

Tilapia

AQUACULTURE CURRICULUM GUIDE

YEAR TWO SPECIES MODULE

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

1995 Preliminary Edition

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

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

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

Description: The module consists of the following four problem areas:

Module: Tilapia

Problem Areas: Determining Opportunities in Tilapia Culture
Exploring the Life Cycle of Tilapia
Obtaining Seedstock - Spawning to Fingerlings
Growing Out Tilapia

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

- A. Determining Opportunities in Tilapia Culture
 - Identify the areas of the world where Tilapia occur naturally
 - List the most common cultured species
 - Describe how Tilapia reaches the consumer in the United States
 - Discuss the economics of producing Tilapia in the United States
- B. Exploring the Life Cycle of Tilapia
 - Describe how Tilapia were first introduced to the United States
 - List pros and cons as they relate to introducing a new species
 - List the environmental requirements of Tilapia
 - List common cultured species and their hybrids
 - Discuss the reproductive characteristics of Tilapia
- C. Obtaining Seedstock - Spawning to Fingerlings
 - Describe the hatchery systems that are used to spawn Tilapia
 - Discuss the factors that affect hatchery production
 - Describe the most common procedures used in spawning Tilapia
 - Discuss 3 methods to produce male progeny for stocking
- D. Growing Out Tilapia
 - Describe environments where Tilapia are cultured
 - Describe the type of fingerlings needed for stocking
 - Explain the factors related to stocking rates
 - Explain what Tilapia eat and how they feed
 - List the factors related to growth rate
 - Explain the environmental parameters critical to intensive culture of Tilapia
 - Discuss how Tilapia are harvested and marketed
 - Discuss some of the diseases and parasites that can affect Tilapia

Aquaculture Curriculum Guide

Teaching Plan:

Module: Tilapia Species - Section A

Problem Area: Determining Opportunities in Tilapia Culture

Estimated Time: 2-4 hours

Goal: The goal of this problem area is to learn about the origins of Tilapia culture, the worldwide culture of Tilapia, and the possibilities for Tilapia culture in the United States.

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

- identify the areas of the world where Tilapia occur naturally
- list the most commonly cultured species
- describe how Tilapia reaches the consumer in the United States
- discuss the economics of producing Tilapia in the United States

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

Essential:

Introduction to Aquaculture by Landau, Matthew, John Wiley Sons, Inc., NY, 1992.

Copies of the transparencies made from the masters attached to this teaching plan.

Additional:

Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms by Bardach, John E., John H. Rythe & William O. McLarney, Wiley-Interscience: NY, 1972.

Aquaculture - An Introduction, by Lee, Jasper S. and Michael E. Newman, Interstate Publishers, Inc., Danville, IL, 1992.

The Biology and Culture of Tilapias by Pullin. R. S. and R. H. McConnell. Int. Center for Living Aquatic Res. Man., Manila, 1982 (available from Argent Chemical Laboratories, 8702 - 152nd Ave. NE, Redmond, WA 98052).

The Second International Symposium on Tilapia In Aquaculture, by Pullin R. S. et al. Eds., Int. Center for Living Aquatic Res. Man., Manila, 1988 (available from Argent Chemical Laboratories).

American Tilapia Association. Status Repo 1375 Baxter Ave. NW, Amana, IA 52203

Content and Procedures

Preparation (Interest Approach):

To develop student interest in this module, list the following items on the board:

1. Taste (strong fishy or mild)
2. Texture (flaky or chewy)
3. Feeding (Commercial feeds can be used or natural food only.)
4. Survival Rate (survives well or high loss in confinement)
5. Spawning (difficult or easy in captivity)
6. Water Temperature Requirements (lives well in warm water or requires cold water)
7. Dissolved Oxygen (must have high DO or survives well on low DO)

Ask the students through a show of hands to indicate their choice for an "ideal" fish for aquaculture. Record their choices on the board. Tell them that there is an "almost ideal" fish that fits most of the bill and it is called Tilapia. Ask them if they have ever heard of Tilapia. Ask if anyone has ever eaten Tilapia. Explain to the students that they will learn the positive and negative attributes of Tilapia as an aquaculture species.

Presentation:

A. How are Tilapia classified?

Write the family and genus on board.

1. Tilapia are members of the family Cichlidae, which are generally considered to be substrate spawners.
2. In the United States, the genus is commonly called Tilapia by the American Fisheries Society. Worldwide, they are classified as Oreochromis (maternal mouthbrooder) and Sarotherodon (paternal mouthbrooder). There are more than 110 species.
3. There are about 10 species that have been cultured.
4. Tilapia are sometimes called St. Peter's fish because they are thought to be the fish St. Peter caught in the Sea of Galilee.

B . What is the distribution of Tilapia?

Using a wall map have students locate the areas involved.

1. Tilapia are thought to have originated in south central Africa. They spread north to Syria and south to Madagascar. People have spread Tilapia beyond their native

Aquaculture Curriculum Guide

range. From a bas-relief depicting a fish pond found on the wall of an Egyptian tomb, it is thought that people began culturing Tilapia about 4,000 years ago.

