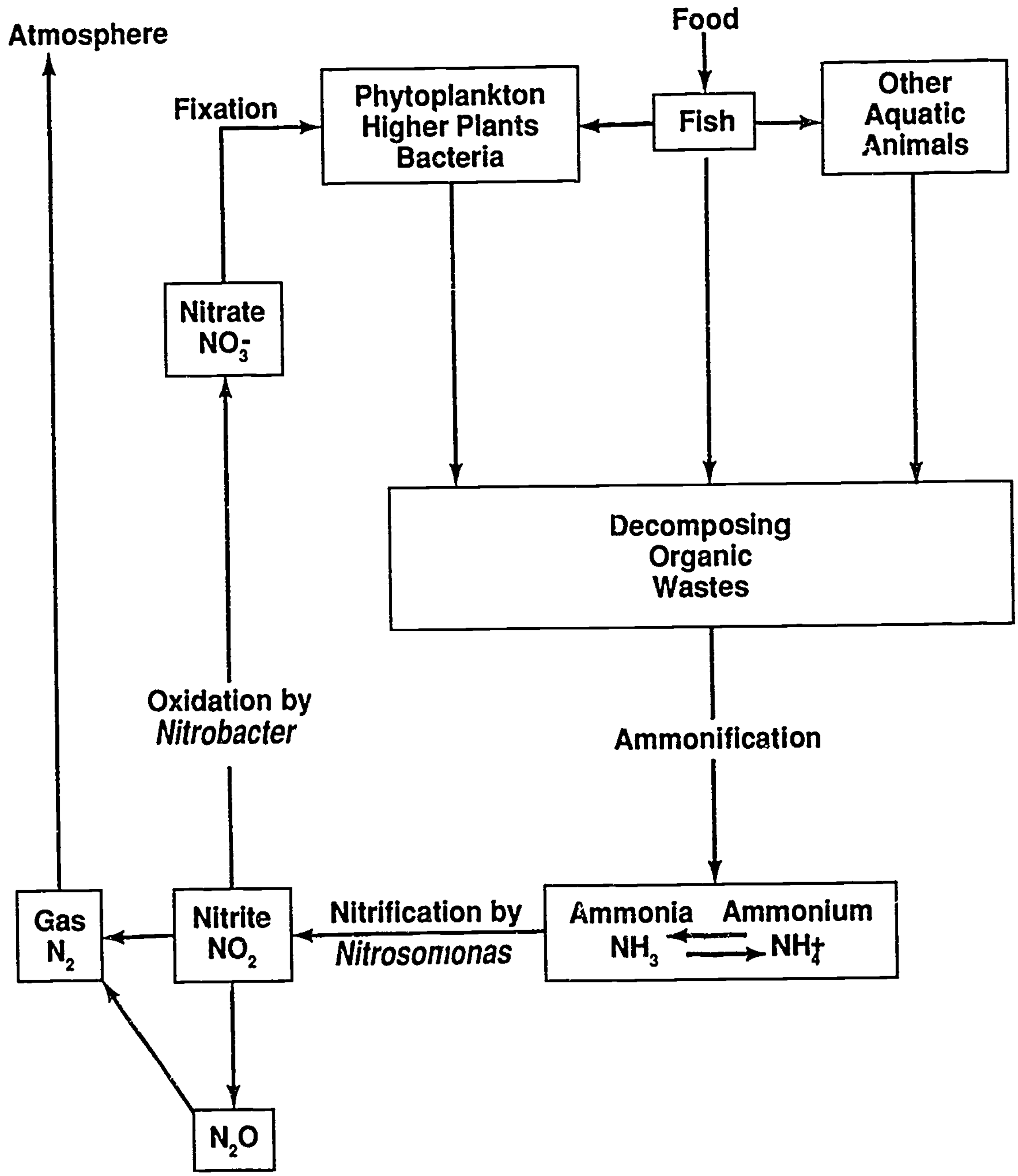
b. Is applied by dissolving in water according to label instructions and cautions;

c. Is not harmful to fish when applied in recommended doses;

d. Has long residual action, prohibiting regrowth;

e. Rapidly decaying phytoplankton may lead to DO depletion.

Nitrogen Cycle



WATER QUALITY MANAGEMENT
UNIT VII

HANDOUT #1
TABLE OF CRITICAL SECCHI DISC READINGS FOR DIFFERENT STANDING CROP WEIGHTS OF CHANNEL CATFISH

TABLE 3: Critical Secchi disc readings (inches) for earthen ponds containing different standing crop weights of channel catfish. For each standing crop density (pounds per acre), a lower Secchi disc reading than that shown for any combination of temperature and dissolved oxygen concentration taken in late afternoon indicates that dissolved oxygen will fall below 2 ppm before dawn. For combinations of temperature and dissolved oxygen that are designated safe (S), the dissolved oxygen concentration should not drop to 2 ppm regardless of the Secchi disc reading.

Water Temperature in Late Afternoon		Dissolved Oxygen Concentration (ppm) in Late Afternoon										
°C	°F	2	3	4	5	6	7	8	9	10	11	12
20	68.0	10	S	S	S	S	S	S	S	S	S	S
22	71.6	23	13	S	S	S	S	S	S	S	S	S
24	75.2	34	23	15	9	S	S	S	S	S	S	S
26	78.8	39	29	21	15	9	S	S	S	S	S	S
28	82.4	39	34	27	21	15	10	7	S	S	S	S
30	86.0	39	36	29	25	20	15	10	7	S	S	S
32	89.6	39	38	33	27	23	19	16	12	9	6	S

Standing crop 1,000 pounds per acre

°C	°F	2	3	4	5	6	7	8	9	10	11	12
20	68.0	15	S	S	S	S	S	S	S	S	S	S
22	71.6	31	17	9	S	S	S	S	S	S	S	S
24	75.2	39	27	17	10	S	S	S	S	S	S	S
26	78.8	39	34	25	19	13	7	S	S	S	S	S
28	82.4	39	38	29	23	18	13	9	S	S	S	S
30	86.0	39	39	34	27	23	18	14	10	7	S	S
32	89.6	39	39	36	31	26	22	18	15	12	7	S

Standing crop 1,500 pounds per acre

°C	°F	2	3	4	5	6	7	8	9	10	11	12
20	68.0	19	7	S	S	S	S	S	S	S	S	S
22	71.6	36	19	10	S	S	S	S	S	S	S	S
24	75.2	39	31	21	13	7	S	S	S	S	S	S
26	78.8	39	36	27	21	15	9	S	S	S	S	S
28	82.4	39	39	35	26	21	15	10	7	S	S	S
30	86.0	39	39	37	30	25	21	16	13	9	S	S
32	89.6	39	39	39	34	29	24	21	17	14	10	7

HANDOUT #1

Water Temperature in Late Afternoon		Dissolved Oxygen Concentration (ppm) in Late Afternoon										
°C	°F	2	3	4	5	6	7	8	9	10	11	12
		Standing crop 2,000 pounds per acre										
20	68.0	23	9	S	S	S	S	S	S	S	S	S
22	71.6	39	23	13	S	S	S	S	S	S	S	S
24	75.2	39	35	23	15	9	S	S	S	S	S	S
26	78.8	39	39	31	23	17	10	S	S	S	S	S
28	82.4	39	39	36	29	23	17	13	7	S	S	S
30	86.0	39	39	39	35	27	22	18	14	10	7	S
32	89.6	39	39	39	36	31	26	23	19	15	12	8
		Standing crop 2,500 pounds per acre										
20	68.0	28	10	S	S	S	S	S	S	S	S	S
22	71.6	39	25	15	7	S	S	S	S	S	S	S
24	75.2	39	36	25	17	9	S	S	S	S	S	S
26	78.8	39	39	33	25	18	12	7	S	S	S	S
28	82.4	39	39	38	31	25	19	14	10	S	S	S
30	86.0	39	39	39	36	29	24	19	16	12	7	S
32	89.6	39	39	39	38	33	28	24	21	17	13	10
		Standing crop 3,000 pounds per acre										
20	68.0	31	13	S	S	S	S	S	S	S	S	S
22	71.6	39	27	17	9	S	S	S	S	S	S	S
24	75.2	39	39	27	19	10	S	S	S	S	S	S
26	78.8	39	39	36	27	19	13	9	S	S	S	S
28	82.4	39	39	39	34	26	21	15	10	7	S	S
30	86.0	39	39	39	38	31	25	21	17	13	9	S
32	89.6	39	39	39	39	36	31	26	22	19	15	10
		Standing crop 3,500 pounds per acre										
20	68.0	35	15	S	S	S	S	S	S	S	S	S
22	71.6	39	31	19	9	S	S	S	S	S	S	S
24	75.2	39	39	29	21	13	7	S	S	S	S	S
26	78.8	39	39	38	29	21	15	9	S	S	S	S
28	82.4	39	39	39	36	27	22	17	13	9	S	S
30	86.0	39	39	39	39	34	27	23	19	15	10	7
32	89.6	39	39	39	39	37	31	27	24	20	16	13

HANDOUT #1

Water Temperature in Late Afternoon		Dissolved Oxygen Concentration (ppm) in Late Afternoon										
°C	°F	2	3	4	5	6	7	8	9	10	11	12
		Standing crop 4,000 pounds per acre										
20	68.0	39	19	7	S	S	S	S	S	S	S	S
22	71.6	39	36	21	10	S	S	S	S	S	S	S
24	75.2	39	39	31	23	15	8	S	S	S	S	S
26	78.8	39	39	39	31	23	17	10	S	S	S	S
28	82.4	39	39	39	38	29	23	19	15	10	S	S
30	86.0	39	39	39	39	36	29	25	20	16	12	8
32	89.6	39	39	39	39	39	34	29	25	21	18	14

Modified from R. P. Romaire and C. E. Boyd. 1978. "Predicting Nighttime Oxygen Depletion in Catfish Ponds." Alabama Experiment Station, Auburn University Bulletin 505.

WATER QUALITY MANAGEMENT
UNIT VII

ASSIGNMENT SHEET #1
CALCULATE DOSAGES FOR CHEMICAL TREATMENTS

All commercial aquaculturists should know how to calculate treatment rates, determine the amount of chemical or material needed, and apply the treatment. When treatment rates are not correctly calculated, high economic losses result.

In Unit VI, you learned how to calculate pond volumes. Once the volume of a pond is known, you can calculate dosages for chemical treatments with little difficulty. You need to be comfortable working in both metric and English systems of measurement because product instructions, reports, and publications may use either one. You will want to use the conversion tables in Unit VI, Handout #1, and the conversion factor (C.F.) table below.

TABLE 1: Conversion Factors (C.F.)

2.72 pounds per acre foot	1 ppm
1,233 grams per acre-foot	1 ppm
0.0283 grams per cubic foot	1 ppm
0.0000624 pounds per cubic foot	1 ppm
0.0038 grams per gallon	1 ppm
0.0584 grains per gallon	1 ppm
1 milligram per liter	1 ppm
0.001 gram per liter	1 ppm
8.34 pounds per million gallons of water	1 ppm
1 gram per cubic meter	1 ppm
1 milligram per kilogram	1 ppm
10 kilograms per hectare-meter	1 ppm

This assignment sheet is presented in two parts. Part I provides you with instructions and examples for calculating treatment dosages. Part II presents you with some problems so that you can practice what you have learned.

ASSIGNMENT SHEET #1

PART I

Using the Basic Treatment Formula

Most treatments can be calculated using the basic formula:

$$\text{Amount of Chemical Needed} = V \times C.F. \times \text{ppm desired} \times \frac{100}{\%A.I.}$$

Where:

V	=	Volume of water to be treated
C.F.	=	Conversion factor representing the weight of the chemical that must be used to equal 1 ppm in one unit of the volume (V) of water to be treated. The unit of measurement for the results is the same as the unit used for the C.F. (pounds, grams, etc.)
ppm	=	The desired concentration of chemical in the volume (V) of water to be treated expressed in parts per million
$\frac{100}{\%A.I.}$	=	100 divided by the percent of active ingredient (A.I.) contained in the treatment to be used (NOTE: Most chemicals are 100% A.I. unless otherwise specified, so this value is usually 1. The percent A.I. is usually found on the label of most chemicals.)

EXAMPLE: Agricultural gypsum is 80% pure. How much agricultural gypsum is needed to treat a pond with a surface area of 8 acres and an average depth of 3½ feet to produce a gypsum concentration of 25 ppm?

1. Find the volume of the pond in acre-feet by multiplying the surface area times the average depth:

   Pond volume $= 8 \times 3.5$

   $= 28$ acre-feet

2. Find conversion factor for acre-feet on Table 1:

   C.F. = 2.7

3. The concentration of gypsum desired is the parts per million:

   ppm = 25

ASSIGNMENT SHEET #1

4. Divide 100 by the percent of the active ingredient (A.I.):

   %A.I. = 80%

   $\frac{100}{80} = 1.25$

5. P'ug all of these known figures into the basic formula to calculate total amount of gypsum needed:

   Amount of Chemical Needed $= V \times C.F. \times \text{ppm Desired} \times \frac{100}{\%A.I.}$

   $= 28 \times 2.7 \times 25 \times 1.25$

   = **56.1 pounds** of gypsum needed to treat the pond

Copper Sulfate

The treatment rate for copper sulfate is determined by the total alkalinity of the water to be treated because its toxicity varies with the alkalinity of the water. The rule of thumb for copper sulfate use states, "For every 100 ppm alkalinity, you can safely use 0.75 ppm copper sulfate."

Use the following formula to determine the treatment rate of copper sulfate in ppm when the water alkalinity is known. Total alkalinity is expressed in ppm as calcium carbonate.

$$\text{ppm Copper Sulfate} = \frac{\text{Total Alkalinity (ppm)}}{100}$$

EXAMPLE. A pond contains 25 acre-feet of water and has a total alkalinity of 150 ppm. How many pounds of copper sulfate are needed to control an algae problem?

1. Determine the treatment rate of copper sulfate in ppm:

   ppm Copper Sulfate $= \frac{150}{100}$

   = **1.5 ppm**

ASSIGNMENT SHEET #1

2. Use the basic treatment formula to determine the number of pounds needed to treat the pond at a rate of 1.5 ppm:

$$\text{Amount of Copper Sulfate Needed} = V \times C.F. \times \text{ppm desired} \times \frac{100}{\%A.I.}$$

$$= 25 \times 2.7 \times 1.5 \times \frac{100}{100}$$

$$= 101.25 \text{ pounds}$$

Aquatic Herbicide Treatments

The recommended dosage to control a particular plant is found on the label of the product. However, herbicides come in liquid, powder, and granule forms. Liquid herbicides are often mixed with water before application. The following examples show how to calculate treatments using various herbicides under different conditions.

EXAMPLE 1: A pond owner wants to use a herbicide as a foliar spray to control cattails. He wants to apply a 1½% solution in a 3-gallon pump sprayer. He also needs to add spreader as a wetting agent at a rate of ½% solution. How many ounces of herbicide and spreader are required? Given: 1 gallon = 128 fluid ounces.

1. Find the number of ounces in the sprayer by multiplying the sprayer capacity in gallons times the number of ounces in a gallon:

   3 gal x 128 oz/gal = 384 oz

2. Calculate ounces of herbicide needed by finding 1½% of volume capacity:

$$1\tfrac{1}{2}\% = \frac{1.5}{100}$$

$$= 0.015$$

$$384 \text{ oz} \times 0.015 = 5.76 \text{ or } 6 \text{ oz of herbicide needed}$$

3. Calculate ounces of spreader needed by finding ½% of volume capacity:

$$\tfrac{1}{2}\% = \frac{0.5}{100}$$

$$= 0.005$$

$$384 \text{ oz} \times 0.005 = 1.9 \text{ or } 2 \text{ oz of spreader needed}$$

ASSIGNMENT SHEET #1

EXAMPLE 2: A granular herbicide is to be used to control the lilypads in a 3½-acre pond. Only half of the pond is covered with lilypads. The recommended treatment rate is 100 pounds per surface acre. How many pounds of herbicide are needed?

1. The area to be treated is ½ the total pond area:

   3½ = 3.5
   ½ = 0.5

   $\frac{3.5}{0.5}$ = 1.75 acres to treat

2. Find the amount of herbicide needed by multiplying the number of pounds per acre by the number of acres to be treated:

   100 lb/acre x 1.75 acre = 175 pounds of granular herbicide

Salt Treatment for Nitrite Management

Salt (sodium chloride) is used to raise chloride levels in ponds to solve problems associated with high nitrite levels. To calculate the amount of the salt needed in a pond with detectable nitrite concentrations, use the formula below. Salt produces a source of chloride equivalent to 1 ppm when 4.5 pounds are added per acre-foot.

$(5 \times N)-C$ = Concentration of Chloride Needed in ppm

Where: N = ppm of nitrate in pond water

C = ppm of chloride in pond water

EXAMPLE. A water sample contains 4 ppm nitrite and 15 ppm chloride. How much salt is needed to treat an 8-acre pond with an average depth of 6 feet?

1. Find the concentration of chloride needed by using the nitrite formula:

   ppm chloride needed $= (5 \times N) - C$

   $= (5 \times 4) - 15$

   $= 20 - 15$

   = 5 ppm chloride

ASSIGNMENT SHEET #1

2. Determine the amount of salt needed by using the basic treatment formula, but substitute 4.5 pounds for the C.F. because this much salt give 1 ppm chloride per acre-foot.

Amount of Salt Needed $= V \times C.F. \times \text{Desired ppm} \times \frac{100}{\%A.I.}$

$= (8 \text{ acres} \times 6 \text{ feet}) \times 4.5 \text{ lb.} \times 5 \text{ ppm} \times \frac{100}{100}$

$= 48 \times 4.5 \times 5 \times 1$

= **1,080 pounds** of salt

PART II

Solve the following problems to practice computing dosages for chemical treatment of ponds and rearing units.

1. How much potassium permanganate is needed to treat a circular tank with a 6-foot diameter and a water depth of 4 feet when you need a concentration of 4 ppm? Potassium permanganate is 100% active.

2. A water sample contains 3 ppm nitrite and 12 ppm chloride. How much salt is needed to treat an 8 acre pond with an average depth of 6 feet?

3. You want to treat high silt turbidity in a pond with a surface area of 0.26 hectare and an average depth of 1.15 meters. How much 100% pure alum must you apply to give the pond an alum concentration of 25 milligrams per liter?

4. A pond with a volume of 1,000 cubic meters must be treated with a liquid herbicide that has a 75% active ingredient content and a density of 0.85 gram per milliliter (0.85 kilogram per liter). How many liters of the herbicide must be applied to the pond to give a concentration of 1 milligram per liter of active ingredient?

5. A pond contains 54 acre-feet of water and has a total alkalinity of 150 ppm. How many pounds of copper sulfate are needed to control a total-pond algae problem?

6. How many ounces of formalin, a liquid, 100%-pure chemical are needed to treat a holding tank 20 feet by 4 feet with a water depth of 2 1/2 feet to give a concentration of 250 ppm?

   (HINT: Formalin is a liquid; therefore, the unit of weight in grams must be converted to a volume unit. Do this by dividing the number of grams by 1.08, the specific gravity of formalin.)

ASSIGNMENT SHEET #1

7. A 5-acre pond is choked with several aquatic weeds. You want to control the weeds by applying a powder herbicide which is 100% pure. The recommended dosage is 3 pounds per acre-foot. The average depth of the pond is 4½ feet. How many pounds are required for treatment?

8. The average depth of a pond is 0.57 meter and the surface area is 0.01 hectare. How much agricultural gypsum (80% pure) must be applied to produce a gypsum concentration of 50 milligrams per liter?

9. How much algicide (100% active) is needed to treat a 10-acre pond with an average water depth of 4 feet to produce a 1.3 ppm treatment?

10. How much herbicide is needed to treat a 17.5-acre pond with an average depth of 4 feet to obtain a concentration of 0.25 ppm? The herbicide has 75% A.I.

WATER QUALITY MANAGEMENT
UNIT VII

ASSIGNMENT SHEET #2
ANALYZE FACILITY AERATOR NEEDS

You must have an aerator if you are commercially producing fish. However, if you are culturing fish at a very low density (under 500 pounds per acre) you *may* not need an aerator.

This assignment sheet is designed to help you become more familiar with the performance of various types of mechanical aerators now on the market. Choosing the proper aerator for your needs is very important. Before you make a decision or investment, find the answers to the following questions.

Use the Louisiana State University Agricultural Center's publication, *Guide to Oxygen Management and Aeration in Commercial Fish Ponds*, and information obtained from aeration equipment manufacturers, some of which are listed with addresses and phone numbers in the back of the Louisiana publication. If you are not presently engaged in an aquaculture enterprise, you will want to answer these questions based on your projected needs at start-up.

1. What is the need for additional oxygen in the present aquaculture enterprise?

2. What special characteristics of the aquaculture enterprise need to be taken into account?

   EXAMPLES. Extensive, intensive, cage culture, water depth, regularity of shoreline, expansion plans

3. To what seasonal extremes will the aerator be subjected?

4. How effective is the aerator?

   How long will it take to raise the DO level in the entire pond? An increase in DO near the aerator may be helpful in emergencies, but will have little effect on stock growth in a healthy pond system. Cage cultured fish, however, might benefit from a small aerator placed near the cage.

5. What type of energy do I want to use to power the equipment? Which power source is most convenient and least expensive?

   Aerators can be powered by tractor PTO's, electric motors, or gasoline propane, or diesel engines. It is also possible to run an aerator on wind power with an electric motor as back-up.

6. What will be the initial cost, including purchase or manufacture and installation?

7. How reliable is the system I am considering? Is a back-up necessary?

ASSIGNMENT SHEET #2

8. How well-built is the system? Will it require regular service? Is it warranted? Are parts and service available locally?

9. What will be my operating costs?

   Your costs are usually based on the efficiency of the machine and the cost of fuel or electricity. Don't forget about probable increases in utility rates, and remember that DO monitoring is a must for keeping aeration costs down.

10. What will be the value of additional fish produced, feed and health costs reduced, etc.?

    It may be impossible to predict results in your enterprise, but there are certain things you can count on. If without aeration lethal DO levels would occur, the value of aeration is the difference between a crop and no crop. If DO levels without aeration are near the critical level for your species much of the time, then aeration could lead to better health, feed conversion, or growth. If DO levels are above the critical level much of the time, ask yourself whether additional aeration would bring improvements that would justify the cost?

WATER QUALITY MANAGEMENT
UNIT VII

ANSWERS TO ASSIGNMENT SHEET #1

1. 32 grams
2. 648 pounds
3. 74.75 kilograms or about 165 pounds
4. 1.56 liters
5. 218.7 or 219 pounds
6. 44.3 fluid ounces
7. 67.5 pounds
8. 3.56 kilograms
9. 140.4 pounds
10. 62.8 pounds

WATER QUALITY MANAGEMENT
UNIT VII

JOB SHEET #1
CONSTRUCT AND USE A SECCHI DISC TO MEASURE TURBIDITY

A. Equipment and materials

(NOTE. Secchi discs are 20 centimeters (approximately 8 inches) in diameter and may be purchased from scientific supply companies or constructed of sheet metal, plexiglass, or masonite.)

1. 12" x 12" piece of sheet metal
2. Sheet metal snips
3. Eye bolt
4. Lead weight with hole in center

   (NOTE: The weight will be attached to the underside of the disc to allow it to sink readily. A diving weight works well on discs of sheet metal, plexiglass, or masonite. A large heavy magnet can be used on a disc made of sheet metal.)

5. Compass
6. Awl
7. Flat black and flat white marine paint that will adhere to sheet metal
8. 5 feet of calibrated line
9. Rule
10. Pen or pencil and data book for recording results
11. Small open boat for reaching testing locations

B. Procedure for constructing Secchi disc

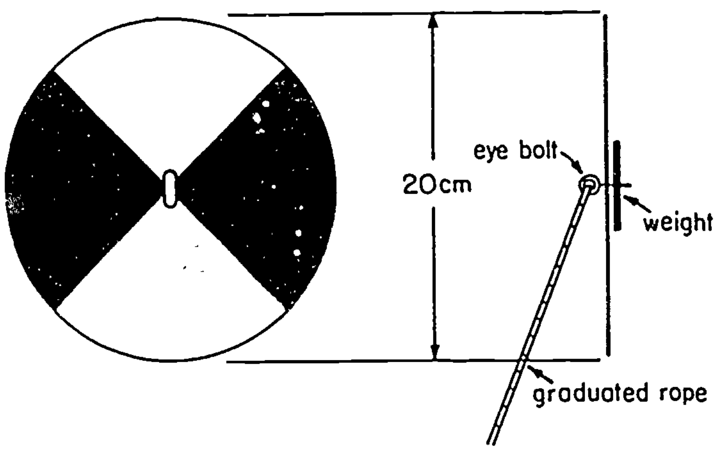
1. Use compass (or pencil and string) to mark an 8-inch (20 centimeter) circle on the square of sheet metal.
2. Cut out circle evenly with sheet metal snips, taking care not to bend the metal or cut your fingers on the sharp edges.
3. Measure 4 inches (10 centimeters) in from outside edge and make a small hole in the center with the awl.

JOB SHEET #1

4. Paint the top of the disc with flat white paint and allow to dry.

5. Draw two perpendicular diameter lines on the white surface to create quadrants as shown in Figure 1.

FIGURE 1



From *Water Quality Management in Pond Fish Culture* by Claude E. Boyd and Frank Lichtkoppler. With permission of Auburn University.

6. Paint two opposite quadrants flat black and allow to dry.

7. Attach lead weight and graduated line with eye bolt as shown in Figure 1.

   (NOTE: If you do not have a graduated line, you can use a ruled 1-meter stick instead.)

8. Clean work area and put away equipment and materials used to construct the disc.

C. Procedure for measuring turbidity with Secchi disc

(NOTE. Conditions for taking Secchi disc readings should be standardized. It is wise to take measurements on clear, sunny, calm days between 9 A.M. and 3 P.M.)

1. Work with a partner, and position boat so that you can take the measurement on the downwind side of the boat with the sun behind you.

2. Record in your data book the date, time, and location of test.

3. Lower disc into water until it just disappears.

4. Viewing the disc directly from above, read the calibrated line or meter stick and have your partner record this measurement in the data book.

JOB SHEET #1

5. Lower the disc a little more, and then raise it until it just reappears.
6. Viewing the disc directly from above, read the calibrated line or meter stick and have your partner record this measurement in the data book.
7. Add the two readings and divide by 2 to find the average; this figure will be the Secchi disc visibility measurement.
8. Change roles and repeat the test several times for comparison and practice.
9. Clean all equipment and return it to proper storage.

WATER QUALITY MANAGEMENT
UNIT VII

JOB SHEET #2
USE AN OXYGEN METER TO MEASURE DO

A. Equipment and materials

1. DO meter

2. Pen or pencil and data book

3. Small open boat for reaching testing locations

B. Procedure

(NOTE: Take readings at dawn and dusk several feet from the shoreline, at both ends of the pond, and near the center of the pond.)

1. Begin at dawn, and position boat at one end of pond; record in data book date, time of day, and approximate location.

2. Following manufacturer's instructions, calibrate meter accuracy.

3. Insert meter probe about six inches into water and move probe slowly back and forth to obtain surface reading; record reading in data book.

4. Repeat this procedure at mid-depth and then at near bottom depth, recording each reading in data book.

5. Move to the center of the pond and then to the opposite end; measure surface, mid-depth, and near bottom DO levels at each of these locations as described in Steps 3 and 4; record measurements in data book.

6. Repeat measuring procedure at dusk and again the following dawn.

7. Find net DO *production* by subtracting the dawn reading from the dusk reading.

8. Find DO *demand* by subtracting the dusk reading from the following dawn reading.

   (NOTE: You will interpret readings and predict depletion in Job Sheet #4.)

9. Return equipment and materials to proper storage.

WATER QUALITY MANAGEMENT
UNIT VII

JOB SHEET #3
USE A WATER QUALITY ANALYSIS KIT TO TEST WATER QUALITY PARAMETERS

A. Equipment and materials

1. Water analysis kit
2. Length of chain or stick 2 feet longer than greatest depth of pond
3. 6 eyebolts
4. Length of cord 2 feet longer than greatest depth of pond
5. Lead weight
6. Pen or pencil and data book
7. Small, open boat for reaching sampling locations

B. Procedure

1. Construct a device for lowering sampler bottle to collection depths (similar to that in Figure 1 or Figure 2 below).

FIGURE 1

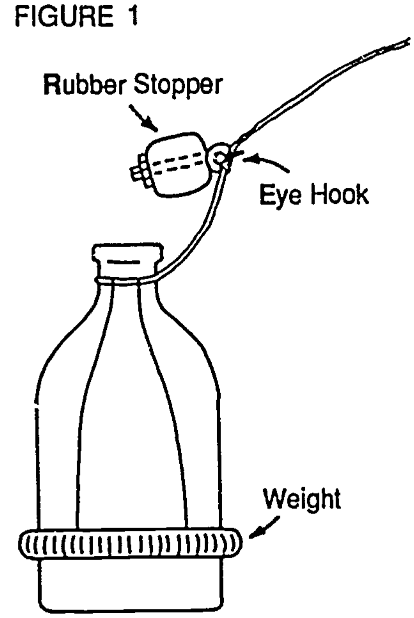
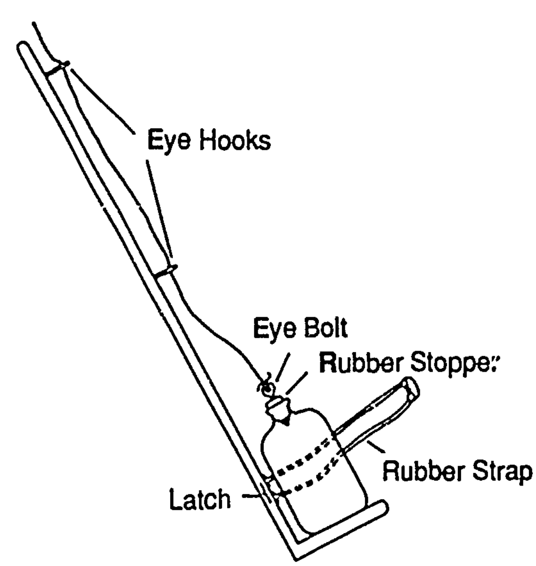


FIGURE 2



From *Water Quality Management in Pond Fish Culture* by Claude E. Boyd and Frank Lichtkoppler. With permission of Auburn University.

JOB SHEET #3

2. Collect water samples for DO and CO_2 analyses from surface, mid-depth, and bottom water layers from the center of the pond and several feet from shoreline at both ends of the pond; avoid sample sites near inflow pipe or near aerator.

   (NOTE: Water samples for DO and CO_2 analyses must be collected so that they do not come in contact with the atmosphere because gases can oe lost or absorbed from the atmosphere.)

   a. Collect surface sample.

      1) Place sampler bottle and stopper below water surface.

      2) Invert both bottle and stopper to allow all trapped air to escape.

      3) Place stopper snugly in bottle *before* lifting bottle from water.

      4) Label bottle "O_2 & CO_2 Sample"; note also on label the date, time of collection, depth collected and location collected.

   b. Collect depth samples.

      1) Lower snugly stoppered bottle to desired depth.

      2) Pull on cord to jerk out stopper and allow bottle to fill.

      3) Lift bottle slowly to surface.

      4) Label mid-depth and bottom sample bottles as you did for surface sample.

3. Collect water samples for total alkalinity, total hardness, pH, ammonia, nitrite, and hydrogen sulfide analyses from surface, mid-depth, and bottom water layers from the center of the pond and several feet from shoreline at both ends of the pond.

4. Return to classroom or laboratory and analyze your samples.

   a. Carefully follow all directions in your water analysis kit.

   b. Measure and perform each procedure with as much precision as possible: even small errors in measuring the sample or chemical reagent volumes can greatly exaggerate the final results.

5. Repeat sampling and analyses as required.

6. Return equipment and materials to proper storage.

WATER QUALITY MANAGEMENT
UNIT VII

JOB SHEET #4
PREDICT LOW DO LEVELS USING SECCHI DISC, PROJECTION, AND CHART METHODS

A. Equipment and materials

1. Secchi disc
2. Water thermometer
3. DO meter
4. Pen or pencil and data book
5. Graph paper
6. Rule
7. Handout #1 (chart on critical Secchi disc readings for different standing crop weights of channel catfish)

B. Procedure for Secchi disc method of predicting low DO levels

(NOTE. This predictive method does not work in ponds having more than 4,000 pounds of fish per acre, in ponds with excessive silt or clay turbidity, or in ponds with water temperatures over 90°F.)

1. Measure Secchi disc depth and water temperature in the late afternoon.
2. Use table in Handout #1 to determine minimum allowable Secchi disc reading.

EXAMPLES: If DO level in late afternoon is 10 ppm, temperature of water is 82°F, and the standing crop of fish is 500 pounds per acre, any Secchi disc reading should predict continuing safe levels of DO. If the DO level is less than 7 ppm, however, any Secchi disc reading less than 7 inches would indicate the potential for impending unsafe DO levels.

C. Procedure for Boyd projection method of predicting low DO levels

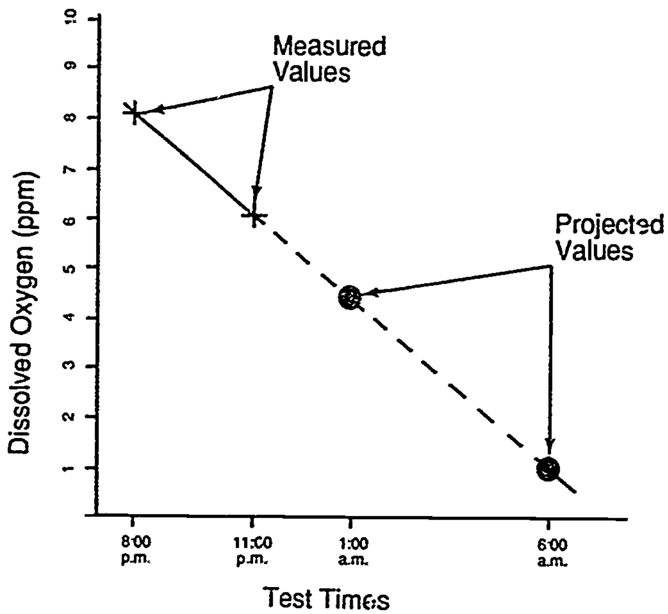
1. Use DO meter to measure DO at dusk and 2 to 4 hours later, taking readings at the surface and about one-quarter, one-half, and three-quarters of total depth at each point of measurement.
2. Find the average reading for each depth.
3. Find an overall average by adding the averages of each site and dividing by the number of locations measured.

JOB SHEET #4

4. Plot these values against the measurement times on a graph similar that in Figure 1.

   (NOTE: Here, dissolved oxygen was 8 ppm at 8:00 p.m. and 6 ppm at 11:00 p.m. The DO concentration at 6:00 a.m. was 1 ppm.)

FIGURE 1



Adapted from R. P. Romaire and C. E. Boyd, 1978, "Predicting Nighttime Oxygen Depletion in Catfish Ponds." Alabama Agricultural Experiment Station, Auburn University, Bulletin 505. As found in *Third Report to the Fish Framers*, page 25.

5. Draw a straight line through the two points to estimate the DO at later hours during the night.

D. Procedure for chart method of predicting low DO

   1. Take dawn and dusk DO readings at the same locations and depths for one week.

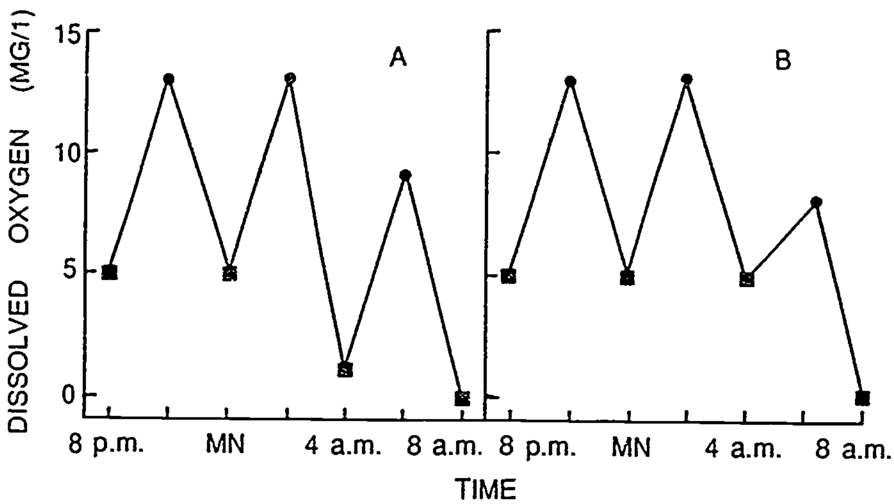
      (NOTE: Aquaculturists take these readings throughout the summer and chart them separately for each pond. The one-week interval specified here is for instructional purposes only.)

JOB SHEET #4

2. Chart readings on a graph set up like that in Figure 2.

(NOTE: The difference between DO concentration at dawn and dusk represents net DO production. The difference between dusk and dawn represents DO demand.)

FIGURE 2 — Daily dissolved oxygen readings taken at dusk (circles) and dawn (squares). (A) represents increased oxygen demand and (B) represents decreased oxygen production without decreased oxygen demand.



From *Water Quality in Channel Catfish Ponds.* With permission.

WATER QUALITY MANAGEMENT
UNIT VII

PRACTICAL TEST #1
JOB SHEET #1
CONSTRUCT AND USE A SECCHI DISC TO MEASURE TURBIDITY

Student's name ______________________ Date ______________________

Evaluator's name ______________________ Attempt no. ______________________

> Student instructions. When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE. Place a check mark in the "Yes" or "No" boxes to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	Yes	No
1. Laid out and cut disc to proper dimensions.	☐	☐
2. Painted disc with proper colors in proper quadrants.	☐	☐
3. Attached weight and graduated line properly.	☐	☐
4. Worked with partner to position boat correctly.	☐	☐
5. Made readings and recorded data accurately.	☐	☐
6. Measured turbidity accurately.	☐	☐
7. Cleaned equipment and returned to proper storage.	☐	☐

Evaluator's comments: ____

____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. [See performance evaluation key below.] If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:	Good	Acceptable	Fair	Poor
Secchi disc preparation	4	3	2	1
Boat positioning	4	3	2	1
Readings and data	4	3	2	1
Turbidity measurement	4	3	2	1

EVALUATOR'S COMMENTS: ____________________

PERFORMANCE EVALUATION KEY

4 — **Skilled**—Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program; additional training may be required.
2 — **Limited skill** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

WATER QUALITY MANAGEMENT
UNIT VII

PRACTICAL TEST #2
JOB SHEET #2
USE AN OXYGEN METER TO MEASURE DO

Student's name ______________________ **Date** ____________________

Evaluator's name ______________________ **Attempt no.** ________________

Student instructions. When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" boxes to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	Yes	No
1. Began at dawn with correct boat position.	☐	☐
2. Calibrated DO meter to specifications.	☐	☐
3. Made surface, mid-depth, and bottom readings.	☐	☐
4. Repeated readings at strategic pond locations.	☐	☐
5. Repeated procedure at dusk and at following dawn.	☐	☐
6. Properly recorded DO production.	☐	☐
7. Properly calculated DO demand.	☐	☐
8. Returned equipment to proper storage.	☐	☐

Evaluator's comments: ____

____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. [See performance evaluation key below.] If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:	Good	Acceptable	Fair	Poor
Procedure and timing	4	3	2	1
DO meter calibration	4	3	2	1
DO production measurement	4	3	2	1
DO demand measurement	4	3	2	1

EVALUATOR'S COMMENTS: ____

____

____

PERFORMANCE EVALUATION KEY

4 — **Skilled**—Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program, limited additional training may be required.
2 — **Limited skill** — Has performed job during training program, additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

WATER QUALITY MANAGEMENT
UNIT VII

PRACTICAL TEST #3
JOB SHEET #3
USE A WATER QUALITY ANALYSIS KIT TO TEST WATER QUALITY PARAMETERS

Student's name ______________________ Date ____________________

Evaluator's name ______________________ Attempt no. ______________

Student instructions. When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE. Place a check mark in the "Yes" or "No" boxes to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	Yes	No
1. Prepared sampler bottle properly.	☐	☐
2. Collected surface, mid-depth, and bottom samples at critical pond locations for DO and CO_2 analysis.	☐	☐
3. Collected surface, mid-depth, and bottom samples at critical pond locations for chemical and pH analysis.	☐	☐
4. Made lab analyses according to kit manufacturer specifications.	☐	☐
5. Evaluated analyses properly.	☐	☐
6. Repeated sampling and analyses as required.	☐	☐
7. Returned equipment to proper storage.	☐	☐

Evaluator's comments: ____

____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE. Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. [See performance evaluation key below.] If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:	Good	Acceptable	Fair	Poor
Sampler bottle preparation	4	3	2	1
DO and CO_2 sample collection	4	3	2	1
Chemical and pH sample collection	4	3	2	1
Lab analyses	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

____

PERFORMANCE EVALUATION KEY

4 — **Skilled**—Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program, limited additional training may be required.
2 — **Limited skill** — Has performed job during training program, additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE. If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

WATER QUALITY MANAGEMENT
UNIT VII

PRACTICAL TEST #4
JOB SHEET #4
PREDICT LOW DO LEVELS USING SECCHI DISC, PROJECTION, AND CHART METHODS

Student's name ______________________ Date ______________

Evaluator's name ______________________ Attempt no. ______________

Student instructions. When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	Yes	No
1. Made late afternoon Secchi disc measurements and evaluations.	☐	☐
2. Took DO meter readings for projection method.	☐	☐
3. Plotted DO measurements and obtained projected values.	☐	☐
4. Took week-long DO readings for chart method.	☐	☐
5. Plotted DO readings on chart.	☐	☐
6. Returned equipment to proper storage.	☐	☐

Evaluator's comments: ____

____

____

JOB SHEET #4 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE. Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. [See performance evaluation key below.] If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:	Good	Acceptable	Fair	Poor
Secchi disc method	4	3	2	1
Projection method	4	3	2	1
Chart method	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

____

PERFORMANCE EVALUATION KEY

4 — **Skilled**—Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program, limited additional training may be required.
2 — **Limited skill** — Has performed job during training program, additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE. If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

WATER QUALITY MANAGEMENT
UNIT VII

TEST

NAME ______________________________ SCORE __________________

1. Match terms related to water quality management with their definitions. Write the correct numbers in the blanks.

_____a.	Muddy or cloudy water caused by suspended particles of soil or plankton	1. B.O.D
_____b.	Swirling agitation of water	2. Oxidation
_____c.	Organisms that can live and grow where there is no free oxygen	3. Turbidity
_____d.	Measure of salt in water	4. Sediment
_____e.	The union of a substance with oxygen resulting in increased positive or decreased negative valence or ion	5. Aerobes
_____f.	Death, particularly death from disease or on a large scale	6. Secchi disc
_____g.	Measure of pH buffering ability	7. Anaerobes
_____h.	To separate out from solution	8. Toxicity
_____i.	Matter that settles to the bottom of the pond	9. Mortality
_____j.	Poisonous	10. Alkalinity
_____k.	Any substance in a solution that tends to stabilize the hydrogen ion concentration by neutralizing any added acid or alkali	11. Buffer
_____l.	Organisms that can live or grow only where free oxygen is present	12. Turbulence
_____m.	Greater than normal solubility of a chemical (oxygen, nitrogen) as a result of unusual temperatures or pressures	

TEST

_____n.	Instrument used to measure light penetration and thus turbidity	13.	Salinity
		14.	Precipitate
_____o.	Biochemical oxygen demand; based on total mass (biomass) and not on individual numbers of stock	15.	Supersaturation
_____p.	A measure of the percent of the total oxygen used that a device is able to put into solution	16.	Oxygen transfer efficiency
		17.	Effluent
_____q.	Water discharge from a rearing unit		

2. Match compounds and elements with their chemical formulas and symbols. Write the correct numbers in the blanks.

_____a.	Lime (calcium carbonate)	1.	DO
_____b	Dissolved oxygen	2.	O_2
_____c.	Copper	3.	N_2
_____d.	Hydrogen sulfide	4.	$CaHCO_3$
_____e.	Ammonium	5.	NH_3
_____f.	Ammonia	6.	NH_4
_____g.	Sodium bicarbonate	7.	NO_2
_____h.	Nitrogen gas	8.	NO_3
_____i.	Calcium	9.	H_2S
_____j.	Potassium permanganate	10.	Fe_2
_____k.	Oxygen gas	11.	Fe_3
_____l.	Lead	12.	$CaCo_3$
_____m.	Nitrite	13.	$Ca(HCO_3)_2$
_____n.	Quicklime	14.	CaO
_____o.	Zinc	15.	$Ca(OH)_2$
_____p.	Nitrate	16.	CO_2
_____q.	Ferrous iron	17.	H_2Co_3
_____r.	Ferric iron	18.	$KMnO_4$
_____s.	Calcium bicarbonate	19.	Cu

TEST

_____t. Hydrated lime — 20. Pb

_____u. Carbon dioxide — 21. Zn

_____v. Carbonic acid — 22. Ca

3. Discuss the importance of oxygen in water quality management by answering the following questions.

   a. What are the seven most important dissolved substances in natural water?

      1) ____________ 5) ____________

      2) ____________ 6) ____________

      3) ____________ 7) ____________

      4) ____________

   b. What, in the aquaculturist's view, is the most important chemical part of water?

      ____

   c. What is the difference between the "O" in DO and the "O" in H_2O?

      ____

      ____

   d. What is the ideal dawn DO reading in warmwater systems? ____________

   e. Why is water quality management not as simple as maintaining a certain minimum DO to ensure survival?

      ____

   f. What is the general rule of thumb for DO management?

      ____

   g. What is the primary natural source of oxygen in the atmosphere? ________

   h. How is DO supplied to raceways and troughs? ____________

      ____

TEST

4. Discuss the role of temperature in oxygen management by answering the following questions.

   a. How does temperature affect the amount of oxygen that can be dissolved in water?

   ____

   b. What happens to DO when high temperatures cause increased transpiration in plants and increased decay of organic materials?

   ____

5. Match natural sources of water temperature variation with their effects. Write the correct numbers in the blanks.

_____a. Affects heat absorption; dark water and colorless water over dark bottom absorb heat faster than their opposites	1.	Solar radiation
	2.	Air temperature
_____b. Gravity-induced flow, and wind-induced waves may cause cooling currents that serve to equalize pond temperature	3.	Water depth
	4.	Color of water and bottom
_____c. Heats water and also causes evaporation, which reduces depth and volume, thus accelerating the rate of heating; shade moderates these effects	5.	Circulation
_____d. Causes shallow bodies of water to warm and cool more rapidly than deeper bodies of water; may cause deep water to stratify, with the colder, denser water sinking to the bottom		
_____e. Affects the water below it by changing its temperature, though water changes temperature more slowly than air; the larger the water surface in contact with the air, the more rapidly the water heats and cools; creates seasonal water temperature variations that may be limiting		

TEST

6. Match types of thermometers for measuring water temperature with their descriptions. Write the correct numbers in the blanks.

_____a. Designed to measure air, liquids, surfaces, and semi-solid materials, this battery-powered digital-display thermometer is easy to read and practical for quick and consistent measurements

_____b. A highly portable thermometer in a rugged case so it cannot be easily broken, this thermometer usually has a top eyelet to add weight and to provide space for attaching a cord so that the thermometer can be handily dropped to different water levels.

_____c. Variously designed to float, clip to tank or trough walls, or to rest upright on bottom, this type of thermometer is handy for small enclosures.

_____d. Designed to record highest and lowest temperatures over a specified period, this thermometer is useful in monitoring daily temperature variations.

1. Electronic probe thermometer
2. Maximum-minimum thermometer
3. Fisherman's thermometer
4. Aquarium thermometer

7. Select facts about temperature management techniques. Write the correct numbers in the blanks.

_____a. Why are aquaculturists often limited to culturing only species that thrive within specified ranges of their local temperature extremes?

1) It is difficult and costly to manage water temperature.
2) No two species thrive at the same temperatures.
3) Species can only be cultured in their native habitats.

_____b. Which of the following is a way of warming water that is too cool?

1) Adding heated water
2) Passing it through warming ponds
3) Using radiant heat form electric lights

_____c. Which of the following is NOT a way of cooling water that is too warm?

1) Removing some warm water and replacing with an equal amount of cool water
2) Using mechanical coolers
3) Providing for shade and wind action

TEST

8. List four causes of DO loss.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

9. List six signs of oxygen deficiency.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

   f. ______________________________

10. Select facts about preventing DO depletion. Write the correct numbers in the blanks.

_____a. What are the three major actions to avoid?

1) Over-aerating, over-warming, over-harvesting
2) Over-seining, over-planting, over-medicating
3) Over-feeding, over-stocking, over-fertilizing

_____b. Why must you control green plant growth?

1) Plants compete with fish for available DO
2) Plants compete with fish for available O_2
3) Plants compete with fish for available CO_2

_____c. Which two variables should be routinely monitored and measured?

1) Water volume and plankton content
2) Turbidity and pH
3) Temperature and DO

_____d. Why must silt and plankton turbidity be monitored?

1) Interferes with sunlight penetration and prevents photosynthesis
2) Interferes with sunlight penetration and prevents transpiration
3) Interferes with sunlight penetration and prevents oxidation

TEST

_____e. Why should you attempt to predict when DO will fall below acceptable levels?

1) So that you will know what size aerator to purchase
2) So that you can keep accurate records
3) So that you can take preventive action

11. Select from a list guidelines for measuring DO. Write an "X" in the blank before each true statement.

_____a. Measure DO weekly so that measurements can be used as a preventive rather than as a diagnostic tool.

_____b. Take measurements at dawn, at noon, and two hours later to see how fast the DO level is declining.

_____c. Measure DO levels throughout the night during hot, cloudy weather, during intense feeding or fertilization programs, or at any time when there is a sudden increase in B.O.D., and DO is apt to fall to critically low levels.

_____d. Measure DO at least 6 inches below the surface and at a variety of locations and depths because DO is generally highest at the surface and around inflows and aerators and lowest at the bottom.

_____e. The best places to measure DO in a trout raceway are near the head of the rearing unit and in its effluent; the difference between the two readings is the neat DO used.

_____f. The best time to measure DO in trout rearing units is 1 hour before feeding when the fishes' metabolism is low and they are not using much DO.

12. Match DO measuring equipment with its descriptions. Write the correct numbers in the blanks.

_____a. Inexpensive and more precise, but also more time consuming, this method requires collecting water samples and analyzing them chemically	1. Battery operated meters
_____b. Inexpensive and not very accurate, this method depends on discriminating among colors that indicate O_2 levels	2. Colormetric test kit
_____c. Expensive but highly accurate and convenient, this method requires inserting a probe at various locations and recording instant electronic readings	3. Titration test kit

TEST

13. Select from a list true statements about methods of correcting DO deficiency. Write an "X" in the blank before each true statement.

_____a. The three major methods of correcting DO deficiency are mechanical aeration, reducing demand, and altering physical or chemical factors.

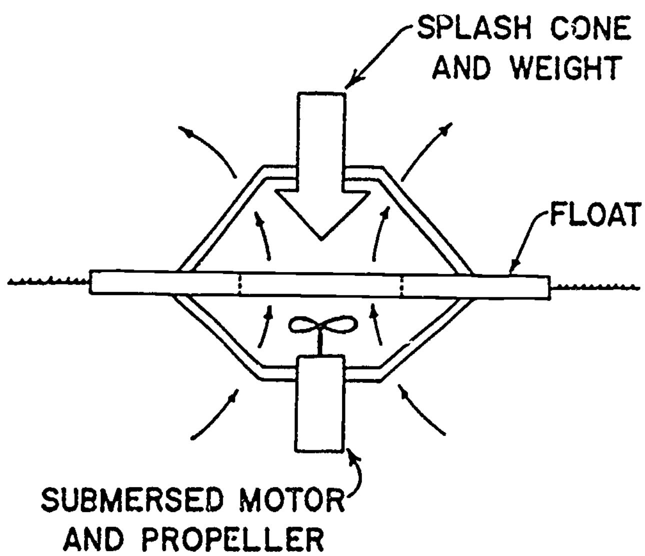
_____b. The aquaculturist can reduce the demand for oxygen by removing excess vegetation from the pond banks.

_____c. Increasing pond volume corrects DO deficiency by reducing the quantity of organic material in proportion to total water volume.

_____d. Liming a pond is the quickest and most effective method of correcting DO deficiency.

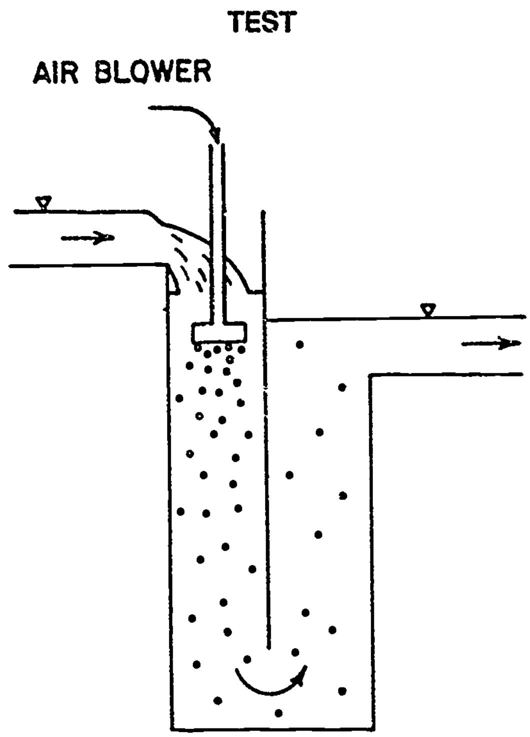
_____e. Adding an oxidizing agent corrects DO deficiency by "burning up" organic material

14. Identify each of the following types of aerators. Write the correct names in the blanks above the descriptions.



a. ____

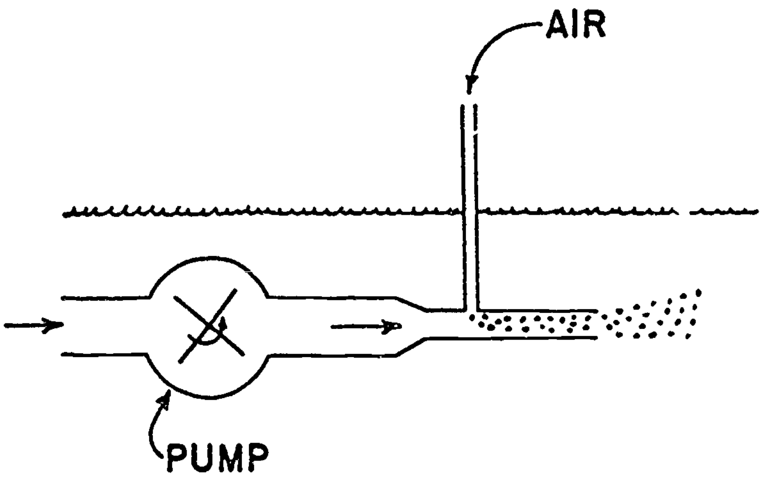
Device that increases the surface area of the water and exposes it to the air by using a rotor or paddlewheel to break up and agitate the water surface.



b. ______________________________

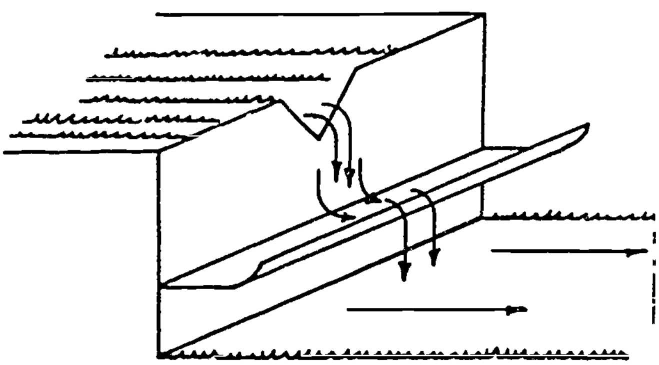
Highly efficient, deeply submerged device that combines diffuser aeration with running water by running it over a bubbler, trapping it, an releasing it.

TEST



c. ____________________

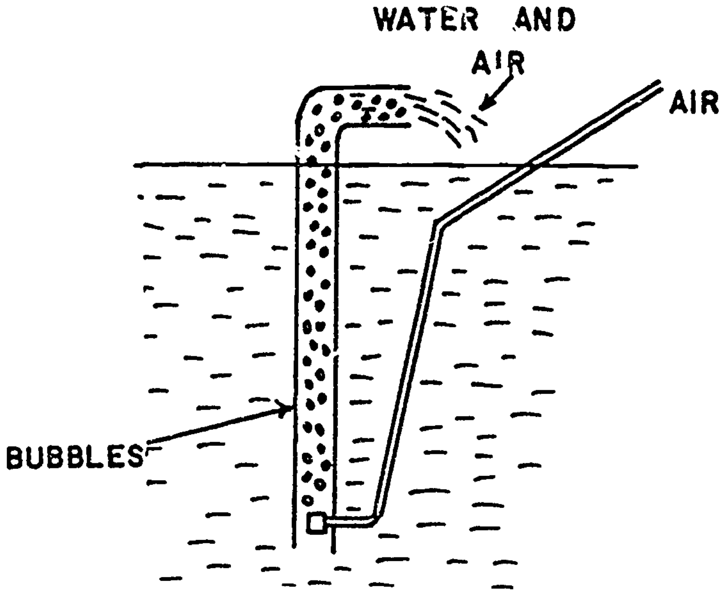
Device that sucks air into the water so that bubbles are formed; a roto. may be added to the motor to create additional turbulence.



d. ____________________

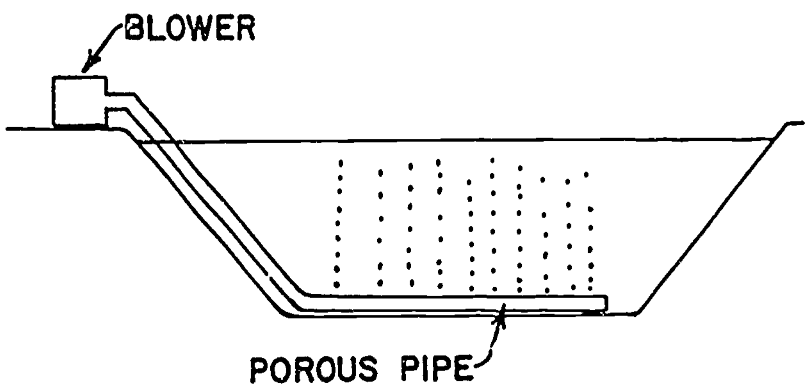
System in which water falling through the air is broken into drops, increasing its surface area.

TEST



e. ____________________

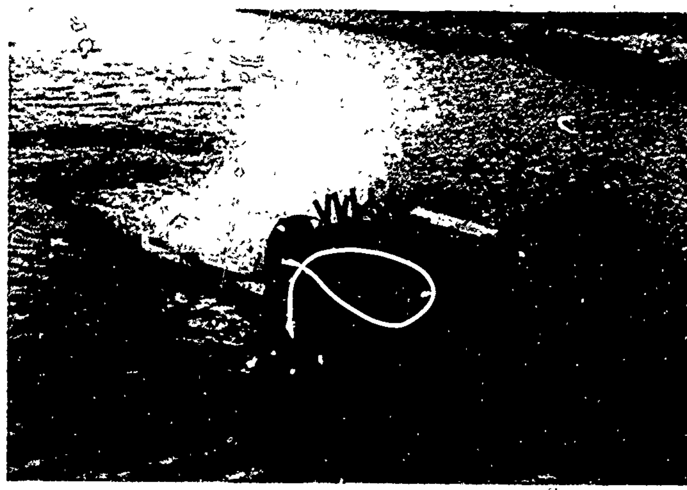
Device composed of an open-ended pipe or tube into which air is released at the submerged end.



f. ____________________

Device that uses a compressor or blower to introduce air bubbles into the water.

TEST



g. ______

Device having fins or paddles attached to a rotating drum; breaks up and agitates the water surface.

h. ______

Device with suction, lift, or turbine pump that pumps water through discharge slits on a sprayer pipe.

TEST

15. Select facts about turbidity remedies. Write the correct numbers in the blanks.

_____a. What two compounds can be added to water to reduce silt turbidity?

1) Gypsum and boric acid
2) Alum and gypsum
3) Lime and chloride

_____b. What is an organic method of reducing silt turbidity?

1) Adding compost
2) Scattering old hay
3) Broadcasting agricultural lime

_____c. When remedying organic turbidity, the aquaculturist must monitor pH. What is the cut-off pH level?

1) 7.5
2) 8.5
3) 9.5

16. Complete statements about the importance of nitrogen compounds in water quality management. Write the correct numbers in the blanks.

_____a. Because air contains ___ percent nitrogen gas and only about ___ percent oxygen gas, there is more dissolved nitrogen than DO in water.

1) 68; 31
2) 71; 28
3) 78; 21

_____b. Nitrogen gas is a problem in water quality management only when ___.

1) O_2 evaporates out of water and leaves it supersaturated with N_2.
2) water drops from a considerable height and the surrounding water becomes supersaturated with N_2.
3) electrical storms release the N_2 in air and it diffuses into the surrounding water, supersaturating it.

_____c. The blood of nearby fish can become supersaturated with N_2, leading to the same gas bubble disease that occurs in ___ saturation.

1) hydrogen
2) carbon dioxide
3) oxygen

_____d. All of the ___ forms of nitrogen are pollutants that can become toxic to aquatic animals.

1) intermediate
2) saturated
3) hydrated

TEST

_____e. ___ is the main source of all nitrogen compounds normally found is dissolved water.

1) Organic waste
2) Plant respiration
3) Nitrogen fixation

_____f. In the nitrogen cycle, nitrogen is converted to ammonia and ammonium, which in turn are reduced by *Nitrosomonas* ___ to nitrate, which is then ___ to nitrate by *Nitrobacter*

1) parasites; fertilized
2) bacteria; oxidized
3) plankton; pulverized

_____g. ___ and ___ are the most harmful intermediate forms of nitrogen.

1) ammonium; nitrite
2) ammonia; nitrate
3) ammonia; nitrite

_____h. ___ is potentially the most dangerous intermediate form of nitrogen; concentrations of ___ or more call for remedial action.

1) Ammonia; 0.1
2) Nitrite; .01
3) Ammonium; 1.0

_____i. Ammonium is ___ times less toxic than ammonia.

1) 75 to 300
2) 75 to 200
3) 75 to 100

_____j. The proportion of ammonia and ammonium in equilibrium is determined by ___.

1) water temperature
2) pH and temperature
3) photosynthesis

_____k. A concentration of ___ ppm of nitrite can be critical, depending on species and amount of chlorides in the water.

1) 0.5
2) 0.05
3) 5.0

TEST

_____l. Nitrate acts as a ___, but can become a pollutant, though toxic levels are 50 to 100 times those of nitrite.

1) buffer
2) oxidizing agent
3) fertilizer

_____m. Generally ammonia, nitrite and nitrate pollution and toxicity are problems only in ___.

1) raceways
2) intensive cultures and closed systems
3) large levee ponds

17. Complete statements about pH and water quality. Write the correct numbers in the blanks.

_____a. The pH of water is influenced by the amount of ___ in solution; most natural bodies of freshwater have a pH between ___.

1) carbon dioxide; 6 and 9
2) calcium carbonate; 4 and 11
3) calcium bicarbonate; 7 and 14

_____b. The acid and basic death points for fishes are about ___ respectively, though critical levels vary slightly for different species.

1) 6 and 9
2) 4 and 11
3) 7 and 14

_____c. ___ raises CO_2 and thus lowers pH; therefore, intensive aquacultural enterprises are more susceptible to pH fluctuations than extensive enterprises.

1) Respiration
2) Photosynthesis
3) Decomposing waste

_____d. ___ lowers CO_2, and thus raises pH

1) Respiration
2) Photosynthesis
3) Decomposing waste

TEST

_____e. Aquaculturists use ___ (limes) to buffer pH and control fluctuations.

1) potassium permanganates
2) hydrogen sulfides
3) calcium carbonates

_____f. ___ waters diluted by heavy rain or snowmelt may become very acidic.

1) Potassium-poor
2) Nitrogen-poor
3) Calcium-poor

18. Select from the following list methods of managing the pH cycle. Write an "X" in the blank before each true statement.

_____a. Aquaculturists should try to maintain pH between 6.5 (slightly acidic) and 9.0 (somewhat basic).

_____b. Water does not have to be maintained at a minimum pH for the species as long as sudden fluctuations that shock and stress the stock are prevented.

_____c. Determine pH at start-up and then check morning, noon, and evening once a week for extensive enterprises with satisfactory growth, and once a day for intensive enterprises.

_____d. Monitor pH before, after, and constantly during fertilizer or lime treatments.

_____e. The two basic preventive management techniques are avoiding organic overloading and adding calcium carbonate, either through filtration or liming.

_____f. If pH is too high and remains so, it can be adjusted by liming or pumping in well-buffered well water.

19. List six purposes of liming.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

TEST

20. Select from a list general guidelines for water chemistry management. Write an "X" in the blank before each true statement.

_____a. Get baseline data on temperature, DO, pH, and alkalinity after stocking and check your water supply—particularly if it is well or groundwater—for hydrogen sulfide and iron.

_____b. Before your start, find the closest person who can help you if you encounter a problem you cannot diagnose or treat, perhaps an experienced fish farmer, a county extension agent, or someone in a university.

_____c. Know your water, and the variables and chemicals that affect it.

_____d. Give priority to CO_2 management.

_____e. Monitor chemistry and appropriate variables, keep complete and accurate records, and do not wait until there is a problem to do chemical testing.

_____f. Always know what is going into your water, and do not add any substance without considering the possible effects on all important chemical parameters.

_____g. Avoid organic overloading by being cautious with feed and fertilizer, and avoid it from the start by choosing the most intensive system you can afford.

_____h. Perform chemical tests daily.

_____i. Monitor your stock's growth; it is biomass, not the number of fish, that determines B.O.D. and volume of wastes.

_____j. Do everything you can in terms of diet and disease control to keep your stock healthy and to keep the water free of harmful disease-producing organisms.

TEST

21. Match aquatic plant control methods with their descriptions. Write the correct numbers in the blanks. Numbers will be used more than once.

_____a. Grow rapidly to several pounds and may injure farm species when seined

_____b. Used to control macrophytes; administered according to label instructions and cautions; and harmless to fish in recommended concentrations

_____c. Used to control phytoplankton, though rapidly decaying phytoplankton may lead to DO depletion

_____d. Cutting, pulling, or raking of rooted plants

_____e. Controls the growth of vascular plants (macrophytes) by creating plankton turbidity, which shades pond bottom and prevents photosynthesis

_____f. Eat tremendous quantities of vascular plants when stocked 10 to 40 per acre, but cannot legally be stocked in many states

_____g. Is applied by dissolving in water according to label instructions; is not harmful to fish when applied in recommended doses, but rapidly decaying phytoplankton may lead to DO depletion

_____h. Is extremely toxic to phytoplankton, and has long residual toxicity, prohibiting regrowth

_____i. Has no residual toxicity, so macrophytes will regrow and require repeated applications; decaying macrophytes may lead to DO depletion

_____j. Will kill fish if administered in doses of 0.5 to 1.0 ppm to waters with alkalinity below 20 ppm

_____k. Is most effective on ponds with no areas shallower than 2 feet, but may create DO depletion if plankton die off

1. Herbicide
2. Natural algicide
3. Synthetic algicide
4. Fertilizer
5. Crass carps
6. Manual control

TEST

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

22. Calculate dosages for chemical treatments. (Assignment Sheet #1)

23. Analyze facility aerator needs. (Assignment Sheet #2)

24. Demonstrate the ability to:

    a. Use a Secchi disc to measure turbidity. (Job Sheet #1)

    b. Use an O_2 meter to measure DO. (Job Sheet #2)

    c. Use a water analysis kit to test water quality parameters. (Job Sheet #3)

    d. Predict low DO levels, using Secchi disc, projection, and chart methods. (Job Sheet #4)

WATER QUALITY MANAGEMENT
UNIT VII

ANSWERS TO TEST

1.
a.	3	j.	8
b.	12	k.	11
c.	7	l.	5
d.	13	m.	15
e.	2	n.	6
f.	9	o.	1
g.	10	p.	16
h.	14	q.	17
i.	4		

2.
a.	12	l.	20
b.	1	m.	7
c.	19	n.	14
d.	9	o.	21
e.	6	p.	8
f.	5	q.	10
g.	4	r.	11
h.	3	s.	13
i.	22	t.	15
j.	18	u.	16
k.	2	v.	17

3. a. 1) Oxygen
   2) Nitrogen compounds
   3) Alkalines
   4) Hydrogen sulfide
   5) Carbon dioxide
   6) Iron
   7) pH
   b. Dissolved oxygen
   c. O_2 is pure oxygen; the O in water is bound by hydrogen
   d. Above 4 ppm
   e. Fish may not grow
   f. More DO is better than less
   g. Photosynthesis
   h. By continuously flowing fresh water

4. a. The higher the water temperature the less oxygen it will hold
   b. Reduces DO levels

5. a. 4
   b. 5
   c. 1
   d. 3
   e. 2

ANSWERS TO TEST

6. a. 1
   b. 3
   c. 4
   d. 2
   e. 2

7. a. 1
   b. 2
   c. 2

8. Answer should include any four of the following:

   a. Respiration by aerobes
   b. High temperatures
   c. Oxidation of organic matter
   d. Oxidation of inorganic substances
   e. Diffusion

9. Answer should include any six of the following:

   a. Fish not eating food and acting more sluggish than usual
   b. Fish gasping (piping) for air at water surface
   c. Fish grouped near the water inflow pipe
   d. Other aquatic animals such as crayfish and snails crawling out of the water in numbers
   e. Fish-eating birds gathering at pond, especially in the morning
   f. Turbidity caused by heavy plankton die-offs
   g. Repeated outbreaks of stress-related disease and parasites
   h. Slow growth

10. a. 3
    b. 1
    c. 3
    d. 1
    e. 3

11. c, d, e

12. a. 3
    b. 2
    c. 1

13. a, c, e

ANSWERS TO TEST

14. a. Surface aerator
    b. U-tube aerator
    c. Venturi aerator
    d. Gravity aerator
    e. Air-lift pump aerator
    f. Diffused air aerator
    g. Paddlewheel aerator
    h. Pump sprayer

15. a. 2
    b. 2
    c. 3

16. a. 3
    b. 2
    c. 3
    d. 1
    e. 1
    f. 2
    g. 3
    h. 1
    i. 3
    j. 2
    k. 1
    l. 3
    m. 2

17. a. 1
    b. 2
    c. 1
    d. 2
    e. 3
    f. 3

18. a, d, e, f

19. Answer should include any six of the following

    a. Raising the pH of the water
    b. Raising the pH of the mud, upon which the effectiveness of fertilizers depends
    c. Buffering or stabilizing pH
    d. Increasing alkalinity of water by making more calcium available
    e. Accelerating the decomposition and mineralization of organic matter, making it available without depleting DO
    f. Killing many fish parasites without harming the fish
    g. Precipitating out excessive suspended organic material
    h. Increasing the amount of carbon available for photosynthesis by increasing the amount of bicarbonate in the system

20. b, c, e, f, i, j

ANSWERS TO TEST

21.
a.	5	g.	3
b.	1	h.	3
c.	2	i.	1
d.	6	j.	2
e.	4	k.	4
f.	5		

22. Evaluated to the satisfaction of the instructor

23. Evaluated to the satisfaction of the instructor

24. a. Evaluated according to criteria in Practical Test #1

    b. Evaluated according to criteria in Practical Test #2

    c. Evaluated according to criteria in Practical Test #3

    d. Evaluated according to criteria in Practical Test #4

FISH HEALTH MANAGEMENT
UNIT VIII

UNIT OBJECTIVE

After completion of this unit, the student should be able to recognize signs and symptoms of common diseases of commercially cultured fish, discuss measures used for disease prevention and control, calculate treatment rates, prepare specimens for laboratory diagnosis, and keep accurate health management records. These competencies will be evidenced by correctly completing the procedures outlined in assignment and job sheets, and by scoring a minimum of 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with fish health management with their correct definitions.
2. Match terms associated with skin and tissue conditions with their correct definitions.
3. Match terms associated with severity of disease or condition with their correct definitions.
4. Match terms associated with behavior or appearance of sick fish with their correct definitions.
5. Discuss the role of stress in fish diseases.
6. List common stressors of fish.
7. Select from a list signs of stress and disease.
8. Select factual statements about common pathogenic viruses.
9. Select factual statements about common pathogenic bacteria.
10. Complete statements about common pathogenic fungi.
11. Complete statements about common pathogenic protozoan parasites.
12. Complete statements about common pathogenic crustacean parasites.
13. Select factual statements about common pathogenic worm parasites.

OBJECTIVE SHEET

14. Select factual statements about general management measures for preventing disease outbreaks.

15. Select factual statements about basic hygiene for disease prevention and corrective management.

16. Match treatment methods with their administration specifics.

17. Complete a list of general guidelines for treatment of fish diseases.

18. Select factual statements about regulations for chemical application in fish production.

19. Solve problems related to common diseases and conditions of fish. (Assignment Sheet #1)

20. Calculate treatment rates. (Assignment Sheet #2)

21. Prepare a list of local, area, or state specialists to contact in the event of a disease emergency. (Assignment Sheet #3)

22. Report on the activities and procedures observed at a disease diagnostic laboratory. (Assignment Sheet #4)

23. Complete record-keeping forms on fish health management practices. (Assignment Sheet #5)

24. Demonstrate the ability to prepare and package a specimen for shipment to a diagnostic laboratory. (Job Sheet #1)

FISH HEALTH MANAGEMENT
UNIT VIII

SUGGESTED ACTIVITIES

A. Invite a representative from a diagnostic laboratory to speak to the class.

B. Urge students to acquire the latest edition of *A Guide to Approved Chemicals in Fish Production and Fishery Resource Management* (or a comparable resource) for their libraries. Copies can be obtained from the University of Arkansas Cooperative Extension Service.

C. Make transparencies.

D. Provide students with objective sheet. Discuss unit and specific objectives.

E. Provide students with information sheet. Discuss information sheet, tailoring information to fit local needs.

F. Provide students with assignment sheets. Discuss and schedule assignment sheets, critique in class.

G. Use overheads to demonstrate completion of record keeping forms in Assignment Sheet #5.

H. Schedule and demonstrate job sheet, complete Practical Test to evaluate student performance.

I. Give written test.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Belusz, Larry. *Fish Farming Techniques*. Columbia, Missouri. University of Missouri Instructional Materials Laboratory, 1987.

B. Hoffman, Glenn L., and Andrew J. Mitchell. *Some Parasites and Diseases of Warmwater Fishes,* Fish and Wildlife Leaflet 6. Stuttgart, Arkansas: Fish Farming Experiment Station/U.S. Fish and Wildlife Service, 1986.

C. Jensen, Gary L. *Handbook for Common Calculations in Finfish Aquaculture*. Baton Rouge, Louisiana: Louisiana Cooperative Extension Service/Louisiana State Agricultural Center, 1987.

D. Meyer, Fred P. *Treatment Tips: How to Determine Chemical Treatments in Fish Farming*. Washington, DC: U.S. Government Printing Office, 1979.

E. Meyer, Fred P., J.W. Warren, and T. G. Carey. *A Guide to Integrated Fish Health Management in the Great Lakes Basin*. Ann Arbor, Michigan. Great Lakes Fishery Commission, 1983.

SUGGESTED ACTIVITIES

F. Moore, Brenda Rogers. "Parasites and Diseases in Pond Fish" in *Third Report to the Fish Farmers. The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington, DC: U.S. Fish and Wildlife Service, 1984.

G. Plumb, John A., ed. *Principal Diseases of Farm Raised Catfish,* Southern Cooperative Series Bulletin No. 225. Auburn University, Alabama: Alabama Agricultural Experiment Station, rev. 1985.

H. Post, George. *Textbook of Fish Health.* Neptune City, New Jersey: T.F.H. Publications, 1987.

I. Schnick, Rosalie A., Fred P. Meyer, and D. Leroy Gray. *A Guide to Approved Chemicals in Fish Production and Fishery Resource Management.* Little Rock, Arkansas. Arkansas Cooperative Extension Service/U.S. Fish and Wildlife Service, 1989.

J. Schubert, Dr. Gottfried. *Fish Diseases. A Complete Introduction.* Neptune City, New Jersey: T.F.H. Publications, 1987.

K. Van Ramshorst, Dr. J.D., ed. *Aquarium Encyclopedia of Tropical Freshwater Fish.* Tucson, Arizona: H.P. Books, 1981.

FISH HEALTH MANAGEMENT
UNIT VIII

INFORMATION SHEET

I. Terms and definitions

A. Stress — Physical strain or weakening caused by changes in the environment that require the fish to use energy to adjust

B. Pathogen — Disease-causing organism

C. Pathogenic — Producing disease

D. Parasite — Plant or animal that lives on or in another animal, usually causing harm

EXAMPLES: Fungi, bacteria, protozoa, worms, grubs, flukes, lice

E. Host — Animal on or in which a parasite lives

F. Cyst — Round, thick membrane with which some parasites are surrounded when in the resting state (Transparency 1)

G. Encyst — To enclose or become enclosed in a cyst, capsule, or sac

H. Prophylactic — Preventing or protecting against disease

EXAMPLE: Fry are often prophylactically treated with oxytetracycline (Terramycin) before stocking in order to lessen their susceptibility to disease caused by the stresses of handling.

I. Hemorrhage — Bleeding

J. Pus — Yellowish-white liquid produced in certain infections

K. Ciliated — Having short, fine, hairlike growths that aid in movement, as found on many adult protozoans

L. Spore — Single-cell reproductive unit capable of creating a new adult individual

M. Tolerance — Residue levels of a drug or chemical that are permitted by regulatory agencies in food eaten by humans

EXAMPLE: The tolerance for oxytetracycline (Terramycin) is 0.1 ppm in salmonids and catfish. This means that any of these fish sold for food may contain no more than 0.1 ppm of the drug at the time of slaughter.

N. Pesticide — Broad name for chemicals that control or kill insects, fungi, parasites, and other pests

INFORMATION SHEET

O. **Withdrawal time** — Period of time that must pass after drug, chemical, or pesticide treatment before an animal can be eaten

EXAMPLE: The withdrawal time for oxytetracycline (Terramycin) is 20 days. This means that oxytetracycline treatment must be stopped 20 days before fish are marketed for food.

P. **Facultative** — Capable of living under varying conditions

EXAMPLE: Some bacteria are capable of living in the presence or absence of oxygen; some parasites can live on dead organic matter or living tissues.

Q. **Opportunistic** — Waiting for a combination of favorable circumstances

EXAMPLE: Opportunistic bacteria and parasites live harmlessly in the same water with fish, infecting only fish weakened by stress, or infecting only under specific circumstances such as a particular temperature range.

II. **Terms associated with skin and tissue conditions**

A. **Lesion** — An injury, damage, or wound

B. **Cyst** — An abnormal pocket or sac-like structure filled with fluid or diseased matter

C. **Ulcer** — An open sore (other than a wound) on the skin or membrane that festers and contains pus

D. **Fistula** — An abnormal tube-like passage from an abscess or hollow organ to the skin

E. **Abscess** — Swollen area in the body tissue where pus gathers

F. **Necrosis** — Condition in which tissue is dead or decayed

G. **Nodule** — Small knot, knob, or lump of tissue

H. **Edema** — Fluid-filled, swollen tissue condition

III. **Terms associated with severity of disease or condition**

A. **Chronic** — Disease lasting a long time or recurring

B. **Acute** — Disease of severe but short duration; not chronic

C. **Virulent** — Extremely infectious or malignant

D. **Malignant** — Very harmful; causing or likely to cause death

E. **Benign** — Doing little or no harm; not malignant

INFORMATION SHEET

F. **Infectious** — Said of diseases that are caused by pathogens; catching; capable of being transmitted from one fish or animal to another

EXAMPLE: Infectious disease may be caused by bacteria, viruses, or other parasites.

G. **Noninfectious** — Said of conditions, disorders, and abnormalities that are not caused by pathogens and cannot be transmitted from one fish or animal to another

EXAMPLES: Nutritional disorders, contaminant problems (brown blood disease), environmental stressors, behavioral and physical abnormalities

IV. **Terms associated with behavior or appearance of sick fish**

A. **Flashing** — Twisting, turning sideways, and rubbing on plants or objects when swimming

B. **Topping** — Rising to the water surface

C. **Piping** — Gasping at water surface

D. **Erratic swimming** — Abnormal swim patterns such as whirling or spiraling, head standing, or darting wildly

E. **Lethargy** — Listlessness; slow, weak movements

F. **Edema** — Abnormal accumulation of fluid in the cells that causes swelling, protruding scales, and bulging eyes

V. **The role of stress in fish diseases** (Transparency 1)

A. Three factors must occur together for an infectious disease outbreak to develop:

1. The presence of a pathogen,

2. Susceptible fish,

3. A predisposing (stressful) condition.

(NOTE: Experienced fish farmers take precautions to prevent the simultaneous occurrence of these three factors. Their precautions make up the preventive medicine or health maintenance program of an aquacultural program.)

B. Many fish pathogens are common in ponds and natural water systems where fish are present, but they cause problems only when fish are weakened or made susceptible by a predisposing environmental factor (stressor).

C. When fish are unable to adjust to environmental stressors they become stressed.

INFORMATION SHEET

D. Stress reduces the resistance of fish to bacterial and parasitic infections, and an infectious disease condition often develops.

EXAMPLES: Experienced catfish farmers know that they should expect outbreaks of bacterial diseases shortly after a near depletion of oxygen in a rearing pond.

E. The key to disease control lies in reducing stress factors through good management.

VI. Common stressors

A. Low DO levels

B. Sudden changes in water temperature

C. Poor nutrition caused by inadequate diet

EXAMPLES: Inadequate feed formula, old feed, feed exposed to high temperature.

D. Water chemistry imbalances

EXAMPLES: pH levels and levels of nitrate, ammonia, metabolic wastes that are sublethal but beyond the acceptable range for the species; DO deficiency

E. External parasites

F. Handling during stocking, grading, sampling, or harvesting

G. Crowding

H. Sublethal levels of water pollutants such as pesticides

I. Injuries

VII. Signs of stress and disease

A. Behavioral signs

1. Lethargy
2. Loss of appetite
3. Clamped or folded fins
4. Frantic, erratic swimming
5. Sluggish swimming
6. Long periods of bottom resting

INFORMATION SHEET

7. Flashing, scratching, and rubbing against objects
8. Loss of equilibrium
9. Loss of ability to adjust buoyancy—floating/sinking behavior
10. Topping and/or piping
11. Crowding the inflow area

B. Clinical signs

1. Mortality
2. Hollow-bellied profile
3. Blood in fins; ragged fins
4. Hemorrhage (bloody appearance of skin)
5. Lesions on body
6. Abnormal growth or swelling on body
7. Spinal deformity
8. Visible parasites
9. Splotches, spots, discoloration, scale loss
10. Milky turbidity of skin
11. Edema
12. Popeye

VIII. **Common pathogenic viruses** (See Handout #1 and Assignment Sheet #1 for a reference chart of common fish diseases caused by these pathogens)

(NOTE: The presence of bacterial and viral pathogens can be verified only by laboratory culture. Most parasites can be verified by microscopic examination, and a few are visible to the naked eye.)

A. Viruses are ultramicroscopic or submicroscopic pathogens capable of multiplying only in living cells, and regarded both as living organisms and as complex proteins.

B. Viral diseases are generally acute, marked by high mortality.

C. In most cases, there is no effective treatment for viral diseases; the only control is through prevention.

INFORMATION SHEET

D. Any time a viral disease is suspected, samples of fish should be checked at a laboratory capable of doing virological work.

IX. **Common pathogenic bacteria**

A. Bacteria are one-celled microorganisms that can be pathogenic or benign.

(NOTE: Pathogenic bacteria cause such fish diseases as ESC, "hole-in-the-head" disease of catfish, and ulcer disease of goldfish. Benign bacteria are necessary for fermentation and nitrogen fixation, among other beneficial functions.)

B. Diseases caused by bacteria are often chronic rather than acute, but may also cause a high percentage of deaths.

C Bacterial diseases are often associated with environmental stressors because bacteria pathogens are usually opportunistic, occurring naturally in most waters and causing infections only when most resistance is lowered.

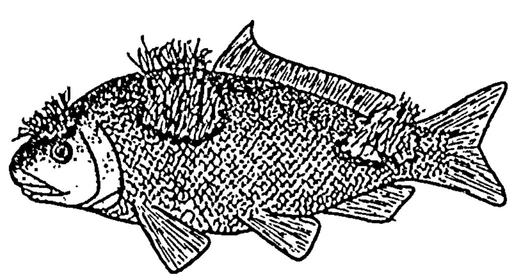
D Some species of bacteria can develop resistance to commonly used antibiotics if exposed to the drug too often or for extended periods; for this reason, it may be unwise to use oxytetracycline as a prophylactic treatment, or to use it as a long-term food additive or "cure-all."

E. Minimizing stress is the best method of preventing bacterial diseases.

X. **Common pathogenic fungi**

A. Fungi are plants without chlorophyll that grow on organic matter as a mass of threads. (Figure 1)

EXAMPLE: FIGURE 1 — A fish infected with fungi



B. The fungi that cause fish diseases are always present in water and are facultative, living on dead or decaying organic matter or on living tissue.

C. Generally fungi are secondary invaders to other diseases, injury due to handling, temperature shock, or the presence of dead eggs or tissues.

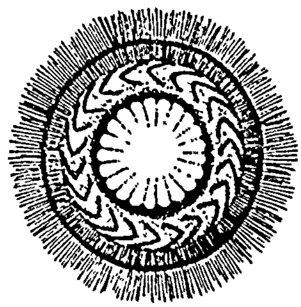
D. When a fish is injured or diseased, waterborne fungi spores attach to dead or injured tissue and establish a colony; once the fungi are established, they spread to healthy tissue and if untreated, eventually causes death.