2. Tilapia are found throughout tropical and subtropical latitudes. They were introduced to Java in 1939. The Japanese spread Tilapia to other areas in the Pacific Basin during WW II.

3. Tilapia were introduced to North and South America following WW II. Tilapia culture in the United States (Hawaii) began in 1959. Tilapia culture appeared on the mainland (southern states) after 1959.

C. What species are commonly cultured?

Write the 4 species on the board. Discuss each one. Show photo or slide of each one.

1. Four species are most widely cultured: aurea, mossambica, hornorum, and nilotica.
2. The least desirable species of the 4 is hornorum. It is still widely cultured for production of hybrid all-male fish for stocking.
3. Aurea and nilotica grow more rapidly than hornorum, reproduce at later age and larger size.
4. Pure stocks of species are difficult to find since the range of species overlap and there has been considerable hybridization.
5. Hybrids are being produced by fish breeders to take advantage of the desirable characteristics of each species.
6. Some common trademarked names of commercially produced hybrids include Java Red, Florida Red, Rocky Mountain White, and Golden Tilapia.

D. Who in the world eats Tilapia?

From looking at the wall map, ask students to guess who eats Tilapia. Ask why Tilapia is not well known in the United States. It is not native here.

1. Tilapia exist in wild populations as well as in aquaculture environments. Tilapia are very popular food fishes in the tropical and subtropical regions of the world. Tilapia and carp are the most widely produced freshwater food fishes in the world. Since the fish are consumed from both wild and cultured sources, reliable data on total consumption are not available.

2. Tilapia are a recent introduction in the United States. The American Tilapia Association reported in 1990 that Tilapia production in the United States had reached 7-8 million pounds. Tilapia are also imported into the United States, Southeast Asia, and Central and South America.

3. Tilapia production in the United States may rank 4th after catfish, salmon, and trout.

E. What are the marketing channels for Tilapia in the United States?

If available, prepare Tilapia and other species for taste test. It is suggested that fillets be grilled.

1. Tilapia reach the consumer in several ways. They may be imported from producers in other parts of the world or they may originate from U.S. producers.
2. International producers market their products much the same as seafood producers. Several multinational corporations are involved.

Aquaculture Curriculum Guide

3. In 1991 almost half of the U.S. production was sold live in domestic Asian markets. Some of these markets include Los Angeles, New York City, and Chicago. The other half is sold as fresh fillets. Most imported Tilapia are sold frozen to the institutional trade.

4. Tilapia are sold live, fresh, and frozen - whole and fillets. They are also processed and packaged in frozen meals. Some restaurants feature Tilapia on their menus.

5. Most U.S. consumers are not familiar with Tilapia. Where high-quality Tilapia have been marketed, they have found good consumer acceptance. Tilapia flesh is white, flaky, mild and not too fishy. In short, it is suitable for United States' tastes because consumers in the United States prefer fish that are somewhat bland and do not taste like "fish." Tilapia take on the taste of the spices used in preparation. Some people compare the taste and texture to sole, orange roughy, flounder, or bass.

6. Tilapia are susceptible to off-flavors. To keep acceptance in the United States high, off-flavors must not occur. Wild caught fish and fish produced in less than desirable environments often have off-flavors. For example, algae can cause off-flavors. Producers should taste-test fish before marketing or risk the chance of losing customers.

F. Is it economically feasible to produce Tilapia?

Use TM A2 to show how Tilapia are cultured.

1. Tilapia are produced in ponds, tanks, and cages. Production costs vary widely (\$0.50-1.50/lb in 1991) because of the varied input costs associated with each form of production.

2. One principal economic problem in culturing Tilapia in the United States is the availability of low-cost, low-quality fish from domestic and international sources. These fish compete against high-quality fish in the marketplace.

3. Because of the cold climate, year-round outdoor culture in the United States is limited to its extreme southern regions and to isolated situations where warm water is available, i.e., geothermal regions, power plant cooling water, and indoor systems. Summer pond/tank production is also a possibility in much of the United States if fingerlings can be overwintered economically and depending on state laws governing exotic species.

4. In 1991, prices for live fish at the farm ranged from \$1.00-1.50/lb. Wholesale prices of fillets ranged from \$3.50-5.00/lb. Retail prices ranged from \$3.99-7.99/lb for fillets.

5. Even though Tilapia can be produced as economically in ponds as catfish, Tilapia are considered to be more expensive to process since the yield is lower (38% for boneless, skin-on fillets) and more labor intensive to fillet. Production in ponds often range from 12,000-14,000 lbs/acre. Also, since many Tilapia are ready for market at the same time (October-November), the majority must be frozen.

Review:

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

Application Activities:

Application can be addressed in several ways. Ask students to survey their parents and friends to determine if anyone has eaten Tilapia. Obtain Tilapia from a commercial source, prepare it, and conduct a taste test with the public. Students can survey the community to determine if Tilapia is sold in stores or served in restaurants.

Evaluation:

Evaluation should focus on the extent to which students achieved the objectives of the problem area. Examples include oral questioning, a class debate on the merits of producing Tilapia in an aquaculture environment, written reports, and written exams. Example exam questions are attached.

U.S. Production Rank

- #1 Catfish
- #2 Salmon
- #3 Trout
- #4 Tilapia

Production Methods

- Ponds
- Tanks
- Cages

Where Tilapia Can Be Cultured in the United States

- Extreme southern regions of continental United States
- Tropical areas such as Hawaii
- Geothermal regions
- Power plant cooling water
- Indoor systems
- Summer pond/tank production

Economics of Production (1991 Estimates)

- Prices for live fish at farm: \$1.00-1.50/lb
- Prices for fillets: \$3.50-5.00/lb (wholesale) and \$3.99-7.99 (retail)
- Production cost (large operation): \$0.50-1.50/lb
- Fillet yield: 38%
- Pond yield: up to 12,000-14,000 lbs per acre

Aquaculture Curriculum Guide

Quiz for Section A

Name:

Date:

Quiz on Determining the Opportunities in Tilapia Culture

Circle T for True statements and F for False statements.

1. T F Tilapia originated in South America.
2. T F Tilapia occur naturally in the temperate regions of the world.
3. T F Tilapia were first produced in the southern United States after 1959.
4. T F Tilapia are sometimes call St. Peter's fish.
5. T F The 3 most commonly cultured species are aurea, mossambica, and nilotica.
6. T F The least desirable species for culture is nilotica.
- 7 T F All Tilapia for human consumption are imported into the United States.
- 8T F Tilapia is distributed to the consumer much the same as seafood.
9. T F The live price paid to farmers for Tilapia ranges from \$2.00- 3.00 per pound.
10. T F Production costs of Tilapia range from \$0.5-0.60 per pound.

Key for Quiz - Section A:

1. F
2. F
3. T
4. T
5. T
6. F
7. F
8. T
9. F
10. T

Aquaculture Curriculum Guide

Teaching Plan:

Module: Tilapia Species - Section B

Problem Area: Exploring the Life Cycle of Tilapia

Estimated Time: 48 hours

Goal: The goal of this problem area is to help students understand the biology and life cycle of Tilapia. In addition, students will learn cultural requirements of Tilapia.

Learning Objectives: Upon completing this problem area, students will be able to:

- describe how Tilapia were first introduced to the United States
- list pros and cons as they relate to introducing a new species
- list the environmental requirements of Tilapia
- list common cultured species and their hybrids
- discuss the reproductive characteristics of Tilapia

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

Essential:

Copies of the transparencies made from the masters attached to this teaching plan.

Introduction to Aquaculture, by Landau, Matthew, John Wiley & Sons, Inc., NY, 1992

Additional:

The Biology and Culture of Tilapias by Pullin, R. S. and R. H. McConnell., Int. Center for Living Aquatic Res. Man., Manila, 1982.

The Second International Symposium on Tilapia in Aquaculture by Pullin, R. S. et al. Eds. Int. Center for Living Aquatic Res. Man., Manila, 1988.

World map and/or globe

Content and Procedures

Preparation (Interest Approach)

To develop student interest in this module, ask the following question: What conditions are necessary to sustain the life of a person? List their answers on the board. Possible answers include air, water, food, shelter, clothing. How does this list differ when applied to fish? Discuss their answers. Explain that all living organisms have environmental requirements. Explain that the class is going to learn about the particular cultural requirements of Tilapia so that we can understand how they can be "aqua-cultured" by humans.

Presentation:

A. Why aren't Tilapia well known to people in the United States?

Show on the world map tropical and temperate regions of the world. Look in the dictionary for characteristics of each. Relate this information to culture requirements.

1. As presented earlier, Tilapia are distributed all over the tropical and subtropical altitudes. The reason they do not exist naturally in more temperate climates is that they are tropical fish and cannot survive in cold water.
2. Tilapia are considered to be some of the most hardy fish known. They tolerate crowding and poor water quality. They can exist in water too warm and too low in DO for other fishes. Many of them can exist in brackish water.

B. How were Tilapia introduced into the United States?

Ask students why it concerns many people when a new species is introduced into an area outside its natural range.

May compete with native species. Unintended consequences.

1. Tilapia were originally introduced in the United States for biological vegetation control. They are still used to some extent for this purpose. They are also used to a limited extent for a commercial food animal and as a sport species. There is some interest in the use of Tilapias in waste lagoons as a living organism (filter feeder) to remove nutrients before waste water is discharged. In addition, they are used in the aquarium industry.
2. Some biologists perceive Tilapia as threats to the environment and to native fishes. There is evidence that Tilapia can quickly populate and then dominate a lake or stream if environmental conditions are favorable to them. Through their aggressiveness, they can also disrupt the spawning of native fishes.
3. In most parts of the continental United States Tilapia cannot establish a sustaining population because they die during the winter. This characteristic eliminates the

overpopulation problem that can exist in southern states, Hawaii, and other U.S. territories and protectorates.

C. What are some of the environmental characteristics?

Use TM B1 to explain some of the cultural requirements.