INFORMATION SHEET

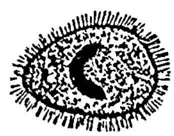
XI. **Common pathogenic protozoan parasites** (Transparencies 2 and 3)

A. Protozoan parasites are microscopic single-celled animals that live in water. (Figures 2 and 3)

EXAMPLE: FIGURE 2 — Adult parasite of the *Trichodina* genus



EXAMPLE: FIGURE 3 — Adult Ich protozoan (*Ichthyophthiriasis multifiliis*)



B. Most protozoan parasites require a fish host, but some are facultative, becoming a problem only when poor water quality, low oxygen, or poor nutrition stress fish.

C. Nearly all losses of fish due to parasites are caused by protozoans.

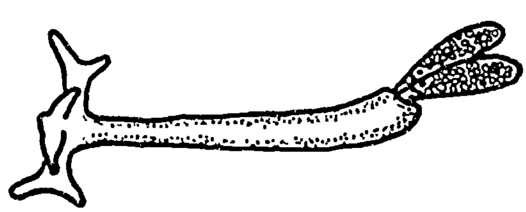
D. Some protozoan parasites are called sporozoa; these parasites encyst in the skin, organs, or ovaries, where they multiply and rupture, releasing hundreds of infectious spores.

XII. **Common pathogenic crustacean parasites**

A. Crustacean parasites are small parasites related to insects; they have a hard outer shell and jointed appendages.

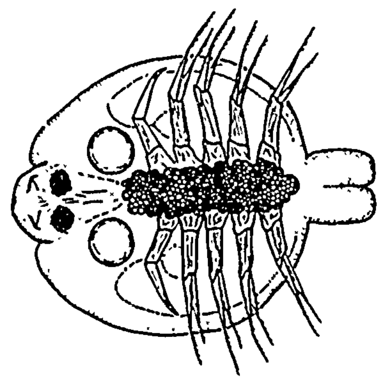
B. The two main crustacean parasites that infect commercially cultured fish are the anchor parasite and the fish louse. (Figures 4 and 5)

EXAMPLE: FIGURE 4 — Anchor parasite (*Lernaea cyprinacea*)



INFORMATION SHEET

EXAMPLE: FIGURE 5 — Fish louse of the genus *Argulus*



C. These parasites attach themselves to or burrow into the skin or gills, and can be seen with the naked eye.

(NOTE: The female anchor parasite burrows into the skin and then anchors herself by expanding her head. Only the thornlike egg sacs remain outside the fish's body.)

D. Crustacean parasites injure the skin and may transmit infectious disease from one fish to another, but they do not generally cause death unless in large numbers.

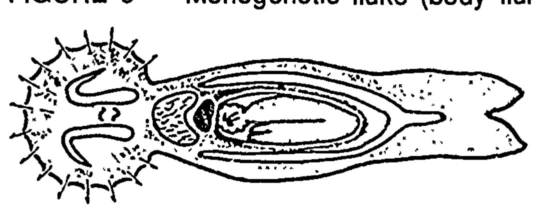
E. Movement of wildlife, such as ducks or muskrats, from pond to pond can spread the parasite.

XIII. Common pathogenic worm parasites

A. Fish may be primary, intermediary, and sometimes final hosts to a number of parasitic worms, all of which cause organ or tissue damage, and some of which are potential disease agents.

B. **Flukes** (and their larvae, **grubs**) are microscopic to medium-sized *trematodes* that attach themselves with a special organ surrounded with hooklets; some flukes live in the gills or eyes only, and others live on or in the body and on the fins. (Figure 6)

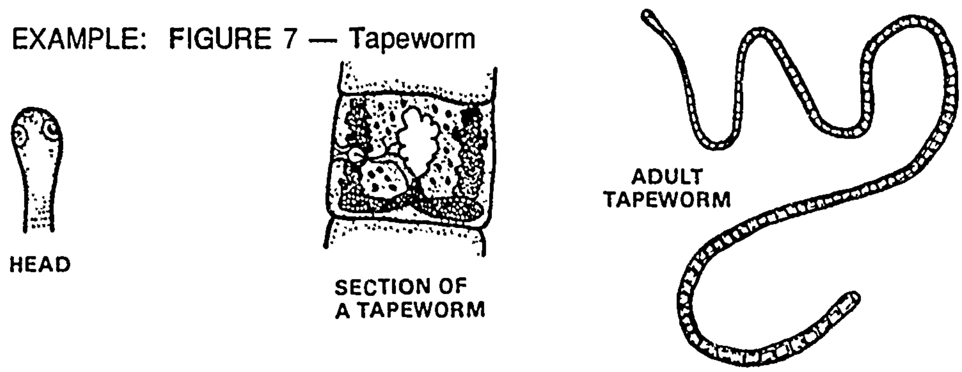
EXAMPLE: FIGURE 6 — Monogenetic fluke (body fluke)



INFORMATION SHEET

C. **Tapeworms (cestoda)** have complicated life cycles that involve one or more intermediate hosts. (Figure 7 and Transparency 4)

EXAMPLE: FIGURE 7 — Tapeworm



D. **Roundworms (nematoda)** have a life cycle involving one or two intermediate hosts; sometimes the fish is the final host and other times the fish is the intermediate host; adult round worms can be seen with the naked eye and usually occur in the intestine; larval forms often infest the body cavity where they cause much damage.

E. **Leeches** attach themselves externally, take a blood meal, and leave the fish for varying periods of time; the damage done to the fish depends on the number and the size of the leeches, and the amount of blood removed.

XIV. General management measures for preventing disease outbreaks

A. If possible, use high-quality spring or well water that is free of wild fish and contains no harmful contaminants.

B. Monitor and maintain water quality.

C. If you must obtain stock from a supplier, make sure that the supplier is reputable and that the stock has no history of serious health problems.

(NOTE: Some states require fish health inspection of salmonids before importation. Check with the state fish and game department.)

D. Treat fish for external parasites before stocking.

E. Acclimate fish before transporting or stocking.

F. Avoid overcrowding fish at any time and especially during hot weather.

G. Inspect your stock daily; learn and look for signs of stress or disease.

H. Know your water, your fish, and the diseases that affect your species.

I. Feed a nutritionally balanced ration specifically formulated for the species being cultured; adjust amounts as needed, and feed at regular intervals.

INFORMATION SHEET

J. Avoid anything that causes unnecessary stress to the fish.

EXAMPLES: Visitors at pondside or in the vicinity of cages, excessive or prolonged handling, sudden changes in feed or environment

XV. **Basic hygiene for disease prevention and corrective management**

A. When water from streams or lakes must be used, disinfect water or install Saran sock or sand-gravel filters to prevent the introduction of wild fishes and most parasites.

(NOTE: Ultra-violet filters have been used to disinfect or sterilize water at some trout and salmon hatcheries, but these require clear water to be effective.)

B. Disinfect or sterilize nets, buckets, holding and transporting tanks to prevent fish from becoming infected before they are stocked, and to prevent disease spread from pond to pond.

C. Kill residual disease organisms, spores, and unharvested fish that may be a reservoir of disease by draining and disinfecting ponds before stocking.

XVI. **Treatment methods and their administration** (Handouts #3 and #4 and Assignment Sheets #2 - #5)

A. **Dip** — Fish is dipped into a concentrated chemical solution for 15 to 45 seconds.

B. **Flush** — Chemical is added to systems such as raceways, tanks, and egg incubators and allowed to flush through the unit within a predetermined time.

C. **Short-term bath** — Chemical is added directly to rearing or holding unit, left a specified period of time, and then flushed from unit.

D. **Indefinite bath** — Low concentration of chemical is applied to pond or hauling tank and allowed to dissipate naturally.

E. **Oral**

1. Medication is added to feed and fed to fish.

2. Medication is placed in a gelatin capsule and inserted into the fish's stomach with a balling gun.

F. **Injection** — Medication is placed into body cavity or muscle tissue with a syringe and needle.

(NOTE: Generally only large, valuable fish, such as broodfish, are injected with antibiotics.)

INFORMATION SHEET

XVII. General guidelines for treatment of fish diseases

A. When you suspect a disease or harmful noninfectious condition, *act promptly*: first contact your nearest disease diagnostic laboratory, and then send live specimens and a water sample. (Job Sheet #1)

B. Obtain an accurate diagnosis. The use of the wrong treatment can result in more losses than would occur with no treatment at all.

(NOTE. An accurate diagnosis is impossible without a laboratory examination of the sick fish and an analysis of the water in which the sick fish are being raised. This is particularly important because laboratory investigation usually reveals multiple causes for fish loss. Without correctly identifying all of the causes, the proper treatment and treatment sequence cannot be prescribed.)

C. After you have obtained an accurate diagnosis, ask yourself whether treatment is the best course of action.

EXAMPLES: Is the disease treatable, and what is the probability of a successful treatment?
Is it economically feasible to treat the fish when you consider cost, handling, prognosis, etc.?
Does the loss rate and the present disease justify the treatment?
What ecological and water-quality effects will the treatment cause?
Can the required chemical be administered without killing plants or depleting DO?
Will the water temperature, sunlight, etc. make the chemical ineffective?
Would the best and most cost-effective solution be to immediately market the fish to a processor?

D. Know the volume of your ponds *before* treatment is needed.

Know what water quality factors (pH, total alkalinity, temperature) increase or decrease the toxicity of the chemical.

F. Keep accurate, up-to-date records.

G. Plan ahead: Have available the phone number of your county agent or diagnostician, and basic medicines and chemicals for emergency treatment.

H. Read label instructions and cautions carefully and follow all directions concerning application methods and prohibited uses.

INFORMATION SHEET

I. Calculate and measure accurately, and never increase or reduce the stated dosage.

(NOTE: The saying "the more the better" is not only dangerous, it is illegal. Only the application rates described on the label are permitted. Careless calculating or measuring, or adding that "little extra for luck" could lead to contamination of the water and soil, kills of desirable organisms, and chemical residues in fish flesh.)

J. Mix solutions well, especially for dips and short-term baths, so that fish are not harmed by pockets of concentrated solution.

K. If the treatment chemical has not been used before, test the chemical on a small number of fish in a container (large bucket, plastic wastebasket) before treating the whole rearing unit.

XVIII. Regulations for chemical application in fish production

A. The Environmental Protection Agency (EPA) has been charged by Congress with the control of the use of pesticides, and the U.S. Food and Drug Administration (FDA) has been charged with the control of the use of drugs.

B. All producers, handlers, and applicators can be held legally accountable if they misuse a chemical.

C. Only uses described on the label of the chemical are permitted, and only at the application rates listed, applications at less than or more than the approved rate are equally illegal.

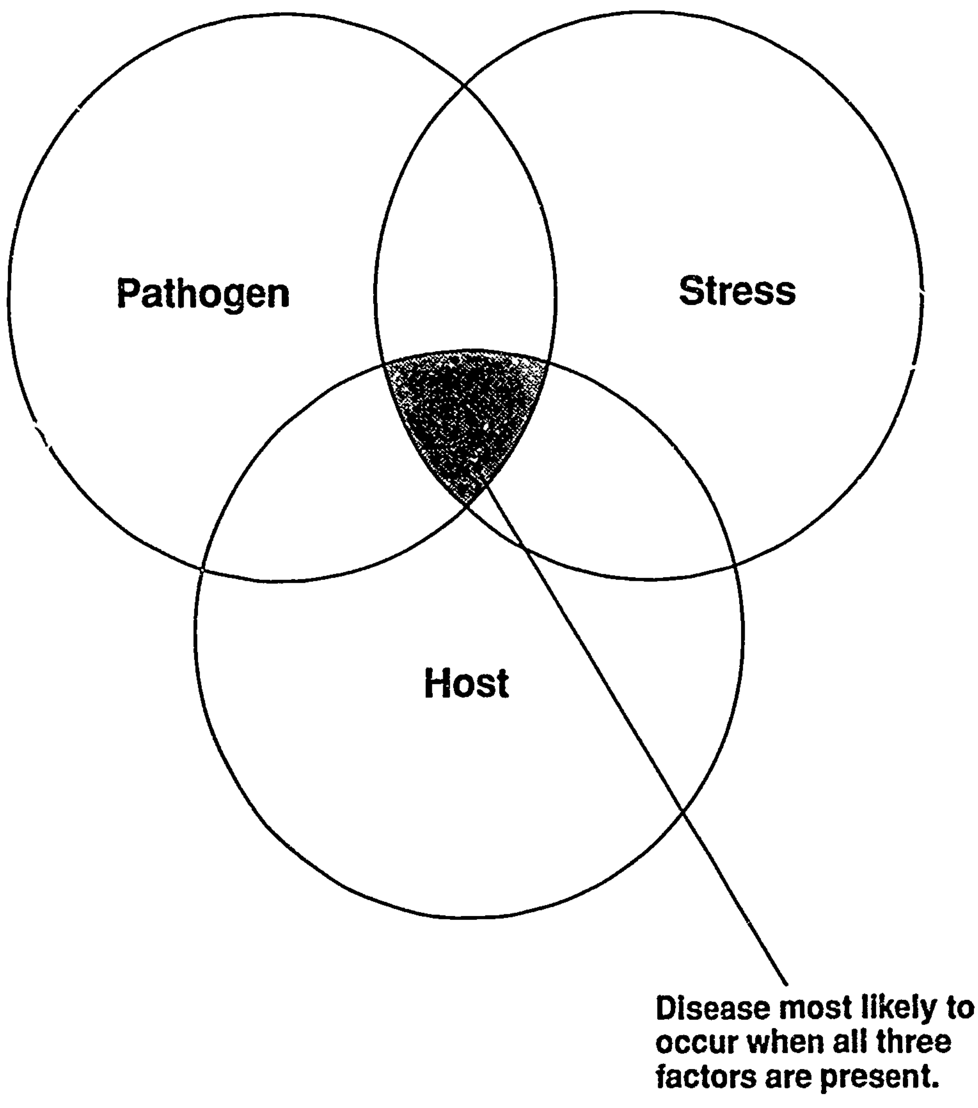
D. The FDA has two categories, "food fish" and "non-food fish," in determining which fishery use patterns are permitted: *food fish* are those species that may be eaten by man, and regulations cover all life stages from egg to adult, *non-food fish* refers to bait and ornamental fishes.

E. Permits are required by FDA if fish culturists produce their own medicated feeds.

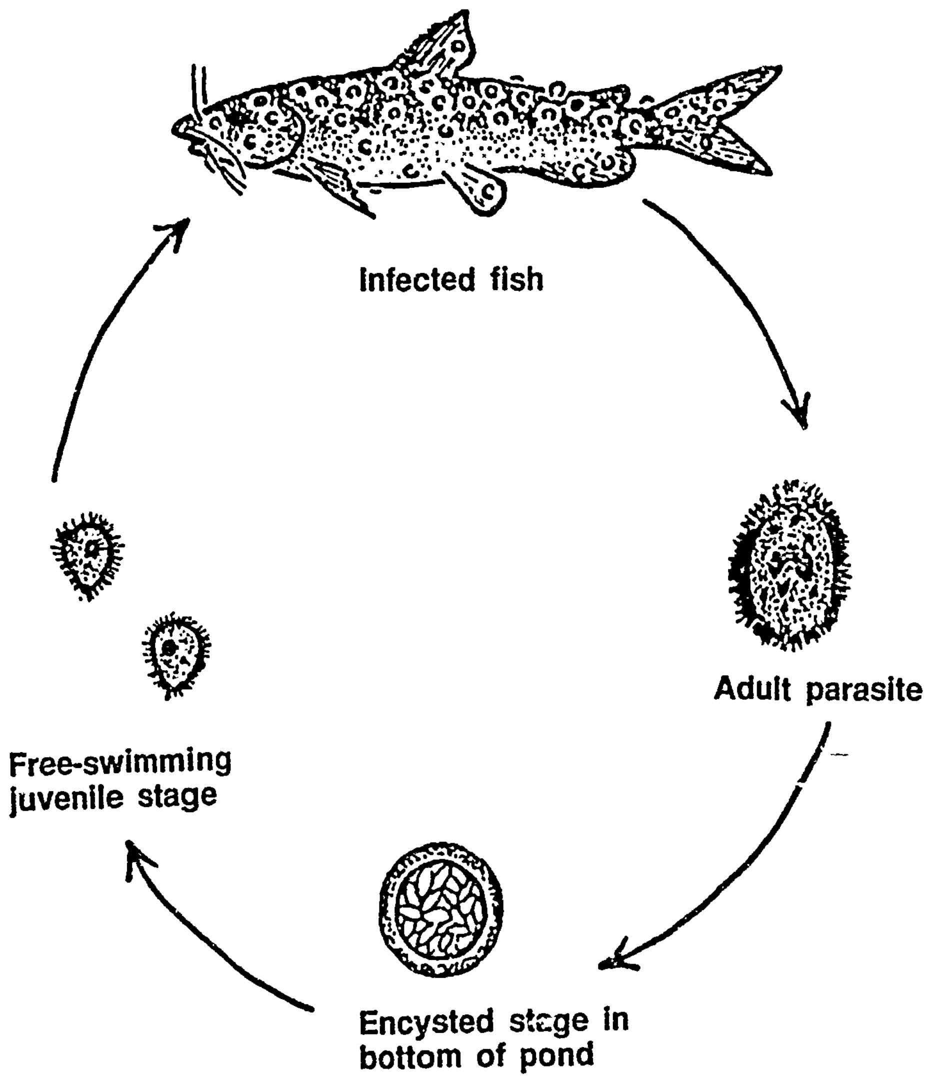
F. The discharge of water from fish culture facilities is overseen by EPA under the National Pollutant Discharge Elimination System, which issues discharge permits to facilities that require them.

G. Recently both the EPA and the FDA have begun to enforce regulations that govern the use of drugs and chemicals in fish culture, violators are subject to disciplinary action.

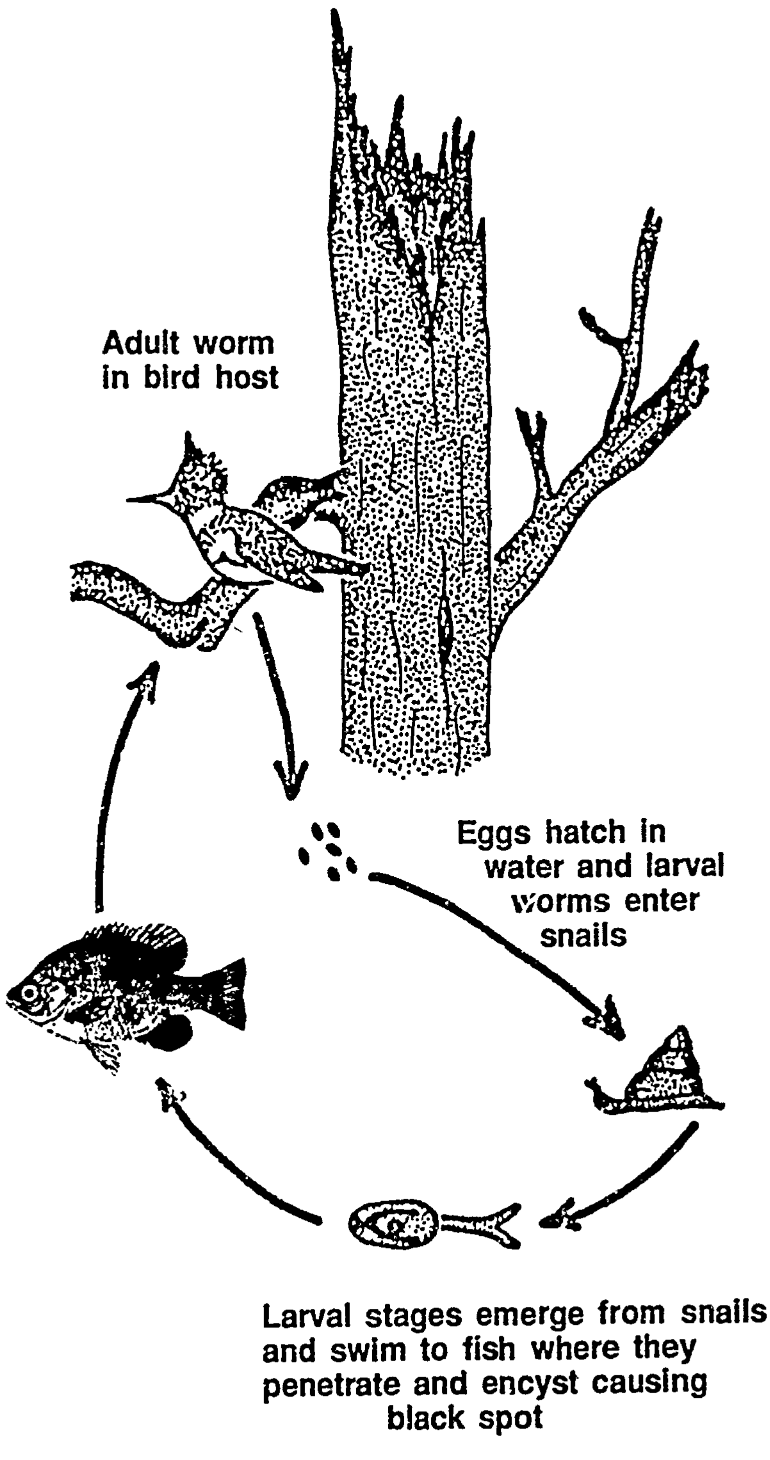
Role of Stress in Fish Diseases



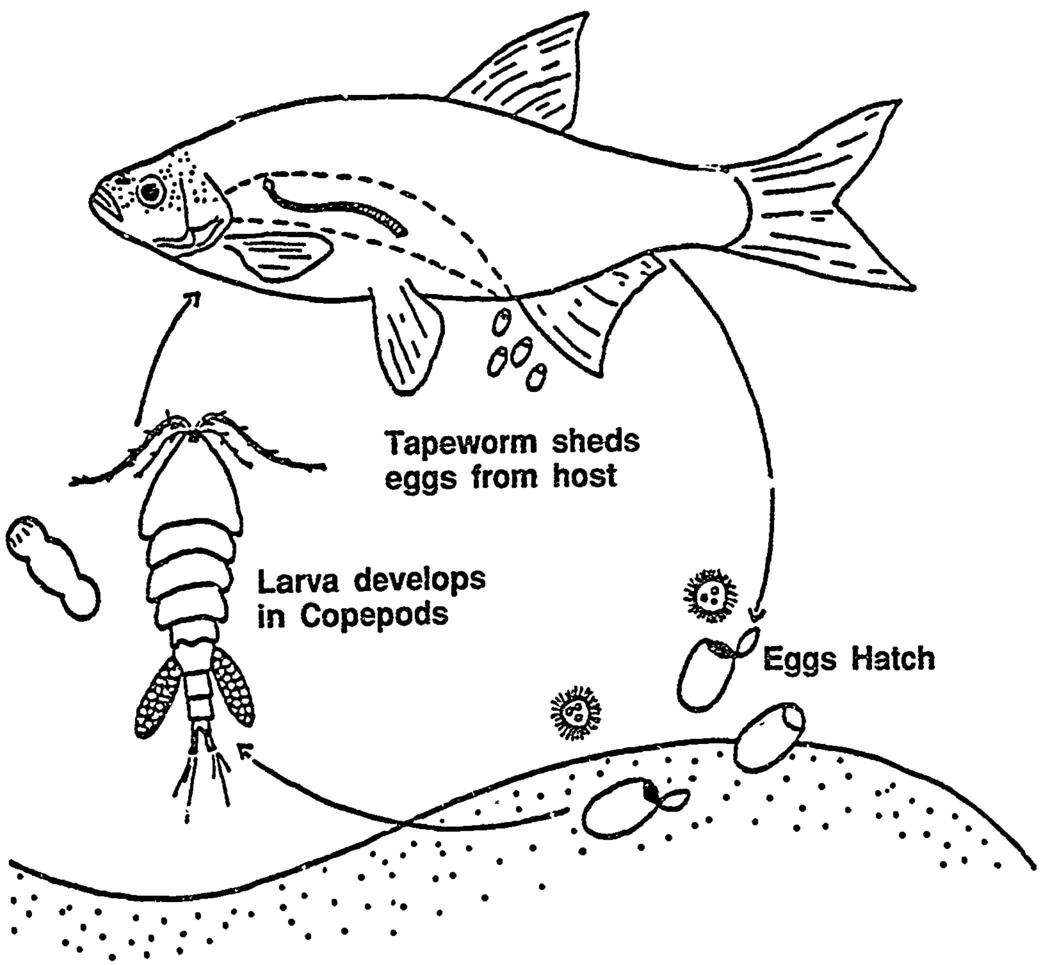
Life Cycle of the Ich Parasite



Life Cycle of the Black-Spot Parasite



Life Cycle of the Asian Tapeworm



HEALTH FISH MANAGEMENT
UNIT VIII

HANDOUT #1 — COMMON INFECTIOUS DISEASES OF CULTURED FISH

Special Note. Items with an asterisk (*) are compounds that have not been approved for use with food fish, and whose use for the purpose discussed is restricted.

The status of these chemicals can change from year to year, so check with closest diagnostic laboratory or the *Journal of Fish Health Management*, published by the Fish Health Section of the American Fisheries Society.

Disease:	CHANNEL CATFISH VIRUS (CCVD)
Causative organism:	Channel catfish virus
Susceptible species:	Channel catfish during their first summer, usually when they are less than 5-inches long
Clinical and behaviroal signs:	Swollen abdomen containing clear yellow fluid; popeye; erratic swimming, hemorrhage at bases of fins and through skin on ventral surface; dark red spleen
Contributing factors:	Low dissolved oxygen, high ammonia levels, water temperature above 68°F (and especially above 85°F); rough handling; chemical stress
Prevention:	Maintain good water quality; maintain DO levels at 4 ppm and higher; do not overcrowd or overhandle during first summer; avoid use of chemical prophylactics; disinfect nets, tanks, and equipment when fish are handled or transported; purchase fry from virus-free broodstock
Possible therapeutic agents or medications:	None known

Materials in Handout #1 adapted from
Some Parasites and Diseases of Warmwater Fishes.

HANDOUT #1

Disease:	BACTEREMIA (HEMORRHAGIC SEPTICEMIA)
Causative organism:	*Aeromonas hydrophila*, *Pseudomonas fluorescens* and possibly other bacteria
Clinical and behavioral signs:	Listlessness and lethargy; reduced feeding; topping; shallow reddish ulcers with ragged margins exposing necrotic skin and muscle; swollen fluid-filled belly; raised scales; popeye; red streaks in fin rays and bases of fins; frayed fins; reddened area around anus
Contributing factors:	Warm water in spring, especially when fish spawn, are handled, overcrowded, or moved; low DO; stress from disease or malnutrition
Prevention:	Avoid overcrowding and rough handling, especially during summer; maintain good water quality; provide well-fortified feed containing higher than recommended levels of Vitamin C
Possible therapeutic agents or medications:	Terramycin in diet; terramycin or acriflavine* in transport water may retard the transfer of the bacterium, but will not cure infected fish
Susceptible species:	All fishes; most common disease of cultured catfish

Disease:	COLUMNARIS DISEASE
Causative organism:	The bacterium *Flexibacter columnaris*
Susceptible species:	All fishes, including salmonids and channel catfish
Clinical and behavioral signs:	Discolored patches on body with little or no hemorrhaging; scale loss; mouth and barbel erosion; fin erosion and tail loss; decayed areas in gills (NOTE: Discolored patches and scale loss superficially look like damage caused by fungus infections.)
Prevention:	Avoid overcrowding and rough handling, especially during summer; maintain good water quality; provide well-fortified feed containing higher than recommended levels of Vitamin C
Possible therapeutic agents or medications:	Water treatments with potassium permanganate; terramycin-medicated feed may be helpful if the infection is systemic (internal)

HANDOUT #1

Disease:	FURUNCULOSIS
Causative organism:	The bacterium *Aeromonas salmonicida*
Susceptible species:	Trout and goldfish, particularly goldfish broodfish
Clinical and behavioral signs:	Ulcers or lesions with irregular margins on sides of fish; lesions start as small white spots and progress to large hemorrhagic sores; scale loss at site of ulcer; body swellings; ragged or missing pectoral fins
Contributing factors:	Stress associated with spawning, handling, and transporting, warm water temperatures; poor nutrition; overstocking; infected eggs
Prevention:	Collect, handle, and transport goldfish broodfish in winter when the water temperature is less than 55°F; use young broodfish; offer a nutritionally complete feed fortified with Vitamin C; purchase healthy stock; do not overstock.
Possible therapeutic agents or medications:	Destroy the stock and disinfect facility.

Disease:	ENTERIC SEPTICEMIA OF CATFISH (ESC) (HOLE IN THE HEAD DISEASE)
Causative organism:	*Edwardsiella ictaluri*
Susceptible species:	Channel catfish
Clinical and behavioral signs:	White or reddish raised area between eyes develops into (hole-in-the-head) ulcer, pimple-like lesions over general body surface; swollen fluid-filled abdomen; loss of appetite; listlessness: hang tail down, erratic swimming in circles, bloody internal organs
Contributing factors:	Low DO, high ammonia and nitrate levels, water temperatures between 70°F and 82°F
Prevention:	Maintain good quality water; keep DO level above 4 ppm; provide good-quality feed with supplemental Vitamin C; avoid broodfish that have a history of the disease
Possible therapeutic agents or medications:	Terramycin or Romet-30 in the feed

HANDOUT #1

Disease:	FUNGUS INFECTION
Causative organism:	Fungi, usually of the genera *Saprolegnia* and *Achlya*
Susceptible species:	All freshwater fishes and their eggs
Clinical and behavioral signs:	Localized discolored areas or lesions; general cotton-like or fur-like growth, that takes on the color of materials suspended in the water
Contributing factors:	Stress; mechanical injury, disease, low DO, prolonged periods of very low temperatures (NOTE: Fungus infections are usually secondary and indicate poor conditions. Fungi seldom infect healthy fish.)
Prevention:	Maintain good water quality; feed nutritionally adequate feeds all year; feeding just before winter and in early spring is especially important
Possible therapeutic agents or medications:	Copper sulfate* and potassium permanganate

Disease:	COSTIASIS DISEASE
Causative organism:	Protozoa of the genus *Ichtyobodo* (sometimes called *Costia*)
Susceptible species:	All freshwater fishes
Clinical and behavioral signs:	Blue-gray film over body surface; lack of appetite; listlessness, lethargy; gill filaments may appear ragged on visual examination
Contributing factors:	Overcrowding aggravated by fluctuating water temperatures (common in fall and spring); malnutrition
Prevention:	Maintain good water quality; feed nutritionally complete feeds
Possible therapeutic agents or medications:	Table salt, formalin, or acetic acid; copper sulfate* followed by potassium permanganate

Disease:	TRICHODINIASIS
Causative organism:	Protozoa of the genus *Trichodina*
Susceptible species:	All freshwater fishes
Clinical and behavioral signs:	Listlessness; lethargy; reduced feeding; frayed fins

HANDOUT #1

Contributing factors: Low DO, high concentration of organics in water, fluctuating temperatures during fall and spring; malnutrition

Prevention: Maintain good water quality; keep DO at 4 ppm or above; feed adequate amounts of nutritionally complete feed; avoid overcrowding, especially fingerlings

Possible therapeutic agents or medications: Formalin, potassium permanganate, and copper sulfate*

Disease: ICHTHYOPHTHIRIASIS (ICH or ICK)

Causative organism: A ciliated protozoan—*Ichthyophthirius multifiliss*—commonly called Ick

Susceptible species: All freshwater fishes

Clinical and behavioral signs: Small raised spots that look like sprinkled table salt cover entire body and fins, flashing and rubbing behaviors, heavily infected fish may gather at intake or outlet of the pond or tank

Contributing factors: Poor water quality, malnutrition, water source contaminated with wild fish; water temperatures of 60°F to 75°F

Prevention: Avoid contaminated water supply, nets, and equipment; maintain good quality water, offer nutritionally adequate feeds

Possible therapeutic agents or medications: Formalin, table salt, copper sulfate*, and potassium permanganate

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Disease: MILK SCALE DISEASE

Causative organism: Sporozoan *Myxobolus notemigoni*

Susceptible species: Golden shiners

Clinical and behavioral signs: Visible cysts beneath the scales; loose milky looking scales; chronic high mortality from secondary invaders

Contributing factors: Poor quality water; crowding; poor nutrition

Prevention: Maintain water quality; drain and sterilize pond after outbreak; offer nutritionally complete feeds

Possible therapeutic agents or medications: No effective treatment, treat for secondary infection, apply prophylactic external treatment to protect against secondary infection, and increase amount of feed during 4 weeks while scale are regenerating

HANDOUT #1

Disease:	CHILODONELLIASIS
Causative organism:	Parasites *Chilodonella cyprini* (cold-water form) and *Chilodonella hexsticha* (warm-water form)
Susceptible species:	Most freshwater fishes
Clinical and behavioral signs:	Bright red gills that sometimes bleed when touched
Contributing factors:	Poor quality water containing high levels of organic matter, crowding; malnutrition; water temperatures of 40°F to 70°F
Prevention:	Maintain good quality water; feed adequate amounts of good quality feed, especially in early spring and late winter
Possible therapeutic agents or medications:	Formalin and potassium permanganate

Disease:	INFECTIOUS HEMATOPOIETIC NECROSIS (IHN)
Causative organism:	Virus
Susceptible species:	Rainbow trout are severely affected, but Coho seem to be resistant to this virus.
Clinical and behavioral signs:	Lethargy; whirling; dark coloration; abdominal swelling; pale gills; hemorrhages at bases of fins.
Contributing factors:	Survivors of the disease are life-long carriers, fish to fish and fish to egg are the primary avenues for infection; feeding of byproducts of infected fish is another means of transmission; mortality is highest in young fish and resistance appears to increase with age.
Prevention:	Avoidance of IHM-infected eggs and fish
Possible therapeutic agents or medications:	None known; destroy infected fish and disinfect facility

Disease:	INFECTIOUS PANCREATIC NECROSIS (IPN)
Causative organism:	Virus spread through feces, eggs, seminal and ovarian fluids from parent to progeny via the eggs; also spread by fish surviving the disease as they become carriers of the virus
Susceptible species:	All salmonids and goldfish

HANDOUT #1

Clinical and behavioral signs:	Increase in mortality; spiraling along the long body axis; overall darkening of body; popeye; abdominal swelling; hemorrhages at bases of fins.
Contributing factors:	First-feeding fry are most susceptible, susceptibility decreases with age
Prevention:	Prevent contact between host and virus; do not stock infected fish into lakes, reservoirs, or streams that serve as water sources for hatcheries or wild broodstock.
Possible therapeutic agents or medications:	None known; destroy infected fish and disinfect facility

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Disease:	WHIRLING DISEASE (*MYXOSOMA CEREBRALIS*)
Causative organism:	Parasite *Myxosoma cerebalis*;. young fish become infected by spores released from dead fish and shed by living fish. The ingested parasite is thought to leave the spore capsule in the intestine and migrate to the head cartilage where it grows.
Susceptible species:	All salmonids, though brown trout and Coho tend to be resistant
Clinical and behavioral signs:	No signs of the disease may show until 40 to 60 days after infection when fish chase their tails, or whirl until exhausted
Contributing factors:	Fish are most susceptible during the first 12 months of life
Prevention:	Avoid importing infected fish, including frozen trout or salmon, and the use of contaminated water; disease can be controlled by rearing young fish in spore-free water in metal or concrete tanks. Once the fish are 3 to 5 inches long, they may be placed in contaminated ponds, and will acquire a low-level infection that makes them resistant to the disease.
Possible therapeutic agents or medications:	No proven chemotherapy is available.

Disease:	BACTERIAL KIDNEY DISEASE (BKD)
Causative organism:	Bacterium (*Renibacterium salmoninarum*) infected eggs are a major source of the infection in disease-free hatcheries; outbreaks can occur a year or more after receipt of eggs. Eggs cannot be disinfected.
Susceptible species:	Coho and Atlantic salmon are highly susceptible; brook trout are severely affected and brown trout less so; rainbow trout are the least severely affected.

HANDOUT #1

Clinical and behavioral signs:	White blisters and ulcers develop on the kidney, liver, spleen, and heart
Contributing factors:	Water hardness and temperature
Prevention:	Avoid infected fish and eggs
Possible therapeutic agents or medications:	No proven chemotherapy cure is available at this time; in some situations the disease can be "controlled" with antibiotics such as erythromycin; eradicate by destroying infected fish and disinfecting water supply.

Disease:	ENTERIC REDMOUTH (ERM)
Causative organism:	Bacterium *Yersinia ruckeri* spread by carriers who have survived the disease and by contaminated water
Susceptible species:	All salmonids, and particularly rainbow trout
Clinical and behavioral signs:	Inflammation and erosion of the jaws and palate of salmonids; lethargy; dark color
Contributing factors:	Poor water quality; stress during hauling; low DO
Prevention:	Restrict transfer of carriers; detection is difficult in healthy carrier fish; disinfect eggs coming in; maintain water quality.
Possible therapeutic agents or medications:	Can be "controlled" with antibiotics (sulfamerazine) and improved water quality with high DO. Eradicate by destroying infected fish and disinfecting water supply.

Disease:	PROLIFERATIVE GILL DISEASE (PGD) ("HAMBURGER" GILL DISEASE)
Causative organism:	Unknown
Susceptible species:	Warmwater species, particularly catfish
Clinical and behavioral signs:	Clubbed, bloody gills; gill filaments fall off when rubbed; piping; congregating at inflow pipe; loss of appetite; death
Contributing factors:	Most commonly found in new ponds in spring and fall
Prevention:	None

HANDOUT #1

Possible therapeutic agents or medications:	None known, but it sometimes helps to pump aged water from another pond

Disease:	TRICHOPHRYA
Causative organism:	Stalked protozoan, *Trichophrya* invading the gills
Susceptible species:	All warmwater species, particularly catfish
Clinical and behavioral signs:	Loss of appetite; pale, eroded, clubbed gills; lethargy
Contributing factors:	Stress, reduced water quality
Prevention:	Maintain water quality and nutrition
Possible therapeutic agents or medications:	Potassium permanganate, copper sulfate*, formalin

Disease:	MONOGENETIC FLUKES
Causative organism:	Monogenetic flukes of the genera *Gyrodactylus* (body fluke) *Dactylogyrus*, and *Cleidodiscus*; all are similar in appearance
Susceptible species:	All warmwater fishes
Clinical and behavioral signs:	Flashing, rubbing against pond sides and bottom; listlessness, staying near edge of pond; gills may be flared on small fish (NOTE: When there are many flukes, their primary damage, combined with secondary bacterial infection may cause death.)
Contributing factors:	Poor water quality, inadequate nutrition, crowding, fluctuating water temperatures
Prevention:	Maintain good water quality
Possible therapeutic agents or medications:	Masoten*, formalin, potassium permanganate

Disease:	FISH GRUBS (LARVAL FLUKES)
Causative organism:	Fish grubs of the genera *Crassiphiala* and *Clinostomum* (yellow grub), and *Posthodiplostomum* (white grub)

HANDOUT #1

Susceptible species:	Bluegills and other sunfishes, black basses, and most minnows
Clinical and behavioral signs:	Small pigmented nodules (either black, cream-colored, or white) in the flesh and visceral cavity, and sometimes in the gills, loss of equilibrium; deformity
Contributing factors:	Infected fish, presence of intermediate hosts (fish-eating birds and snails)
Prevention:	Eradicate snails in ponds, and remove bird roosts in area
Possible therapeutic agents or medications:	None

Disease:	ANCHOR PARASITE
Causative organism:	Parasitic crustacean (copepod) *Lernaea Cyprinacea*
Susceptible species:	All freshwater fishes especially baitfish, catfish, and carp (NOTE: It takes only one *Lernaera* to kill a small minnow as it has an affinity for the heart region.)
Clinical and behavioral signs:	Small reddish lesions on surface, often surrounded by fungus, parasite looks like a small thorn (similar to a broom straw) inserted into the flesh of the fish; anchor end of the parasite, embedded in the fish, prevents manual detachment without further injury to host fish
Contributing factors:	Stocking fish infected with anchor parasite, movement of wildlife (ducks, muskrats) from pond to pond
Prevention:	Examine stock for parasite, and stock parasite-free fish
Possible therapeutic agents or medications:	Masoten*

Disease:	FISH LICE
Causative organism:	Parasites of the genus *Argulus*
Susceptible species:	All freshwater fishes
Clinical and behavioral signs:	Flashing and rubbing against tank sides or pond bottom; listlessness; red spots; chronic mortality (when infestations are heavily infected)
Contributing factors:	Stocking fish infected with fish lice

HANDOUT #1

Prevention:	Examine stock for parasite, and stock parasite-free fish
Possible therapeutic agents or medications:	Masoten*

Disease:	TAPEWORM
Causative organism:	*Bothriocephalus opsarichthydis* (Asian tapeworm) *Corallobothrium fimbriatum* (catfish tapeworm), and others
Susceptible species:	All fishes—especially black basses, Chinese carps, catfishes, sunfishes, golden shiners
Clinical and behavioral signs:	Often no outward indication but fish may lose weight, be listless, or become sterile, severe infestations distend the abdomen and block the intestine; chronic mortality
Contributing factors:	Stocking broodfish infected with tapeworms, purchase of contaminated fry and fingerlings; use of surface water containing tapeworm-infested hosts; droppings of fish-eating birds in or near pond
Prevention:	Avoid maintaining or purchasing infected fry, fingerlings, or broodfish; drain, dry, and disinfect ponds between fish crops
Possible therapeutic agents or medications:	Di N-butyl tin oxide for non-food enterprises

FISH HEALTH MANAGEMENT
UNIT VIII

HANDOUT #2 — NONINFECTIOUS CONDITIONS OF CULTURED FISH

Condition:	OXYGEN STARVATION
Cause:	DO deficiency
Signs/ symptoms:	Fish gathered at the water inflow or outlet; fish gasping at the water surface; sudden mortality
Prevention:	Aerate water; monitor DO levels and attempt to predict drops
Treatment:	Aerate water

Condition:	ACIDOSIS
Cause:	Water that is too acid for species
Signs/ symptoms:	Fish shooting through water with sudden rapid fin movements; fish gasping for air and sometimes jumping out of the water, death occurring very quickly or taking a slow course; milky turbidity of the skin; red, inflamed skin; brown deposit on the gills
Prevention:	Monitor pH level, maintain pH in an optimal range for the species being cultured
Treatment:	Raise the pH and total hardness of the water by liming, determine cause of imbalance and correct to prevent recurrence

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Condition:	ALKALOSIS
Cause:	Water that is too basic for species
Signs/ symptoms:	Corroding of the skin and gills; milky turbidity of the skin; mortality
Prevention:	Monitor pH level, maintain pH at an optimal range for the species being cultured
Treatment:	Reduce the pH level and total hardness by adding alum or agricultural gypsum; determine cause of imbalance and correct to prevent recurrence

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Condition:	GAS BUBBLE DISEASE
Cause:	Gas (oxygen or nitrogen) found naturally in well and spring water, ice melt/heating; air in water lines or pumps

HANDOUT #2

Signs/ symptoms:	Bubbles under the skin and in gill tissues, fish rustle when taken out of the water
Prevention:	Monitor DO levels, maintain DO at optimum levels for species being cultured; control algae growth, and avoid blooms, especially during periods of intense sunlight
Treatment:	Correct by mechanical aeration which releases excess gas

---

Condition:	POISONING
Cause:	Toxic substance, or toxic levels of a substance in water
Signs/ symptoms:	Varies with the poison; may cause sudden mortality
Prevention:	Use high-quality spring or well water if possible, monitor water for harmful levels of ammonia, nitrate, CO_2, iron, etc.; test water and soil for pesticides before constructing pond or stocking
Treatment:	Treatment varies according to the toxin present, some conditions cannot be reversed; emergency measures call for dilution with fresh, clean water or for total water change

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Condition:	NUTRITIONAL DEFICIENCY
Cause:	Unsuitable, too much, or too little food; vitamin deficiency
Signs/ symptoms:	Slow growth; body deformities such as broken spine; lethargy; slow weak movements; loss of appetite; hollow-bellied profile
Prevention:	Feed a nutritionally balanced ration specifically recommended for the species being cultured; feed at regular intervals, and only as much as the fish eat in about a 10 minute period; do not over- or underfeed; calculate feed conversion and adjust feed accordingly
Treatment:	Some conditions cannot be reversed, change type or amount of feed, or feeding times; check for parasite infestation and treat accordingly

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Condition:	MECHANICAL INJURY
Cause:	Predator bite, rough handling, fighting during spawning, other external causes
Signs/ symptoms:	Visible wound; possible parasites or fungus growth, loss of appetite, erratic swimming

HANDOUT #2

Prevention:	Screen tank cultures and small ponds with netting to protect from fish-eating birds; avoid overhandling or rough handling during harvest; separate sexes after spawning if necessary
Treatment:	Many wounds are self-healing; treat large wounds with a long-duration bath for the control of parasites and fungus; dispose of severely injured or dead fish

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Condition:	BROWN BLOOD DISEASE
Cause:	High nitrite levels oxidizing hemoglobin in blood to methemoglobin
Signs/ symptoms:	Topping; loss of appetite; brown oxygen-poor blood; sudden mortality
Prevention:	Monitor nitrite levels in water; anticipate high nitrite levels with rising water temperatures and pH
Treatment:	Chloride—common salt—effectively reverses effects at a minimum of 5 ppm per acre-foot

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Condition:	ANEMIA
Cause:	Poor nutrition; chronic disease
Signs/ symptoms:	Lethargy; pale gills; loss of appetite; loss of color; mortality
Prevention:	Feed a balanced ration; control disease
Treatment:	Nutritionally complete diet

FISH HEALTH MANAGEMENT
UNIT VIII

HANDOUT #3 — FDA-APPROVED CHEMICALS FOR FISH CULTURE

TABLE 1: Registered or Approved Therapeutants*

Product	Sponsor	Fishery Use	Tolerance	Comments
Acetic acid, commercial grade (Vinegar)	-----	Parasiticide — 1,000 to 2,000 ppm for 1-10 min	Exempted from tolerance	Food fish use; declared as Generally Recognized as Safe (GRAS) by FDA as general purpose food additive.
Formalin-F (Formalin)	Natchez Animal Supply Company, Natchez, Mississippi	Parasiticide for use on trout, salmon, catfish, largemouth bass, and bluegill — 25 ppm in ponds; up to 250 ppm for 1 h in tanks and raceways Fungicide for use on trout, salmon, and ecocide eggs — 1,000 to 2,000 ppm for 15 min in egg treatment tanks	None required	Food fish use; do not apply to ponds warmer than 80°F when a heavy bloom of phytoplankton is present, or when the concentration of dissolved oxygen is less than 5 ppm; dilute efflucent of fish treatment tanks by 10x and the contents of egg treatment tanks by 75x; egg treatments at 250 ppm for 1 hour are also effective.
Furanace capsules (Nifurpyrinol, Furpyridinol; P-7138)	Amdal Company Division of Abbott Laboratories North Chicago, Illinois	Antibacterial drug against columnaris disease of aquarium fish — 3.8 mg capsule to 10 gal of water for 1 h	None established	Nonfood fish use only; do not use in salt water aquariums or wl "e egg or live-bearing fish are reproducing.
Masoten (Trichlorfon)	Animal Health Division	Parasiticide against anchorworms, lice, and gill flukes on goldfish or bait fish — 0.25 ppm active ingredient for indefinite period	None established	Nonfood fish use only; not for use in streams; do not apply to ponds used as a source of drinking water for humans or animals; removed from Pre-RPAR review and returned to reregistration process.

AQ-451

HANDOUT #3

Paracide-F (Formalin)	~ent Chemical Laboratories Redmond, Washington	Parasiticide for use on trout, salmon, catfish, largemouth bass, and bluegill — 25 ppm in ponds; up to 250 ppm for 1 h in tanks and raceways Fungicide for use on trout, salmon, and esocid eggs — 1,000 to 2,000 ppm for 15 min in egg treatment tanks	None required	Food fish use; do not apply to ponds warmer than 80°F when a heavy bloom of phytoplankton is present, or when the concentration of dissolved oxygen is less than 5 ppm; dilute effluent of fish treatment tanks by 10x and the contents of egg treatment tanks by 75x; egg treatments at 250 ppm for 1 hour are also effective.
Romet -30, Romet B (R05. sulfadimethoxine + ormetoprim)	Hoffman-La Roche, Inc. Nutley, New Jersey	Antibacterial against furunculosis on salmonids and against enteric septicemia on catfish — 50 mg/kg of fish per day for 5 days	0.1 ppm in salmonids and catfish	Food fish use; do not treat salmonids within 6 weeks of marketing or release as stocker fish; withdraw catfish from medication 3 days before slaughter or before release as stocker fish.
Salt (Sodium chloride)	-----	Osmoregulatory enhancer — 0.5% to 1% for indefinite period; 3% for 10-30 min	Exempted from tolerance	Food fish use; declared as GRAS by FDA.
Salfamerazine in Fish Grade (Sulfamerazine)	American Cyanamid Company Princeton, New Jersey	Antibacterial against furunculosis on salmonids — 10 g/100 lb of fish per day for 14 days in feed; discontinue use after 14 days	Zero tolerance in uncooked edible tissues of trout	Food fish use; do not treat within 3 weeks of marketing or stocking in stream open to fishing.
Terramycin for Fish (Oxytetracycline)	Pfizer, Inc. New York, New York	Antibacterial against *Aeromonas, Hemophilus, and Pseudomonas* — 2.5-3.75 g/100 lb of fish per day for 10 days in feed	0.1 ppm in salmonids and catfish	Food fish use; 20-day pre-slaughter withdrawal.

Trade names given; common names in parentheses.

HANDOUT #3

TABLE 2: Registered or Approved Anesthetics*

Product	Sponsor	Fishery Use	Tolerance	Comments
Carbonic acid	-----	Anesthetic— 200-400 ppm for 4 min	Exempted from tolerance	Food fish use; declared as GRAS by FDA as general purpose food additive.
Finquel (MS-222; tricaine methanesulfonate)	Argent Chemical Laboratories Redmond, Washington	Anesthetic— 15-66 ppm for 6-48 h for sedation; 50-330 ppm for 1-40 min for anesthesia	None required	Food fish use; 20-day withdrawal after use before harvesting fish for food.
Sodium bicarbonate (Baking soda)	-----	Anesthetic— 142-642 ppm for 5 min	Exempted from tolerance	Food fish use; declared as GRAS by FDA as general purpose food additive.

*Trade names given; common names in parentheses.

TABLE 3: Registered or Approved Disinfecting Agents*

Product	Sponsor	Fishery Use	Tolerance	Comments
Net-Dip (Didecyl dimethyl ammonium chloride) [Distributed as Sanaqua by Aquavet, Mayward, California]	General Drug and Chemical Corporation North Kansas City, Missouri	Disinfection of aquarium and fish holding equipment; 2 fl oz in 4 gal water for 10 min; disinfection in fish disease control institutions: 3.5 fl oz in 4 gal for 10 min	None established	Nonfood fish use, do not use directly on fish or other cultured aquatic life.
Olin HTH Dry Chlorinator Granula (Calcium hypochlorite)	Olin Corporation Stamford, Connecticut	Disinfectant and sanitizer — 200 ppm available chlorine for 1 h to sanitize fish tanks, raceways, and utensils. 5-10 ppm residual chlorine for 12-24 h to control algae and bacteria in fish ponds	Exempted from tolerance	Food fish use; to control algae or kill bacteria in fish ponds, remove all fish from pond before treatment.

AQ-453

HANDOUT #3

Povidone-iodine compounds (Polyvinylpyrrolidone)	-----	Disinfection of fish eggs	None required	Food fish use; exempted from registration by FDA; EPA has registered several povidone-iodine compounds as general sanitizing agents. These can be used to sanitize and disinfect aquaculture facilities; water, and eggs. Experimentally used as a viricide.
Quaternary ammonium	-----	Disinfection of water, gear, and tanks	None required	Food fish use; exempted from registration by FDA; EPA has registered several quaternary ammonium compounds as general sanitizing agents. These can be used to sanitize aquaculture facilities and water. Experimentally used to control bacterial gill disease.

*Trade names given; common names in parentheses.

TABLE 4: Registered or Approved Water Treatment Compounds*

Product	Sponsor	Fishery Use	Tolerance	Comments
Fluorescein sodium	-----	Dye to check water flows or dilution— 0.1 ppm	None required	Food fish use; exempted from registration by EPA.
Lime	-----	Pond sterilant— 1,338 lb/A of quick lime; 1,784 lb/A of slaked lime	Exempted from tolerance	Food fish use; declared as GRAS by FDA as general purpose food additive. EPA issued a Data Call-In letter in March, 1983, and it was referred to a Registration Standard.
Oxytetracycline	-----	Fish marker— Used to place fluorescent band on scales and bone	0.1 ppm in salmonids and catfish	Food fish use; FDA ruled that there is no health concern when used as directed; required withdrawal is 7 days for oral treatment, 15 days if injected.

HANDOUT #3

Potassium permanganate	-----	Oxidizer and detoxifier— 2 ppm	None required	Food fish use; exempted from registration by EPA.
Rhodamine B and WT	-----	Dye to check water flows or dilution rates—20 ppb	Exempted from tolerance	Food fish use; exempted from registration by EPA.
Tetracycline	-----	Fish marker—Used to place fluorescent band on scales and bone	None required	Food fish use; FDA ruled that there is no health concern when used as directed; required withdrawal time is 15 days is injected.

*Trade names given; common names in parentheses.

Tables 1 through 4 used with permission of University of Arkansas Cooperative Extension Service and U.S. Fish and Wildlife Service. From *A Guide to Approved Chemicals in Fish Production and Fishery Resource Management*, 1989.

AQ-455

FISH HEALTH MANAGEMENT
UNIT VIII

HANDOUT #4 — CONVERSION CHARTS FOR CALCULATING TREATMENT DOSAGES

TABLE 1: Weight of Chemical That Must Be Added to One Unit Volume of Water to Give One Part per Million (ppm)

2.72 pounds per acre-foot	= 1 p.p.m.
1,233 grams per acre-foot	= 1 p.p.m.
0.0283 gram per cubic foot	= 1 p.p.m.
0.0000624 pound per cubic foot	= 1 p.p.m.
0.0038 gram per gallon	= 1 p.p.m.
0.0584 grain per gallon	= 1 p.p.m.
1 milligram per liter	= 1 p.p.m.
0.001 gram per liter	= 1 p.p.m.
8.34 pounds per million gallons of water	= 1 p.p.m.

TABLE 2: Conversion for One Unit of Volume to Another Unit of Volume

			To		
From	Centimeter	Meter	Inch	Feet	Yard
Centimeter	1	0.01	0.3937	0.0328	0.0109
Meter	100	1	39.37	3.281	1.0936
Inch	2.540	0.054	1	0.0833	0.0278
Feet	30.48	0.3048	12	1	0.3333
Yard	91.44	0.9144	36	3	1

TABLE 3: Conversions for Units of Weight

		To			
From	Gram	Kilogram	Grain	Ounce	Pound
Gram........	1	0.001	15.43	0.0353	0.0022
Kilogram...	1000	1	1.54×10^{4}	35.27	2.205
Grain........	0.0648	6.48×10^{-5}	1	0.0023	1.43×10^{-4}
Ounce.......	28.35	0.0284	437.5	1	0.0625
Pound.......	453.6	0.4536	7000	16	1

HANDOUT #4

TABLE 4: Conversions for Units of Length

FROM	TO				
	cm	m	in.	ft.	yd.
cm	1	0.01	0.39370	.03280	.0109
m	100	1	39.373	.2811	.0936
in.	2.540	0.0254	1	0.08330	.0278
ft.	30.48	0.3048	1210	.3333	
yd.	91.44	0.9144	3631		

cm = centimeter; m = meter; in. = inches; ft. = foot; yd. = yard

TABLE 5: Conversions for Units of Weight

1 acre-foot	= 43,560 cubic feet
1 acre-foot	= 325,850 gallons
1 acre-foot of water	= 2,718,144 pounds
1 cubic foot of water	= 62.4 pounds
1 gallon of water	= 8.34 pounds
1 gallon of water	= 3,785 grams
1 liter of water	= 1,000 grams
1 fluid ounce	= 29.57 grams
1 fluid ounce	= 1.043 ounces
1 grain per gallon	17.1 milligrams/liter
1 milliliter of water	1 gram
1 cubic meter of water	1 metric ton
1 quart of water	946 grams
1 teaspoon	4.9 milliliters
1 tablespoon	14.8 milliliters
1 cup	8 ounces
1 acre-foot/day of water	226.3 gallons/minute
1 acre-inch/day of water	18.9 gallons/minute
1 acre-inch/hour of water	452.6 gallons/minute
1 second foot of water	448.8 gallons/minute
1 cubic foot/second of water	448.8 gallons/minute
1 foot of water	0.43 pounds/square inch
1 foot of water	0.88 inch of mercury (HG)
1 horsepower	550 foot-pounds/second
1 horsepower	745.7 watts
1 kilowatt	1,000 watts
1 kilowatt	1.34 horsepower
1 hectare	10,000 square meters
1 hectare	2.47 acres
1 acre	4,048 square meters

Tables 1-5 from *Handbook for Common Calculations in Finfish Aquaculture* by Gary L. Jensen. With permission.

HANDOUT #4

TABLE 6: Conversion for Parts per Million, Proportion, and Percent

Parts per million	Proportion	Percent
0.1	1:10,000,000	0.00001
0.25	1:4,000,000	0.0[illegible]25
1.0	1:1,000,000	0.0[illegible]
2.0	1:500,000	0.0002
3.0	1:333,333	0.0003
4.0	1:250,000	0.0004
5.0	1:200,000	0.0005
8.4	1:119,047	0.00084
10.0	1:100,000	0.001
15.8	1:66,667	0.0015
20.0	1:50,000	0.002
25.0	1:40,000	0.0025
50.0	1:20,000	0.005
100.0	1:10,000	0.01
150.0	1:6,667	0.015
167.0	1:6,000	0.0167
200.0	1:5,000	0.02
250.0	1:4,000	0.025
500.0	1:2,000	0.05
1667.0	1:600	0.1667
5000.0	1:200	0.5
6667.0	1:150	0.667
30000.0	1:33	3.0

From *Principal Diseases of Farm Raised Catfish*, Oct. 1985

FISH HEALTH MANAGEMENT
UNIT VIII

HANDOUT #5 — QUICK REFERENCE TO FISH DISEASE SIGNS AND PROBLEMS

Dead or dying fish — Many diseases

Open lesions or sores, bloody or reddened areas — Bacteria; bacteria secondary to parasite infections; external parasites; toxins

Gaping mouths — Low oxygen; diseased gills

Scale loss — *Myxobolus notemigoni* (milk scale disease); external parasites; fighting; predation; rough handling

Gills pale, eroded, puffy, bloody, or brown, or gill covers flared — Anemia; vitamin deficiency; gill disease; environmental stress; toxins; external parasites; *Branchiomyces* (fungus); *Flexibacter columnaris* (bacterium)

Bleached skin color — Vitamin E deficiency; low oxygen

Exophthalmia (popeye), stargazing — Bacterial dropsy; brain flukes; gas bubble disease; malnutrition; environmental contaminates

Bloated belly (dropsy) — Bacteremia; white grubs (flukes); *Ligula* (tapeworm); catfish virus (affects fingerlings)

Excess mucus (light gray film), sloughing of skin, scratches on body — External parasites; fungus; fighting; predation

Spinal curvature — Vitamin C deficiency; pesticides; genetic deformities

Folded fins or tail, pectoral fins pointed forward — Toxins; many diseases

Nodules, pustules, white pots — Myxospordian cysts (protozoans); larval trematodes (flukes); *Ichthyophthirius* or "ich" (protozoan); yellow grub (fluke); larval nematodes

Fluid in body cavity (cloudy, bloody, or clear) — Bacterial dropsy; channel catfish virus; malnutrition

Bloody internal organs — Bacteria; virus; vitamin A or B deficiency

White "fungus" patches — External fungus; *Epistylis* (protozoan)

Frayed fins or tail, eroded tail — External parasites; *Flexibacter columnaris* or other bacteria; chemical contaminants

Emaciation (thin fish, pinheads), reduced growth — Any disease that causes fish to reduce feed intake or cease feeding; underfeeding; malnutrition; intestinal worms (helminths); vitamin deficiency

HANDOUT #5

Air bubbles under skin — Gas bubble disease (excessive nitrogen or oxygen in the water)

Cloudy eyes — Eye flukes; nutritional deficiencies

Red spots near bases of fins — Larval *Lernaea* (copepod); external parasites; bacteria

Gray, chalky white, or dull opaque yellowish ovaries or eggs in golden shiners — *Pleistophora ovarian* (protozoan)

Ruptured abdomen — Toxic algae (in fry); *Ligula* (cestode); white grub (trematode)

Dirty gray or yellow lesions — Bacteria; external parasites; external fungi

Foul-smelling lesions — *Edwardsiella tarda* (bacterium)

Hole-in-the-head — *Edwardsiella ictaluri* (bacterium)

Brown blood — Nitrite toxicity

From "Parasites and Diseases of Pond Fish" by Brenda Rogers Moore, et al
in *Third Report to the Fish Farmers*, 1984.

FISH HEALTH MANAGEMENT
UNIT VIII

ASSIGNMENT SHEET #1 — SOLVE PROBLEMS RELATED TO COMMON DISEASES AND CONDITIONS OF FISH

Many different diseases produce symptoms of confusing similarity. For this reason, it is particularly important that the producer's diagnosis is confirmed as soon as possible by appropriate tests carried out in the laboratory. A prompt response allows the application of the correct treatment before it is too late.

In addition, the experienced culturist learns those factors of water chemistry, environment, and season that predispose fish to disease. Thus armed, the culturist can take preventive measures to avoid disease outbreak.

While nothing takes the place of experience and accurate laboratory diagnosis, this assignment sheet is designed to help you learn the basic behavioral and clinical signs of various diseases and conditions, their causes, contributing factors, and possible treatments

Study Handouts #1 and #2. Discuss the handouts with your classmates and instructor. When you think that you understand and have learned the information on both handouts, complete this assignment sheet, following the instructions before each section.

1. Match the following infectious and noninfectious diseases with their correct behavioral and clinical signs. Write the correct numbers in the blanks.

_____ a. First-summer catfish about 3 inches long develop swollen abdomens containing clear yellow fluid, dark red spleens, popeye, and hemorrhage at the bases of their fins; they have an erratic swim pattern.

_____ b. Some of your trout eggs develop patches or mats of a furry greyish growth.

_____ c. You have been having trouble with herons and kingfishers at your minnow farm. You have finally solved the problem by placing netting over your ponds, but now you notice that your minnows have small black nodules on their flesh and gills.

1. Chilodonelliasis
2. Monogenetic
3. Acidosis
4. Brown blood disease

ASSIGNMENT SHEET #1

_____ d. You have leased your pond for winter duck hunting, and in the spring you discover that some of the grass carp you stocked for biological weed control have what looks like slender splinters sticking from their skin.

_____ e. In spring you notice that some of your catfish are topping and that there seems to be a loss of appetite. A sample shows that some fish have shallow reddish ulcers that expose necrotic skin, red streaks in the fins, and a reddened area around the anus.

_____ f. Your fish have gathered at the pond intake, and some of them are flashing and rubbing on the sides of the pond. Examination of a sample shows tiny white spots that look like salt sprinkled on their bodies and fins.

_____ g. You have been having water quality problems since organically fertilizing a pond. A sample of fish shows some with bright red gills that bleed when you touch them.

_____ h. Recently, you stocked your pond with catfish. The spring weather is warm for a day or two and then the temperatures drop drastically for a few days. You notice that some of your catfish look biotchy, some have frayed barbels and fins, and a few have lost their tails.

_____ i. You have stocked at a very high density, and now in the fall, inspection of your stock reveals ragged gill filaments and a blue-gray film on the body surface of some of the fish; further, the fish are not eating well and seem listless and lethargic.

5. Oxygen starvation
6. CCVD
7. Larval flukes (Black spot disease)
8. Fungus infection
9. Ich
10. Anchor parasite
11. Bacteremia (Hemorrhagic Septicemia)
12. Columnaris disease
13. Enteric septicemia of catfish (ESC)
14. Tapeworm
15. Costiasis disease

ASSIGNMENT SHEET #1

_____ j. You have just experienced a fish kill. The dead fish have a milky turbidity to their skin and brownish deposits on their gills. A couple of days before the kill, you noticed that the fish seemed very active, and some were even jumping from the water.

_____ k. One morning after a week of very hot weather you wake to the fish farmer's nightmare: all of the fish in one of your ponds are floating belly up.

_____ l. Some of your channel catfish have lost their appetites and are listlessly hanging tail down in the water; others are swimming in circles. You examine the ailing fish and find that they all have a reddish raised area or an ulcer between their eyes.

16. Alkalosis

17. Trichodiniasis

18. Fish lice

19. Gas bubble disease

20. Furunculosis

2. Read the following statements, and then label them "T" (true) or "F" (false).

_____ a. Fish are most susceptible to Chilodonelliasis at water temperatures between 40°F and 70°F.

_____ b. Gas bubble disease causes fish to rustle when taken out of the water and is caused by gas supersaturation.

_____ c. Hole-in-the-head disease affects salmonids, bass, and sunfish.

_____ d. Hemorrhagic septicemia is the most common disease of baitfish.

_____ e. Channel catfish virus is successfully treated with Terryamycin.

_____ f. Fungus infections seldom infect healthy fish.

_____ g. Fish-eating birds and snails serve as intermediate hosts for fish grubs.

_____ h. Masoten, formalin, or potassium permanganate are chemicals used to control fish grubs.

_____ i. Common table salt reverses the effects of brown blood disease.

_____ j. All fishes, but especially black basses, Chinese carps, catfish, sunfish, and golden shiners are susceptible to tapeworm infestations.

_____ k. Anchor parasites can be detected only by microscopic examination of internal tissue.

ASSIGNMENT SHEET #1

_____ l. Enteric septicemia of catfish (ESC) affects only bullheads and blue catfish.

_____ m. Milk scale disease is caused by a sporozoan protozoan.

_____ n. Masoten is used to control both anchor parasites and fish lice.

_____ o. External parasites cause acute mortality.

_____ p. Medicated feeds are used in the treatment of both hemorrhagic and enteric septicemia.

_____ q. The pH of water is lowered by liming.

_____ r. Milk scale disease affects only cold water species.

_____ s. Goldfish fry are particularly susceptible to goldfish furunculosis.

_____ t. Ich is caused by the protozoan *Ichtyobodo*.

3. List two preventative measures for each of the following diseases or conditions.

   a. CCVD

      1) ____

      2) ____

   b. Bacteremia (Hemorrhagic septicemia)

      1) ____

      2) ____

   c. Enteric septicemia of catfish

      1) ____

      2) ____

   d. Chilodonelliasis

      1) ____

      2) ____

   e. Flukes

      1) ____

      2) ____

ASSIGNMENT SHEET #1

f. Grubs (Larval flukes)

1) ______________________________

2) ______________________________

g. Fungus infection

1) ______________________________

2) ______________________________

h. Trichodiniasis

1) ______________________________

2) ______________________________

i. Ich

1) ______________________________

2) ______________________________

j. Anchor parasite and fish louse

1) ______________________________

2) ______________________________

k. Oxygen starvation

1) ______________________________

2) ______________________________

l. Acidosis and alkalosis

1) ______________________________

2) ______________________________

m. Gas bubble disease

1) ______________________________

2) ______________________________

ASSIGNMENT SHEET #1

n. Brown blood disease

1) ______

2) ______

o. Infectious pancreatic necrosis (IPN)

a. ______

b. ______

p. Whirling disease (*Myxosoma cerebralis*)

a. ______

b. ______

q. Enteric redmouth (ERM)

a. ______

b. ______

r. Trichophrya

a. ______

b. ______

4. Evaluate your answers to 3, and review the prevention column in Handouts #1 and #2 if necessary. What do you find are the three most important measures a fish culturist can take to prevent disease List them below.

a. ______

b. ______

c. ______

FISH HEALTH MANAGEMENT
UNIT VIII

ASSIGNMENT SHEET #2 — CALCULATE TREATMENT RATES

All commercial aquaculturists should know how to accurately calculate treatment rates, determine the amount of chemical or drug needed, and apply the treatment. Producers can experience high economic losses when treatment rates are not properly calculated.

Before any calculation is made, the unit of measurement must be determined. The unit of measurement selected should be convenient for the specific situation. For instance, the large volume of water in ponds is usually expressed as acre-feet while the volume of a small tank may be expressed in gallons or cubic feet. Liquid units must be used for liquid treatments and weight units must be used for dry treatments. For this reason, the aquaculturist must be able to use conversion tables. In addition, a working knowledge of both the English and metric systems of measurement is essential because reports, publications, and treatment label instructions may use either one.

This assignment sheet is presented in two parts. Part I presents examples of typical calculations for practical situations. Part II provides a series of problems so that you can practice calculating treatment rates. Refer to Handout #4 for necessary conversion tables.

PART I

Most treatments can be calculated by using the basic formula

$$\text{Amount of Chemical Needed} = V \times CF \times \text{ppm Desired} \times \frac{100}{\%\ A.I.}$$

Where:

V = Volume of water in unit to be treated

CF = Conversion factor that represents the weight of the chemical that must be used to equal 1 ppm in one unit of the volume of water to be treated

ppm = The desired concentration of the chemical in the volume of water to be treated, expressed in parts per million

$\frac{100}{\%\ A.I.}$ = 100 divided by the percent of active ingredient (A.I.) contained in the chemical to be used. The percent A.I. is usually found on the label

ASSIGNMENT SHEET #2

EXAMPLE 1. How much potassium permanganate is needed to treat a pond 660 feet long by 660 feet wide by 4 feet deep with a concentration of 2 ppm? Potassium permanganate is 100% active ingredient.

1. Find the volume of water in the pond:

   $V = L \times W \times D$

   $= 660 \text{ feet} \times 660 \text{ feet} \times 4 \text{ feet}$

   $= 1{,}742{,}400 \text{ cubic feet}$

2. Convert cubic feet to acre-feet for convenience:

   $$\text{Acre-feet} = \frac{\text{Cubic Feet}}{\text{No. Cubic Feet in 1 Acre-Foot}}$$

   $$= \frac{1{,}742{,}400}{43{,}560}$$

   $$= 40$$

3. Find the conversion factor (CF) for acre-feet in Handout #4:

   CF = 2.7 pounds (the weight required to give 1 ppm in 1 acre-foot)

4. Find the amount of copper sulfate needed by substituting known numbers into the basic formula:

   $$\text{Amount of Copper Sulfate Needed} = V \times CF \times ppm \times \frac{100}{\% \text{ A.I.}}$$

   $$= 40 \times 2.7 \times 2 \times \frac{100}{100}$$

   $$= 216 \text{ pounds}$$

EXAMPLE 2: How much Masoten (80 percent active) is needed to treat a pond of 5 surface acres and an average depth of 3 feet with 0.25 ppm active ingredient?

1. Find the volume of water in the pond:

   V = No. of Surface Acres × Average Depth

   $= 5 \times 3$

   = 15 acre-feet

ASSIGNMENT SHEET #2

2. Find the conversion factor (CF) in Handout #4:

   CF = 2.7

3. Find the amount of Masoten needed by substituting known numbers into the basic formula:

$$\text{Amount of Masoten Needed} = V \times CF \times ppm \times \frac{100}{\%A.I.}$$

$$= 15 \times 2.7 \times 0.25 \times \frac{100}{80}$$

$$= 12.6 \text{ pounds}$$

EXAMPLE 3: How much formalin is needed to treat a circular tank that is 8 feet in diameter and has a water depth of 2 feet with 250 ppm? Formalin is a liquid with 100 percent active ingredient.

1. Use the formula below to find the volume of a circular tank:

   $V = \pi r^2 D$

   Where: $\pi = 3.14$

   r = radius squared

   D = diameter of tank

$$V = \pi r^2 D$$

$$= 3.14 \times (4 \text{ feet}) \times 2 \text{ feet}$$

$$= 100.5 \text{ cubic feet}$$

2. Find the conversion factor (CF) for cubic feet in Handout #4:

   CF = 0.283 grams

3. Find the weight of formalin needed by substituting known numbers in the basic formula:

$$\text{Amount of Formalin Needed} = V \times CF \times ppm \times \frac{100}{\% A.I.}$$

$$= 100.5 \times 0.0283 \times 250 \times \frac{100}{100}$$

$$= 711 \text{ grams}$$

ASSIGNMENT SHEET #2

4. Convert grams (unit of weight) to cubic centimeters (unit of volume) because formalin is a liquid; to do this divide the units of weight by 1.08, the specific gravity of formalin:

$$\text{Volume Unit} = \frac{\text{Weight Unit}}{\text{SG (Specific Gravity)}}$$

$$= \frac{711}{1.08}$$

= 658 cubic centimeters needed

5. For convenience, convert cubic centimeters to fluid ounces:

   a. Use Handout #4 to find the correct conversion factor:

      CF = 0.0338

   b. Multiply the conversion factor by the number of cubic centimeters to find the number of fluid ounces:

      Volume in Fluid Ounces = CF × cc

      = 0.0338 × 658

      = 22.2 fluid ounces

Constant Flow Treatment Calculations

Sometimes fish such as trout in raceways or tanks with a continuous flow of water through them must be treated. In such cases, the following formulas and examples can be used to make the necessary calculations. Liquid chemicals work best for constant-flow treatment, but other chemicals can be dissolved before treatment. The tank or trough should be pretreated before beginning chemical delivery from the siphon. A variety of containers can be used with an adjustable clamp on the siphon hose to control the delivery rate.

ASSIGNMENT SHEET #2

Determining the Amount of Chemical Needed

EXAMPLE. A trough has a continuous flow rate of 5 gpm and needs a 60-minute constant-flow treatment of potassium permanganate (100 percent active ingredient) at a concentration of 10 ppm. How many grams of potassium permanganate must be dispensed to maintain the desired treatment concentration?

1. Use Handout #4 to find the conversion factor (CF)

   CF = 0.0338 gm

2. Find the weight of chemical needed by substituting known numbers into the basic formula:

   $$\text{Weight of Chemical Needed} = \underset{\text{(gpm)}}{\text{Flow Rate}} \times \underset{\text{(Min)}}{\text{Treatment Time}} \times \text{ppm Desired} \times \text{CF} \times \frac{100}{\%\ \text{A.I.}}$$

   $$= 5\ \text{gpm} \times 60\ \text{min} \times 10\ \text{ppm} \times 0.338\ \text{gm} \times \frac{100}{100}$$

   $$= 11.4\ \text{grams}$$

Determining Amount of Chemical to Add to the Siphon Container

Four factors must be known before any treatment can start using a constant flow device.

1. Total flow of water through tank or raceway during period of treatment
2. Total volume of solution that the siphon device will deliver during the treatment period
3. The concentration of the chemical to be maintained during the treatment period in ppm
4. The amount of chemical delivered from the siphon

   (NOTE. This last value cannot be calculated until all of the other values are obtained from factors 1 through 4.)

   Calculating Factor 1, total flow of water

   EXAMPLE. A tank receives a flow of 4 gpm. A constant-flow treatment will last 60 minutes. How many gallons of water will flow through the tank?

ASSIGNMENT SHEET #2

a. Measure the volume of water delivered in 1 minute (4 gallons)

b. Multiply by the number of minutes in the treatment period:

Total Water Flow = gpm × Treatment Time

= 4 × 60

= 240 gallons

Calculating Factor 2, total volume of solution that the siphon device will deliver

EXAMPLE: A siphon device delivers 200 ml in 5 minutes. How many gallons will it deliver during a 60-minute treatment?

a. Measure the volume of solution delivered in 5 minutes (200 ml)

b. Multiply this value by 1/5 the number of minutes in the treatment:

$$\text{Total Vol.} = \text{Measured Vol. Delivered in 5 Min.} \times \frac{\text{Treatment Time}}{5}$$

$$= 200 \text{ ml} \times \frac{60 \text{ min.}}{5}$$

= 2,400 ml or 2.4 liters

Calculating Factor 3, concentration of chemical, is a known value

Calculating Factor 4, amount of chemical delivered from the siphon

EXAMPLE: The water flow in a tank is 10 gpm, and a siphon device will deliver 100 ml of a chemical solution in 5 minutes. The desired treatment is formalin at a rate of 167 ppm for 1 hour. How much formalin needs to be added to the siphon container?

a. Find total volume of water to treat:

Total Vol. = gpm × Treatment Period

= 10 × 60

= 600 gallons

ASSIGNMENT SHEET #2

b. Find volume of solution that siphon will deliver during treatment:

$$\text{Siphon Vol. Delivered} = 5 \text{ Minute Vol} \times \frac{\text{Treatment Period}}{5}$$

$$= 100 \times \frac{60}{5}$$

$$= 1{,}200 \text{ ml or } 1.2 \text{ liters}$$

c. The treatment concentration is 167 ppm or 1:6000

d. Find the amount of formalin that needs to be added to the siphon container by substituting known values into the basic treatment formula:

$$\text{Amount of Chemical} = V \times CF \times \text{ppm desired} \times \frac{100}{\%\ A.I.}$$

$$= 600 \times 0.0338 \times 167 \times \frac{100}{100}$$

$$= 381 \text{ grams}$$

e. Formalin is a liquid with a specific gravity of 1.08, so convert to fluid volume:

$$\text{Fluid Vol.} = \frac{381 \text{ grams}}{1.08 \text{ grams/ml}}$$

$$= 353 \text{ ml}$$

The siphon device will contain 343 ml of formalin and 847 ml of water for a total of 1,200 ml.

Calculating Amount of Copper Sulfate

Copper sulfate is used to treat external parasites. The treatment rate must be determined by knowing the total alkalinity of the water to be treated, because the toxicity of copper sulfate to fish varies depending on the alkalinity of the water. Toxicity increases as alkalinity decreases, and low alkaline waters (less than 50 ppm) have a narrow margin of safety. Also, the effectiveness of copper sulfate may be lowered when it is used in waters with alkalinities above 350 to 400 ppm because of the fast precipitation of the copper sulfate from the pond water.

ASSIGNMENT SHEET #2

Use the following formula when calculating copper sulfate treatment rates.

$$\text{ppm Copper Sulfate} = \frac{\text{ppm Total Alkalinity}}{100}$$

EXAMPLE. A pond contains 25 acre-feet of water and has a total alkalinity of 150 ppm. How many pounds of copper sulfate are needed to control a parasite problem?

1. Determine treatment rate of copper sulfate in ppm:

$$\text{ppm Copper Sulfate} = \frac{\text{ppm Total Alkalinity}}{100}$$

$$= \frac{150}{100}$$

$$= 1.5$$

2. Use the basic treatment formula to determine how many pounds are needed to treat the pond at a rate of 1.5 ppm:

$$\text{Amount of Copper Sulfate Needed} = V \times CF \times \text{ppm Desired} \times \frac{100}{\text{\% A.I.}}$$

$$= 25 \times 2.7 \times 1.5 \times \frac{100}{100}$$

$$= 101.25 \text{ pounds}$$

Calculating Amount of Salt

Salt—also known as sodium chloride—is used in fish culture to raise the level of chloride in ponds to combat high nitrite levels that cause brown blood disease.

Salt produces a source of chloride equivalent to 1 ppm when 4.5 pounds are added per acre-foot of water. To calculate the concentration of salt needed in a pond with detectable nitrite concentrations, use the formula:

$$\text{ppm Chloride} = (5 \times N) - C$$

Where: N = ppm of nitrite in pond water

C = ppm chloride in pond water

ASSIGNMENT SHEET #2

EXAMPLE: A water sample contains 4 ppm nitrite and 15 ppm chloride. How much salt is needed to treat an 8 acre pond with an average depth of 6 feet?

1. Find the concentration (ppm) needed:

   ppm Chloride $= (5 \times N) - C$

   $= (5 \times 4) - 15$

   $= 20 - 15$

   $= 5$ ppm

2. Use the basic treatment formula to determine the total amount of salt needed, but substitute 4.5 pounds for the CF because this much salt gives 1 ppm chloride per acre-foot:

   Amount Chloride Needed $= V \times CF \times \text{ppm Desired} \times \frac{100}{\%\ A.I.}$

   $= (8 \text{ acres} \times 6 \text{ feet}) \times 4.5 \times 5 \times \frac{100}{100}$

   $= 48 \times 4.5 \times 5 \times 1$

   $= 1{,}080$ pounds

PART II

Practice calculating treatment levels by solving the following problems.

1. How much Masoten (80 percent active ingredient) is needed to treat a pond that has 12 acres of water and an average depth of 5 feet with a concentration of 0.25 ppm?

2. How much liquid formalin is needed to treat with 250 ppm a circular tank 12 feet in diameter with a water depth of 5 feet?

3. How much potassium permanganate is needed to treat a holding tank 10 feet long by 2 1/2 feet wide with a water depth of 2 1/2 feet? You want a concentration of 15 ppm.

4. A pond contains 42 acre-feet of water and has a total alkalinity of 165 ppm. How many pounds of copper sulfate are needed to control an external parasite problem?

5. A trout raceway has a continuous flow of 15 gpm and needs a 90-minute constant flow treatment of potassium permanganate at a concentration of 10 ppm. How many grams of potassium permanganate must be dispensed to maintain the desired treatment concentration?

ASSIGNMENT SHEET #2

6. The water flow in a tank is 12 gpm, and a siphon device will deliver 125 ml of a chemical solution in 5 minutes. The desired treatment is formalin at the rate of 172 ppm for 1 hour. How much formalin needs to be added to the siphon container?

7. A trough receives a flow of 8 gpm. A constant flow treatment will last 90 minutes. How many gallons of water will flow through the tank?

8. A siphon device delivers 350 ml in 5 minutes. How many gallons will the device deliver during a 60-minute period?

9. A water sample of your pond shows a nitrite concentration of 4 ppm and a chloride concentration of 13 ppm. How much salt is needed to treat a 20 acre pond with an average water depth of 3 1/2 feet?

10. How much Terramycin is needed to treat 10,000 pounds of catfish with 2.5 grams active Terramycin per 100 pounds of fish for 7 days?

FISH HEALTH MANAGEMENT
UNIT VIII

ASSIGNMENT SHEET #3 — PREPARE A LIST OF LOCAL, AREA, OR STATE SPECIALISTS TO CONTACT IN THE EVENT OF A DISEASE EMERGENCY

Gather literature on fish farming from your local library, a nearby university, or an established fish farmer in your area. Compile a list of local, area, or state diagnostic laboratories and specialists in diagnosing fish diseases. List names, addresses, and telephone numbers when possible. Your Cooperative Extension Service might be a good place to start.

FISH HEALTH MANAGEMENT
UNIT VIII

ASSIGNMENT SHEET #4 — REPORT ON ACTIVITIES AND PROCEDURES OBSERVED AT A DISEASE DIAGNOSTIC LABORATORY

Your instructor will make arrangements for you to visit a disease diagnostic laboratory to observe the activities and procedures that take place there. Before your visit, make a list of questions, such as those below, that your audience might ask. Take your questions and a notebook and pencil with you so that you can record the answers to your questions and take notes on your observations. When you return, organize your notes and write a report to be presented to your class.

Suggested Questions

1. What disease is most frequently diagnosed?
2. What species of fish are most often shipped to you for diagnosis?
3. What is the turn-around time? How soon may a fish farmer expect a diagnosis after you have received a specimen?
4. What advice would you give fish farmers in regard to shipping specimens?
5. After you have diagnosed a disease, do you prescribe or recommend a treatment?
6. What diagnosis methods do you use?
7. What hygiene methods are practiced?
8. What education and degree must you have to become a diagnostician?
9. Who, besides fish farmers, sends you specimens for diagnosis?
10. What advice would you give a fish farmer regarding disease prevention?
11. What advice would you give regarding treatment?
12. How large is the facility? How many people work at the facility? What are their titles and job duties?
13. How large is the area that the facility serves?

FISH HEALTH MANAGEMENT
UNIT VIII

ASSIGNMENT SHEET #5 — COMPLETE RECORD KEEPING FORMS ON FISH HEALTH MANAGEMENT

Prevention, rather than treatment, should be the goal of every fish farmer. Most problems develop or become serious because of poor management. Experienced fish farmers *know their fish, know their water, know their chemicals, know the diseases that affect their species, and know the environmental conditions that make their fish susceptible to stress and disease.* They monitor water quality, inspect stock daily, and keep complete and accurate health management records.

Each fish culturist has individual methods for keeping records, some recording daily information on forms such as those below, and some using a computer program designed especially for health management record keeping. It is not the method that is important, it is the act of keeping records that makes the difference.

Visit an established fish farm over the period of a week. Record your health management observations on the form below or on a similar form. Keep a file on each fish investigated for disease.