1. Tilapia do not grow well at temperatures below 16°C (60°F) and many will die at 50°F. Their immune systems are reduced when the temperature falls below 68°F.
2. Tilapia are omnivorous but are often described as primarily herbivorous. Some prefer higher plants while others are adapted to feed on plankton. In an aquaculture situation, they are usually fed a grain-based prepared feed.
3. Tilapia are freshwater fish, but some species are well-adapted to brackish water. Some species cannot tolerate sea water.
4. Tilapias are similar in appearance to sunfish such as bluegills. Normal color patterns include blue, green and black. They often have red highlights. Golden, white, pink, and red colors are also propagated commercially for aquaculture. These colors are desirable in some markets, but some people may associate these colors with goldfish or carp and may discriminate against fish with these colors. When it comes to skinless fillets, color is not a factor.

D. What species are commonly cultured?

Use TM B2 to show common species.

1. Cultured Species. Four species are most widely cultured. These are aurea, mossambica, nilotica, and hornorum. Many other species exist and are being evaluated for aquaculture. These include andersoni, galilea, heudelod, macrochir, melanopleura, and zillii. Many other species exist and some of them may be used in aquaculture systems in the future.
2. Hybridization. Hybrids are commonly used in aquaculture systems. Hybrids of certain crosses of mouthbrooders are nearly all males. Many of the hybrids grow faster and larger than either of the parents. Unwanted reproduction is also reduced with some hybrids.

Use TM B4 to explain hybrids.

3. Perhaps the most popular hybrids are female nilotica x male hornorum and female nilotica x male aurea. These crosses produce predominantly male offspring which grow fast and reach weights of .5 to 1 lb in 200-250 days. Another hybrid is female mossambica x male hornorum.

E. What are some of the reproductive characteristics of Tilapia?

Explain what a “mouthbrooder” is. Have students use reference materials to find other tropical fish with this characteristic. Optional activity: Keep tropical hobby fish in aquarium. Select mouthbrooders for this activity.

1. Most commercially cultured species of Tilapia are mouthbrooders. The males build nests on the bottom of ponds much as bluegills do. After a brief courtship the females spawn. Eggs are laid in the nest and then picked up by the female. The male discharges sperm into the nest. The female picks up the sperm in her mouth. Thus,

Aquaculture Curriculum Guide

the eggs are fertilized inside the female's mouth. (Note: Males of some species or hybrids also hold young in their mouths.) Also, for some species, the male fertilizes the eggs in the nest. Hatching typically occurs in 3-5 days, depending upon water temperature.

2. Once the eggs have hatched, the fry (larvae) remain in the mouth of the female until the yolk sac has been absorbed. The swimbladder then inflates. For a few days after the fry are released (10-15), the female usually remains near the fry. The young fry will retreat inside the female's mouth when they feel threatened.

3. Sexual maturity for females occurs very early. Females can be mature at only 10 cm in length and 3 months of age for mossambica (6 months for aurea) and nilotica. Females lay about 35-1000 eggs at a time. They may have as many as 6-11 broods per year.

4. Photoperiod is not a critical factor in spawning as long as there are at least 10-16 hours of light (some sources list 12-14 hours as optimum). Temperature is critical; Tilapia will not spawn if the temperature falls below 20°C. The optimum temperature is 82-86°F.

5. One major problem encountered in raising Tilapia (unless all-male hybrids are stocked) in pond culture can be overpopulation. As reproduction occurs, the population grows at a rate such that stunting can occur. Success or failure of the enterprise may rest on the producer's ability to solve this problem. Solutions to this problem will be addressed later in this module. Some producers have not experienced this problem of overpopulation. They maintain that the larger fish will consume the smaller fish, thus limiting the effects of overpopulation. However, eggs are still being produced by the females, resulting in loss of efficiency.

Review:

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

Application Activities:

Application can be addressed in several ways. Students can conduct library research on various species of tropical fish that are also mouthbrooders. They can report their findings to the class. Students can also use reference materials to determine the pros and cons of introducing non-native species to a new environment. Examples include zebra mussels, common carp, nutria, and rabbits in Australia. Emphasize both the positive and negative results. An aquarium project with either Tilapia or other tropical mouth brooders would be an excellent application. No special nesting materials are needed to spawn Tilapia in an aquarium.

Evaluation:

Evaluation should focus on the extent to which students achieved the objectives of the problem area. Examples include oral questioning, a class debate on the merits of producing Tilapia in an aquaculture environment, written reports, and written exams. Example exam questions are attached.

Tilapia Cultural Characteristics

Temperature: Need temperatures above 16°C (60°F).
Some may die when temperatures fall
below 50°F.

Diet: Considered to be omnivorous.
Some eat higher plants; some
eat plankton.

Salinity: Considered to be freshwater fish.

Appearance: Shaped like bluegills. Colors range from
blue to green to black. Golden, pink,
white, and red fish are produced
for aquaculture.

Commonly Cultured Tilapia Species

- aurea
- mossambica
- nilotica
- hornorum

Other Tilapia Species

Many species exist and are being evaluated for potential in aquaculture. These include:

- andersoni
- galilea
- heudeloti
- macrochir
- melanopleura
- zilli

Hybridization for Tilapia Aquaculture

Many hybrids are being tested. Some of the more common hybrids being used in aquaculture include:

Female

Male

1. nilotica x hornorum
2. nilotica x aurea

(produces nearly all-male offspring)

3. mossambica x hornorum

Reproduction Facts for Tilapia

- Mouthbrooders - Eggs are incubated in female's mouth.
- Eggs hatch in 3-5 days.
- Fry (larvae) remain in female's (or male's) mouth until yolk sac has been absorbed and swimbladder inflates.
- For a few days after fry are released, female remains near fry. When danger is sensed, fry return to female's mouth for protection.
- Sexual maturity for females begins when they are about 10 cm in length and 3 months of age (mossambica) or about 6 months for aurea and nilotica.
- Females lay about 35-1000 eggs at a time and may raise 6-11 broods in a year.
- Photoperiod is not considered to be a factor in spawning as long as there are at least 10-14 hours of light (12 hours considered to be optimum).

- No spawning occurs when temperature falls below 20°C.
- Overpopulation may be a major problem, resulting in stunting.

Quiz for Section B

Name:

Date:

Directions: Write your answer in the space provided.

1. Why were Tilapia first introduced into the United States?

2. List 2 reasons why some biologists perceive Tilapia to be a threat to the native environment.

3. What is the major reason why Tilapia cannot establish a population in the northern states?

4. What domestic fish looks most like Tilapia?

5. What do Tilapias eat?

6. What are the 4 most commonly cultured species?

7. What is a "mouthbrooder"?

8. What are the 2 most common hybrids?

9. List a hybrid that results in nearly all-male offspring.

10. What can be the result of overpopulation in Tilapia?

Aquaculture Curriculum Guide

Key for Quiz - Section B

1. biological vegetation control
2. overpopulate and dominate a stream, disrupt spawning of native species
3. too cold in fall, winter, and spring
4. bluegill
5. omnivorous - eat plants and plankton
6. aurea, mossambica, nilotica
7. fish that incubates its eggs in its mouth
8. female nilotica and male hornorum; female mossambica and male hornorum
9. female nilotica and male hornorum or aurea
10. stunting of all fish in the water

Teaching Plan::

- Module:** Tilapia - Section C
- Problem Area:** Obtaining Seedstock - Spawning to Fingerlings
- Estimated Time:** 5-10 hours
- Goal:** The goal of this problem area is to help students understand spawning, production of fry, and production of fingerlings.
- Learning Objectives:** Upon completing this problem area, students will be able to:

describe the hatchery systems that are used to spawn Tilapia
discuss the factors that affect hatchery production
describe the most common procedures used in spawning Tilapia
discuss 3 methods to produce male progeny for stocking

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

Essential:

Copies of the transparencies made from the masters attached to this teaching plan.

Hatchery Systems for Mouthbrooding Tilapias,” in R.O. Smitherman and D. Tave (Eds.) **Proceedings: Auburn Symposium on Fisheries and Aquaculture**, by Behrends, Leslie L., and Lee., Auburn University, AL, 1984.

Recent Advances in Aquaculture, by Muir, James F. and R. J. Roberts, Westview Press: Boulder CO.

A large aquarium set up or tank set up (see Year One materials) to spawn Tilapia as a class project. An alternative would be to spawn a tropical (hobby) fish that is a mouth brooder.

Additional:

The Biology and Culture of Tilapias, by Pullin. R. S., R. H. McConnell., Int. Center for Living Aquatic Res. Man., Manila ,1982.

The Second International Symposium on Tilapia in Aquaculture, by Pullin, R. S. et al., Eds. Int. Center for Living Aquatic Res. Man., Manila, 1988.

Content and Procedure

Preparation (Interest Approach)

To develop student interest in this module, ask the students the following questions:

- Where does one get the seed to plant tomatoes?
- Where does one get chicks to stock a broiler house?
- Where does one get pine seedlings to start a forest?

The answers should include both producing and purchasing the seed, chicks, or seedlings. Why would one choose to purchase seed rather than produce it? Answers should include easier to purchase, less knowledge needed to purchase, more economical to purchase, do not have facilities to produce seed, do not have time to produce seed, and purchased seed may be of higher quality than seed produced at home. Finally, explain that Tilapia seedstock is similar to the above. One can produce it or buy it from an outside source. Which is better? That depends on many factors that will be discussed in this topic area.

Presentation:

A. What hatchery systems are used to spawn Tilapia?

Use TM C1 to explain hatchery systems.

1. In most aquaculture enterprises, obtaining spawn is one of the most difficult tasks. Tilapia spawn is easier and more often than other species and don't have an easily definable spawning season.
2. Hatchery systems for producing Tilapia can be grouped into four general categories: earthen spawning ponds, small tanks, nylon net enclosures (hapas), and aquaria.
3. Spawning in ponds, called the spawning/rearing method, is the least complex and most used. It is also the least efficient in terms of production for the volume of water used. Problems include low broodstock density, less selective breeding, inefficient harvesting techniques, and cannibalism.

Use TM C2 to explain spawning in ponds.

4. Hatchery systems utilizing tanks, suspended nets, or aquaria can be managed more intensively for higher production. Aquaria are the most productive and are used extensively to propagate genetically pure strains. These strains are then used to produce F1 hybrids for production systems.

B. What factors affect hatchery production?

Conduct a discussion using transparencies or board. Use TM C3 to explain production.