WEEK OF ______________________________

Observation	Date	Time	Pond #1	Pond #2	Pond #3
DO level					
pH					
Total alkalinity					
Nitrite					
Total ammonia nitrogen					
Unionized ammonia					
Chloride					
Total hardness					
Temperature					
Behavioral and clinical signs of disease					
External parasites observed					
Feeding behavior					
Number of mortalities					

ASSIGNMENT SHEET #5

FISH INVESTIGATED FOR DISEASE

Investigation No.: ____________________ Date: ____________________

Species: ____________________ Sex __________ Age ____________________

Pond No.: ______ Alive ______ Dead ______ Has been dead for: __________

History: ____

____

____

____

Date sent to diagnostic laboratory: __________________________________

Examination: ____

Diagnosis: ____

____

____

Treatment chemical: ____

Treatment method: ____

Date treatment begun: ______________ Date treatment ended: ______________

Result: ____

Preventive measures to take in future: _______________________________

____

FISH HEALTH MANAGEMENT
UNIT VIII

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. a. 6
   b. 8
   c. 7
   d. 10
   e. 11
   f. 9
   g. 1
   h. 12
   i. 15
   j. 3
   k. 5, 4
   l. 13

2. a. T
   b. T
   c. F
   d. F
   e. F
   f. T
   g. T
   h. F
   i. T
   j. T
   k. F
   l. F
   m. T
   n. T
   o. F
   p. T
   q. F
   r. F
   s. F
   t. F

3. Answers should include any two of each of the following

   a. Maintain good quality water
   Maintain DO levels at 4 ppm and higher
   Do not overcrowd or overhandle during first summer
   Avoid use of chemical prophylactics
   Disinfect nets, tanks, and equipment when fish are handled or transported
   Purchase fry from virus free broodstock

   b. Avoid overcrowding and rough handling, especially during summer
   Maintain good water quality
   Provide well-fortified feed containing higher than recommended levels of Vitamin C

   c. Maintain good quality water
   Keep DO level above 4 ppm
   Provide good-quality feed with supplemental Vitamin C
   Avoid broodfish that have a history of the disease

   d. Maintain good quality water
   Feed adequate amounts of good quality feed, especially in early spring and late winter

   e. Maintain good water quality
   Offer adequate feeds
   Avoid overcrowding

ANSWERS TO ASSIGNMENT SHEETS

f. Eradicate snails in ponds, and remove bird roosts in area

g. Maintain good water quality
Feed nutritionally adequate feeds all year
Feeding just before winter and in early spring is especially important

h. Maintain good water quality
Keep DO at 4 ppm or above
Feed adequate amounts of nutritionally complete feed
Avoid overcrowding, especially fingerlings

i. Avoid contaminated water supply, nets, and equipment
Maintain good quality water
Offer nutritionally adequate feeds

j. Examine stock for parasite, and stock parasite-free fish

k. Aerate water
Monitor DO level and attempt to predict drops

l. Monitor pH level
Maintain pH in an optimal range for the species being cultured

m. Monitor DO levels
Maintain DO at optimum levels for species being cultured
Control algae growth, and avoid blooms, especially during periods of intense sunlight

n. Monitor and maintain good water quality
Monitor water for high temperatures and high pH which may precede high nitrite levels

o. Prevent contact between host and virus
Do not stock infected fish into lakes, reservoirs, or streams that serve as water sources for hatcheries or wild broadstock

p. Avoid importing infected fish
Maintain young in spore-free water

q. Restrict transfer of carriers
Disinfect eggs coming in
Maintain water quality

r. Maintain water quality and nutrition

4. a. Monitor and maintain good water quality
   b. Offer nutritionally adequate feeds
   c. Avoid stress

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #2

1. 50.6 pounds
2. 617 cubic centimeters or 20.8 fluid ounces
3. 26.53 grams
4. 187.11 pounds
5. 51.3 grams
6. 435.7 ml formalin + 1,064.3 ml water for a total solution of 1,500 ml
7. 720 gallons
8. 4,200 ml or 4.2 liters
9. 2,205 pounds
10. 1,750 grams

Assignment Sheets #3 - #5 — Evaluated to the satisfaction of the instructor

FISH HEALTH MANAGEMENT
UNIT VIII

JOB SHEET #1 — PREPARE AND PACKAGE A SPECIMEN FOR SHIPMENT TO A DIAGNOSTIC LABORATORY

A. Equipment and materials

1. Transport box with styrofoam liner
2. Plastic bags
3. Pure oxygen
4. Rubber bands
5. Crushed or "artificial" ice
6. Dry ice
7. Shipping labels
8. Formalin
9. Clean glass containers
10. Knife
11. Paper toweling
12. Aluminum foil

B. Procedure for shipping live fish

(NOTE. Live fish are preferred by most diagnosticians. Preferably about 10 sick or dying fish exhibiting one or more disease signs should be sent or taken to the diagnostic laboratory.)

1. Call the diagnostic laboratory to notify them of the shipment.
2. Select 5 to 10 of the smallest affected fish.
3. Place fish in a plastic bag with about 1 gallon of water from the pond in which they became sick.
4. Fill the remaining volume of the plastic bag with pure oxygen.
5. Seal the bag tightly by folding over the top, twisting, and wrapping securely with a rubber band.

JOB SHEET #1

6. Pack the bag in a sturdy box with a styrofoam liner.

   (NOTE: These lined boxes are sometimes available from pet shops and aquarium supply stores that receive shipments of tropical fish.)

7. Compensate for hot weather by placing a watertight bag of crushed ice or artificial ice beside the bagged fish—unless they are tropical varieties that cannot withstand low temperatures.

8. Use your health management records to complete a fact sheet to accompany the specimen; include the following information.

   a. Water information—source, temperature, pH, alkalinity, nitrite and ammonia content, DO concentration, condition of plankton bloom

   b. Area and depth of pond and recent management history

   c. Fish age; original source

   d. Estimated organic content of pond—Secchi disc reading and depth of detritus on bottom

   e. Previous diseases and treatments

   f. Information about possible insecticides and herbicides used in area

   g. Disease signs observed in sick or dying fish

   h. Number of fish involved, and rate and duration of die-off

9. Label the box "Biological Specimens—Perishable" and ship by fastest service available; often this is express delivery on a local bus line.

C. Procedure for preparing frozen dead specimens for shipment

1. Call diagnostic laboratory to notify them of shipment.

2. Place freshly dead or freshly killed fish in small quantity of water in watertight plastic bag.

3. Expel the air from the bag and seal tightly with a rubber band.

4. Place bag in freezer and freeze thoroughly.

5. When fish is frozen, place bag in a well-insulated, leak-proof styrofoam container with dry ice (which should keep the fish frozen for 72 hours), or artificial ice (which should keep the fish frozen for 48 hours), or regular ice (for shipments under 24 hours).

   (CAUTION: Never pack dry ice in an air-tight container. The fish must not come in contact with dry ice or its fumes, because some viruses are inactivated by carbon dioxide.)

JOB SHEET #1

6. Address container and ship to nearest diagnostic laboratory.

D. Procedure for shipping preserved fish

(NOTE. Preserved fish may be suitable for diagnosis of outbreaks of certain parasites, such as Ich, anchor parasites, or leeches. Check with the laboratory to see if preserved fish are suitable for diagnosis.)

1. Call diagnostic laboratory and notify them of the shipment.

2. Put on rubber gloves.

3. Slit the body cavity of freshly killed, small, sick fish—or remove affected areas from larger fish—and place them in a jar of 10 percent formalin.

4. Leave sample in solution for one day or more.

5. Remove sample and wrap in absorbent paper toweling soaked with formalin.

6. Place wrapped sample in a plastic bag and seal tightly with a rubber band.

7. Cushion sample well in a sturdy shipping box to prevent leakage.

8. Address container and ship to nearest diagnostic laboratory.

E. Procedure for shipping fish suspected of insecticide toxicity

(NOTE. All samples *must* be collected by the State Department of Agriculture. Because of the question of liability, the specific pesticide must be identified.)

1. Consult a diagnostic laboratory, if consultation makes you suspect insecticide toxicity, wrap the fish in aluminum foil (not in plastic) and freeze immediately.

2. Refrigerate immediately about 2 gallons of pond water in clean glass containers, using aluminum foil to line the lids.

3. Carefully pack the frozen fish and refrigerated water in a sturdy shipping box, cushioning well and surrounding with crushed ice or dry ice.

4. Address container and ship to nearest diagnostic center.

5. Call diagnostic laboratory to notify them of shipment.

FISH HEALTH MANAGEMENT
UNIT VIII

PRACTICAL TEST #1
JOB SHEET #1 — PREPARE AND PACKAGE A SPECIMEN FOR SHIPMENT TO A DIAGNOSTIC LAB

Student's Name____ Date____________

Evaluator's Name______________________________________ Attempt No._____

When you are ready to perform Job Sheet #1, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to indicate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	Yes	No
1. Notified laboratory of shipment.	☐	☐
2. Prepared live fish for shipment.	☐	☐
3. Included fact sheet for lab.	☐	☐
4. Selected fastest express service.	☐	☐
5. Prepared frozen dead specimens for shipment.	☐	☐
6. Prepared preserved fish for shipment.	☐	☐
7. Prepared fish suspected of pesticide toxicity for shipment.	☐	☐
8. Cleaned work area.	☐	☐

Evaluator's Comments ____

____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE. Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:	Good	Acceptable	Fair	Poor
Safety Observation	4	3	2	1
Fish Selection	4	3	2	1
Handling Shipping Materials	4	3	2	1
Preparation of Records	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — **Skilled** — Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program.
2 — **Limited skill** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR'S NOTE. If an average score is needed to complete a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

FISH HEALTH MANAGEMENT
UNIT VIII

TEST

NAME ____ SCORE ____________

1. Match terms associated with fish health management with their correct definitions. Write the correct numbers in the blanks.

______ a.	Producing disease	1.	Stress
______ b.	Single-cell reproductive unit capable of creating a new adult individual	2.	Pathogen
		3.	Pathogenic
______ c.	Bleeding	4.	Parasite
______ d.	Period of time that must pass after drug, chemical, or pesticide treatment before an animal can be eaten	5.	Host
		6.	Cyst
______ e.	To enclose or become enclosed in a cyst, capsule or sac	7.	Encyst
______ f.	Having short, fine hairlike growths that aid in movement, as found on many protozoans	8.	Prophylactic
		9.	Hemorrhage
______ g.	Plant or animal that lives on or in another animal, usually causing harm	10.	Pus
		11.	Ciliated
______ h.	Physical strain or weakening caused by changes in the environment that require the fish to use energy to adjust	12.	Spore
		13.	Tolerance
______ i.	Waiting for a combination of favorable circumstances	14.	Pesticide
______ j.	Capable of living under varying conditions	15.	Withdrawal time
		16.	Facultative
______ k.	Disease-causing organism	17.	Opportunistic
______ l.	Yellowish-white liquid produced in certain infections		
______ m.	Animal on or in which a parasite lives		

TEST

______ n. Residue levels of a drug or chemical that are permitted by regulatory agencies in food eaten by humans

______ o. Round, thick membrane with which some parasites are surrounded when in the resting state

______ p. Preventing or protecting against disease

______ q. Broad name for chemicals that control or kill insects, fungi, parasites, and other pests

2. Match terms associated with skin and tissue conditions with their correct definitions. Write the correct numbers in the blanks.

______ a. Fluid-filled swollen tissue condition

______ b. An abnormal tube-like passage from an abscess or hollow organ to the skin

______ c. An injury, damage, or wound

______ d. Swollen area in the body tissue where pus gathers

______ e. An open sore (other than a wound) on the skin or membrane that festers and contains pus

______ f. An abnormal pocket or sac-like structure filled with fluid or diseased matter

______ g. Condition in which tissue is dead or decayed

______ h. Small knot, knob, or lump of tissue

1. Lesion
2. Cyst
3. Ulcer
4. Fistula
5. Abscess
6. Necrosis
7. Nodule
8. Edema

3. Match with their correct definitions terms associated with severity of disease or condition. Write the correct numbers in the blanks.

______ a. Said of diseases that are caused by pathogens; catching; capable of being transmitted from one fish or animal to another

______ b. Doing little or no harm; not malignant

1. Chronic
2. Acute

TEST

______ c.	Disease lasting a long time or recurring	3.	Virulent
______ d.	Said of conditions, disorders, and abnormalities that are not caused by pathogens and cannot be transmitted from one fish or animal to another	4.	Malignant
		5.	Benign
		6.	Infectious
______ e.	Very harmful; causing or likely to cause death	7.	Noninfectious
______ f.	Extremely infectious or malignant		
______ g.	Disease of severe but short duration; not chronic		

4. Match with their correct definitions terms associated with behavior of appearance of sick fish. Write the correct numbers in the blanks.

______ a.	Listlessness; slow, weak movements	1.	Flashing
______ b.	Twisting, turning sideways, and rubbing on plants or objects when swimming	2.	Topping
		3.	Erratic swimming
______ c.	Abnormal accumulation of fluid in the cells that causes swelling, protruding scales, and bulging eyes	4.	Lethargy
		5.	Edema
______ d.	Rising to the water surface	6.	Piping
______ e.	Gasping at water surface		
______ f.	Abnormal swim patterns such as whirling or spiraling, head standing or darting wildly		

5. Discuss the role of stress in fish diseases. Answer the following questions.

   a. What three factors must occur together for an infectious disease outbreak to develop?

      1) ______________________________

      2) ______________________________

      3) ______________________________

   b. Why don't fish pathogens in ponds and natural water systems make the water unfit for fish survival?

      ____

      ____

TEST

c. When do fish become stressed?

____

d. How does stress make fish prone to disease?

____

e. What is the key to disease control?

____

6. List five common stressor of fish.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

7. Select from the following list signs of stress and disease. Write an "X" in the blank before each correct answer.

Behavioral signs

______ a. Lethargy and loss of appetite

______ b. Upright fins

______ c. Frantic, erratic swimming

______ d. Sluggish swimming

______ e. Long periods of bottom feeding

______ f. Flashing, scratching, and rubbing against objects

______ g. Loss of parasites

______ h. Loss of ability to adjust buoyancy—floating/sinking behavior

______ i. Bottoming

______ j. Piping

______ k. Crowding the inflow area

TEST

Clinical signs

______ a. Mortality

______ b. Plump-bellied profile

______ c. Blood in fins; ragged fins

______ d. Lesions on body

______ e. Spinal uniformity

______ f. Visible parasites

______ g. Splotches, spots, discoloration, scale loss

______ h. Milky turbidity of water

______ i. Edema

______ j. Popeye

______ k. Hemorrhage (bloody appearance of the skin)

8. Select factual statements about pathogenic viruses. Write the correct numbers in the blanks.

______ a. Which of the following statements about virus pathogens is correct?

1) Virus pathogens are capable of multiplying only in necrotic cells.
2) Virus pathogens are ultra microscopic or submicroscopic
3) Virus pathogens are regarded as both vegetable organisms and complex vitamins.

______ b. Why are viral diseases marked by high mortality?

1) They are generally chronic
2) They are generally malignant
3) They are generally acute

______ c. Since there is no effective treatment for viral diseases, what is the only effective control?

1) Prevention
2) Isolation
3) Sterilization

TEST

______ d. Which of the following should be done any time a viral disease is suspected?

1) Samples should be checked at a laboratory capable of doing virological work.
2) The farmer should examine a representative sample under the microscope.
3) The pond should be completely drained, treated with a viricide, and the sick fish disposed of.

9. Select factual statements about pathogenic bacteria. Write the correct numbers in the blanks.

______ a. Which of the following statements about bacteria is true?

1) Bacteria are multi-celled microorganisms that can be malignant or beneficial.
2) Bacteria are single-celled microorganisms that are ultra-microscopic or sub-microscopic.
3) Bacteria are one-celled microorganisms that can be pathogenic or benign.

______ b. Which of the following describes the severity of diseases caused by bacteria?

1) Chronic
2) Acute
3) Virulent

______ c. Why are bacterial diseases often associated with environmental stressors?

1) Bacteria pathogens are usually facultative.
2) Bacteria pathogens are generally opportunistic.
3) Bacteria pathogens are generally saprophytic.

______ d. Why is it unwise to use antibiotics as prophylactic treatment of bacterial diseases?

1) Some species can become mutants when exposed to long periods of treatment.
2) Some species can develop resistance to the antibiotic.
3) Some species are opportunistic and can multiply in the presence of the antibiotic.

______ e. Which of the following is the best method of preventing bacterial disease?

1) Minimizing stress
2) Using antibiotics
3) Adding steroids to feed

TEST

10. Complete statements about common pathogenic fungi. Write the correct words in the blanks.

    a. Fungi are plants without ____________________ that grow on organic matter as a mass of threads.

    b. The fungi that cause diseases are always present in water and are ____________________, living on dead or decaying organic matter or on living tissue.

    c. Generally fungi are ____________________ invaders to other diseases, injury due to handling, temperature shock, or the presence of dead eggs or tissues.

    d. When a fish is injured or diseased, waterborne fungi ____________________ attach to dead or injured tissue and establish a colony.

    e. Once the fungi are established, they spread to healthy tissue and if untreated, eventually cause ____________________.

11. Complete statements about common pathogenic protozoan parasites. Write the correct words in the blanks.

    a. Protozoan parasites are microscopic ____________________ animals that live in water.

    b. Most protozoan parasites require a ____________________ host.

    c. Some protozoan parasites are ____________________, becoming a problem only when poor water quality, low oxygen, or poor nutrition stress fish.

    d. Nearly all losses of fish due to parasites are caused by ____________________.

    e. Some protozoan parasites are called ____________________; these parasites encyst in the skin, organs, or ovaries where they multiply and rupture, releasing hundreds of infectious ____________________.

TEST

12. Complete statements about common pathogenic crustacean parasites. Write the correct numbers in the blanks.

    ______ a. Crustacean parasites are small parasites related to ___; they have a hard outer shell and jointed appendages.

    1) bacteria
    2) amphibians
    3) insects

    ______ b. Two main crustacean parasites that infect commercially cultured fish are the ___ and the ___.

    1) anchor parasite; fish louse
    2) Ich parasite; fish leech
    3) cestode parasite; larval fluke

    ______ c. These parasites attach themselves to or burrow into the skin or ___, and can be seen with the naked eye.

    1) gills
    2) organs
    3) lymph nodes

    ______ d. Crustacean parasites injure the skin and may transmit ___ from one fish to another, but do not generally cause death unless in large numbers.

    1) stress
    2) disease
    3) malignancy

    ______ e. Movement of ___ from pond to pond can spread the parasite.

    1) water
    2) wildlife
    3) vegetation

13 Select factual statements about common pathogenic worm parasites. Write the correct numbers in the blanks.

    ______ a. How do fish serve as hosts for a number of parasitic worms?

    1) They may be primary, secondary, and sometimes final hosts.
    2) They serve as primary hosts.
    3) They serve as secondary and sometimes final hosts.

    ______ b. What is the main parasitic worm belonging to the trematode class?

    1) Leech
    2) Fluke
    3) Tapeworm

TEST

______ c. What is the main parasitic worm parasite belonging to the nematode class?

1) Grubs
2) Roundworms
3) Tapeworms

______ d. To what class does the tapeworm belong?

1) Trematode
2) Nematode
3) Cestode

______ e. How do leeches infest fish?

1) They attach themselves with a special organ surrounded with hooklets.
2) They enter the intestine via an intermediate host.
3) They attach themselves externally, take a blood meal, and leave the fish for varying periods of time.

______ f. Which of the following describes the life cycle of the tapeworm?

1) Ciliated adult parasite becomes encysted in the pond bottom, eggs hatch and become free-swimming in juvenile stage, juveniles attach themselves to the fish.
2) Eggs hatch in the water and larval worms enter snails, larval stage emerges from snail and swims to fish, where it encysts, adult bird eats fish, bird excretes eggs into water.
3) Eggs hatch in the water and larva invades copepod; copepod is eaten by fish, larva develops into an adult in fish's digestive system, and eggs are excreted by fish.

14. Select factual statements about general management measures for preventing disease outbreaks. Write an "X" in the blank before each correct statement.

______ a. If possible use high-quality surface water that is free of wild fish and contains no harmful contaminants.

______ b. Monitor and maintain water quality.

______ c. Do not obtain stock from a supplier.

______ d. Treat fish for internal parasites before stocking.

______ e. Acclimate fish before transporting or stocking.

______ f. Avoid overcrowding fish at any time and especially during hot weather.

______ g. Inspect your stock monthly; learn to look for signs of stress or disease.

______ h. Know your water, your fish, and the diseases that affect your species.

TEST

______ i. Feed a nutritionally balanced ration specifically formulated for the species being cultured; adjust amounts as needed, and feed at regular intervals.

______ j. Avoid anything that causes unnecessary stress to the fish.

15. Select factual statements about basic hygiene for disease prevention and corrective management. Write the correct numbers in the blanks.

______ a. Which of the following measures must be taken to prevent the introduction of wild fishes and most parasites?

1) Disinfect water or install Saran sock or sand-gravel filters
2) Sterilize water or install baffle levees
3) Use piscicide or screen filter

______ b. Which of the following measures should be taken to prevent fish from becoming infected before they are stocked, and to prevent disease spread from pond to pond?

1) Treat the fish prophylactically with oxytetracycline.
2) Disinfect or sterilize nets, buckets, holding and transporting tanks.
3) Install ultra-violet or sand-gravel filters.

______ c. Which of the following is the method used to kill residual organisms, spores, and unharvested fish that may be a reservoir of disease?

1) Disinfecting water and installing ultra-violet filters.
2) Lowering oxygen level and treating with potassium permanganate.
3) Draining and disinfecting ponds before stocking.

16. Match treatment methods with their administration specifics. Write the correct numbers in the blanks.

______ a. Medication is added to feed and fed to fish; medication is placed in a gelatin capsule and inserted into the fish's stomach with a balling gun

______ b. Chemical is added directly to rearing or holding unit, left a specified period of time, and then flushed from unit

______ c. Fish is dipped into a concentrated chemical for 15 to 45 seconds

______ d. Medication is placed into body cavity or muscle tissue with a syringe and needle

1. Dip
2. Flush
3. Short-term bath
4. Indefinite bath
5. Oral
6. Injection

TEST

______ e. Chemical is added to systems such as raceways, tanks, egg incubators, and allowed to flush through the unit within a predetermined period of time

______ f. Low concentration of chemical is applied to pond or hauling tank and allowed to dissipate naturally

17. Complete a list of general guidelines for treatment of fish diseases. Write the specific guidelines suggested by the following key words or phrases.

    a. What to do when you suspect a disease or harmful noninfectious condition.

    ____

    ____

    b. Obtaining an accurate diagnosis: ______________________________

    ____

    c. Deciding to treat after you have obtained an accurate diagnosis: ________

    ____

    d. Pond volume: ______________________________

    ____

    e. Water quality factors: ______________________________

    ____

    f Records: ______________________________

    g. Planning ahead: ______________________________

    ____

    h. Label instructions and cautions: ______________________________

    ____

    i Dosages: ______________________________

    ____

    j. Mixing solutions: ______________________________

    ____

TEST

k. Using chemical that has not been used before: ______________________

____

18. Select factual statements about regulations for chemical application ... fish production. Write the correct numbers in the blanks.

_____ a. What agency has been charged by Congress with the control of the use of pesticides?

1) The U.S. Food and Drug Administration
2) The U.S. Soil Conservation Service
3) The Environmental Protection Agency

_____ b. What agency has been charged with the control of the use of drugs?

1) The World Health Organization
2) U.S. Food and Drug Administration
3) U.S. Environmental Protection Agency

_____ c. Which of the following can be held legally accountable for misusing a chemical?

1) Producers, handlers, applicators
2) Retailers and wholesalers
3) Both 1 and 2

_____ d. Which of the following application rates are legal?

1) Those no more than half again the listed application rate.
2) Those no less than half the listed application rate.
3) Only those at the application rates listed.

_____ e. Which of the following are the two categories used by the FDA in determining chemical use patterns?

1) Food fish and non-food fish
2) Domestic fish and wild fish
3) Exotic fish and domestic fish

_____ f. Which of the following would require a permit from the FDA?

1) Treatment of infectious disease
2) Production of medicated feed
3) Transportation of infectious fish

_____ g. Which of the following would require a permit?

1) Discharge of water from fish culture facility
2) Steroid injection of brood fish
3) Whole-pond treatment with any treatment chemical

TEST

______ h. Which of the following enforces regulations that govern the use of drugs and chemicals in fish culture?

1) EPA and FDA
2) AVA and local police
3) AMA and local veterinary associations

(NOTE. Test questions 19 through 24 list the assignment and job sheets. They are an important part of this test. If they have not been completed, check with your instructor for scheduling and evaluation dates and procedures.)

19. Solve problems related to common diseases and conditions of fish. (Assignment Sheet #1)

20. Calculate treatment rates. (Assignment Sheet #2)

21. Prepare a list of local, area, or state specialists to contact in the event of a disease emergency. (Assignment Sheet #3)

22. Report on the activities and procedures observed at a disease diagnostic laboratory (Assignment Sheet #4)

23. Complete record-keeping forms on fish health management practices. (Assignment Sheet #5)

24. Demonstrate the ability to prepare and package a specimen for shipment to a diagnostic laboratory. (Job Sheet #1)

FISH HEALTH MANAGEMENT
UNIT VIII

ANSWERS TO TEST

1. a. 3
   b. 12
   c. 9
   d. 15
   e. 7
   f. 11
   g. 4
   h. 1
   i. 17
   j. 16
   k. 2
   l. 10
   m. 5
   n. 13
   o. 6
   p. 8
   q. 14

2. a. 8
   b. 4
   c. 1
   d. 5
   e. 3
   f. 2
   g. 6
   h. 7

3. a. 6
   b. 5
   c. 1
   d. 7
   e. 4
   f. 3
   g. 2

4. a. 4
   b. 1
   c. 5
   d. 2
   e. 6
   f. 3

5. a. 1) Presence of a pathogen
      2) Susceptible fish
      3) Predisposing (stressful) condition
   b. They cause problems only when fish are weakened or made susceptible by predisposing environmental factors (stressors)
   c. When they are unable to adjust to environmental stressors
   d. Reduces resistance to infection
   e. Reducing stress factors through good management

ANSWERS TO TEST

6. Answer should include any five of the following:
   a. Low DO levels
   b. Sudden changes in water temperature
   c. Poor nutrition caused by inadequate diet
   d. Water chemistry imbalances
   e. External parasites
   f. Handling during stocking grading, sampling or harvesting
   g. Crowding
   h. Sublethal levels of water pollutants such as pesticides
   i. Injuries

7. Behavioral signs — a, c, d, f, h, j, k
   Clinical signs — c, d, f, g, i, j, k

8. a. 2
   b. 3
   c. 1
   d. 1

9. a. 3
   b. 1
   c. 2
   d. 2
   e. 1

10. a. Chlorophyll
    b. Facultative
    c. Secondary
    d. Spores
    e. Death

11. a. Single-celled
    b. Fish
    c. Facultative
    d. Protozoans
    e. Sporozoa; spores

12. a. 3
    b. 1
    c. 1
    d. 2
    e. 2

ANSWERS TO TEST

13. a. 1 d. 3
    b. 2 e. 1
    c. 2 f. 3

14. b, e, f, h, i, j

15. a. 1
    b. 2
    c. 3

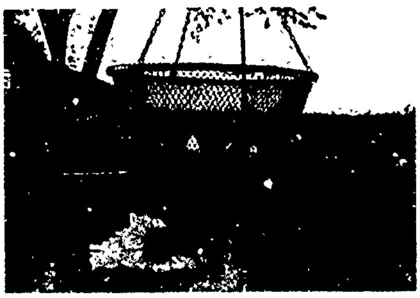
16. a. 5
    b. 3
    c. 1
    d. 6
    e. 2
    f. 4

17. a. Act promptly; first contact your nearest disease diagnostic laboratory, and then send a live specimen and water sample.
    b. The use of the wrong treatment can result in more losses than would occur with no treatment at all.
    c. Ask yourself whether treatment is the best course of action.
    d. Know pond volume before treatment is needed.
    e. Know which factors increase or decrease the toxicity of the chemical.
    f. Keep up-to-date, accurate records.
    g. Have available the phone number of your county agent and basic medicines and chemicals for emergency treatment.
    h. Read carefully and follow all directions concerning application and prohibited uses.
    i. Mix well so that fish are not harmed by concentrated solution.
    j. Test chemical on a small number of fish in a container before treating whole rearing unit.

18. a. 3 e. 1
    b. 2 f. 2
    c. 3 g. 1
    d. 3 h. 1

19-23. Evaluated to the satisfaction of the instructor

24. Evaluated according to criteria in Practical Test #1



COMMERCIAL CATFISH PRODUCTION UNIT IX

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss the principles of commercial catfish production, prepare stocking and feeding schedules, calculate feed conversion ratios and cost of gain, make an anticipated loss projection, and accurately keep records for a commercial catfish enterprise. These competencies will be evidenced by correctly completing the procedures outlined in assignment and job sheets, and by scoring a minimum of 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to commercial catfish production with their definitions.
2. Complete statements about the advantages of raising catfish.
3. Complete statements about the limitations of raising catfish.
4. Arrange in order the phases of fingerling production.
5. Complete guidelines for stocking broodfish.
6. Complete statements about managing broodfish in pens.
7. Select from a list factual statements about managing broodfish in open ponds.
8. Select from a list factual statements about egg, fry, and fingerling management.
9. Complete statements about fry stocking rates for fingerling grow-out.
10. List guidelines for obtaining fingerlings for food-fish production.
11. Provide data about size options for stocking fingerlings for food-fish production.
12. Provide data about food-fish stocking rates.
13. Distinguish among types of commercial catfish feeds.
14. Complete statements about size and quality of catfish feed.

OBJECTIVE SHEET

15. Select from a list guidelines for feeding food fish.
16. Select from a list true statements about producing catfish in cages.
17. List advantages of cage culture.
18. List limitations of cage culture.
19. Discuss tank and raceway culture of channel catfish.
20. Keep daily, weekly, and monthly production records. (Assignment Sheet #1)
21. Calculate stocking rates. (Assignment Sheet #2)
22. Calculate FCR and estimate fish weights from feed records. (Assignment Sheet #3)
23. Calculate feed requirements and costs. (Assignment Sheet #4)
24. Demonstrate the ability to perform pond sampling to estimate average fish weights and standing crop weight. (Job Sheet #1)

COMMERCIAL CATFISH PRODUCTION
UNIT IX

SUGGESTED ACTIVITIES

A. Make transparency.

B. Obtain and duplicate a month's records for a catfish enterprise so that students may complete Assignment Sheet #1.

C. Duplicate handout so that students may complete Assignment Sheets #2 — #4.

D. Provide students with objective sheet. Discuss unit and specific objectives.

E. Provide students with information sheet. Discuss information sheet, providing many examples and illustrations. Personalize and localize material to meet the needs of your students.

F. Provide students with assignment sheets. Discuss and schedule assignment sheets, critique in class.

G. Schedule and demonstrate job sheet. Evaluate job sheet performance with Practical Test #1.

H. Give written test.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Belusz, Larry. *Fish Farming Techniques.* Columbia, Missouri: The Instructional Materials Laboratory, University of Missouri, 1987.

B. Boyd, Claude E., et al. *Water Quality in Channel Catfish Ponds (A Report from the Water Quality Subcommittee of Regional Research Project S-168).* Mississippi State Agricultural and Forestry Experiment Station, 1981.

C. Carroll, Cecil. *Cage Fish Farming Handbook.* El Reno, Oklahoma: Carroll's Fish Farm, 1987.

D. *Catfish Aquaculture: A Decision-Making Guidebook.* Baton Rouge, Louisiana: Louisiana Cooperative Extension Service, Louisiana State University Agricultural Center, 1987.

E. Dupree, Harry K., and Jay V. Huner, eds. *Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington, D.C.: U.S. Fish and Wildlife Service, 1984.

SUGGESTED ACTIVITIES

F. Jensen, Gary L. *Commercial Production of Farm-Raised Catfish.* Baton Rouge, Louisiana: Louisiana Cooperative Extension Service, Louisiana State University Agricultural Center, 1987.

G. Jensen, Gary L. *Handbook for Common Calculations in Finfish Aquaculture.* Baton Rouge, Louisiana: Louisiana Cooperative Extension Service, Louisiana State University Agricultural Center, 1987.

H. Reigh, Robert C., ed. *Proceedings of the Louisiana Aquaculture Conference, 1988.* Baton Rouge, Louisiana: Louisiana Cooperative Extension Service, Louisiana State University Agricultural Center, 1988.

I. Wellborn, Thomas L. Jr. *Catfish Farmer's Handbook.* Mississippi State University/Mississippi Cooperative Extension Service, 1987.

COMMERCIAL CATFISH PRODUCTION
UNIT IX

INFORMATION SHEET

I. Terms and definitions

A. **Premix** — Feed additive that contains vitamins and minerals

B. **Extruded** — Pushed through a die to give a certain shape; method of producing floating fish food

C. **Clean cropping** — Harvesting all fish at one time

D. **Topping** — Harvesting only those fish that have grown to marketable size

E. **Feed conversion ratio (FCR)** — The average number of pounds of feed eaten by the fish to gain 1 pound of weight

EXAMPLE: An FCR of 1.5 means that the fish consumes 1.5 pounds of feed to gain 1 pound in weight.

F. **Broadcast** — To scatter feed over a wide area

G. **Genital papilla** — Small nipplelike projection of tissue on male catfish

H. **Standing crop weight** — Total weight of all fish in a pond

I. **Incubation** — Process by which eggs are placed in a favorable environment for hatching

J. **Intensive production** — Raising of fish in densities higher than could be supported in the natural environment; requires feeding of formulated feeds

K. **Extensive production** — Raising of fish in low densities in ponds where the fish feed primarily on natural feeds

L. **Acclimated** — Gradually introduced to changes in water temperature and quality

M. **Off-flavor** — Musty or muddy tasting fish flesh

II. Advantages of raising catfish

A. Farm-raised channel catfish is the freshwater aquaculture crop of greatest economic importance in the United States today.

B. As traditional agriculture crops become less profitable, more farmers are turning to farming catfish as a second or third crop in their farm management programs.

C. Because of a national trend toward increased seafood (and catfish) consumption, catfish farming is presently experiencing rapid growth.

INFORMATION SHEET

D. The number of processors and markets is expanding (particularly in the southeast), and contracts with national fast-food restaurants have introduced catfish to nontraditional U.S. and international markets.

E There is more research and development for farm-raised channel catfish than for any other warmwater species, so start-up farmers have some sound scientific data and tested procedures on which to base their production methods.

III. Limitations of raising catfish

A. Catfish farming requires high risk and intensive management to handle water quality, disease, and off-flavor problems.

(NOTE: Row crop farmers must learn water and pond management techniques that are completely different from their background and farming practices. Crops can be lost overnight, and often, round-the-clock monitoring and management are necessary.)

B. If existing ponds are not suitable for the desired enterprise, start-up requires major alteration of land to build ponds and levees; returning the land to its original state is complex and costly.

C. Start-up can require a substantial financial commitment.

(NOTE: Investment costs can reach $4000 to $5000 per acre to purchase land, develop ponds, acquire needed equipment, and grow a crop of fish.)

D. Presently there is limited availability of loan capital for facility construction and crop production.

E. Feed costs and market prices fluctuate more for catfish production than for certain more established species such as trout.

F. The unavailability of processing plants and markets may prohibit start-up or limit productic .

G. Cash flow is delayed until crop is marketed.

IV. Phases of fingerling production

POINT OF INTEREST: Fingerling production requires more technical skill and management than producing food fish from fingerlings. Fingerling producers must manage the reproductive behavior of their brood stock, incubate and hatch eggs, and rear fry. The main goal of the fingerling producer is to produce a given number of fingerlings of a desired size in a certain length of time.

A. Stocking and pairing broodfish

B. Managing spawning

INFORMATION SHEET

C. Managing incubation and hatching

D. Managing sac-fry

E. Maintaining and feeding swim-up fry

F. Stocking fingerling grow-out ponds and feeding fry until they reach desired fingerling size

V. **Guidelines for stocking broodfish**

A. For maximum spawning rates, stock domestic broodfish that are at least 3 to 4 years old.

B. Determine the sex of the broodfish so that they can be stocked in equal numbers or in other common female-to-male ratios such as 2:1 or 3:2.

C. Select female broodfish with good sex characteristics: full, well-rounded abdomen, soft movable ovaries when felt through the abdominal wall, and pink genitals. (Figure 1)

D. Select male broodfish with heavily muscled head wider than the body, dark color under the jaw, and large, protruding genital papilla. (Figure 1)

EXAMPLE: FIGURE 1

Male Female

From *Third Report to the Fish Farmers.* With permission.

INFORMATION SHEET

E. Stock broodfish so that their total weight is not over 1,200 pounds per surface acre of water.

(NOTE: Most broodfish ponds are from 1 to 5 acres.)

VI. Managing spawning broodfish in pens

A. Broodfish may be spawned in pens roughly 10 feet long by 5 feet wide placed in 2 or 3 feet of water near the shore; the sides of the pen are embedded in the pond bottom and should extend at least 12 inches above the water.

(NOTE: This method is used most often in selective breeding for specific genetic traits.)

B. A spawning container is placed in the pen, generally with its open end toward the center of the pond.

EXAMPLES: Milk can, weighted 5-gallon bucket, ammunition can, wooden box, crock

C. Special care must be taken to select spawning pairs of about equal size. In the confines of the pen, the male can injure and even kill the female.

D. Spawning activity usually begins when the nightly water temperature stabilizes above 70°F; the female releases batches of eggs over a period of time and the male releases milt to fertilize them.

E. The eggs fall to the bottom of the spawning container in a mound held together with a sticky adhesive material.

(NOTE: This procedure is repeated several times until the spawning is completed—in as short a period as an hour or as long a period as 20 hours.)

F. Spawning containers are checked every 2 to 4 days, preferably in the late morning.

G. After the parent fish spawn, the eggs may be moved to the hatchery and the brooding pair removed and replaced in the pen with a new pair of broodfish, or the female may be removed and the male then left to hatch the eggs.

VII. Managing spawning broodfish in open ponds

A. Open pond spawning is less demanding than pen spawning because the farmer does not need to critically select, sex, or pair the broodstock.

B. Two or three spawning containers for each four pairs of fish are placed in the pond—generally no deeper than arm's length—their open ends usually toward the center of the pond.

INFORMATION SHEET

C. The location of each container is marked with a float or stake, and the containers are checked every 2 to 4 days, preferably in the late morning.

(NOTE: Caution should be used when checking spawning containers because adult male channel catfish guard the eggs and can bite. The producer should first probe gently with a plastic pipe, and then slowly raise the container to the surface and tilt out some of the water to inspect the bottom for eggs or fry.)

D. Eggs can be left to be incubated by the male in the pond, but it is to the producer's advantage to transfer the eggs to an incubation trough in a hatchery.

(NOTE. Transferral of the eggs has several advantages: it prevents or reduces the spread of diseases and parasites from adults to young, prevents the broodfish from eating or dislodging the eggs, and may increase the percentage of eggs hatched.)

E. If eggs are hatched in the pond, the fry may be

1. Transferred to specially prepared fry culture ponds after being emptied into a floating tub and their numbers estimated by volume; or

2. Left in the pond and the broodfish removed.

(NOTE: Periodic seining with a small-mesh seine provides a rough estimate of fry numbers and rate of growth.)

VIII. Egg, fry, and fingerling management (Transparency 1)

A. Eggs

1. Egg masses are generally transferred to hatching troughs or incubators inside the hatchery.

2. Paddles rock the egg masses and cause oxygen-rich water to flow through them in imitation of the male catfish's fanning action.

3. With a trough water flow of about 5 gallons per minute and a minimum maintained water temperature of 78°F, hatching takes place in 7 or 8 days.

B. Yolk-sac fry

1. Sac fry that hatch from the eggs are usually kept in the hatching trough.

2. Sac fry require no feed because they get their nutrition from the yolk sac.

3. When the yolk sac is absorbed 3 to 5 days after hatching, the fry swim to the surface for food.

4. Swim-up fry are transferred to rearing troughs or earthen fry ponds.

INFORMATION SHEET

C. Swim-up fry

1. Swim-up fry reared in a trough are fed a high-protein meal (45% to 50% crude protein) every 2 to 4 hours around the clock.

2. Pond-reared swim-up fry feed on plankton, particularly zooplankton, and are also fed 10 to 25 pounds of "starter" meal or pellets per acre two or three times a day.

D. Fingerlings

1. After 6 to 10 days, swim-up fry are stocked in fingerling rearing ponds.

2. Generally fingerlings are stocked to grow to fish-food-stocking sizes within 120 to 150 days.

3. Fingerlings are fed one or two times a day at a rate based on a percentage of the standing crop weight. (Assignment Sheet #4)

IX. Fry stocking rates for fingerling grow-out

A. Fry are stocked by number per surface acre.

B. The stocking rate depends on desired size at harvest and limit on maximum feeding rate.

C. The more intense the stocking rate, the smaller the catfish at harvest. (Table 1)

EXAMPLE:

TABLE 1: Stocking Guide for Channel Catfish Fingerlings at Different Densities over a 120- 150-Day Growing Season

Number of Fry Stocked per Acre	Length at Harvest (Inches)
10,000	7-10
30,000	6-8
53,000	5-7
73,000	4-6
95,000	3-5
120,000	3-5
140,000	3-4
200,000	2-3
300,000	1-2
500,000	1

From *Commercial Production of Farm-Raised Catfish* by Gary L. Jensen. With permission.

INFORMATION SHEET

X. Guidelines for obtaining fingerlings for food-fish production

A. Purchase fingerlings from a reliable dealer with a reputation for providing healthy stock.

(NOTE: Buying healthy stock is the first step in ensuring the success of your catfish enterprise.)

B. Do not accept fish that have frayed fins, are obviously skinned up, or that have red blotches or white spots resembling salt on their skin.

C. Try to be present to verify sizes, weights, and counts when fish are loaded on the transport truck.

D. Follow the transport truck to the farm, and supervise to make sure that the correct number of fingerlings are stocked in each pond, and that the fish are well-acclimated to the pond water.

E. Obtain an agreement from the fingerling supplier that specifies liability or fish replacement policy in case of fish losses during or shortly after stocking.

XI. Size options for stocking fingerlings for food-fish production

A. Clean-crop fall harvesting of food-sized catfish requires the spring purchase of 5- to 6-inch fingerlings in the southern states, 6- to 8-inch fingerlings in the more northern states, and 8- to 10-inch fingerlings in Iowa and states further north.

B. Partial harvesting, or topping off, requires the purchase of fingerlings of mixed sizes (4 to 8 inches) and the restocking of one 5-inch fingerling for each pound of fish harvested.

(NOTE: Stocking ponds with different sizes of fish at different times reduces competition between large and small fish, allows the producer to harvest fish more often during the year, and provides the needed continuous supply of fish to the processors.)

C. To shorten the grow-out period or to culture larger sport fish or fish suitable for steaks and filets, stocker fish weighing ½ pound or more should be stocked in the spring.

(NOTE: The size of the fingerlings stocked is important. Research has shown that large fingerlings can gain more weight in a time period than smaller fish. In the south at temperatures between 75°F and 85°F, as a rule, 6 to 8-inch fingerlings grow to 1 pound in 20 to 21 weeks; 8 to 10 inch fingerlings grow to 1 pound in 15 weeks; and 10 to 12 inch stockers grow to 1 pound in 9 weeks.)

INFORMATION SHEET

XII. Food-fish stocking rates (Assignment Sheet #2)

(NOTE: The number of fish stocked depends on many variables. market demand, production method, feeding, aeration, experience, and management skill are some of the more important. The following are general guidelines only. Assignment Sheet #2 provides accurate mathematical methods for estimating stocking rates.)

A. New producers should consider not stocking more than 3,000 to 4,000 fish per surface acre of water if the desired market size is 1¼ pounds or more.

(NOTE: This level of stocking allows the first-time producer to gain experience in management procedures while reducing potential problems.)

B. Stocking rates for extensive production vary from 500 to 2,000 catfish fingerlings per surface acre of water.

C. Stocking rates for intensive commercial ponds vary from 2,500 to 6,000 or more catfish fingerlings per surface acre of water.

XIII. Types of commercial catfish feed

A. Extruded floating feed

1. Manufactured to float on the water surface, this type of feed is preferred by most producers because stock can be observed and monitored while eating.

2. This type of feed is generally more water stable than sinking feeds and does not get lost in the vegetation or bottom mud.

B. Pelleted sinking feed

1. This feed is slow-sinking and can be purchased in an 80/20 ratio where 80 percent sinks and 20 percent floats.

2. Sinking feed requires more management than others because pellets quickly fall apart in the water and can be lost in the bottom mud, adding to organic debris.

3. The greatest advantage of sinking feed is its lower price.

4. Sinking feed is generally the preferred type of feed for winter feeding.

C. Medicated feed containing an antibiotic may be of the floating or sinking type, floating medicated feed is coated on the surface; medicine is added to the ingredients of sinking medicated feed.

INFORMATION SHEET

XIV. Size and quality of catfish feed

A. Feeds are available in 50-pound bags or can be delivered in 20 to 22-ton bulk loads.

B. Feeds are manufactured in a variety of sizes from meal crumble to large pellets; it is important to match the feed size to the fish size. (Figure 2)

EXAMPLE: FIGURE 2

C. Mixed feed sizes are used in ponds containing mixed sizes of fish.

D. The highest quality feed is nutritionally complete: it contains vitamin and mineral premixes, and its protein content is between 32 and 35 percent.

E. Supplemental feeds may be of high quality but they do not contain all the essential ingredients or adequate levels to be nutritionally complete.

XV. Guidelines for feeding food fish

A. Calculate basic feed allowances against average expected gains or use a feeding chart. (Assignment Sheet #4)

B. As a rule of thumb, do not feed more than can be eaten in 10 to 20 minutes.

(NOTE: Catfish grow fastest when fed all they can eat. Over-feeding means wasted food, but more importantly, uneaten food sinks to the bottom and can create water quality problems.)

C. "Feed the fish and not the pond" by adjusting the daily feed allowance as fish gain weight and temperatures change.

EXAMPLE: Do not feed fish a standard conversion rate such as 3% during the entire growing season. Larger fish cannot consume 3%, and temperature influences appetite.

INFORMATION SHEET

D. Feed over-wintered catfish sinking-pellet feed to prevent weight loss and to maintain health.

E. Do not feed when temperatures are 50°F or less 2 feet below the water surface.

F. Feed by broadcasting the feed by hand from the bank or a boat in small ponds, or by mechanical feed blowers in large ponds.

G. Distribute the feed from the length of at least two banks in each pond, and over a larger area if the pond contains fish of different sizes.

H. Feed fish once or twice a day between 9 A.M. and 5 P.M. or when levels of DO are high; avoid feeding close to or after sunset when DO levels drop.

(NOTE: Fish may feed poorly during a sudden temperature drop, a heavy rain, or at temperatures above 90°F.)

I. Sample fish routinely and calculate food conversion ratios (FCR) to determine the cost and efficiency of your feeding program. (Assignment Sheet #3; Job Sheet #1)

J. Store feed properly in a cool, dry area, and do not store over 30 days in the summer.

(NOTE. Improperly stored feed can produce mold that can be harmful to the catfish. Feed stored too long or exposed to sunlight for an extended period—particularly vitamin premixes—will lose its nutritional value.)

XVI. Producing catfish in cages

A. Bodies of water that cannot be seined, drained, or otherwise harvested can be used for small-scale catfish production in cages.

EXAMPLES: Stripmines, gravel pits, lakes, large reservoirs, irregular farm ponds

B. Small-scale production can be carried out in almost any farm pond of 1 acre or more with a depth of 8 feet or deeper; larger-scale production requires a body of water at least 5 acres in area.

(NOTE: A producer should not expect to produce more than 1,500 pounds of catfish per year per acre without supplemental aeration or a significant inflow of fresh water.)

C. Cages are floated in the water, their tops several inches above the surface for ease of feeding, and their bottoms 2 to 4 feet from the pond bottom so that the water supply is not fouled by fish wastes. (Figure 3)

INFORMATION SHEET

EXAMPLE: FIGURE 3

D. Cages allow for the production of several noncompatible species at the same time.

EXAMPLE: Catfish can be grown in cages and bass can be free in the open water; or catfish can be cage or pen raised in the summer and trout can be cultured in the pens or cages in the winter.

E. Cages are usually stocked with channel catfish 4 to 8 inches long at a density of 8 to 12 per cubic foot.

> POINT OF INTEREST: Fingerlings should be graded as tightly as possible—within a 2-inch range—to prevent fighting. Two-year-old stockers should not be cage cultured because they, too, will fight.

F. Caged fish must be fed a nutritionally complete floating feed of high protein content—32% to 38% protein.

G. To reduce losses from stress or disease, medicated feed is often fed for the first 10 to 14 days after stocking.

H. Confined fish should be fed at least 6 days a week—preferably 7 days—and only in amounts that they will eat in 20 minutes.

XVII. Advantages of cage culture

A. Allows for use of marginal bodies of water.

B. Does not require expensive alteration of the land.

C. Start-up investment is lower than that for pond or container production.

D. Recordkeeping is easier because the catfish can be readily seen and do not require catching for weighing and monitoring.

INFORMATION SHEET

E. Harvesting is easy as the cages merely need to be lifted from the water.

XVIII. Limitations of cage culture

A. The cost of cage construction is relatively high because durable materials are expensive.

B. There is little commercial application in ponds less than 5 acres in area.

C. A hole in the wire or mesh, or wind damage to the cage can result in the loss of the fish.

D. Cages can be vandalized and fish stolen.

E Fish are more susceptible to death from low DO.

F. There will be considerable size variation if fish are not graded.

G. There is no large-scale commercial value.

H. Disease and parasite outbreaks may increase because the fish are stressed by crowding.

XIX. Tank and raceway culture of channel catfish

A. Catfish can be produced in linear or circular raceways, tanks, or vats.

B. These systems require a continual supply of high-quality, highly oxygenated water to dilute or flush uneaten food and fish wastes from the containers.

C. Most of these systems require pumping, and adequate amounts of suitable quality water at an affordable cost is the major limitation in this type of culture system.

(NOTE: Earthen raceways have been used to produce channel catfish, but sufficient low-cost water near 82°F is not available in most areas where channel catfish are raised.)

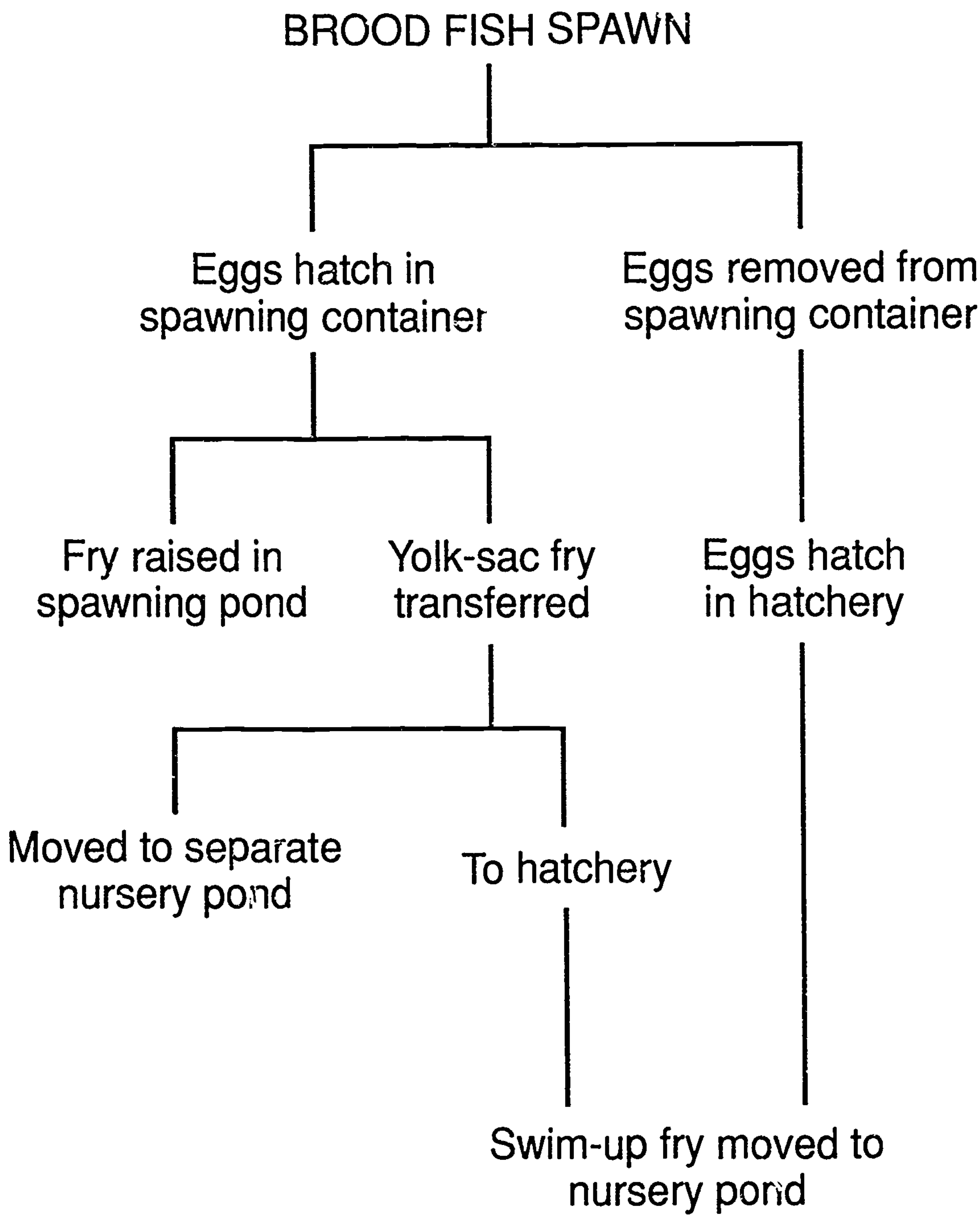
D. Many of these units recirculate the water and require backup ammonia and biological filters, pumps, and emergency power units.

E. Because the tank bottom and water supply usually provide no supplemental nutrients, the catfish must be fed high-quality nutritionally complete feeds.

F. Generally, container culture for commercial production is cost prohibitive, though it is used successfully in hatcheries and for research.

EXAMPLES: Researchers have used recirculating water in tanks containing test fish; in some recirculating tanks, vegetables are grown to extract waste products from the tank and provide useful crops; some linear raceways have been constructed in which all water transfer and aeration is by gravity.

Methods of Handling Catfish Eggs for Fry Production



From *Commercial Production of Farm-Raised Catfish* by Gary L. Jensen. With permission.

COMMERCIAL CATFISH PRODUCTION
UNIT IX

HANDOUT #1
TABLES FOR CALCULATING STOCKING NUMBERS AND SIZES

TABLE 1: **Estimated Percent of Body Weight Consumed by Channel Catfish of Different Sizes at Different Water Temperatures Above 70°F**

Fish Size		
Average Weight (Pounds)	Pounds per 1,000 Fish	Estimated Daily Food Consumption Rate (% Body Weight)
0.02	20	4.0
0.06	60	3.0
0.25	250	2.7
0.50	500	2.5
0.70	750	2.2
1.00	1000	1.6
1.50	1500	1.3

TABLE 2: **Length-Weight Relationship for Channel Catfish Fingerlings and Food Fish**

Total Length (Inches)	Average Weight per 1000 Fish (Pounds)	Number of Fish per Pound	Average Weight per Fish (Pounds)
1	1.3	767.7	.0013
2	3.5	285.7	.0100
3	10.0	100.0	.0100
4	20.0	50.0	.0200
5	32.0	31.1	.0321
6	60.0	17.0	.058
7	93.0	10.8	.0926
8	112.0	9.0	.1111
9	180.0	5.5	.1818
10	328.0	3.1	.3280
11	395.0	2.5	.3950
12	509.0	1.9	.5090
13	656.0	1.5	.6560
14	850.0	1.1	.8500
15	1090.0	0.92	1.0900
16	1290.0	0.82	1.2900
17	1432.0	0.69	1.4320
18	1750.0	0.57	1.7500
19	2200.0	0.45	2.2000
20	2890.0	0.35	2.8900
21	3290.0	0.30	3.2900
22	3470.0	0.29	3.4700
23	3600.0	0.28	3.6000

Tables from *Handbook for Common Calculations in Finfish Aquaculture* by Gary L. Jensen, Louisiana Cooperative Extension Service, with permission.

COMMERCIAL CATFISH PRODUCTION
UNIT IX

ASSIGNMENT SHEET #1
KEEP DAILY, WEEKLY, AND MONTHLY CATFISH PRODUCTION RECORDS

To be successful at catfish production, you must be a good manager, and to manage your enterprise profitably, you must keep thorough and accurate records of the numbers and weight of fish in every pond at any given time. You must also record the details of your feeding practices: dates, amounts, FCR's, etc.; and all information regarding pond or disease treatment.

There are many reasons for keeping good records, one of the most important being that many lending institutions require records before they will lend money. You will also need records for income tax purposes. Without records, you will not be able to calculate feed conversion ratios and optimum stocking rates. Without these figures, you will not know whether you are making or losing money. And, finally, if you do not keep records, you will not be able to identify problem areas that need correcting for the most efficient and economical management.

To complete this assignment sheet, you must record on the appropriate forms, information given in the enterprise data supplied by your instructor. Record data for the enterprise on the following forms or use a computer recordkeeping system. Excellent computer programs for catfish recordkeeping are available from your county agent of the Cooperative Extension Service. If you do not have a computer, you can develop your own system based on the forms included in this assignment sheet.

ASSIGNMENT SHEET #1

1. Daily Feeding Record

Record on a daily feeding form the amount of feed fed daily for each pond in the enterprise.

Daily Feeding Record

Week of __________ to __________

Pond #	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Total

ASSIGNMENT SHEET #1

2. Weekly pond record

Record on a weekly pond record the pond number and date, dates of stocking, stocking rates and weights, and total weight stocked. Obtain the estimated feed conversion ratio (FCR) from information in the enterprise data. Producers obtain estimated FCRs from experience, their pond conversion ratio calculations records, or through calculations after sample counts or at last harvest. In Assignment Sheet #3 you learn how to calculate FCR and estimate fish weights from feed records.

Most of the information required on The Weekly Pond Record is self-explanatory. Find Column 3 by dividing each entry in Column 2 by the estimated FCR. Column 4 should be running totals of original stocking weight plus weekly gains. Use Column 7 for notations.

EXAMPLES: Average fish size (total fish weight divided by number of fingerlings), disease treatments, explanation of losses

Weekly Pond Record

Pond/Unit # _____

Size ________ Acres

Date Stocked	Weight Fingerlings	Number Fingerlings	Total Stocked Weight

Est. Conv. Ratio: ________ Total ________ ________

Col. 1 Week Ended	Col. 2 Lb Feed Fed	Col. 3 Lb Gain	Col. 4 Total Fish Weight	Col. 5 Lb Harvested or Lost	Col. 6 Price Received Per lb	Col. 7 Remarks (Treatments, feed, etc.)
TOTAL						

ASSIGNMENT SHEET #1

3. Pond conversion ratio calculations

Before completing pond conversion ratio calculations, find the correct factor (CF) by calculating adjustments for feed fed:

a. Beginning feed inventory = ____________________
b. Total feed purchased = ____________________
c. Ending feed inventory = ____________________
d. Feed used (a + b – c) = ____________________
e. Total feed fed from pond records = ____________________
f. Correction factor (d + e) = ____________________

After obtaining the CF, record it on the Pond Conversion Ratio Calculation form. Record the information required in Columns 1, 3, 4, and 5. To obtain Column 2, multiply the CF by Column 1. Calculate Column 5 by subtracting the value in Column 3 from Column 4 and then dividing this result into the value in Column 2.

Pond Conversion Ratio Calculations

Correction Factor (CF) = __________

Pond #	Col. 1 Est. lb. Feed Fed	Col. 2 Actual lb. Feed Fed (1) × (CF)	Col. 3 Total Stocking Wt.	Col. 4 Total lb. Harvested	Col. 5 Conversion Ratio 2/ (4 – 3)

COMMERCIAL CATFISH PRODUCTION
UNIT IX

ASSIGNMENT SHEET #2
CALCULATE STOCKING RATES

The number and size of fish stocked in a pond are important because the number of fish stocked affects the level of management needed, and the size of fish stocked influences the length of time needed for fish to reach a desired market size.

Fish are usually stocked based on the surface area of water, unless they are stocked into tanks or raceways with continuous water flow. The number of catfish to stock into commercial ponds depends on three factors:

Maximum feeding rate;
Size of fish desired at harvest;
Maximum pounds of fish that can be fed at maximum daily feeding rate.

This assignment sheet is designed to give you practice in determining the correct number and size fish to stock for various situations. Part I provides information and examples; Part II provides you with stocking problems so that you can practice calculating stocking rates You must use the tables in Handout #1 for information needed to make your calculations.

PART I

Calculating Food Fish Stocking Rates

EXAMPLE 1. You want to stock 6-inch channel catfish fingerlings at 3,000 per acre in your 12 acre pond. What will be tne total number of fish in your pond? How many pounds of fingerlings will you request from the supplier?

1. Find the total number of fish in your pond by simply multiplying the number of fish desired per acre times the number of acres:

   Total No. of Fish to Stock = No. of Fish/Acre × No. Acres

   = 3,000 × 12

   = 36,000 fish

2. Find the number of pounds to purchase by first looking on Table 2 in Handout #1 to find the estimated number of pounds per 1,000 channel catfish of a 6-inch length:

   6-inch length = 60 pounds per 1,000 fish

ASSIGNMENT SHEET #2

3. Find the total number of pounds to purchase by dividing the total number by 1,000 and multiplying by the number of pounds per 1,000 fish:

$$\text{Total No. of Pounds Needed} = \frac{\text{Total No. to Stock}}{1{,}000} \times \text{lb}/1{,}000$$

$$= \frac{36{,}000}{1{,}000} \times 60$$

$$= 36 \times 60$$

$$= 2{,}160 \text{ pounds}$$

EXAMPLE 2: You have just stocked 3,250 pounds of fish in your pond and now you make a sample check to determine the number of fish delivered. Your sample of 150 fish weighs 9 pounds. How many fish were stocked?

$$\text{No. of Fish Stocked} = \frac{\text{No. Fish in Sample} \times \text{Total Weight Stocked}}{\text{Weight of Sample}}$$

$$= \frac{50 \times 3{,}250}{9}$$

$$= \frac{87{,}500}{9}$$

$$= 54{,}167 \text{ fish}$$

EXAMPLE 3: You are a fingerling producer, and a local fish farmer has told you that she wants to stock 30,000 fish. Your sample check reveals that 100 fish of the size she wants weigh 7 pounds. How many pounds will you sell her?

$$\text{No. of Pounds Needed} = \frac{\text{No. Fish Desired} \times \text{Weight of Sample}}{\text{No. Fish in Sample}}$$

$$= \frac{30{,}000 \times 7}{100}$$

$$= \frac{210{,}000}{100}$$

$$= 2{,}100 \text{ pounds}$$

ASSIGNMENT SHEET #2

EXAMPLE 4: You have a 17.5 acre levee pond with aeration and well. You want to grow food fish to an average size of 1½ pounds without exceeding the maximum feeding rate (MFR). How many fish can you stock?

1. Use the chart below to find the maximum feeding rate:

Pond Set-up	Suggested Maximum Feeding Rate* (Pounds/Acre/Day)
Watershed pond, no aeration	30 to 35
Watershed pond with aeration	50 to 60
Levee pond with well, no aeration	35 to 40
Levee pond with well and aeration	100

*Maximum feeding rate = 100 pounds of feed per acre per day.

2. Use Table 1 in Handout #1 to find estimated feed consumption ate for 1½ pound fish at harvest:

   Estimated feed consumption rate = 1.3% of body weight consumed daily.

3. Find total fish weight per acre:

$$\text{Total Fish Weight} = \frac{\text{Maximum Feeding Rate}}{\text{Percent of Est. Feed Consumption Expressed as a Decimal}}$$

$$= \frac{100}{.013}$$

$$= 7{,}692 \text{ pounds/acre}$$

4. Find number of fish to stock per acre:

$$\text{No. Fish to Stock/Acre} = \frac{\text{Total Pounds/Acre}}{\text{Average Weight at Harvest Expressed as a Decimal}}$$

$$= \frac{7{,}692}{1.50}$$

$$= 5{,}128 \text{ fish/acre}$$

ASSIGNMENT SHEET #2

5. Find total number of fish to stock by multiplying the number of acres by the number of fish per acre:

   17.5 acres × 5,128 fish = 89,740 fish/pond

EXAMPLE 5. A fingerling producer wants to grow fish to an average size of 6 inches. He does not want to exceed a feeding rate of 75 pounds per acre per day. How many fish should be stocked?

1. Use Table 1 in Handout #1 to find the estimated feed consumption rate:

   Estimated feed consumption rate = 3% of body weight consumed daily.

2. Find the total weight at harvest:

$$\text{Total Weight at Harvest} = \frac{\text{Maximum Feeding Rate}}{\text{Percent of Est. Feed Consumption Expressed as a Decimal}}$$

$$= \frac{75}{0.03}$$

$$= 2{,}500 \text{ pounds/acre}$$

3. Find the average weight of a 6-inch fish in Table 2, Handout #1:

   Average weight of 6-inch fish at harvest = .0588 or about .06 pound.

4. Calculate the fish stocking rate per acre by dividing the total weight at harvest by the average weight per fish at harvest:

$$\text{Stocking Rate/Acre} = \frac{\text{Total Weight at Harvest}}{\text{Average Weight per Fish}}$$

$$= \frac{2{,}500}{0.06}$$

$$= 41{,}666 \text{ fish/acre}$$

ASSIGNMENT SHEET #2

Calculating Replacement Stock After Topping

Catfish farmers commonly harvest several times a year by topping their stock: seining out those fish that have reached market size. After topping, one fish is stocked for each fish harvested.

In order to know the number of fish to restock, the producer must weigh and count a sample of fish harvested. The producer must also know the total weight in pounds of the fish harvested.

EXAMPLE: You have topped 15,000 pounds of fish from your pond. A random sample of 50 fish weighed a total of 55 pounds. How many fish should be stocked to replace those harvested?

$$\text{Restock No.} = \frac{\text{No. Fish in Sample} \times \text{Total Weight Harvested (lb)}}{\text{Total Weight of Sample (lb)}}$$

$$= \frac{50 \times 15{,}000}{55}$$

$$= 13{,}636 \text{ fish}$$

Calculating Broodfish Stocking Rates

Stocking broodfish for fingerling production requires careful planning. If too many fry are produced, the enterprise can lose money. In addition, the production of too many fry can cause overcrowding, which leads to disease and slow growth.

To calculate broodfish stocking numbers, the producer needs the following given information, which is based on experience and published research:

— Broodfish are normally stocked at a maximum of 1,200 pounds per acre, with a male to female ratio of 2:3 (2 males for each 3 females).

— Fifty percent of female broodfish will spawn (produce eggs).

— Each spawning female will produce an average of 2,600 eggs per pound of body weight.

— The survival of eggs during hatching is 95%.

— The survival of fry to lengths of 4 to 6 inches is 70%.

— The maximum stocking rate of fry to reach an average of 4 to 6 inches after 120 to 150 days of culture is 75,000 per acre.

ASSIGNMENT SHEET #2

EXAMPLE: A catfish fingerling producer wants to raise 800,000 fingerlings to an average length of 4 to 6 inches. The producer needs to know how many acres of ponds will be needed to produce these fish, and how many pounds of male and female broodfish to stock.

1. First the producer must calculate the number of fry needed:

Given: Fry survival 70% or .70

$$\text{No. Fry Needed} = \frac{\text{No. Fingerlings Desired}}{\text{Decimal Percent of Fry Survival}}$$

$$= \frac{800{,}000}{0.70}$$

$$= 1{,}142{,}857 \text{ fry needed}$$

2. With this figure, the number of fingerling ponds can be determined:

Given: Maximum fingerling stocking rate = 75,000 per acre

$$\text{No. Water Acres for Fingerling Ponds} = \frac{\text{Total Fry Stocked}}{\text{Given No. per Acre}}$$

$$= \frac{1{,}142{,}857}{75{,}000}$$

$$= 15.24 \text{ acres of fingerling rearing ponds}$$

3. Now the producer can determine the number of eggs needed:

Given: Egg survival 95% or .95

$$\text{No. Eggs Needed} = \frac{\text{No. of Fry Required}}{\text{Decimal \% of Egg Survival}}$$

$$= \frac{1{,}142{,}857}{0.95}$$

$$= 1{,}203{,}007 \text{ eggs}$$

ASSIGNMENT SHEET #2

4. With this information, the number of pounds of female broodfish can be calculated:

Given: Each spawning female produces 2,600 lbs. eggs per lb. of body weight.

$$\text{No. Pounds Spawning Females} = \frac{\text{Eggs Needed}}{\text{Egg Production/Pound Body Weight}}$$

$$= \frac{1{,}203{,}007}{2{,}600}$$

$$= 463 \text{ pounds}$$

(NOTE: This poundage is doubled because only 50% female broodfish spawn.)

$$= 926 \text{ pounds female broodfish}$$

5. Now the number of female broodfish can be determined by dividing the average desired weight per female broodfish (4 pounds) into the total pounds of female broodfish found above:

$$\text{Total No. Female Broodfish} = \frac{\text{Total Pounds Needed}}{\text{Average Weight/Female}}$$

$$= \frac{926}{4}$$

$$= 231 \text{ broodfish}$$

6. Calculate the number of male broodfish needed:

Given: Stock 2:3, 2 males for each 3 females

$$\text{No. Male Broodfish Needed} = \frac{\text{No. Females Needed}}{3} \times 2$$

$$= \frac{231}{3} \times 2$$

$$= 77 \times 2$$

$$= 154 \text{ males}$$

ASSIGNMENT SHEET #2

7. Find the number of pounds of male broodfish needed by multiplying the number of males by their average weight (assume for the sake of the example that males average 4.5 pounds each):

$$\text{Total Pounds of Male Broodfish} = \text{Total No.} \times \text{Average Weight/Male}$$

$$= 154 \times 4.5$$

$$= 693 \text{ pounds}$$

8. Finally, determine the minimum number of acres needed for spawning ponds:

Given: Recommended pounds per acre in spawning ponds = 1,200

$$\text{Minimum Acres for Spawning Ponds} = \frac{\text{Total Pounds of Broodfish (M + F)}}{\text{Recommended Pounds/Acre}}$$

$$= \frac{926 + 693}{1{,}200}$$

$$= \frac{1{,}619}{1{,}200}$$

$$= 1.35 \text{ acres minimum}$$

Calculating Numbers of Fry Stock

Because channel catfish fry are so tiny, it is difficult to estimate their numbers by visual inspection. However, small fish double their weight quickly, so it is important to make number estimations just before they are stocked in fingerling grow-out ponds. Fingerling producers make these estimates in two ways: 1) by measuring water volume displacement, and 2) by weighing. The calculations for both methods are simple. A fish counter is used to determine numbers.

The volumetric method involves counting a known number of fry and measuring water displacement. About 300 fry are counted and placed in a graduated cylinder. The amount of water displaced is recorded. Then all fry—not just those in counted sample—are placed in a large container graduated in milliliters and the amount of water displaced is recorded. The fingerling producer can now calculate total numbers of fry based on these figures.

ASSIGNMENT SHEET #2

EXAMPLE: A sample of 300 fry raised the water volume in a 100-milliliter graduated cylinder from 50 to 62 ml. All fry were then placed in a graduated measuring container containing 500 ml of water. The fry raised the water volume to 900 ml. How many total fry do you have?

Use the volumetric formula to estimate fry numbers:

$$\text{Total No. of Fry} = \frac{\text{No. of Fry in Sample} \times \text{Volume Change for All Fry}}{\text{Volume Change for Counted Fry}}$$

$$= \frac{300 \times (900 - 500)}{62 - 50}$$

$$= \frac{300 \times 400}{12}$$

$$= \frac{120{,}000}{12}$$

$$= 10{,}000 \text{ fry}$$

To use the weighing method of estimating numbers of fry, a container of water is weighed to the nearest gram on a triple beam scale. A sample of 300 fry are counted and added to the container, and the increase in weight to the nearest gram is recorded. Next, a larger container of water is weighed and then all fry—not just those in the sample count—are placed in this container and the weight increase recorded. The fingerling producer can now calculate total numbers of fry based on these figures.

EXAMPLE: A container and water weigh 300 grams. A sample count of 300 fish is placed in the container, and the new weight is 370 grams. Next, a larger container with water weighed 900 grams without fish. With the addition of all the fry, it weighed 1,250 grams. How many total fish were weighed?

Use the weighing formula:

$$\text{Total No. of Fry} = \frac{\text{No. of Fry in Sample} \times \text{Weight Change with All Fry}}{\text{Weight Change with Counted Sample}}$$

$$= \frac{300 \times (1{,}250 - 900)}{(370 - 350)}$$

$$= \frac{105{,}000}{20}$$

$$= 5{,}250 \text{ fry}$$

ASSIGNMENT SHEET #2

PART II

Practice calculating stocking rates and numbers by completing the following problems.

1. A pond is 5 acres in size and 3,000 fish is the desired stocking rate per acre. How many fingerlings must be purchased from the supplier?

2. You want to stock a total of 40,000 4-inch fingerlings in your pond. How many pounds of fish should you stock?

3. A sample of 150 fish weighs 9 pounds. How many pounds are needed to stock 54,167 fish?

4. A fingerling producer wants to raise fish to an average size of 6 inches but does not want to exceed a feeding rate of 65 pounds per acre per day. How many fish should be stocked?

5. You have a watershed pond without aeration and want to raise food fish to an average size of 1 pound without exceeding the maximum daily consumption rate. How many fish can you stock per acre? How many fish can you stock if you add an extra 5% to adjust for losses?

6. Supposing the pond in number 5 were a levee pond with aeration and well. How many fish could you stock per acre? How many with adjustment for losses?

7. You have just topped 17,000 pounds of fish from a pond. Your sample of 45 fish weighs a total of 51.5 pounds. How many fish must you stock to replace those harvested?

8. You want to produce 130,000 fingerlings to a length of 4 to 6 inches. How many each of male and female broodfish must you stock? How many acres of broodfish ponds do you need? Of fingerling rearing ponds?

9. Your broodfish have spawned and you have successfully reared the fry to fingerling rearing-pond size. Now you need to estimate the number of fry you have for stocking. Your sample count of 400 fry raises the water volume in a 100-ml graduated cylinder from 50 to 75 ml. When you place all of your fry stock in a larger graduated container, they raise the water volume from 500 ml to 1,000 ml. How many total fry do you have for stocking?

10. You are about to stock a fingerling rearing pond and need to know the number of fry you have. You weigh a container and water at 400 grams, and then place a sample count of 300 fry in it. The new weight is 475 grams. Next you weigh a larger container and water at 800 grams. When you place all fry stock in this container, the weight increases to 1,175 grams. How many fry do you have? How many should you stock for a 6-inch harvest without exceeding a feeding rate of 70 pounds per acre?

The problems and procedures in this assignment sheet were adapted from Gary L. Jensens *Handbook for Common Calculations in Finfish Aquaculture.* With permission.

COMMERCIAL CATFISH PRODUCTION
UNIT IX

ASSIGNMENT SHEET #3
CALCULATE FCR AND ESTIMATE FISH WEIGHTS FROM FEED RECORDS

Aquaculturists calculate feed conversion ratios (FCRs) to determine the cost efficiency of raising fish. The FCR is the weight gained by fish after eating a known amount of feed.

EXAMPLE. A FCR of 1.5 means that the fish ate an average of 1.5 pounds of feed to gain 1 pound in weight.

Feed conversion ratios for catfish vary from less than 1.5 to as high as 4 or more. The higher the FCR, the smaller the profit margin. If the FCR is much higher than 2, the producer tries to reduce it.

To determine the FCR, the producer must keep records of the amount of feed fed to fish in each pond and must record fish losses and number of pounds of fish harvested. The FCR can be calculated monthly when fish are sampled, and when fish are harvested.

This assignment sheet is presented in two parts. Part I provides examples and information on how to calculate FCR and weight gain from feed records. Part II presents some practical problems so that you may practice calculating feed conversion ratios and weight gains.

PART I

EXAMPLE 1. A producer stocked 67,500 fingerlings weighing 50 pounds per 1,000. Later the fish were sampled and the average weight of fish was 1/4 or 0.25 pound (250 pounds per 1,000 fish). During this time, 10 tons plus 1,600 pounds of feed were fed. No fish losses were observed. What is the FCR?

1. Convert all feed to pounds:

   1 ton = 2,000 pounds

   Total Pounds Fed = (No. Tons × 2,000) + No. Pounds

   = (10 × 2,000) + 1,600

   = 20,000 + 1,600

   = 21,600 pounds

2. Determine final weight by multiplying the number of fish by the average weight from sample:

   Final Weight = Average Weight × No. Fish

   = 0.25 × 67,500

   = 16,875 pounds

ASSIGNMENT SHEET #3

3. Determine total weight gain by subtracting initial weight from final weight.

Total Weight Gain = Total Weight − Initial Weight

= 16,875 − 3,375

= 13,500 pounds

4. Substitute your results into the basic formula for FCR:

$$FCR = \frac{\text{Amount of Feed Fed (Pounds)}}{\text{Total Weight Gain (Pounds)}}$$

$$= \frac{21,600}{13,500}$$

$$= 1.6$$

The producer fed 1.6 pounds of feed to gain 1 pound of fish weight.

EXAMPLE 2: You had an estimated standing crop of 22,500 pounds of fish at the last sampling. A new sample estimates the total fish weight at 33,000 pounds. However, between these two samplings, you lost a recorded 2,500 pounds of fish. During the period between samplings you fed 11 tons plus 1,400 pounds of feed. What is your FCR?

1. Find the total pounds fed:

Total Pounds Fed = (11 × 2,000) + 1,400

= 22,000 + 1,400

= 23,400 pounds

2. Find the total weight gain:

Total Weight Gain = (Final Weight − Last Weight) + Pounds Lost

= (33,000 − 22,500) + 2,500

= 10,500 + 2,500

= 13,000 pounds

(NOTE: The lost fish weight must be included because these fish figured into the standing crop sampling (Last Weight). Economically, however, the producer has lost not only the weight, but also the feed these fish ate before dying.)

ASSIGNMENT SHEET #3

3. Substitute these figures into the basic formula to find the FCR:

$$FCR = \frac{\text{Amount of Feed Fed (Pounds)}}{\text{Total Weight Gain (Pounds)}}$$

$$= \frac{23{,}400}{13{,}000}$$

$$= 1.8$$

(NOTE: Fish losses increase the FCR. If you calculate the FCR for the producer in Example 2 *without including the lost fish*, the FCR jumps to 2.23. Comparing the two figures, one can see that even though the fish are converting well at an FCR of 1.8 pounds, the real cost of production is actually at an FCR of 2.23 pounds because of the fish that have been fed but cannot be marketed due to loss.)

Estimating Weights from Feed Records

Once you know the feed conversion ratio for your fish at the time of standing crop estimation, you can estimate the pounds of weight of fish in the pond by knowing the amount of feed you have fed the fish and the initial weight of the fish.

By calculating weights from weekly feed records, you can estimate the new fish weight gain in a pond and adjust your feeding allowance to keep up with the growth of the fish. To estimate weights from feed records, use the basic FCR formula:

$$FCR = \frac{\text{Amount of Feed Fed (Pounds)}}{\text{Total Weight Gain (Pounds)}}$$

EXAMPLE. A pond was stocked with 30,000 fish that weighed 70 pounds per 1,000. During a period of time, the fish were fed 2,250 pounds of feed and no losses were observed. You have calculated a feed conversion ratio of 1.7. What is the total weight of the fish in the pond?

1. Determine the initial stocking weight of fish:

$$\text{Initial Stocking Weight} = \frac{\text{Total No. Fish}}{1{,}000} \times 70$$

$$= \frac{30{,}000}{1{,}000} \times 70$$

$$= 30 \times 70$$

$$= 2{,}100 \text{ pounds}$$

ASSIGNMENT SHEET #3

2. Find estimated weight gain:

   a. Substitute known values into basic FCR formula:

   $$\text{FCR} = \frac{\text{Amount of Feed Fed (Pounds)}}{\text{Total Weight Gain (Pounds)}}$$

   $$1.7 = \frac{2{,}500}{W} \text{ (Estimated Weight Gain)}$$

   b. Divide 1.7 by 1 and cross multiply:

   $$\frac{1.7}{1} = \frac{2{,}500}{W}$$

   $$1.7\ W = 2{,}500$$

   c. Divide each side of the equation by 1.7:

   $$\frac{1.7\ W}{1.7} = \frac{2{,}500}{1.7}$$

   $$W = 1{,}470 \text{ pounds gained}$$

3. Estimate total weight of fish in pond:

   Total Weight = Initial Weight + Weight Gain

   = 2,100 + 1,470

   = 3,570 pounds

PART II

Solve the following problems to practice calculating FCR and weights from weekly feed records.

1 You have stocked 48,000 fingerlings at an average weight of 32 pounds per 1,000. When you later sample the fish, their average weight is 0.06 pounds. Between samplings, you fed 1 ton plus 550 pounds of feed and experienced no fish losses. What is your FCR?

2 You have stocked 375 broodfish with an average weight of 3.5 pounds. You later sample the fish and their average weight is 4.3 pounds. Between samplings, you have fed 1/4 ton of feed and have observed no losses. What is your FCR?

3. At your last sampling, you estimated your standing crop at 18,400 pounds. The following sample estimated total fish weight at 28,150 pounds. Between samplings, you lost a recorded 1,600 pounds of fish. In the period of time between the two samplings, you fed 3 tons plus 1,400 pounds of feed. What is your FCR (including fish lost)? What is your real cost of production (FCR not including fish lost)?

ASSIGNMENT SHEET #3

4. Your estimated standing crop is 15,000 pounds at first sampling and 24,000 at the following sampling. Between samplings, you lost 2,000 pounds of fish and fed 9 1/2 tons of feed. What is your FCR (including fish lost)? What is your real cost of production (FCR not including fish lost)?

5. A pond was stocked with 30,000 fish that weighed 70 pounds per 1,000 fish. During a period of time, the fish were fed 2,500 pounds of feed at an FCR of 1.9. What is the estimated total weight of the fish?

6. Calculate weight gains of fish in problem 5, using FCRs of 1.6, 1.8, and 2.0. What differences do you observe? How would you apply this information to catfish feeding practices?

The problems and procedures in this assignment sheet were adapted from Gary L. Jensen's *Handbook for Common Calculations in Finfish Aquaculture*. With permission.

COMMERCIAL CATFISH PRODUCTION
UNIT IX

ASSIGNMENT SHEET #4
CALCULATE FEED REQUIREMENTS AND COSTS

In the United States, fish farmers feed their stock high-protein feeds; therefore feed becomes a major production cost. The cost of feeding fish is determined by the FCR and the cost of feed. For planning purposes and cost management, fish farmers should know how to estimate their feed requirements over time.

This assignment sheet is presented in two parts. Part I presents examples and calculation methods. Part II provides realistic problems so that you can practice calculating feed requirements and costs.

PART I

Calculating Feed Costs

Table 1 below illustrates how the FCR and price affect the cost of producing catfish. Use the table to estimate feed costs and requirements.

TABLE 1: **Cost of Feed in Cents to Produce a 1-Pound Catfish at Different FCRs and Feed Prices**

	Feed Cost per Ton				
FCR	$200	$225	$250	$275	$300
1.5	15.0	16.9	18.8	20.6	22.5
1.6	16.0	18.0	20.0	22.0	24.0
1.7	17.0	19.1	21.3	23.4	25.5
1.8	18.0	20.3	22.5	25.8	27.0
1.9	19.0	21.4	23.4	26.1	28.5
2.0	20.0	22.4	25.0	27.5	30.0

From *Handbook for Common Calculations in Finfish Aquaculture* by Gary Jensen, Louisiana Cooperative Extension Service. With permission.

EXAMPLE. If 4,000 pounds of fish were produced per acre, the feed was $250 per ton, and the FCR was 1.8, what would be the cost of feed per acre?

1. Use Table 1 to find cost of feed in cents to produce a 1-pound fish with feed at $250/ton and FCR at 1.8:

   Feed Cost per Pound = 22.5 cents or $.225

ASSIGNMENT SHEET #4

2. Find the cost per acre:

Cost per Acre = Weight of Fish/Acre × Cost/Pound

= 4,000 × .225

= $900/acre

Calculating Feed Requirements

Feed requirements for catfish change with age, size, health, and water requirements. Feed requirement charts are available for catfish of different sizes and at different water temperatures. However, these feed consumption rates should be used only as guidelines. Individual fish farmers should keep records specific to their enterprises to determine their own figures.

EXAMPLE 1: A pond was stocked with 45,000 fish that weigh 50 pounds per 1,000 fish. The desired feeding rate is 3% of their weight daily. How much feed is needed for 1 day and for 1 week?

1. Determine total pounds of fish stocked:

$$\text{Total Weight Fish} = \frac{\text{No. Fish Stocked}}{1{,}000} \times 50$$

$$= \frac{45{,}000}{1{,}000} \times 50$$

$$= 45 \times 50$$

$$= 2{,}250 \text{ pounds}$$

2. Find number of pounds to feed daily:

Total Daily Feed = Total Weight Fish × Decimal Feeding Rate

= 2,250 × 0.03

= 67.5 pounds/day

3. Find number of pounds to feed weekly:

Total Weekly Feed = No. Pounds/Day × No. Days Fed/Week

= 67.5 × 7

= 472.5 pounds/week

ASSIGNMENT SHEET #4

EXAMPLE 2: A 12 acr. pond contains 2,000 pounds of fish per acre. A bacterial disease is diagnosed and double strength (2×) Terramycin medicated feed is needed. The daily recommended feeding rate is 1.5% body weight per day for a total of 10 days. The feed comes in 50-pound bags. How many bags of medicated feed should be ordered?

1. Find total pounds of fish in pond:

   Total Weight Fish = No. Pounds/Acre × No. Acres

   = 2,000 × 12

   = 24,000 pounds

2. Calculate the amount of medicated feed needed per day:

   Amount Med. Feed/Day = Total Weight Fish × Decimal Feeding Rate

   = 24,000 × 0.15

   = 360 pounds/day

3. Find total pounds of medicated feed needed for 10-day treatment period:

   Amount Med. Feed/10-Day = Amount Med. Feed/Day × No. Treatment Days

   = 360 × 10

   = 3,600 pounds/10-day period

4. Determine number of bags of feed to purchase:

   $$\text{No. Bags to Purchase} = \frac{\text{Amount of Feed/Treatment Period}}{\text{No. Pounds/Bag}}$$

   $$= \frac{3{,}600}{50}$$

   = 72 bags

EXAMPLE 3. You have a 45 acre fish farm and expect an annual average production per acre of 3,500 pounds of catfish. What is the estimated amount of feed you must purchase for the year, and what will be your feed costs at $250/ton? You expect an FCR of 1.8.

ASSIGNMENT SHEET #4

1. Determine the number of pounds of fish you expect to produce for the year:

 (NOTE: The number of pounds will actually be the weight gained and not the total weight of fish produced. You are calculating costs and requirements here based on your projected gains.)

 Total Estimated Weight Gain = Projected No. Pounds/Acre × No. Acres

 $= 3{,}500 \times 45$

 $= 157{,}500$ pounds

2. Use basi FCR formula to determine feed requirements for this number of fish:

$$\text{FCR} = \frac{\text{Pounds of Feed Fed}}{\text{Weight Gain of Fish}}$$

$$1.8 = \frac{\text{Pounds of Feed Fed}}{157{,}000}$$

$$\frac{1.8}{1} = \frac{\text{Pounds of Feed Fed}}{157{,}000}$$

 Pounds of Feed Fed $= 1.8 \times 157{,}000$

 $= 283{,}500$ pounds

3. Convert to tons:

 1 ton = 2,000 pounds

$$\text{No. Tons} = \frac{283{,}500}{2{,}000} \times 1$$

 $= 141.75$ tons feed/year

4. Calculate your approximate cost of feed for 1 year:

 Feed Cost/Year = No. Tons Feed Needed × Price/Ton

 $= 141.75 \times \$250$

 $= \$34{,}020$ per year

EXAMPLE 4: To keep pace with the growth of fish, the feed allowance should be adjusted at least every two weeks when fish are feeding well. With this in mind, what would be the new daily allowance for fish in Example 1 after two weeks of feeding?

ASSIGNMENT SHEET #4

1. The fish have gained weight after two weeks and the adjusted feed allowance is now based on 3% of the new weight.

   (NOTE: The new weight can be determined by pond sampling [Job Sheet #1], or by estimating weight gain from feed records and expected FCR [Assignment Sheets #1 and #3]. In this example, use an expected FCR of 1.6.)

2. Find the amount of feed fed for 2 weeks:

   Feed Fed for 2 Weeks = No. Pounds Feed/Day × No. Days in 2 Weeks

   = 67.5 × 14

   = 945 pounds

3. Substitute known values into the basic FCR formula:

$$\text{FCR} = \frac{\text{Total Feed Fed}}{\text{Weight Gain of Fish}}$$

$$1.6 = \frac{945}{\text{Weight Gain of Fish (2 Wk.)}}$$

$$\frac{1.6}{1} = \frac{945}{\text{Weight Gain of Fish (2 Wk.)}}$$

$$\text{2 Week Weight Gain} = \frac{945}{1.6}$$

   = 590 pounds

4. Calculate the new fish weight:

   New Weight = Initial (Stocking) Weight + Weight Gained

   = 2,250 + 590

   = 2,840 pounds

5. Calculate the new daily feed allowance:

   Adjusted Feed Allowance/Day = New Weight × Decimal Feed Allowance

   = 2,840 × 0.03

   = 85.2 pounds/day

ASSIGNMENT SHEET #4

PART II

Practice calculating feed requirements and costs by solving the following problems.

1. You have 12 water acres under cultivation and are producing 2,500 pounds of catfish per acre at an FCR of 1.6 and a feed cost of $225 per ton. What are your per acre and per enterprise feed costs?

2. You have stocked a 6-acre pond with 3,000 fish per acre weighing 32 pounds per 1,000 fish. Your desired feed consumption rate is 3% of their weight daily. How much feed is needed for 1 day? Two weeks?

3. Your farm has 12 acres of water. Your expected annual average production per acre is 3,000 pounds of fish. About how much feed will you have to purchase for the year, and what will be your total feed cost if feed is expected to cost $275 a ton? Your experience tells you to expect an FCR of 1.7.

4. One of your 17.5-acre ponds contains 4,600 pounds of fish per acre. You have discovered a disease and will treat the fish by feeding medicated feed at 2% of body weight daily for 10 days. The feed you want comes in 50-pounds bags. How many bags of medicated feed should you buy?

5. What would be the adjusted daily feed allowance for fish in problem 2, assuming an FCR of 1.9?

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COMMERCIAL CATFISH PRODUCTION
UNIT IX

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1 — Evaluated to the satisfaction of the instructor.

Assignment Sheet #2

1. 15,000 fingerlings
2. 800 pounds
3. 3,250 pounds
4. 2,167 pounds/acre
   36,000 fish
5. 2,188 fish/acre
   2,625 fish/acre adjusted for loss
6. 6,250 fish/acre
   7,500 fish/acre adjusted for loss
7. 14,854 fish
8. 29 males; 43 females
   .21 or about 1/5 acre of broodfish pond
9. 8,000 fry
10. 1,500 fry

Assignment Sheet #3

1. FCR 1.8
2. FCR 1.6
3. FCR (including lost fish) 1.7
   FCR (not including lost fish) 1.9
4. FCR (including lost fish) 1.7
   FCR (not including lost fish) 2.1
5. 3,416 pounds
6. FCR 1.6 = 1,562 lb. gain
   FCR 1.8 = 1,389 lb. gain
   FCR 1.9 = 1,316 lb. gain
   FCR 2.0 = 1,250 lb. gain
   The higher the FCR the less weight gain.
   Use the FCR to increase weight of fish each week and then use new weight to adjust feed allowance.

Assignment Sheet #4

1. $450/acre
   $5,400/enterprise
2. 17.28 lb./day
   120 lb./2 week period
3. 15.3 tons/year
   $4,208/year
4. 322 bags feed
5. 19 lb./day

Assignment Sheet #5 — Evaluated to the satisfaction of the instructor.

COMMERCIAL CATFISH PRODUCTION
UNIT IX

JOB SHEET #1
PERFORM POND SAMPLING TO ESTIMATE AVERAGE FISH WEIGHTS AND STANDING CROP WEIGHT

A. Equipment and materials

1. 100-foot long seine with mesh size to catch smallest fish in pond
2. Hanging scale that weighs up to at least 50 pounds with increments in ounces
3. Bucket for weighing fish
4. Homemade tripod or bar off truck on which to hang scale
5. Dip net
6. Small amount of feed
7. Forms and pen or pencil for recording data learned

B. Procedure

(NOTE. Sample the fish during the coolest time of day or when it is overcast to minimize stress. Always handle fish with wet hands, move the fish in the water, and handle quickly.)

1. Calibrate and hang scale.
2. Toss some feed into a corner where fish normally feed.
3. When fish come to feed, pull the seine quickly across the corner to capture the fish.
4. Collect first random sample by passing the dip net through the fish from bottom to top.
5. Count fish in dip net, then transfer to bucket and weigh; record number and weight:

   (NOTE: Try to net at least 30 fish per sample. The more fish you sample, the more accurate your estimate.)

   Sample 1: No. fish ____________ Total weight ____________________

6. Repeat procedure to collect and weigh two more random samples, record numbers and weights:

   Sample 2: No. fish ____________ Total weight ____________________

   Sample 3: No. fish ____________ Total weight ____________________

JOB SHEET #1

7. Compare the weights of the three samples; if they are not similar, collect more samples until a consistent value is found.

8. Clean work area and put away sampling equipment.

9. Estimate the standing crop weight:

   a. Convert ounces to pounds and calculate the average weight of fish for each sample; use the following formula, and record your findings.

   $$\text{Average Weight/Fish} = \frac{\text{Total Pounds in Sample}}{\text{No. of Fish in Sample}}$$

   Sample 1: Average weight per fish = ____________________

   Sample 2: Average weight per fish = ____________________

   Sample 3: Average weight per fish = ____________________

   b. Now determine the total number of fish and average weight of all fish together for the three samples; record, and then use the formula below to calculate average weight of fish.

Sample No.	No. Fish	Total Weight (Pounds)
1	________	________
2	________	________
3	________	________
Totals	________ fish	________ pounds

   $$\text{Average Fish Weight} = \frac{\text{Total Pounds of Samples}}{\text{Total No. Sampled}}$$

   c. Use the values you have learned and the formula below to estimate the standing crop of fish in the pond.

   $$\text{Standing Crop Weight} = \text{Average Fish Weight} \times (\text{No. Fish Stocked} - \text{Fish Lost or Harvested})$$

COMMERCIAL CATFISH PRODUCTION
UNIT IX

PRACTICAL TEST #1

JOB SHEET #1 — PERFORM POND SAMPLING TO ESTIMATE AVERAGE FISH WEIGHTS AND STANDING CROP WEIGHT

Student's name ______________________ **Date** ________________

Evaluator's name ______________________ **Attempt no.** ________________

Student instructions. When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	Yes	No
1. Set up scales and equipment properly	☐	☐
2. Fed and captured fish properly	☐	☐
3. Collected and weighed three samples	☐	☐
4. Estimated standing crop weight	☐	☐
5. Calculated average fish weight	☐	☐
6. Estimated standing crop	☐	☐
7. Returned equipment to storage	☐	☐

Evaluator's comments: ____

____

____

PRACTICAL TEST #1

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE. Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. [See performance evaluation key below.] If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:	Complete	Acceptable	Poor	Unacceptable
Preparation	4	3	2	1
Fish collection procedures	4	3	2	1
Weighing procedures	4	3	2	1
Standing crop estimation	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY
4 — **Skilled** — Can perform job with no additional training. 3 — **Moderately skilled** — Has performed job during training program, additional training may be required. 2 — **Limited skill** — Has performed job during training program, additional training is required to develop skill. 1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE. If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

COMMERCIAL CATFISH PRODUCTION
UNIT IX

TEST

NAME______________________________ SCORE ________________

1. Match terms related to commercial catfish production with their correct definitions. Write the correct numbers in the blanks.

_____a.	Process by which eggs are placed in a favorable environment for hatching	1. Premix
_____b.	To scatter feed over a wide area	2. Extruded
_____c.	Gradually introduced to changes in water temperature and quality	3. Clean cropping
_____d.	Harvesting all fish at one time	4. Topping
_____e.	Feed additive that contains vitamins and minerals	5. Feed conversion ratio (FCR)
_____f.	The average number of pounds of feed eaten by the fish to gain 1 pound in weight	6. Broadcast
_____g.	Musty or muddy tasting fish flesh	7. Genital papilla
_____h.	Raising fish in densities higher than could be supported in the natural environment; requires feeding of formulated feeds	8. Standing crop weight
_____i.	Pushed through a die to give a certain shape; method of producing floating fish food	9. Incubation
_____j.	Raising fish in low densities in ponds where the fish feed primarily on natural feeds	10. Extensive production
_____k.	Harvesting only those fish that have grown to marketable size	11. Intensive production
_____l.	Total weight of all fish in a pond	12. Acclimated
_____m.	Small nipplelike projection of tissue on male catfish	13. Off-flavor

TEST

2. Complete statements about the advantages of raising catfish. Write the correct numbers in the blanks.

_____a. Farm-raised channel catfish is the freshwater aquaculture crop ___ in the United States today.

1) of greatest economic importance
2) requiring the most intensive labor
3) of most fish farmers

_____b. As traditional agriculture crops become ___, more farmers are turning to farming catfish as a second or third crop in their farm management process.

1) more profitable
2) more diverse
3) less profitable

_____c. Because of a national trend toward ___, catfish farming is presently experiencing rapid growth.

1) gourmet foods
2) increased seafood consumption
3) Cajun dishes

_____d. The number of processors and markets is expanding (particularly in the southeast), and contracts with ___ have introduced catfish to nontraditional U.S. and international markets.

1) large supermarket chains
2) fast-food restaurants
3) international food distributors

_____e. There is more ___ for farm-raised channel catfish than for any other warmwater species.

1) research and development
2) government money available
3) marketing potential

3. Select factual statements about the limitations of raising catfish. Write the correct numbers in the blanks.

_____a. Catfish farming requires ___ to handle water quality, disease, and off-flavor problems.

1) migrant workers
2) experience in agricultural management
3) high risk and intensive management

TEST

______b. If existing ponds are not suitable for the desired enterprise, start-up requires ___ to build ponds and levees.

1) major alteration of land
2) substantial equipment purchase
3) large bank loans

______c. Start-up can require a substantial ___.

1) financial commitment
2) amount of time
3) number of species

______d. Presently there is limited availability of ___ for facility construction and crop production.

1) equipment
2) technical knowledge
3) loan capital

______e. Feed costs and market prices ___ for catfish production than for certain more established species such as trout.

1) are more stable
2) fluctuate more
3) are lower

______f. The unavailability of ___ may prohibit start-up or limit production.

1) channel catfish
2) experienced farm labor
3) processing plants and markets

______g. Cash flow is ___ until crop is harvested.

1) increased
2) delayed
3) moderated

4. Arrange in order the phases of fingerling production. Write a "1" before the first phase, a "2" before the second phase, and so on.

______a. Managing sac-fry

______b. Stocking and pairing broodfish

______c. Stocking fingerling grow-out ponds and feeding fry until they reach desired fingerling size.

______d. Managing spawning

TEST

______e. Maintaining and feeding swim-up fry

______f. Managing incubation and hatching

5. Complete guidelines for stocking broodfish. Write the correct numbers in the blanks.

______a. For maximum spawning rate ___.

1) stock domestic broodfish that are at least 3 to 4 years old
2) stock wild broodfish that are at least 2 to 3 years old
3) stock domestic broodfish no more than 2 years old

______b. Determine the sex of broodfish so that they can be stocked in equal numbers or in other common female-to-male ratios such as ___.

1) 1:2 or 2:3
2) 1:3 or 2:4
3) 2:1 or 3:2

______c. Select ___ broodfish with good sex characteristics: full, well-rounded abdomen; soft, movable sex organs; pink genitals.

1) male
2) female
3) male and female

______d. Select ___ broodfish with good sex characteristics: heavily muscled head wider than body; dark color under jaw; large, protruding genital papilla.

1) male
2) female
3) male and female

______e. Stock broodfish so that their total weight is not over ___ per surface acre of water.

1) 1,000
2) 1,200
3) 1,500

6. Complete statements about raising broodfish in pens. Write the correct numbers in the blanks.

______a. Broodfish may be spawned in pens roughly 10 feet long by 5 feet wide placed in ___; the sides of the pen are embedded in the pond bottom and should extend at least ___ above water.

1) 4 to 5 feet of water near the outlet; 10 inches
2) 2 to 3 feet of water near the shore; 12 inches
3) 3 to 4 feet of water near the inlet; 2 feet

TEST

______b. A spawning container is placed in the pen, generally with its open end ___.

1) toward the center of the pond
2) toward the shore
3) toward the surface of the water

______c. Special care must be taken to select spawning pairs ___: in the confines of the pen, the male can injure and even kill the female.

1) from the same hatching
2) in which the male is smaller than the female
3) of about equal size

______d. Spawning activity usually begins when the nightly water temperature stabilizes above ___; the female releases batches of eggs over a period of time, and the male releases ___ to fertilize them.

1) 65°F; malt
2) 75°F; molt
3) 70°F; milt

______e. The eggs fall to the bottom of the spawning container in a mound held together with ___.

1) glair
2) a sticky adhesive material
3) milt

______f. Spawning containers are checked every ___, preferably in the late morning.

1) 2 to 4 days
2) 2 to 4 hours
3) 2 to 4 weeks

______g. After the parent fish spawn, the eggs may be moved to the hatchery and the brooding pair removed and replaced in the pen with a new pair of broodfish, or ___.

1) the male may be removed and the female left to hatch the eggs
2) the female may be removed and the male left to hatch the eggs
3) the male, female, and spawning container may be moved to another spawning pen

7. Select from a list factual statements about managing spawning broodfish in open ponds. Write an "X" in the blank before each true statement.

______a. Open pond spawning is more demanding than pen spawning.

______b. Open pond broodfish do not need to be selected, sexed, or paired.

TEST

______c. Two or three spawning containers for each four pairs of fish are placed in the pond.

______d. Spawning containers are placed no deeper than 4 feet, with their open ends generally facing the shore.

______e. The location of each spawning container is marked with a float or stake.

______f. Spawning containers in open ponds are checked every 2 to 4 hours, preferably in late morning.

______g. Eggs can be left to be incubated by the female in the pond.

______h. It is to the producer's advantage to transfer the eggs to an incubation trough in a hatchery.

______i. If eggs are hatched in the pond, the fry may be transferred to nursery ponds with a pair of females.

______j. The fry may be left in the pond and the broodfish removed.

______k. Whether left in the pond or transferred, fry numbers should be estimated.

8. Select from a list factual statements about egg, fry, and fingerling management. Write an "X" in the blank before each true statement.

______a. Egg masses are generally transferred to hatching troughs or incubators inside the nursery.

______b. Paddles rock the egg masses and cause oxygen-rich water to flow through them in imitation of the female's fanning action.

______c. With a trough water flow of about 5 gallons per minute and a minimum maintained water temperature of 78°F, hatching takes place in 7 or 8 hours.

______d. Sac fry that hatch from the eggs are usually kept in the hatching trough.

______e. Sac fry require no feed because they get their nutrition from the yolk sac.

______f. When the yolk sac is absorbed 3 to 5 weeks after hatching, the fry swim to the surface for food.

______g. Swim-up fry are transferred to rearing troughs or earthen fry ponds.

______h. Swim-up fry reared in a trough are fed high-protein meal (45% to 50% crude protein) every 2 to 4 hours around the clock.

______i. Pond-reared swim-up fry feed on parasites, particularly crustaceans, and are also fed 5 to 10 pounds of "starter" meal or pellets per acre two or three times a day.

TEST

______j. After 3 to 6 days, swim-up fry are stocked in fingerling rearing ponds.

______k. Generally fingerlings are stocked to grow to fish-food sizes within 120 to 150 days.

______l. Fingerlings are fed one or two times a day at a rate based on a percentage of th standing crop weight.

9. Complete statements about fry stocking rates for fingerling grow-out. Write the correct numbers in the blanks.

______a. Fry are stocked by ___.

1) volume per surface acre
2) weight per surface acre
3) number per surface acre

______b. The stocking rate depends on ___.

1) desired size at harvest and maximum protein in feed
2) desired size at stocking and maximum days to harvest
3) desired size at harvest and limit on maximum feeding rate

______c. The more intense the stocking rate, the ___.

1) smaller the catfish at harvest
2) fewer days until harvest
3) less expensive the harvest

10. List four guidelines for obtaining fingerlings for food-fish production.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

d. ______________________________

____

TEST

11. Provide data about size options for stocking fingerlings for food-fish production. Write the correct rates in the blanks.

    a. Clean-crop fall harvesting of food-sized catfish requires the purchase of ________________ to ________________-inch fingerlings in the spring.

    b. Partial harvesting, or topping off, requires the purchase of fingerlings of mixed sizes (________________ to ________________ inches), and the restocking of one ________________-inch fingerling for each pound of fish harvested.

    c. To shorten the growing period, or to culture larger sport fish or fish suitable for steaks or filets, stocker fish weight ________________ pound(s) or more should be stocked in the spring.

12. Provide data about food-fish stocking rates. Write the correct stocking rates in the blanks.

    a. New producers should consider not stocking more than ________________ to ________________ fish per surface acre of water if the desired market size is ____________ pound(s) or more.

    b. Stocking rates for extensive production vary from ________________ to ________________ catfish fingerlings per surface acre of water.

    c. Stocking rates for intensive production vary from ________________ to ________________ or more catfish fingerlings per surface acre of water.

13. Distinguish among types of commercial catfish feed. Write "EF" in the blanks before descriptions of extruded floating feed, "PS" before pelleted sinking feed, and "MF" before medicated feed.

    ______a. The greatest advantage of this feed is its low price.

    ______b. This is generally the preferred feed for winter feeding.

    ______c. This feed is preferred by most producers because stock can be observed and monitored while eating.

TEST

_____d. Requiring more management than others, the pellets of this feed fall apart in the water and get lost in the bottom mud, adding to organic debris.

_____e. This feed contains added medications (antibiotics), either on the surface or added to the ingredients.

_____f. This feed can be purchased in an 80/20 ratio.

_____g. This feed is generally more water stable than others and does not get lost in the vegetation or bottom mud.

14. Complete statements about size and quality of catfish feed. Write the correct numbers in the blanks.

_____a. Feeds are available in ___-pound bags and can be delivered in ___ to ___-ton bulk loads.

1) 50; 20, 22
2) 40; 10, 12
3) 25; 5, 10

_____b. Feeds are manufactured in a variety of sizes from _____; it is important to match the feed size to the fish size.

1) powder fine to 4-inch blocks
2) meal crumble to large pellets
3) pea size to 1-inch pellets

_____c. ___ feed sizes are used in ponds containing ___ sizes of fish.

1) Small; medium
2) Large; small
3) Mixed; mixed

_____d. The highest quality feed is nutritionally complete; it contains vitamin and mineral premixes, and its protein content is between ___.

1) 22 and 25 percent
2) 32 and 35 percent
3) 42 and 45 percent

_____e. ___ feeds may be of high quality, but they do not contain all the essential ingredients or adequate levels to be nutritionally complete.

1) Supplemental
2) Broodfish
3) Extruded

TEST

15. Select from a list guidelines for feeding food fish. Write an "X" in the blank before each true guideline.

_____a. Calculate basic feed allowances against average expected gains or use a feeding chart.

_____b. As a rule of thumb, do not feed more than can be eaten in 5 to 10 minutes.

_____c. "Feed the fish, not the pond" by feeding a standard conversion rate.

_____d. Feed over-wintered catfish extruded floating feed to prevent weight loss and to maintain health.

_____e. Distribute the feed from the length of at least two banks of the pond, and over a larger area if the pond contains fish of different sizes.

_____f. Feed by broadcasting the feed from the bank or a boat in small ponds, or by mechanical feed blowers in large ponds.

_____g. Do not feed when temperatures are 50°F or less 2 feet below the water surface.

_____h. Feed fish once or twice a day between 9 A.M. and 5 P.M. or when levels of DO are low; avoid feeding close to or after sunrise.

_____i. Sample fish routinely and calculate food conversion ratios (FCR) to determine the cost and efficiency of your feeding program.

_____j. Store feed properly in a cool, dry area, and do not store over 60 days in summer.

16. Select from a list true statements about producing catfish in cages. Write an "X" in the blank before each true statement.

_____a. Bodies of water that cannot be seined, drained, or otherwise harvested can be used for small-scale catfish production in cages.

_____b. Small-scale production can be carried out in almost any farm pond of 5 acres or more with a depth of 8 feet or deeper; larger-scale production requires a body of water at least 10 acres in area.

_____c. Cages are floated in the water, their tops several inches above the surface for ease of feeding, and their bottoms 2 to 4 feet from the pond bottom so that the water supply is not fouled by fish wastes.

_____d. Cages allow for the production of several noncompatible species at the same time.

_____e. Cages are usually stocked with channel catfish 8 to 12 inches long at a density of 10 to 20 per cubic foot.

TEST

_____f. Caged fish must be fed a nutritionally complete sinking feed of high protein content—32% to 38% protein.

_____g. To reduce losses from stress or disease, medicated feed is often fed for the first 10 to 14 days after stocking.

_____h. The fish should be fed at least 4 days a week and only in amounts that they will eat in 5 minutes.

17. List three advantages of cage culture.

a. ____

____

b. ____

____

c. ____

____

18. List five limitations of cage culture.

a. ____

____

b. ____

____

c. ____

____

d. ____

____

e. ____

____

TEST

19. Discuss tank and raceway culture of channel catfish by answering the following questions.

    a. What three container culture systems can be used to produce channel catfish?

       1) ____________________

       2) ____________________

       3) ____________________

    b. Why do container systems require a continual supply of high-quality, highly oxygenated water?

       ____

    c. What is the major limitation of container systems that require pumping?

       ____

    d. What equipment do those units that recirculate water require?

       ____

    e. Why must container cultured catfish be fed high-quality nutritionally complete feeds?

       ____

    f. Though container culture is cost prohibitive for commercial production, where is it used most successfully?

       ____

(NOTE: If the following activities have not been completed prior to the test, schedule due dates and evaluation times with your instructor.)

20. Keep daily, weekly, and monthly production records. (Assignment Sheet #1)

21. Calculate stocking rates. (Assignment Sheet #2)

22. Calculate FCR and estimate fish weights from feed records. (Assignment Sheet #3)

23. Calculate feed requirements and costs. (Assignment Sheet #4)

24. Demonstrate the ability to perform pond sampling to estimate average fish weights and standing crop weight. (Job Sheet #1)

COMMERCIAL CATFISH PRODUCTION
UNIT IX

ANSWERS TO TEST

1. a. 9
   b. 6
   c. 12
   d. 3
   e. 1
   f. 5
   g. 13
   h. 11
   i. 2
   j. 10
   k. 4
   l. 8
   m. 7

2. a. 1
   b. 3
   c. 2
   d. 2
   e. 1

3. a. 3
   b. 1
   c. 1
   d. 3
   e. 2
   f. 3
   g. 2

4. a. 4
   b. 1
   c. 6
   d. 2
   e. 5
   f. 3

5. a. 1
   b. 3
   c. 2
   d. 1
   e. 2

6. a. 2
   b. 1
   c. 3
   d. 3
   e. 2
   f. 1
   g. 2

ANSWERS TO TEST

7. b, c, e, h, j, k

8. a, c, d, e, g, h, k, l

9.
   a. 3
   b. 3
   c. 1

10. Answer should contain any four of the following:

    a. Purchase fingerlings from a reliable dealer with a reputation for providing healthy stock.

    b. Do not accept fish that have frayed fins, are obviously skinned up, or that have red blotches or white spots resembling salt on their skin.

    c. Try to be present to verify sizes, weights, and counts when fish are loaded on the transport truck.

    d. Follow the transport truck to the farm, and supervise to make sure that the correct number of fingerlings are stocked in each pond, and that the fish are well-acclimated to the pond water.

    e. Obtain an agreement from the fingerling supplier that specifies liability or fish replacement policy in case of fish losses during or shortly after stocking.

11.
    a. 5, 6
    b. 4, 8, 5
    c. ½

12.
    a. 3,000, 4000; 1¼
    b. 500, 2,000
    c. 2,500, 6,000

13.
    a. PS
    b. PS
    c. EF
    d. PS
    e. MF
    f. PS
    g. EF

14.
    a. 1
    b. 2
    c. 3
    d. 2
    e. 1

ANSWERS TO TEST

15. a, e, f, g, i

16. a, c, d, f, g

17. Answer should include any three of the following:

    a. Allows for use of marginal bodies of water.
    b. Does not require expensive alteration of the land.
    c. Start-up investment is lower than for pond or container production.
    d. Recordkeeping is easier because the catfish can be seen and do not require catching for weighing and monitoring.
    e. Harvesting is easy as the cages merely need to be lifted from the water.

18. Answer should include any five of the following:

    a. The cost of cage construction is relatively high because durable materials are expensive.
    b. There is little commercial application in ponds less than 5 acres in area.
    c. A hole in the wire or mesh, or wind damage to the cage can result in the loss of fish.
    d. Cages can be vandalized and fish stolen.
    e. Fish are more susceptible to death from low DO.
    f. There will be considerable size variation if fish are not graded.
    g. There is no large-scale commercial value.
    h. Disease and parasite outbreaks may increase because the fish are stressed by crowding.

19. a. Linear or circular raceways, tanks, or vats
    b. Uneaten foods and fish wastes must be flushed from the container
    c. Suitable quality water at an affordable cost
    d. Backup ammonia and biological filters, pumps, emergency power units
    e. Because the tank bottom and water provide no supplemental nutrients
    f. In hatcheries and for research

20—23. Evaluated to the satisfaction of the instructor

24. Evaluated according to criteria in Practical Test #1

COMMERCIAL TROUT PRODUCTION
UNIT X

UNIT OBJECTIVE

* Trout Raceways

After completion of this unit, the student should be able to discuss the principles of commercial trout production; calculate loading rates; predict ammonia loads based on fish load, food consumption, and water flow rates; artificially spawn trout broodfish; and inventory a raceway load. These competencies will be evidenced by correctly completing the procedures outlined in the assignment and job sheets and by scoring a minimum of 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to commercial trout production with their correct definitions.
2. Select factual statements about trout culture.
3. Label the external anatomy of a rainbow trout.
4. Complete statements about basic water quality requirements.
5. Match types of trout farming enterprises with their correct descriptions.
6. List the phases of trout production.
7. Complete statements about broodfish management.
8. Complete statements about egg management.
9. Complete statements about fry and fingerling management.
10. Select from a list general guidelines for feeding different sized fish.
11. Select from a list general management guidelines.
12. Select facts about types of impoundment and rearing units.
13. Select facts about raceway design.
14. Match water use systems with their correct descriptions.
15. Complete statements about typical stocking/loading rates.

* Courtesy Clear Springs Trout Company, Buhl, Idaho.

OBJECTIVE SHEET

16. Distinguish between Flow Index and Density Index.

17. Keep trout production records. (Assignment Sheet #1)

18. Calculate raceway carrying capacity based on flow and density indexes. (Assignment Sheet #2)

19. Predict ammonia loads based on food consumption, fish load, and water flow rate. (Assignment Sheet #3)

20. Demonstrate the ability to:

    a. Artificially spawn trout broodfish. (Job Sheet #1)

    b. Inventory a raceway load. (Job Sheet #2)

COMMERCIAL TROUT PRODUCTION
UNIT X

SUGGESTED ACTIVITIES

A. Read unit and prepare own notes and examples.

B. Invite a representative from the U.S. Fish and Wildlife Service or a state or federal trout hatchery to speak to the class about trout production.

C. Provide students with objective sheet. Discuss unit and specific objectives.

D. Provide students with information sheet. Discuss information sheet, personalizing and localizing it to meet the needs of your class and locality.

E. Obtain data from a commercial trout operation so that students can complete Assignment Sheet #1.

F. Provide students with assignment and job sheets. Discuss and schedule assignment sheets. Use overheads to demonstrate completion of record-keeping forms.

G. Schedule, demonstrate, and evaluate job sheet procedures. Have students work with experienced trout producer to perform Job Sheet #1.

H. Give written test. Critique in class.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Beem, Marley, and Glen Gebhart. "Cage Culture of Rainbow Trout," *Langston University Extension Facts*. Langston, Oklahoma: Langston University with support of the USDA/Cooperative State Research Service, n.d.

B. Kincaid, H. L., W. R. Bridges, A. E. Thomas, and M. J. Donahoo. "Rearing Capacity of Circular Containers of Different Sizes for Fry and Fingerling Rainbow Trout," *The Progressive Fish Culturist*, Vol. 38, No. 1, January 1976.

C. Klontz, George W., Philip C. Downey, and Richard L. Focht. *A Manual for Trout and Salmon Production*. Murray, Utah: Sterling H. Nelson and Sons, Inc., Murray Elevators Division, 1979, rev. 1985.

D. Marriage, L. Dean, Audrey E. Borell, and Paul M. Scheffer. *Trout Ponds for Recreation*. Washington, D.C.: U.S. Government Printing Office, 1976.

E. Piper, Robert G., et. al., *Fish Hatchery Management*. Washington, D.C.: United States Department of the Interior, Fish and Wildlife Service, 1982.

F. Scheffer, Paul M. and L. Dean Marriage. *Trout Farming*. Leaflet 552. Washington, D.C.: U.S. Department of Agriculture, U.S. Government Printing Office, 1975.

COMMERCIAL TROUT PRODUCTION
UNIT X

INFORMATION SHEET

I. Terms and definitions

A. **Eyed egg** — Egg in which two black spots—the developing eyes of the embryo—can easily be seen

B. **Alevins (sac fry)** — Fry that obtain nourishment from attached yolk sac

C. **Swim-up fry** — Fry that have lost their yolk sac and are ready for food

D. **Hen** — Female trout

E. **Cock** — Male trout

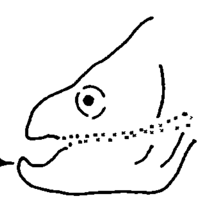
F. **Ripe** — Containing fully developed eggs; ready to spawn

G. **Stripping** — Manually releasing eggs and milt from broodfish

H. **Milt** — Secretion that contains sperm produced by a male fish

I. **Kype** — Upward curving hook of lower jaw that occurs at spawning

EXAMPLE: FIGURE 1

Kype →


J. **Feed conversion ratio (FCR)** — The average number of pounds of feed eaten by the fish to gain 1 pound of weight

EXAMPLE: An FCR of 1.5 means that the trout consumes 1.5 pounds of feed to gain 1 pound of weight. It takes about 2 pounds of feed to produce a 1 pound fish under favorable growing conditions.

K. **Anadromous** — Fish that lives in salt water but spawns in fresh water

L. **Complete feed** — Feed that supplies 100 percent of the dietary requirements of the fish; used when there is little or no access to natural food

M. **Total length** — Length between tip of snout and end of tail

N. **cfs** — Cubic feet per second

O. **fps** — Feet per second

INFORMATION SHEET

P. **Water-hardening** — Process that takes place within a 30 to 90 minute period after spawning in which the egg become turgid with water, loses its stickiness, and can no longer be fertilized

Q. **Shocking** — Process of sharply striking egg trays, siphoning eggs from one container to another, or pouring eggs from incubator trays into tub of water from 2 or 3 feet to detect undeveloped or infertile eggs

(NOTE: Shocking is done after the eggs have developed to the eyed stage. Undeveloped or infertile eggs remain tender. They rupture when shocked, allowing water to enter the egg and coagulate the yolk, which turns the egg white. The white eggs can easily be picked out and discarded.)

R. **Standard Environmental Temperature (SET)** — The temperature at which all of the species' physiological systems operate optimally

(NOTE: Each species of fish has its own SET. The SET for rainbow trout is 59°F. For each degree Fahrenheit below SET there is a corresponding 5 percent decrease in growth rate from the optimum permissible at SET. This means that at 39°F [20°F below SET], growth virtually ceases for the rainbow trout.)

S. **Weir** — A structure for measuring/controlling water flow

T. **Total ammonia** — The measurement of both forms of dissolved ammonia, ammonium, NH_4+ (ionized), and ammonia, NH_3 (un-ionized)

(NOTE: Total ammonia is also referred to as ammonia nitrogen, but it is the total ammonia values that are normally reported. The ammonia, NH_3, value is calculated from pH and temperature. Using ammonia ionization tables helps make the calculations easier.)

II. Facts about trout culture

A. Trout belong to the family *Salmonidae,* in which there are 68 species.

B. The three most commonly farmed species are rainbow trout, Atlantic salmon, and Coho salmon.

C. There are 14 species of trout in North America, but the rainbow trout (*Oncorhynchus gairdneri*) is the species of most importance in fish farming.

D. All members of the family *Salmonidae* are cold water fish preferring clean, highly oxygenated water and water temperatures below 68°F.

E. Trout are the most popular table fish in the U.S., command a good price on the market, and enjoy a high status among freshwater sport fish.

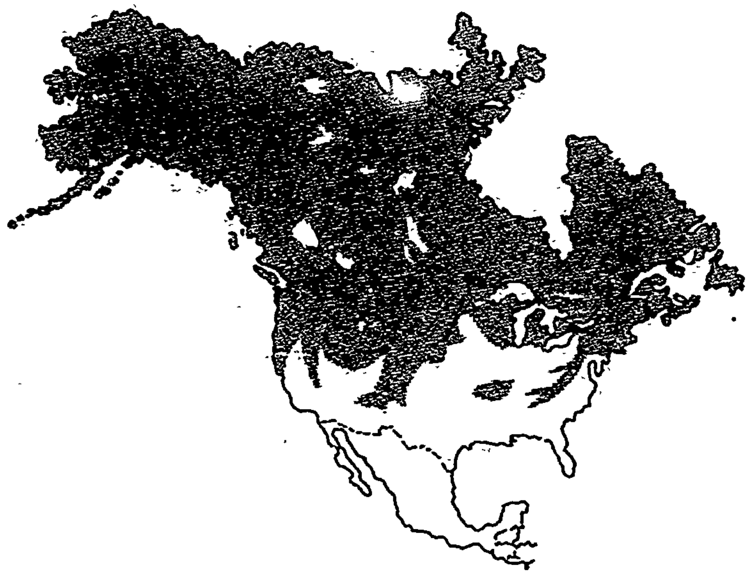
F. The world commercial production of cultured trout is over 127 million pounds per year, not counting those grown in small ponds for home and local consumption.

INFORMATION SHEET

G. Because trout are coldwater species, most large commercial trout farms in the U.S. are located in the northern states, with Idaho being the leading trout-producing state; but trout are also successfully produced as far south as northern Georgia. (See Figure 2 map.)

(NOTE: The shaded part of the map indicates where trout farming is most likely to be successful. However, at any elevation or in any latitude, raceways or ponds fed by cold springs or cold-water wells are suitable for trout farming.)

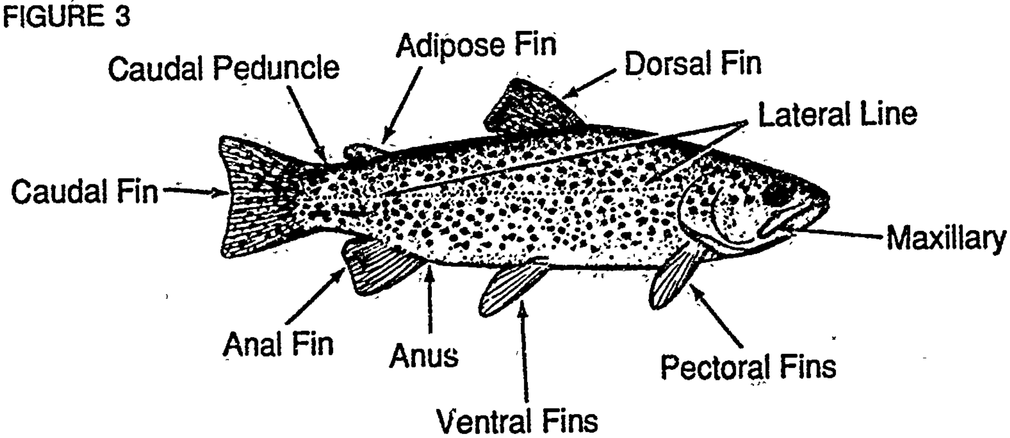
EXAMPLE: FIGURE 2



H. In some southern states—such as Mississippi, Missouri, Oklahoma, Arkansas, and Texas—rainbow trout are often cage cultured in freshwater ponds during a winter growing period of about 150 days.

III. **External anatomy of a rainbow trout** (Figure 3)

FIGURE 3



INFORMATION SHEET

IV. Basic water requirements for trout culture

A Temperature — Water temperatures can range between 33°F and 78°F, but water temperatures between 50°F and 60°F are best for optimum growth; the SET for rainbow trout is 59°F.

(NOTE Not only do trout make their fastest growth at a SET of 59°F and within a 50 F to 60°F range, but at these water temperatures, they are less susceptible to parasites and disease.)

B Flow rate -- Raceway water flow of between 0.05 to 0.09 fps is sufficient to flush out waste but does not overwork the trout, causing them to use too much energy swimming against the flow.

C Exchange rate - The optimum water replacement time for raceways is 20 to 30 minutes or 2 to 3 changes of water per hour.

D Oxygen - Water must have at least 5 ppm of DO, and saturation is optimum; 7 ppm is the minimum where eggs are hatched.

E Hardness — Hard water—50 to 250 ppm dissolved solids or more—produces trout more economically than soft water, and management problems are fewer.

F Nitrite - Levels of as little as 0.05 are fatal; levels should be held below 0.1 to 0 2 mg L for optimum growth and health.

G. pH — pH should be maintained between 7.5 and 8.0.

POINT OF INTEREST At a pH of 6 to 6.5 the mucous slimecoat of fish is virtually nonexistent and the fish "feel dry."

H Ammonia — NH . the un-ionized form, is toxic to fish; if levels exceed 0.0125 ppm a decline in trout growth and health may occur. (Assignment Sheet #3)

(NOTE The level of NH toxicity depends mainly upon the pH of the water. An increase of one pH unit from 8.0 to 9.0 increases the amount of un-ionized ammonia approximately ten times.)

V. Types of trout farming enterprises

A Fee-fish pond -- Eight-inch and larger trout are stocked in a pond and fished by the public for a fee, some operators lease fishing privileges on an annual basis

B Eyed-egg production — Adult trout are reared and held in isolated raceways or ponds until the spawning season when the female is ripe; the eggs are then stripped from the female and fertilized. (Job Sheet #1)

(NOTE The eggs are called eyed eggs when the eyes of the embryonic trout are visible—usually within 2 or 3 weeks.)

INFORMATION SHEET

C. **Fingerling production** — Eyed eggs are managed in special hatching trays through which water flows continually; after hatching, fish are managed until they grow to fingerling size—1 to 6 inches; they are then sold to other growers or to private pond owners.

D. **Food-fish production** — Fingerlings are grown in raceways until they are about 8 to 14 inches long; they are then sold to restaurants, retail markets, fee-fish operators, or to private pond owners.

VI. **Phases of trout production**

A. Broodstock maintenance and spawning

B. Egg incubation and hatching

C. Sac fry management

D. Swim-up fry maintenance and feeding

E. Fingerling to food fish management and feeding

VII. **Broodfish management**

A. Female broodfish should be between 3 to 4 years old for quality egg production (numbers, size, and viability of eggs).

B. Use male broodstock 2 to 3 years old.

C. Rotate in new, younger broodstock and dispose of broodstock that has become too old.

D. Know the spawning times for the strain of rainbow trout you are culturing.

(NOTE: Different strains of rainbow trout spawn at different times of the year. It is now possible to get eggs at all months of the year, though it is more difficult to find eggs during the mid-summer months.)

E. Maintain broodstock in water temperatures of 56°F or less.

F. Female broodstock will develop distended bellies and swollen vents as their spawning time nears.

G. Male broodstock will have a pronounced kype and bright color during the spawning period.

VIII. **Egg management**

A. Ship eggs only in one of four developmental stages: as immature eggs in the living female, as mature unfertilized eggs, as fertilized, water-hardened eggs, or as eyed eggs; the latter two methods are preferred.

B. Take great care not to jar or shake the eggs during their sensitive stage—a period extending roughly 48 hours after water-hardening.

(NOTE. Salmonid eggs remain tender until the eyes are sufficiently pigmented to be visible.)

C. Shock, clean, measure, and count eggs during the eyed stage of development.

D. Disinfect eggs received from other hatcheries in a separate facility to prevent spread of disease.

E. Maintain eggs on submerged screen trays in a hatching trough or vertical tray incubator, and ensure that oxygen-rich water flows through them.

F. Maintain DO content of water at 7 ppm during incubation.

G. Keep eggs covered and away from direct light.

H. Incubate eggs at optimum temperatures for the strain you are culturing. (See Table 1.)

EXAMPLE: TABLE 1 **Number of Days and Daily Temperature Units Required for Trout Eggs to Hatch**

	Water Temperature, °F					
Species	35	40	45	50	55	60
Rainbow trout						
Number of days to hatch	--*	80	48	31	24	19
Daily temperature units	--	640	624	558	552	532
Brown trout						
Number of days to hatch	156	100	64	41	-	--
Daily temperature units	468	800	832	738	--	--
Brook trout						
Number of days to hatch	144	103	68	44	35	--
Daily temperature units	432	824	884	799	805	--
Lake trout						
Number of days to hatch	162	108	72	49	--	--
Daily temperature units	486	864	936	882	--	--

*Spaces without figures indicate incomplete data rather than proven inability of eggs to hatch in those temperatures.

(NOTE: One daily temperature unit [DTU] equals 1°F above freezing [32°F] for a 24-hour period. For example, if the water temperature for the fist day of incubation is 56°F, it would contribute 24 DTU [56°-32°]. DTU can be used as a guide to estimate hatching dates.)

Table and information from Leitritz and Lewis as found in Piper's *Fish Hatchery Management.*

INFORMATION SHEET

IX. Fry and fingerling management

A. Yolk-sac fry

1. Yolk-sac fry require no feed because they get their nutrition from the yolk sac.

2. When the yolk sac is absorbed, the fry swim to the surface for food.

3. Swim-up fry are transferred to rearing troughs.

B. Swim-up fry

1. Swim-up fry are reared in troughs ranging in size from 12′ × 18" × 12" up to 20′ × 3′ × 3′.

2. Swim-up fry require a feed containing a minimum of 45 percent to 50 percent protein.

C. Fingerlings

1. Once fingerlings are 2+ inches, they can be placed in raceways or ponds.

2. Fingerlings require a feed containing at least 35 percent to 50 percent protein.

X. General guidelines for feeding different sized trout

> POINT OF INTEREST: It takes about 2 pounds of feed to produce a 1-pound trout in 10 to 14 months in water temperatures of 50°F to 65°F. If raised in water colder than 50°F, trout take 2 years or more to reach market size; in water warmer than 65°F, they grow slowly and are more susceptible to diseases.

A. **Swim-up fry** — Feed starter feed from around-the-clock automatic feeders, or feed small amounts eight or nine times a day, distributing feed well across the water surface.

B. **Fry 1 to 2 inches** — Feed recommended starter feeds of slightly larger granule size (#1 or #2), but watch fry closely: If fry are taking the feed into their mouths and "spitting" it out, the feed is probably too large; feed eight or nine times a day or with an automatic round-the-clock feeder.

C. **Fingerlings 2½ inches to 4½ inches** — At 2½-inch size, feed fine crumbles (#3), and progress to coarse crumbles (#4) four or five times a day.

INFORMATION SHEET

D. **Trout 4 to 6 inches** — Feed ⅛-inch pellet (#5) four times daily according to the feeding chart, taking care to distribute the feed evenly.

E. **Trout 6 inches and larger** — Feed intermediate sized pellet (3⁄16-inch, #6) four times a day.

F. **Broodstock** — Feed ¼-inch pellet one or two times a day.

XI. General management guidelines

A. Calculate feeding rates and use the detailed feeding schedules provided by fish feed dealers so that you do not over- or underfeed.

B. Feed rainbow trout a high-quality, complete commercial feed with a minimum protein content of 36 percent.

(NOTE: Trout are carnivorous, so require a high percentage of protein in their diets. The protein should be at least 90 percent digestible.)

C. Regularly monitor DO, water temperature, pH, and ammonia.

D. Keep routine and accurate records, keep daily records of mortality and feed fed. (Assignment Sheet #1)

E. Establish a regular routine of raceway cleaning, inventorying, and fish grading. (Job Sheet #2)

F. Regularly examine fish and fish growth data for signs of impending disease problems.

G. Practice partial harvesting so that fish do not become overcrowded, or have ready enough extra raceways for fish to grow into.

H. Measure raceway water flow rates and volumes—do not guess. (Assignment Sheet #2)

INFORMATION SHEET

XII. Types of impoundment or rearing units for trout culture

A. Trout are most commonly produced in container culture systems in which **linear or circular raceways**, tanks, or vats are used. (Figure 4)

EXAMPLE: FIGURE 4 — Linear Raceway

Courtesy Nebraska Game and Parks Commission

B. Trout may be cultured in **earth ponds** through which a constant flow of high-quality water moves; these ponds can be as small as 0.1 acre, but depth or flow must be sufficient to maintain high DO and cool water temperature; the bottoms of these ponds should be covered with coarse gravel (cobble).

(NOTE: Ponds are more difficult to keep clean, and their fish loads are lower than raceways.)

C. Trout may be intensively cultured in **cages**, both in freshwater and in sea water; cage culture allows the producer to take advantage of lakes and reservoirs too large for intensive culture, irrigation canals, winter ponds in southern latitudes, and ocean bays.

XIII. Raceway design

A. Raceways vary in size, but a typical length times width times water depth (L × W × D) ratio is approximately 30:3:1.

EXAMPLES: 80′ × 8′ × 2.5′; 60′ × 6′ × 2′

INFORMATION SHEET

B. To prevent the trout from leaping out, 6 to 12 inches of freeboard is added to the water depth dimension.

C. The raceway floor slope should equal 0.6 inches to 1.0 inches per each 10 feet of length.

D. Raceways may be constructed of concrete, fiberglass, or dug out earth lined with a synthetic liner.

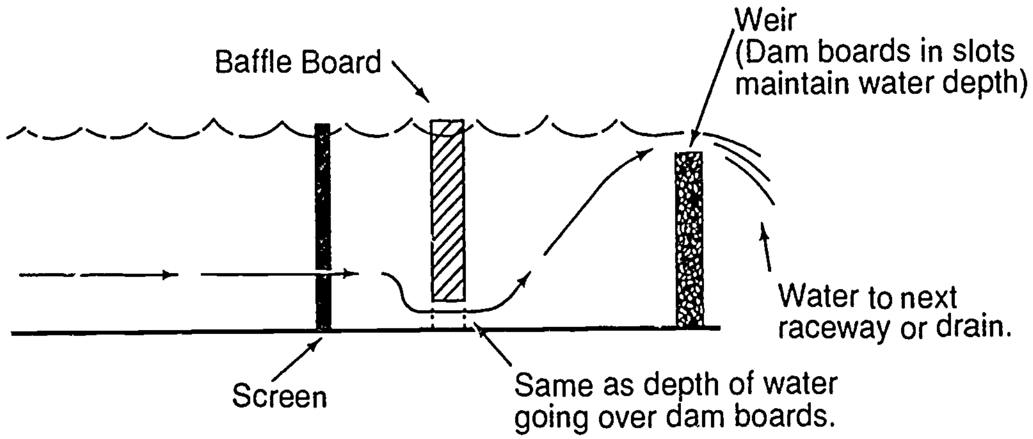
E. The overflow or drain end of the raceway should contain an across-the-raceway weir preceded by a baffle board, which is raised from the bottom the same distance as the depth of water flowing over the weir. (Figure 5)

(NOTE: Baffles, when properly used, keep the raceway bottom clean.)

F. A screen, containing approximately 1 square foot of screen for each 25 gpm water flow, is placed before the baffle board. (Figure 5)

(NOTE: An inexpensive screen can be made out of hail screen attached to a redwood frame; choose 1/4 inch or 1/2 inch mesh size depending on fish size.)

EXAMPLE: FIGURE 5



XIV. Water use systems

A. **Single pass** — Water flows through only one unit and is then discharged.

B. **Single reuse** — Two units in series use the same water.

INFORMATION SHEET

C. Multiple reuse — Several units in series use the same water.

(NOTE. Ideally, fish should be raised intensively in single-pass systems, but the lack of suitable quantities of water make this impractical. The culturist should know that the carrying capacity in succeeding reuse units will be less than that of the first pond in the series. There are no set figures for capacity reductions.)

XI. Typical stocking/loading rates

A. Stocking ponds

(NOTE: The carrying capacity of a pond is limited because of temperature build-up and oxygen content. Stocking rates are measured in pounds of fish per surface acre or in numbers. The following are generalized rates. The actual rate should always be specifically calculated for the species and water quality parameters of a pond.)

1. Coldwater ponds usually produce enough oxygen and natural food to support the extensive culture of about 100 pounds of trout per surface acre.

2. In the Midwest and Southwest U.S., spring stocking a 1-acre pond with 500 2- to 4-inch rainbow fingerlings will produce 7- or 8-inch (4 ounce) trout the first year; stocking half that rate will produce 10-inch (8-ounce) trout.

3. In the Mid- to Northeastern U.S., the standard fall stocking rate is 600 3- to 4-inch rainbow fingerlings per surface acre to produce 10-inch trout the first year.

4. In general, 2-inch to 4-inch trout fingerlings are more likely to survive to pan size than are 1-inch to 2-inch fingerlings.

B. Loading raceways

1. Raceway loading rates are dependent on many factors, but particularly on flow rates, exchange rates, DO levels, and water velocity.

2. As a rule of thumb, trout are loaded at densities in pounds per cubic foot no greater than 0.5 times their length in inches.

EXAMPLES: Load 2-inch trout at 1 pound per cubic foot; load 4-inch trout at 2 pounds per cubic foot; load 6-inch trout at 3 pounds per cubic foot, and so on.

C. Cages

1. In Oklahoma, the upper cage limit for trout is fifteen 7-inch (3-ounce) fingerlings per cubic foot of cage to produce ½-pound to ¾-pound fish at spring harvest.

INFORMATION SHEET

2. The maximum safe pond limit is about 1,200 trout per acre, but this figure can be exceeded with experience, especially in ponds over 5 acres and those with a constant flow of water through them.

XVI. Flow and density indexes

A. **Flow index** — The relationship of fish weight and size to water inflow; deals with amount of oxygen available for life support and growth

B. **Density index** — The relationship of fish weight and size to water volume; the spatial relationship of one fish to another

COMMERCIAL TROUT PRODUCTION
UNIT X

ASSIGNMENT SHEET #1 — KEEP TROUT PRODUCTION RECORDS

To be successful in trout production, you must be a good manager, and to manage your enterprise profitably, you must keep thorough and accurate records.

There are many reasons for keeping good records, one of the most important being that many lending institutions require records before they will lend money. You will also need your records for income tax purposes. Without records, you will not be able to calculate feed conversion ratios and optimum loading rates. You will not know whether you are making or losing money. And, finally, if you do not keep records, you will not be able to identify problem areas that need correcting for the most efficient and economical management.

This assignment sheet is based on National Fish Hatcheries' recordkeeping methods and recommendations. The following charts and instructions were printed in *Fish Hatchery Management*, a 1982 publication of the Fish and Wildlife Service, by Robert Piper, et al.

Your instructor will provide you with data from a commercial trout operation. Use that data to complete the following National Fish Hatcheries production records.

ASSIGNMENT SHEET #1

LOT HISTORY PRODUCTION

STATION	
LOT NUMBER	SPECIES

INITIAL FEEDING	DATE	NUMBER OF FISH	WEIGHT OF FISH	LENGTH	WEIGHT PER 1000 FISH

MONTH	FISH ON HAND END OF MONTH		WEIGHT PER 1000	MORTALITY	FISH SHIPPED		FISH ADDED		WEIGHT GAIN (POUNDS)		FOOD FED (POUNDS)		FEED COST	CONVERSION		UNIT FEED COST TO DATE	
	NUMBER 1000's	WEIGHT	POUND	NUMBER	NUMBER	WEIGHT	NUMBER	WEIGHT	MONTH	TO DATE	MONTH	TO DATE	TO DATE	MONTH	TO DATE	PER POUND	PER 1000
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
TOTAL																	

DAY OF YEAR (JULIAN)	MONTH	DIET IDENTIFICATION	LENGTH ON LAST DAY OF MONTH	CURRENT MONTH'S LENGTH INCREASE	NO. DAYS SINCE INITIAL FEEDING	AVERAGE DAILY LENGTH INCREASE (INCHES)		LENGTH INCREASE 30 DAY MONTH	TEMPERATURE UNITS		TEMPERATURE UNITS PER INCH GAIN	
			INCHES	INCHES		FOR MO	TO DATE		FOR MO	TO DATE	FOR MO	TO DATE
		18	19	20	21	22	23	24	25	26	27	28
TOTAL												

PERCENT SURVIVAL UNTIL TRANSFERRED, RELEASED OR DISTRIBUTED SAC FRY ________ % FEEDING FRY ________ % FISH ________ %

REMARKS

Temperature units are monthly temperature units, which equal 1°F above 32°F for the average monthly water temperature.

From *Fish Hatchery Management*. With permission.

COMMERCIAL TROUT PRODUCTION
UNIT X

ASSIGNMENT SHEET #2 — CALCULATE RACEWAY CARRYING CAPACITY BASED ON FLOW AND DENSITY INDEXES

The carrying capacity of a raceway is dependent on a number of factors, most particularly water chemistry, oxygen levels, flow rates, and fish densities. Most carrying capacity tables are based on the maximum fish load possible without oxygen depletion.

In this assignment sheet you will use flow and density indexes to calculate raceway trout loading (carrying) capacities.

This assignment sheet is divided into three parts. Part I provides examples and information on Flow Index calculations. Part II provides information on Density Index calculations, and Part III presents some practical problems so that you may use the two indexes to practice calculating carrying capacities.

PART I

Carrying capacity is the animal load a system can support. Carrying capacity depends on water flow, volume, exchange rate, temperature, oxygen content, pH, size and species of fish being reared, and the accumulation of metabolic products.

In 1955, David Haskell presented two major premises . regard to raceway loading.

1. The carrying capacity is limited by oxygen consumption and accumulation of metabolic products.

2. The amount of oxygen consumed and the quantity of metabolic products produced are proportional to the amount of food fed.

Haskell states, "If the carrying capacity of a trough or pond is known for any particular size fish at a particular temperature, then the safe carrying capacity for other sizes and temperatures is that quantity of fish which will require the same weight of feed daily."

Based on Haskell's premises, a formula was derived for a *Flow Index* in which fish size in inches is used instead of weight of food fed to calculate the safe carrying capacity for various sized trout.

EXAMPLE. 900 pounds of trout can safely be held in a raceway supplied with 150 gpm water. What is the Flow Index?

1. To calculate the Flow Index, use the formula:

   $F = W \div (L \times W)$

   Where F = Flow Index

   W = Known permissible weight of fish

   L = Length of fish in inches

   W = Water inflow in gpm

ASSIGNMENT SHEET #2

$$F = W \div (L \times W)$$

$$= 900 \div (4 \times 150)$$

$$= 1.5$$

2. To find the maximum or permissible weight of fish when it is not known, either add fish to a rearing unit with a uniform water flow until the oxygen content is reduced to the minimum acceptable level (5 ppm for trout), or determine the existing weight of fish in a rearing unit by adjusting the water inflow until the oxygen content is reduced to 5 ppm; then use the Flow Index and the following formula to determine permissible loading weight:

   $W = F \times L \times I$

   Where W = Maximum fish weight

   F = Flow Index

   L = Length of fish in inches

   I = Inflow requirement in gpm

   EXAMPLE: In the example above, a Flow Index of 1.5 was determined for a raceway safely holding 900 pounds of 4-inch trout in 150 gpm water flow. (1) How many pounds of 8-inch trout can be loaded? (2) How many pounds of 2-inch trout?

   (1) $W = F \times L \times I$

   $= 1.5 \times 8 \times 150$

   = 1,800 pounds of 8-inch trout

   (2) $W = F \times L \times I$

   $= 1.5 \times 2 \times 150$

   = 450 pounds of 2-inch trout

3. If the weight of the fish is increased or decreased in a raceway, the adjusted water inflow requirement can be calculated using the formula:

   $I = W \div (F \times L)$

   $= (1800 + 450) \div (1.5 \times 8)$

   = 188 gpm inflow

ASSIGNMENT SHEET #2

PART II

While the Flow Index allows the calculation of carrying capacity in relation to water flow, or, more specifically oxygen availability, the Density Index allows the culturist to load fish according to *density* — pounds of fish per cubic foot of .earing space.

A rule of thumb that is used to avoid overcrowding is to hold trout at densities in pounds per cubic foot no greater than 0.5 their length in inches: 2-inch trout at 1 pound per cubic foot, 4-inch trout at 2 pounds per cubic foot, and so on.

The following formula is used to avoid overcrowding raceways:

$W = D \times V \times L$

Where W = Permissible weight of fish

D = Density Index (0.5 for rainbow trout)

V = Volume of raceway in cubic feet

L = fish length in inches

Raceway or pond volumes can be calculated using the formula $V = W \div (D \times L)$.

PART III

Solve the following problems to practice calculating raceway carrying capacities.

1. 1200 pounds of 3-inch trout can be safely held in a raceway supplied with 225 gpm water. What is the Flow Index?
2. What would be the Flow Index in 1 above if the water flow was 175 gpm?
3. How many pounds of 8-inch trout can safely be held in a raceway with a Flow Index of 1.2 and an inflow rate of 150 gpm?
4. How many pounds of 4-inch trout can safely be held in a raceway with a Flow Index of 2.0 and an inflow rate of 250 gpm?
5. You want to add 350 pounds of 4-inch trout to the raceway in problem 4. What is the adjusted water inflow requirement?
6. You have a raceway that is 60 feet long by 6 feet wide with a 2 foot water depth. How many pounds of 8-inch rainbow trout can you safely load?
7. How many pounds of 4-inch rainbow trout can you load in a raceway that is 80 feet long, 8 feet wide, with a water depth of 2.5 feet?
8. How many pounds of 6-inch rainbow trout can be safely loaded in the raceway of problem 7?

ASSIGNMENT SHEET #2

9. How many pounds of 2-inch rainbow trout can be loaded in the raceway in problem 6?

10. Is the following statement true or false? Why? "Fish density can be increased as fish increase in size."

COMMERCIAL TROUT PRODUCTION
UNIT X

ASSIGNMENT SHEET #3 — PREDICT AMMONIA LOADS BASED ON FOOD CONSUMPTION, FISH LOAD, AND WATER FLOW RATE

When fish excrete ammonia into the water, some of it reacts with the water to produce ammonium ions, nontoxic forms of ammonia, and the rest is present as un-ionized ammonia, which at levels above 0.0125 ppm is toxic to trout. Standard water quality measurements do not distinguish between the two forms, and both are grouped as "total ammonia."

Because of the importance of ammonia to fish production, total ammonia in raceway or trout rearing water should be measured on a regular basis. However, the culturist can estimate total ammonia with a formula based on fish metabolism.

This assignment sheet is divided into two parts. Part I provides information and examples on calculating total ammonia. Part II presents some practical problems so that you may practice calculating total ammonia.

PART I

While ammonia can enter the water from the water source and from microbes breaking down waste feed, most of it comes from fish metabolism. The amount of metabolism and thus the amount of ammonia excreted is conditioned by the amount of food fish eat. Because of this, for each hatchery and feed type, an *ammonia factor* can be calculated with the following formula:

Ammonia Factor = ppm Total Ammonia × Inflow gpm ÷ Lb. Food/Day

To establish the factor, total ammonia should be measured in raceways, tanks, and ponds several times over one day. Once the factor is established, the formula can be turned around to give estimates of total ammonia:

ppm Total Ammonia = Lb. Food/Day × Ammonia Factor ÷ Inflow gpm

EXAMPLE. A raceway with three units in a series has a water flow of 200 gpm. Fish in the first unit receive 10 pounds of food per day, the second unit is fed 5 pounds of feed per day, and the third unit is fed 20 pounds of feed per day. The ammonia factor is 3.0. In the absence of any water treatment, what is the expected concentration of total ammonia nitrogen at the bottom of each unit?

Unit 1: $10 \times 3 \div 200 = 0.15$ ppm

Unit 2: $(10 + 5) \times 3 \div 200 = 0.23$ ppm

Unit 3: $(10 + 5 + 20) \times 3 \div 200 = 0.53$ ppm

ASSIGNMENT SHEET #3

PART II

Solve the following problems to practice calculating total ammonia in trout raceways and rearing units.

1. A raceway with four units in series has a water flow of 235 gpm. Fish in the first unit are fed 30 pounds of feed a day, those in the second unit are fed 14 pounds, those in the third unit are fed 7 pounds, and those in the fourth unit are fed 7 pounds. The ammonia factor is 2.5. What is the expected concentration of total ammonia nitrogen in the bottom of each unit?

   Unit 1 = ____________________

   Unit 2 = ____________________

   Unit 3 = ____________________

   Unit 4 = ____________________

2. A 2-unit raceway with an inflow of 300 gpm is fed 55 pounds of feed each unit daily. The ammonia factor is 2.6. What is the estimated total ammonia concentration in each unit?

   Unit 1 = ____________________

   Unit 2 = ____________________

3. What is the ammonia factor for a system with 0.42 ppm total ammonia, 250 gpm water flow, and 30 pounds of food fed per day?

   Ammonia factor = ______________

4. What would be the ammonia factor for problem 3 if the inflow was 150 gpm?

   Ammonia factor = ______________

5. What would be the ammonia factor for problem 3 if the fish were fed 60 pounds of feed?

   Ammonia factor = ______________

COMMERCIAL TROUT PRODUCTION
UNIT X

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1 — Evaluated to the satisfaction of the instructor

Assignment Sheet #2

1. 1.7
2. 2.2
3. 1,440 pounds
4. 2,000 pounds
5. 293 gpm
6. 2,880 pounds
7. 3,200 pounds
8. 4,800 pounds
9. 720 pounds
10. True; because of the relationship between the amount of feed that can be metabolized and the pounds of fish that can be carried

Assignment Sheet #3

1. Unit 1 = 0.32 total ammonia
   Unit 2 = 0.46 total ammonia
   Unit 3 = 0.54 total ammonia
   Unit 4 = 0.62 total ammonia

2. Unit 1 = 0.47 total ammonia
   Unit 2 = 0.95 total ammonia

3. 3.5 ammonia factor

4. 2.1 ammonia factor

5. 1.75 ammonia factor

COMMERCIAL TROUT PRODUCTION
UNIT X

JOB SHEET #1 — ARTIFICIALLY SPAWN TROUT BROODFISH

A. Equipment and materials

1. Spawning bench
2. Spawning pan
3. Cotton gloves
4. Anesthetic
5. Ripe female and male trout in separate holding tanks
6. Two additional holding tanks empty of fish
7. Dip nets
8. Tub of clean water
9. Balance scale sensitive to 1 gram
10. One-cup measure
11. Feather for stirring
12. Trout incubator

B. Procedure

1. Calculate the amount of anesthetic needed for each trout holding tank.

   (NOTE: This calculation is explained in Unit VIII if you need to review.)

2. Administer the correct amount of anesthetic to each of the holding tanks, and then set up work station while waiting for anesthetic to take its full effect.

   (NOTE: Rainbow trout placed in a 265 ppm solution of MS-222 require 30 to 45 seconds to become relaxed.)

3. Dip-net female trout from holding tank, and then rinse the anesthetic off by dipping the fish in and out of a tub of clean water.

JOB SHEET #1

4. Strip eggs from female trout:

(NOTE: Handle fish as little as possible to reduce stress, and avoid contaminating the eggs or sperm with blood, skin mucus, or water. Blood may clot and plug the egg's micropyle—the opening through which the sperm must enter. The fish's skin mucus may contain the anesthetic used to sedate the brood fish. If it contaminates the spawning pan, it will reduce sperm motility. Prolonged exposure of either eggs or sperm to water reduces fertility. The eggs water-harden and will no longer admit the sperm. Sperm mixed with water is very active for 15 seconds, but after 2 minutes, no activity is recorded.)

a. Grasp female trout near the head with your dominant hand.

b. Grasp female trout's body just above the tail with your non-dominant hand.

c. Hold the trout belly downward close to the lip of a clean, dry spawning pan. (Figure 1)

(NOTE: By positioning the fish at the lip of the pan, water running off of the fish and your hands will not go into the pan.)

d. Force eggs out by gently massaging the fish, beginning just forward of the vent and working back toward it. (Figure 1)

CAUTION: Avoid heavy pressure. Avoid putting pressure too far forward on the body as there is danger of damaging the heart or other organs.

FIGURE 1

Courtesy Nebraska Game and Parks Commission

JOB SHEET #1

e. If eggs do not flow freely, choose another female; the fish is not sufficiently ripe or the vent is malformed and plugged, and the fish should not be used.

f. When the eggs have been extruded, return the female fish to a holding tank containing no anesthetic and allow the fish to recover.

5. Holding the male fish over the pan of eggs, add a small amount of milt (sperm) from the male fish, stripping the milt in the same way that you stripped the eggs from the female fish. (Figure 2)

FIGURE 2

Courtesy Nebraska Game and Parks Commission

6. Return male broodfish to unanesthetized broodfish holding tank.

7. Add a half to a full cup of water to help activate the sperm, and gently but thoroughly mix the milt and eggs with your finger or a feather.

8. Leave the mixed eggs and sperm in a dim area undisturbed for 5 minutes.

9. Add water to wash the eggs; allow eggs to water-harden by leaving them in a dim location for 30 to 90 minutes.

10. Count eggs by hand if small numbers are involved, or drain and weigh in pre-weighed baskets to the nearest 0.1 gram several 100-egg samples.

11. Calculate numbers by dividing the total weight of the eggs by the average weight of one egg.

12. Place eggs in incubator.

13. Clean work area and return equipment and materials to proper storage.

COMMERCIAL TROUT PRODUCTION
UNIT X

JOB SHEET #2 — INVENTORY A RACEWAY LOAD

A. Equipment and materials

1. Crowding screens
2. Live box, 3′ × 3′ × 2′ high
3. Dip nets
4. Metric beam balance for weighing small fish
5. Avoirdupois spring scale
6. Measuring board graduated in millimeters
7. Anesthetizing agent

B. Procedure

1. Stop feeding fish 18 to 24 hours before inventory to minimize the effects of the handling stress caused by the crowding and weighing process.
2. Place a crowder screen a few feet below the water intake, after making sure that the area above the screen is free of fish.
3. Use other crowder screens to crowd fish from the lower end of the raceway to the point where the fish obscure the bottom edge of the crowding screen.
4. Set the live box into the water on the downstream side of the lower screen.
5. Place five dip-nets of fish into the live box.
6. Remove one dip-net sample for weighing and counting.
7. Release the rest of the fish below the downstream screen.

   (NOTE: Steps 5, 6, and 7 will be repeated five times so that five samples of fish are subsampled from five different groups of fish.)

8. Weigh fish

   a. Tare a container of water to zero on the scale by placing the container on the scales and adjusting the value to zero.

JOB SHEET #2

b. Dump the dip-netted fish into the container of water and record the weight to the nearest appropriate unit.

(NOTE: Weigh at least 100 grams of 1.5- to 3-inch fish per sample on the metric beam balance. Samples of fish 3 to 6 inches should be weighed to the nearest gram, and samples of fish more than 6 inches should be weighed to the nearest pound on the spring scale.)

9. Count the number of fish per pound in at least three samples.

10. Divide the total number of fish in all samples by the sum of the individual sample weights to obtain an accurate raceway count; record.

No. of Trout in Raceway = ______________________________

11. Anesthetize at least one—and preferably two—of the pound-count samples, and measure the fish to the nearest millimeter; record all lengths.

______________ ______________ ______________

______________ ______________ ______________

12. Divide the sum of the lengths by the number of fish measured to obtain an average length; record.

Average length = ______________________________

13. Using the data obtained, estimate the total pounds of fish in the raceway, provided the initial loading weight and number are known and the accrued mortality subtracted (Assignment Sheet #2).

Est. Total Pounds of Trout in Raceway = ______________________________

14. Remove crowder screens.

15. Return equipment and materials to proper storage.

16. Resume normal feeding practices after a period of 4 to 5 hours in which the fish adjust.

COMMERCIAL TROUT PRODUCTION
UNIT X

PRACTICAL TEST #1

JOB SHEET #1 — ARTIFICIALLY SPAWN TROUT BROODFISH

Student's name ______________________________ Date ____________

Evaluator's name ______________________________ Attempt No. ______

Student instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	Yes	No
1. Calculated amount of anesthetic.	☐	☐
2. Administered anesthetic to holding tanks.	☐	☐
3. Stripped eggs from female trout.	☐	☐
4. Stripped milt from male trout.	☐	☐
5. Mixed eggs and milt and allowed to water-harden.	☐	☐
6. Counted eggs.	☐	☐
7. Placed eggs in incubator.	☐	☐

EVALUATOR'S COMMENTS: ______________________________

____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:	Well done	Acceptably done	Incomplete	Unacceptable
Calculating and administering anesthetic	4	3	2	1
Stripping female	4	3	2	1
Stripping male	4	3	2	1
Mixing milt and eggs	4	3	2	1
Counting eggs	4	3	2	1

EVALUATOR'S COMMENTS: ____________________________________

PERFORMANCE EVALUATION KEY

4 — **Skilled** — Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program; limited additional training may be required.
2 — **Limited skill** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE. If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

COMMERCIAL TROUT PRODUCTION
UNIT X

PRACTICAL TEST #2

JOB SHEET #2 — INVENTORY A RACEWAY LOAD

Student's name ______________________ Date __________

Evaluator's name ______________________ Attempt No. ______

Student instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	Yes	No
1. Stopped feeding to minimize stress.	☐	☐
2. Placed screens and collected trout.	☐	☐
3. Selected 5 dip-net samples.	☐	☐
4. Counted and averaged fish for weight count.	☐	☐
5. Measured and averaged fish length.	☐	☐
6. Estimated total number of raceway fish.	☐	☐
7. Estimated total pounds of trout in raceway.	☐	☐
8. Returned equipment to proper storage.	☐	☐

EVALUATOR'S COMMENTS: ______________________

____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:	Well done	Acceptably done	Incomplete	Unacceptable
Pond preparation and sampling	4	3	2	1
Averaging numbers	4	3	2	1
Averaging weight	4	3	2	1
Averaging length	4	3	2	1
Total fish estimate	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

____

PERFORMANCE EVALUATION KEY

4 — **Skilled** — Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program, limited additional training may be required.
2 — **Limited skill** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE. If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

COMMERCIAL TROUT PRODUCTION
UNIT X

TEST

NAME ______________________________ SCORE __________

1. Match terms related to commercial trout production with their correct definitions. Write the correct numbers in the blanks.

______a.	Fish that lives in salt water but spawns in fresh water	1.	Eyed egg
______b.	Egg in which two black spots—the developing eyes of the embryo—can easily be seen	2.	Cock
______c.	Cubic feet per second	3.	Hen
______d.	The average number of pounds of feed eaten by the fish to gain 1 pound of weight	4.	Alevins (sac fry)
______e.	A structure for measuring/controlling water flow	5.	Stripping
______f.	Containing fully developed eggs; ready to spawn	6.	Water-hardening
______g.	Feet per second	7.	Shocking
______h.	Process that takes place within a 30 to 90 minute period after spawning in which the egg becomes turgid with water, loses its stickiness, and can no longer be fertilized	8.	cfs
______i.	Manually releasing eggs and milt from broodfish	9.	fps
______j.	Fry that obtain nourishment from attached yolk sac	10.	Standard Environmental Temperature (SET)
______k.	Male trout	11.	Feed conversion ratio (FCR)
______l.	Female trout	12.	Swim-up fry
______m.	Length between tip of snout and end of tail	13.	Ripe
______n.	Fry that have lost their yolk sac and are ready for food	14.	Kype

TEST

_____o.	Secretion that contains sperm produced by the male fish	15.	Milt
_____p.	Feed that supplies 100 percent of the dietary requirements of the fish; used when there is little or no access to natural food	16.	Complete feed
_____q.	Process of sharply striking egg trays, siphoning eggs from one container to another, or pouring eggs from incubator trays into tub of water from 2 to 3 feet to detect undeveloped or infertile eggs	17.	Total length
_____r.	The temperature at which all of the species physiological systems operate optimally	18.	Weir
_____s.	Upward curving hook of lower jaw that occurs at spawning	19.	Anadromous
_____t.	The measurement of both forms of dissolved ammonia, ammonium, NH_4+, ionized, and ammonia, NH_3, un-ionized	20.	Total ammonia

2. Select factual statements about trout culture. Write the correct numbers in the blanks.

_____a. To what family does the trout belong?

1) *Salmonidae*
2) *Ictalurus*
3) *Lepomis*

_____b. How many species are there in the trout family?

1) 86
2) 43
3) 68

_____c. Which of the following coldwater species is most commonly farmed for food?

1) Brook trout
2) Rainbow trout
3) Brown trout

_____d. Of the 14 species of trout found in North America, what species is of most importance in fish farming?

1) Rainbow trout
2) Brook trout
3) Brown trout

TEST

_____e. All members of the family are coldwater fish requiring highly pure, highly oxygenated water below which of the following temperatures?

1) 78°F
2) 68°F
3) 58°F

_____f. Which of the following is the most popular table fish in the U.S. today?

1) Catfish
2) Trout
3) Sport fish such as bass

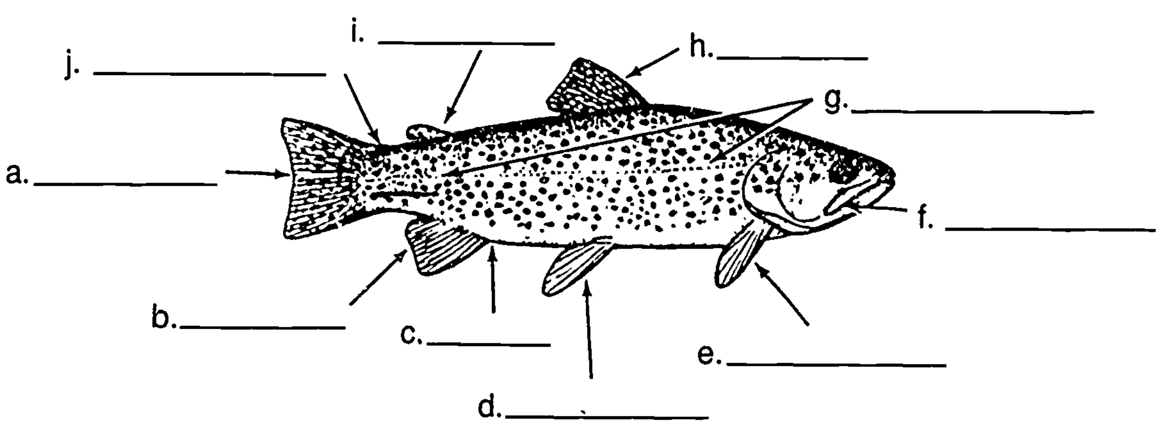
_____g. What is the leading trout-producing state?

1) Iowa
2) Indiana
3) Idaho

_____h. In southern states where trout may be cultured during the winter months in cages, what is the approximate growing period?

1) 150 days
2) 228 days
3) 110 days

3. Label the external anatomy of the rainbow trout in the illustration below.



TEST

4. Select basic water quality requirements for trout culture. Write the correct numbers in the blanks.

______a. What is the optimum range and the SET for trout culture water temperature?

1) 33°F to 78°F; 65°F
2) 50°F to 60°F; 59°F
3) 39°F to 55°F; 50°F

______b. What is the recommended flow rate for raceway and tank culture?

1) 0.05 to 0.09 fps
2) 0.25 to 0.50 fps
3) 0.01 to 0.05 fps

______c. What is the minimum DO concentration where eggs are hatched?

1) 5 ppm
2) 7 ppm
3) supersaturation

______d. What is the most economical water hardness range for trout culture?

1) 20 ppm to 50 ppm dissolved solids or more
2) 75 ppm to 150 ppm dissolved solids or more
3) 50 ppm to 250 ppm, dissolved solids or more

______e. Below which of the following levels must nitrite be held for optimum growth and health?

1) 0.1 to 0.2 mg/L
2) 0.5 to 0.7 mg/L
3) 0.3 to 0.6 mg/L

______f. At which of the following values should pH be maintained?

1) 6.9 and 7.9
2) 7.8 and 8.4
3) 7.5 and 8.0

______g. What is the optimum water replacement time for raceways?

1) 20 to 30 minutes, or 2 to 3 changes per hour
2) 60 minutes, or 1 change per hour
3) 10 to 15 minutes, or 4 to 6 changes per hour

______h. If levels of NH_3, un-ionized ammonia, exceed 0.0125 ppm, what happens?

1) Trout will die within hours
2) Trout will exhibit erratic behavior
3) A decline in trout growth and health may occur

TEST

5. Match trout farming enterprises with their descriptions. Write the correct numbers in the blanks.

_____a.	Fingerlings are grown in raceways until they are bout 8 to 14 inches long: they are then sold to restaurants, retail markets, fee-fish operators, or to private pond owners.	1. Fee-fish pond
_____b.	Adult trout are reared and held in isolated raceways or ponds until the spawning season when the female is ripe; the eggs are then stripped from the female and fertilized with milt from a male.	2. Eyed-egg production
_____c.	Eight-inch or longer trout are stocked in a pond and fished by the public for a fee; some operators lease fishing privileges on an annual basis.	3. Fingerling production
_____d.	Eyed eggs are managed in special trays or running water; after hatching, fish are managed until they grow to fingerling size—1 to 6 inches; they are then sold to other growers or to private pond owners.	4. Food-fish production

6. List the five phases of trout production.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

7. Complete statements about broodfish management. Write the correct numbers in the blanks.

_____a. Female broodfish should be between _____ years old for quality egg production.

1) 1 to 2
2) 3 to 4
3) 4 to 5

TEST

______b. Use female broodstock _____ years old.

1) 1 to 2
2) 2 to 3
3) 4 to 5

______c. Rotate in _____ broodstock, and dispose of broodstock that has become too old.

1) new, younger
2) mature, tested
3) hybrid, vigorous

______d. Know the _____ for the strain of rainbow trout you are culturing.

1) disease history
2) production rate
3) spawning times

______e. Maintain broodstock in water temperatures of _____ or less.

1) 59°F
2) 58°F
3) 56°F

______f. Choose female broodstock with _____ bellies and swollen vents.

1) distended
2) concave
3) dark-colored

______g. Choose male broodstock with a pronounced _____ and bright color.

1) vent
2) kype
3) alevin

8. Complete statements about egg management. Write the correct numbers in the blanks.

______a. Ship eggs only in one of four developmental stages; as immature eggs in the living female, as mature, unfertilized eggs, as fertilized _____ eggs, or as eyed eggs.

1) water-hardened
2) hard water
3) water-softened

TEST

_____b. Take great care not to shake or jar the eggs during their sensitive stage—a period extending roughly _____ hours after fertilization.

1) 12
2) 24
3) 48

_____c. Shock, clean, measure, and count eggs during the _____ stage of development.

1) fertilized
2) eyed
3) unfertilized

_____d. Disinfect eggs received from other hatcheries in _____ to prevent spread of disease.

1) batches of 1,000
2) a separate facility
3) aluminum buckets

_____e. Maintain eggs _____ in a hatching trough or vertical tray incubator, and ensure that oxygen-rich water flows through them.

1) on submerged screen trays
2) on floating boards
3) in submerged jars

_____f. Maintain DO content of water at _____ ppm during incubation.

1) 5
2) 6
3) 7

_____g. Keep eggs covered and away from _____.

1) inlet water flow
2) trough walls
3) direct light

_____h. Incubate eggs at _____ temperatures for the strain you are culturing.

1) Minimum
2) Maximum
3) Optimum

TEST

9. Complete statements about fry and fingerling management. Write the correct numbers in the blanks.

_____a. Yolk-sac fry require. _____.

1) high-protein feed because they get only carbohydrate from the yolk
2) starter feed around the clock from automatic feeders
3) no feed because they get their nutrition from the yolk

_____b. When the yolk sac is absorbed, the fry _____.

1) forage among the aquatic flora for food
2) swim to the water surface for food
3) fast for 24 hours until digestion is complete

_____c. Swim-up fry are reared in _____ ranging in size from 12′ × 18" × 12" up to 20′ × 3′ × 3′.

1) raceways
2) submerged trays
3) troughs

_____d. Swim-up fry required a feed containing a minimum of _____ protein.

1) 34 to 45 percent
2) 35 to 40 percent
3) 45 to 50 percent

_____e. Once fingerlings are _____ inches long. they can be placed in raceways or ponds.

1) 1+
2) 2+
3) 3+

_____f. Fingerlings require a feed containing at least _____ protein.

1) 35 to 50 percent
2) 30 to 40 percent
3) 32 to 45 percent

10. Select from a list general guidelines for feeding different sized trout. Write an "X" in the blank before each correct guideline.

_____a. Feed swim-up fry starter feed from around-the-clock feeders, or feed small amounts eight or nine times a day, distributing feed well across the water surface.

_____b. Feed 1-inch to 2-inch fry #1 or #2 granules five or six times a day.

_____c. Feed 2½-inch to 4½-inch fingerlings #5 crumbles four or five times a day.

TEST

______d. Feed trout 4 to 6 inches ⅛-inch pellets four times daily according to feeding chart.

______e. Feed trout 6 inches and larger 3/16-inch pellets four times a day.

______f. Feed broodstock ½-inch pellets two or three times a day.

11. Select from a list general management guidelines. Write an "X" in the blank before each correct guideline.

______a. Feed rainbow trout a high-quality, complete commercial feed with a minimum protein content of 32 percent.

______b. Regularly monitor DO, water temperature, pH, and ammonia.

______c. Keep routine and accurate records; keep daily records of mortality and feed fed.

______d. Regularly examine fish growth data to determine average lengths and weights.

______e. Practice partial harvesting so that fish do not become overcrowded, or have ready enough extra raceways for fish to grow into.

______f. Estimate raceway water flow rates and volumes on a daily basis.

______g. Calculate feeding rates and use detailed feeding schedules provided by feed dealers so that you do not over- or underfeed.

12. Select facts about types of impoundment and rearing units. Write the correct numbers in the blanks.

______a. In which types of container culture systems are trout most commonly produced?

1) Linear or circular raceways
2) Vertical raceways
3) Single pass raceways

______b. Trout can be cultured in earth ponds as small as which of the following?

1) 1.0
2) 0.5
3) 0.1

TEST

_____c. How should the bottoms of earthen ponds be treated?

1) Planted in rice or water primrose to provide shelter and supplemental nutrients
2) Contain benthic organisms and adequate aquatic flora for browsing
3) Be covered with coarse gravel (cobble)

_____d. Trout may be intensively cultured in _____, both in freshwater and in sea water.

1) Cages
2) Pens
3) Live-cars

13. Select facts about raceway design. Write the correct numbers in the blanks.

_____a. What is the typical length, times width, times water depth ratio for raceways?

1) 10:2:2
2) 30:3:1
3) 15:5:1

_____b. How much freeboard is added to the water depth dimension to prevent trout from leaping from the raceway?

1) 4 to 8 inches
2) 12 to 24 inches
3) 6 to 12 inches

_____c. What is the correct raceway floor slope?

1) 0.6 to 1.0 inches per 10 feet of length
2) 0.4 to 0.8 inches per 12 feet of length
3) 6 to 10 inches per 15 feet of length

_____d. Which of the following is NOT a raceway construction material?

1) Concrete
2) Fiberglass
3) Pre-formed plastic

_____e. How much should the baffle board be raised from the bottom of the raceway?

1) The same distance as the freeboard
2) The same distance as the depth of water going over the weir
3) The same distance as the screen width

TEST

______f. Which of the following is the recommended screen size?

1) 2 square feet of screen for each 10 gpm water flow
2) 0.5 square foot of screen for each 20 gpm water flow
3) 1 square foot of screen for each 25 gpm water flow

14. Match water use systems with their correct descriptions. Write the correct numbers in the blanks.

______a. Two units in series use the same water	1.	Single reuse
______b. Water flows through only one unit and is then discharged	2.	Single pass
______c. Several units in series use the same water	3.	Multiple reuse

15. Complete statements about typical stocking/loading rates. Write the correct numbers in the blanks.

______a. Coldwater ponds usually produce enough oxygen and natural food to support the extensive culture of about _____ pounds of trout per surface acre.