1. Hatchery production involves the number of female broodstock, average number of fry per clutch (eggs from one female), average time interval between spawns, and duration of the spawning season.
2. Several biological and environmental factors affect the above parameters: water, temperature and photoperiod, water quality, nutrition, age and size of broodstock, broodstock density and sex ratio, egg/fry removal, incubation, and disease control.

Use TM C4 to explain biological and environmental factors.

3. Water temperature and photoperiod are two of the major environmental stimuli that regulate sexual development and spawning. In the Tilapia's natural habitat, water temperature and day length are relatively constant. Tilapia spawn year around under these conditions.
4. In temperate climates, spawning begins to occur when temperatures reach 22°C and photoperiods are between 10-16 hours of daylight. Tilapia can be induced to spawn in aquaria year-round by maintaining temperatures of 25-29°C and photoperiods of 10-16 hours of light.

Use TM C5 to explain how temperature and photoperiod affect spawning.

5. Water quality may also have an effect on spawning. Some hatchery operators exchange water every 12 days. Some hatchery operators also feel that hatchery production of some species (aurea and mossambica) may be increased by using brackish water.
6. Nutrition is considered to be critical in hatchery systems that do not have natural food available to the broodstock. A high protein feed is recommended. Producers use a variety of prepared feeds ranging from catfish fingerling feed (40% protein) to trout grower (40-42% protein).
7. The number of eggs/fry is positively correlated with size of female broodstock.
8. Some species (mossambica) produce more fry when the ratio is 3 females to 1 male as compared with any other ratio. Some biologists recommend a 1:1 ratio to reduce incidence of inbreeding. Also, as broodstock density increases, the number of eggs per female tends to decrease. A density of 10 fish or less per square meter is recommended.
9. Tilapias incubate their eggs and provide care of newly hatched fry for about 20-25 days. This limits the frequency of spawning since the hatchery manager is waiting for the fry to become independent. Some hatchery managers remove eggs 2 days after fertilization or fry when they reach 10-16 mm to increase the frequency of spawning. Cannibalism is also reduced since small fingerlings will eat newly hatched fry. The producer must segregate fry according to size to prevent cannibalism.

10. If fertilized eggs are removed from the female, the hatchery manager must provide for incubation of the eggs. The eggs require constant movement. The female does this naturally. Shaker tables or recirculation systems with standard hatchery jars can achieve hatching rates of up to 90%. Some producers have converted 2-liter plastic pop bottles to hatchery jars.

11. Most drugs are not approved for use by the FDA in production systems. Researchers and growers are attempting to gain approval for some therapeutics for aquaculture. Check with your state aquaculture extension specialist for current recommendations. Raising the temperature of Tilapia eggs and fry to 90°F is one of the most cost-effective ways to treat fungus and bacteria problems.

C. What is the most common method of spawning?

Conduct a discussion using transparencies or board.

1. Tilapia are typically spawned in an earthen pond. This method is known as spawning/rearing. The spawning pond should be stocked with 25-30 females/1000 square meters and 12-15 males. Fry are netted from the pond and (if needed) sorted for size.

Use TM C6 to describe earthen pond method.

2. After the pond is stocked, and the water temperature reaches about 25-29°C, the males will begin to dig small round holes in the bottom of the pond. These depressions look much like the nests of bluegills and other native species. The female deposits her eggs into the nest a few at a time and takes them into her mouth. It may take an hour to lay the entire clutch. Large females (.75-2 lb) can lay 700-2000 eggs.

Activity: If pond is available, have a class project to spawn Tilapia. Drain pond first and make sure no other fish are present in pond.

3. As the female takes the eggs into her mouth, the male deposits sperm into the nest or into the water. The female picks up the sperm, and fertilization of the eggs takes place in the female's mouth.

4. Hatching occurs about 3-5 days (depending on water temperature) after fertilization. The fry (larvae) are retained in the female's mouth until the yolk sac is absorbed. The fry are then released, but may return to the female's mouth at night or when they feel threatened. During this time the female may not eat. The fry can exist by themselves at this time. The major function of the mouthbrooding is protection from predators, including larger Tilapia fingerlings. (Fry can be removed from the pond by netting.) Some producers cannot get enough fry by this method since many of the fry will be eaten. They seine the broodfish and cause them to panic. The broodfish will then release the 1-3-day-old fry from their mouths. The producer then quickly seines the schools of fry with a fine mesh dip net before the larger fish can eat them. This method also helps producers to obtain uniform size fry. Some producers seine the broodfish and flush the fry from their mouths. The fry are placed in a separate pond or an indoor facility and fed until they are ready for stocking. Fingerlings should be graded for size using mechanical bar graders before stocking. Pelleted feed is used. Little is known about their specific nutritional requirements. Some producers use a 60% trout fry ration. The fry consume plankton and detritus from the water.

5. The young fry can become sexually mature in as few as 2-3 months, typically 6 months (1 lb) is more accurate for commercially produced hybrid. They can reproduce every 3-6 weeks as long as the water temperature remains warm. They can be sexed when they are about 2 inches long or about 50 g in weight. Mossambica can be sexed at 10 g in weight.