1) 100
2) 300
3) 600

______b. In the Midwest and Southwest U.S., spring stocking a l-acre pond with 500 2-4 inch rainbow fingerlings will produce _____ trout the first year.

1) 10-inch (8 ounce)
2) 8- or 9-inch (6 ounce)
3) 7- or 8-inch (4 ounce)

______c. In the Mid- to Northeastern U.S., the standard fall pond stocking rate is _____ rainbow fingerlings per surface acre to produce 10-inch trout the first year.

1) 400 2- to 4-inch
2) 500 4- to 6-inch
3) 600 3- to 4-inch

______d. In general, 2- to 4-inch trout fingerlings are more likely to _____ than are 1-inch to 2-inch fingerlings.

1) Grow
2) Survive
3) Die

TEST

_____e. Raceway loading rates are dependent on many factors, but particularly on flow rates, exchange rates, DO levels, and _____.

1) Water velocity
2) Water depth
3) Water hardness

_____f. As a general rule of thumb, trout are loaded at densities in pounds per cubic foot no greater than _____ their length in inches.

1) 0.3
2) 0.5
3) 0.8

_____g. In Oklahoma the upper cage limit for trout is _____ fingerlings per cubic foot of cage to produce ½-pound to ¾-pound fish at spring harvest.

1) twenty 5-inch
2) twelve 8-inch
3) fifteen 7-inch

_____h. The maximum safe pond limit [stocked in cages] is about _____ trout per acre.

1) 500
2) 1,000
3) 1,200

16. Distinguish between Density Index and Flow Index. Write and "X" in the blank before the description of Flow Index.

_____a. The relationship of fish weight and size to water volume; the spatial relationship of one fish to another

_____b. The relationship of fish weight and size to water inflow; deals with the amount of oxygen available for life support and growth

(NOTE: Test questions 16 through 20 list the assignment and job sheets. They are an important part of this test. If they have not been completed, check with your instructor for scheduling and evaluation procedures.)

17. Keep trout production records. (Assignment Sheet #1)

18 Calculate raceway carrying capacity based on flow and density indexes. (Assignment Sheet #2)

19. Predict ammonia loads based on food consumption, fish load, and water flow rate. (Assignment Sheet #4)

20. Demonstrate the ability to:

a. Artificially spawn trout broodfish. (Job Sheet #1)

b. Inventory a raceway load. (Job Sheet #2)

COMMERCIAL TROUT PRODUCTION
UNIT X

ANSWERS TO TEST

1.
a.	19	k.	2
b.	1	l.	3
c.	8	m.	17
d.	11	n.	12
e.	18	o.	15
f.	13	p.	16
g.	9	q.	7
h.	6	r.	10
i.	5	s.	14
j.	4	t.	20

2.
a.	1	e.	2
b.	3	f.	2
c.	2	g.	3
d.	1	h.	1

3.
a. Caudal peduncle
b. Adipose fin
c. Dorsal fin
d. Lateral line
e. Maxillary
f. Pectoral fins
g. Ventral fins
h. Anus
i. Anal fin
j. Caudal fin

4.
a.	2	e.	1
b.	1	f.	3
c.	2	g.	1
d.	3	h.	3

5.
a. 4
b. 2
c. 1
d. 3

6.
a. Broodstock maintenance and spawning
b. Egg incubation and hatching
c. Sac fry management
d. Swim-up fry management and feeding
e. Fingerling to food fish management and feeding

ANSWERS TO TEST

7. a. 2
   b. 2
   c. 1
   d. 3
   e. 3
   f. 1
   g. 2

8. a. 1 e. 1
   b. 3 f. 3
   c. 2 g. 3
   d. 2 h. 3

9. a. 3
   b. 2
   c. 3
   d. 3
   e. 2
   f. 1

10. a, d, e

11. b, c, e, g

12. a. 1
    b. 3
    c. 3
    d. 1

13. a. 2
    b. 3
    c. 1
    d. e
    e. 2
    f. 3

14. a. 1
    b. 2
    c. 3

15. a. 1 e. 1
    b. 3 f. 2
    c. 3 g. 3
    d. 2 h. 3

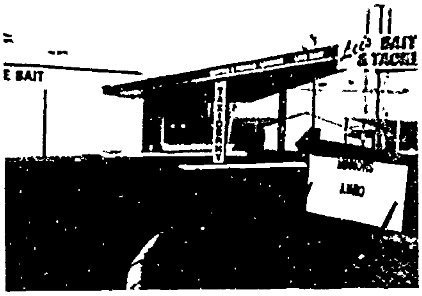
ANSWERS TO TEST

16. b

17. — 20. Evaluated to the satisfaction of the instructor

21. a. Evaluated according to criteria in Practical Test #1

    b. Evaluated according to criteria in Practical Test #2



COMMERCIAL BAITFISH PRODUCTION
UNIT XI

UNIT OBJECTIVE

After completion of this unit, the student should be able to evaluate the local demand for baitfish and determine the feasibility of undertaking commercial baitfish production. These competencies will be evidenced by completing the procedures in the assignment and job sheets and by scoring a minimum of 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with commercial baitfish production with their correct definitions.
2. Complete factual statements about the baitfish industry.
3. List marketing options.
4. Select from a list factors affecting marketing success.
5. Identify popular baitfish species.
6. Distinguish among general characteristics of popular baitfish species.
7. Select factual statements regarding guidelines for the selection of broodstock.
8. Distinguish among the reproductive and spawning characteristics of golden shiner, fathead minnow, and goldfish.
9. Match propagation methods with their descriptions.
10. Match to their correct descriptions methods of pond preparation for the propagation and rearing of baitfish.
11. Match predators with their control techniques.
12. Discuss propagation techniques and stocking rates for golden shiners and goldfish.
13. Distinguish between free-spawning and fry transfer methods of propagating fathead minnows.
14. Discuss fertilization techniques for plankton production.

SPECIFIC OBJECTIVES

15. Complete statements about feeding practices.
16. Complete statements about basic harvesting equipment needs.
17. Select from a list general guidelines for harvesting and transferring baitfish to holding troughs.
18. Match harvesting methods with their correct descriptions.
19. Select from a list guidelines for maintaining baitfish in holding troughs.
20. Match grading procedures with correct grading equipment.
21. Select from a list guidelines for transporting fish to long distance markets.
22. Select from a list guidelines for transporting fish to short distance markets.
23. Survey baitfish dealers to evaluate local supply and demand. (Assignment Sheet #1)
24. Visit a baitfish farm and report on the operation. (Assignment Sheet #2)
25. Demonstrate the ability to:
    a. Trap, count or weigh, and grade a sample of baitfish. (Job Sheet #1)
    b. Make a spawning mat. (Job Sheet #2)
    c. Bring baitfish eggs into hatching area and watch them hatch. (Job Sheet #3)

COMMERCIAL BAITFISH PRODUCTION
UNIT XI

SUGGESTED ACTIVITIES

A. Arrange a field trip to a local baitfish producer to assist students in completing assignment and job sheets.

B. Gather equipment and materials necessary for students to complete job sheets. Explain and demonstrate uses as necessary.

C. Invite a local baitfish producer to the class to talk about personal experience with the various aspects of commercial baitfish production. species' characteristic and desirability, pond preparation and management, propagation, feedings, transporting, marketing and recordkeeping.

D. Provide students with objective sheet.

E. Provide students with information sheet.

F. Discuss unit and specific objectives.

G. Discuss information sheet.

H. Schedule assignment sheets and critique in class.

I. Schedule, demonstrate, and evaluate job sheets.

J. Give test.

(NOTE: As the test is long, it may be helpful to administer it in two or more sections.)

REFERENCES USED IN DEVELOPING THIS UNIT

A. Dupree, Harry K., and Jay V. Huner. *Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington, D.C.: U.S. Fish and Wildlife Service, 1984.

B. Giudice, John J., D. Leroy Gray, and J. Mayo Martin. *Manual for Bait Fish Culture in the South.* Fayetteville, Arkansas. University of Arkansas Cooperative Extension Service and the U.S. Fish and Wildlife Service, n.d.

C. Reigh, Robert C., ed. *Proceedings of the Louisiana Aquaculture Conference, 1988.* Baton Rouge, Louisiana. Louisiana State University Agricultural Center, 1988.

COMMERCIAL BAITFISH PRODUCTION
UNIT XI

INFORMATION SHEET

I. Terms and definitions

A. **Propagation** — Reproduction; raising or breeding

B. **Slurry** — Thin, watery mixture of feed

C. **Seeding** — Pumping plankton from a pond with bloom to a pond without bloom to promote plankton growth

D. **Spawning mat** — Artificial nest, generally of Spanish moss or a synthetic material such as spandex, on which fish lay eggs (Figure 1)

EXAMPLE: FIGURE 1

From *Manual for Bait Fish Culture in the South* by John J. Guidice, et. al. With permission.

E. **Saprophyte** — Organism that lives on dead or decaying organic matter

F. **Parasite** — Organism that lives in or on another live organism, generally causing harm

G. **Protozoa** — Microscopic, single-celled animals living in water; mostly parasitic

H. **Omnivorous** — Eating both vegetable and animal food

I. **Carnivorous** — Eating only animal food

J. **Ovarian** — Having to do with the ovaries, the female egg producing glands

K. **Tubercles** — Hornlike projections on the head of breeding fathead minnows

L. **Domestic** — Tame; bred and raised in captivity

M. **Head** — Inflow end of holding trough

INFORMATION SHEET

N. Foot — Drain end of holding trough

O. Metabolism (metabolic) — Chemical and physical processes by which an organism breaks down matter and releases it as waste or energy

P. Temper — To allow fish to adjust to different water chemistry and temperature

Q. Pond run — Ungraded by size or sex

II. Facts about baitfish industry

A. Baitfish have been raised in the mid-western United States since the 1920s

B. In the United States, commercial production of baitfish is worth more than $100 million at the fish farm level.

C. The major fish species raised for bait are golden shiners, fathead minnows, and goldfish, all of the minnow family.

D. The major baitfish-producing states are Arkansas, Kansas, Missouri, and Minnesota.

E. Arkansas is the major baitfish-producing state in the South, supplying about one-half of the nation's supply.

F For the past several years, the water acreage devoted to baitfish production — nearly equal to that of catfish production — has remained stable.

> POINT OF INTEREST: During 1985-1987, baitfish in Arkansas was unchanged with about 21,000 acres in golden shiners, 3,600 acres in fathead minnows, and 2,700 acres in goldfish. Catfish farming, on the other hand, is experiencing a period of rapid growth.

III. Marketing options

A. Producers can sell fish to wholesalers (jobbers) who then sell them to retail markets.

B. Producers can sell fish directly to area retailers.

C. Producers can retail the fish themselves, selling all or part of their fish directly to fisherman.

INFORMATION SHEET

IV. Factors that affect marketing success (Assignment Sheet #1)

A. Fisherman are very demanding consumers.

B. Bait needs — and fisherman's demands — change with the seasons.

C. Oversupply or shortages of bait are not always foreseeable, and yet are realities that must be expected and dealt with.

D. The retail price may be so high that sales drop as fishermen seine for their own bait or use artificial lures

E. Prices can fall when a competitor cuts prices to promote business.

F. Poor weather can reduce sport fishing and thus cause a decline in sales.

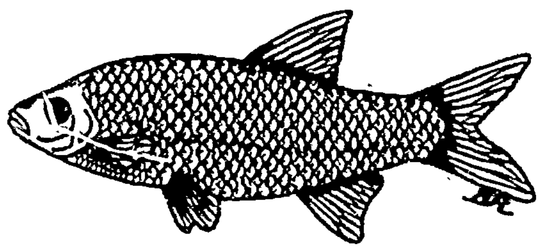
G. Baitfish are perishable and do not lend themselves well to stockpiling or increased inventories.

H. As profits increase, competition becomes keener.

V. Most popular baitfish species (Figures 2-5)

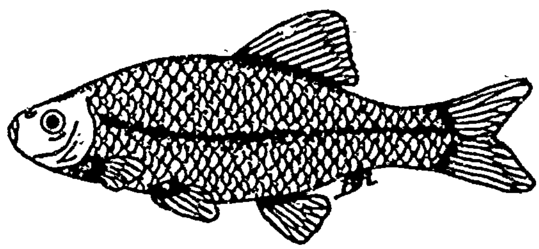
A. Golden shiner

FIGURE 2



B. Fathead minnow

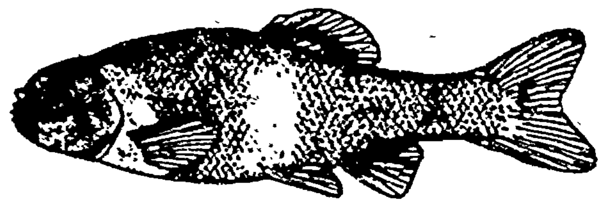
FIGURE 3



INFORMATION SHEET

C. Fathead minnow, breeding male

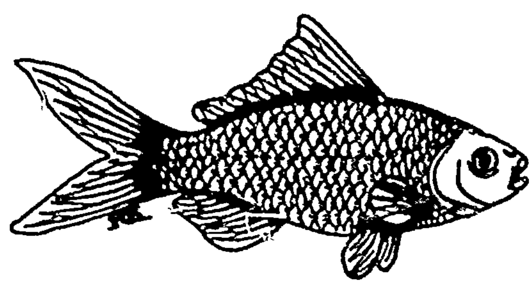
FIGURE 4



From Eddy and James C. Underhill, *How to Know the Freshwater Fishes*, 3rd ed.

D. Goldfish

FIGURE 5



Figures 2, 3, and 5 from *Manual for Bait Fish Culture in the South* by John J. Guidice, et. al.. With permission.

INFORMATION SHEET

VI. Species characteristics

Characteristic	Golden shiner	Fathead minnow	Goldfish
Physical appearance	Deep body; large, loosely attached silver or gold scales; downward curving lateral line, pointed dorsal fin; can grow to over 10 inches.	Streamlined body, small scales, dull color, rounded dorsal fin; does not often grow larger than 3 inches.	Thick body, large olive to red or gold scales, long graceful fins; can grow to 2 pounds if not overcrowded.
Hardiness	Delicate, easily damaged species prone to losing its scales; sensitive to handling during hot weather; excitable: leaps from holding tanks and bait containers.	Somewhat delicate but hardier than golden shiner; can be handled carefully during hot weather; males may die after spawning.	Very hardy; easy to handle, transport, and store.
Popularity	Most popular baitfish because of its bright, flashing appearance and liveliness on hook.	Popular baitfish because it tolerates careful handling in warm weather.	Not a widely popular baitfish because of its sluggishness on hook.
Markets/uses	Casting bait for sport fishing	Casting bait for sport fishing; new variety (rosy red) used as feeder fish and as forage fish for bass.	Trotline bait; feeder fish for carnivorous aquarium fish; used as forage fish for bass and catfish broodfish

INFORMATION SHEET

VII. Guidelines for selection of broodstock

A. Golden shiner

1. Avoid wild stock; select instead domestic stock that has been raised in captivity as these broodfish are easier to handle.

2. Select broodstock each year from the yearling population to protect against *Plistophora ovariae*, an ovarian protozoan.

   (NOTE: The older the female, the more likely she is to be infected. Female golden shiners grow faster than males. Some have been known to live for 8 years and attain a length of over 10 inches.)

3. Choose healthy, lively broodstock with upright fins and no missing scales or dull areas on the sides or back.

B. Fathead minnow

1. Select male broodstock with care as adult males grow larger than females, a characteristic that may create problems when a mechanical grader is used for broodstock selection.

2. Separate sexes by using a 15/64 to 16/64 bar grader.

3. Select lively, healthy broodfish with upright fins, and no missing scales, head or eye deformity, or distended abdomen.

4. Be aware that many adult males die after spawning.

C. Goldfish

1. Select broodstock that will produce the color most desired by the market in your area.

   EXAMPLES: If bronze is the preferred color, broodstock should be so selected. For 100% bronze offspring, the broodstock pair should be bronze Shubunkin variety. If an increase in the number of red stock is desired, early-coloring fingerlings should be selected from the rearing ponds and reared in separate ponds for later use as broodstock.

2. Select broodstock that will produce the slim-bodied stock generally preferred by fishermen.

3. Before spawning occurs, remove any broodfish with an undesirable shape or color.

4. Choose lively, healthy broodstock with upright, flowing fins and no signs of disease or parasite infection.

   (NOTE: Though goldfish are a hardy species, they are plagued by many parasites and diseases.)

INFORMATION SHEET

VIII. Reproduction and spawning

Characteristic	Golden shiner	Fathead minnow	Goldfish
Sexual maturity	1 year	1 year	1 year
Spawning season	Starts when water temp. reaches 70°F and continues through June in South.	Starts when water temp. nears 65°F and continues during cool periods in summer; may start again in fall.	Starts when water temp. reaches 60°F.
Breeding appearance	No significant change from nonbreeding appearance.	Male develops dark head covered with breeding tubercles, and a thick pad on back behind head. (NOTE: The pad is used for preparing the nest site and in caring for the eggs.)	Female's vent becomes larger, redder, and protrudes more than male's; at all times male can be sexed by noting serrated pectoral spines; female's are not serrated.
Average number of eggs	Up to 10,000	200 to 500 during each of many repeated spawns.	2,000 to 4,000 during each of several spawns.
Nesting habits	Eggs released randomly, preferably above living plants, but also cling to rocks, debris, and roots; culturists place spawning mats in pond for egg deposits.	After fertilization male places eggs on underside of hard objects in shallow water; culturists place bricks, smooth pieces of tile, and floating boards in ponds for egg deposits.	Same as, or very similar to, golden shiner.
Hatching	Eggs hatch in 4 to 8 days at water temperatures of 75°F to 80°F; no protection given to eggs or fry by the adults.	Eggs usually hatch in 5 to 6 days; male guards eggs until fry emerge.	Eggs hatch in 2 to 8 days, depending on water temp.; no protection given to eggs or fry by the adults.

INFORMATION SHEET

IX. Propagation methods (Job Sheet #3)

A. **Wild or free spawning** — Spawning, egg laying, hatching, and growing of young occur in the same pond.

B. **Egg transfer** — Spawning and egg laying occur in a specially prepared spawning pond; eggs are transferred to a rearing pond.

C. **Fry transfer** — Fry produced by either free spawning or egg transfer method are trapped, counted and transferred to rearing ponds.

X. Pond preparation for propagation and rearing (Job Sheet #2)

A. **Wild or free spawning pond** — Pond is drained or lowered, predators are killed or controlled, and grass is planted on the dry bottom or along the shoreline to provide natural spawning sites; or, if plant growth is scarce, spawning mats are placed in pond.

B. **Spawning pond for egg transfer method** — To prevent uncontrolled egg deposits, all aquatic vegetation and leaves and roots of marginal plants are killed; predators are killed or controlled; spawning mats are placed in groups 1 inch below shallow water at edge of pond with ends touching.

C. **Spawning pond for fathead minnow fry transfer** — Predators are killed or controlled, and existing spawning sites are supplemented with rocks, pieces of tile, bricks, or 4- by 12-inch sections of board stapled to a wire at 12-inch intervals and stretched parallel to the shore in shallow water. (Figures 6 and 7)

EXAMPLES:

FIGURE 6

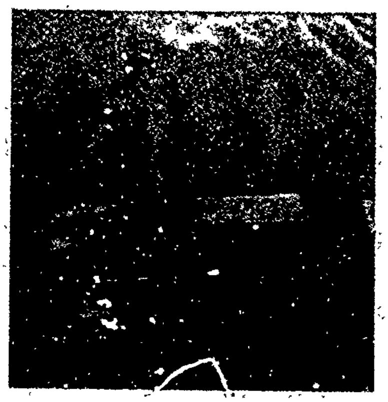
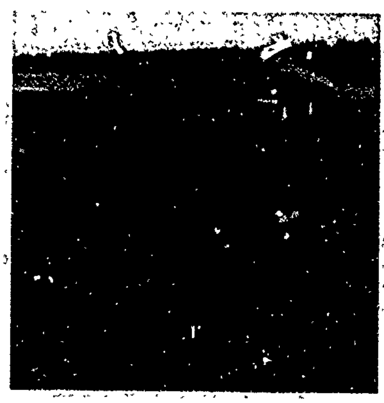


FIGURE 7



Figures 6 and 7 from *Manual for Bait Fish Culture in the South* by John J. Guidice, et. al. With permission.

D. **Fry rearing pond** — Pond is rid of toxins, cleared of all predators, and fertilized to establish a plankton bloom, which provides natural food for fry and also shades out aquatic weeds.

INFORMATION SHEET

XI. Predators and their control

Predator	Prey: Egg	Fry	Fingerling	Broodfish	Control
Turtle	X	X	X	X	Shoot or trap; completely dry pond and treat small potholes with calcium hypochlorite (HTH).
Snail	X				Fill bottom of pond to 1 inch flood and treat with 10 ppm copper sulfate; then add 500 pounds per acre of hydrated limestone.
Crayfish	X	X			Same as for turtles, or stock with 6 or 8 channel catfish per surface acre; channel catfish should be free of disease or parasites.
Insects	X	X			Apply 3 gallons of diesel fuel plus 1 quart of crankcase oil per surface acre; apply upwind side of pond and let flow across surface; start before stocking with eggs; repeat once a week until fish are 1 inch long.
Cyclops and large zooplankton	X	X			After eggs are placed in pond, apply Masoten at 0.25 ppm.
Wild fish	X	X	X	X	Use well water or screen and filter surface water; treat potholes with hydrated lime or calcium hypochlorite after harvest.
Snakes		X	X		Shoot; trap; mow levees closely.
Frogs and tadpoles	X	X	X		Harvest adults, and in spring dip out egg masses; remove cover on pond banks and in pond.
Muskrat				X	Trap and/or use zinc phosphide-treated bait.
Birds			X	X	Use scaring devices; shoot ducks during waterfowl season; all other birds are protected by law. CHECK WITH LOCAL AUTHORITIES BEFORE TAKING ANY CONTROL MEASURES!

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INFORMATION SHEET

XII. Propagation and stocking of golden shiner and goldfish (Job Sheet #1)

(NOTE: Propagation methods for golden shiner and goldfish are very similar.)

A. Wild or free spawning method:

1. Stock golden shiner at a rate of 20 to 40 pounds of ungraded broodfish per acre; stock 100 to 300 goldfish broodstock per acre, depending on size.

2. If spawning activity diminishes, stimulate it by rapidly raising the level of the pond or by adding potassium permanganate, which chemically shocks the fish into spawning.

3. To extend the spawning season, add large quantities of cool water, preferably to small narrow ponds.

4. After adults have spawned, remove them from the pond and store in another pond for future broodstock use, or sell as bait.

B. Egg transfer method

1. Stock 400 to 500 pounds of golden shiners per acre and goldfish at a rate of 800 to 1,000 pounds per acre.

2. When the fish are ready to spawn, place spawning mats 1 inch below shallow water with one side of the mat at the edge of the pond, arranging mats end to end in groups.

3. Transfer mats to rearing ponds when they are uniformly covered with eggs.

   (NOTE: Do not leave mats in ponds until eggs become so abundant that they touch. Too many eggs on a mat encou age the growth of a saprophytic fungus that may spread over developing eggs.)

4. Estimate the number of eggs on each mat, and then--depending on the average number of eggs per mat--stock from 50 to 75 mats per acre in golden shiner ponds; 50 to 150 mats per acre in goldfish rearing ponds.

5. When spawning becomes very light, remove most of the mats from the spawning pond, leaving at least one mat in each spawning area to prevent fish from depositing eggs on other material.

6. After spawning stops and hatching is completed, remove, wash, and store all spawning mats.

INFORMATION SHEET

C. Fry transfer method

1. When the fry produced by either the wild spawning method or the egg transfer method are about 3/4 inch long, capture with lift traps or short, fine-mesh seines during coolest part of the day.

2. Count the fry by first counting the number of fry in 1 ounce and then multiplying by the number of ounces transferred.

   EXAMPLE: If by count, there are 200 fry per ounce, and there are 32 ounces in a quart, the volume of fry needed to yield a stocking of 200,000 is 31.25 quarts per acre.

3. Transfer fry to rearing ponds in buckets graduated in quarts; stock golden shiners at rates from 50,000 to 200,000 per acre and goldfish at rates from 25,000 to 1 million per acre.

   (NOTE: Actual stocking rates depend on how soon salable fish are needed, size of fish desired, level of pond management, and the length of the growing season.)

XIII. Propagation of fathead minnows

(NOTE. Propagation methods differ for fathead minnows because of their different spawning habits. Fathead culture is restricted tc use of either the free spawning method or the fry transfer method.)

A. Wild or free-spawning method

(NOTE. Large ponds can be stocked using the free spawning method, but the disadvantage is that these ponds tend to become overpopulated, resulting in stunted populations.)

1. Stock at a rate of 500 to 2,000 broodfish per acre at a 5:1 ratio, 5 females to 1 male.

2. Provide supplemental spawning sites by placing rocks, pieces of tile, bricks, or boards in the pond.

B. Fry transfer method

(NOTE: This is the favored method of fathead minnow producers.)

1. Stock prepared spawning ponds with 20,000 to 25,000 broodstock per acre at a 5:1 female to male ratio.

2. Provide supplemental spawning sites by placing rocks, pieces of tile, bricks, or boards in the pond.

3. When they are 1/2 to 3/4 inch long, capture fry with fine-mesh seine or lift trap, estimate numbers, and transfer to rearing ponds.

INFORMATION SHEET

4. Stock rearing ponds at a rate of 50,000 to 300,000 fish per acre.

XIV. Fertilization for the production of plankton

(NOTE: Success in raising baitfish fry depends on the management of plankton—natural food for fry—so that it is available when the fry are ready to eat.)

A. Organic and inorganic fertilizers are used to establish plankton blooms in fry rearing ponds.

B. The bloom should be dense enough so that a Secchi disc can be seen only faintly at 10 inches.

C. If the water begins to clear of plankton, more fertilizer is applied, or the pond is seeded from a nearby pond with a good bloom.

D. If soil analysis indicates a need, finely ground limestone is added before or while the pond is filling.

E. Nitrate of soda and super-phosphate are used on acid soils, and ammonium phosphate is used on basic soils.

F. When organic and inorganic combinations are used, manures are applied at rates of 400 to 1,000 pounds per surface acre while 100 pounds of a 16-20-0 inorganic fertilizer or equivalent is applied per surface acre.

G. To produce a bloom with inorganic fertilizer used alone, the farmer applies about 200 pounds of 16-20-0 per application per acre.

H. Some producers use liquid fertilizers with good results. when sprayed on the water surface, more phosphorus is available for pond organisms instead of being tied up in the bottom soil.

INFORMATION SHEET

XV. Feeding practices

Feeding Practices

Species	Extensive Culture	Intensive Culture
Golden shiner	Pond water is fertilized until plankton bloom creates Secchi disc reading of 8 to 9 inches; bloom is maintained until fry reach about 1 inch and before hot weather. After fish reach 1 inch, fertilizer is reduced and fresh water is added until Secchi disc reading is 14 inches; pond is maintained at 14-inch reading.	If fry come to the surface and eat when a small amount of food is thrown into pond, they can be fed feed. When starting fry on feed, ponds are checked at downwind edge 2 hours after feeding to see that all feed has been eaten; if feed is left, feed amounts are reduced. For faster growth, shiners are fed more than once a day, and as they grow, their feed is increased every few days. Heavily fed shiner ponds can be fed at least 40 pounds of feed per acre per day with resulting production levels of 600 to 800 pounds per acre.
Fathead minnow	Same as for golden shiner.	Young fish are begun on starter feed in fertilized ponds that contain up to 25,000 broodfish, with some producers also feeding grower feed for the broodfish. When fry are transferred to fertilized rearing pond, they are fed starter feed on all sides of the pond until they are about 3/4 inch long. When fry are about 3/4 inch long, the producer changes to pelleted grower feed, blending 3 parts pellets with 1 part starter feed until fish learn to eat the pellets, at which time a full pellet ration is fed. Generally production levels will vary from 350 to 1,200 pounds per acre.
Goldfish	Water is fertilized until plankton bloom creates a Secchi disc reading of 5 to 7 inches. After fish grow to about 1 inch long and before hot weather, the water is cleared by pumping in fresh water or by stopping fertilization to allow the bloom to recede to a Secchi disc reading of 10 inches; the pond is maintained at this reading.	Fertilization is the same as for golden shiner ponds; production may be increased with supplemental feeding using golden shiner diets in which egg yolk is substituted for some other ingredients such as feather meal. After the fish are feeding well and are about 1 inch long, the starter meal is changed to pellets as it was for fathead minnows. Fish are fed an amount they can consume in 2 to 3 hours. Fertilizer and feed in intensive cultures can produce yields of 3,000 pounds or more per acre.

INFORMATION SHEET

XVI. **Basic harvesting equipment**

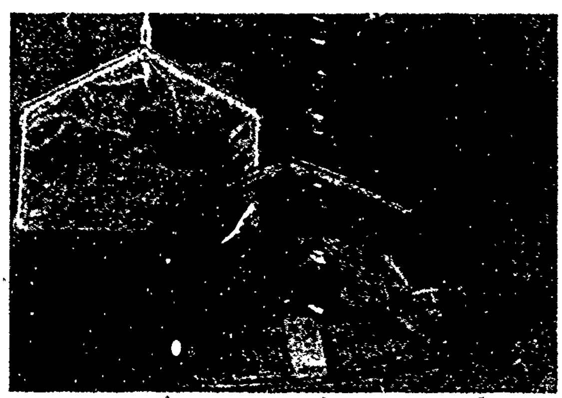
A. Knotless woven nylon seine and dipnets made of 3/16-inch mesh (Figures 8 and 9)

(NOTE: To seine a whole pond, the seine should be 33 percent longer than the width of the pond to compensate for the semicircle formed when the net is moved forward. Likewise, the depth of the seine should be 33 percent greater than the maximum pond depth.)

EXAMPLE: FIGURE 8

From *Manual for Bait Fish Culture in the South* by John J. Guidice, et. al. With permission.

EXAMPLE: FIGURE 9



From *Manual for Bait Fish Culture in the South* by John J. Guidice, et. al. With permission.

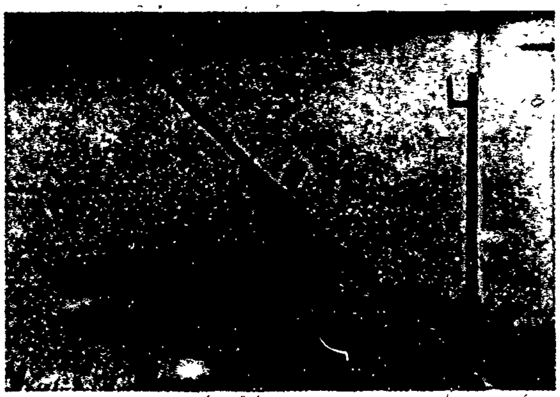
B. Clean, zinc coated or plastic buckets, 4 to 5 gallon capacity

C. One-ton truck with two 300-gallon tanks for transfer of fish to holding tanks

INFORMATION SHEET

D. Lift traps if harvesting fathead minnows or goldfish; screen box if harvesting entire population of small pond (Figures 10 and 11)

EXAMPLE: FIGURE 10



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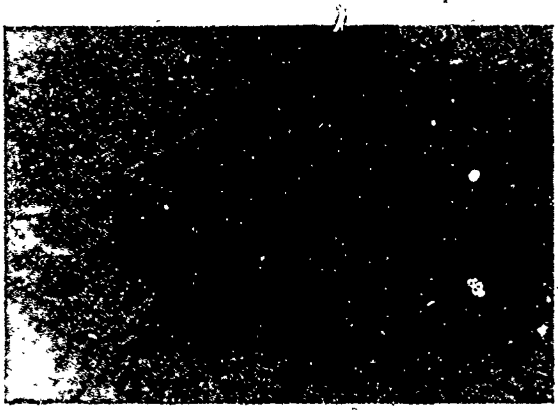
EXAMPLE: FIGURE 11



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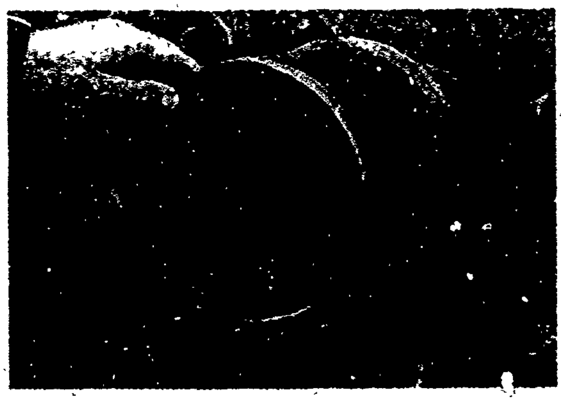
INFORMATION SHEET

E. Cylinder traps with one or two funnels if harvesting fathead minnows in cold weather (Figure 12)

EXAMPLE: FIGURE 12



F. Holding tanks, 10 to 40 feet long and 2 feet deep, supplied with fresh, cool water and equipped with an aeration device

XVII. Harvesting methods

A. Pond draining

1. This method is used to harvest the entire population of a small pond; and is a particularly good method for harvesting delicate golden shiners because it requires no seining.

2. The water level is lowered and the fish are confined to a small area so that the water temperature can be lowered overnight--ideally to 60°F--by adding well or spring water.

3. In the early morning, the fish are flushed through the drainpipe and collected in a screen box at the outflow, or dip netted from the harvest basin into buckets.

B. Seining the whole pond

1. Seines of the appropriate mesh size, length, and depth are pulled slowly from one end of the pond to the other, trapping the fish in a small area.

2. Dip nets are used to dip the fish from the seine into buckets for relay to the harvest truck.

C. Baiting and seining

1. This method is generally used for partial harvests.

2. Fish are baited into a corner of the pond with wet or pelleted feed that will sink near the shore in shallow water.

INFORMATION SHEET

3. The feeding fish are captured by pulling a seine slowly and quietly across the corner with a length of rope.

4. As soon as the seine is pulled and gathered, it is moved to deeper water so the fish can move away from the surface.

5. Fish are dipped from the seine with dip nets and relayed to the harvest truck in buckets as for full pond seining.

D. Lift traps

1. Lift traps are used in harvesting goldfish and fathead minnows

2. Lift traps are usually constructed of 3/16-inch nylon mesh on a 4-foot square steel frame that can be carried in a pick-up; they are generally suspended in the pond from a pipe resting on a fulcrum pole. (See Figure 10)

3. Fish are baited into this nylon mesh trap while it is lying on the bottom of the pond.

4. The net is lifted, and the captured fish are then dipped from the trap and relayed to the harvest truck in buckets.

E. Cylinder traps

1. Cylinder traps are used to harvest fathead minnows in cold weather

2. They are made of wire mesh 1 foot in diameter and 2 feet long, and are baited with small bags of fish food. (See Figure 12.)

3. Fish that enter the traps cannot easily get out through the small funnel opening.

4. Traps are emptied directly into buckets for relay to harvest truck.

XVIII. General harvesting and hauling guidelines

A. When baiting is not used, withhold feed for at least 24 hours prior to harvest to prevent fouling of holding water.

B. In summertime harvest ponds whose surface temperatures are 75°F and above with great care and during cool, early morning hours.

C. Slow the metabolic rate of excitable golden shiners by dropping the water temperature 15 degrees.

(NOTE. Golden shiners can tolerate abrupt temperature drops of 15 degrees for short periods of time; this technique "sedates" these nervous fish and makes harvesting and handling easier for both the producer and the fish.)

INFORMATION SHEET

D. To avoid shock, gradually lower the water temperature to 60° F to 65°F for fathead minnows and bait-sized goldfish as these species cannot tolerate 15-degree temperature drops.

E. Fit harvesting tanks with at least one agitator or with a source of compressed air or oxygen, and aerate the tank water before placing fish in tanks.

F. If more than one tank is used, empty the buckets of fish alternately into the tanks to prevent overcrowding of one tank while the other is being filled.

G. In cool weather load each tank with about 1 pound of fish per gallon of water, in warm weather, reduce the load to about 2/3 pound per gallon.

XIX. Guidelines for maintaining baitfish in holding troughs

A. Following harvest, hold baitfish undisturbed for at least 24 hours so that they can undergo a "hardening" process before grading and handling, and so that they will pass all food and not foul the transport water.

B. Control water quality by ensuring adequate water exchange and aeration, and by avoiding overcrowding.

(NOTE: Baitfish hold best in water containing a minimum of 3 to 5 ppm oxygen.)

C. In the summer, hold baitfish at water temperatures close to 70°F by blending warm water with cooler well water.

D. Continually monitor holding troughs, removing dead or injured fish routinely.

E. Remove any tadpoles, trash fish, and detritus from holding troughs.

F. Return to the pond any fish that have been stored over 1 week.

G. When they are emptied, scrub holding troughs with a chlorinated material, such as household bleach, and rinse well.

H. Have a back-up energy source for pumping and aeration.

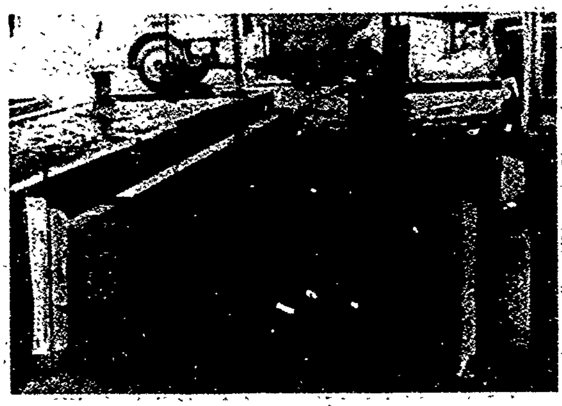
I. Have available back-up equipment, such as aerators, and an adequate supply of water.

INFORMATION SHEET

XX. **Grading equipment and procedures**

A. Single grader panel (Figure 13)

EXAMPLE: FIGURE 13



From *Manual for Bait Fish Culture in the South* by John J. Guidice, et: al. With permission.

1. A panel of spaced vertical bars is slowly moved from the head to the foot of the trough.

2. Those fish that are too large to slip through the bars are trapped at the foot and moved to another holding tank with fish of similar size.

B. Multiple grader panels

1. Grader panels are arranged in the trough so that bar space gets progressively smaller toward the head of the trough.

2. Fish are placed in the first compartment at the foot of the trough and are graded as they swim toward the inflowing water.

C. Grader box (Figure 14)

1. A free-standing or floating box with spaced vertical bars is placed in the water and fish are placed in it.

(NOTE: Fathead minnows grade better in floating box graders with bottom panels.)

INFORMATION SHEET

2. The larger fish that cannot pass between the bars are moved to another holding tank with fish of a similar size. (Figure 14)

EXAMPLE: FIGURE 14

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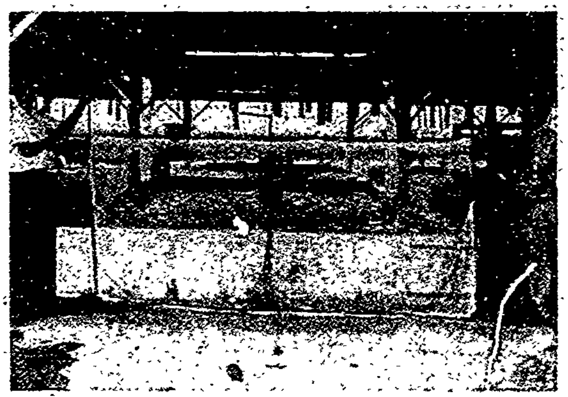
D. Barrier screens, tank nets, and crowders (Figure 15)

EXAMPLE: FIGURE 15—Barrier screen



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INFORMATION SHEET

1. Wooden or metal frames covered with screen, netting, or perforated metal plates are inserted into the guide slots on the sides of the holding trough.

2. Screens, crowders, and tank nets are used to move fish within the tank, and to block fish from certain areas.

XXI. Transporting fish to long-distance markets

A. Long-distance markets are markets more than 24 hours away.

B. Fish are shipped to market on transport vehicles--generally trucks--equipped with several to many large aluminum, fiberglass, or plywood transport tanks.

C. The tanks are closed systems aerated with compressed air, liquid oxygen, mechanical agitators, or a combination of these methods.

D. Fish are slowly tempered to the water temperature of the receiving tanks, usually 20 minutes for each 10 degree decrease in water temperature.

E. Loading rates depend on size of fish, length of transport, water temperature, and water quality.

EXAMPLES: Tables 1 and 2

Table 1: Normal Load Capacity in Pounds per Gallon of Water for Baitfish Transported by Tank (with Agitators or Blower System) in Hard Water at 65°F

Average Length (Inches)	Duration of Transport Hours 1	6	12	24
2	2	1.5	1	1
3	3	2	1	1

The loading rate can be increased by 25% when pure oxygen is added. For each 10°F increase in water temperature, the load should be decreased by 25%.

Table adapted from Harry K. Dupree and Jay V. Huner, "Transportation of Live Fish," *Third Report to the Fish Farmers,* 1984.

INFORMATION SHEET

Table 2: Weight in Pounds per Thousand Baitfish

Total Length (Inches)	Golden Shiner	Fathead Minnow	Goldfish
2	3.9	3.3	5.4
2.5	5.4	7.6	9.0
3	8.6	11.0	17.0
3.5	13.5	19.8	24.5
4	19.0	24.4	40.0

Table adapted from Harry K. Dupree and Jay V. Huner, "Transportation of Live Fish," *Third Report to the Fish Farmer*, 1984.

F. Because fish are crowded into transport tanks for economy, the production of water-fouling fish wastes is kept at a minimum in one or more of the following ways:

1. Fish are starved for a period of time before loading;

2. The fish's metabolic rate is lowered by cooling the water in the transport tanks to 60°F by icing;

   (NOTE: Some transport trucks have ice compartments above each tank, others pump cool water through coiled tubing from an ice compartment at one end of the unit.)

3. The fish's metabolic rate is lowered by adding 0.1% to 0.3% table salt or an anesthetic chemical to the water.

   (NOTE: Salt is often added to the transport water of excitable golden shiners.)

XXII. Transporting fish to short-distance markets

A. Short-distance markets are markets less than 24 hours away.

B. Fish are starved for a minimum of 24 hours and the night before transport, the temperature of holding tank water is gradually reduced to 60°F; salt or an anesthetic chemical may be added.

C. On the morning of the transport, 6 pounds of baitfish are placed in 14 pounds of water in thick plastic bags, about 18 inches wide by 32 inches long.

D. Each bag is inflated with oxygen and sealed by twisting the top, folding it down, and securing it tightly with a rubberband.

E. Bags of fish are placed in styrofoam-lined cardboard boxes for temperature control and loaded on transport trucks or another type of transport vehicle.

COMMERCIAL BAITFISH PRODUCTION
UNIT XI

ASSIGNMENT SHEET #1
SURVEY BAITFISH DEALERS TO EVALUATE LOCAL SUPPLY AND DEMAND

Visit bait retailers in your area to evaluate local supply and demand for baitfish. Use your knowledge of the area and the yellow pages of the phone directory to locate three or four bait stores. Visit each of these businesses and talk with the owners to find the answers to questions such as those that follow. Write your questions and answers in a notebook so that you can compare answers and draw conclusions following your interviews.

Sample Questions

1. What baitfish species do you sell?
2. Which species is most popular with the consumers in this area?
3. Have customers requested a species that you do not stock?
4. What size baitfish is in most demand?
5. Who is your source of supply?
6. How dependable is your supply source? Can you get the baitfish you need when you need them?
7. What prices are you presently paying the supplier for each species?
8. What prices are you presently selling each species for?
9. How does species demand change seasonally?
10. What are the peak demand periods?
11. How many pounds of baitfish do you generally purchase annually?
12. How often do you take deliveries?
13. How large are your holding facilities and what are your holding techniques?
14. How long do you generally hold stock?
15. What is your average mortality loss on delivered fish?

COMMERCIAL BAITFISH PRODUCTION
UNIT XI

ASSIGNMENT SHEET #2
VISIT A BAITFISH FARM AND REPORT ON THE OPERATION

Make arrangements to visit a baitfish farm in your area. If possible, plan to visit in the spring when the producer is getting brood ponds ready, handling spawning mats, flooding fry ponds, feeding production ponds, and harvesting and loading fish for sale. Plan to spend at least two full days observing the day-to-day pond management and recordkeeping practices used by the producer.

Ask many questions and record answers and your observations in a notebook. After your visit write a report on the operation you observed. Present your report orally to the class.

Sample Questions

1. Why did the producer select the species being raised?
2. How did the producer get started in the baitfish business?
3. What is the size of the enterprise? How long has the producer been in the baitfish farming business?
4. What financing was necessary and what local institutions were helpful?
5. What documentation (cost projections, etc.) did the financial institution(s) require?
6. What start-up problems did the producer encounter?
7. What advice would the producer give to someone thinking of undertaking commercial baitfish production?
8. What markets does the producer serve, and how stable are these markets?
9. What market methods does the producer use? To wholesaler? To retailers? Direct to consumer?
10. What are the present wholesale and retail prices being asked?
11. Approximately how large a profit margin does the producer realize yearly?
12. What harvesting and hauling methods does the producer use?
13. What recordkeeping system does the producer keep?
14. What pond preparation and predator control methods does the producer use?
15. To whom does the producer turn for parasite and disease diagnosis?
16. Where does the producer purchase feed? Medication? Chemicals? Equipment? Transport services? Pond construction services?

ASSIGNMENT SHEET #2

17. How, where, and how long does the producer store feed?
18. What types of commercial feed are bought?
19. What are feed prices at present?
20. Does the producer mix farm-formulated feeds?
21. What harvesting and hauling methods does the producer use?
22. How many holding troughs does the producer maintain, and how are they arranged?
23. What is the major water source? What is the water capacity?
24. What aeration equipment is used?
25. What is the primary power source?

COMMERCIAL BAITFISH PRODUCTION
UNIT XI

JOB SHEET #1
TRAP, COUNT OR WEIGH, AND GRADE A SAMPLE OF BAITFISH

A. Equipment and materials

1. Pick-up truck
2. Lift seine/fulcrum and boom
3. 16% protein bait feed
4. Scales
5. Galvanized or plastic buckets
6. Floating grader of appropriate bar space

TABLE 1

Space Between Bars (Inches	Fish Size	Pounds/1,000
13/64 - 16/64	Small crappie bait	3 to 5
17/64 - 23/64	Large crappie bait	6 to 12
23/64 - 32/64	Bass bait	12 to 20
33/64 -	Trotline bait	20 and over

Table adapted from John J. Giudice, D. Leroy Gray, and J. Mayo Martin, *Manual for Baitfish Culture in the South.* With permission.

7. 3/16-inch nylon mesh dip nets
8. Pencil and paper for recording data

B. Procedure

1. Transport equipment to capture site in pick-up.
2. Set up fulcrum and boom, and attach lift seine.
3. Place a portion of the 16% feed in the seine, and lower the seine slowly to the pond bottom.
4. While waiting for the fish to gather, set up hanging scale.

JOB SHEET #1

5. Fill a couple of buckets about half full with pond water; weigh each bucket and record weight.

   Bucket #1 = ____________________ lb./oz. water

   Bucket #2 = ____________________ lb./oz. water

6. When fish have gathered in the lift net, use the fulcrum/boom to lift it until the top edges are about 5 inches above the water surface.

7. Dip out fish with dip net, count, and transfer to buckets; record the total number in each bucket.

   Bucket #1 = ______________ fish

   Bucket #2 = ______________ fish

8. Weigh each bucket and then subtract first weight from this weight to get total weight of fish.

   Bucket #1 = ____________ fish at ____________ lbs.

   Bucket #2 = ____________ fish at ____________ lbs.

9. Divide the number of fish into the total weight to get the average weight per fish.

   $$\text{Average Weight per Fish} = \frac{(\text{Lbs. Bucket \#1} + \text{Lbs. Bucket \#2})}{(\text{No. Fish/Bucket \#1} + \text{No. Fish/Bucket \#2})}$$

   Average Weight per Fish = ____________________ oz.

10. Place floating grader in the pond and empty the buckets of fish into the grader.

11. Release the fish into the pond, gather equipment, and return it to proper storage.

COMMERCIAL BAITFISH PRODUCTION
UNIT XI

JOB SHEET #2
MAKE A SPAWNING MAT

A. Equipment and materials

1. 8 feet woven steel-welded wire with 2- by 4-inch mesh
2. Wire cutters
3. Pliers
4. Steel tape
5. 1 dozen hog rings
6. Quantity of Spanish moss or synthetic material such as Astroturf or spandex

B. Procedure

1. Use wire cutters to clip length of wire to approximately a 20 inch width.
2. Measure 48 inches from one end, and fold the wire mesh in half at this point, using pliers to bend wire.
3. Sandwich Spanish moss between the two layers of woven wire.
4. Secure the moss between the top and bottom by fastening the wire layers together with hog rings.
5. Use wire cutters to remove selected wires from the top side, making the mesh size 4 by 4 inches.
6. Clean work area and return equipment to proper storage.

COMMERCIAL BAITFISH PRODUCTION
UNIT XI

JOB SHEET #3
BRING BAITFISH EGGS INTO HATCHING AREA AND WATCH THEM HATCH

A. Equipment and materials

1. Spawning mat

2. Magnifying glass

B. Procedure

1. When spawning mat is uniformly covered with eggs, remove it from spawning pond and transfer it to rearing pond.

2. Estimate the number of eggs on the mat by counting the number in one 4 by 4 square of wire mesh and multiplying by the number of squares on the mat.

3. Record the date that the mat was placed in the rearing pond.

4. Observe the mat daily; record developments and the date of first hatching.

5. Observe the sac fry and record the date when they first become swim-up fry.

COMMERCIAL BAITFISH PRODUCTION
UNIT XI

PRACTICAL TEST #1

JOB SHEET #1 — TRAP, COUNT OR WEIGH, AND GRADE A SAMPLE OF BAITFISH

Student's Name ______________________________ Date __________

Evaluator's Name ______________________________ Attempt no. _____

Student instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	Yes	No
1. Prepared seine, scale, and buckets properly.	☐	☐
2. Dipped and counted fish properly.	☐	☐
3. Weighed and averaged weight properly.	☐	☐
4. Used grader properly.	☐	☐
5. Released fish and returned equipment.	☐	☐

EVALUATOR'S COMMENTS: ______________________________

____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:				
Preparation	Excellent 4	Acceptable 3	Fair 2	Poor 1
Weighing and Averaging	Accurate 4	Acceptable 3	Poor 2	Inaccurate 1
Grader use	Effective 4	Acceptable 3	Poor 2	Unacceptable 1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — **Skilled** — Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program; limited additional training may be required.
2 — **Limited skill** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

COMMERCIAL BAITFISH PRODUCTION
UNIT XI

PRACTICAL TEST #2
JOB SHEET #2 — MAKE A SPAWNING MAT

Student's Name ______________________________ Date ________

Evaluator's Name ______________________________ Attempt no. ______

Student instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	Yes	No
1. Cut woven wire to proper dimensions.	☐	☐
2. Sandwiched Spanish moss into mat properly.	☐	☐
3. Secured moss and wires with hog rings.	☐	☐
4. Trimmed top mesh to proper size.	☐	☐
5. Returned equipment to proper storage.	☐	☐

EVALUATOR'S COMMENTS: ______________________________

____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:				
Mesh preparation	Excellent 4	Good 3	Fair 2	Poor 1
Moss application	Excellent 4	Good 3	Fair 2	Poor 1
Final trim	Excellent 4	Good 3	Fair 2	Poor 1
Mat Quality	Excellent 4	Good 3	Fair 2	Poor 1

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — **Skilled** — Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program; limited additional training may be required.
2 — **Limited skill** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

COMMERCIAL BAITFISH PRODUCTION
UNIT XI

PRACTICAL TEST #3

JOB SHEET #3 — BRING BAITFISH EGGS INTO HATCHING AREA AND WATCH THEM HATCH

Student's Name ______________________________ Date __________

Evaluator's Name ______________________________ Attempt no. _____

Student instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	Yes	No
1. Selected uniformly egg-covered mat.	☐	☐
2. Used 4 x 4 square to estimate eggs on mat.	☐	☐
3. Recorded date eggs went to rearing pond.	☐	☐
4. Observed hatching on daily schedule and recorded developments.	☐	☐
5. Recorded date sac fry appeared.	☐	☐
6. Recorded date swim-up fry appeared.	☐	☐

EVALUATOR'S COMMENTS: ____

____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:

Preparation	Excellent 4	Good 3	Fair 2	Poor 1
Counting and Estimating Eggs	Accurate 4	Acceptable 3	Poor 2	Inaccurate 1
Daily Observations	Complete 4	Acceptable 3	Too few 2	Unacceptable 1
Hatching and other observations	Complete 4	Acceptable 3	Too few 2	Unacceptable 1

EVALUATOR'S COMMENTS: ____________________

____

PERFORMANCE EVALUATION KEY

4 — **Skilled** — Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program; limited additional training may be required.
2 — **Limited skill** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

COMMERCIAL BAITFISH PRODUCTION
UNIT XI

TEST

Name ______________________________ Score ______________

1. Match terms associated with commercial baitfish production with their correct definitions. Write the correct numbers in the blanks.

_____a.	Eating both animal and vegetable food	1.	Propagation
_____b.	Reproduction; raising or breeding	2.	Slurry
_____c.	Microscopic single-celled animals living in water; mostly parasitic	3.	Spawning mat
		4.	Saprophyte
_____d.	Drain end of holding trough	5.	Parasite
_____e.	To allow fish to adjust to different water chemistry and temperature	6.	Protozoa
_____f.	Artificial nest, generally of Spanish moss, or a synthetic material such as spandex, on which fish lay eggs	7.	Omnivorous
		8.	Carnivorous
_____g.	Tame; bred and raised in captivity	9.	Ovarian
_____h.	Thin, watery mixture of feed	10.	Tubercles
_____i.	Inflow end of holding trough	11.	Domestic
_____j.	Organism that lives on dead or decaying organic matter	12.	Head
		13.	Foot
_____k.	Organism that lives on another live organism, generally causing harm	14.	Metabolism
_____l.	Chemical and physical processes by which an organism breaks down matter and releases it as waste or energy	15.	Temper
_____m.	Hornlike projections on the head of breeding fathead minnows		
_____n.	Pumping plankton from a pond with bloom to a pond without bloom to promote plankton growth		
_____o.	Ungraded by size or sex		

TEST

_____p. Having to do with the ovaries, the female egg-producing glands

_____q. Eating only animal food

16. Seeding

17. Pond run

2. Complete factual statements about the baitfish industry. Write the correct numbers in the blanks.

_____a. Baitfish have been raised in the mid-western United States since the _____.

1) 1920s
2) 1940s
3) 1950s

_____b. In the United States commercial production of baitfish is worth _____ at the fish farm level.

1) $500 million
2) $300 million
3) $100 million

_____c. The major fish species raised for bait are _____, all of the minnow family.

1) golden shiners, fathead minnows, and goldfish
2) common shiners, plains minnows, and silver chubs
3) red shiners, creek chubs, and longnose daces

_____d. The major baitfish-producing states are _____.

1) Oklahoma, Mississippi, Louisiana, and Missouri
2) Arkansas, Kansas, Missouri, and Minnesota
3) Georgia, Louisiana, West Virginia, and Maryland

_____e. _____ is the major bait-producing state in the South, supplying about 1/2 of the nation's supply.

1) Mississippi
2) Louisiana
3) Arkansas

_____f. For the past several years, the water acreage devoted to baitfish production—nearly equal to that of catfish production—has _____.

1) remained stable
2) grown rapidly
3) decreased considerably

TEST

3. List baitfish marketing options.

   a. ____________________

   b. ____________________

   c. ____________________

4. Select from a list factors affecting marketing success. Write an "X" in the blank before each factor.

   _____a. Fishermen are very undemanding consumers.

   _____b. Bait needs—and fishermen's demands—change with the seasons.

   _____c. Oversupply or shortages of bait are not always foreseeable, and yet are realities that must be expected and dealt with.

   _____d. The retail price may be so high that sales drop as fishermen seine for their own bait or use artificial lures.

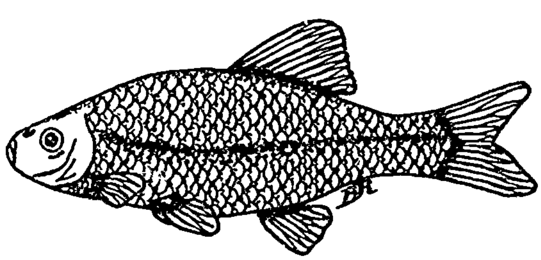
   _____e. Prices can rise when a competitor cuts prices to promote business.

   _____f. Good weather can increase sport fishing and thus deplete the stock.

   _____g. Baitfish are perishable and do not lend themselves well to stockpiling or increased inventories.

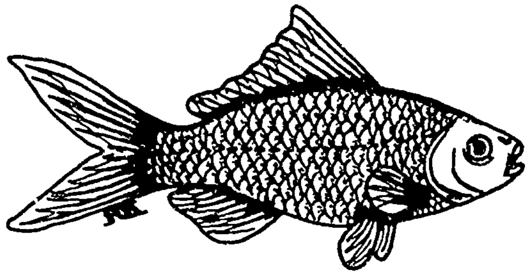
   _____h. As profits decrease, competition becomes keener.

5. Identify the following baitfish species. Write the correct names under the illustrations.

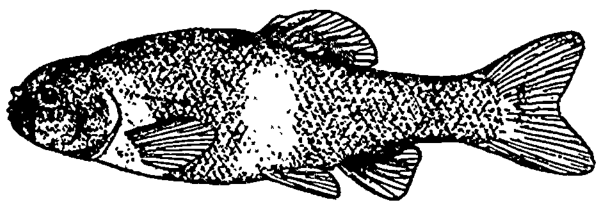


a. ____________________

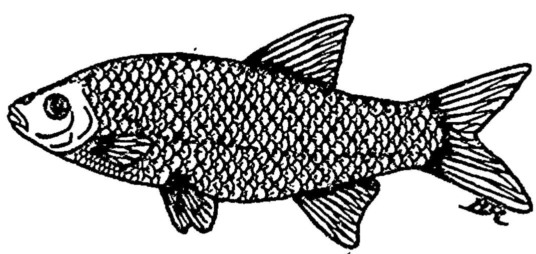
TEST



b. ____



c. ____



d. ____

TEST

6. Distinguish among general characteristics of popular baitfish species. Write "GS" in the blanks before characteristics of golden shiners, "FM" in the blanks before characteristics of fathead minnows, and "G" before characteristics of goldfish.

_____a. Delicate, easily damaged species prone to losing its scales; sensitive to handling during hot weather; excitable: leaps from holding tanks and bait containers.

_____b. Not a widely popular baitfish because of its sluggishness on the hook.

_____c. Used for casting bait for sport fishing; new variety (rosy red) used as feeder fish and as forage for bass.

_____d. Thick body, large olive to red or gold scales, long graceful fins; can grow to 2 pounds if not overcrowded.

_____e. Somewhat delicate, but can be handled carefully during hot weather; males may die at spawning.

_____f. Deep body; large, loosely attached silver scales; downward curving lateral line, pointed dorsal fin; can grow to over 10 inches.

_____g. Trotline bait; feeder fish for carnivorous aquarium fish; used as forage fish for bass and catfish broodfish.

_____h. Streamlined body, small scales, dull color, rounded dorsal fin; does not often grow larger than 3 inches.

_____i. Very hardy, easy to handle, transport, and store.

_____j. Most popular baitfish because of its bright, flashing appearance and liveliness on hook.

_____k. Casting bait for sport fishing.

_____l. Popular baitfish because it tolerates careful handling in warm weather.

7. Select factual statements regarding guidelines for the selection of broodstock. Write the correct numbers in the blanks.

Golden Shiners

_____a. Avoid wild stock; select instead domestic stock that has been _____ as these broodfish are easier to handle.

1) raised in captivity
2) inoculated against disease
3) over-wintered at least one season

TEST

_____b. Select broodstock each year from the _____ population to protect against *Phistophora ovariae*, an ovarian protozoan.

1) fry
2) adult
3) yearling

_____c. Choose healthy, lively broodstock with _____ fins and no missing scales or dull areas on the sides or back.

1) folded
2) dark red
3) upright

Fathead minnow

_____a. Select male broodstock with care as adult males ____ than females, a characteristic that may create problems when a mechanical grader is used for broodstock selection.

1) grow larger
2) are more delicate
3) are more round-bellied

_____b. Separate sexes by using a ____ bar grader.

1) 12/16 or 14/16
2) 15/64 or 16/64
3) 15/32 or 16/32

_____c. Select lively, healthy broodfish with no _____ or distended abdomen.

1) tubercles on head
2) head or eye deformity
3) upright fins or scales

_____d. Be aware that _____.

1) many adult males die before spawning
2) many adult females die after spawning
3) many adult males die after spawning

Goldfish

_____a. Select broodstock that will _____.

1) produce the fry size most desired by the market in your area
2) produce the color most desired by the market in your area
3) produce the weight most desired by the market in your area

TEST

_____b. Select broodstock that will produce the _____ generally preferred by fishermen.

1) slim-bodied stock
2) thick-bodied stock
3) short-bodied

_____c. Before spawning occurs, remove any broodfish with _____.

1) soft, flowing fins
2) a marketable shape or color
3) an undesired shape or color

_____d. Choose lively, healthy fish with no signs of disease or _____.

1) pigment
2) parasites
3) plankton

8. Distinguish among the reproductive and spawning characteristics of golden shiner, fathead minnow, and goldfish. Write "GS" before characteristics of golden shiners, "FM" before fathead minnows, and "G" before characteristics of goldfish. Some blanks may contain more than one answer.

_____a. Sexually mature at 1 year.

_____b. Releases 2,000 to 4,000 eggs during each of several spawns.

_____c. Breeding appearance is not significantly different than that of nonbreeding appearance.

_____d. Eggs usually hatch in 5 to 6 days; male guards eggs until fry emerge.

_____e. Spawning starts when water temperature reaches 60°F.

_____f. Eggs released randomly, preferably above living plants, but also cling to rocks, debris, and roots; culturists place spawning mats in pond for egg deposits.

_____g. Releases up to 10,000 eggs.

_____h. During breeding season, male develops dark head covered with breeding tubercles, and a thick pad on back behind head.

_____i. Spawning season starts when water temperature nears 65°F, and continues during cool periods in summer; may start again in fall.

_____j. During breeding, female's vent becomes larger, redder, and protrudes more than male's; at all times male can be sexed by noting serrated pectoral spines; female's are not serrated.

TEST

_____k. After fertilization, male places eggs on underside of hard objects in shallow water; culturists place bricks, smooth pieces of tile, and bloating boards in ponds for egg deposits.

_____l. Eggs hatch in 2 to 8 days, depending on the water temperature no protection is given to eggs or fry by the adults.

_____m. Spawning starts when water temperature reaches 70°F and continues through June in the South.

_____n. Releases 200 to 500 eggs during each of many spawnings.

_____o. Eggs hatch in 4 to 8 days at water temperatures of 75°F to 90° F; no protection is given to the eggs or fry by the adults.

9. Match propagation methods with their descriptions. Write the correct numbers in the blanks.

_____a. Spawning and egg laying occur in a specially prepared spawning pond; eggs are transferred to a rearing pond.

_____b. Spawning, egg laying, hatching, and growing of young occur in same pond.

_____c. Fry produced by either of the other methods, are trapped, counted, and transferred to rearing ponds.

1. Wild or free spawning
2. Egg transfer
3. Fry transfer

10 Match to their correct descriptions methods of pond preparation for propagation and rearing. Write the correct numbers in the blanks.

_____a. To prevent uncontrolled egg deposits all aquatic vegetation and leaves and roots of marginal plants are killed; predators are killed or controlled; spawning mats are placed in groups 1 inch below shallow water at the edge of the pond with edges touching.

_____b. Predators are killed or controlled, and existing spawning sites are supplemented with rocks, pieces of tile, bricks, or 4- by 12-inch sections of board stapled to a wire at 12-inch intervals and stretched parallel to the shore in shallow water.

1. Wild or free-spawning pond
2. Spawning pond for egg transfer method

TEST

_____c. Pond is drained or lowered, predators are killed or controlled, and grass is planted on the dry bottom or along the shoreline to provide natural spawning sites; or, if plant growth is scarce, spawning mats are placed in the pond.

_____d. Pond is rid of toxins, cleared of all predators, and fertilized to establish a plankton bloom, which provides natural food for fry and also shades out aquatic weeds.

3. Spawning pond for fathead minnow fry transfer
4. Fry rearing pond

11. Match predators with their control techniques. Write the correct numbers in the blanks.

_____a. After eggs are placed in pond, apply Masoten at 0.25 ppm.

_____b. Use scaring devices; shoot in season; check with local authorities before taking any control measures.

_____c. Shoot or trap; completely dry pond, and treat small potholes with calcium hypochlorite (HTH).

_____d. Harvest adults, and in spring dip out egg masses; remove cover on pond banks and in pond.

_____e. Shoot; trap; mow levees closely.

_____f. Fill pond to 1 inch flood and treat with 10 ppm copper sulfate; then add 500 pounds per acre of hydrated limestone.

_____g. Apply 3 gallons of diesel fuel plus 1 quart of crankcase oil per surface acre; apply upwind side of pond and let flow across surface; start before stocking with eggs; repeat once a week until fish are 1 inch long.

_____h. Same as for turtles, or stock with 6 or 8 channel catfish per surface acre; channel catfish should be free of disease or parasites.

1. Turtle
2. Snail
3. Crayfish
4. Insects
5. Cyclops and large zooplankton
6. Wild fish
7. Snakes
8. Frogs and tadpoles

TEST

_____i.	Trap and/or use zinc phosphide-treated bait.		9.	Muskrat
_____j.	Use well water or screen filter surface water; treat potholes with hydrated lime or calcium hypochlorite after harvest.		10.	Birds

12. Complete statements about the propagation and stocking of golden shiner and goldfish. Write the correct numbers in the blanks.

Wild or free-spawning method

_____a. Stock golden shiner at a rate of _____ pounds of ungraded broodfish per acre; stock _____ goldfish broodstock per acre, depending on size.

1) 10 to 20; 50 to 100
2) 20 to 40; 100 to 300
3) 40 to 50; 300 to 600

_____b. If spawning activity diminishes, stimulate it by _____.

1) rapidly lowering the level of the pond or by adding calcium hypochlorite, which chemically shocks the fish into spawning.
2) rapidly raising the level of the pond or by adding large quantities of warm water, which shocks the fish into spawning.
3) rapidly raising the level of the pond or by adding potassium permanganate, which chemically shocks the fish into spawning.

_____c. To extend the spawning season, _____, preferably to small narrow ponds.

1) add large quantities of cool water
2) add large quantities of hydrated lime
3) add large quantities of potassium permanganate

_____d. After the adults have spawned, _____, or sell as bait.

1) remove them from the pond and store in another pond for future broodstock use
2) remove the females from the pond and store the males in another pond for future broodstock use
3) remove the males from the pond and store the females in another pond for future broodstock use

Egg transfer method

_____a. Stock _____ pounds of golden shiners per acre and goldfish at a rate of _____ pounds per acre.

1) 200 to 300; 500 to 800
2) 100 to 250; 200 to 500
3) 400 to 500; 800 to 1,000

TEST

_____b. When the fish are ready to spawn, place spawning mats _____ below shallow water, with one side of the mat at the edge of the pond, arranging mats end to end in groups.

1) 1 foot
2) 1 inch
3) 1/2 meter

_____c. Transfer mats to rearing ponds when _____.

1) eggs become so abundant that they touch
2) they are uniformly covered with eggs
3) eggs number approximately 10,000

_____d. Estimate the number of eggs on each mat/ and then — depending on the average number of eggs per mat — stock from _____ mats per acre in golden shin ponds; _____ mats per acre in goldfish rearing ponds.

1) 10 to 25; 20 to 40
2) 20 to 50; 50 to 75
3) 50 to 75; 50 to 150

_____e. Wher spawning becomes very light, remove most of the mats from the spawning pond, leaving at least _____ in each spawning area to prevent fish from depositing eggs on other material.

1) 1 mat
2) 2 mats
3) 3 mats

_____f. After spawning stops and hatching is completed, _____ all spawning mats.

1) remove, sterilize, and store
2) remove and discard
3) remove, wash and store

Fry transfer method

_____a. When fry produced either by the wild spawning or egg transfer method are about ____ long, capture with lift traps or fine-mesh seines during coolest part of day.

1) 1/2 inch
2) 5/8 inch
3) 3/4 inch

TEST

_____b. Count the fry by first counting the number of fry in ____ and then multiplying by the number of ____ transferred.

1) 1 quart; quarts
2) 1 pound; pounds
3) 1 ounce; ounces

_____c. Transfer fry to rearing ponds in buckets graduated in quarts; stock golden shiners at rates from ____ per acre and goldfish at rates from ____ per acre.

1) 25,000 to 100,000; 50,000 to 1/2 million
2) 50,000 to 200,000; 25,000 to 1 million
3) 75,000 to 500,000; 75,000 to 5 million

13. Distinguish between free-spawning and fry transfer methods of propagating fathead minnows. Write "FS" in the blanks before descriptions of free-spawning methods, and "FT' in the blanks before descriptions of fry transfer methods. Blanks may contain more than one answer.

_____a. Stock prepared spawning ponds with 20,000 to 25,000 broodstock per acre at a 5:1 female to male ratio.

_____b. When they are 1/2 to 3/4 inch long, capture fry with a fine-mesh seine or lift trap, estimate numbers, and transfer to rearing ponds.

_____c. Stock at a rate of 500 to 2,000 broodfish per acre at a 5:1 ratio, 5 females to 1 male.

_____d. Provide supplemental spawning sites by placing rocks, pieces of tile, bricks, or boards in the pond.

_____e. Stock rearing ponds at a rate of 50,000 to 300,000 fish per acre.

14. Discuss fertilization techniques for plankton production. Answer the following questions.

a. What are the two basic types of fertilizers used to establish plankton blooms in fry ponds?

____

____

b. What Secchi disc reading indicates that the bloom is dense enough?

____

TEST

c. What two steps can be taken if the water begins to clear of plankton?

____

____

d. If a need is determined when is finely ground limestone added?

____

e. What two compounds are used on acid soils?

____

____

f. What compound is used on basic soils?

____

g. When the two types of fertilizers are used in combinations, what is the application rate for manures? For inorganic fertilizers?

Manures: ______________________________

Inorganic fertilizers: ______________________________

h. What is the application rate for inorganic fertilizer used alone?

____

i. What is the advantage to spraying liquid fertilizers on the pond surface?

____

15. Complete statements about feeding practices. Write the correct numbers in the blanks.

_____a. In extensive culture, pond water for golden shiner or fathead minnow production is fertilized until a plankton bloom creates a secchi disc reading of _____ inches; bloom is maintained until fry reach about _____ inch and before hot weather.

1) 4 to 5; 1/4 inch
2) 6 to 8; 1/2 inch
3) 8 to 9; 1 inch

TEST

_____b. In intensive culture, if golden shiner fry _____ when a small amount of food is thrown into the pond, they can be fed feed.

1) come to the surface and eat
2) swim to the bottom
3) do not hide in the vegetation

_____c. Pond water for extensive culture of fathead minnows and golden shiners is maintained at a ____ Secchi disc reading.

1) 13-inch
2) 14-inch
3) 15-inch

_____d. When starting golden shiner fry on feed, ponds are checked at downwind edge _____ after feeding to see that all feed has been eaten

1) 1 hour
2) 2 hours
3) 3 hours

_____e. Heavily fed shiner ponds can be fed at least _____ of feed per acre per day with resulting production levels of 600 to 800 pounds per acre.

1) 40 pounds
2) 50 pounds
3) 60 pounds

_____f. Young fathead minnows are begun on starter feed in fertilized ponds that contain up to _____ brood fish, with some producers also feeding grower feed for the broodfish.

1) 125,000
2) 2,500
3) 25,000

_____g. Fathead minnow fry in the rearing pond are fed _____ until they are about 3/4 inch long.

1) on all sides of the pond
2) on the downwind side of the pond
3) on two sides of the pond

_____h. When fathead minnow fry are about 3/4 inch long, the producer changes to _____ feed, blending 3 parts to 1 part starter feed until the fish learn to eat the new feed and a full ration is fed.

1) powdered grower feed
2) pelleted grower feed
3) sinking starter feed

TEST

_____i. Extensively cultured goldfish are fed by fertilizing the water until a plankton bloom creates a Secchi disc reading of _____.

1) 3 to 5 inches
2) 9 to 14 inches
3) 5 to 7 inches

_____j. After goldfish in extensive culture grow to about 1 inch, the plankton bloom is allowed to recede to a Secchi disc reading of _____; the pond is maintained at this reading.

1) 10 inches
2) 12 inches
3) 14 inches

_____k. Fertilization of intensively cultured goldfish ponds is the same as that for golden shiners, but production may be increased with supplemental feeding using golden shiner diets in which _____ is submitted for some other ingredients such as feather meal.

1) soybean meal
2) egg yolk
3) rice bran

_____l. Intensively cultured goldfish are fed any amount they can consume in _____.

1) 5 to 10 minutes
2) 2 to 3 hours
3) 12 hours

_____m. Fertilizer and feed in intensive goldfish cultures can produce yields of _____ pounds or more.

1) 6,000
2) 5,000
3) 3,000

16. Complete statements about basic harvesting equipment needs. Write the correct numbers in the blanks.

_____a. The seine and dip nets should be made of _____.

1) Knotless woven nylon of 3/16-inch mesh
2) Knotted woven rayon of 5/8-inch mesh
3) Braided, treated cotton of 1/3-inch mesh

TEST

_____b. Buckets should be made of plastic or be zinc coated, and should have a capacity of _____.

1) 4 or 5 quarts
2) 4 or 5 gallons
3) 4 or 5 pints

_____c. The producer needs a 1-ton truck with _____ tanks for transfer of fish to holding tanks.

1) three 50-gallon
2) two 100-gallon
3) two 300-gallon

_____d. For harvesting the entire population of a small pond, the producer needs a _____.

1) live car
2) screen box
3) boom hoist

_____e. _____ are needed for harvesting fathead minnows or goldfish.

1) Lift traps
2) Full-pond seines
3) Panel traps

_____f. _____ are needed for harvesting fathead minnows in cold weather.

1) Cylinder traps
2) Lift traps
3) Inflatable seines

_____g. The producer will need holding tanks _____, supplied with fresh, cool water and equipped with an aeration device.

1) 5 to 10 feet long and 3 feet deep
2) 6 to 12 feet long and 1 foot deep
3) 10 to 40 feet long and 2 feet deep

TEST

17. Match harvesting methods with their correct descriptions. Write the correct numbers in the blanks.

(NOTE: Numbers will be used more than once and some blanks may contain more than one number.)

_____a. Used to harvest fathead minnows in cold weather.

_____b. Used to harvest the entire population of a small pond; particularly good method for harvesting delicate golden shiners.

_____c. Generally used for partial harvests.

_____d. Used in harvesting goldfish and fathead minnows.

_____e. Water level is lowered and fish are confined to small area so that water temperature can be lowered overnight —ideally to 60°F—by adding well or spring water.

_____f. Are made of wire mesh 1 foot in diameter and 2 feet long, and are baited with small bags of fish food.

_____g. Fish are baited into a corner of the pond with wet or pelleted feed that will sink near the shore in shallow water.

_____h. Seines of the appropriate mesh size, length, and depth are pulled slowly from one end of the pond to the other, trapping the fish in a small area

_____i. Fish are baited into this nylon mesh trap while it is lying on the bottom of the pond.

_____j. Dip nets are used to dip the fish from the seine into buckets for relay to the harvest truck.

1. Pond draining
2. Seining the whole pond
3. Baiting and seining
4. Lift traps
5. Cylinder traps

TEST

_____k. Usually constructed of 3/16-inch nylon mesh on a 4-foot square steel frame that can be carried in the bed of a pick-up; are generally suspended in the pond from a pipe resting on a fulcrum pole.

_____l. In the early morning, the fish are flushed through the drainpipe and collected in a screen box at the outflow, or dip netted from the harvest basin into buckets.

_____m. Are emptied directly into buckets for relay to the harvest truck.

_____n. Net is lifted on fulcrum pole, and the captured fish are dipped from the net and relayed to the harvest truck in buckets.

_____o. Fish that enter the traps cannot easily get out through the small funnel opening.

_____p. Feeding fish are captured by pulling the seine slowly and quietly across the corner of the pond with a length of rope.

_____q. As soon as the seine is pulled and gathered, it is moved to deeper water so the fish can move away from the surface.

18 Select from a list general guidelines for harvesting and transferring baitfish to holding troughs. Write an "X" in the blank before each correct guideline.

_____a. When baiting is not used, withhold feed for at least 12 hours prior to harvest to prevent fouling of water.

_____b. In summertime, harvest ponds whose surface temperatures are 75°F and above with great care and during cool, early morning hours.

_____c. Slow the metabolic rate of fathead minnows by dropping the water temperature 15 degrees.

_____d. To avoid shock, gradually lower the water temperature to 60°F to 65°F for golden shiners and bait-sized goldfish as these species cannot tolerate 15-degree temperature drops.

TEST

_____e. Fit harvesting tanks with at least one agitator or with a source of compressed air or oxygen, and aerate the tank water before placing fish in tanks.

_____f. If more than one tank is used, empty the buckets of fish into one tank to prevent underfilling tanks.

_____g. In cool weather, load each tank with about 1 pound of fish per gallon of water; in warm weather, reduce the load to about 2/3 pound per gallon.

19. Select from a list guidelines for maintaining fish in holding troughs. Write an "X" in the blank before each correct guideline.

_____a. Following harvest, hold baitfish undisturbed for at least 24 hours so that they can undergo a "hardening" process before grading and handling, and so that they will pass food and not foul the transport water.

_____b. Control water quality by ensuring adequate water exchange and aeration, and by avoiding overcrowding.

_____c. In summer, hold baitfish at water temperatures close to 75°F by blending warm water with cooler well water.

_____d. Continually monitor holding troughs, chemically treating sick or injured fish routinely.

_____e. Remove any tadpoles, trash fish, and detritus from holding troughs.

_____f. Return to the pond any fish that have been stored over 3 weeks.

_____g. When they are emptied, scrub holding troughs well with a chlorinated material, such as household bleach, and rinse well.

_____h. Have a back-up energy source for pumping and aeration.

_____i. Have available back-up equipment, such as aerators, and an adequate supply of water.

20. Match grading procedures with correct grading equipment. Write the correct numbers in the blanks.

_____a.	A free-standing or floating container with spaced vertical bars is placed in the water and fish are placed in it; the larger fish cannot pass between the bars and are moved to another holding tank with fish of similar size.	1. Single grader panel

TEST

_____b.	Are arranged in the trough so that bar space gets progressively smaller toward the head of the trough; fish are placed in the first compartment at the foot of the trough and are graded as they swim toward the inflowing water.	2.	Multiple grader panels
		3.	Grader box
		4.	Barrier screens, tank nets, and crowders
_____c.	Wooden or metal frames covered with screen, netting, or perforated metal plates are inserted into the guide slots on the sides of the holding trough; are used to move the fish within the tank, and to block fish from certain areas.		
_____d.	Is moved slowly from the head to the foot of the trough; those fish that are too large to slip through the bars are trapped at the foot and moved to another holding tank with fish of similar size.		

21 Select from a list factual statements about transporting fish to long-distance markets. Write an "X" in the blank before each correct statement.

_____a. Long-distance markets are more than 12 hours away.

_____b. Fish are shipped to market on transport vehicles — generally trucks — equipped with several to many large aluminum, fiberglass, or plywood transport tanks.

_____c. The tanks are open systems aerated with compressed air, liquid nitrogen, mechanical agitators, or a combination of these methods.

_____d. Fish are slowly tempered to the water temperature of the receiving tanks, usually 40 minutes for each 5 degree decrease in water temperature.

_____e. Loading rates depend on size of fish, length of transport, water temperature and water quality.

_____f. Water-fouling wastes are kept at a minimum by starving the fish for a period of time before loading;

_____g. Lower the fish's body temperature by cooling the water in the transport tanks to 60°F by icing;

_____h. Lower the fish's metabolic rate by adding 0.1% to 0.3% table salt or an anesthetic chemical to the water.

TEST

22. Select from a list factual statements about transporting fish to short-distance markets Write an "X" in the blank before each correct statement.

_____a. Short distance markets are less than 12 hours away.

_____b. Fish are starved for a minimum of 24 hours, and the night before transport, the temperature of the holding tank water is gradually reduced to 60°F; salt or an anesthetic chemical may be added.

_____c. On the morning of transport, 10 pounds of baitfish are placed in 10 pounds of water in thick plastic bags, about 18 inches wide by 32 inches long.

_____d. Each bag is inflated with oxygen and sealed by twisting the top, folding it down, and securing it tightly with a rubber band.

_____e. Bags of fish are placed in styrofoam-lined cardboard boxes for temperature control and loaded on transport trucks or another type of transport vehicle.

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

23. Survey baitfish dealers to evaluate local supply and demand. (Assignment Sheet #1)

24. Visit a baitfish farm and report on the operation. (Assignment Sheet #2)

25. Demonstrate the ability to:

    a. Trap, count or weigh, and grade a sample of baitfish. (Job Sheet #1)

    b. Make a spawning mat. (Job Sheet #2)

    c. Bring baitfish eggs into hatching area and watch them hatch. (Job Sheet #3)

COMMERCIAL BAITFISH PRODUCTION
UNIT XI

ANSWERS TO TEST

1.
   a. 7
   b. 1
   c. 6
   d. 13
   e. 15
   f. 3
   g. 11
   h. 2
   i. 12
   j. 4
   k. 5
   l. 14
   m. 10
   n. 16
   o. 17
   p. 9
   q. 8

2.
   a. 1
   b. 3
   c. 1
   d. 2
   e. 3
   f. 1

3.
   a. Producers can sell fish to wholesalers (jobbers) who then sell them to retail markets.
   b. Producers can sell fish directly to area retailers.
   c. Producers can retail the fish themselves, selling all or part of their fish directly to fishermen.

4. b, c, d, g

5.
   a. Fathead minnow
   b. Goldfish
   c. Fathead minnow, breeding male
   d. Golden shiner

6.
   a. GS
   b. G
   c. FM
   d. G
   e. FM
   f. GS
   g. G
   h. FM
   i. G
   j. GS
   k. GS
   l. FM

7. Golden shiners

   a. 1
   b. 3
   c. 3

ANSWERS TO TEST

Fathead minnow

a. 1
b. 2
c. 2
d. 3

Goldfish

a. 2
b. 1
c. 3
d. 2

8.

a.	G, GS, FM	i.	FM
b.	G	j.	G
c.	GS	k.	FM
d.	FM	l.	G
e.	G	m.	GS
f.	GS, G	n.	FM
g.	GS	o.	GS
h.	FM		

9. a. 2
b. 1
c. 3

10. a. 2
b. 3
c. 1
d. 4

11.

a.	5	f.	2
b.	10	g.	4
c.	1	h.	3
d.	8	i.	9
e.	7	j.	6

12. Wild or free-spawning method

a. 2
b. 3
c. 1
d. 1

ANSWERS TO TEST

Egg transfer method

a. 3
b. 2
c. 2
d. 3
e. 1
f. 3

Fry transfer method

a. 3
b. 3
c. 2

13. a. FT
b. FT
c. FS
d. FS, FT
e. FT

14. a. Organic; inorganic
b. 10 inches
c. Applying fertilizer; seed from nearby pond
d. Before or while pond is filling
e. Nitrate of soda; super-phosphate
f. Ammonium phosphate
g. 400 to 10,000 pounds/surface acre
100 pounds/surface acre
h. 200 pounds/ surface acre
i. Makes phosphorus available for pond organisms instead of tying it up in bottom soil

15. a. 3
b. 1
c. 2
d. 2
e. 1
f. 3
g. 1
h. 2
i. 3
j. 1
k. 2
l. 2
m. 3

16. a. 1
b. 2
c. 3
d. 2
e. 1
f. 1
g. 3

ANSWERS TO TEST

17.
a. 5
b. 1
c. 3
d. 4
e. 1
f. 5
g. 3
h. 2
i. 4
j. 2, 3, 4
k. 4
l. 1
m. 5
n. 4
o. 5
p. 3
q. 3

18. b, e, g

19. a, b, e, g, h, i

20.
a. 3
b. 2
c. 4
d. 1

21. b, e, f, h

22. b, d, e

23-24. Evaluated to the satisfaction of the instructor.

25.
a. Evaluated according to criteria in Practical Test #1
b. Evaluated according to criteria in Practical Test #2
c. Evaluated according to criteria in Practical Test #3

COMMERCIAL CRAYFISH PRODUCTION
UNIT XII

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify crayfish species commonly cultured in the U.S., distinguish between male and female crayfish, and discuss commercial crayfish production methods. These competencies will be evidenced by completing the procedures in the assignment and job sheets and by scoring a minimum of 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to

1. Match terms associated with commercial crayfish production with their correct definitions.
2. Complete statements about crayfish aquaculture.
3. Match crayfish body parts with their functions.
4. Select from a list factual statements about species selection.
5. Distinguish between red swamp and white river crayfishes.
6. Select from a list factual statements about the reproduction and life cycle of crayfish.
7. Match crayfish pond types with their descriptions.
8. Complete statements about open pond design.
9. Arrange in order the open pond management cycle.
10. Discuss recirculating ponds.
11. Complete statements about water quality requirements for crayfish.
12. Complete statements about start-up stocking rates.
13. Complete statements about feeds and feeding practices.
14. Select from a list factual statements about harvesting crayfish.
15. Complete statements about handling and shipping crayfish.

SPECIFIC OBJECTIVES

16. Identify crayfish species and sexes. (Assignment Sheet #1)

17. Identify the external and internal parts of a crayfish. (Assignment Sheet #2)

18. Research techniques for soft-shell crayfish production, and report to the class. (Assignment Sheet #3)

19. Demonstrate the ability to construct a crayfish trap. (Job Sheet #1)

COMMERCIAL CRAYFISH PRODUCTION
UNIT XII

SUGGESTED ACTIVITIES

A. Obtain as many different species of live crayfish as possible. Place in numbered containers and display so that students can complete Assignment Sheet #1.

B. Obtain a copy of Pennak's *Fresh Water Invertebrates of the United States*, or a similar resource, to aid students in completing Assignment Sheet #1.

C. Obtain dissecting knives and frozen crayfish for each student, so that students may complete Assignment Sheet #2.

D. Gather materials necessary for the completion of Job Sheet #1. Have available sample traps and seines for student inspection.

E. Make transparencies.

F. Provide students with objective sheet. Discuss unit and specific objectives.

G. Provide students with information sheet. Discuss information sheet.

H. Provide students with assignment and job sheets. Discuss, demonstrate, and schedule assignment and job sheets.

I. Give test.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Black, Joe B. and Jay V. Huner. "Breeding Crayfish," *Carolina Tips*, Vol. 42, No. 4. Burlington, North Carolina, April 1, 1979.

B. "Crawfish in Louisiana," Agricultural Notes #86-001. Baton Rouge, Louisiana. Center for Small Farm Research, College of Agriculture, Southern University, n.d.

C. "Crawfish. Louisiana at Its Best," Pamphlet, Lafayette, Louisiana. Louisiana Crawfish Farmers Association, n.d.

D. Culley, Dr. Dudley D. "Water Quality and Soft-Shell Crawfish Production" Paper. Forestry, Wildlife, and Fisheries, [no pub., no date].

E. De La Bretonne, Lawrence W. Jr., and Robert P. Romaire. "Commercial Crawfish Cultivation Practices: A Review." *Journal of Shellfish Research*, Vol. 8, No. 1, 1989.

F. Dupree, Harry K., and Jay V. Huner, eds. *Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington, D.C.: U.S. Fish and Wildlife Service, 1984.

SUGGESTED ACTIVITIES

G. Fore, John. "Soft-Shell Crawfish," Pamphlet. Denham Springs, Louisiana. Louisiana Soft-Shell Crawfish Association, Louisiana Crawfish Promotion Board, and Louisiana Seafood Promotion and Marketing Board, n.d.

H. Huner, J. V., and J. E. Barr. *Crawfish in the Classroom*. Baton Rouge: Louisiana Department of Education and Louisiana Sea Grant College Program, n.d.

I. Huner, J. V., and Vernon A. Pfister. "Feasibility of Stocking Juvenile Crawfish in Small Ponds," from review in *Crawfish Tales*. Baton Rouge, Louisiana: Center for Small Farm Research, College of Agriculture and Home Economics, Southern University, November 1987.

J. McLarney, William. *The Freshwater Aquaculture Book*. Point Roberts, Washington, Hartley & Marks, Inc., 1984.

K. Reigh, Robert C., ed. *Proceedings of the Louisiana Aquaculture Conference, 1988*. Baton Rouge, Louisiana, Louisiana State University Agricultural Center, 1988.

L. Romaire, Robert P. "Overview of Harvest Technology Used in Commercial Crawfish Aquaculture." *Journal of Shellfish Research*, Vol. 8, No. 1, 1989.

COMMERCIAL CRAYFISH PRODUCTION
UNIT XII

INFORMATION SHEET

I. Terms and definitions

A. **Regenerate** — The ability to regrow a lost body part, such as a claw

B. **Glair** — Glue-like substance secreted by the female crayfish; used to attach laid eggs to her swimmerets

C. **Gastroliths** — Two small stones in the crayfish's head in which calcium carbonate is stored; used for hardening the shell after molting (Transparency 2)

D. **Crustacean** — Class in arthropod phylum containing crayfish, crabs, lobsters, shrimp, prawn, and others

E. **Decapod** — An animal, such as a crayfish, with ten legs

F. **Exoskeleton** — Hard outer shell

(NOTE: In crayfish, the exoskeleton is made of inorganic calcium carbonate (chalk) and a mixture of chitin and modified proteins.)

G. **Polytrophic** — Eating a wide variety of material, both plant and animal

H. **Purging** — Process of cleansing crayfish systems by not feeding and changing water often during the holding period

I. **In berry** — Said of female crayfish carrying eggs

J. **Peeling plant** — Crayfish processing plant

II. Facts about crayfish culture

A. Freshwater crayfish are decapod crustaceans found throughout the world.

(NOTE: Of the 500+ species of crayfish worldwide, about 300 are native to North America; Australia has 100 species, Europe about 10, and western Asia one. Though crayfish are found in Africa, it has no native species.)

B. Crayfish are a nutritious food eaten in many parts of the world; they are particularly well-liked in Scandinavia and are used extensively in the Cajun dishes now popular in the U.S.

C. In addition to being marketed for food, crayfish are also sold to biological supply houses and schools, sold for fish bait, and exported to European countries, especially Sweden.

INFORMATION SHEET

D. Ten to 20 million pounds of crayfish are harvested annually in Europe, Africa, and Australia, with 100 million pounds or more harvested in the U.S.

E. Of the world's production of edible crayfish, 80 percent are harvested or caught in Louisiana as a cash crop that was worth $65 million in 1988, when 135,000 acres of ponds were in production.

F. The red swamp crayfish (*Procambarus clarkii*) and the white river crayfish (*Procambarus acutus*) are the two species most commonly cultured in the U.S. (See Figures 1 and 2.)

(NOTE: In Louisiana and parts of Texas, the word "crawfish" is used instead of "crayfish," and "crawdad" is another common reference to crayfish.)

III. **Crayfish body parts and their functions** (Transparency 1)

A. **Chela (claw)** — One of two front legs used for defense and to capture food and hold prey

B. **Antennule** — One of two small sensors covered with setae—tiny hairlike structures sensitive to touch, smell, and taste

C. **Cephalothorax** — The midsection of a crayfish, consisting of the head and thorax fused together and enclosed by the carapace

D. **Carapace** — Rigid, very hard part of the exoskeleton that protects the heart and gills

E. **Abdomen (tail)** — Powerfully muscled body section that permits the crayfish to move rapidly backward; underneath are located five pairs of swimmerets

F. **Swimmerets** — Leg-like structures on the abdomen used for mating and transporting eggs and young (also known as *pleopods*)

G. **Uropod** — Paddle-shaped abdominal structures used for swimming backwards

H. **Telson** — Terminal abdominal structure that, with the uropods, forms the tail fan that allows the crayfish to swim backwards

I. **Pereipods** — Eight walking legs—four on each side—attached to the thorax behind the claws

J. **Rostrum** — Rigid, beak-like shell section that protects brain, stomach, and eyes

K. **Compound** eye — Organ of sight, providing excellent color vision

L. **Antenna** — One of two large sensors covered with setae and used for touch and smell

INFORMATION SHEET

IV. **Species selection**

A. The two species of crayfish that have been found to be best suited for commercial culture are:

1. The red swamp crayfish (*Procambarus clarkii*),

2. The white river crayfish (*Procamburus acutus acutus*)

B. Culturists should try to select species that produce large hatches and that go into a dormant period while in berry.

C. The species most adaptable for culture are those found in shallow, swampy waters, particularly those waters that dry up seasonally.

D. Since crayfish have specific habitat requirements, avoid selecting a species native to fast-moving rocky streams or permanent lakes and ponds with stable conditions.

E. Avoid also deep burrowing crayfish—those that dig burrows 20 to 30 feet deep—as they are seldom found on the surface and do not perform well in ponds.

F. Know how to recognize the different species of crayfish (Assignment Sheet #1) so that you avoid selecting a dwarf species common to roadside ditches; the adult size dwarf species is only 0.8 to 1.8 inches.

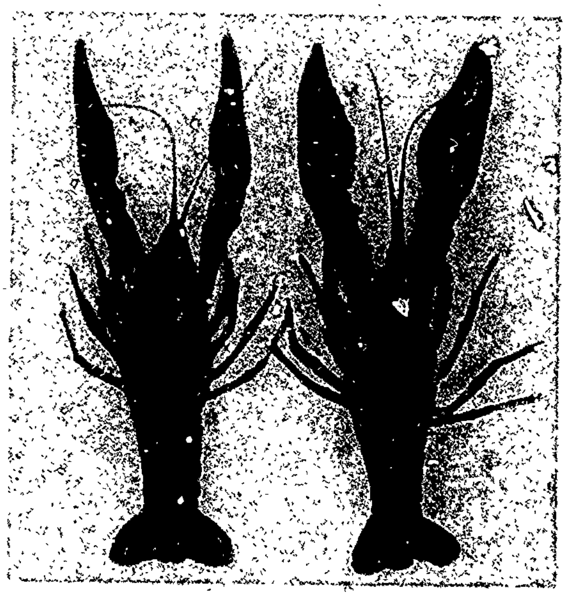
POINT OF INTEREST: One species, Shufeldt's dwarf, is very common to crayfish ponds—especially new ones—and proud owners are sometimes disappointed to learn that what they thought was an excellent crop of newly hatched red swamp or white river crayfishes is really a pond full of grown dwarf crayfish.

INFORMATION SHEET

V. Species Identification (Figures 1 and 2; Assignment Sheet #1)

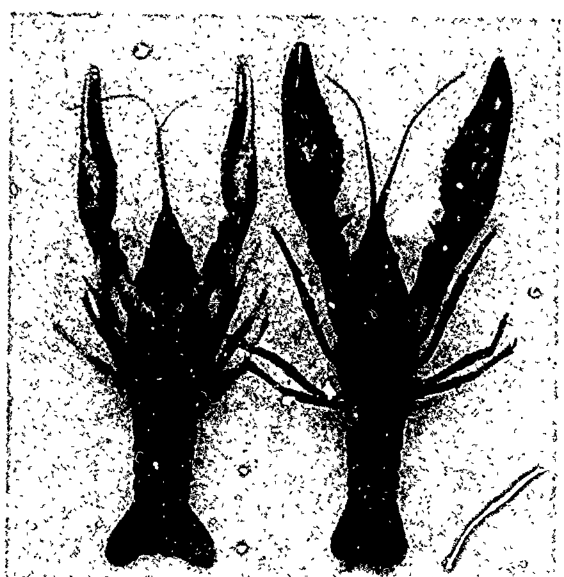
A. Top view: white river crayfish left, red swamp right.

FIGURE 1



B. Bottom view: white river crayfish left, red swamp right.

FIGURE 2

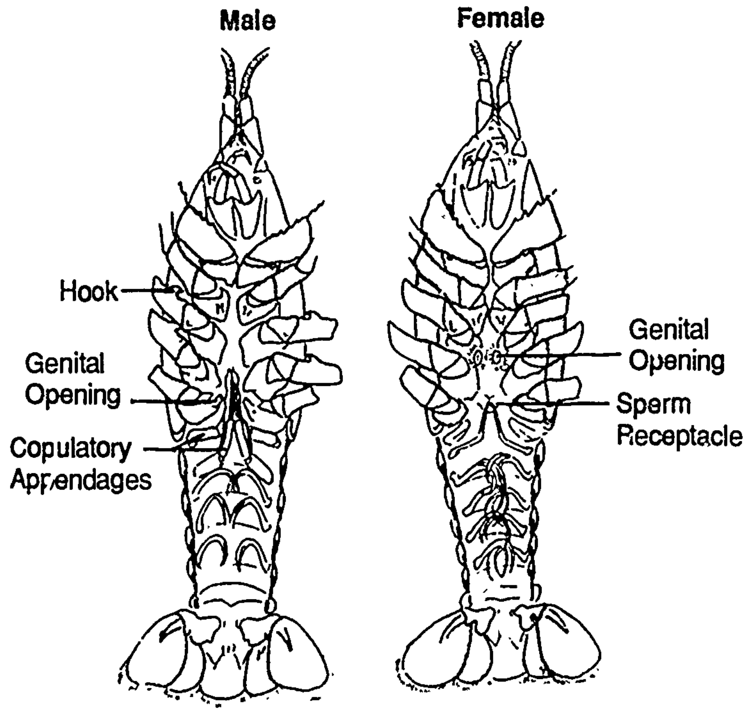


INFORMATION SHEET

VI. Reproduction and life cycle

A. Sperm is transferred from the male to the female on abdominal swimmerets and is stored in a receptacle at the base of the female's abdomen. (Figure 3)

FIGURE 3



From *Crawfish in the Classroom*. With Permission

B. Three to 4 months later (average), the female burrows underground where she lays 100 to 500 dark brown eggs that are fertilized with the stored sperm and firmly glued to her swimmerets with secreted glair.

(NOTE: Depending on temperature, egg laying may take place from 1 to 8 months after mating.)

INFORMATION SHEET

C. The eggs hatch in 2 to 3 weeks at 70°F, but the young crayfish remain attached to the mother for another 3 weeks until they have undergone two molts and are large enough to fend for themselves.

D. After molting, the crayfish absorbs water and expands, doubling in weight, its new exoskeleton remains soft for about 12 hours and then gradually hardens as it absorbs calcium carbonate from the supply stored in its gastroliths and from food and water.

E. A crayfish molts about 11 times before reaching maturity, and has a life span of from 1 to 3 years, depending on the species.

> POINT OF INTEREST: Crayfish in their soft-shell stage are being cultivated and marketed as a seafood delicacy that requires no shelling. However, cultivation of soft-shelled crayfish has shown recent decline because markets failed to expand with production. (Assignment Sheet #3)

VII. Types of crayfish ponds

A. **Marsh pond** — Created by diking off some marginal low-lying land that has little value for any other purpose, these are low production ponds, averaging 300 to 500 pounds per acre.

B. **Wooded pond** — Occurring naturally in swampy or flooded areas, these ponds contain trees, shrubs, and natural vegetation and have a low production rate, averaging about 400 to 600 pounds per acre, they are difficult to harvest because of trees, roots, stumps, and other obstacles.

C. **Open rice pond** — Normally managed for rice production, crayfish are a secondary crop in these ponds that can average up to 2,500 pounds per acre; after the rice is harvested, the stubble is left as forage for the crayfish.

D. **Open permanent pond** — Designed especially for cultivating crayfish, rice is usually planted as forage in these ponds that have a production rate averaging 1,200 pounds per acre.

VIII. Open pond design

A. Open ponds vary in size from 5 to 80 surface acres, but to be commercially productive, open permanent ponds must be at least 20 surface acres, with 20- to 40-acre ponds most common.

B. Open ponds are ideally constructed on flat land and of high-calcium, heavy clay soils fertile enough to support a rice or other forage crop for the crayfish.

(NOTE: Heavy clay soils are not desirable for rice ponds, but are desirable for permanent open ponds.)

C. Perimeter levees are constructed 3 feet high to maintain a water level of 18 to 24 inches with a freeboard of at least 1 foot.

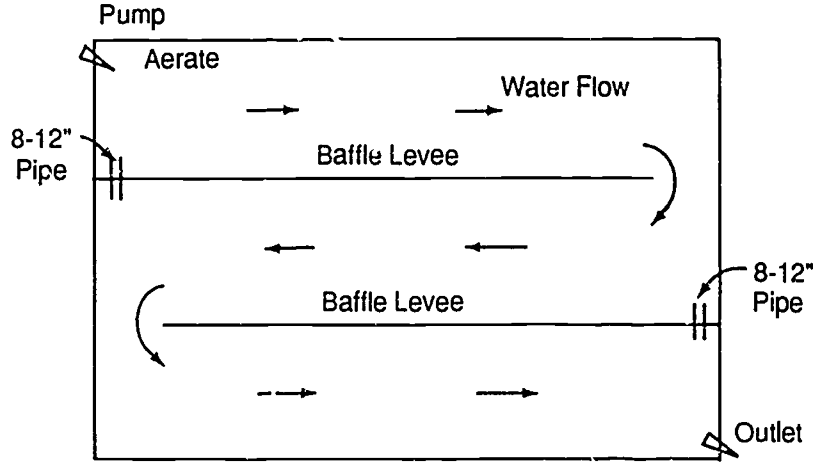
INFORMATION SHEET

D. Levees are built to a minimum 9-foot base width to prevent the crayfish from causing leakage when they burrow into the levee.

E. Land slope should not be greater than 6 inches from levee to levee.

F. To aid in water circulation and reduce pumping costs, baffle levees should be placed every 150 to 200 feet and extend to within 40 to 50 feet of the levee on the open side. (Figure 4)

EXAMPLE: FIGURE 4



IX. Open permanent pond management cycle

A. In early spring, adult crayfish are stocked at rates of 25 to 100 pounds per acre.

B. In late spring, the pond is slowly drained, forcing adult crayfish to burrow and lay eggs.

C. Eggs hatch out in large numbers during summer and early fall.

D. During the summer, the pond bottom is allowed to dry and is then cultivated and planted with rice, rye grass, or millet.

E. In early fall the land crop is harvested, the pond is shallowly flooded, and water is circulated to maintain water quality.

(NOTE: In most ponds, rice is not harvested; only 25 percent to 30 percent of ponds are double-cropped, and in the other ponds, rice is planted strictly for forage not as a grain crop.)

F. The pond is then flushed of the oxygen-deficient water caused by the decay of the crop stubble, and is filled with fresh, aerated water.

G. In the South, crayfish are harvested again in late fall and in winter.

(NOTE. In the Northeast and Midwest, growth does not begin until late spring and the crayfish are harvested only in the summer.)

INFORMATION SHEET

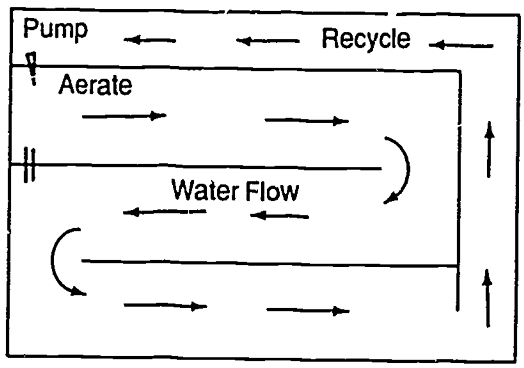
X. Recirculating open ponds

A. Recirculating ponds are constructed with internal levees so that water may be recycled.

B. After first flood, drain, and refill, the pond water is recycled and reused many times, aerating each time it is recycled.

C. When the water reaches the end of the cycle, it is relifted by a pump and dropped through a cascade aeration screen. (Figure 5)

EXAMPLE: FIGURE 5



D. Recirculating ponds have many advantages:

1. Discharge permits may not be required,
2. Less water is used,
3. Ponds may be located in water shortage areas,
4. Pumping costs are decreased because the pump lift required is much less than pumping from an external source.

XI. Water quality

A. Water may be obtained from a surface source, groundwater, or both, but should be fresh to slightly brackish (salinity at less than 2 ppt), and requires a pumping capacity of about 70 to 100 gpm/acre.

B. Water history should be evaluated for pollutants that will kill crayfish—especially those pesticides normally used to treat rice, soybeans, and cotton crops.

INFORMATION SHEET

C. Surface water should be pumped through a ½-inch expanded metal screen to remove large predatory fish.

D. Well water (groundwater) should be analyzed for its oxygen and iron content.

(NOTE: Well water is apt to have iron levels above 0.2 ppm and should be carefully analyzed for iron content. Levels above 0.2 ppm coat the gills of the crayfish, interfere with oxygen intake, and can cause death. Iron can be removed by aerating water first.)

E. DO in the pond water should be maintained at high concentrations, ideally at 5 mg/L or higher with a minimum level of 3.0 mg/L.

(NOTE: At DO levels of 2.0 mg/L and less, crayfish are sometimes seen at the water surface, turning on their sides to expose their gills to the oxygen in the air, or they may even crawl out of the pond.)

F. The best pH for crayfish growth is near 7.0, and growth rate changes are noticeable when the pH drops below 6 or rises above 9.

G. Pond water should be hard (high calcium content) for hardshell production, but tray water for soft-shell production should be soft (no more than 5 mg/L calcium) to retard shell hardening.

XII. Start-up stocking rates

A. Ponds constructed in early spring are stocked in mid- to late spring with an average broodstock of 50 pounds of crayfish per acre.

(NOTE: Stocking is done just before the dormant period. Then the pond is drained, planted, and reflooded to coincide with the hatching of the young.)

B. Crayfish are stocked at a 1:1 ratio: one female to one male.

C. At least 10 percent to 20 percent of females should have brown to tan eggs.

D. Low stocking rates are used in wet areas where there are existing populations of commercial crayfish.

XIII. Feeds and feeding practices

A. While basically scavengers and detritus feeders, crayfish will eat almost anything organic.

B. Crop stubble such as rice, aquatic plants, rotted leaves, and rotted hardwoods provide the greatest bulk of food consumed; rice seed is generally planted at 100 pounds per acre to provide forage, and spoiled hay is sometimes used for supplemental feeding.

(NOTE. Louisiana culturists and growers of bait crayfish have successfully fed aquatic plants, sorghum, soybean meal, millet, cornmeal, cottonseed meal, rice bran, cut hay, potatoes, commercial fish food, ground fresh fish, and even dog and cat food.)

INFORMATION SHEET

C. Depending on water temperature, a crayfish eats 1 to 5 percent of its body weight per day, stopping 2 to 3 days before molting.

D. Intensive feeding of cultured crayfish has rarely been done, though crayfish feeds have recently been developed to use as supplemental feed in ponds and as feed for crayfish held in trays for soft-shell production.

E. Soft-shell crayfish in trays are fed 1 to 3 percent of their body weight once a day or half that amount in morning and again in the evening.

F. Crayfish are not fed 24 hours before harvesting and are often purged before marketing.

XIV. Harvesting

A. Harvesting crayfish is time consuming (120 to 180 days) and expensive (40 to 60 percent of the budget).

B. Crayfish can be harvested with a variety of traps (Job Sheet #1), by seining, or by complete draining of ponds.

C. Most food-sized crayfish are trapped; bait-sized and soft-shell crayfish are generally seined with a seine more heavily weighted than that used for fish.

D. Using ⅓ pound of bait per trap, traps are baited daily with fish, manufactured bait, or a combination of both, and are fished 4 to 6 days a week at a concentration of 15 to 30 traps per acre, with 20 traps per acre most common.

E. On-farm labor or workers on shares are used to harvest crayfish; a person "walking" a pond can fish 400 traps per day, but new front and rear wheel boats enable a farmer to run 200 traps per hour.

(NOTE: New mechanical harvesting methods may reduce the high cost of baiting and emptying the traps. Harvesting methods will receive increased research in the next few years.)

XV. Handling and shipping

A. Crayfish are frequently graded into three sizes, both at the pond and at the peeling plants:

1. 15 per pound and larger animal for export;

2. 16 to 25 per pound live market product;

3. 25 and greater per pound food crayfish for peeling.

B. Hard-shell crayfish can be held in shallow troughs for several days with little feed; they are stocked in the troughs at densities of 70 per square foot (2 to 3 inches long) or 45 per square foot (3 to 4 inches long).

INFORMATION SHEET

C. Water in the holding troughs is not allowed to rise above their legs and is changed at least once a day, thus preventing them from molting and also purging their systems.

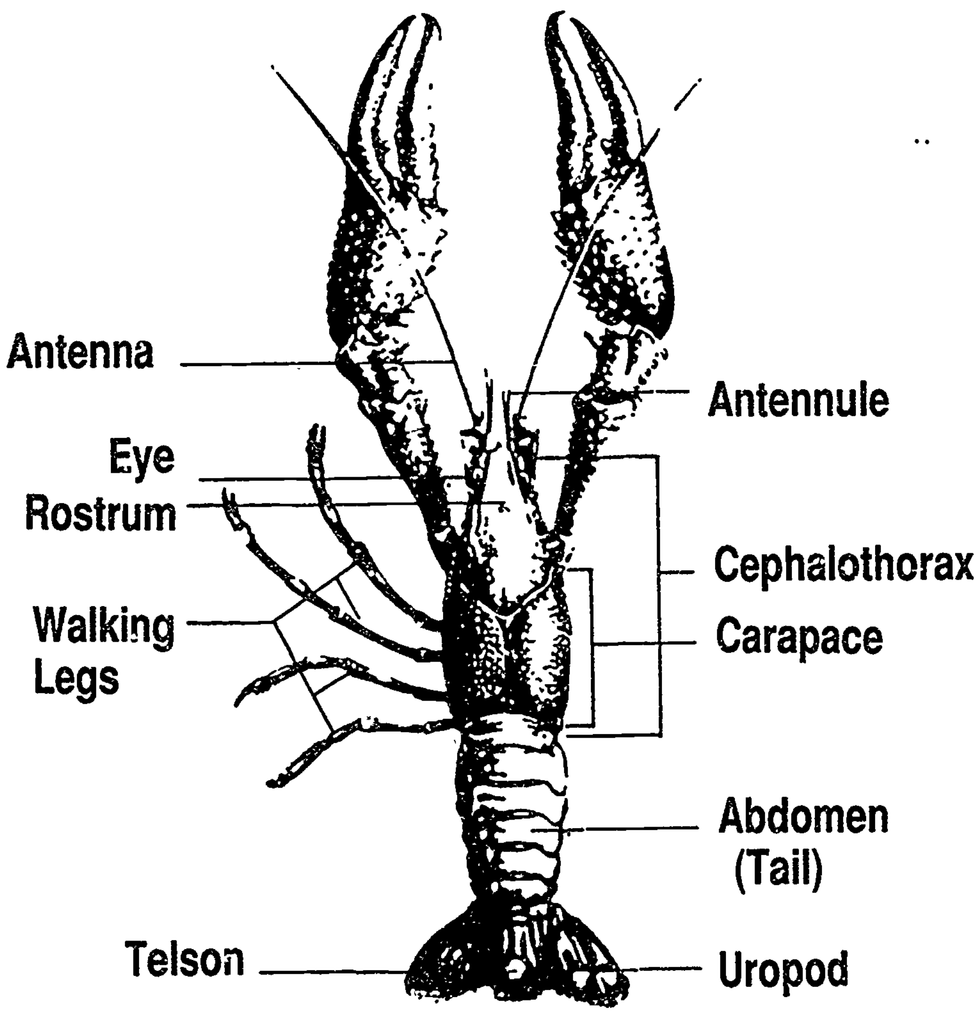
(NOTE: If the crayfish are completely covered with water, the water must be aerated. Crayfish can molt only if completely covered with water, and for this reason, as well as the expense of aeration, they are usually kept in very shallow water in the holding troughs.)

D. Crayfish 3 inches long or longer are usually shipped in porous bags kept cool (42°F to 46°F) and damp.

E. Smaller bait-sized crayfish—loosely packed to prevent crushing and to permit air circulation—are shipped in damp moss or coarse sawdust and refrigerated at 40°F to 75°F.

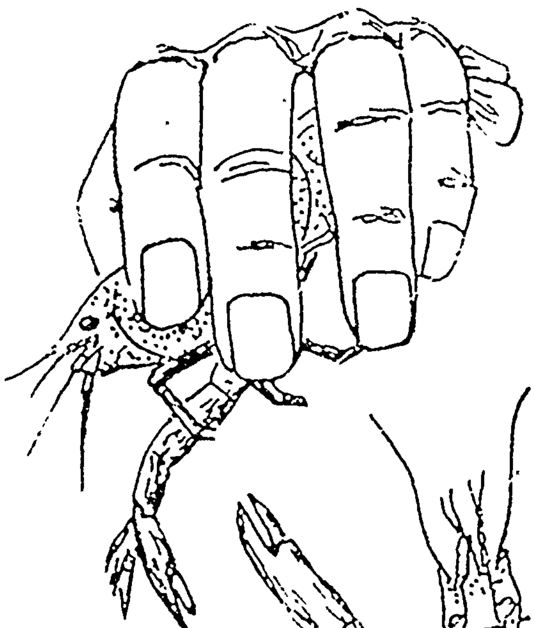
(NOTE: The gill chambers of crayfish are located on both sides of the head. As long as these chambers are damp, the crayfish can breathe and survive.)

Parts of a Crayfish

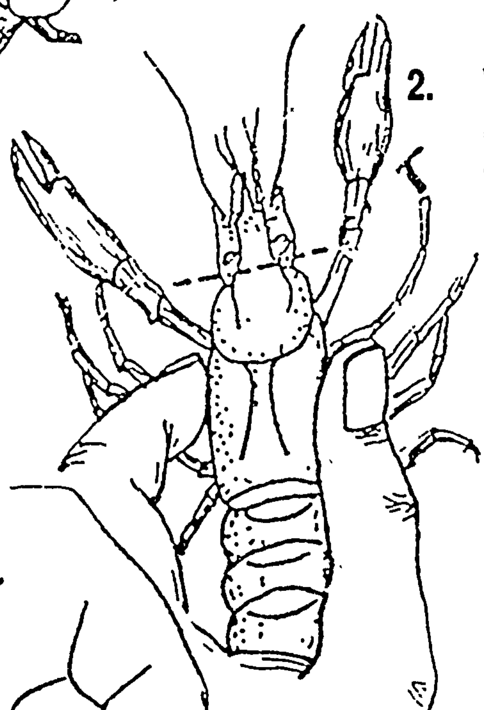


Adapted from *Crawfish in the Classroom.* With permission.

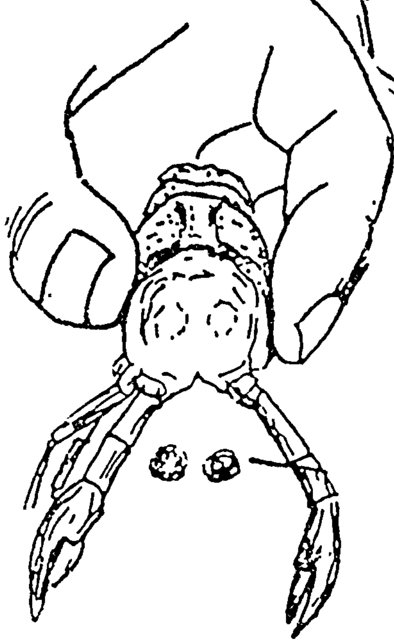
Preparation of Soft-Shell Crayfish



1. Grasp crawfish by carapace.



2. With knife or scissors cut just behind the eyes to remove head.



3. Squeeze carapace to force out the two small calcium deposits.

COMMERCIAL CRAYFISH PRODUCTION
UNIT XII

ASSIGNMENT SHEET #1
IDENTIFY CRAYFISH SPECIES AND SEXES

Your instructor has provided samples of a number of species of crayfish. They are displayed live in numbered containers on a specimen table. Examine each crayfish and determine whether it is a male or female. Use Pennak's *Fresh Water Invertebrates of the United States*, or a similar resource guide, to identify each species. Record your observations below, adding numbers if necessary.

#1 _____M _____F; Species: ______________________________

#2 _____M _____F; Species: ______________________________

#3 _____M _____F; Species: ______________________________

#4 _____M _____F; Species: ______________________________

#5 _____M _____F; Species: ______________________________

#6 _____M _____F; Species: ______________________________

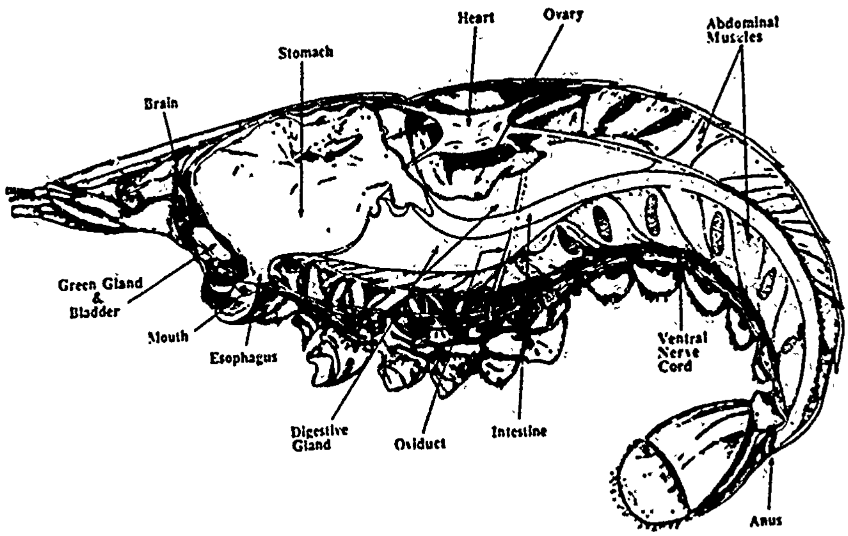
COMMERCIAL CRAYFISH PRODUCTION
UNIT XII

ASSIGNMENT SHEET #2
IDENTIFY THE EXTERNAL AND INTERNAL PARTS OF A CRAYFISH

Your instructor will provide you with a crayfish. Examine its features and use Transparency 1 to aid you in identifying its external parts. Test your memory by working with a partner and naming the parts to each other without the aid of a labeled illustration.

After you are satisfied that you can identify the external parts of the crayfish, work with your partner to dissect the crayfish. Find and identify the internal parts illustrated in the figure below.

FIGURE 1: Internal Parts of a Crayfish



From *Crawfish in the Classroom.* With permission.

COMMERCIAL CRAYFISH PRODUCTION
UNIT XII

ASSIGNMENT SHEET #3
RESEARCH TECHNIQUES FOR SOFT-SHELL CRAYFISH PRODUCTION, AND REPORT TO THE CLASS

This assignment sheet requires that you gather resource material on soft-shell crayfish production and write a report to be given to the class. Include in your report basic production, harvesting, and marketing techniques. Point out the differences between soft-shell and hard-shell production, and determine advantages and disadvantages of soft-shell culture.

Write to the Louisiana Cooperative Extension Service, Louisiana State University Agricultural Center, Knapp Hall, Baton Rouge, LA 70803-1900, explaining your project and asking for information. Also use the resources available at your school and public library. If you live near a producer of soft-shell crayfish, this person, of course, would also be an excellent source of information.

COMMERCIAL CRAYFISH PRODUCTION
UNIT XII

JOB SHEET #1
CONSTRUCT A CRAYFISH TRAP

A. Equipment and materials

1. Roll of 3-foot wide chicken wire or plastic-coated wire

   (NOTE: The mesh size will vary with the size of crayfish being harvested. Use 3/4-inch mesh for crayfish 3 inches and longer; 5/8-inch mesh for crayfish 2 1/2 inches and longer; and 1/2-inch mesh for crayfish 1 3/4 inches and longer.)

2. Wire cutters

3. Pliers

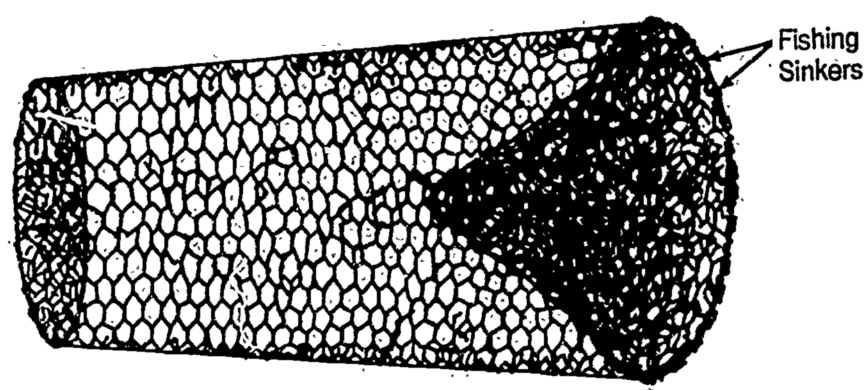
4. 3-foot length of heavy-duty fishing line

5. Large fishing weights (sinkers), about 40 (optional)

6. One large fishing bobber or buoy

B. Procedure (Figure 1)

FIGURE 1



1. Cut a 3-foot by 4-foot length of chicken wire.

2. Roll into a cylinder and attach at the seam by bending the ends of the wire together with the pliers.

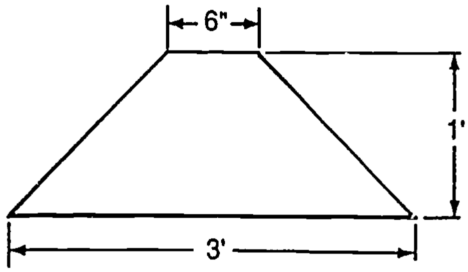
3. Set the cylinder on its end on the remaining chicken wire and cut a circle for the bottom about 2 inches larger than the circumference of the cylinder.

JOB SHEET #1

4. Attach the bottom to the cylinder by bending and clipping the edges of the circle, and bending the ends of the wire together with pliers.

5. Cut a 1-foot piece of chicken wire and shape as shown in Figure 2.

FIGURE 2



6. Roll this piece into a funnel shape, and attach at the seam by bending the edges of the wire together with pliers.

7. Fit the funnel into the open end of the trap, and attach by bending the wire with pliers.

8. Clamp fishing weights (sinkers) around the outside edge of the funnel opening as shown in Figure 1.

   (NOTE: Sinkers are rarely used, so this step may be omitted if local situation does not require weights.)

9. Attach a 2-foot length of rope or heavy-duty fishing line to the top center of cage, and attach a large fishing bobber or buoy to the rope.

   (NOTE: The buoy is used to mark the location of the underwater trap.)

10. Return tools and materials to proper storage.

COMMERCIAL CRAYFISH PRODUCTION
UNIT XII

PRACTICAL TEST #1
JOB SHEET #1
CONSTRUCT A CRAYFISH TRAP

Student's name ______________________ **Date** __________

Evaluator's name ______________________ **Attempt no.** ______

Student instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	Yes	No
1. Selected proper tools and materials.	☐	☐
2. Cut wire to proper sizes and shapes.	☐	☐
3. Formed base of trap properly.	☐	☐
4. Formed funnel properly.	☐	☐
5. Attached weights to trap.	☐	☐
6. Attached rope and buoy to trap.	☐	☐

EVALUATOR'S COMMENTS: ______________________________________

____

____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for ev.luation.)

Criteria:	Excellent	Good	Fair	Unacceptable
Cutting materials	4	3	2	1
Shaping materials	4	3	2	1
Final product	4	3	2	1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — **Skilled** — Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program; limited additional training may be required.
2 — **Limited skills** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

COMMERCIAL CRAYFISH PRODUCTION
UNIT XII

TEST

NAME ______________________________ SCORE __________

1. Match terms associated with commercial crayfish production with their definitions Write the correct numbers in the blanks.

_____a.	Process of cleansing crayfish systems by not feeding and changing water often during the holding period	1.	Regenerate
		2.	Glair
_____b.	Glue-like substance secreted by the female crayfish; used to attach laid eggs to her swimmerets	3.	Gastroliths
		4.	Crustacean
_____c.	Two small stones in the crayfish's head in which calcium carbonate is stored; used for hardening the shell after molting	5.	Decapod
		6.	Exoskeleton
		7.	Polytrophic
_____d.	Said of the female crayfish carrying eggs	8.	Purging
_____e.	An animal, such as a crayfish, with ten legs	9.	In berry
		10.	Peeling plant
_____f.	The ability to grow a lost body part, such as a claw		
_____g.	Hard outer shell		
_____h.	Eating a wide variety of material, both plant and animal		
_____i.	Class in arthropod phylum containing crayfish, crabs, lobsters, shrimp, prawn and others		
_____j.	Crayfish processing plant		

2. Complete statements about crayfish culture. Write the correct numbers in the blanks.

_____a. Freshwater crayfish are __ found throughout the world.

1) octaped mollusks
2) decapod crustaceans
3) biped vertebrates

TEST

_____b. Crayfish are a nutritious food eaten in may parts of the world; they are particularly well liked in __ and are used extensively in the __ dishes now popular in the U.S.

1) Mexico; Mexican
2) China; Chinese
3) Scandinavia; Cajun

_____c. In addition to being marketed for food, crayfish are also sold to __, sold for fish bait, and exported to European countries, especially __.

1) biological supply houses and schools; Sweden
2) pet food producers; Latin America
3) organic fertilizer producers; England

_____d. Ten to 20 million pounds of crayfish are harvested annually in Europe, and Australia, with __ million pounds or more harvested in the U.S.

1) 100
2) 200
3) 300

_____e. Of the world's production of crayfish, 80 percent is harvested or caught in __ as a cash crop that was worth 65 million in 1988, when 135,000 acres of ponds were in production.

1) Mississippi
2) Louisiana
3) Texas

_____f. The __ crayfish and the __ crayfish are the two species most commonly cultured in the U.S.

1) red bayou; white swamp
2) white river; red lake
3) red swamp; white river

3. Match crayfish body parts with their functions. Write the correct numbers in the blanks.

_____a. Leg-like structures on the abdomen used for mating and transporting eggs and young	1. Antenna
	2. Antennule
_____b. One of two small sensors covered with setae—tiny hairlike structures sensitive to touch, smell, and taste	3. Chela
	4. Swimmerets

TEST

_____c.	Powerfully muscled body section that permits the crayfish to move rapidly backward; underneath are located five pair of swimmerets	5.	Uropod
_____d.	One of two front legs used for defense and to capture food and hold prey	6.	Cephalothorax
_____e.	Paddle-shaped abdominal structures used for swimming backwards	7.	Carapace
_____f.	The midsection of a crayfish, consisting of the head and thorax fused together and enclosed by the carapace	8.	Abdomen (tail)
_____g.	Terminal abdominal structure that—with the uropods—forms the tail fan that allows the crayfish to swim backwards	9.	Telson
_____h.	Organ of sight, providing excellent color vision	10.	Pereipods
_____i.	Eight walking legs—four on each side—attached to the thorax behind the claws	11.	Rostrum
_____j.	One of two large sensors covered with setae and used for touch and smell	12.	Compound eye
_____k.	Rigid, beaklike shell section that protects the brain, stomach, and eyes		
_____l.	Rigid, very hard part of the exoskeleton that protects the heart and gills		

4. Select from a list factual statements about species selection. Write an "X" in the blank before each correct statement.

_____a. Four species of crayfish have been found to be best suited for commercial culture; the red river crayfish, the white swamp crayfish, the papershell crayfish, and the softshell crayfish.

_____b. Culturists should try to select species that produce large hatches and that go into a dormant period while in berry.

_____c. The species most adaptable for culture are those found in shallow, fast-running streams, particularly those that dry up seasonally.

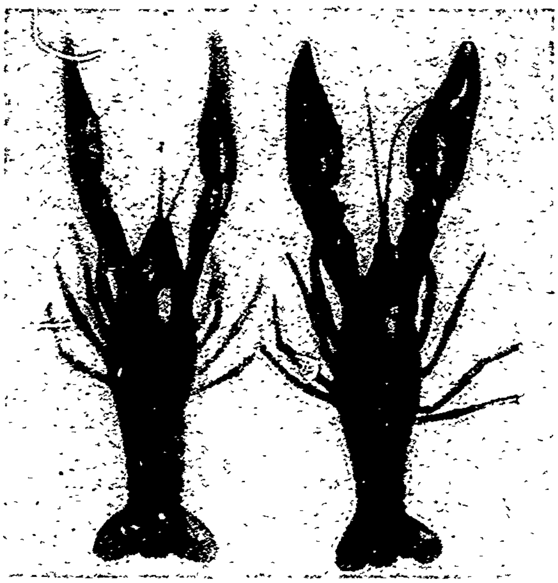
_____d. Since crayfish have specific habitat requirements, avoid selecting a species native to fast-moving rocky streams or permanent lakes and ponds with stable conditions.

TEST

_____e. Avoid also deep burrowing crayfish—those that dig burrows 2 to 3 feet deep—as they are seldom found on the surface and do not perform well in ponds.

_____f. Know how to recognize the different species of crayfish so that you avoid selecting a dwarf species common to roadside ditches; the adult size dwarf species is only 0.8 to 1.8 inches.

5. Distinguish between red swamp and white river crayfishes. Write the correct names under the illustrations below.



a. Left: ________________________ b. Right: ________________________

TEST

6. Select from a list factual statements about the reproduction and life cycle of crayfish. Write an "X" in the blank before each correct statement.

_____a. Sperm is transferred from the male to the female on the telson and is stored in a receptacle in the female's abdomen.

_____b. Three to 4 months later, the female burrows underground where she lays 100 to 500 dark brown eggs that are fertilized with the stored sperm and firmly glued to her swimmerets with a glue-like substance.

_____c. The eggs hatch in 2 to 3 days at 80°F, but the young crayfish remain attached to the mother for another 3 days until they have undergone two molts and are large enough to fend for themselves.

_____d. After molting, the crayfish absorbs water and swells, often doubling in weight; its new exoskeleton remains soft for about 12 hours and then gradually hardens as it absorbs calcium carbonate from the supply stored in its gastroliths and from food and water.

_____e. A crayfish molts about 11 times before reaching maturity, and has a life span of from 1 to 3 years, depending on the species.

7. Match crayfish pond types with their descriptions. Write the correct numbers in the blanks.

_____a. Normally managed for rice production, crayfish are a secondary crop in these ponds that can average up to 2,500 pounds per acre; after the rice is harvested, the stubble is left as forage for the crayfish

_____b. Created by diking off some marginal low-lying land that has little value for any other purpose, these are low production ponds, averaging 300 to 500 pounds per acre.

_____c. Designed especially for cultivating crayfish, rice is usually planted as forage in these ponds that have a production rate averaging 1,200 pounds per acre.

_____d. Occurring naturally in swampy or flooded areas, these ponds contain trees, shrubs, and natural vegetation and have a low production rate, averaging about 400 to 600 pounds per acre; they are difficult to harvest because of trees, roots, stumps, and other obstacles.

1. Marsh pond
2. Wooded pond
3. Open rice pond
4. Open permanent pond

TEST

8 Complete statements about open pond design. Write the correct numbers in the blanks.

_____a. Open ponds vary in size from 5 to 80 surface acres, but to be commercially productive, open permanent ponds must be at least _____ surface acres, with __ -acre ponds most common.

1) 10; 20- to 30
2) 5; 10- to 20
3) 20; 20- to 40

_____b. Open ponds are ideally constructed on flat land and of high- __, heavy clay soils fertile enough to support a rice or other forage crop for the crayfish.

1) phosphorus
2) calcium
3) mineral

_____c. Perimeter levees are constructed __ feet high to maintain a water level of __ inches with a freeboard of at least 1 foot.

1) 5; 25 to 36
2) 3; 18 to 24
3) 6; 12 to 24

_____d. Levees are built to a minimum __ -foot base width to prevent the crayfish from causing leakage when they burrow into the levee.

1) 9
2) 8
3) 7

_____e. Land slope should not be greater than __ from levee to levee.

1) 6 inches
2) 16 inches
3) 60 inches

_____f. To aid in water circulation and reduce pumping costs, baffle levees should be placed every 150 to 200 feet and extend to within __ feet of the levee on the open side.

1) 20 to 30
2) 40 to 50
3) 60 to 70

TEST

9. Arrange in order the open pond management cycle. The first phase in the cycle has been labeled. Write a "2" before the second phase of the cycle, a "3" order before the third phase, and so on.

_____a. Pond bottom is allowed to dry and is then cultivated and planted with rice, rye grass, or millet.

_____b. The pond is slowly drained, forcing adult crayfish to burrow and lay eggs.

__1__c. Adult crayfish are stocked at rates of 25 to 100 pounds per acre.

_____d. Crayfish are harvested.

_____e. Pond is flushed of oxygen-deficient water caused by the decay of the crop stubble, and is filled with fresh, aerated water.

_____f. Eggs hatch out in large numbers.

_____g. Land crop is harvested, the pond is shallowly flooded, and water is circulated to maintain water quality.

10. Discuss recirculating ponds. Answer the following questions.

a. What construction feature enables pond water to be recirculated?

____

b. When does the recirculating cycle begin?

____

c. What happens to the recycled water when it reaches the end of the cycle?

____

d. What advantages do recirculating ponds offer over conventional ponds?

____

____

11. Complete statements about water quality requirements for crayfish. Write the correct numbers in the blanks.

_____a. Water may be obtained from a surface source, groundwater, or both, but should be fresh to slightly brackish (salinity __), and requires a pumping capacity of about __ gpm/acre.

1) at less than 3 ppt; 200
2) of more than 12 ppt; 150
3) at less than 2 ppt; 70 to 100

_____b. Water should be analyzed for pollutants that will kill crayfish—especially those pesticides normally used to treat __.

1) rice, soybeans, and cotton crops
2) wheat, rye, and sorghum crops
3) root vegetable and peanut crops

_____c. Surface water should be __ to remove large predatory fish.

1) treated with a piscicide
2) sterilized with a surfactant
3) pumped through a ½-inch expanded metal screen

_____d. Well water (groundwater) should be analyzed for its __ content.

1) nitrogen and lead
2) oxygen and iron
3) hydrogen and copper

_____e. Oxygen in the pond water should be maintained at high concentrations, ideally at __ or higher with a minimum level of __.

1) 5 mg/L; 3.0 mg/L
2) 4 mg/L; 2.0 mg/L
3) 3 mg/L; 1.0 mg/L

_____f. The best pH for crayfish growth is near 7.0, and growth rate changes are noticeable when the pH drops below __ or rises above __.

1) 6.2; 7.7
2) 6.0; 7.2
3) 6; 9

_____g. Pond water should be hard (high calcium content) for hardshell production, but tray water for soft-shell production should be soft (no more than __ calcium) to retard shell hardening.

1) 8 mg/L
2) 5 mg/L
3) 6 mg/L

12 Complete statements about start-up stocking rates. Write the correct numbers in the blanks.

_____a. Ponds constructed in early spring are stocked in mid- to late spring with __ pounds of crayfish per acre.

1) an average broodstock of 50
2) an average broodstock of 75
3) an average broodstock of 100

TEST

_____b. Crayfish are stocked at a __.

1) 1:2 ratio; one male to two females
2) 1:2 ratio; one female to 2 males
3) 1:1 ratio; one male to one female

_____c. __ stocking rates are used in wet areas where there are existing populations of commercial crayfish.

1) Low
2) High
3) Replacement

_____d. At least __ percent of females should have brown to tan eggs.

1) 5
2) 10 to 20
3) 50

13. Complete statements about crayfish feeds and feedings practices. Write the correct numbers in the blanks.

_____a. While basically scavengers and detritus feeders, crayfish will eat almost anything __.

1) inorganic
2) organic
3) organic or inorganic

_____b. Crop stubble such as rice, aquatic plants, rotted leaves, and rotted hardwoods provide the greatest bulk of food consumed; rice seed is generally planted at 100 pounds per acre to provide forage, and __ is sometimes used for supplemental feeding.

1) dog food
2) spoiled hay
3) feather meal

_____c. Depending on temperature, a crayfish eats __ percent of its body weight per day, stopping 2 to 3 days before molting.

1) 1 to 5
2) 2 to 4
3) 3 to 5

_____d. __ of cultured crayfish has rarely been done.

1) Ranching
2) Intensive feeding
3) High-protein feeding

TEST

_____e. Soft-shell crayfish in trays are fed __ percent of their body weight once a day or half that amount in morning and again in the evening.

1) 3 to 5
2) 2 to 4
3) 1 to 3

_____f. Crayfish are not fed 24 hours before harvesting and are often __ before marketing.

1) disinfected
2) purged
3) stripped

14. Select from a list factual statements about harvesting crayfish. Write an "X" in the blank before each correct statement.

_____a. Harvesting crayfish is time consuming (120 to 180 days) and expensive (40 to 60 percent of the budget.)

_____b. Crayfish can be harvested with a variety of traps, by seining, or by complete draining of ponds.

_____c. Most food-sized crayfish are seined; bait-sized and soft-shell crayfish are generally trapped.

_____d. Traps are baited weekly with fish, manufactured bait, or a combination of both.

_____e. Traps are fished each day at a concentration of 20 to 40 traps per acre.

_____f. On-farm labor or workers on shares are used to harvest crayfish.

_____g. A person "walking" a pond can fish 200 traps a day, but new front and rear wheel boats enable a farmer to run 50 traps on hour.

15 Select factual statements about handling and shipping crayfish. Write the correct numbers in the blanks.

_____a. Which of the following are the three common grading sizes for crayfish?

1) 15 per pound and larger for export
16 to 25 per pound live market product
25 and greater per pound food crayfish for peeling

2) 10 per pound and larger for export
12 to 15 per pound live market product
20 and greater per pound food crayfish for peeling

3) 20 per pound and larger for export
25 to 30 per pound live market product
26 and greater per pound food crayfish for peeling

TEST

_____b. How long can hard-shell crayfish be held in troughs with little feeding?

1) Several days
2) Several weeks
3) Several months

_____c. What is the usual trough stocking density of 3- to 4-inch crayfish?

1) 70 per square foot
2) 55 per square foot
3) 45 per square foot

_____d. Why is the water in the holding troughs not allowed to rise above the crayfish' legs?

1) Shallow water prevents them from mating and controls disease spread
2) Shallow water prevents them from molting and purges their systems
3) Shallow water prevents them from injuring themselves by attempting to burrow and prevents escape from the trough

_____e. How are hard-shell crayfish 3 inches long or longer shipped?

1) In styrofoam containers held at 50°F with dry ice
2) In porous bags kept cool and damp
3) In 4 mil plastic bags filled with compressed air and sealed

_____f. How are bait-sized crayfish shipped?

1) Loosely packed in damp moss or coarse sawdust and refrigerated at 40°F to 75°F
2) Loosely packed in burlap sacks
3) In plastic bags filled with compressed air and sealed

(NOTE. Test questions 16 through 19 list the assignment and job sheets. They are an important part of this test. If they have not been completed, check with your instructor for scheduling and evaluation dates.)

16. Identify crayfish species and sexes. (Assignment Sheet #1)

17. Identify the external and internal parts of a crayfish. (Assignment Sheet #2)

18. Research techniques for soft-shell crayfish production, and report to the class. (Assignment Sheet #3)

19. Demonstrate the ability to construct a crayfish trap. (Job Sheet #1)

COMMERCIAL CRAYFISH PRODUCTION
UNIT XII

ANSWERS TO TEST

1. a. 8 f. 1
   b. 2 g. 6
   c. 3 h. 7
   d. 9 i. 4
   e. 5 j. 10

2. a. 2
   b. 3
   c. 1
   d. 1
   e. 2
   f. 3

3. a. 4 g. 9
   b. 2 h. 12
   c. 8 i. 10
   d. 3 j. 1
   e. 5 k. 11
   f. 6 l. 7

4. b, d, f

5. a. White river
   b. Red swamp

6. b, d, e

7. a. 3
   b. 1
   c. 4
   d. 2

8. a. 3
   b. 2
   c. 2
   d. 1
   e. 1
   f. 2

ANSWERS TO TEST

9. a. 4
   b. 2
   c. 1
   d. 7
   e. 6
   f. 3
   g. 5

10. a. Internal levees
    b. After first flood, drain, refill
    c. It is relifted by pump and dropped through a cascade aeration screen
    d. Discharge permits may not be needed; less water is used; ponds may be located in water shortage areas; pumping costs are decreased

11. a. 3
    b. 1
    c. 3
    d. 2
    e. 1
    f. 3
    g. 2

12. a. 1
    b. 3
    c. 1
    d. 2

13. a. 2
    b. 2
    c. 1
    d. 2
    e. 3
    f. 2

14. a, b, e, f

15. a. 1
    b. 1
    c. 3
    d. 2
    e. 2
    f. 1

16.-18. Evaluated to the satisfaction of the instructor.

19. Evaluated according to criteria in Practical Test #1

OTHER COMMERCIAL SPECIES
UNIT XIII

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss the general characteristics and commercial culture of various freshwater, marine, and hobby fishes, and of prawns, bullfrogs, and alligators. These competencies will be evidenced by correctly completing the procedures in the assignment sheets and by scoring a minimum of 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to various commercial fish and animal species with their correct definitions.
2. Select facts to complete statements about the commercial culture of tilapia.
3. Select from a list methods of managing tilapia to control overpopulation.
4. Select facts to complete statements about the culture of largemouth bass.
5. Complete statements about the culture of bluegill and hybrid sunfish.
6. Select facts to complete statements about the culture of crappies.
7. Distinguish between descriptions/uses of common and Chinese carps.
8. Select from a list factual statements about the commercial production of striped and hybrid striped bass.
9. Discuss marine species that can be cultured in freshwater.
10. Select factual statements about the commercial production of alligators.
11. Select facts to complete statements about the commercial production of bullfrogs.
12. Select factual statements about the commercial culture of hobby and ornamental fish.
13. Interview local hobby and ornamental fish retailers to determine area supply and demand. (Assignment Sheet #1)

OBJECTIVE SHEET

14. Visit a facility that cultures a species discussed in this unit, and report on the operation. (Assignment Sheet #2)

OTHER COMMERCIAL SPECIES
UNIT XIII

SUGGESTED ACTIVITIES

A. Provide students with objective sheet. Discuss unit and specific objectives.

B. Provide students with information sheet. Discuss information sheet, personalizing it to your locality and situation.

C. Provide as much supplemental material on each species as possible. Use *Third Report* bibliography as a source for finding these materials.

D. If available in your community, invite a producer of one of the species discussed in this unit to discuss production methods with the class.

E. Survey the class to determine whether or not any of the students has ever raised or is raising aquarium fish. Have this student or your local aquarium fish retailer talk to the class about hobby fish.

F. Schedule assignment sheets and discuss in class. Prepare hobby fish retailer for visits by students.

G. Give test.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Dupree, Harry K., and Jay V. Huner. "Propagation of Black Bass, Sunfishes, Tilapias, Eels, and Hobby Fish," in *Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington, D.C.: U.S. Fish and Wildlife Service, 1984.

B. *The Fish Book. NEBRASKAland Magazine.* Lincoln, Nebraska. Nebraska Game and Parks Commission, 1987.

C. Huet, Marcel. *Textbook of Fish Culture. Breeding and Cultivation of Fish.* Translated by Henry Kahn. Surrey, England: Fishing News Books Ltd., 1970.

D. Huner, J.V., and Harry K. Dupree. "Propagation of Aquatic Animals Other than Fish. Crayfish, Prawns, Bullfrogs, and Alligators," in *Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research.* Washington, D.C.: U.S. Fish and Wildlife Service, 1984.

E. McLarney, William. *The Freshwater Aquaculture Book.* Point Roberts, Washington. Hartley & Marks, Inc., 1984.

F. Reigh, Robert C., ed. *Proceedings of the Louisiana Aquaculture Conference, 1988.* Baton Route, Louisiana, Louisiana State University Agricultural Center, 1988.

G. Swift, Donald R. *Aquaculture Training Manual.* Surrey, England. Fishing News Books Ltd., 1985.

SUGGESTED ACTIVITIES

H. Van Ramshorst, Dr. J. D., ed. *Aquarium Encyclopedia of Tropical Freshwater Fish* Tucson, Arizona, 1981.

OTHER COMMERCIAL SPECIES
UNIT XIII

INFORMATION SHEET

I. Terms and definitions

A. **Polyculture** — Raising two or more species in the same pond or enclosure

B. **Monoculture** — Raising a single species in a pond or enclosure

C. **Unisex culture** — Raising only one sex—usually male—of a species

D. **Ranching** — Obtaining wild-bred stock and raising it to marketable size under controlled conditions

E. **Farming** — Breeding and raising stock under controlled conditions

F. **Exotic** — A fish or animal that is not native to the state or locale

G. **Brackish water** — Water that is slightly salty

H. **Hybrid** — Crossbreeding fish of different varieties, races, or species

EXAMPLES: Hybrid striped bass (female striped bass × male white bass) bluegill hybrid (female green sunfish × male bluegill sunfish), redear hybrid (female green sunfish × male redear sunfish)

I. **Prolific** — Producing many young

J. **Forage** — Food obtained by browsing or searching, or the act of searching or browsing for food

K. **Anadromous** — Fish, such as salmon and striped bass, that move from saltwater to freshwater rivers to spawn

L. **Metamorphose** — To change from one form to another as from a tadpole to a frog

INFORMATION SHEET

II. Tilapia (Figure 1)

EXAMPLE: FIGURE 1

A. Tilapias—warm, freshwater fish native to Africa—are important food fish throughout the Middle East, Africa, India, and parts of Asia and Latin America; they were first introduced into the U.S.A. for vegetation control.

B. Tilapias are fast growers, become sexually mature at an early age, spawn every 6 weeks after maturity, have few diseases or parasites, and thrive under conditions that would kill most fish; most can live in brackish water and some adapt readily to sea water.

C. Because Tilapias are hardy and very prolific, they are considered a threat to the ecological balance, and their commercial production in the U.S. is limited by strict laws governing not only their production by also their possession, and by the short growing season necessary for this cold-intolerant species.

(NOTE: Tilapias stop feeding when the water temperature falls below 60°F, and die at water temperatures of 45°-55°F. Despite this intolerance to cold water, however, tilapias have disrupted native fish populations in power plant cooling reservoirs as far north as southern Oklahoma where they survive in the warm discharge waters.)

D. Presently in the U.S., tilapias are used to control unwanted aquatic vegetation, in limited numbers as a food fish and sport species, as feed for broodfish, and as forage for carnivorous fish; they are also sold as hobby fish.

> POINT OF INTEREST: Many species of tilapia are very colorful, and because these fish mature when they are still small (at about 6 months) and have interesting breeding habits, they have become very popular aquarium fish. Many species brood both eggs and fry in their mouths.

E. Tilapias have been polycultured with some success with food-sized channel catfish and buffaloes.

INFORMATION SHEET

III. Methods of managing tilapia to control overpopulation

(NOTE: The major problem with managing tilapia species for commercial culture is over-reproduction and the resultant overcrowding and stunted growth.)

A. Continuously harvest the largest fish with a selective seine net.

B. Remove the young from the pond as they are produced, rear them in fry ponds, and then stock them in grow-out ponds.

(NOTE: This method is not very successful as the fish tend to breed before they are market size and overpopulation can again occur.)

C. Use predator fish for population control.

D. Culture a unisex population so that there can be no breeding.

(NOTE: All-male populations are used. Males are selected by hand, or populations are achieved by the use of hybrids, or by feeding young fish a male hormone to cause a sex reversal in females.)

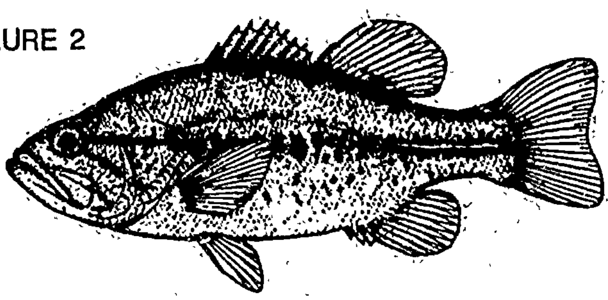
E. Rear tilapia in cages where they cannot breed successfully as there is no pond bottom on which to spawn, or if they do spawn the eggs fall out of the cage and are lost.

F. Rear species that can grow in salt or brackish water; tilapia cannot breed in salty water.

IV. Largemouth bass (Figure 2)

POINT OF INTEREST: In some states largemouth bass are regarded as game fish and cannot be sold as food fish.

EXAMPLE: FIGURE 2



From Eddy and James C. Underhill, *How to Know the Freshwater Fishes*, 3rd ed. Copyright 1978. Wm. C. Brown Publishers, Dubuque, Iowa. All rights reserved. Reprinted by special permission.

A. The black bass is a member of the sunfish family and is used as a sport fish and to control the composition of fish populations.

B. Largemouth bass can be trained to eat artificial feed.

INFORMATION SHEET

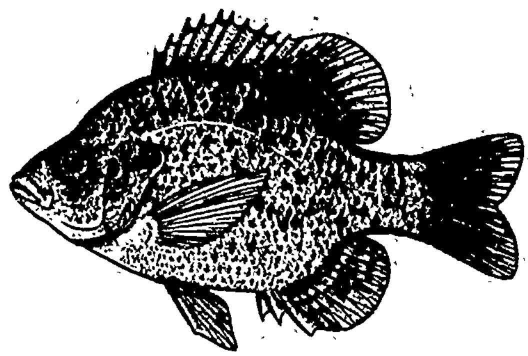
C. Largemouths grow at very unequal rates and cannibalism becomes a problem after fish are 1½ inches to 2 inches long.

D. Common polyculture combinations are largemouth bass, channel catfish, and bigmouth buffaloes; or largemouth bass and channel catfish; or largemouth bass and bluegill or hybrid sunfish.

(NOTE: In largemouth bass/channel catfish polyculture, fry or fingerlings are stocked directly into catfish ponds. The bass eat wild forage that competes with catfish for food.)

V. **Bluegill and hybrid sunfish** (Figure 3)

EXAMPLE: FIGURE 3 — Redear sunfish



From Eddy and James C. Underhill, *How to Know the Freshwater Fishes*, 3rd ed. Copyright 1978. Wm. C. Brown Publishers, Dubuque, Iowa. All rights reserved. Reprinted by special permission.

A. Bluegill and hybrid sunfish are widely cultured for stocking recreational and farm ponds.

B. Pure strain sunfishes spawn readily and are easy to produce; most species hybridize spontaneously in both natural and culture ponds.

C. The best hybrid for sport fishing is a female green sunfish crossed with either a male bluegill or a redear sunfish.

D. Because sunfish interbreed so readily, pond preparation is very important in the monoculture production of these fish: ponds must be thoroughly dried and potholes treated with toxicants to kill unwanted fish that might survive in holes or crayfish burrows.

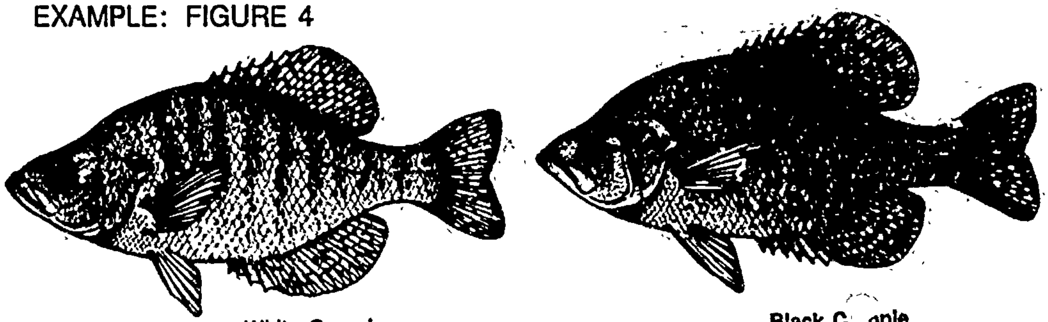
E. Culturists usually stock bluegills in fertilized ponds with largemouth bass to control overpopulation as both species are highly carnivorous.

F. Presently, there is some interest in monoculture of largemouth bass or single-species sunfish.

INFORMATION SHEET

VI. **Crappies** (Figure 4)

EXAMPLE: FIGURE 4



White Crappie　　　　Black Crappie

A. Members of the sunfish family, crappies are sometimes used as a substitute for largemouth bass in turbid farm ponds that are marginal for bass/bluegill populations.

B. Crappies are mainly used in low intensity polyculture in the south central states and in fee-fishing ponds.

C. Crappies school and spawn in colonies, deposit their sticky eggs near overhead cover, and in the wild may grow to 12 inches in four years.

D. Crappies produce poorly in small ponds, so are usually cultured in ponds of from 3 to 12 acres.

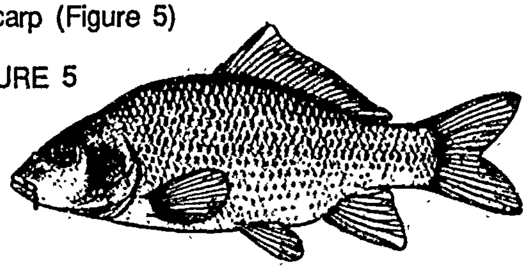
E. Crappies can overpopulate, and should be stocked when heavy, continual harvest is planned.

VII. **Carps**

POINT OF INTEREST: Colorful koi, sold as hobby fish, are a variety of common carp.

A. Common carp (Figure 5)

EXAMPLE: FIGURE 5



INFORMATION SHEET

1. The common carp is a member of the minnow family and was introduced into the U.S. in the late 1800s by the U.S. Fish Commission with the purpose of culturing it as a food fish; while it never caught on as a food fish, it has become established as a wild fish in 47 of the 50 states.

2. Though the common carp is the most important food fish in Europe and Asia, in the U.S. today, its most common production is in polyculture with catfish, and even then it is not often cultured.

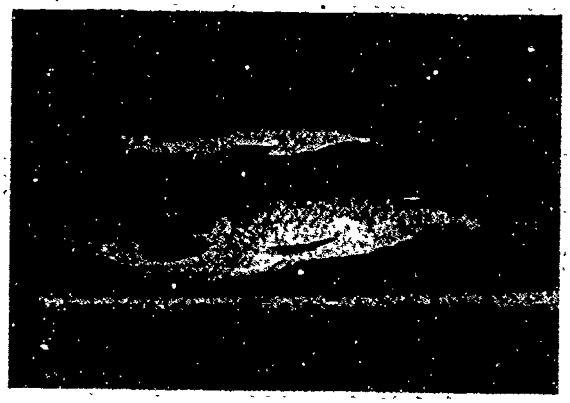
3. The carp is an ideal species for aquaculture: it has been domesticated over many years of selective breeding, grows rapidly, converts food very efficiently, is disease resistant, tolerates low temperatures, is an excellent food fish.

4. The mirror carp—a variety of common carp—is raised for trotline bait in some areas, but in many states the use of carp as bait is illegal.

5. Presently, culture of common carp for food is extremely limited in the U.S.; however, it is predicted that in the future the common carp, like the catfish, will become popular and will play an important role in commercial aquaculture.

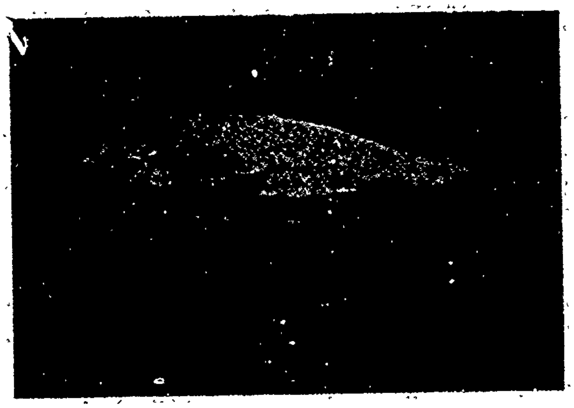
B. Chinese carp (Figures 6 and 7)

EXAMPLE: FIGURE 6 — Grass carp



INFORMATION SHEET

EXAMPLE: FIGURE 7 — Bighead carp, showing 3-month growth



1. Like common carp and tilapia, Chinese carps have long been cultured in Asia and Europe for food fish; in the 1960s they were introduced into the U.S. for aquatic vegetation control (grass carp) and for nutrient removal in sewage and animal waste lagoons (silver carp); today, their acceptance as food fish is increasing in the U.S.

   (NOTE: The grass carp is also called the white amur.)

2. The three most popular varieties feed differently: grass carp in nature feed solely on aquatic plants but will take pelleted feed; bighead carp feed naturally on plankton but will accept baitfish and sinking catfish feed; silver carp feed on plankton in both natural and managed environments.

3. Chinese carps can be produced in monoculture, or in polyculture of grass carp/bighead carp or grass carp/silver carp, and grass carp are sometimes used as aquatic weed control in catfish and baitfish ponds.

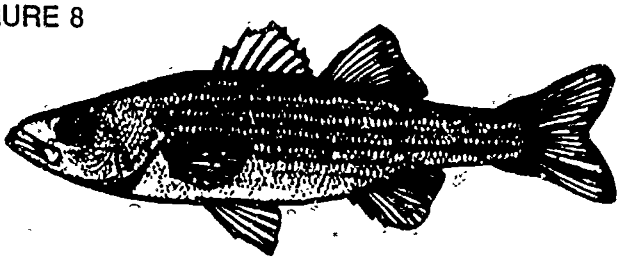
4. Production techniques for intensive pond culture of channel catfish generally apply to the monoculture of grass carp, but seining, handling, and transportation are more difficult because Chinese carps jump over the seine and thrash wildly when handled.

5. Some states have outlawed Chinese carps because of fears that they will become established and disrupt ecosystems as the common carp is said to have done.

INFORMATION SHEET

VIII. Striped bass (Figure 8)

EXAMPLE: FIGURE 8



From Eddy and James C. Underhill, *How to Know the Freshwater Fishes*, 3rd ed.

A. Striped bass and hybrid white bass/striped bass have become important sport fish in U.S. reservoirs and rivers.

B. Striped bass and hybrids may also be used as management fish to help control overabundance of sunfish, particularly crappies.

C. They are a high-quality food fish, and there is some interest in their commercial production for the food-fish market.

D. Striped bass can grow very large and are not suited for small ponds; in addition they are anadromous in nature, coming into freshwater only to spawn.

E. Producing hybrid striped bass from broodstock is a time-consuming and complex procedure; the culturist must work with 15 to 30 pound female striped bass, which are strong but delicate fish easily stressed by handling.

F. Generally, striped bass brood females are collected from the wild by electroshock when they move upstream to spawn; they are then manually stripped of their eggs or tank spawned, and the eggs are fertilized artificially with milt collected from male white bass or male striped bass.

G. Fertilized and washed eggs are incubated in plastic or glass hatching jars, and fry are transported or transferred to pond culture when they are 4 to 5 days old.

H. Pond culture is the preferred method for producing fingerling striped bass and hybrids, and success depends on the production of zooplankton for food and on careful grading and harvesting before the plankton are depleted and the larger fish prey on the smaller fish.

(NOTE: Harvesting is a delicate procedure because any abrasion or penetration of the frys' slimecoat usually results in death caused by bacterial or fungal infection.)

INFORMATION SHEET

IX. Marine species that can be cultured in freshwater

A. Red drum

1. Red drum fry have been produced for many years in Texas for stocking into estuaries in an attempt to increase populations in the Gulf of Mexico; presently red drum are in demand as a food fish because of the rise in popularity of Cajun cuisine.

2. Freshwater stocking as a sport fish is limited to saltwater marsh areas and to freshwater lakes receiving heated water from power plants because these fish can survive water temperatures below 50°F if salinity is high, but die in low water temperatures in freshwater.

3. Culture of red drum is expensive and time consuming, and mortality of broodfish, fry, and fingerlings can be extremely high; further research is necessary before commercial culture will be feasible.

B. Eels

1. The commercial production of food-sized eels and the capture of elvers (small eels) for export has created interest among U.S. aquaculturists.

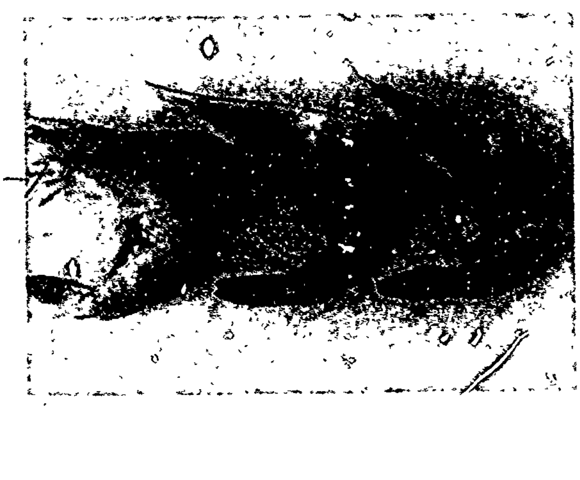
2. Eels spawn at sea and seed stock must be captured from the wild when elvers migrate upstream from the sea; at this time they are 2 to 3 inches long, transparent, and called *glass eels*.

3. Eels are raised in ponds that require water quality management techniques similar to those for catfish culture, and the elvers must be trained to eat artificial feed.

4. Without a stable supply of elvers and with few American markets, eel culture is risky, yet eel culture would supplement farm income where seed eels can be obtained and where ethnic and bait markets are nearby.

C. Freshwater prawn (Figure 9)

EXAMPLE: FIGURE 9



INFORMATION SHEET

1. There is great demand for prawns, and freshwater prawns of the genus *Macrobrachium* grow readily in freshwater, are large, and of high food quality; they are also more manageable than marine varieties.

2. There is a developed prawn culture in Hawaii, but studies in the southwestern U.S. have not been promising because this species cannot survive water temperatures below 60°F, which limits the growing season to 5 to 7 months.

3. Seed stocks are purchased from tropical growers, and the prawns breed and spawn in fresh water; newly hatched larvae are placed in brackish water and then stocked directly into fresh water as soon as they metamorphose.

4. Prawns of 0.6 to 1.1 ounces can be harvested in about 140 to 150 days and are then ready for sale or the table.

X. Alligators

A. Alligators are highly valued for their hide and meat; demand is so great that prices are high and alligator production is profitable.

B. Presently, alligators are being commercially cultured in Texas, Georgia, South Carolina, Louisiana, and Florida.

C. Strict regulations govern intra- and interstate commerce in alligators and alligator products.

D. Alligators are either farmed or ranched; in farming, eggs are collected each year from pen-raised breeders, hatched, and used to establish the market supply.

E. In ranching, eggs or hatchlings are collected each year from the wild population, are raised under controlled conditions, and then a certain percent are returned to the wild and the rest are marketed.

(NOTE: Generally, contracts are drawn up among the rancher, the landowner, and the Department of Wildlife and Fisheries. In Louisiana, the rancher must commit to both the Louisiana Department of Wildlife and Fisheries and the landowner to restock as alligators 48-inches or longer, 17 percent of the gross number of eggs or hatchlings collected.)

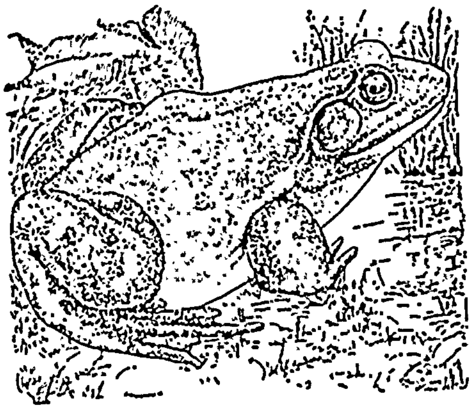
F. Alligators may be raised outdoors in fenced earthen ponds, or indoors in heated incubation and rearing containers.

G. In heated environments, alligators grow to harvestable length (5 to 6 feet) in 26 months; in unheated environments, 48 to 52 months are required.

INFORMATION SHEET

XI. Bullfrogs (Figure 10)

EXAMPLE: FIGURE 10



A. The Japanese and Taiwanese practice open pond culture of bullfrogs from eggs to adults, but their techniques have never been applied successfully in the U.S., where presently there is limited commercial operation.

B. Most come from the wild, though demand for food frogs and live frogs for biological research is greater than supply and availability is seasonal, making the possibility of commercial production appealing.

C. However, frog culture is a very complex operation because of the complicated life cycle and demanding feeding habits of the bullfrog.

XII. Hobby and ornamental fish

A. Most domestically bred hobby fish are cultured at the more than 30) farms located near Tampa in central Florida; other hobby fish are imported from throughout the world, those imported are usually colorful, unique, and difficult to propagate.

B. Tanks, vats, and earthen ponds are used to culture hobby fish, a typical farm propagating 20 to 30 or more species in separate containers.

> POINT OF INTEREST: A typical tropical fish or home aquarium text may list 50 to 100 different species, not to mention popular mutants or hybrids of various species.

INFORMATION SHEET

C. Feeding is one of the major costs of production because expensive pigments (coloring agents) are often included in the feed to promote bright colors in the fish.

D. Water temperature is a primary management concern of hobby fish producers because most species are tropical and sensitive to temperatures below 60°F.

E. Predator control—especially bird predators—can be a problem because birds can easily see and capture these bright, small fishes.

F. Great care must be taken when harvesting hobby fish. fish that die in retail stores soon after purchase by the aquarium owner, must be replaced by the producer.

G. Hobby fishes are normally shipped by air express, with about 15,000 to 20,000 containers shipped each week from Florida wholesalers to retailers throughout the country.

OTHER COMMERCIAL SPECIES
UNIT XIII

ASSIGNMENT SHEET #1
INTERVIEW LOCAL HOBBY AND ORNAMENTAL FISH RETAILERS TO DETERMINE AREA SUPPLY AND DEMAND

In this assignment sheet, you will visit tropical fish retailers in your area to evaluate local supply and demand.

Use your knowledge of the area and the yellow pages of the phone directory to locate one or two tropical fish stores. Visit each of these businesses and talk with the owners to find the answers to questions such as those that follow. Write your questions and answers in a notebook so that you can compare answers and draw conclusions after your interviews.

Sample Questions

1. What tropical fish species do you sell? (Have the owner give you a tour of the tanks, introducing you to the various species.)
2. Which species are domestically cultured and which are imported?
3. Which species is most popular with the consumers in this area?
4. Which species are suitable for a community tank (polyculture) and which must be monocultured? Why?
5. What are the retail and wholesale prices for the different species?
6. Who is your source(s) of supply?
7. How dependable is your supply source? Can you get the stock you want when you want it?
8. Are stock delivered to your door or must you pick them up at a central supplier elsewhere?
9. How are stock packaged when they arrive?
10. How do you acclimate your stock to the new environments?
11. What guarantees does your supplier provide concerning survival at and after time of delivery?
12. How do you package the fish for customer transfer to the home?
13. What is your policy regarding replacing fish or stock that dies within a day or two of purchase?
14. What is your average mortality loss on delivered stock?

ASSIGNMENT SHEET #1

15. How long do you generally hold fish before sale?

16. What types of diseases and problems have you encountered with the species you stock for sale?

OTHER COMMERCIAL SPECIES
UNIT XIII

ASSIGNMENT SHEET #2
VISIT A FACILITY THAT CULTURES A SPECIES DISCUSSED IN THIS UNIT AND REPORT ON THE OPERATION

Make arrangements to visit a facility that cultures a species introduced in this unit. Plan to spend at least one full day observing the day-to-day pond management and recordkeeping practices used by this producer.

Ask many questions and record answers and your observations in a notebook. After your visit, write a report on the operation you observed. Present your report orally to the class.

Sample Questions

1. How is the species being cultured? (Polyculture, monoculture, farmed, ranched, intensive, extensive, etc.)
2. Why did the producer select this particular species?
3. How long has the producer been culturing this species?
4. What markets does the producer serve, and how stable are these markets?
5. What are the present wholesale and retail prices being asked for this species?
6. What breeding techniques does the producer use?
7. What harvesting methods does the producer use?
8. What pond preparation and predator control does the producer use?
9. What legal restrictions, if any, must the producer observe?
10. What recordkeeping system does the producer keep?
11. What type of feed is fed? Is feed purchased or produced on the farm?
12. What types of equipment are particular to this species?
13. What management problems has the producer encountered with this species?
14. What disease and parasite problems has the producer encountered with this species?
15. Would the producer recommend this species to a beginning aquaculturist? Why or why not?

OTHER COMMERCIAL SPECIES
UNIT XIII

TEST

NAME ______________________________ SCORE ________________

1. Match terms related to various commercial fish and animal species with their correct definitions. Write the correct numbers in the blanks.

______ a.	Water that is slightly salty	1.	Polyculture
______ b.	Raising only one sex—usually male—of a species	2.	Monoculture
______ c.	Food obtained by browsing or searching, or the act of browsing or searching for food	3.	Unisex culture
______ d.	Crossbreeding fish of different varieties, races, or species	4.	Ranching
______ e.	Raising two or more species in the same pond or enclosure	5.	Farming
______ f.	Obtaining wild-bred stock and raising it to marketable size under controlled conditions	6.	Exotic
______ g.	Producing many young	7.	Brackish water
______ h.	To change from one form to another as from a tadpole to a frog	8.	Hybrid
______ i.	Breeding or raising stock under controlled conditions	9.	Prolific
______ j.	Fish such as salmon or striped bass that move from saltwater to freshwater rivers to spawn	10.	Forage
______ k.	A fish or animal that is not native to the state or locale	11.	Anadromous
______ l.	Raising a single species in a pond or enclosure	12.	Metamorphose

TEST

2. Select facts to complete statements about the culture of tilapia. Write the correct numbers in the blanks.

   ______ a. Tilapias are warm, freshwater fish native to ___.

   1) Asia
   2) Africa
   3) Australia

   ______ b. Tilapias are important food fish throughout the Middle East, Africa, Asia, India, and parts of Asia and Latin America: they were first introduced into the U.S.A. for ___.

   1) vegetation control
   2) parasite control
   3) the gourmet food market

   ______ c. Tilapias are fast growers, become sexually mature at an early age, spawn every ___ after maturity, have few diseases or parasites, and thrive under conditions that would kill most fish; most can adapt to brackish water and some adapt readily to sea water.

   1) 4 months
   2) 6 weeks
   3) 6 months

   ______ d. Because tilapias are hardy and very prolific, they are ___.

   1) very popular culture fish
   2) fast becoming a popular food fish
   3) considered a threat to the ecological balance

   ______ e. Commercial production of tilapia is limited by ___.

   1) strict laws governing their production and possession
   2) the short growing season necessary for this cold intolerant species
   3) both 1 and 2

   ______ f. Presently in the U.S., tilapias are used ___.

   1) to control unwanted aquatic vegetation
   2) as a popular food fish
   3) as a baitfish species

   ______ g. Tilapias are also popular ___.

   1) as feed for other fish
   2) as hobby fish
   3) both 1 and 2

TEST

______ h. Tilapia have been polycultured with some success with food-sized ___.

1) channel catfish and buffaloes
2) red drum and striped bass
3) prawns and crayfish

3. Select from a list methods of managing tilapia to control overpopulation. Write an "X" in the blank before each correct method.

______ a. Continuously harvest the smallest fish with a selective seine net.

______ b. Remove the young from the pond as they are produced, rear them in fry ponds, and then stock them in grow-out ponds.

______ c. Use predator fish for population control.

______ d. Culture a monoculture population so that there can be no breeding.

______ e. Rear tilapia in cages where they cannot breed successfully as there is no pond bottom on which to spawn, or if they do spawn, the eggs fall out of the cage and are lost.

______ f. Rear species that can grow in warm water; tilapia cannot breed in warm water.

4. Select facts to complete statements about the culture of largemouth bass. Write the correct numbers in the blanks.

______ a. This black bass is a member of the ___ family and is used as a sport fish and to control the composition of fish populations.