D. What other hatchery systems can be used?

Activity: Refer to Year One materials. Set up a tank or large aquarium. Spawn Tilapia as a class project. Follow temperature and other requirements listed in module. Have a separate aquarium ready to receive fry as they are netted.

1. Tank production of fry is also successful. One example is a rectangular plywood tank unit. Another example is the use of aquaria. It is interesting to note that no special nesting materials must be supplied. Gravel is sometimes used, but a clean tank is preferred. Tilapia will continue to spawn as long as the basic environmental requirements are met.

2. Little is known about stocking densities or male/female sex ratios. Only 1 male is placed in a tank or aquarium. The 1 male to 4-5 females rule still applies, but some researchers feel that a ratio of 1 male to 3 females is better when using aquaria for spawning. Other researchers say a 1:1 ratio is best; the genetics can be controlled (i.e., no inbreeding) and records can be kept. Tilapias are territorial; increasing the number of males causes aggression. Some cannibalism has been observed when tanks are overcrowded: the fish will consume the eggs or fry. This can be reduced by netting out the fry as they are observed. Also, use the nylon net enclosure so fry can separate themselves from the larger fish. Some authors say that a 55-gallon aquarium be used; others report success with aquaria as small as 20 gal. Depth is not as critical as bottom area.

3. There are some advantages to producing fry in a tank or aquaria system. Although considered to be impractical or uneconomical for many production systems, this type of hatching system allows for more control. Environmental factors can be controlled and specific; controlled crosses can be made. For these reasons, this type of hatching system is useful in producing consistent quality fish for stocking or brood stock.

E. What methods are used to produce male fingerlings for stocking?

1. No matter which type of hatchery system is employed, the problem for some producers is overpopulation. It is not enough to simply produce fry. Producing fry is not difficult. Some producers don't have a hatchery; Tilapia will reproduce as long as their basic requirements are met. Stocking fry of mixed sexes into a pond or tank can prove to be a disaster if production of food size fish is the goal. Under these conditions the fish will become sexually mature and will start reproducing. All fish will remain small. Solving this problem can spell the difference between success and failure in a commercial operation. If left alone, the excessive reproductive behavior of Tilapia can cause a pond to become overstocked. The result will be stunted fish of little or no value. Some producers have not experienced this problem. They state that the biggest problem is having enough of the same size and quality fish to stock ponds at high density in the spring for grow out. They maintain that the fish will be of market size before much reproduction has occurred. They further state that most of the resulting fry will be consumed by the older fish. Naturally, there must be no large fish in the pond when fingerlings are stocked in the spring.

2. There are three basic ways of addressing overpopulation if it is a problem. These include hand sorting of individual fish for monosex stocking of all male populations, hybridizing two species to produce almost 100% male progeny, and using androgens (male hormones) to cause sex reversal of females. In each case, the goal is to produce all-male fry (and fingerlings) for stocking. Males grow about 20-30% faster than females.

Use TM C7 to explain the three methods of producing male progeny.

3. The first attempt at solving this problem involves hand sorting. Fry are fed until they reach a size (30-40 g) that they can be sorted by sex. The sorting process is labor

intensive and not 100% successful. People sex the fish by examining their urogenital papillae. The visual differences are minimal and it takes a skillful eye to keep from making a mistake. Only males are stocked from this process thus wasting the other 50% females. With the possibility of error, some females will be stocked with males.

Research has shown that even a few females in a pond can produce offspring that over time will cause a change in population density. Also, the males will not grow as fast. Even with the problems associated with hand sorting, this method is still used in many parts of the world where alternatives are not practical. In a school situation, hand sorting may also prove to be prudent.

4. Another method of achieving all-male fingerlings for stocking is by hybridizing two Tilapia species. By selecting the correct combination of species, a Tilapia producer can end up with almost 100% male fry. Another possible benefit is that it is thought that hybrids are capable of more rapid growth as a result of heterosis (effect of crossbreeding). Perhaps the most popular hybrid is female nilotica x male

honorum. This cross produces nearly all-male offspring that are cold tolerant, grow fast, and reach weights of .5 to 1 lb in 150-250 days. Other hybrids are female mossambica x male honorum and nilotica x aureus. The disadvantage to this technique remains that no cross results in 100% male offspring. Also more management is required to maintain "pure" lines of broodstock. This method is very popular in commercial operations. One advantage that should be stressed is that few females are discarded when fry are produced this way.

5. The third method involves sex reversal of fry (during the first 30 days after leaving brooding) before their gonads develop. Fry are fed androgen-treated diets to cause them to develop into males. The typical androgen treatment involves the use of methyltestosterone or ethyltestosterone. Gonad differentiation takes place between day 16 and day 20 for some species such as mossambica. The time varies for different species. Success rates for this procedure are reported to be as high as 95-

100%. This procedure is still considered to be experimental and is not used extensively in commercial Tilapia operations in most parts of the world. Exceptions include Israel and Taiwan. The concern is in marketing hormone-treated fish. Most researchers assert that the hormone levels in treated fish are no higher than in nontreated fish. This procedure can only be used under specific approval by FDA. At some time in the future, this method may become the standard in the world. Research continues in this area.