1) minnow
2) sunfish
3) salmonid

______ b. Largemouth bass can be trained ___.

1) to eat artificial feed
2) to spawn at convenient intervals
3) to forage selectively

______ c. Largemouths grow at very unequal rates and ___ becomes a problem after fish are 1½ inches to 2 inches long.

1) stunted growth
2) overpopulation
3) cannibalism

TEST

______ d. Common polyculture combinations are ___.

1) largemouth bass, channel catfish, and bigmouth buffaloes or bluegill or hybrid sunfish
2) largemouth bass, smallmouth bass, and red drum or striped or hybrid striped bass
3) both 1 and 2

5. Complete statements about the culture of bluegill and hybrid sunfish. Write the correct words in the blanks.

a. Bluegill and hybrid sunfish are widely cultured for stocking ______________________ and ______________________ ponds.

b. Pure strain sunfishes spawn readily and are easy to produce, most species ______________________ spontaneously in both natural and culture ponds.

c. The best hybrid for sport fishing is the female __________________ sunfish crossed with either the male __________________ or __________________ sunfish.

d. Because sunfish ______________________ so readily, pond preparation is very important in the ______________________ of these fish; ponds must be thoroughly dried and potholes treated with toxicants to kill unwanted fish that might survive in holes or crayfish burrows.

e. Culturists usually stock bluegills in fertilized ponds with __________________ to control overpopulation as both species are highly carnivorous.

f. Presently there is some interest in the ______________________ of largemouth bass or single-species sunfish.

TEST

6. Select facts to complete statements about the culture of crappies. Write the correct numbers in the blanks.

   ______ a. Crappies are members of the ___ family.

   1) sunfish
   2) minnow
   3) salmonid

   ______ b. Crappies are sometimes used as a substitute for largemouth bass in ___ farm ponds that are marginal for bass/bluegill populations.

   1) spring-fed
   2) small
   3) turbid

   ______ c. Crappies school and spawn in colonies, deposit their sticky eggs near overhead cover, and in the wild may grow to ___ inches in four years.

   1) 12
   2) 16
   3) 22

   ______ d. Crappies produce poorly in small ponds, so are usually cultured in ponds of from ___ acres.

   1) 10 to 20
   2) 3 to 12
   3) 12 to 20

   ______ e. Crappies can ___, and should be stocked when heavy, continual harvest is planned.

   1) be difficult to harvest
   2) hybridize
   3) overpopulate

7. Distinguish between characteristics/uses of Chinese and common carps. Write "CO" before descriptions of common carp, and "CH" before descriptions of Chinese carp.

   ______ a. A member of the minnow family introduced into the U.S. in the late 1800s by the U.S. Fish Commission with the purpose of culturing it as a food fish.

   ______ b. The three most popular species feed differently: grass carp in nature feed solely on aquatic plants but will take pelleted feed; bighead carp feed naturally on plankton but will accept baitfish and sinking catfish feed; silver carp feed on plankton in both natural and managed environments.

   ______ c. Some states have outlawed these carps because of fears that they will become established and disrupt ecosystems.

TEST

______ d. The mirror carp is raised for trotline bait in some areas, but in many states the use of carp for bait is illegal.

______ e. Presently the culture of this carp for food in the U.S. is extremely limited; however, it is predicted that in the future, this carp, like the catfish, will become popular and will play an important role in commercial aquaculture.

______ f. Production techniques for intensive pond culture of channel catfish generally apply to the monoculture of the grass carp, but seining, handling, and transportation are more difficult because these carps jump over the seine and thrash wildly when handled.

______ g. This carp is the most important food fish in Europe and Asia; in the U.S. today, its most common production is in polyculture with catfish, and even then it is not often cultured.

______ h. This carp is an ideal species for aquaculture; it has been domesticated over many years of selective breeding, grows rapidly, converts food very efficiently, is disease resistant, tolerates low temperatures, and is an excellent food fish.

______ i. This carp has long been cultured in Asia and Europe for food fish; in the 1960s, these carp were introduced into the U.S. for aquatic vegetation control (grass carp) and for nutrient removal in sewage and animal waste lagoons; acceptance as a food fish is increasing.

______ j. This carp can be produced in monoculture or in polyculture of grass carp/bighead carp or grass carp/silver carp, and grass carp are sometimes used as aquatic weed control in catfish and baitfish ponds.

8 Select from a list factual statements about the commercial production of striped and hybrid striped bass. Write an "X" in the blank before each correct statement.

______ a. Striped bass and hybrid white/striped bass have become important sport fish in U.S. reservoirs and rivers.

______ b. Striped bass and hybrids may also be used as management fish to control overabundant aquatic vegetation.

______ c. They are a high-quality food fish, and there is some interest in their commercial production for the food-fish market.

______ d. Striped bass can grow very large, and are not suited for small ponds; in addition they are anadromous in nature, coming into freshwater only to spawn.

______ e. Producing hybrid striped bass from broodstock is a time-consuming and complex procedure; the culturist must work with 15 to 30 pound female striped bass, which are strong and hardy fish not easily stressed by handling.

TEST

_______ f. Generally, striped bass brood males are collected from the wild by seining or trapping when they move upstream to spawn; they are then manually stripped of their eggs or tank spawned, and the eggs are fertilized artificially with the milt collected from male white or striped bass.

_______ g. Fertilized and washed eggs are incubated in plastic or glass hatching jars, and fry are transferred to pond culture when they are 1 or 2 days old.

_______ h. Pond culture is the preferred method of producing fingerling striped bass and hybrids, and success depends on the production of zooplankton for food and on careful grading and harvesting before the plankton are depleted and the larger fish prey on the smaller fish.

9. Discuss marine species that can be cultured in freshwater. Answer the following questions.

   a. Why has Texas produced red drum fry for many years?

   ____

   b. Why are red drum in demand presently as a food fish?

   ____

   c. Under what conditions can red drum survive low water temperatures?

   ____

   d. Why is commercial production of red drum presently not feasible?

   ____

   e. Where do eels spawn?

   ____

   f. How large are wild eels captured for commercial production?

   ____

   g. What are transparent eels, 2 to 3 inches long called?

   ____

   h. What is the feasibility of commercially producing eels in the U.S.? Explain.

   ____

   ____

TEST

i. What makes the production of freshwater prawns commercially desireable?

____

____

j. What state leads in the culture of prawn?

____

k. What limits the growing season for prawn?

____

l. How are prawn seed stock obtained?

____

m. How long does it take prawns stocked at 0.6 to 1.1 ounces to be ready for harvest?

____

10 Select factual statements about the commercial production of alligators. Write the correct numbers in the blanks.

_____ a. Which of the following makes alligator production profitable?

1) Great demand for highly valued hide and meat
2) Great demand for highly valued teeth and skeleton
3) Great demand for highly valued eggs and breeders

_____ b. Which of the following states are presently commercially culturing alligators?

1) Arizona and California
2) Louisiana and Florida
3) Mississippi and Oklahoma

_____ c. Which of the following is true about intra- and interstate commerce in alligators and alligator products?

1) It is illegal
2) It requires bonding and licensing
3) It is strictly regulated

TEST

______ d. Which of the following describes alligator ranching?

1) Eggs are collected each year from pen-raised breeders, hatched, and used to establish a market supply
2) Eggs or hatchlings are collected each year from the wild population, raised under controlled conditions; a certain percentage are returned to the wild and the rest are marketed
3) Both 1 and 2

______ e. Which of the following describes alligator rearing options?

1) Outdoors in earthen ponds or indoors in aerated and air-conditioned rearing containers.
2) Outdoors in fenced swamps or indoors in saltwater incubation and rearing containers.
3) Outdoors in earthen ponds or indoors in heated incubation and rearing containers.

______ f. Which of the following are the correct lengths of time for alligators to grow to harvestable length in heated and unheated environments?

1) Heated: 26 months; unheated: 48 to 52 months
2) Heated: 16 months; unheated: 38 to 42 months
3) Heated: 36 months; unheated: 58 to 62 months

11. Select facts to complete statements about the commercial production of bullfrogs Write the correct numbers in the blanks.

______ a. Most come from ___, though demand for food frogs and live frogs for biological research is greater than supply and availability is seasonal, making the possibility of commercial production appealing.

1) the wild
2) Florida
3) importing from Asia

______ b. Frog culture is a very complex operation because of the complicated ___ and demanding ___ of the bullfrog.

1) facilities needed; sexual needs
2) water chemistry needs; metamorphosis
3) life cycle; feeding habits

______ c. The Japanese and Taiwanese practice open pond culture of bullfrogs from eggs to adults, but their techniques ___, where presently there is limited commercial operation.

1) have never been approved in the U.S.
2) are too expensive for production in the U.S.
3) have never been applied successfully in the U.S.

TEST

12. Select factual statements about the commercial production of hobby and ornamental fish. Write the correct numbers in the blanks.

_____ a. Where are most of the domestically bred hobby and ornamental fish cultured in the U.S?

1) Hawaii
2) Southern California
3) Florida

_____ b. About how many species does a typical hobby fish farm propagate?

1) 20 to 30
2) One
3) 10

_____ c. What is the major cost of raising hobby and ornamental fish?

1) Import fees
2) Container and aeration systems
3) Feed

_____ d. What is the primary management concern of producers of hobby and ornamental fish?

1) Water quality
2) Water temperature
3) Transport to markets

_____ e. Which of the following predators is the biggest threat to hobby and ornamental fish?

1) Birds
2) Reptiles
3) Aquatic insects

_____ f. Why must great care be taken when harvesting hobby fish?

1) They are very delicate and lose their scales easily
2) Those that die in the retail stores must be replaced by the producer
3) Fish suffocate in the seines

TEST

______ g. How are hobby fish normally shipped?

1) Hauling truck
2) Interstate bus lines
3) Air express

(NOTE: Test questions 13 and 14 list the assignment sheets. They are an important part of this test. If they have not been completed, see your instructor for scheduling and evaluation procedures.)

13. Interview local hobby and ornamental fish retailers to determine area supply and demand. (Assignment Sheet #1)

14. Visit a facility that cultures a species discussed in this unit, and report on the operation. (Assignment Sheet #2)

OTHER COMMERCIAL SPECIES
UNIT XIII

ANSWERS TO TEST

1. a. 7 g. 9
   b. 3 h 12
   c. 10 i 5
   d. 8 j. 11
   e. 1 k. 6
   f. 4 l. 2

2. a. 2 e. 1
   b. 1 f. 1
   c. 2 g. 3
   d. 3 h. 1

3. b, c, e

4. a. 2
   b. 1
   c. 3
   d. 1

5. a. Recreational, farm
   b. Hybridize
   c. Green; bluegill, redear
   d. Interbreed; monoculture
   e. Largemouth

6. a. 1
   b. 3
   c. 1
   d. 2
   e. 3

7. a. CO f. CH
   b. CH g. CO
   c. CH h. CO
   d. CO i. CH
   e. CO j. CH

8. a, c, d, g, h

TEST

9. a They are attempting to increase populations in the Gulf of Mexico.
   b. They are popular in Cajun cuisine.
   c. If salinity is high
   d. It is expensive, time consuming, and mortality can be high
   e. At sea
   f. 2 to 3 inches long
   g. Glass eels
   h. Not very feasible; there must be ethnic and bait markets nearby
   i. There is great demand, they grow readily in freshwater, they have a high food quality, and they are manageable.
   j. Hawaii
   k. They cannot survive water temperatures below 60°F
   l. They are purchased from tropical growers.
   m. 140 to 150 days

10. a. 1
    b. 2
    c. 3
    d. 2
    e. 3
    f. 1

11. a. 1
    b. 3
    c. 3

12. a. 3
    b 1
    c. 3
    d. 2
    e. 1
    f. 2
    g. 3

13. Evaluated to the satisfaction of the instructor

14. Evaluated to the satisfaction of the instructor

HARVESTING AND HAULING
UNIT XIV

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss harvesting and hauling equipment, methods, and procedures. The student should also be able to grade fish, calculate loading rates, package fish for transport, and check shipping water parameters. These competencies will be demonstrated by properly completing the procedures in the assignment and job sheets and by scoring a minimum of 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to harvesting and hauling with their correct definitions.
2. Distinguish between advantages of total and partial harvest.
3. Distinguish between limitations of harvesting strategies.
4. Select from a list guidelines for quality control.
5. Match harvesting equipment with their correct uses.
6. Match grading equipment with their correct uses.
7. Select pre-harvest guidelines from a list.
8. Complete statements about harvesting techniques and procedures.
9. Select from a list factual statements about pond-to-shed transport procedures.
10. Complete statements about holding practices.
11. Completes statements about grading practices.
12. Select factual statements about hauling equipment.
13. Solve problems regarding loading procedures and rates.
14. Select factual statements about hauling and water quality.
15. Match hauling chemicals with their correct descriptions/rates.
16. Complete statements about unloading procedures.

OBJECTIVE SHEET

17. Select from a list guidelines for the care of nets.

18. Calculate loading rates. (Assignment Sheet #2)

19. Observe and report on a commercial harvest. (Assignment Sheet #2)

20. Survey your area and state for laws and regulations concerning interstate and intrastate shipping. (Assignment Sheet #3)

21. Demonstrate the ability to:

    a. Check water temperature and other shipping parameters. (Job Sheet #1)

    b. Grade fish. (Job Sheet #2)

    c. Package fish in a plastic bag. (Job Sheet #3)

    d. Disinfect fish transport tanks and equipment. (Job Sheet #4)

HARVESTING AND HAULING
UNIT XIV

SUGGESTED ACTIVITIES

A. Arrange for the class to visit a commercial fish farm so that they may complete assignment and job sheets.

B Show students examples of graders, seines, dip nets, and other harvesting and hauling equipment.

C. Gather equipment and materials needed for completion of job sheets.

D. Arrange for an experienced fish farmer to visit the class and talk about safety, permits, and licenses necessary for harvesting and hauling.

E. Read unit and make your own notes.

F. Provide students with object sheet. Discuss unit and specific objectives.

G Provide students with information sheet. Discuss information sheet, supplementing and localizing to meet students' needs.

H. Stress the importance of keeping routine and accurate records.

I Provide students with assignment and job sheets. Discuss and schedule assignment sheets.

J. Schedule and demonstrate job sheet. Evaluate job sheet performance.

K. Give unit test.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Avery, Jimmy L. "Production Practices of Commercial Catfish Farming," in *Proceedings of the Louisiana Aquaculture Conference, 1988*, Robert C. Reigh, ed. Baton Rouge, Louisiana: Louisiana State University Agricultural Center, 1988.

B. Belusz, Larry. *Fish Farming Techniques*. Columbia, Missouri: The Instructional Materials Laboratory, University of Missouri, 1987.

C. Dupree, Harry K., and Jay V. Huner. "Transportation of Live Fish," in *Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research*. Washington, DC: U.S. Fish and Wildlife Service, 1984.

D Guidice, John J., D. Leroy Gray, and J. Mayo Martin. *Manual for Bait Fish Culture in the South*. Stuttgart, Arkansas: University of Arkansas Cooperative Extension Service and the U.S. Fish and Wildlife Service, 1982.

SUGGESTED ACTIVITIES

E. Huner, Jay V., Harry K. Dupree, and Donald C. Greenland. "Harvesting, Holding, and Grading Fish," in *Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research*, Harry K. Dupree and Jay V. Huner, eds. Washington, DC: U.S. Fish and Wildlife Service, 1984.

F. Jensen, Gary, L. *Commercial Production of Farm-Raised Catfish*. Baton Rouge, Louisiana: Louisiana Cooperative Extension Service, Louisiana State University Agricultural Center, 1988.

G. Swift, Donald R. *Aquaculture Training Manual*. Surrey, England: Fishing News Books, Ltd., 1985.

HARVESTING AND HAULING
UNIT XIV

INFORMATION SHEET

I. Terms and definitions

A. **Total harvest** — Harvesting strategy that involves one-time seining or trapping and annual draining of pond

B. **Multiple harvest (partial harvest)** — Harvesting strategy that requires numerous yearly seinings or trappings and complete draining of pond each 6 to 8 years.

C. **Seine** — Long piece of netting with a series of floats on the top and lead weights on the bottom; the sides may be supported with brails (wooden poles) or equipped with haul lines

D. **Trammel seine** — A seine with two course outer nets that support a fine-mesh inner net which fish swim into and force through the course layers, trapping themselves as the fine-mesh net is forced in around them

E. **Toggle** — A pin or rod inserted through a loop of haul line to attach it to the seine

F. **Snatch block** — Pulley

G. **Antibiotic** — Chemical that kills or controls the growth of bacteria and other microorganisms

H. **Bacteriostat** — Chemical that stops the growth or multiplication of bacteria

I. **Anesthetizing compound** — Agent used to sedate fish and slow their metabolic rate

J. **Tempering** — Gradually acclimating (accustoming) fish to changes in water chemistry and temperature

K. **Understocking** — Stocking smaller sized fingerlings along with larger fish

L. **Off flavor** — Musty, muddy taste of fish flesh generally caused by some blue-green algae and bacteria

(NOTE: Off-flavor is most common in late summer when water temperatures are high, large amounts of feed are used, and algal blooms are dense. It also occurs in cool weather during spring and fall.)

M. **Topping/understocking** — Periodically harvesting marketable fish from the rearing unit and stocking smaller fish in their place

N. **Drawdown** — process of lowering the water level in a pond, or completely draining a pond

INFORMATION SHEET

II. Advantages of harvesting strategies

A. Total harvest

1. Allows the producer the security of contracting for the sale of an entire crop at one time.

2. Allows for disease, weed, and predator treatment of pond bottom.

3. Requires only one labor-intensive harvesting period per season.

4. Allows for multiple use of land as crops may be grown on the pond bottom during the period that the pond is empty.

5. Is the only method that allows for harvesting nearly 100 percent of the crop.

B. Partial harvest

1. Allows the producer to periodically harvest whatever quantity and size of fish desired.

2. Tends to increase total production because fish can be harvested near the point where their growth rate falls off and rearing unit can be understocked.

3. Can be used to harvest all types of rearing units, particularly ponds with deep water and irregular bottoms and banks.

4. Allows producer to market fish when the market price is optimum.

5. Produces year-round supply of fish to market.

6. Increases cash flow but requires more capital.

III. Limitations of harvesting strategies

A. Total harvest

1. Depends on even growth rate and the assumption that all fish will be marketable size at harvest time.

2. Requires scraping out and treating of rearing unit or pond bottom, which can be time consuming, especially if potholes and low areas exist in the pond.

3. Restricts producer to the market price at the time of harvest.

4. Means lost feeding days and a fuel bill if pumping is required to refill the rearing units.

INFORMATION SHEET

B. Partial harvest

1. Requires many labor-intensive harvesting periods.

2. Means harvesting during hot summer months when fish are more prone to stress and disease.

3. If method is used too often, causes fish baited into the seines or traps to become wary of trapping methods and difficult to catch.

4. Requires extra capital to replace stock.

IV. Guidelines for quality control

A. If fish are to be sold to a processing plant, contact the processor at least one month before harvest because fish must be tested for off-flavor at least two times.

B. Use a harvesting method that reduces the chances of muddying the water as muddy waters can create off-flavor problems.

C. Harvest in the coolest weather possible, avoid harvesting after blue-green algae bloom or after a stormy period that has muddied the water.

D Before and during harvesting of food fish, sample for off-flavor by cooking and testing a sample.

E. If off-flavor is detected, hold fish until off-flavor disappears.

(NOTE: Holding marketable-size fish while waiting for them to lose their musty flavor is economically unsound and presents the risk of loss through disease or water quality deterioration, but unfortunately it is the most acceptable alternative at present. Using filter alum, lime, or potassium permanganate to reduce clay or slit levels or to neutralize off-flavor compounds, or using herbicides to kill blue-green algae are methods that have not been tested adequately to be proven effective in eliminating off-flavor.)

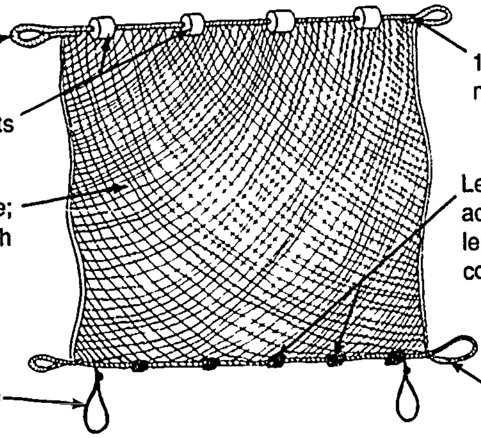
INFORMATION SHEET

V. Harvesting equipment

A. Seines (Figures 1-6)

1. **Lead-line seine** — Trapping seine with bottom line of leaded rope; used for multiple harvest

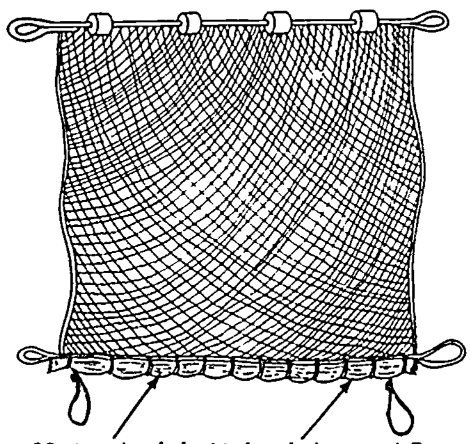
EXAMPLE: FIGURE 1



2. **Mud-line seine** — Full-pond seine, usually 200 to 1,600 feet long and 8 feet deep; made of nylon netting with bottom line of multiple strands of rope to prevent the digging effect of weighted lines.

(NOTE: When used for harvesting catfish, the netting on these seines is coated with tar or asphalt to prevent the fish's spines from becoming entangled in the netting. The seine should be one-third deeper than the deepest part of the pond and one-third longer than the widest part of pond to be seined.)

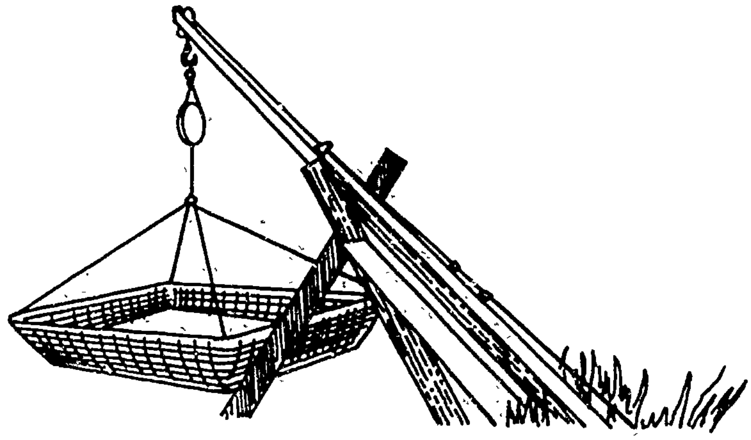
EXAMPLE: FIGURE 2



INFORMATION SHEET

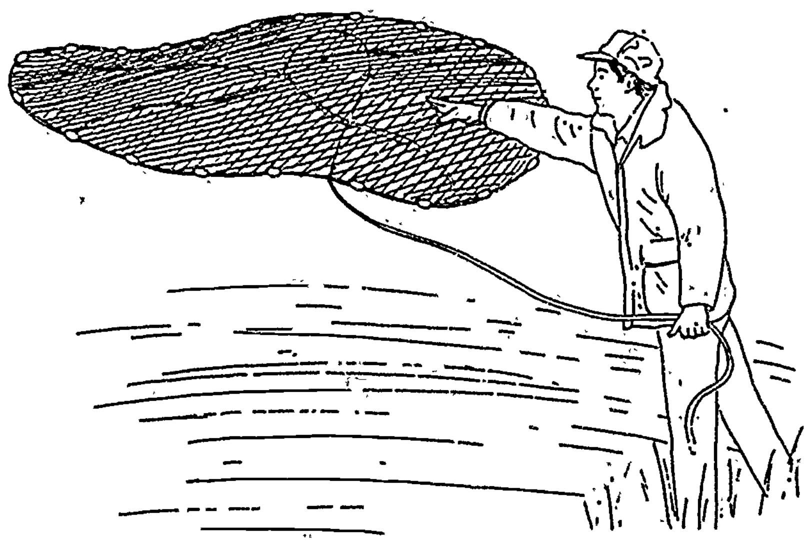
3. **Lift seine** — Square or rectangular trapping seine on a metal frame; suspended in pond from a pipe resting on an on-shore fulcrum that raises the seine after fish are baited over the top; used on ponds with irregular bottoms and for baitfish and other scaled species.

EXAMPLE: FIGURE 3



4. **Cast net** — Round seine hand-thrown for partial harvests or periodic sampling of surface-feeding fish

EXAMPLE: FIGURE 4



INFORMATION SHEET

5. **Live-car seine** — Seine that can be attached and detached from the harvesting seine using a loading frame and drawstrings; used widely for harvesting and grading catfish, these seines are anchored with stakes and supported with support rods so that fish can be removed from them for transport.

EXAMPLE: FIGURE 5

6. **Brailing bag (brailer)** — Netting sack with metal-framed mouth used to scoop fish from harvest seine and lift them to transport truck

EXAMPLE: FIGURE 6

From *Third Report to the Fish Farmers*, "Harvesting, Holding and Grading Fish," by Jay V. Hunner et. al. With permission.

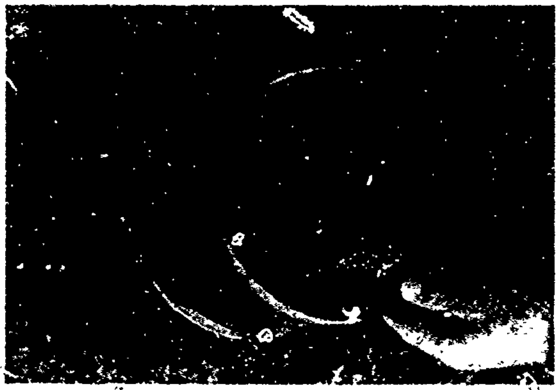
INFORMATION SHEET

B. Traps (Figure 7)

1. **Panel trap** — used in ponds with seining obstacles; this trap consists of chicken-wire screened wooden panels that are installed gradually so as not to interrupt fish feeding

2. **Cylinder trap** — One foot in diameter and 2 feet long, these traps may have one or two funnels and are primarily used to harvest bait fish

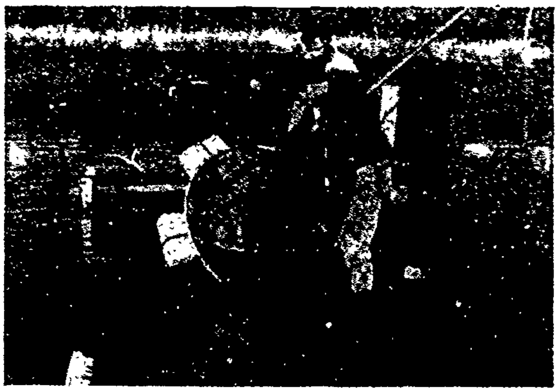
EXAMPLE: FIGURE 7



C. Miscellaneous harvesting equipment (Figures 8-13)

1. **Dip net** — Used to dip fish from seines, holding tanks, and transport tanks

EXAMPLE: FIGURE 8



INFORMATION SHEET

2. **Seine stakes** — Used to support sides of seine to prevent fish from escaping

EXAMPLE: FIGURE 9

3. **Hydraulic-powered seine reel** — Used to store, transport, and gather in large harvesting seines

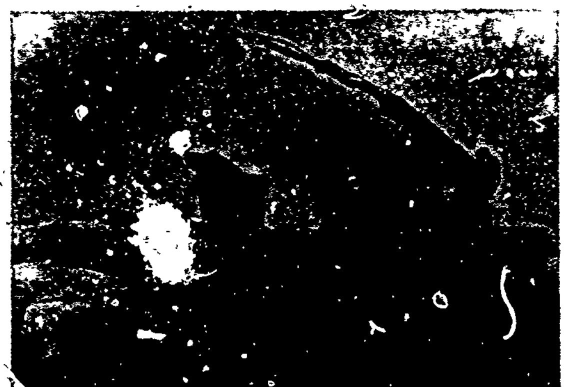
EXAMPLE: FIGURE 10

INFORMATION SHEET

4. **Tractor or truck with boom winch** — Used to lift fish from seine to transport truck

   (NOTE: Many boom winches have in-line scales that allows the weighing of fish during the loading process, thus reducing the time and labor required as well as additional handling of the fish.)

   EXAMPLE: FIGURE 11



From *Commercial Production of Farm Raised Catfish* by Gary L. Jensen. With permission.

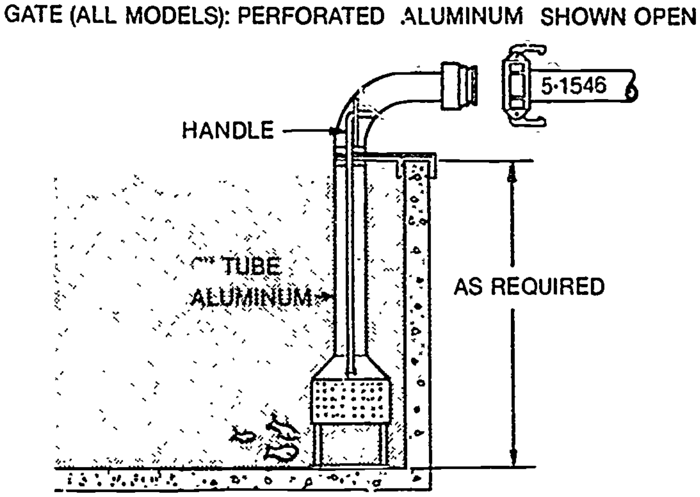
5. **Seine assist** — Used to catch the top of the seine and pull it forward, freeing the bottom seine line from the mud

INFORMATION SHEET

6. **Fish pump** — Used in trout raceways and large tanks to pipe fish and water directly from seine to a grading bin above the hauling tank

   (NOTE: Early fish pump designs functioned poorly and often injured the fish. Newer, more efficient designs have replaced the older models, but it may still be difficult to meter the fish into the intake at a steady rate without occasional clogging.)

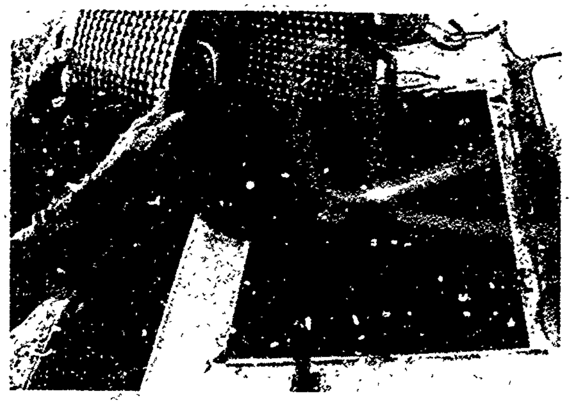
   EXAMPLE: FIGURE 12



Courtesy Neilsen Metal Industries, Inc., Salem, Oregon

7. **Fish basket** — Container for transfer of fish from harvest site to transport truck or holding vats

   EXAMPLE: FIGURE 13

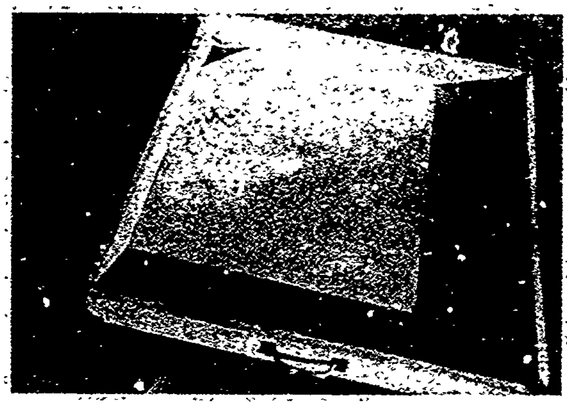


INFORMATION SHEET

VI. **Grading equipment** (Figures 14-16)

A. **Sorting table** — Used in shed grading to allow for the hand-grading of fish and culling of deformed fish

EXAMPLE: FIGURE 14

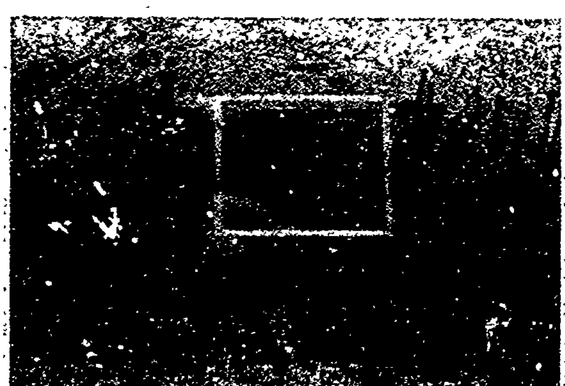


B. **Net grader** — Generally used for in-pond grading within the harvesting seine

(NOTE: Fish crowded into the harvesting seine may be put into net graders such as live cars or socks for further grading or holding. Fish can also be crowded and graded using a shorter cutting seine of appropriate mesh size. A cutting seine is pulled inside the larger harvesting seine.)

C. **Grader box** — Container used to grade small fish such as baitfish or fingerlings in holding trough

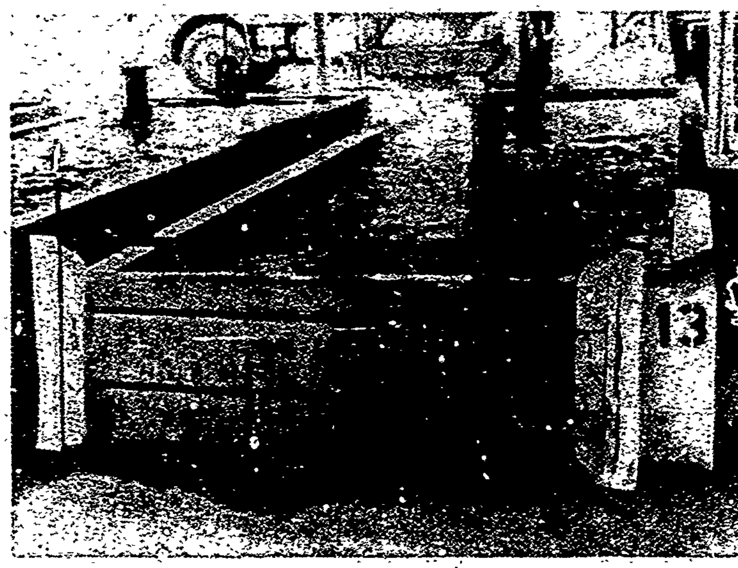
EXAMPLE: FIGURE 15



INFORMATION SHEET

D. **Panel grader** — Barred panel used in holding tank to grade fingerlings and baitfish

EXAMPLE: FIGURE 16



From *Manual for Bait Fish in the South* by John J. Guidice, et. al. With permission.

VII. **Preparation for harvesting**

A. Choose a harvesting method that fits your marketing strategy, your species, and pond type.

B. Determine whether you will harvest your own crop or hire custom harvesters.

(NOTE: Harvesting can be expensive and is the most labor intensive part of fish farming. Most producers harvest their own fish, but many fish buyers will handle the harvesting operation and reduce the producer's labor needs. Often, custom harvest relieves the producer of much of the liability incurred during transport. However, processing plants generally will not send a truck out to pick up loads of less than 5,000 pounds.)

C. Do not feed fish at least one day before harvesting.

(NOTE: When fish are handled or transported, they disgorge recently eaten food, which adds to oxygen problems during hauling. Also, processing plants may deduct 3 percent of the total weight if fish have food in their stomachs.)

D. *Before* harvest, sample food fish for off-flavor; do not risk having a load of fish refused by the processor or buyer.

INFORMATION SHEET

E. Make sure that all needed equipment is available, in good repair, and disinfected before you begin harvesting, have all harvesting equipment ready at the pond bank.

F. Take special care to ensure that aeration equipment and backup aeration is available and functioning properly.

G. Keep complete and accurate records of fish numbers, sizes, weights, mortality, disease and parasite problems, chemicals used, date and time of harvest, and market price.

VIII. Harvesting techniques and procedures

POINT OF INTEREST: Harvesting is easiest for fish raised in cages or tanks where dip nets are used to remove and transfer fish. Raceways are also easy to harvest by crowding the fish to one end and using dip nets, a boom and brailing bag, or a fish pump to harvest the crop. In ponds, fish can be harvested by fishing, gill netting, trapping, and seining. When harvesting, the same daily routines should be followed — same trucks, same people, same sounds. The fish become skittish at changes as minor as a different-sounding engine.

A. Seining

(NOTE: Multiple seining of a full pond is the most common harvesting technique for levee-type catfish ponds.)

1. Sticks, branches, and other debris that might tear the seine are removed from the pond.

2. The seine net is played out along the levee opposite the landing site (usually the shallow end), and the haul lines are attached to seine brails or toggles are lead through snatch blocks along the lateral pond banks (to keep the net spread and close to shore) and then to a tractor equipped with a line hauler or to a powered line hauler.

3. As the net ends approach the snatch blocks, the haul lines are released from the blocks and taken along the bank to the next set of snatch blocks or to the landing site.

4. To avoid premature overcrowding of the fish, usually hauling is stopped while the seine bag is still well out of the pond.

5. When the catch is exceptionally large, a cutting seine is used inside the large seine.

6. Seined fish are scooped into a boom-mounted brailing bag, weighed on an in-line scale, and lifted to the aerated hauling truck; or they may be pumped to the transport vehicle with a fish pump.

7. Short seines are pulled by hand.

INFORMATION SHEET

B. Corral seine trapping

(NOTE: This method works best when fish are actively feeding.)

1. The seine is arranged in a corner of the pond and the lead ropes are drawn to shore where the seine is to be loaded.

2. Sinking feed is scattered between the seine and the shore.

3. Fish swim around the ends of the seine to feed, and after several days, when the fish are accustomed to feeding within the area, the seine ends are pulled to shore with the attached ropes, thus enclosing the fish.

4. The entire seine is pulled close to shore, and the fish are dip netted out and loaded.

5. The corral seine technique of partial harvest cannot be used more than once a week because fish become wary of the net.

6. Harvesting can be alternated among ponds and at different areas of large ponds.

C. Drop-seine trapping

1. This technique works well in weed-choked ponds and ponds with small cleared areas.

2. In this technique, a corral seine is set in a semicircle around a feeding station and the ends of the seine are attached to the shore.

3. Portions of the net are lifted off the pond bottom and hung on triggers, thus providing "doors" to the feeding site.

4. When the triggers are pulled, the net falls to the bottom, thus encircling the fish that have come to feed.

5. The trapped fish are then generally netted with a shorter cutting seine.

6. Catfish do not usually feed in the trap for 1 or 2 weeks after the net has been positioned, and require 3 to 7 days to become reacclimated after each drop.

D. Lift net trapping

1. A square or rectangular lift net is lowered to the bottom of the pond, and fish are baited over the top of the net.

2. When fish are accustomed to feeding within the net, it is raised by means of a fulcrum pole, and the trapped fish are lifted to the transport tank.

3. The mesh size may be adjusted to make this seine self grading.

INFORMATION SHEET

E. Simple traps

> POINT OF INTEREST: Traps are used exclusively for harvesting crayfish, and are commonly used for harvesting baitfish, particularly fathead minnows and goldfish. Cage traps may also be used to trap catfish since they depend largely on their sense of smell to locate food. Other species, such as bass and trout, are visual feeders so it is seldom possible to trap them in any numbers.

1. Cylinder traps with funnel-type entrances are baited and placed in shallow areas where fish frequently feed.

2. The locations of the traps are marked with poles or buoys.

3. Traps are checked periodically, and when enough fish have become trapped, the traps are emptied into buckets for transfer to holding tanks or transport tanks.

F. Fish pump

(NOTE: This method is used primarily for harvesting trout from raceways.)

1. The amount of fish to be transported in a hauling tank is weighed, counted, and separated, usually by partitioning off a portion of the raceway.

2. The fish are then crowded toward the pump's submerged intake.

3. Fish are pumped up to water-filled hauling unit where fish and water are separated: fish into the hauling tank and water back to the raceway or rearing unit.

IX. Rearing-unit-shed transport

A. Transporting fish from the rearing unit to the shipping shed is an important part of the harvesting process.

B. The hauling unit must be large enough to accommodate fish without crowding, and should be filled with clean, well-aerated water, even for the shortest hauling distances.

C. Because they are held in small amounts of water, fish placed in tubs or buckets can experience a rapid rise in water temperature and a corresponding drop in DO.

D. Fish harvested in the winter can experience cold shock because of the difference between rearing unit water temperature and air temperature, winter-harvested fish must be immediately placed in transport containers with as little exposure to the air as possible.

INFORMATION SHEET

E. Cooler water reduces self-inflicted injuries and lowers stress and metabolism.

F. Channel catfish and golden shiners harvested in the summer may be put into water 10 to 15 degrees cooler than the pond water, while the temperature difference for most other species should not exceed 5 degrees.

G. In addition to lowering the water temperature, the farmer can add up to 1 percent table salt, antibiotics or bacteriostats, and an anesthetizing agent to the shed transport water.

(NOTE: Anesthetics cannot legally be used on food fish.)

X. **Holding practices** (Job Sheet #1)

A. It is often necessary to hold channel catfish fingerlings, baitfish, and sport fishes for several days after harvest.

B. Keeping fish in good condition during this holding period is very important. covered facilities are best, especially during hot weather, and adequate supplies of oxygenated water must be available.

(NOTE: processing plants deduct the weight of dead fish from the total.)

C. Holding tanks may be concrete or fiberglass, and are either round or rectangular; a tank 4 feet by 10 feet with 2 feet of water holds about 500 gallons of water and can carry 300 pounds of fish if sufficient aeration and water exchange are provided.

(NOTE: Capacity will vary with seasonal changes in water temperature.)

D. While fish are in holding tanks, they can be treated for infectious diseases and parasites, graded, and held for a sufficient length of time to recover from the effects of the chemicals and drugs; they are also acclimated to handling and transport.

E. Food fish, large sport fish, and even minnows are often held in the pond in live-cars; plastic containers similar to fish cages are also used to hold fish in ponds before transportation.

F. Fish should be counted or weighed before they are placed in holding tanks or live-cars; live-cars must be properly staked to prevent fish from escaping.

XI. **Grading practices** (Job Sheet #2)

A. To ensure uniformity of size, some grading is usually required with fingerlings as well as with food fish.

B. Sorting tables, net graders, panel graders, and grading boxes are used to sort fish by size and to remove any foreign fish, plants, tadpoles, or other undesired animals.

INFORMATION SHEET

C. Food-fish grading is often oone in the rearing unit with live-cars or other net graders.

D. Fingerlings and baitfish are usually graded in the shipping shed at the time of sale; they are graded in holding tanks with panel graders or grading boxes so that they can be sorted without being handled with dip nets. (See Table 1)

E. To avoid undue stress, shipping-shed grading should not be attempted until several hours after the fish have been removed from the rearing unit.

F. Small fish should be graded out of the population first, and the quantity of fish in the grader at any one time should not exceed 5 pounds per cubic foot of grader capacity.

G. In trout culture, the need for grading is minimized by feeding techniques that provide access to food by less aggressive fish.

POINT OF INTEREST: Studies have shown that segregation of smaller fish does not induce faster growth. Some fish are genetically unable to grow fast.

INFORMATION SHEET

TABLE 1: Bar Grader Sizes for Minnows and Channel Catfish and Mesh Sizes for Net Grader for Channel Catfish

Fish, and spacing between grader bars, or mesh size of net (inches)	Length of fish held (inches)[a]
Minnows	
Bar grader	
11/64	1 1/2
12/64	1 3/4
13/64	2
14/64	2 1/4
15/64	2 1/2
16/64	2 3/4
Channel Catfish	
Bar grader	
27/64	3
32/64	4
40/64	5
48/64	6
56/64	7
64/64	8
96/64	11 (3/4 lb.)
Net grader	
1/4	1-2
3/8	3-4
1/2	4-5
3/4	7-8
1	8-10 (1/2 lb)
1 3/8	3/4 lb.
1 5/8	1 1/2 lb.
1 3/4	2 lb.

[a]Weight where specified.

From *Third Report to the Fish Farms*, "Harvesting, Holding, and Grading Fish," by Jay V. Hunner, et. al. With permission.

INFORMATION SHEET

XII. Hauling equipment (Figure 17)

EXAMPLE: FIGURE 17

A. Hauling truck — Truck units may be of many sizes and types; single-axle units of 1/2, 3/4, 1, and 1 1/2 tons are commonly used; some producers use gooseneck trailers attached to a pickup truck, and some haulers use large tandem units.

B. Hauling tank — May be aluminum, fiberglass, or marine plywood; is generally rectangular, and may be one unit or divided into compartments to facilitate hauling several species at the same time and make possible partial unloadings; most contain quick release gates and removal chutes for rapid unloading.

C. Life support equipment — The type of equipment used depends on the type of hauling tank, species hauled, hauling distance, and other particulars of the situation.

EXAMPLES: Spraying devices, baffles, screens, recirculating pumps, aerators, electrical agitators, compressed and liquid oxygen, chillers, filters, backup generators

D. Nets, tubs, and a scale — These are standard for all transport units.

XIII. Loading procedures and rates (Assignment Sheets #1-#4)

(NOTE: Loading rates differ with species, size, water temperature and quality, duration of transport, and type of shipping unit used. Guidelines and rate tables are given in Handout #1.)

A. Simulate the loading situation by running a static test.

B. If fish cannot be tempered in the holding vats before loading for shipment, the water temperature in the shipping unit must be adjusted.

C. Tempering requires 20 minutes per 10°F decrease in water temperature, and is accomplished by mechanical refrigeration or with ice.

INFORMATION SHEET

D. One-half pound of ice reduces the water temperature of one gallon of water by about 10°F.

(NOTE: Ice can be added directly to the holding water for most species, but for fathead minnows and all fry, the ice must be placed in plastic bags and packed around the holding container.)

E Loading rates can be raised 25 percent for each 10-degree decrease in water temperature and should be lowered by 25 percent for each 10-degree increase in water temperature.

F Loading rates can be increased by 25 percent when pure oxygen is added.

G. In general, fewer pounds of small fish than of large fish can be transported per gallon of water.

EXAMPLE: One gallon of water will safely transport one pound of 4-inch fingerlings, two pounds of 8-inch catfish, or four pounds of 16-inch fish.

H. If transportation time exceeds twelve hours, the loading rate should be decreased by 25 percent.

I. If transportation time exceeds sixteen hours, the loading rate should be decreased by 50 percent or a complete in-transit water change should be arranged.

J. During winter, hauling temperatures of 45°F to 50°F are preferred, while 60°F to 65°F is preferred in summer.

XIV. **Hauling and water quality** (Job Sheet #1)

A. Dissolved oxygen

1. Dissolved oxygen is the single most important factor in hauling.
2. Oxygen consumption increases during handling and loading.
3. Provide additional oxygen (above 7 ppm but below saturation) during loading and for the first hour of transport.
4. After the first hour, maintain the DO level at 6 to 7 ppm.

B. Water temperature

1. Water temperature greatly influences oxygen consumption.
2. For each 1°F rise in water temperature, the fish load should be reduced by about 5.6 percent; conversely, for every 1°F decrease in water temperature, the fish load may be increased by 5.6 percent.

INFORMATION SHEET

C. Ammonia

1. Excretory products lower water quality.

2. Ammonia is the main metabolic product of fish and is excreted through the gills.

3. Total ammonia can reach 10 ppm or higher without harming the fish, depending ont he fish load and the duration of the haul.

4. Exposure to 0.13 to 0.14 ppm of un-ionized ammonia for 6 hours or longer, however, can adversely affect trout and other species.

5. Temperature and time of last feeding are important factors in regulating ammonia excretion.

    a. Fish under 8 inches should be starved for a minimum of 48 hours; fish over 8 inches should be starved for a minimum of 72 hours.

    b. Water temperature should be kept as low as is tolerated by the species being transported.

D. Carbon dioxide (CO_2)

1. A product of respiration, CO_2 acidifies transport water.

2. Acidity reduces the effects of un-ionized ammonia and also reduces the oxygen-carrying capacity of fish blood.

3. Trout are distressed when CO_2 levels approach 25 ppm.

4. Adequate ventilation, which reduces the buildup of CO_2 is necessary for transport units.

XV. Hauling chemicals

(NOTE: Some of the following chemicals may be added to the hauling water.)

A. Water-hardening chemicals — 0.1 to 0.3 percent table salt and 50 ppm calcium chloride added to hauling water low in calcium hardens the water decreasing stress and delaying mortality.

B. Anesthetic chemicals — Fish are often anesthetized or sedated to slow their oxygen consumption and prevent injuries caused by hyperactivity. Quinaldine at 15 to 30 ppm appears to be the most practical for warmwater fishes, while MS-222 (tricaine methanesulfonate) at 0.1 to 1.0 grams per gallon in water buffered between 7 and 8 pH is the choice for trout.

C. Bacteriostatic chemicals — Nitrofurazone at 10 ppm, acriflavine at 1 to 2 ppm, Combiotic at 15 ppm, or oxytetracycline at 20 ppm are some of the common bacteriostatic chemicals used to decrease mortality caused by bacterial diseases.

INFORMATION SHEET

D. Buffering chemicals — Chemicals added to buffer the water include "tris" buffer (tris-hydroxymenthyl-amino-methane) at 5 to 10 grams per gallon, and sodium bicarbonate at 1 ppt.

E Antifoam chemicals — Because foam interferes with gas exchange and observation of the fish, some haulers use a 10 percent solution of Dow Corning AF (antifoam chemical) at the rate of 1 ounce (25 mL) per 100 gallons of water.

XVI. Unloading

A. At the stocking or receiving site, the fish must be slowly tempered to the temperature of the receiving water, the temperature difference should not exceed 5°F.

(NOTE: A 12-volt submersible sump pump is used to pump pond or rearing unit water to hauling tank to temper fish.)

B. In addition, some time may be required to adjust the fish to a different ion concentration so that they do not go into ion shock, which is particularly damaging when fish raised in hard water are stocked in soft water.

(NOTE: There is usually no problem when fish cultured in soft water are stocked in hard receiving water.)

C. To reduce stress, fish should be unloaded and tempered as quickly as possible and with minimum handling.

D. All transport tanks and equipment must be disinfected as soon after delivery as possible to avoid the spread of infectious disease. (Job Sheet #4)

XVII. Guidelines for the care of nets

A. Clean nets of debris after each use.

B. Do not roll and store wet seines and nets.

C. To prevent rot and prolong the life of seines, spread them in the sun to dry before storing.

D. Inspect seines frequently for holes, and repair small holes before they become large.

(NOTE: It will pay the producer to learn net maker's knots and repair techniques.)

E. Treat nylon nets with a commercial coating that protects against deterioration from sunlight, aids in the resistance of dirt and fish slime, and reduces the incidence of abrasion damage.

F. Polyethylene nets require no treatment.

HARVESTING AND HAULING
UNIT XIV

HANDOUT #1 — LOADING RATE TABLES

TABLE 1: Estimated Pounds of Channel Catfish That Can Be Hauled per Gallon of Water per Unit of Transportation Time at 65°F

Weight of fish (number per pound)	Transit period (hours)		
	8	12	[illegible]
1	6.30	5.55	4.80
2	5.90	4.80	3.45
4	5.00	4.10	2.95
50	3.45	2.50	2.05
125	2.95	2.20	1.80
250	2.20	1.75	1.50
500	1.75	1.65	1.25
1,000	1.25	1.00	0.70
10,000	0.20	0.20	0.20

TABLE 2: Pounds of Black Bass or Sunfishes That Can Be Transported per Gallon of Water at Temperatures of 65°F to 85°F.

Weight of fish (number per pound)	Total length (inches)	Approx. number per gallon	Pounds per gallon
25	4	25	1.00
100	3	67	0.66
400	2	200	0.50
1,000	1	333	0.33

TABLE 3: Pounds per Gallon of Rainbow Trout That Can Be Transported Up to 8 Hours

Number/Pound	Total length (inches)	Pounds per gallon
735	1.5	0.5-1.0
155	2.5	1.0-2.0
38-20	4-5	2.0-3.0
5-1.8	8-11	2.5-3.0

HANDOUT #1

TABLE 4: Capacity (Normal) Load in Pounds of Fish per Gallon of Water for Transportation by the Tank Method (with Agitators or Blower Systems) of Fish in Good Condition in Hard Water at 65°F.

Type of fish and average length (inches)	Duration of transport (hours) 1	6	12	24
Fingerling food fish				
2	2	1 1/2	1	1
8	3	3	2	1 1/2
Adult food fish				
14	4	4	3	2
Baitfish				
2	2	1 1/2	1	1
3	3	2	1	1

The loading rate can be increased by 25% when pure oxygen is added. For each 10°F increase in water temperature, the loading should be decreased by 25%.

HANDOUT #1

TABLE 5: Weight (Pounds) per 1,000 Fish of Different Species, in Relation to Total Length

TL[b] (in.)	Families and species[c]: Catfishes: CC	BL	FC	Sunfishes: LB	Bg	RS	GS	BC	WC
2		2.8	3.3	3.5	5.0	5.4	5.2	3.7	3.5
2½	4.6	5.4	6.3	7.0	9.8	10.1	10.1	7.2	7.0
3	7.7	9.0	10.7	12.3	17.2	17.6	17.4	12.2	11.8
3½	12.3	14.3	16.7	19.8	28.6	27.8	27.7	19.3	19.8
4	18.3	21.0	24.6	29.7	41.4	41.1	41.3	28.6	29.6
4½	26.0	29.9	34.6	42.9	59.5	58.2	59.9	40.6	42.4
5	35.2	40.7	46.9	59.0	82.4	79.5	81.9	55.7	58.4
5½	46.9	53.7	61.9	78.8	110	106	109	73.9	78.2
6	60.5	69.8	79.3	103	144	136	141	95.6	102
6½	76.4	88.1	100	132	185	173	179	121	130
7	95.2	110	139	165	234	215	223	151	163
7½	117	134	152	204	286	264	273	186	200
8	141	162	183	248	352	320	331	228	245
8½	168	194	218	299	416	383	396	269	295
9	199	229	257	354		453		321	351
9½	233	269	303	420		532		375	414
10	272	312	350	491		619		436	484
11	376	414	471	657				573	648
12	501	532	618	857					845
13	654	680	801	1,094					1,078
14	834	872	1,014	1,373					1,351
15	1,048	1,100	1,263	1,695					1,688
16	1,297	1,366	1,558	2,073					2,031
17	1,585	1,674	1,880	2,484					
18	1,914	2,029	2,255	2,958					
19	2,288	2,433	2,678	3,490					
20	2,709	2,891	3,152	4,082					
22	3,183	3,414	3,717	4,738					

(NOTE: TABLE 5 continues on next page.)

HANDOUT #1

TABLE 5: Weight (Pounds) per 1,000 Fish of Different Species, in Relation to Total Length

	Families and species									
	Suckers		Carps and Minnows					Others		
	SB	BB	CC	Gf	GS	FM	RS	RT	TS	WB
2	4.1		7.6	5.4	3.9	3.3	2.5	3.2	3.0	
2½	8.1		13.7	9.0	5.4	7.6	4.6	5.1	5.8	7.8
3	14.0	16.2	22.2	17.0	8.6	11.0	8.8	8.8	9.6	13.3
3½	22.4	25.7	33.4	24.5	13.5	19.8		17.6	14.9	20.8
4	33.7	38.3	47.4	40.0	19.0	24.4		25.6	21.8	31.8
4½	48.2	54.2	64.6		31.5	28.3		35.0	29.9	44.3
5	66.3	74.2	85.0		44.0			63.9	40.3	60.6
5½	88.6	98.3	109		60.0				52.2	80.5
6	116	127	137					104		104
6½			167							132
7			206					174		165
7½			247							203
8			293					218		246
8½			344							294
9			399					328		349
9½			460							410
10			527					449		478
11			677					535		635
12			851					681		823
13			1,050					868		1,045
14			1,276					1,086		1,303
15			1,574					1,330		1,610
16			1.903					1,674		1,940
17			2,296					2,049		2,324
18			2,747					2,335		
19			3,233					2,910		
20			3,776					3,267		
22			4,401					3,634		

[a]Data from various sources, but primarily from W. Swingle and e. Shell. 1971. Tables for computing relative conditions of some common freshwater fishes. Alabama Agricultural Experimental Station Circular 183. Auburn, Alabama.
[b]Total length (inches).
[c]Abbreviations follow in the order shown, left to right (see Table 1.1 for scientific names. C, Catfishes, CC, channel catfish, BF, blue catfish, FC flathead catfish. Sunfishes. LB, largemouth bass, Bg, bluegill, RS, redear sunfish, GS, green sunfish, BC, black crappie, WC, white crappie. Suckers. SB, smallmouth buffalo, BB, bigmouth buffalo. Carps and minnows. CC, common carp, Gf, goldfish, GS, golden shiner, FM, fathead minnow, RS, red shiner. Others. RT, rainbow trout; TS, treadfin shad; WB, white bass.

HANDOUT #1

TABLE 6: Carrying Capacity (in Pounds) of Fish in 18- x 32-Inch Plastic Bags Containing 2 Gallons (about 15 lb) of Water at 65°F

Stage or (for fingerlings) total length in inches	Duration of transport (hours) 1	12	24	48
Eggs	1.0- 3.0	1.0-2.5	1.0-2.0	0.5-1.0
Fry				
Yolk-sac	2.0- 6.0	1.4-5.0	0.8-4.0	0.2-2.0
Swim-up	1.0- 4.0	0.9-3.2	0.8-2.5	0.4-1.3
Fingerlings				
1/2	1.8- 6.0	1.5-5.0	1.2-4.0	0.6-2.0
1	2.0- 7.0	1.7-6.0	1.3-5.0	0.7-2.5
2	2.0- 8.0	1.8-7.0	1.5-6.0	0.7-3.0
Large fish	4.0-10.0	3.0-7.5	2.0-5.0	1.0-2.5

(NOTE: Before transporting fish, the shipper should package trial boxes of fish and subject them to the extremes of temperature and anticipated time en route to the destination. An experienced shipper provides a sizable safety factor in loading weight to allow for delays en route and exposure to heat.)

HARVESTING AND HAULING
UNIT XIV

ASSIGNMENT SHEET #1 — CALCULATE LOADING RATES

Loading rates are the number of pounds of fish or eggs that can be shipped per one gallon of water. These rates are affected by species of fish, temperature of hauling water, distance of transport, and aeration provided. Calculating loading rates requires reading rate tables and using simple math. Use the tables in Handout #1 to help you calculate the loading rates for the following problems.

1. A producer is shipping twenty 4-pound channel catfish broodfish in 17- by 17-inch plastic bags containing about 2 gallons of 65°F water. The transport will last about 20 hours. How many broodfish can the producer ship per bag?

   Answer: ______________________________

2. You want to ship 50 pounds of catfish eggs to a destination 12 hours away. You will ship in 17- by 17-inch plastic bags each containing 2 gallons of 65°F water. How many bags will you need (double bagging), and how many pounds of eggs can be loaded in each?

   Answer: ______________________________

3. A producer wants to ship 12,000 1-pound catfish to a destination 12 hours away. What minimum hauling capacity (in gallons) must the hauling tank have if the water is cooled to 60°F and pure oxygen is used?

   Answer: ______________________________

4. A producer wants to transport 8-inch fingerlings to a destination 24 hours away and has a hauling truck with a tank capacity of 1,2000 gallons. How many pounds of fish can the producer transport?

   Answer: ______________________________

5. A baitfish producer wants to ship 3-inch fish to a market 6 hours away. The producer's haul truck has a 600 gallon tank capacity. How many pounds of fish can the producer load at a water temperature of 65°F? About how many fish would this be?

   Answer: ______________________________

6. If in problem 5 the temperature of the shipping water was increased to 75°F, how many fewer pounds must be loaded?

   Answer: ______________________________

7. A producer wants to load 24,000 adult channel catfish food-fish in hard water at 70°F for a 12-hour transport. What is the loading rate (pounds of fish per gallon)? How many gallons of transport water are needed?

   Answer: ______________________________

ASSIGNMENT SHEET #1

8. What is the adjusted loading rate if the producer in problem 7 decreases the water temperature by 10°F and uses pure oxygen?

Answer: ______________________________

HARVESTING AND HAULING
UNIT XIV

ASSIGNMENT SHEET #2 — OBSERVE AND REPORT ON A COMMERCIAL HARVEST

Your instructor will arrange for you to observe a commercial fish harvest. Pay close attention to the equipment and procedures used. Follow the guidelines below to ask questions and take notes. After the harvest, write a report and present your findings to the class.

Date of harvest ______________________________

Place of harvest ______________________________

Name of owner or operator ______________________________

Weather conditions ______________________________

Kind of fish harvested ______________________________

Time harvest began ______________ Time harvest ended ______________

Number of laborers ______________________________

Type of seines used ______________________________

Sizing and grading system ______________________________

Water temperature in pond ______________ In transport vehicle ______________

Approximate number of fish harvested ______________________________

Approximate weight of fish harvested ______________________________

Approximate value of fish harvested ______________________________

Distance to processing facility ______________________________

Mortality rate at pond site ______________________________

Special equipment required ______________________________

Chemicals required (pond and transport) ______________________________

Items of special interest such as emergency equipment on standby, age of pond, success or failure in previous harvests, plans for restocking and future harvests.

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HARVESTING AND HAULING
UNIT XIV

ASSIGNMENT SHEET #3 — SURVEY YOUR AREA AND STATE FOR LAWS AND REGULATIONS CONCERNING INTERSTATE AND INTRASTATE SHIPPING

Who is responsible for fish that die shortly after delivery—the producer, the harvester/hauler, or the buyer? Can you transport Mississippi catfish to Oklahoma? Can you transport tilapia from eastern to western Oklahoma? What permits do you need to ship fish by air? By rail? By truck? What species can be shipped?

In this assignment sheet, you will try to find the answers to these and other questions regarding state and area shipping laws and regulations. Start your search for information by contacting your Cooperative Extension Service and established fish farmers in your area. Read as much literature on the subject as you can. After you have completed your research, report your findings to the class.

Guidelines:

Telephone number of Cooperative Extension Service ______________________

Address ____

____

Agent or representative contacted ______________________________

Other persons or agencies contacted ______________________________

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Magazines, bulletins, books, and other published information consulted ____________

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HARVESTING AND HAULING
UNIT XIV

JOB SHEET #1 — CHECK WATER TEMPERATURE AND OTHER SHIPPING PARAMETERS FOR SHIPPING FISH

A. Equipment and materials

1. Fahrenheit thermometer
2. DO meter
3. Hach test kit
4. Ice
5. Four 3-mil 18-by-24-inch plastic shipping bags
6. Dip nets
7. Rubberbands
8. One pound of ½-inch fingerlings that have been feeding
9. One pound of ½-inch fingerlings that have not been fed in 24 hours
10. Two uninsulated cardboard boxes 12" × 12" × 24", or styrofoam box 24" × 23" × 12" and uninsulated cardboard box large enough to hold the insulated one.

B. Procedure

1. Double the bags by slipping one inside the other, and use marker to label the two doubled bags: "Bag #2/NF" (no feed), and "Bag #2/F".
2. Measure two gallons of shipping water into each of the plastic bags.
3. Take and record temperature of shipping water in each bag.
4. If water is above 65°F, add about one pound of ice, allow to dissolve, and take temperature again.

   (NOTE: One-half pound of ice reduces the temperature of one gallon of water by about 10 degrees.)

5. Repeat step 3 until water temperature in each bag is between 60°F and 65°F; record temperature.

   Bag #1/NF, temperature = __________ Bag #2/F, temperature = __________

6. Use meter to measure DO content of the shipping water in each bag; DO content should be optimum for species being shipped.

   Bag #1/NF, DO = ____________ Bag #2/F, DO = ____________

JOB SHEET #1

7. Measure levels of carbon dioxide in each sample, following directions with Hach kit; water should be free of these compounds.

   Bag #1/NF, CO_2 = ____________ Bag #2/F, CO_2 = ____________

8. Measure ammonia (NH_3) levels in each bag.

   Bag #1/NF, ammonia = ________ Bag #2/F, ammonia____________

9. Measure total alkalinity; it should be 90 ppm or above (as calcium bicarbonate).

   Bag #1/NF, total alkalinity ________ Bag #2/F, total alkalinity ________

10. Measure pH, following directions with Hatch kit; pH should be near 7.5.

    Bag #1/NF, pH ______________ Bag #2/F, pH ______________

11. Dip-net sample *unfed fish* into Bag #1/NF and a sample of *fed fish* into Bag #2/F.

12 Expel air from bags with hands, reinflate bags with compressed oxygen, twist tops closed, bend tops over, and secure with a rubberband.

13 Place each bag in an uninsulated cardboard or styrofoam box in a cool area, and wait 8 hours.

14. At the end of 8 hours, unseal bags, examine fish, and remeasure temperature, DO, and CO_2. Compare these measurements to your original measurements.

	Bag #1/NF	Bag #2/F
Condition of fish	____________	____________
Water temperature	____________	____________
Eight-hour DO	____________	____________
Eight-hour CO_2	____________	____________

15. Use hatch kit to measure ammonia level in each bag and compare to your original measurements.

    Bag #1/NF, eight-hour NH_3 ____________________

    Bag #2/F, eight-hour NH_3 ____________________

JOB SHEET #1

16. Repeat steps 1 through 15, but this time wait overnight.

	Bag #1/NF	Bag #2/F
Condition of fish	____________	____________
Water temperature	____________	____________
Overnight DO	____________	____________
Overnight CO_2	____________	____________
Overnight NH_3	____________	____________

17. Repeat steps 1 through 15, but this time instead of sealing bags as in step 12, leave bags open and unscaled; wait 8 hours.

	Bag #1/NF	Bag #2/F
Condition of fish	____________	____________
Water temperature	____________	____________
Eight-hour DO	____________	____________
Eight-hour CO_2	____________	____________
Eight-hour NH_3	____________	____________

18. What conclusions can you draw by comparing your readings?

    (NOTE: Your instructor may ask you to add shipping chemicals to the original shipping water and to then measure and compare chemistry of both shipping water samples.)

19. Return equipment to proper storage.

HARVESTING AND HAULING
UNIT XIV

JOB SHEET #2 — GRADE FISH

A. Equipment and materials

1. Holding tank panel graders of decreasing bar widths selected for desired sizes of species (See Table 1 in Information Sheet)

2. Box grader of selected bar spacing for desired size of species (See Table 1 in Information Sheet)

3. Crowder panel

4. Dip net

5. Holding tank containing various sizes of species to be graded

B. Procedure for grading with panel graders

1. Crowd fish at the foot of holding tank by inserting crowder panel at the head of the tank and moving it slowly toward the foot.

2. Insert selected grading panels in tank, arranging them so that the bar space gets progressively smaller toward the head of the tank.

3. Fish will grade themselves as they swim toward the incoming water.

4. Take care that fish do not become crowded in any compartment.

C. Procedure for grading with grader box

1. Place floating grader box in empty holding tank or in holding tank containing smaller fish of the size to be graded out.

2. Dip-net fish to be graded from adjacent tank or from bucket, and place in grader box.

3. After smaller fish have swum from box, place fish retained in box in adjacent tank.

   (NOTE: Thump the water surface to speed grading procedure.)

4. Repeat this process until you have accumulated a load of a particular size fish.

5. Return equipment to proper storage.

HARVESTING AND HAULING
UNIT XIV

JOB SHEET #3 — PACKAGE FISH IN A PLASTIC BAG

A. Equipment and materials

1. Polyethylene bags, 18" × 32" , 3-mil for baitfish or hobby fish, 4-mil for large sport fish, or 6-mil for channel catfish
2. Small plastic bags of ice or commercial "blue ice"
3. Uninsulated cardboard box 12" × 12" × 24", or styrofoam box 24" × 23" x 12" and uninsulated cardboard box large enough to hold insulated one
4. Diabasic sodium phosphate, tris buffer, or sodium bicarbonate
5. Acriflavine, nitrofurazone, or oxytetracycline
6. Salt (and MS-222 if desired)
7. Measuring teaspoon and gallon measure
8. Compressed oxygen
9. Rubberbands
10. Shipping label and pan
11. Dip nets

B. Procedure

1. Add accurately measured transport chemicals to shipping water as necessary and at recommended rates; read labels carefully.
2. Fill doubled plastic bag with about two gallons of 65°F water.
3. Dip fish into bag at stocking rate recommended in Table 1.
4. Deflate bag by pressuring out the air with your hands.
5. Reinflate bag with compressed oxygen.
6. Twist top of bag, bend top down, and secure tightly by twisting a rubberband around it.
7. Place plastic bag in uninsulated cardboard or styrofoam shipping container.

JOB SHEET #3

8. Place small bags of ice around bag.

   (NOTE: Sometimes shippers add ice directly to the shipping water. However, direct application of ice cools the water too rapidly for some species of fish such as fathead minnows, tropical fish, and fry of all species.)

9. Close cardboard container and label for shipment.

10. Return equipment to proper storage.

HARVESTING AND HAULING
UNIT XIV

JOB SHEET #4 — DISINFECT FISH TRANSPORT TANKS AND EQUIPMENT

A. Equipment and materials

1. Fluid and dry weight measuring utensils

2. Water source and hose

3. Empty transport tanks, nets, buckets, rubber gloves and boots, and any other piece of equipment, including transfer pipes, that came in contact with transported fish or transport water

4. Calcium hypochlorite base, 65% available chlorine (HTH)

5. Glacial acetic acid

6. pH test kit

B. Procedure

1. Fill tank or other container with desired amount of water.

2. Test for pH; if pH is above 6, add one fluid ounce of glacial acetic acid per 100 gallons of water.

3. Mix water and acetic acid well.

   (CAUTION: NEVER ADD THE ACID TO THE DRY HTH. ADDING THE ACID TO THE DRY POWDER MAY CAUSE AN EXPLOSION.)

4. Add ½ ounce of HTH per twenty-five gallons of acidified water.

5. Submerge smaller objects to be disinfected—nets, boots, gloves, etc.— in solution container.

6. Allow mixture to sit for 30 minutes in tank or container.

7. Flush tanks, transfer pipe, and pumps thoroughly.

8. Remove objects from container, empty container, and let disinfected equipment air dry.

   (NOTE. Often complete drying—particularly in the sun—disinfects equipment.)

9. Repeat disinfection procedure after each use. Use Table 1 to calculate required concentration of HTH and glacial acetic acid for tanks of difference capacities.

JOB SHEET #4

TABLE 1: Amounts of HTH and Glacial Acetic Acid for Different Tank Capacities

Tank Capacity (gallons)	HTH (oz.)	Glacial Acetic Acid (oz.)
150	3	1.5
600	12	6.0
1,200	24	12.0
2,500	50	25.0

Dupree and Huner, "Transportation of Live Fish," *Third Report to the Fish Farmers*, p. 175.

10. Return equipment to proper storage.

HARVESTING AND HAULING
UNIT XIV

PRACTICAL TEST #1
JOB SHEET #1 — CHECK WATER TEMPERATURE AND OTHER PARAMETERS FOR SHIPPING FISH

Student's name ______________________ Date ______________

Evaluator's name ______________________ Attempt no. ______________

When you are ready to perform Job Sheet #1, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to indicate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	Yes	No
1. Prepared and labeled bags properly.	☐	☐
2. Recorded temperature in bags properly.	☐	☐
3. Made chemical and DO measurements properly.	☐	☐
4. Sealed bags.	☐	☐
5. Repeated tests after eight hours.	☐	☐
6. Compared and recorded results.	☐	☐
7. Repeated tests after an overnight wait.	☐	☐
8. Compared and recorded results.	☐	☐
9. Repeated process with unsealed bags.	☐	☐
10. Returned equipment to proper storage.	☐	☐

Evaluator's Comments : ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and anothe- test procedure must be submitted for evaluation.)

Criteria:				
Equipment Selection	Good 4	Acceptable 3	Fair 2	Poor 1
Procedure	All completed 4	Mostly completed 3	Poorly completed 2	Improperly completed 1
Use of chemicals	Carefully used 4	Properly used 3	Poorly used 2	Improperly used 1
Safety	Well observed 4	Acceptably observed 3	Poorly observed 2	Improperly observed 1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — **Skilled** — Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program.
2 — **Limited skill** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR'S NOTE. If an average score is needed to complete a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

HARVESTING AND HAULING
UNIT XIV

PRACTICAL TEST #2
JOB SHEET #2 — GRADE FISH

Student's name ____________________ Date ____________

Evaluator's name ____________________ Attempt no. ____________

When you are ready to perform Job Sheet #1, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to indicate whether or nct the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and trv again.)

The student:	Yes	No
1. Prepared panel grading tank properly.	☐	☐
2. Used crowder panel to move fish.	☐	☐
3. Inserted grading panels in declining sequence and permitted fish to grade themselves.	☐	☐
4. Prepared grader box properly.	☐	☐
5. Dip-netted fish to be graded with care.	☐	☐
6. Permitted smaller fish to swim from box.	☐	☐
7. Repeated procedure as needed to obtain quantity of one-size fish.	☐	☐
8. Returned equipment to proper storage.	☐	☐

Evaluator's Comments: ____

____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:				
Tank Preparation	Good 4	Acceptable 3	Fair 2	Poor 1
Crowder Panel Use	Slow and proper 4	Acceptable 3	Too fast 2	Unacceptable 1
Dip Net Use	Good 4	Fair 3	Poor 2	Unacceptable 1
Grader Box Use	Good 4	Fair 3	Poor 2	Unacceptable 1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — **Skilled** — Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program.
2 — **Limited skill** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR'S NOTE: If an average score is needed to complete a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

HARVESTING AND HAULING
UNIT XIV

PRACTICAL TEST #3
JOB SHEET #3 — PACKAGE FISH IN A PLASTIC BAG

Student's name ______________________ Date ______________

Evaluator's name ______________________ Attempt no. ______________

When you are ready to perform Job Sheet #1, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to indicate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	Yes	No
1. Prepared plastic bag properly.	☐	☐
2. Added chemicals in proper quantity.	☐	☐
3. Filled bag with appropriate stocking rate.	☐	☐
4. Deflated bag and reinflated bag with compressed oxygen.	☐	☐
5. Placed bags properly in shipping containers.	☐	☐
6. Closed shipping containers.	☐	☐
7. Returned equipment to proper storage.	☐	☐

Evaluator's Comments: ____

____

____

JOB SHEET #3 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE. Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:				
Equipment Selection	Good 4	Acceptable 3	Fair 2	Poor 1
Procedure	All completed 4	Mostly completed 3	Poorly completed 2	Improperly completed 1
Use of chemicals	Carefully used 4	Properly used 3	Poorly used 2	Improperly used 1
Safety	Well observed 4	Acceptably observed 3	Poorly observed 2	Improperly observed 1

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — **Skilled** — Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program.
2 — **Limited skill** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR'S NOTE. If an average score is needed to complete a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

HARVESTING AND HAULING
UNIT XIV

PRACTICAL TEST #4
JOB SHEET #4 — DISINFECT FISH TRANSPORT TANKS AND EQUIPMENT

Student's Name____ Date____________

Evaluator's Name_______________________________________ Attempt No._____

When you are ready to perform Job Sheet #1, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to indicate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	Yes	No
1. Prepared tank and checked for pH.	☐	☐
2. Added acetic acid.	☐	☐
3. Handled acid and HTH safely.	☐	☐
4. Disinfected all smaller equipment in tank.	☐	☐
5. Emptied tank and allowed it to air dry.	☐	☐
6. Reviewed tank capacities and chemical requirements.	☐	☐
7. Returned equipment to proper storage.	☐	☐

Evaluator's Comments ____

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____

JOB SHEET #4 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE. Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another test procedure must be submitted for evaluation.)

Criteria:				
Equipment Selection	Good 4	Acceptable 3	Fair 2	Poor 1
Procedure	All completed 4	Mostly completed 3	Poorly completed 2	Improperly completed 1
Use of chemicals	Carefully used 4	Properly used 3	Poorly used 2	Improperly used 1
Safety	Well observed 4	Acceptably observed 3	Poorly observed 2	Improperly observed 1

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — **Skilled** — Can perform job with no additional training.
3 — **Moderately skilled** — Has performed job during training program.
2 — **Limited skill** — Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** — Is familiar with process, but is unable to perform job.

(EVALUATOR'S NOTE. If an average score is needed to complete a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

HARVESTING AND HAULING
UNIT XIV

TEST

NAME______________________________________ SCORE ____________________

1. Match terms related to harvesting and hauling with their definitions. Write the correct numbers in the blanks.

_____a. Process of lowering the water level of a pond, or completely draining a pond

_____b. Gradually acclimating (accustoming) fish to changes in water chemistry or temperature

_____c. Harvesting strategy that involves one-time seining or trapping and annual draining of pond

_____d. Chemical that stops growth of bacteria and other micro-organisms

_____e. Long piece of netting with a series of floats on the top and lead weights on the bottom, the sides may be supported with brails (wooden poles) or equipped with haul lines

_____f. Pulley

_____g. Musty, muddy taste of fish flesh generally caused by some blue-green algae and bacteria

_____h. Agent used to sedate fish and slow their metabolic rate

_____i. A pin or rod inserted through a loop of haul line to attach it to the seine

_____j. Harvesting strategy that requires numerous yearly seinings or trappings and complete draining of pond each 6 to 8 years

_____k. Stocking smaller sized fingerlings along with larger fish

1. Total harvest
2. Multiple harvest
3. Seine
4. Toggle
5. Snatch block
6. Antibiotic
7. Bacteriostat
8. Anesthetizing compound
9. Tempering
10. Off flavor
11. Understocking
12. Trammel seine
13. Drawdown

TEST

_____l. Chemical that kills or controls the growth of bacteria and other microorganisms

_____m. Periodically harvesting marketable fish from the rearing unit and stocking smaller fish

_____n. A seine with two course outer nets that support a fine-mesh inner net which fish swim into and force through the course layers, trapping themselves as the fine-mesh net is forced in around them

2. Distinguish between advantages of total and partial harvest. Write "TH" before advantages of total harvest and "PH" before advantages of partial harvest.

_____a. Allows the producer the security of contracting for the sale of an entire crop at one time.

_____b. Can be used to harvest all types of rearing units, particularly those ponds with deep water and irregular bottoms and banks.

_____c. Requires only one labor-intensive harvesting period per season.

_____d. Allows the producer to periodically harvest whatever quantity and size fish desired.

_____e. Allows the producer to market fish when the market price is optimum.

_____f. Allows for disease, weed, and predator treatment of pond bottom.

_____g. Is the only method that allows for harvesting nearly 100 percent of the crop.

_____h. Tends to increase total production because fish can be harvested near the point where their growth rate falls off and the rearing unit can be understocked.

_____i. Allows for multiple use of land as crops may be grown on the pond bottom during the period that the pond is empty.

_____j. Produces year-round supply of fish to market.

_____k. Increases cash flow but requires more capital.

TEST

3. Distinguish between limitations of total and partial harvest. Write "TH" in the blanks before limitations of total harvest and "PH" in the blanks before limitations of partial harvest.

_____a. Requires many labor-intensive harvesting periods.

_____b. Means harvesting during hot summer months when fish are more prone to stress and disease.

_____c. Depends on even growth rate and the assumption that all fish will be marketable at harvest time.

_____d. Restricts the producer to the market price at time of harvest.

_____e. Means lost feeding days and a fuel bill if pumping is required to refill the rearing units.

_____f. If method is used too often, causes fish baited into the seines or traps to become wary of trapping methods and difficult to catch.

_____g. Requires scraping out and treating of rearing unit or pond bottom, which can be time consuming, especially if potholes and low areas exist in the pond.

_____h. Requires extra capital to replace stock.

4. Select from a list guidelines for quality control. Write an "X" in the blank before each correct guideline.

_____a. If fish are to be sold to a processing plant, contact the processor at least one week before harvest because fish must be tested for off-flavor at least once before harvest.

_____b. Use a harvesting method that reduces the chances of muddying the water, as muddy waters can create off-flavor problems.

_____c. Harvest in the warmest weather possible; avoid harvesting after blue-green algae bloom or after a stormy period that has muddied the water.

_____d. Before and during harvesting of food fish, sample for off-flavor by cooking and tasting a sample.

_____e. If off-flavor is detected, hold fish until off-flavor disappears.

TEST

5. Match harvesting equipment with their correct uses. Write the correct numbers in the blanks.

_____a. Trapping seine used in deep ponds with irregular shorelines

_____b. Round seine hand-thrown for partial harvests or periodic sampling of surface-feeding fish

_____c. This seine can be attached and detached from the harvesting seine using a loading frame and drawstrings; used widely for harvesting and grading catfish, these seines are anchored with stakes and supported with support rods so that fish can be removed from them for transport.

_____d. Netting sack with metal-framed mouth used to scoop fish from the harvest sine

_____e. Full-pond seine with bottom line of multiple strands of rope to prevent the digging effect of weighted lines

_____f. Trapping seine with bottom line of leaded rope; used for multiple harvest

_____g. Square or rectangular trapping seine on a metal frame; used on ponds with irregular bottoms and for baitfish and other scaled species

1. Lead-line seine
2. Mud-line seine
3. Corral seine
4. Lift seine
5. Cast net
6. Live-car seine
7. Brailing bag

Traps

_____a. Used in ponds with seining obstacles, this trap consists of chicken-wire screened wooden panels that are installed gradually so as not to interrupt fish feeding

_____b. One foot in diameter and 2 feet long, these traps may have one or two funnels and are primarily used to harvest fathead minnows.

1. Panel trap
2. Cylinder trap

TEST

Miscellaneous harvesting equipment

_____a.	Used to store, transport, and gather in large harvesting seines	1.	Dip net
_____b.	Used to catch the top of the seine and pull it forward, freeing the bottom line from the mud	2.	Hydraulic powered seine reel
_____c.	Used to lift fish from seine to transport truck	3.	Tractor or truck with boom wench
_____d.	Used in trout raceways and large tanks to pipe fish and water directly from seine to grading bin above hauling tank	4.	Seine stakes
_____e.	Container used to transfer fish from harvest site to transport truck or holding tanks; used to store, transport, and gather in large harvesting	5.	Seine assist
_____f.	Used to dip fish from sines, holding tanks, and transport tanks	6.	Fish pump
_____g.	Used to support sides of seine to prevent fish from escaping	7.	Fish basket

6. Match grading equipment with their correct uses. Write the correct numbers in the blanks.

_____a.	Used in shed grading to allow for hand-grading of fish and culling of deformed fish	1.	Sorting tables
_____b.	Barred panel used in holding tank to grade fingerlings and baitfish	2.	Net grader
_____c.	Generally used for in-pond grading within the harvesting seine	3.	Grader box
_____d.	Container used to grade small fish such as baitfish or fingerlings in holding trough	4.	Panel grader

TEST

7. Select pre-harvest guidelines from a list. Write an "X" in the blank before each guideline.

_____a. Choose a harvesting method that fits your marketing strategy, your species, and pond type.

_____b. Determine whether you will harvest your own crop or hire custom harvesters.

_____c. Do not feed fish at least 1 hour before harvesting.

_____d. After harvest, sample food fish for off-flavor to ensure that fish will not be refused by the processor or buyer.

_____e. Make sure that all needed equipment is available, in good repair, and sterilized before you begin harvesting; have all harvesting equipment ready at the grading shed.

_____f. Make sure that all needed equipment is available, in good repair, and sterilized before you begin harvesting; have all harvesting equipment ready at the grading shed.

_____g. Take special care to ensure that aeration equipment and backup aeration are available and functioning properly.

_____h. Keep complete and accurate records of fish numbers, sizes, weights, mortality, disease and parasite problems, chemicals used, date and time of harvest, and market price.

8 Complete statements about harvesting techniques and procedures. Write the correct numbers in the blanks.

Seining

_____a. ___ that might tear the seine are removed from the pond.

1) Large fish, turtles, and aquatic vegetation
2) Large rocks and submerged stumps
3) Sticks, branches, and other debris

_____b. The seine is played out ___, and the haul lines are attached to seine brails or toggles are lead through snatch blocks along ___ and then to a powered line hauler or to a tractor equipped with a line hauler.

1) along the levee opposite the landing site (usually the shallow end); the lateral pond banks
2) along the levee at the landing site (usually the shallow end); the parallel pond banks
3) along the two shortest sides of the pond; the dam (usually the deepest end)

TEST

_____c. As the net ends approach the snatch blocks, the haul lines are ___ and taken along the bank to the next set of snatch blocks or to the landing site.

1) replaced
2) released
3) doubled

_____d. To avoid ___, usually hauling is stopped while the seine bag is still well out in the pond.

1) snagging the seine
2) overcrowding the fish
3) overloading the seine hauler

_____e. When the catch is exceptionally large, ___ seine is used inside the large seine.

1) a lift
2) an umbrella
3) a cutting

_____f. Seined fish are scooped into a boom-mounted ___, weighed on an in-line scale, and lifted to the aerated hauling truck; or they may be pumped to the transport vehicle with a fish pump.

1) brailing bag
2) lift seine
3) funnel trap

_____g. Short seines are pulled ___.

1) with a mechanical seine hauler
2) with a seine assist
3) by hand

Corral seine trapping

_____a. The seine is arranged ___ and the lead ropes are drawn to shore where the seine is to be loaded.

1) in a corner of the pond
2) as close to the center of the pond as possible
3) in deep water at the drain end of the pond

_____b. ___ feed is scattered between the seine and the shore.

1) Sinking
2) Floating
3) High-protein

TEST

_____c. Fish swim ___ to feed, and after several days, when the fish are accustomed to feeding within the area, the seine ends are pulled to shore with the attached ropes, thus enclosing the fish.

1) to the surface
2) through the seine netting
3) around the ends of the seine

_____d. The entire seine is ___, and the fish are dip-netted out and loaded.

1) lifted from the water on a fulcrum
2) pulled close to shore
3) boom lifted to the haul truck

_____e. The corral seine technique cannot be used more than ___ because fish become wary of the net.

1) once a day
2) once a week
3) once a month

_____f. Harvesting can be ___.

1) concentrated in different areas of the pond
2) alternated among ponds and at different areas of large ponds
3) accomplished on an alternate month basis

Drop-seine trapping

_____a. This technique works well in ___.

1) week-choked ponds and ponds with small cleared areas
2) large levee ponds
3) deep ponds with irregular bottoms

_____b. In this technique, a ___ seine is set in a semicircle around a feeding station and the ends of the seine are attached to the shore

1) lift
2) submergible
3) corral

_____c. Portions of the net are lifted off the pond bottom and hung on ___, providing "doors" to the feeding site

1) toggles
2) triggers
3) brailers

TEST

_____d. When these devices are pulled, ___.

1) the seine float line inflates raising it to the surface and trapping the fish
2) the seine is raised by means of a fulcrum pole and the fish are trapped
3) the seine net falls to the bottom, encircling the fish that have come to feed

_____e. The trapped fish are then generally netted with ___.

1) a shorter cutting seine
2) dip nets
3) a live car seine

_____f. Catfish do not usually feed in the trap for ___ weeks after the net has been positioned, and require ___ days to become reacclimated after each drop.

1) 3 or 6; 1 to 2
2) 2 or 3; 8 to 10
3) 1 or 2; 3 to 7

Lift net trapping

_____a. A ___ lift net is lowered to the bottom of the pond, and fish are baited over the top of the net.

1) triangular
2) round or oblong
3) square or rectangular

_____b. When fish are accustomed to feeding within the net, it is raised ___, and the trapped fish are lifted to the transport tank.

1) with a fulcrum pole
2) with a hydraulic boom
3) with a seine hauler

_____c. The mesh size may be adjusted to make this seine ___.

1) self-adjusting
2) self-grading
3) self-harvesting

TEST

Simple traps

_____a. Cylinder traps with ___ entrances are baited and placed in shallow areas where fish frequently feed.

1) funnel-type
2) panel
3) trigger-set

_____b. The location of the traps are marked with ___.

1) poles or buoys
2) sensors
3) brails

_____c. Traps are checked periodically and when enough fish have become trapped, the traps are emptied into buckets for transfer to ___.

1) market
2) grow-out ponds
3) holding or transport tanks

Fish pump

_____a. The amount of fish to be transported in a hauling tank is weighed, counted, and separated, usually by ___.

1) partitioning off a portion of the raceway
2) dip-netting to holding tanks
3) grading with panel graders

_____b. The fish are then crowded toward the pump's ___.

1) overflow pipe
2) submerged intake
3) submerged outlet

_____c. Fish are pumped up to water-filled hauling unit where ___.

1) fish and water are separated
2) fish are weighed
3) fish are measured and water is weighed

TEST

9. Select from the list factual statements a ›out pond to shed transport proc‹ ‹ures. write an "X" in the blank before each cor ect statement.

____a. Transporting fish from the reading unit to the shipping shed is the least important part of the harvesting prc‹‹ess.

____b. The hauling unit must be large enough to accommodate fish without crowdir.g, and should be filled with clean, well-aerated water if the pond is one-half or more miles from the shed.

____c. Because they are held in small amounts of water, fish placed in tubs or buckets can experience a rapid rise in water temperature and a corresponding drop in DO.

____d. Fish harvested in winter can experience cold shock because of the difference between rearing unit water temperature and air temperature; winter harvesting fish must be immediately placed in transport containers with as little exposure to the air as possible.

____e. Cooler water reduces self-inflicted injuries and lowers stress and metabolism.

____f. Channel catfish and golden shiners harvested in the summer may be put into water 10 to 15 degrees cooler than the pond water, while water temperature difference for most other species should not exceed 5 degrees.

____g. In addition to lowering the water temperature, the farmer can add up to 1 percent table salt, antibiotics or bacteristats, and anesthetizing agent to the shed transport water.

10. Completed statements about holding practices. Write the correct numbers in the blanks.

____a. It is often necessary to hold ___, baitfish, and sport fishes for several days after harvest.

1) channel catfish fingerlings
2) rainbow trout
3) hobby and ornamental fish

____b. Keeping fish in good condition during this period is very important: ___ are best, especially during hot weather, and adequate supplies of oxygenated water must be available.

1) shaded open ponds
2) recirculating outdoor ponds
3) covered facilities

TEST

_____c. Holding tanks may be concrete or fiberglass, and are either round or rectangular; a tank 4 feet by 10 feet with 2 feet of water holds about ___ gallons of water and can carry ___ pounds of fish if sufficient aeration and water exchange are provided.

1) 200; 100
2) 400; 200
3) 500; 300

_____d. While fish are in holding tanks, they can be treated for infectious diseases and parasites, graded, and held for a sufficient length of time to recover from the effects of the chemicals and drugs; they are also ___.

1) inoculated against certain diseases
2) acclimated to handling and transport
3) fed intensively

_____e. Food fish, large sport fish, and even minnows are often held ___; plastic containers similar to fish cages are also used to hold fish in ponds before transportation.

1) in brailing bags
2) in the pond in live-cars
3) in corral seines

_____f. Fish should be ___ before they are placed in holding tanks or live-cars; live cars must be properly staked to prevent fish from escaping.

1) counted and weighed
2) anesthetized
3) inoculated

11. Complete statements about grading practices. Write the correct numbers in the blanks.

_____a. To insure uniformity of size, some grading is usually required with ___ as well as with food fish.

1) broodfish
2) fingerlings
3) fry

_____b. ___, net graders, panel graders and grading boxes are used to sort fish by size and to remove any foreign fish, plants, tadpoles, or other undesired animals.

1) Transport tanks
2) Hauling buckets
3) Sorting tables

TEST

_____c. Food fish grading is often done in the rearing unit with ___ and other net graders.

1) live-cars
2) dip nets
3) umbrella nets

_____d. Fingerlings and baitfish are usually graded in the shipping shed at the time of sale; they are graded in holding tanks with panel graders or grading boxes so that they can be sorted without ___.

1) being handled with dip nets
2) being anesthetized
3) being counted

_____e. To avoid undue stress, shipping shed grading should not be attempted until several ___ after the fish have been removed from the rearing unit.

1) weeks
2) days
3) hours

_____f. Small fish should be graded out of the population first, and the quantity of fish in the grader at an one time should not exceed ___ pounds per cubic foot of capacity.

1) 4
2) 5
3) 6

_____g. In ___ culture the need for grading is minimized by feeding techniques that provide access to food by less aggressive fish.

1) catfish
2) hobby fish
3) trout

12. Select factual statements about hauling equipment. Write the correct numbers in the blanks.

_____a. Which of the following are the most commonly used hauling truck sizes?

1) 1¼, 1½, 2 ton
2) ½, ¾, 1 and 1½ ton
3) 2 ton

_____b. Which of the following statements is NOT true?

1) Some producers use gooseneck trailers attached to a pickup truck.
2) Some haulers use large tandem units.
3) Most commonly, haulers use fleets of mid-sized trucks for convenience.

TEST

_____c. Which of the following materials may be used for hauling tank construction?

1) Steel reinforced concrete
2) Plastic or styrofoam
3) aluminum, fiberglass, or marine plywood

_____d. Which of the following are reasons for dividing the hauling tank into compartments?

1) Facilitating hauling several species at one time and making possible partial unloadings
2) Preventing disease spread
3) Making unloading faster and easier

_____e. Which of the following is NOT a factor that dictates the types of life support equipment used?

1) Size of hauling truck
2) Hauling distance
3) Type of hauling tank

_____f. Which of the following are standard equipment for all transport units?

1) Grading screens and grading boxes
2) nets, tubs, and a scale
3) Recirculating pumps and liquid oxygen chillers

13. Solve the following problems regarding loading procedures and rates. Write your answers in the blanks.

a. You have 300 gallons of water at 78°F, and you want to temper it to 68°F with ice. Approximately how many pounds of ice will yo need, and how long will it take to reduce the water temperature?

Pounds of ice = ________________________

Time to temper to 68°F = ________________________

b. You have 500 gallons of water at 65°F. How many pounds of catfish can you transport?

No. of pounds = ________________________

c. How many pounds of catfish could you transport in problem b if you used pure oxygen?

No. of pounds = ________________________

TEST

d. How many fewer pounds could you transport in problem b if you raised the water temperature 20 degrees?

No. of pounds = ______________________

e. How much would a loading rate of 1400 pounds be reduced for a 12-hour transport? For a 16-hour transport?

12-hour transport rate = ______________________

16-hour transport rate = ______________________

14. Select from a list factual statements about hauling and water quality. Write an "X" in the blank before each true statement.

_____a. Ammonia is the single most important factor in hauling.

_____b. Fish under 8 inches should be starved for a minimum of 48 hours.

_____c. Ammonia is the main metabolic product of fish and is excreted through the gills.

_____d. Provide additional oxygen (above 10 ppm but below saturation) during loading and for the first hour of transport.

_____e. For each 10°F rise in water temperature, the fish load should be reduced by 6.5 percent.

_____f. For every 1°F decrease in water temperature, the fish load should be increased by 5.6 percent.

_____g. Trout and other species can be adversely affected by exposure to 0.13 to 0.14 ppm unionized ammonia.

_____h. Oxygen consumption decreases during handling and loading.

_____i. Total ammonia can reach 10 ppm or higher without harming the fish, depending on the fish load and duration of haul.

_____j. Trout are distressed when CO_2 levels approach 25 ppm.

_____k. A product of respiration, CO_2 neutralizes transport water.

TEST

15 Match hauling chemicals with their descriptions/rates. Write the correct numbers in the blanks. Each number will be used twice.

_____a.	0.1 to 0.3 percent table salt and 50 ppm calcium chloride	1.	Water hardening chemicals
_____b.	10 percent solution of Dow Corning AF at a rate of 1 ounce (25 mL) per 100 gallons of water	2.	Anesthetic chemicals
_____c.	10 ppm nitrofurazone, 1 to 2 ppm acriflavine, 15 ppm Combiotic, or 20 ppm oxytetracycline	3.	Bacteriostatic chemicals
_____d.	Chemicals used to neutralize the water	4.	Buffering chemicals
_____e.	Chemicals used to harden the water to decrease stress and delay mortality	5.	Antifoam chemicals
_____f.	Chemicals used to eliminate foam that interferes with gas exchange and observation of fish		
_____g.	15 to 30 ppm Quinaldine for warmwater fishes; 0.1 to 1.0 grams per gallon MS-222 (tricaine methanesulfonate) in water buffered between 7 and 8 pH for trout		
_____h.	Tris-hydroxymenthyl-amino-methane at 5 to 10 grams per gallon, and sodium bicarbonate at 1 ppt		
_____i.	Chemicals used to lessen mortality caused by bacterial diseases		
_____j.	Chemicals used to anesthetize or sedate fish to slow their oxygen consumption and prevent injuries caused by hyperactivity		

16 Complete statements about unloading procedures. Write the correct numbers in the blanks.

_____a. At the stocking or receiving site, the fish must be slowly tempered to the temperature of the receiving water; the temperature difference should not exceed ___.

1) 15°F
2) 10°F
3) 5°F

TEST

_____b. In addition, some time may be required to adjust the fish to different ___ so that they do not go into ___ shock, which is particularly damaging when fish raised in hard water are stocked in soft water.

1) pH levels; acid
2) ion concentration; ion
3) mineral content; aqua

_____c. To reduce ___, fish should be unloaded and tempered as quickly as possible and with minimum handling.

1) stress
2) shock
3) disease

_____d. All transport tanks and equipment must be ___ as soon after delivery as possible to avoid the spread of infectious disease.

1) disinfected
2) sterilized
3) hosed down

17. Select from a list guidelines for the care of nets. Write an "X" in the blank before each correct guideline.

_____a. Clean nets at least once a week.

_____b. Do not roll and store wet seines and nets.

_____c. To prevent rot and prolong the life of seines, do not expose them to the sun before storing.

_____d. Inspect seines frequently for holes, and repair small holes before they become large.

_____e. Treat cotton nets with a commercial coating that protects against deterioration from sunlight, aids in the resistance of dirt and fish slime, and reduces the incidence of abrasion and damage.

_____f. Polyethylene nets require no treatment

(NOTE. Test questions 18 through 21 list the assignment and job sheets. If they have not been completed, check with your instructor for scheduling and evaluation procedures.)

18. Calculate loading rates. (Assignment Sheet #1)

19. Observe and report on a commercial harvest. (Assignment Sheet #2)

20. Survey your area and state for laws and regulations concerning interstate and intrastate shipping. (Assignment Sheet #3)

TEST

21. Demonstrate the ability to:

    a. Check water temperature and other shipping parameters. (Job Sheet #1)

    b. Grade fish. (Job Sheet #2)

    c. Package fish in a plastic bag. (Job Sheet #3)

    d. Disinfect fish transport tanks and equipment. (Job Sheet #4)

HARVESTING AND HAULING
UNIT XIV

ANSWERS TO TEST

1. a. 13
   b. 9
   c. 1
   d. 7
   e. 3
   f. 5
   g. 10
   h. 8
   i. 4
   j. 2
   k. 11
   l. 6
   m. 12

2. a. TH
   b. PH
   c. TH
   d. PH
   e. PH
   f. TH
   g. TH
   h. PH
   i. TH
   j. PH
   k. PH

3. a. PH
   b. PH
   c. TH
   d. TH
   e. TH
   f. PH
   g. TH

4. b, d, e

5. Seines
   a. 3
   b. 6
   c. 7
   d. 8
   e. 2
   f. 5
   g. 1
   h. 4

   Traps
   a. 1
   b. 3
   c. 2

   Miscellaneous harvesting equipment
   a. 2
   b. 5
   c. 3
   d. 6
   e. 4
   f. 7
   g. 1

6. a. 1
   b. 4
   c. 2
   d. 3

ANSWERS TO TEST

7. a, b, d, e, h

8. Seining

a.	3	e.	3
b.	2	f.	1
c.	2	g.	3
d.	2		

Corral seine trapping

a.	1	d.	2
b.	1	e.	2
c.	3	f.	2

Drop-seine trapping

a.	1	d.	3
b.	3	e.	2
c.	2	f.	3

Lift net trapping

a. 3
b. 1
c. 2

Simple traps

a. 1
b. 1
c. 3

Fish pump

a. 1
b. 2
c. 1

9. c, d, e, f

10.

a.	1	e.	2
b.	3	f.	2
c.	3	g.	3
d.	2		

11.

a.	2	d.	1
b.	3	e.	3
c.	1	f.	2

12.

a.	2	d.	1
b.	3	e.	1
c.	3	f.	2

ANSWERS TO TEST

13. a. 150 pounds
    20 minutes
    b. 2,000 pounds
    c. 2,500 pounds
    d. 1,000 pounds
    e. 1,150 pounds
    700 pounds

14. b, c, f, g, i, j

15. a. 1 f. 5
    b. 5 g. 2
    c. 3 h. 4
    d. 4 i. 3
    e. 1 j. 2

16. a. 3 c. 1
    b. 2 d. 1

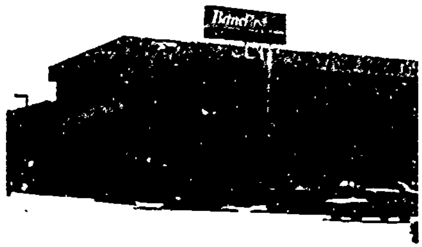
17. b, d

18. Evaluated to the satisfaction of the instructor

19. Evaluated to the satisfaction of the instructor

20. Evaluated to the satisfaction of the instructor

21. a. Evaluated according to criteria in Practical Test #1
    b. Evaluated according to criteria in Practical Test #2
    c. Evaluated according to criteria in Practical Test #3
    d. Evaluated according to criteria in Practical Test #4



BUSINESS MANAGEMENT
UNIT XV

UNIT OBJECTIVE

After completion of this unit, the student should be able to estimate operating costs and projected returns for an aquacultural enterprise. The student should also be able to work with a computer program to evaluate an aquacultural operation. These competencies will be evidenced by correctly completing the procedures outlined in the assignment sheets and by scoring a minimum of 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to aquacultural business management with their correct definitions.
2. List reasons for keeping records.
3. Distinguish between basic kinds of records.
4. Distinguish between production credit and consumption credit.
5. Select from a list guidelines for building and maintaining a good credit standing.
6. List the three C's of good credit.
7. Select from a list factors that a lender looks for in a borrower.
8. Select from a list factors that a borrower looks for in a lender.
9. Select from a list indicators of good loan repayment ability.
10. Select from a list indicators of poor loan repayment ability.
11. Match with their correct descriptions major types of credit extended by businesses.
12. Select correct descriptions of types of loans issued by banks and other lending institutions.
13. List sources of credit for aquacultural enterprises.
14. Match methods of computing interest with their correct definitions.

OBJECTIVE SHEET

15. Calculate true annual interest rates.
16. List the essential components of all budgets.
17. Select budgeting principles from a list.
18. Prepare an equipment cost comparison report. (Assignment Sheet #1)
19. Estimate fixed costs. (Assignment Sheet #2)
20. Develop an enterprise budget to determine actual costs and expected returns. (Assignment Sheet #3)
21. Develop a cash flow projection. (Assignment Sheet #4)
22. Use a computer to evaluate an aquacultural operation. (Assignment Sheet #5)
23. Interview a local lender and report on attitudes about aquaculture capital. (Assignment Sheet #6)
24. Complete a checklist to determine individual potential in the aquaculture industry. (Assignment Sheet #7)

BUSINESS MANAGEMENT
UNIT XV

SUGGESTED ACTIVITIES

A. Obtain aquaculture business management computer programs from your Cooperative Extension Service or a nearby university, or make available to the students a computer program with which you are familiar.

B. Invite a loan officer from a local lending institution to speak to the class about the institution's lending requirements and policies in regard to extending aquacultural credit.

C. Provide students with objective sheet. Discuss unit and specific objectives.

D. Provide students with information sheet. Discuss information sheet. Use handouts and many examples to reinforce materials in the information sheet.

E. Provide students with assignment sheets. Schedule and discuss assignment sheets. Use handouts to provide additional information and forms needed for the development of the various budgets. Demonstrate and provide assistance to students in completing the computer budget and evaluations required in Assignment Sheet #5.

F. Give written test.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Beem, Marley, and Steven Anderson. "Catfish Farming," No. 9002.1 Stillwater, Oklahoma. Oklahoma Cooperation Extension Service/Oklahoma State University, n.d.

B. Cramer, Lawrence A. "Tax Tips for Aquaculture Investors and Producers," in *Proceedings of the Louisiana Aquaculture Conference, 1988,* Robert C. Reigh, ed. Baton Rouge, Louisiana, 1988.

C. Garrard, Anthony B., Marty J. Fuller, and Mark E. Keenum. *Economic Analysis of Small-scale Processing for Mississippi Farm-raised Catfish.* Mississippi Agricultural & Forestry Experiment Station, June 1988.

D. Huner, J.V., and Harry K. Dupree. "Methods and Economics of Channel Catfish Production, and Techniques for the Culture of Flathead Catfish and Other Catfishes," in *Third Report to the Fish Farmers: The Status of Warmwater Fish Farming and Progress in Fish Farming Research*, ed. Harry K. Dupree and Jay V. Huner. Washington, D.C.: U.S. Fish and Wildlife Service, 1984.

E. Jensen, Gary L. *Commercial Production of Farm-Raised Catfish.* Baton Rouge: Louisiana Cooperative Extension Service and Louisiana Agricultural Experiment Station, 1987.

SUGGESTED ACTIVITIES

F. Keenum, Mark E. and John E. Waldrop. *Cash Flow Analysis of Farm-Raised Catfish Production in Mississippi.* Mississippi Agricultural & Forestry Experiment Station, August 1988.

G. Killcreas, Dr. Wallace, et. al. *A Records Program for Catfish and Shrimp Production, Financial Data and Management Decisions for IBM PC and Compatible Microcomputers.* Mississippi Agricultural & Forestry Experiment Station, September 1985.

H. Killcreas, Dr. Wallace, et. al. *GROWCATS Fish Growth Simulation Model for Production Planning.* Mississippi Agricultural & Forestry Experiment Station, January 1987.

I. Meigs, Frank E., III. "Financing Options for Aquaculture," in *Proceedings of the Louisiana Aquaculture Conference, 1988,* Robert C. Reigh, ed. Baton Rouge, Louisiana, 1988.

J. Sadler, Tom. "A Producer Looks at Catfish Farming," in *Proceedings of the Louisiana Aquaculture Conference, 1988.* Robert C. Reigh, ed. Baton Rouge, Louisiana, 1988.

K. Steward, Jim, and Dr. Raleigh Jobes. *Farm & Ranch Business Management.* Moline, Illinois: Deere & Company, 1985.

L. White, David, et. al. *WATERQ: A Microcomputer Program for Pond Water Management.* Mississippi Agricultural & Forestry Experiment Station, October 1988.

M. Williams, Kenneth. *Economic Evaluation of Small Scale Catfish Production.* Langston, Oklahoma: Langston University/Kerr Center for Sustainable Agriculture, 1987.

BUSINESS MANAGEMENT
UNIT XV

INFORMATION SHEET

I. Terms and definitions

A. **Budget** — A formal plan that projects the use of assets for a future time; a schedule of expected returns or costs

B. **Enterprise budget** — A look at the costs and risks involved with producing one commodity or making one product

C. **Cash flow summary** — A list or record of actual monthly cash levels for a business

D. **Cash flow projection** — An estimate of monthly cash inflows and outflows over a period of time, usually one year

(NOTE: A two-year projection is generally used in fish farming because this time period provides more accurate data)

E. **Capital** — The amount of money that can be obtained through borrowing or selling of assets that is used to promote the production of other goods

F. **Assets** — The property or resources owned and controlled by a business

G. **Depreciation** — The decrease in value resulting from the wear and tear of use, accident, destructive weather, poor management, and the obsolescence of equipment and processes

H. **Fixed costs** — Costs that usually do not fluctuate with an increase or decrease in production

EXAMPLES: Taxes, insurance, interest rates on investments

I. **Variable costs** — Costs that increase or decrease in relation to an increase or decrease in production

J. **Enterprise** — A specific process or activity that requires a certain amount of risk to make a profit

K. **Return** — The money available after production expenses are subtracted from total income

L. **Net worth statement** — Financial condition of a business at a definite point in time; it lists all assets, values of assets, and liabilities of a business; also known as a *balance sheet, financial statement*, or *statement of financial condition*

M. **Income statement** — Financial record that reflects the profitability of the business over a specified period of time, also known as a *profit and loss statement* or an *operating statement*

INFORMATION SHEET

N. **Break even** — The point where income is equal to the total of the fixed costs and variable costs of doing business

O. **Payback** — Number of years it takes to recover the initial investment

P. **Profit** — The money that remains after all fixed and variable costs are deducted from income

II. Reasons for keeping records

A. To comply with income tax reporting requirements

B. To let you compare past performance with present performance and future goals

C. To provide the information that you need to prepare management tools such as cash flow projections, whole farm budgets, risk management plans

D. To help you obtain credit

E. To provide the information needed to apply for government programs

F. To help you decide what to produce

III. Kinds of records

A. **Financial** — Show money received and expenses owed for the business

EXAMPLES: Cash flow summary, net worth statement, income statement, whole farm or ranch and detailed enterprise analysis

B. **Physical** — Show data pertaining to production of aquaculture crop

EXAMPLES: Stocking rates, water quality management data, water acres farmed, births, deaths, family labor, numbers or pounds harvested, fish health data

IV. Types of credit

A. **Production credit** — Credit that usually returns its original cost plus an amount for interest profit

(NOTE: Production credit is usually treated as part of the cost of doing business, the same as any other production input.)

B. **Consumption credit** — Credit for personal use rather than for a use that will generate future income

(NOTE: Consumption credit allows people to satisfy their present wants without first accumulating the necessary money.)

INFORMATION SHEET

V. Guidelines for building and maintaining a good credit standing

A. Establish a credit rating.

B. Shop around for the best type of loan and interest rate.

C. Get your credit from specialists.

(NOTE: Lenders who make farm loans regularly—and particularly loans to aquaculturists—usually understand the farmer's problems and are sympathetic to the farmer's needs. However, few lending agencies have experience with aquaculture business. Consequently, aquaculture loans are difficult to obtain.)

EXAMPLES: Commercial banks, Federal Land Bank, Production Credit Association

D. Use the right type of credit.

EXAMPLES. Short-term for seasonal operating expenses; intermediate-term for large equipment purchases; long-term for financing land or for capital improvements

E. Plan ahead for credit needs by using cash flow projections.

F. Borrow only to make or save money.

(NOTE: The first rule of farm-business borrowing should be: *Borrow only when the borrowed funds will make you more than the cost of borrowing them.*)

G. Plan the use of loan funds with your lender.

H. Work out a repayment plan for every loan.

I. Meet your payments when due.

J. Avoid accumulating debts in several places as this is a sign to lenders that you are not planning your credit needs.

K. Take an annual inventory.

(NOTE: An inventory will provide information for financial statements and will allow you to take a look at your financial position.)

INFORMATION SHEET

VI. The three C's of good credit

(NOTE: The three C's of good credit must be met before credit will be extended.)

A. Character

(NOTE: Character is determined by integrity in money matters, honesty, reliability, willingness to pay, and a record of financial responsibility.)

B. Capital

(NOTE: Capital is measured by financial resources such as equity in a house, household goods, automobile or other vehicle, life insurance, and savings account.)

C. Cash-flow

(NOTE: Cash-flow is judged by present and future income and by present commitments.)

VII. Factors that a lender looks for in a borrower

A. Good character

B. Managerial ability

C. Stable financial position

D. Ability to repay

E. Sound purpose for loan

F. Adequate security for loan

VIII. Factors that a borrower looks for in a lender

A. Good reputation

B. Equitable policies

C. Permanence and dependability

D. Knowledge of aquaculture

E. Fair and competitive cost of credit

IX. Indicators of good loan repayment ability

A. Good managerial ability

B. Complete and accurate records and budgets

INFORMATION SHEET

C. Sufficient repayment capacity

D. Product price rise

E. Increase in size of operation

F. Additional income

G. Reliable cost and income estimates

H. Loan money used only for intended purpose

X. Indicators of poor loan repayment ability

A. Low production per unit

EXAMPLES: Poor crop yields, small fingerling crop; small returns from stocker sales

B. Low price per unit sold

EXAMPLES: Poor market, poor marketing strategy, poor quality product, low prices for product

C. High cash production costs

EXAMPLES: High feed costs, high labor costs, high replacement costs

D. High cash overhead costs

EXAMPLES: Heavy debt load, high interest rates, heavy taxes, high maintenance cost for buildings and machinery

E. High cash living costs

EXAMPLES: Sickness, education of children, extravagance

F. Borrowing above the ability to repay

EXAMPLES: Cash flow projection not realistic enough; repossessed equipment or machinery

G. Overestimating the amount of the loan that can be repaid each year

INFORMATION SHEET

XI. Major types of credit extended by businesses

A. Open account credit

(NOTE: This type of credit is often extended by services such as utility companies and doctors.)

1. The customer may buy in person, by mail, or by telephone.
2. No down payment or interest is charged.
3. A statement is sent monthly.
4. The customer has a stated period in which to repay with no interest charge.

B. Revolving charge account

1. A maximum amount is usually established.
2. Payments are made monthly, depending on the terms of the business.
3. Interest is charged.
4. New purchases can be added, up to an established maximum amount.

   EXAMPLE: The customer has a $400 credit limit and pays $50 per month plus 18% interest if the full amount of credit is used.

C. Optional revolving credit

(NOTE: This is a combination of the open and revolving credit accounts.)

1. The business sends monthly bills.
2. The entire bill can be paid within an agreed number of days after billing without interest.
3. If the entire bill is not paid, the customer makes a monthly payment and the unpaid balance is subject to a service charge and/or interest.

INFORMATION SHEET

L. Installment credit

1. Payments are made over a long period of time.
2. Interest is charged.
3. A service charge is sometimes added.
4. The consumer has the option of repaying the entire amount at any time.
5. If the consumer does not maintain payments, the merchandise may be repossessed by the lender.

XII. **Types of loans issued by banks and other lending institutions**

A. **Collateral loan** — Loan in which legal title to item purchased is held as security or collateral by lending institution

(NOTE: This type of loan is often used for expensive items such as hauling trucks, boom trucks, and large aerators.)

B. **Life insurance loan** — Loan based on cash value of a person's permanent insurance policy

C. **Secured personal loan** — Loan made with collateral — such as blue chip stock — that is safe and will not lose value

D. **Unsecured personal loan (signature loan)** — Loan given to a customer with a good credit rating based simply on the customer's promise to repay

E. **Demand loan** — Short-term loan (for less than one year) that is repaid in installments or in full at the end of a specified time

F. **Passbook loan** — Arrangement that allows a person to borrow the amount in his or her savings account without having to withdraw the savings

G. **Education loan** — Loan to finance a post-secondary (after high school) education, with repayment usually deferred until after graduation

H. **Consolidated loan** — Money borrowed to pay all debts

(NOTE: The money borrowed is repaid in smaller payments and over a longer period than it would take to pay off the debts separately.)

INFORMATION SHEET

I. **Credit card loan** — Using a bank credit card such as VISA or Mastercharge to finance purchases or to borrow money

(NOTE: The borrower usually has three years to pay. While credit cards are convenient because there is no need to carry large amounts of cash and because the borrower can make one easy payment a month, it is important to remember that almost all types of credit include a substantial interest charge. For the privilege of not having to pay the full amount at the time of purchase or loan, the borrower pays about $25 for every $16 or $17 worth of merchandise or cash borrowed.)

J. **Check credit loan** — A bank loan automatically extended through the borrower's checking account

(NOTE: There is usually a higher monthly service charge for this option.)

EXAMPLE: The borrower writes a check for $50 more than he or she has in a checking account and the bank automatically makes a loan to that person for $50.

K. **Home improvement loan** — Special loan for the purpose of increasing the value of a home by adding a room, putting on a new roof, and so on

L. **Mortgage loan** — Loan made on real estate, with the property pledged as security for the loan

EXAMPLES: FHA loan, VA loan, FmHA loan

XIII. Sources of credit for aquacultural enterprises

A. Commercial banks

B. Individuals

C. Merchants or dealers

EXAMPLE: Feed companies

D. Finance companies

E. Insurance companies

F. Federal Land Bank Associations

G. Production Credit Associations

H. Farmer's Home Administration (FHA)

I. State Commissioners of the Land Office

INFORMATION SHEET

XIV. **Definitions of methods of computing interest**

A. **Simple interest** — Amount paid for borrowing money that is repaid in a single lump sum

B. **Remaining balance** — Interest calculated by multiplying outstanding principal by contractual rate for period in question

C. **Add-on** — Interest placed on the original loan for the entire period of the loan; the sum of the total interest and principal is divided by the number of payments to obtain the amount of each installment

D. **Discount** — Interest calculated on the original amount of the loan for the full period of the loan; this amount, plus any other loan costs, is subtracted from the amount of the loan at the beginning, with the borrower receiving the difference

XV. **Formula for calculating the true annual interest rate**

$$\frac{\text{Total Finance Charges}}{\text{1/2 Original Loan}} \times \frac{\text{Number of Payments}}{\text{Number of Years}} \times \frac{1}{\text{Number of Payments, plus 1}} = \text{True Annual Interest Rate}$$

EXAMPLE: Ray Smith purchased an aerator for $4500. He made a down payment of $500, and financed the remaining $4000 over 2 years at 14 percent interest. Using the add-on method for computing interest, Ray's monthly payments were $213.33. His total finance charges were $1120.

$$\frac{\$1120}{\$2000} \times \frac{24}{2} \times \frac{1}{25} = .2688 \times 100 = 26.88\% \quad \text{True Annual Interest Rate}$$

INFORMATION SHEET

XVI. **Four essential components of all budgets**

A. Capital

B. Labor

C. Land

D. Management

XVII. **Budgeting principles**

(NOTE: All budgeting involves one or more of four fundamental economic principles that should be learned before you try to budget your resources.)

A. Invest more if returns increase.

EXAMPLE: Joe Piccolo will continue to feed additional rations to his catfish as long as he gets an additional weight increase (yield) worth more than the cost of the feed.

B. Invest as little as possible in costs (inputs).

EXAMPLE: Joe will substitute a lower cost feed for a high-cost feed as long as he gets a good FCR.

C. Invest in a different product if the return (output) is greater.

EXAMPLE: Which will mean greater profits — fish farming or crop farming? Baitfish production or food-fish production? Catfish for food or catfish fingerlings for grow-out?

D. Invest money where it will earn the largest returns.

EXAMPLES: Joe invests in gravel for the top of his levees because not doing so will cost him feed days. Joe buys a bulk feed storage tank rather than buying by the bag.

BUSINESS MANAGEMENT
UNIT XV

HANDOUT #1 — FIVE-YEAR SAMPLE ENTERPRISE BUDGET

Ist Year Estimated Costs & Returns — **1 acre/5500 lbs.**
40 acres land — 35 acres water

Direct Costs:

Feed (1.5:1 conversion) 8250 lbs. @ $.15 lb. (300: ton)	$1238.—
Fingerlings 4500/acre @ $.15 ea.	675.—
Electricity	86.—
Fuel	76.—
Chemicals	31.—
Repairs & Maintenance	85.—
Management & Labor ($17,500)	500.—
Harvest & Haul @ $.03 lb.	165.—
Liability Insurance	15.—
	$2871.—
Interest-Operating Capital (14% for 9 mo.)	301.—
Total Direct Costs	$3172.—

Fixed Costs:

Depreciation on Pond & Equip. (100% over 10 yrs. on $85,000. = $8500. yearly)	$243.—
Interest on Investment Capital (10% on $85,000. = $8500. yearly)	243.—
Principal on Investment capital (7 yrs. on $85,000. = $12,150. yearly)	347.—
Taxes & Insurance ($15/acre taxes — $15/acre insurance)	30.—
Total Fixed Costs	863.—
Total Costs ($141,225.)	$4035.—

Income:

5500 lbs. @ $.80 lb. = $4400.
Total Costs = –4035.

$ 365. profit/acre

35 acres × 365. per acre = $12,775. profit

Figures from actual budgets used by Jim Paul, Edmond, Oklahoma.

HANDOUT #1

2nd Year Estimated Costs & Returns — **1 acre/5500 lbs.**
54 acres land — 47 acres water

Direct Costs:

Feed (1.5:1 conversion) 8250 lbs. @ $.15 lb. (300: ton)	$1238.—
Fingerlings 4500/acre @ $.15 ea.	675.—
Electricity	86.—
Fuel	76.—
Chemicals	31.—
Repairs & Maintenance	85.—
Management & Labor ($23,500)	500.—
Harvest & Haul @ $.03 lb.	165.—
Liability Insurance	15.—
	$2871.—
Interest—Operating Capital (14% for 9 mo.)	301.—
Total Direct Costs	$3172.—

Fixed Costs:

Depreciation on Pond & Equip. ($8500. + $1500 = $10,000. yr.)	$213.—
Interest on Investment Capital (10% on $85,000. = $8500. yearly)	181.—
Principal on Investment capital (7 yrs. on $85,000. = $12,150. yearly)	259.—
Taxes & Insurance ($15/acre taxes — $15/acre insurance)	30.—
Total Fixed Costs	683.—
Total Costs ($181,185.)	$3855.—

Income:

5500 lbs. @ $.80 lb. = $4400.
Total Costs = −3855.

$ 545. profit/acre

47 acres × $545. acre = $25,615. profit

HANDOUT #1

3rd Year Estimated Costs & Returns

1 acre/5500 lbs.
67 acres land — 58 acres water

Direct Costs:

Feed (1.5:1 conversion) 8250 lbs. @ $.15 lb. (300: ton)	$1238.—
Fingerlings 4500/acre @ $.15 ea.	675.—
Electricity	86.—
Fuel	76.—
Chemicals	31.—
Repairs & Maintenance	85.—
Management & Labor ($29,000)	500.—
Harvest & Haul @ $.03 lb.	165.—
Liability Insurance	15.—
	$2871.—
Interest—Operating Capital (14% for 9 mo.)	301.—
Total Direct Costs	$3172.—

Fixed Costs:

Depreciation on Pond & Equip. ($11,500. yearly)	$198.—
Interest on Investment Capital (10% on $85,000. = $8500. yearly)	147.—
Principal on Investment capital (7 yrs. on $85,000. = $12,150. yearly)	210.—
Taxes & Insurance ($15/acre taxes — $15/acre insurance)	30.—
Total Fixed Costs	585.—
Total Costs ($217,906.)	$3757.—

Income:

5500 lbs. @ $.80 lb. = $4400.
Total Costs = –3757.
$ 643. profit/acre

58 acres × $643. acre = $37,294. profit

HANDOUT #1

4th Year Estimated Costs & Returns — **1 acre/5500 lbs.**
80 acres land — 70 acres water

Direct Costs:

Feed (1.5:1 conversion) 8250 lbs. @ $.15 lb. (300: ton)	$1238.—
Fingerlings 4500/acre @ $.15 ea.	675.—
Electricity	86.—
Fuel	76.—
Chemicals	31.—
Repairs & Maintenance	85.—
Management & Labor ($35,000)	500.—
Harvest & Haul @ $.03 lb.	165.—
Liability Insurance	15.—
	$2871.—
Interest—Operating Capital (14% for 9 mo.)	301.—
Total Direct Costs	$3172.—

Fixed Costs:

Depreciation on Pond & Equip. ($13,000. yearly)	$186.—
Interest on Investment Capital (10% on $85,000. = $8500.— yearly)	122.—
Principal on Investment Capital (7 yrs. on $85,000. = $12,120. yearly)	174.—
Taxes & Insurance ($15/acre taxes — $15/acre insurance)	30.—
Total Fixed Costs	512.—
Total Costs ($257,880.)	$3684.—

Income:

5500 lbs. @ $.80 lb. = $4400.
Total Costs = −3684.

$ 716. profit/acre

70 acres × $716. per acre = $50,120. profit

HANDOUT #1

5th Year Estimated Costs & Returns — **1 acre/5500 lbs.**
95 acres land — 83 acres water

Direct Costs:

Feed (1.5:1 conversion) 8250 lbs. @ $.15 lb. (300: ton)	$1238.—
Fingerlings 4500/acre @ $.15 ea.	675.—
Electricity	86.—
Fuel	76.—
Chemicals	31.—
Repairs & Maintenance	85.—
Management & Labor ($41,500)	500.—
Harvest & Haul @ $.03 lb.	165.—
Liability Insurance	15.—
	$2871.—
Interest—Operating Capital (14% for 9 mo.)	301.—
Total Direct Costs	$3172.—

Fixed Costs:

Depreciation on Pond & Equip. ($14,500. yearly)	$175.—
Interest on Investment Capital (10% on $85,000. = $8500.— yearly)	103.—
Principal on Investment Capital (7 yrs. on $85,000. = $12,150. yearly)	147.—
Taxes & Insurance ($15/acre taxes — $15/acre insurance)	30.—
Total Fixed Costs	455.—
Total Costs ($301,041.)	$3627.—

Income:

5500 lbs. @ $.80 lb. = $4400.
Total Costs = –3627.

$ 773. profit/acre

83 acres × $773. per acre = $64,159. profit

HANDOUT #1

Investment Capital — **Based on 40 acres land, 35 acres water**

Pond Construction — 3 — 13 1/3 acre ponds 24,500 cu. yds. levee (6.2 cu. yd./ft.) @ $1.00 per cu. ft.		= $25,000.—
Water Supply 1000 gpm total (25 gpm/acre req'd)		= 10,000.—
Feeding Equipment		= 5,000.—
Miscellaneous Equipment		= 45,000.—
Tractor (1-50 H.P. used)	$15,000.—	
Aeration Equipment	18,000.—	
Boat, Mc'or & Trailer	2,000.—	
Mower	2,000.—	
Oxygen Meter & Test Equip.	1,000.—	
Harvest Equipment	2,000.—	
Other	5,000.—	
Total Investment Costs	$85,000.—	

BUSINESS MANAGEMENT
UNIT XV

HANDOUT #2 — VARIOUS BUDGETS FOR SMALL-SCALE CATFISH PRODUCTION

Enterprise Budget for One Cage Containing 300 Channel Catfish

Variable Costs	
Fingerlings, 6-8 in., 315, (+5% for mortality) @ $.24 ea.	$ 75.60
Feed, 600 lb. @ $.14/ lb.	84.00
Aquatic culture license	10.00
Misc. (fuel, transportation)	20.00
Interest of 11% on operating capital for 7 months	12.17
Total Variable Costs	$ 201.77
Fixed Costs	
Cage construction materials $50.00/cage amortized over 10 yr. life span	$ 5.00
Misc. materials (dip net maintenance)	10.00
Total Fixed Costs	$ 15.00
Total Startup Costs	$ 216.77
Yearly Fixed + Variable Costs	$ 216.77
Break-even price (per lb) to cover variable costs	$ 0.67
to cover total yr. costs	$ 0.72

NOTE. All budgets in Handout #2 are for existing ponds so they do not include any construction costs. Land costs are not included, and except for harvesting labor, no labor costs are included. The exclusion of those items accounts for the low break-even cost reflected at the end of each budget. Take into account these items when using these budgets for guidelines.

All budgets on the following pages from Kenneth Williams
Fisheries Research/Extension Specialist, Langston University, Oklahoma.

HANDOUT #2

Enterprise Budget for Cage Culture in a 1 Acre Pond

Production = 900 lb/ac.
3 cages, 1 cu. yd. ea.
300 fish/cage + 5% loss = 945 fish

Variable Costs	
Fingerlings, 6-8 in., 945 @ $0.24 ea.	$ 226.80
Feed, 1800 lb. @ $.14/ lb.	252.00
Aquatic culture license	10.00
Misc. (fuel, transportation)	20.00
Interest of 11% on operating capital for 7 months	32.65
Total Variable Costs	$ 541.45
Fixed Costs	
Cage construction materials $50.00/cage × 3 cages = $150.00 amortized over 10 yr. lifespan	$ 15.00
Misc. materials (dip net, maintenance)	15.00
Total Fixed Costs	$ 30.00
Yearly Fixed + Variable Costs	$ 571.45
Total Start-up Costs	$ 706.45
Break-even price (per lb) to cover variable costs	$ 0.60
to cover total yr. costs	$ 0.64

HANDOUT #2

Enterprise Budget for Commercial Cage Culture In a 40-Acre Lake

Production = 40.000 lbs.
13 cages, 8' × 8' × 4' = 256 cu. ft./cage (+ 2 spare cages).
3,000 fish/cage.

Variable Costs	
Fingerlings, 6 in. @ $0.12 ea.	$ 4,800.00
Feed, 72,000 lb. @ $0.14/ lb.	10,080.00
Fuel, for boat 50 gal. @ $1.00/gal.	50.00
Interest on operating capital of 12% for 1 yr.	$ 1,791.60
Total Variable Cost	$16,721.60
Fixed Costs	
Cage Construction Materials $252.64/cage × 15 cages = $3,789.60 amortized over 10 yr.	$ 378.96
Aquatic culture license	10.00
Boat, motor, etc. $950 amortized 10 years	95.00
Oxygen meter $175.00 Amt. 5 yr.	35.00
Feed bin, $1200. Amt. 10 yr.	120.00
Storage shed $4500 amt. 10 yr.	450.00
Work dock $2,500 amt. 10 yr.	250.00
Chain hoist, $500 amt. 10 yr.	50.00
Misc. dip nets, scales etc./yr.	75.00
Interest for 1 yr. @ 12%	1,643.95
Total Yearly Fixed Costs	$ 3,107.91
Total Yearly Fixed & Variable Costs	19,829.51
Total Start-Up Cost	30,421.20
Labor cost: 4 hr/day 28 hr/wk @ $5.00/hr. = 140.00/wk × 52 wk	$ 7,280.00
Labor for cage construction @ $7.00/hr. 8 hr./cage 15 cages	$ 840.00
Break-even price/lb.	
to cover variable costs	$ 0.42/lb.
to cover fixed & variable costs	$ 0.49/lb.
Wholesale Gross Return @ $0.72/lb.	$28,800.00
Net Return above Total Costs	$ 8,970.49

HANDOUT #2

Catfish Enterprise Budget for a 1-Acre Existing Pond

Stocking Rate: 2500 fish per acre	
Gross Returns ($1.50/lb.)	$3,750.00
Variable Costs (1 acre @ 2500/fish)	
Fingerlings, $0.14 ea. 2500 + 5% loss	$ 367.50
Feed (FCR. 1.8) 4500 lbs. @ $0.14/lb.	$ 630.00
Transportation?	
Interest on Op. cap. @ 12%, 7 mo.	$ 69.83
Total Variable Cost	$1,067.33
Brea Even Price on Var. Cost	$ 0.43/lb
Income above Var. Cost (Retail)	$2,682.67
Fixed Costs (1 ac @ 2500/ac)	
300 ft seine $760.80 amortized 7 yrs	$ 108.69
Live car $199.03 amortized 7 yrs	$ 28.43
Misc. equip. $350.00 amortized 5 yrs	$ 70.00
Aquaculture license	10.00
Total Yearly Fixed Costs	$ 217.12
Total Var. & Fixed Costs	$1,284.45
Total Start-up Cost	$2,387.16
Break-Even Price on Total Cost	$0.51/lb
Income above Total Cost	$2,465.52
Payback Investment 1 yr + Return of	$1,362.84

HANDOUT #2

Catfish Enterprise Budget for a 1-Acre Existing Pond

Stocking Rate: 2500 fish per acre	
Gross Returns ($0.73/lb)	$1825.00
Variable Costs (1 ac @ 2500/fish)	
Fingerlings, $0.14 ea. 2500 + 5% loss	$ 367.50
Feed (FCR.1.8) 4500 lbs @ $0.14/lb	$ 630.00
Interest on operating cap. @ 12%, 7 mo.	$ 69.83
Custom harvest @ $0.03/lb	$ 75.00
Total Variable Costs	$1142.33
Income above Var. Cost (Wholesale)	$ 682.67
Fixed Costs (1 ac @ 2500/ac)	
Aquaculture license	$ 10.00
Misc. equip.	$ 30.00
Interest @ 12%	$ 4.80
Total Fixed Costs	$ 44.80
Total Fixed & Var. Costs	$1187.13
Net Returns	$ 637.87
Break-even Price (per lb.)	$ 0.47

HANDOUT #2

Catfish Enterprise Budget for a 1-Acre Existing Pond

Stocking Rate: 4500 fish per acre	
Gross Returns ($0.73/lb)	$3285.00
Variable Costs (1 ac @ 4500 fish)	
Fingerlings, $0.14 ea. 4500 + 5% loss	$ 661.50
Feed (FCR.1.8) 8100 lbs @ $0.14/lb	$1134.00
Transportation?	
Interest on op. cap. @ 12%, 7 mo.	$ 125.69
Custom harvest @ $0.03/lb	$ 135.00
Total Variable Costs	$2056.19
Income above Var. Cost	$1228.81
Fixed Costs	
Aquaculture license	$ 10.00
Aerator, $1300 amortized 10 yrs.	$ 130.00
Oxygen test kit	$ 40.00
Misc. equip.	$ 30.00
Interest on fixed cost @ 12%	$ 25.20
Total Fixed Costs	$ 235.20
Total Fixed & Var. Costs	$2291.39
Net Return to Management	$ 993.61
Break-even Price (per lb)	$ 0.51

HANDOUT #2

Catfish Enterprise Budget for 1-Acre Existing Pond

Stocking Rate: 4500 fish	
Gross Returns ($1.50/lb)	$6750.00
Variable Costs (1 ac 4500 fish retail sales)	
Fingerlings, $0.14 ea. 4500 + 5% loss	$ 661.50
Feed (FCR.1.8) 8100 lbs @ $0.14/lb	$1134.00
Transportation?	
Interest on op. cap. @ 12%, 7 mo.	$ 125.69
Total Variable Costs	$1921.19
Income above Variable Cost	$4828.81
Fixed Costs	
Aerator, $1300 amortized 10 yrs.	$ 130.00
Oxygen test kit	$ 40.00
Misc. equip. license	$ 360.00
300 ft seine $760.80 amortized 7 yrs.	$ 108.69
Live car, $199.03 amortized 7 yrs.	$ 28.43
Interest on fixed cost @ 12% 1 yr.	$ 80.05
Total Yearly Fixed Costs	$747.17
Total Fixed & Var. Costs	$2668.36
Break-even Price per lb.	$ 0.59
Income above Total Cost	$4081.64
Total Start-up Cost	$4669.07
Pay-back Investment in the 2nd yr.	

HANDOUT #2

Catfish Enterprise Budget for 10 Acres of Existing Ponds

Stocking Rate: 2500 fish/per acre	
Gross returns ($0.73/lb)	$18250.00
Variable Costs (10 ac @ 2500 fish/ac)	
Fingerlings, $0.08 ea. + 5% loss	$2100.00
Feed, (FCR 1.8) 45000 lb @ $0.14/lb	$6300.00
Transportation	
Tractor/fuel etc. 200 hr @ $1.50	$ 300.00
Labor @ 5.00/hr, 40 hr (harvest)	$ 200.00
Interest on op. cap. @ 12% 7 mo.	$ 623.00
Custom Harvest @ $0.03/lb	$ 750.00
Total Variable Costs	$10273.00
Income above Variable Costs	$ 7977.00
Fixed Costs	
Feed Wagon, $4700 amortized 20 yrs	$ 235.00
Oxygen test kit	$ 40.00
Boat, elec. motor, battery $750 amortized 10 yrs	$ 75.00
Feed & equip. storage shed @ $4000, amortized 20 yrs	$ 200.00
Misc. equip. (seines, dip nets, license etc.) $1400 amortized 7 yrs.	$ 200.00
Interest on fixed cost @ 12%/yr	$ 90.00
Total Fixed Costs	$ 840.00
Total Fixed & Var. Costs	$11113.00
Break-even Price per lb	$ 0.45/lb
Net Return to Management	$ 7137.00
Total Start-up Costs	$21253.00
Payback on Investment in 2nd yr.	
Labor Input—low/moderate	
Management Risk—low/moderate	

HANDOUT #2

Catfish Enterprise Budget for 10 Acres of Existing Ponds

Stocking Rate: 4500 fish per acre	
Gross returns ($0.73/lb)	$32850.00
Variable Costs (10 ac @ 4500 fish/ac)	
Fingerlings, $0.08 ea. + 5% loss	$3780.00
Feed, (FCR 1.8) 81000 lb @ $0.14/lb	$11340.00
Transportation?	
Tractor/fuel etc. 250 hr @ $1.50	$ 375.00
Labor @ 5.00/hr, 60 hr (harvest)	$ 300.00
Interest on op. cap. @ 12% 7 mo.	$ 1203.65
Custom Harvest @ $0.03/lb	$ 1350.00
Total Variable Costs	$19748.65
Income above Variable Costs	$ 13101.35
Fixed Costs	
Feed Wagon, $4700 amortized 20 yrs	$ 235.00
Oxygen test kit	$ 40.00
Boat, elec. motor, battery $750 amortized 10 yrs	$ 75.00
Feed & equip. storage shed @ $4000, amortized 20 yrs	$ 200.00
Misc. equip. (seines, dip nets, license etc.) $1400 amortized 7 yrs.	$ 200.00
Aerator $1300 amortized 10 yrs.	$ 130.00
Tractor (40 hp) used $6500	$ 650.00
Interest on fixed cost @ 12%/yr	$ 183.60
Total Fixed Costs	$ 1713.60
Total Fixed & Var. Costs	$21462.25
Break-even Price per lb	$ 0.48/lb
Net Return to Management	$11387.75
Total Start-Up Costs	$38622.25
Payback on investment in 2nd yr.	

BUSINESS MANAGEMENT
UNIT XV

ASSIGNMENT SHEET #1 — PREPARE AN EQUIPMENT COST COMPARISON REPORT

Before you can estimate construction, equipment, and operating costs, you must complete an equipment cost comparison report. Such a report requires that you assess your equipment needs, determine how much equipment is already owned, and decide whether you will purchase, build or contract needed equipment. You must survey the equipment dealers in your area and compare costs of both equipment, if you are buying, and materials, if you are building.

Evaluate needed equipment not only on its cost but also on its quality, durability, your investment desires, and your specific enterprise needs. Ask yourself such questions as "Should I buy a water quality test kit, single-purpose kits, or a battery-operated meter?"

The following list will provide you with some idea of the equipment needed, but you must personalize the list to serve your specific enterprise and farm needs.

Item	Owned Yes	Owned No	No.	Purchase $ Used	Purchase $ New	Construction Materials $
PRODUCTION EQUIPMENT Well pump & engine						
Hatching troughs						
Holding tanks & vats						
Spawning pens						
Floating cages						
Tractor						
Feeder						
Feeder bin & pad units						
Truck						
Aluminum boat						
Boat motor						
Boat trailer						
Transport tank & equip.						
Fixed electric aerator						
Portable aerator						

ASSIGNMENT SHEET #1

Itme	Owned Yes	No	No.	Purchase $ Used	Purchase $ New	Construction Materials $
Storage bldg.						
Side-mount mower						
Oxygen meter & accessories						
Dip nets						
Other						
MISC. FARM SHOP						
Waders						
Water quality test kit						
Battery & charger						
Scales						
Basic tool kit						
Low-lift pump						
Gloves						
Paddles						
Side mower						
Other						
HARVESTING EQUIPMENT						
Boom truck or backhoe						
Seine						
Cutting seine						
Live car						
Loading frame						
Loading scales						
Loading basket						
Seine reel						
Seine support rods						
Water pump						
Boat bracket						
Fish baskets						
Other						

ASSIGNMENT SHEET #1

Item	Owned Yes	Owned No	No.	Purchase $ Used	Purchase $ New	Construction Materials $
PROCESSING						
Sinks						
Pliers						
Skinners						
Band saw						
Scales						
Knives						
Smoker						
Freezer lockers						
Packaging materials & labels						
Stunning equipment						
Tubs & holding vats						
Cleaning tables						
Electric lights						
Other						
FEE-FISH EQUIPMENT						
Concession stands						
Rods & reels for rental						
Bait						
Picnic tables						
Drinking water fountains						
Fish cleaning tables						
Freezer lockers						
Roadside signs						
Site safety signs						
Fishing piers & platforms						
Lifesaving equipment						
Other						

BUSINESS MANAGEMENT
UNIT XV

ASSIGNMENT SHEET #2 — ESTIMATE FIXED COSTS

The investment requirements for an aquacultural enterprise vary depending on location, size of operation, type of enterprise, production level, whother the land is owned or purchased, and whether there are existing ponds and facilities. Other factors include how much equipment is already owned and whether needed equipment is purchased used or new or is home-built. Some producers build their ponds, cages, or raceways to reduce costs, others use family rather than hired labor. Harvesting equipment is another cost that may be excluded because of available custom harvesting and transportation, but it may be essential for others.

Many costs are determined by site-specific factors such as topography, depth to groundwater, fuel costs, and size of ponds or wells. Also land prices can differ from one area to another. The cost of building ponds is determined by dirt-moving costs that vary with location and size of pond. Investment costs per acre generally decrease as farm size increases.

Because of the wide range of enterprises and investment requirements, use the following sample of a fixed costs estimate and the estimation work sheet and reference key on the following pages as guidelines only. You will have to research and compare costs in your locality, and you will have to create a fixed cost work sheet tailored to fit your individual situation.

First determine a dollar amount for each line item that is appropriate for your farm plan. For a more detailed explanation, refer to the reference key that corresponds by number to each line item. Put a zero for total cost if an item is not appropriate or required. Add line items that are required by your specific enterprise. Use the information learned in Assignment Sheet #1 to fill in current costs of equipment and supplies.

This assignment sheet has been adapted from *Commercial Production of Farm-Raised Catfish* by Gary L. Jensen. With permission.

ASSIGNMENT SHEET #2

ESTIMATION WORK SHEET AND REFERENCE KEY

Reference Number	Item: Land	Cost
1.	Land, total acres × cost/acre..........	________
	Land Total Cost:..........	________

1. Marginal land that drains poorly, or produces low crop yields, is often used for catfish farming. Figure about 85% to 90% of the land area will be water depending on size of ponds and levees; the rest will be levees, building or drainage.

Reference Number	Item: Pond Construction	Cost
2.	Land clearing, acres × cost/acre..........	________
3.	Dirt moving, cubic yards × cost/cubic yard..........	________
4.	Drain structure, units × cost/unit..........	________
5.	Water supply line/valve, units × cost/unit..........	________
6.	Ground cover, acres × cost/acre..........	________
7.	Gravel or shellrock, cubic yards × cost/cubic yard..........	________
8.	Drainage ditch, cubic yards × cost/cubic yard..........	________
9.	Water well and casing, units × cost/unit..........	________
10.	Pump and engine, units × cost/unit..........	________
	Pond Construction Total Cost:..........	________

2. Land with trees or other obstacles needs to be cleared before ponds are constructed.

3. Dirt moving costs vary with location and condition of soil at the construction site. In flatland areas with large levees, about 6.2 cubic yards of dirt are moved per linear foot of levee. The actual amount depends on the dimensions of the levee.

4. Each pond should have a drain structure that permits pond draining in several days. Drains should be designed to prevent entry of wild fish and can be located either inside or outside of the pond. Various designs are suitable. The structure should be screened and fitted with a valve as needed.

5. Water supply lines should be large enough to carry the desired flow and be as straight as possible. The discharge water should be aerated before it enters the pond.

6. Unprotected areas of the levees should be covered with vegetation to minimize erosion and stabilize the soil. The vegetation should be suited for your area and may require lime and fertilizer.

ASSIGNMENT SHEET #2

Reference Number	Item: Production Equipment	Cost
12.	Tractors, units x cost/unit	______
13.	Feeder, units x cost/unit	______
14.	Feed bin with pad, units x cost/unit	______
15.	Trucks, units x cost/unit	______
16.	Aluminum boat	______
17.	Boat motor	______
18.	Boat trailer	______
19.	Transport tank and equipment	______
20.	Fixed electric aerators, units x cost/unit	______
21.	Portable aerators, units x cost/unit	______
22.	Storage and service building	______
23.	Side-mount mower	______
24.	Oxygen meter and accessories, units x cost/unit	______
25.	Miscellaneous farm shop equipment	______
26.	Waders, units x cost/unit	______
27.	Scales	______
28.	Low lift pump, units x cost/unit	______
29.	Dip nets, units x cost/unit	______
30.	Water quality test kit	______
31.	Battery and charger	______
	Production Equipment Total Cost:	______

12. Tractors can power aeration devices, pull seines, run relift pumps, operate a feeder and mow levees. The number and horsepower of tractors vary with the farm plan and situation.

13. On farms with many large ponds, a mechanical blower distributes feed to fish in ponds. The feeder can be truck-mounted or tractor-pulled. The capacity of the feed hopper varies form less than one ton to three tons. Match it to the feeding requirements of the farm.

14. Feed should be stored in a cool, dry location to prevent spoilage and loss of vitamin activity. A bulk storage feed bin with gravity flow is recommended. Sizes usually range from 10 to 25 ton capacity. Check with area feed mills to determine the minimum or normal bulk loads that can be delivered. Make sure that the capacity of the bin is adequate to store the expanded floating feed. The density of 32% floating feed is usually about 21 to 23 pounds per cubic foot. Small farms may need to purchase bagged feed because of low daily requirements.

15. Trucks are used to transport light equipment and supplies, check ponds, and transport fish both on and off the farm. The number, type and size of trucks will depend on the situation.

16. A 14-foot aluminum boat is used to dispense chemicals or aquatic weed treatments, check ponds for developing weed problems and harvest fish. A boat equipped with a chemical well is useful.

ASSIGNMENT SHEET #2

29. Dip nets are needed for collecting fish from ponds for disease diagnosis, routine handling and sampling, and harvesting. The mesh size should be suitable for different sizes of fish. Use 1/4" for fingerling fish and 1" for food fish. Two to four should be adequate.

30. A portable water quality test kit is required to check various water quality conditions that can affect the well-being of fish and help with management decision-making.

31. An extra battery and charger will keep all battery-started equipment in operating condition.

Reference Number	Item: Harvesting Equipment	Cost
32.	Boom truck or backhoe	______
33.	Seine, units × cost/unit	______
34.	Cutting seine, units × cost/unit	______
35.	Live car, units × cost/unit	______
36.	Loading frame	______
37.	Loading scales	______
38.	Loading basket	______
39.	Seine reel	______
40.	Seine support rods, units × cost/unit	______
41.	Water pump	______
42.	Boat bracket	______
43.	Fish baskets	______
	Harvesting Equipment Total Cost:	______

32. A careful evaluation determines the best option for harvesting fish. The size and location of the farm operation are key factors to consider. For small farms, where hundreds of pounds of fish are harvested rather than thousands of pounds, fish can be moved in metal tubs or plastic fish baskets. For larger operations, a boom is needed to move thousands of pounds of fish quickly from the pond to a transport truck. A boom is required to service live fish haulers unless fish are loaded from a tank. A boom bar can be rigged on the scoop of a backhoe in place of a boom truck.

33. Seines are used to trap, sample, crowd and harvest fish. Mesh and twine sizes vary, depending on the minimum size of fish desired. Seines should be at least 3 feet deep and long for each 2 feet of water depth and pond width to be seined. Many-ends nylon mud lines are popular, nylon seines should be net-coated. Seines made of polyethylene do not require treatment.

34. Cutting seines are usually about 50 to 100 feet long and are used to crowd fish inside a larger harvesting seine. They are also used to take fish samples to check growth and health of the fish. Mesh size varies, depending on the size of fish desired to harvest.

BUSINESS MANAGEMENT
UNIT XV

ASSIGNMENT SHEET #3 — DEVELOP AN ENTERPRISE BUDGET TO DETERMINE ACTUAL COSTS AND EXPECTED RETURNS

In this assignment sheet you will prepare a budget that estimates your yearly operating costs. Values in your budget should be specific to your proposed farm and site. This is important because costs vary depending on differences in land, equipment, labor, size of operation, money borrowed, and site-specific factors.

Use realistic values in your budget. Find out the mortality factor for the species you will farm, and include it in your budget. (The mortality factor for catfish is usually between 5 and 10 percent but can be higher.) Find out also the feed conversion rate as this effects operating costs. Show all fixed costs computed on an annual basis as well as annual operating expenses. If additional trucks, equipment, or facilities are needed, include these costs also.

Estimate the break-even cost to dete[illegible]e the efficiency of your operation and how competitive the cost will be in your selected market. This analysis is useful in determining whether money should be invested. This analysis is useful in determining whether money should be invested. Estimate the payback period or amount of time required to recover the fixed investment costs. This is important in evaluating the long-term financial status of the business.

Use the 5 year sample enterprise budget in Handout #1 and the budget table on the following page for a catfish production operation as guides for preparing your own enterprise budget. You will need to personalize the budget to fit your specific enterprise needs. Refer to your line-items in Assignment Sheet #2 for fixed cost investment items. Refer to Table 2 at the end of this assignment sheet for the expected life of various items to determine their depreciation values.

This assignment sheet is adapted from *Commercial Production of Farm Raised Catfish* by Gary L. Jensen With permission

ASSIGNMENT SHEET #3

Item	Unit	Price or Cost/Unit	Quantity	Value or Cost Per Pound	Your Cost
4. **INTEREST ON INVESTMENT:** Loan No. Purpose					
1 ( )					
2 ( )					
3 ( )					
4 ( )					
SUBTOTAL:					
5. **TAXES:** Property					
FICA					
State					
Federal					
SUBTOTAL:					
6. **INSURANCE:** Equipment					
Liability					
Life					
SUBTOTAL:					
TOTAL COSTS:					

From your values, determine the following:

1. Income above Operating Expenses: __________
   Total Value Item 1 – Subtotal Item 2
2. Net Return to Land, Management and Risk: __________
   Total Value Item 1 – Subtotals Items 2 + 3 + 4 + 5 + 6
3. Break-even Cash Price: __________
   Per Pound Value Item 1 – Per Pound Sub-total Item 2
4. Total Break-even Price: __________
   Per Pound Subtotals for Items 2 ÷ 3 + 4 + 5 + 6

BUSINESS MANAGEMENT
UNIT XV

ASSIGNMENT SHEET #4 — DEVELOP A CASH FLOW PROJECTION

A cash flow projection enables you to compare projected dollar flows with those that actually happened the previous year. When the two cash flow statements (summary of actual and projected) do not agree, you must analyze the differences and change your course of action.

The cash flow projection forces you to make detailed production plans. You must ask yourself some realistic questions such as those below. The answers to these questions will help you make important management decisions for your aquaculture enterprise.

— What enterprises will I undertake next year?

— How much of each enterprise will I produce?

— What production techniques will I use for each enterprise?

— What are the likely prices that I will receive for the stock produced by my enterprise(s)?

— When will I market my stock?

— How much money must I get approval for from my lender to meet my capital requirements? How much and when must I borrow money for production expenses? When will I need to borrow for new capital investments? When will I be able to repay the loan?

— Am I living within my family budget?

The components of a cash flow projection include all cash inflows and outflows. Cash inflows are:

- — All sales from enterprise activities
- — Government payments
- — Other farm income
- — Sale of capital items (stock, equipment, etc.)
- — Withdrawals from savings
- — Off-farm earnings
- — Other investments

Cash outflows are:

- — All cash expenses for input purchases (chemicals, pesticides, algicides, medications, feed, supplies)
- — Personal income and real estate taxes
- — Other expense items (insurance, utilities, rents, leases, harvesting and hauling service)
- — Capital purchases (breedings and seed stock, equipment, land)
- — Principal payments on loans
- — Interest payments on loans
- — Investments

Cash Flow Projection For 19___.

ASSIGNMENT SHEET #4

Name:________________. Date Completed:__________.

PERIOD		AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL		TOTALS
OPERATING RECEIPTS															
1 Livestock Sales a Fish														1	
2 b Other														2	
3 Sales of Livestock Purchased for Resale									39465					3	39465
4 Crop Sales a													18360	4	18360
5 b														5	
6 Government Payments														6	
7 Other Farm Income														7	
8														8	
9 Total Cash Operating Receipts		—	—	—	—	—	—	—	39465	—	—	—	18360	9	57825
CAPITAL SALES															
10 Breeding Livestock														10	
11 Machinery Equipment														11	
12 Buildings Land														12	
OTHER INFLOWS															
13 Wages and Salaries		1200	1200	1200	1200	1200	800	800	800	1200	1200	1200	1200	13	13200
14 Investments														14	
15														15	
16 Total Cash Inflow (9 + 10 thru 15)		1200	1200	1200	1200	1200	800	800	40265	1200	1200	1200	19560	16	71025
OPERATING EXPENSES															
17 Hired Labor			70	100					100				50	17	320
18 Repairs Machinery and Equipment														18	
19 Buildings and Fences				150										19	
20 Feed				572	570	30	30	30						20	1232
21 Seeds Plants			801											21	
22 Fertilizer Lime Chemicals			2430					1605		375				22	4410
23 Machine Hire												3120		23	3120
24 Supplies														24	
25 Vet Medicine Breeding Fees				325	325									25	650
26 Fuel Oil Lubricants				950			300						947	26	2197
27 Storage Warehousing														27	
28 Taxes (Real Estate and Personal Property)						500								28	500
29 Insurance (Property Liability Crop)														29	
30 Utilities									22					30	22
31 Rents Leases														31	
32 Freight Trucking				375					625					32	1000
33 Miscellaneous			90	90					45			45		33	270
34														34	
35 Livestock Purchased for Resale			29000											35	29000
36 Total Cash Operating Expenses		-0-	32391	2562	895	530	330	1635	792	375	-0-	3165	997	36	43672
CAPITAL EXPENSES															
37 Breeding Livestock														37	
38 Machinery Equipment														38	
39 Buildings Fences Land														39	
OTHER OUTFLOWS															
40 Family Living		900	700	700	700	700	700	700	700	700	700	700	700	40	8600
41 Income Tax and Self Employment														41	
42 Investments	Mobile Home & Truck	437	437	437	437	437	457	202	202	202	202	202	202	42	3834
43														43	
Scheduled Debt Payments															
44 Intermediate Interest														44	
45 principal														45	
46 Long Term Interest		9466												46	9466
47 principal		465												47	465
48 Total Cash Outflows (36 + 37 thru 47)		11268	33528	3699	2032	1667	1467	2537	1694	1277	902	4067	1899	48	66037
CASH FLOW SUMMARY															
49 Beginning Cash Balance		12200	2132	500	500	500	500	500	500	500	423	500	500	49	12200
50 Inflows Outflows (16 - 48)		<10068>	<32328>	<2499>	<832>	<467>	<667>	<1737>	38571	<77>	298	<2867>	17661	50	4988
51 Cash Position (49 + 50)		2132	<30196>	<1999>	<332>	33	<167>	<1237>	39071	423	721	<2367>	18161	51	17188
52 New Borrowing Operating			30696	2499	832	467	667	1737				2867		52	39765
53 New Borrowing Intermediate and Long Term														53	
54 Interest Payments on Operating Loan									2556		22		53	54	2631
55 Principal Payments on Operating Loan									36015		199		3551	55	39765
56 Ending Cash Balance		2132	500	500	500	500	500	500	500	423	500	500	14557	56	14557
DEBT OUTSTANDING															
57 Operating Prin Int		-0-	30696	33195	34027	34494	35161	36898	883	883	684	3551	-0-	57	
58 Intermediate Prin														58	
59 Long Term Prin														59	

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BUSINESS MANAGEMENT
UNIT XV

ASSIGNMENT SHEET #5 — USE A COMPUTER TO EVALUATE AN AQUACULTURAL OPERATION

There are many software programs available for aquaculture record keeping and budgeting. Your instructor will help you select a software program suitable for your enterprise and the hardware available.

Work with the program literature and your instructor to evaluate your operation from both a financial and physical viewpoint. If you have a catfish operation, you might want to try FISHY, a program put out by the Mississippi Agricultural and Forestry Experiment Station, for the financial evaluation of your enterprise. Another good program for financial analysis is AQUACOST, available through Texas A & M. For the physical evaluation, you might want to use a program called GROWCATS, put out by Mississippi State University. GROWCATS estimates the impact of the following:

1. Size and number of fingerlings stocked,
2. Fish harvest weight,
3. Feed conversion ratios, and
4. Amount of feed (percentage of body weight) fed per day and per feeding season

on:

1. The length of the production period and associated harvest weights and dates,
2. Pounds of distribution (over time) of feed needed to grow the fish,
3. Pounds and number of fish produced,
4. Fish losses over the production period.

Another versatile computer program is "Channel Catfish Aquaculture Marketing Systems Analysis" developed by the Agricultural Research and Extension Department at Langston University, Langston, Oklahoma. The program is MS-DOS compatible with screen prompts that provide quick answers and price variables. It is a versatile program suitable for analyzing almost all non-levee pond operations, including cage culture, hill ponds, and multi-use ponds used for fee-fishing and irrigation. The present cost of the disk/documentation package is $10.00. The program is available from:

Langston University Agricultural
Research and Extension Department
P.O. Box 730
Langston, OK 73050

BUSINESS MANAGEMENT
UNIT XV

ASSIGNMENT SHEET #6 — INTERVIEW A LOCAL LENDER AND REPORT ON ATTITUDES ABOUT AQUACULTURE CAPITAL

Review Section XIII in the Information Sheet, and then talk with your instructor and use your phone directory to locate a local lender who is knowledgeable about aquaculture loans.

Set up an appointment to interview the lender. During the interview, write down the answers to questions about interest rates, payment schedules and period, application procedures, paperwork and budgets necessary, collateral, etc.

After the interview, analyze the information you have obtained and report to the class the attitudes of the lender. Compare your lender to lenders interviewed by other class members.

BUSINESS MANAGEMENT
UNIT XV

ASSIGNMENT SHEET #7 — COMPLETE A CHECKLIST TO DETERMINE INDIVIDUAL POTENTIAL IN THE AQUACULTURE INDUSTRY

Under the right circumstances, fish farming—including bait production and fee fishing enterprises — can be very profitable. But, like other forms of farming, fish production may involve substantial investment and risk. The following checklist of factors to consider before entering into fish farming should be helpful in determining your potential in an aquaculture enterprise. It doesn't cover all the possibilities, and answering "yes" to all the questions is no guarantee of success, but then answering "no" to a number of questions doesn't mean automatic failure, either.

Yes	No	**Sources of Information**
☐	☐	Have you made the following personal contacts?
☐	☐	1. Federal and state agencies?
☐	☐	2. Universities, colleges, vocational-technical schools?
☐	☐	3. State and national fish farming associations?
☐	☐	4. Professional consultants, fish farmers, feed distributors, merchandisers?
☐	☐	Have you read everything you can get your hands on concerning fish farming in general and the species and enterprise you plan to operate in particular?
		Economic factors
☐	☐	Is fish farming the best alternative use for your land?
☐	☐	Have you chosen a marketable species and enterprise?
☐	☐	Do you have or can you get necessary financial backing?
☐	☐	Is fish farming the best use of existing capital?
☐	☐	Is the profit potential adequate for the risk involved?
☐	☐	Can you afford losses?
☐	☐	Are there established markets for your product?

ASSIGNMENT SHEET #7

Yes	No	Economic factors (continued)
☐	☐	Do you have alternative marketing strategies?
☐	☐	Are you prepared to market your fish directly? (Or will you depend on processors and wholesalers?)
		Physical factors
☐	☐	Do you already have suitable ponds?
☐	☐	Do you have suitable pond sites?
☐	☐	Will the soil hold water?
☐	☐	Is your water quality high and free of contaminants?
☐	☐	Do you have an auxiliary water supply capable of compensating for evaporation losses, seepage, and flushing if necessary?
☐	☐	Can you drain your ponds?
☐	☐	Do you have equipment and machinery that can be put to multiple use?
		Production factors
☐	☐	Is the necessary seed stock available at reasonable cost?
☐	☐	Are the necessary feeds available at reasonable cost?
☐	☐	Do you have a source of chemicals and drugs needed for water management and fish health?
☐	☐	Do you know of available professional help in the event of disease outbreaks or water problems?
☐	☐	Do you understand water chemistry and oxygen dynamics in fish ponds?

If your responses to these questions are mostly positive, you may feel comfortable about engaging in an aquaculture enterprise.

BUSINESS MANAGEMENT
UNIT XV

TEST

NAME_________________________________ SCORE ______________

1. Match to their correct definitions terms associated with business management. Write the correct numbers in the blanks.

_____a.	A list or record of actual monthly cash levels for a business	1. Budget
		2. Enterprise budget
_____b.	The amount of money that can be obtained through borrowing or selling of assets that is used to promote the production of other goods	3. Cash flow summary
		4. Cash flow projection
_____c.	The point where income is equal to the total of the fixed costs of doing business	5. Capital
		6. Assets
_____d.	Costs that usually do not fluctuate with an increase or decrease in production	7. Depreciation
		8. Fixed costs
_____e.	A formal plan that projects the use of assets for a future time; a schedule of expected returns or costs	9. Variable costs
		10. Enterprise
_____f.	Costs that increase or decrease in relation to an increase or decrease in production	11. Return
		12. Net worth statement
_____g.	Financial record that reflects the profitability of the business over a specified period o time; also knows as a *profit and loss statement* or an *operating statement*	13. Income statement
		14. Break even
		15. Payback
_____h.	A look at the costs and risks involved with producing one commodity or making one product	16. Profit
_____i.	Number of years it takes to recover the initial investment	
_____j.	Financial condition of a business at a definite point in time; it lists all assets, values of assets, liabilities of a business; also known as a *balance sheet, financial statement*, or *statement of financial condition*	

TEST

_____k. An estimate of monthly cash inflows and outflows over a period of time, usually one year

_____l. The property or resources owned and controlled by a business

_____m. The money available after production expenses are subtracted from total income

_____n. A specific process or activity that requires a certain amount of risk to make a profit

_____o. The decrease in value that occurs regardless of repair and maintenance

_____p. The money that remains after all fixed and variable costs are deducted from income

2. List four reasons for keeping records.

   a. ____

   ____

   b. ____

   ____

   c. ____

   ____

   d. ____

   ____

3. Distinguish between basic kinds of records. Write an "F" in the blank before the description of financial records, and "P" in the blank before the description of physical records,

_____a. Show money received and expenses owed for the business

_____b. Show data pertaining to production of aquaculture crop

TEST

4. Distinguish between production credit and consumption credit. Write "PC" before the description of production credit, and "CC" before consumption credit.

   ______a. Credit that usually returns its original cost plus an amount for interest profit

   ______b. Credit for personal use rather than for a use that will generate future income

5. Select from the following list guidelines for building and maintaining a good credit standing. Write an "X" before each correct guideline.

   ______a. Establish a credit rating.

   ______b. Shop around for the best type of loan and interest rate.

   ______c. Get your credit from savings and loan associations.

   ______d. Use the right type of credit.

   ______e. Plan ahead for credit needs by using enterprise budgets.

   ______f. Borrow whenever you do not have immediate available capital.

   ______g. Work out a repayment plan for every loan.

   ______h. Plan the use of loan funds with your family.

   ______i. Meet your payments when due.

   ______j. Plan your credit needs to spread your debts over several areas.

   ______k. Take an annual inventory.

6. List the three C's for good credit.

   a. ______________________________

   b. ______________________________

   c. ______________________________

7. Select from a list factors that a lender looks for in a borrower. Write an "X" before each correct factor.

   ______a. Good reputation

   ______b. Managerial ability

   ______c. Stable financial position

   ______d. Permanence and dependability

TEST

______e. Ability to repay

______f. Sound purpose for loan

______g. Stable family life

______h. Adequate security for loan

8. Select from a list factors a borrower looks for in a lender. Write an "X" before each correct factor.

______a. Good character

______b. Managerial ability

______c. Equitable policies

______d. Permanence and dependability

______e. Knowledge of aquaculture

______f. Fair and competitive cost of credit

9. Select from a list indicators of good loan repayment ability. Write an "X" in the blank before each correct indicator.

______a. Good reputation and character

______b. Complete and accurate records and budgets

______c. Sufficient security for loan

______d. Product price rise

______e. Increase in size of operation

______f. Marginal income

______g. Reliable cost and income estimates

______h. Loan money used only for intended purpose

10 Select from a list indicators of poor loan repayment ability. Write an "X" before each correct indicator.

______a. High production per unit

______b. Low price per unit sold

______c. Low cash production costs

______d. High cash overhead costs

TEST

______e. High cash living costs

______f. Borrowing above the ability to repay

______g. Underestimating the amount of the loan that can be repaid each year

11. Match major types of credit extended by businesses with their correct descriptions Write the correct numbers in the blanks.

______a. Payments are made over a long period of time; interest is charged; a service charge is sometimes added; the customer has the option of repaying the entire amount at any time; if the customer does not maintain payments, merchandise may be repossessed by the lender

______b. The customer may buy in person, by mail or by telephone; no down payment or interest is charged; a statement is sent monthly; the customer has a stated period in which to repay with no interest charge

______c. The business sends monthly bills; the entire bill can be paid within an agreed number of days after billing without interest; if the entire bill is not paid, the customer makes a monthly payment and the unpaid balance is subject to a service charge and/or interest

______d. A maximum amount is usually established; payments are made monthly, depending on the terms of the business; interest is charged; new purchases can be added, up to an established maximum amount.

1. Open account credit
2. Revolving charge credit
3. Optional revolving credit
4. Installment credit

TEST

12. Select correct descriptions of types of loans issued by banks and other lending institutions. Write the correct numbers in the blanks.

______a. Collateral loan

1) Short-term loan for less than one year that is repaid in installments
2) Loan in which legal title to item purchased is held as security or collateral by lending institution
3) Money borrowed to pay all debts

______b. Life insurance loan

1) Loan based on the premiums paid for life insurance
2) Loan based on the insured value of a person's life insurance policy
3) Loan based on the cash value of a person's permanent life insurance policy

______c. Secured personal loan

1) Loan in which legal title to item purchased is held security or collateral by lending institution
2) Loan made on real estate, with the property pledged as security for the loan
3) Loan made with collateral — such as blue chip stock — that is safe and will not lose value

______d. Unsecured personal loan (signature loan)

1) Loan given to a customer with a good credit rating based simply on the customer's promise to repay
2) A bank loan automatically extended through the borrower's checking account
3) Short-term loan (for less than one year) that is repaid in installments or in full at the end of a specified time

______e. Demand loan

1) Short-term loan (for less than one year) that is repaid in installments or in full at the end of a specified time
2) Using a bank credit card such as VISA or Mastercharge to finance purchases or to borrow money
3) Money borrowed to pay all debts

TEST

______f. Passbook loan

1) A bank loan automatically extended through the borrower's checking account
2) Arrangement that allows a person to borrow the amount in his or her savings account without having to withdraw the savings
3) Loan from an automatic teller prompted by a password

______g. Education loan

1) Loan to finance a scholarly project, usually with matching funds from a grantee
2) Loan to finance a post-secondary (after high school) education, with repayment usually deferred until after graduation
3) Loan to finance a graduate education (after 4 years of college or university) with repayment waived after a required period of community service

______h. Consolidated loan

1) Money borrowed to pay all debts
2) Using bank credit cards to pay all debts
3) Loan in which legal title to item purchased is held as security by lending institution

______i. Credit card loan

1) Using a bank passbook to finance purchases or borrow money
2) Using an automatic bank teller card to finance purchases or borrow money
3) using a bank card such as VISA or Mastercharge to finance purchases or borrow money

______j. Check credit loan

1) A bank loan automatically extended through the borrower's savings account
2) A bank loan automatically extended through the borrower's checking account
3) A bank loan automatically extended through the borrower's mortgage principal

TEST

______k. Home improvement loan

1) Special loan for the purpose of increasing the value of a home by adding a room, putting on a new roof, and so on
2) Special home owner's loan based on the amount of equity the borrower has built through mortgage payments against the borrower's mortgage
3) Special loan based on the amount of principal in the home owner's house insurance policy

______l. Mortgage loan

1) Loan made on real estate, with the owner's vehicle(s) held as security
2) Loan made on real estate, with retirement funds pledged as security
3) Loan made on real estate, with the property pledged as security

13. List five sources of credit for aquacultural enterprises.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

14. Match methods of computing interest with their correct definitions. Write the correct numbers in the blanks.

______a. Interest placed on the original loan for the entire period of the loan; the sum of the total interest and principal is divided by the number of payments to obtain the amount of each installment

______b. Amount paid for borrowing money that is repaid in a single lump sum

______c. Interest calculated on the original amount of the loan for the full period of the loan; this amount, plus any other loan costs, is subtracted from the amount of the loan at the beginning, with the borrower receiving the difference

1. Simple interest
2. Remaining balance
3. Add-on
4. Discount

TEST

______d. Interest calculated by multiplying outstanding principal by contractual rate for period in question

15. Calculate true annual interest rates for the following problems. Write your answers in the blanks. Show your work.

    __________a. You have purchased a boat, motor, and trailer for $3,775. You made a down payment of $400, and financed the remaining amount over 3 years at 12 percent interest. Your total finance charges were $985.

    __________b. You replaced your old tractor for one with more horsepower. The new tractor cost $12,000, but you traded in your old one for $4,500. You are financing the remaining $7,500 over 3 years at 11.75 percent interest. Your total finance charges were $2,185.

16. List the four essential components of all budgets.

    a. ____

    b. ____

    c. ____

    d. ____

TEST

17. Select budgeting principles from a list. Write an "X" in the blank before each correct principle.

    _______a. Invest less if returns increase.

    _______b. Invest more if returns increase.

    _______c. Invest as little as possible in costs (inputs).

    _______d. Invest as much as possible in costs (inputs).

    _______e. Invest in a different product if the return (output) is less.

    _______f. Invest in a different product if the return (output) is greater.

    _______g. Invest money where it will earn the largest returns.

(NOTE: Test questions 18 through 24 list the assignment sheets. They are an important part of this test. It they have not been completed, check with your instructor for scheduling and evaluating procedures.)

18. Prepare an equipment cost comparison report. (Assignment Sheet #1)

19. Estimate fixed costs. (Assignment Sheet #2)

20. Develop an enterprise budget to determine actual costs and expected returns. (Assignment Sheet #3)

21. Develop a cash flow projection. (Assignment Sheet #4)

22. Use a computer to evaluate an aquacultural operation. (Assignment Sheet #5)

23. Interview a local lender and report on attitudes about aquaculture capital. (Assignment Sheet #6)

24 Complete a checklist to determine individual potential in the aquaculture industry. (Assignment Sheet #7)

BUSINESS MANAGEMENT
UNIT XV

ANSWERS TO TEST

1.
a.	3	i.	15
b.	5	j.	12
c.	14	k.	4
d.	8	l.	6
e.	1	m.	11
f.	9	n.	10
g.	13	o.	7
h.	2	p.	16

2. Answer should contain any four of the following:

   a. To comply with income tax reporting requirements
   b. To let you compare past performance with present performance and future goals.
   c. To provide the information you need to prepare management tools such as cash flow projections, whole farm budgets, risk management plans
   d. To help you obtain credit
   e. To provide the information needed to apply for government programs
   f. To help you decide what to produce

3. a. F
   b. P

4. a. PC
   b. CC

5. a, b, d, g, i, k

6. a. Character
   b. Capital
   c. Cash-Flow

7. b, c, e, f, h

8. c, d, e, f

9. b, d, e, g, h

10. b, d, e, f, g

ANSWERS TO TEST

11. a. 4
    b. 1
    c. 3
    d. 2

12. a. 2
    b. 3
    c. 3
    d. 1
    e. 1
    f. 2
    g. 2
    h. 1
    i. 3
    j. 2
    k. 1
    l. 3

13. Answer should contain any five of the following:

    a. Commercial banks
    b. Merchants and dealers
    c. Individuals
    d. Finance companies
    e. Insurance companies
    f. Federal Land Bank Associations
    g. Production Credit Associations
    h. Farmer's Home Administration (FHA)
    i. State commissioners of the Land Office

14. a. 3
    b. 1
    c. 4
    d. 2

15. a. 18.72 percent
    b. 13.10 percent

16. a. Capital
    b. Labor
    c. Land
    d. Management

17. b, c, f, g

18-24. Evaluated to the satisfaction of the instructor.

END

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