6. Some producers have not experienced overpopulation problems. They stress stocking high quality, same-sized fingerlings and not being overly concerned with reproduction during the grow out period.

Aquaculture Curriculum Guide

Review:

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

Application Activities:

Application can be addressed in several ways. If the class has access to a tank or suitable pond, a spawning project would make an excellent application. An aquarium spawning project with Tilapia should be required. No special nesting materials are needed to spawn Tilapia in an aquarium. Students can also do library work to locate current articles on spawning and producing Tilapia. Students can do library work to see what other food products have regulations involving the use of hormones, i.e., growth hormones and beef cattle and hormone use with dairy cattle. Students could design a hatchery system on paper to produce 1 million fingerlings each year.

Evaluation:

Evaluation should focus on the extent to which students achieved the objectives of the problem area. Examples include oral questioning, a class debate on the merits of spawning Tilapia by one of the methods studied, written reports, and written exams. Example exam questions are attached.

Hatchery Systems for Tilapia

- Earthen spawning ponds
- Small tanks
- Nylon net enclosures (hapa)
- Aquaria (20-30 gallon)

Spawning Tilapia in Ponds: Most Common Method

- A. Advantages
 1. Least complex
 2. Least costly

- B. Disadvantages
 1. Higher volume of water required
 2. Low broodstock density
 3. Inefficient harvesting techniques
 4. Cannibalism

Hatchery Production

Efficiency is largely a function of:

- The number of female broodstock
- Average number of fry per clutch
- Average time interval between spawns
- Duration of the spawning season

Biological and Environmental Factors Affecting Hatchery Production

- Water temperature
- Photoperiod
- Water quality
- Nutrition
- Age and size of broodstock
- Broodstock density
- Sex ratio
- Egg/fry removal
- Incubation

- Disease control

Temperature/Photoperiod Required for Spawning

- A. Outside
 - 1. In temperate climates, spawning begins at 22°C
 - 2. Photoperiod: 10-16 hours of daylight

- B. Inside
 - 1. Spawn in aquaria year-round at 25-29°C
 - 2. Photoperiod: 12-14 hours of light are optimum

Spawning Tilapia in Earthen Ponds

- Known as spawning/rearing method
- Stocking Rate: 25-30 females/1000 square meters and 12-15 males
- Fry are netted from the pond and (if needed) sorted for size
- Fry stay near pond bank - relatively easy to net with a seine

Three Ways to Produce Male Progeny for Stocking

The goal is 100% male stocking

1. Hand sorting of individual fish for monosex stocking of all male populations.
Note: Not very efficient - one worker can sort only about 1000 males in an 8-hour day.
2. Hybridization of two species to produce almost 100% male progeny.
3. The use of androgens (male hormones) to cause sex reversal of females

Aquaculture Curriculum Guide

Key for Quiz - Section C

1. Earthen ponds
2. The number of female broodstock. Average number of fry per clutch. Average time interval between spawns. Duration of the spawning season
3. Water temperature
Photoperiod
Water quality
Nutrition
Age and size of broodstock
Broodstock density
Sex ratio
Egg/fry removal
Incubation
Disease control
- 4-5 Hybridization. Less skilled labor than hand sorting. Hormones not approved in United States.

Teaching Plan:

Module: Tilapia - Section D

Problem Area: Growing Out Tilapia

Estimated Time: 5-10 hours

Goal: The goal of this problem area is to help students understand how to care for Tilapia in a grow out system.

Learning Objectives: Upon completing this problem area, students will be able to:

describe environments where Tilapia are cultured
describe the type of fingerlings needed for stocking
explain the factors related to stocking rates
explain what Tilapia eat and how they feed
list the factors related to growth rate
explain the environmental parameters for intensive culture of

Tilapia

discuss how are Tilapia harvested and marketed
discuss some of the diseases and parasites that can affect Tilapia.

Instructional Resources: The following resources are needed for this problem area:

Essential:

Copies of the transparencies made from the masters attached to this teaching plan.

Recent Advances in Aquaculture by Muir, James F.& R. J. Roberts, Westview Press: Boulder, CO.

A large aquarium or tank set up (see Year One materials) to grow Tilapia as a class project.

Additional:

Cage Culture of Tilapia, by McGinty, Andrew S. and James E. Rakocy, Southern Regional Aquaculture Center: SRAC Publication No. 281, 1989.

The Biology and Culture of Tilapias, by Pullin. R. S. and R. H. McConnell, Int. Center for Living Aquatic Res. Man., Manila, 1982.

The Second International Symposium on Tilapia in Aquaculture, by Pullin, R. S. et al. Eds. Int. Center for Living Aquatic Res. Man. Manila, 1988.

Tank Culture of Tilapia, by Rakocy, James E., Southern Regional Aquaculture Center, SRAC Publication No. 282, 1989.

Aquaculture Curriculum Guide

Pond Culture of Tilapia, by Rakocy, James E. and Andrew S. McGinty, Southern Regional Aquaculture Center, SRAC Publication No. 280, 1989.

Content and Procedures

Preparation (Interest Approach)

To develop student interest in this module, propose the following situation: A woman phoned you, the teacher, and asked if your class would like to have 100 Tilapia fingerlings. She is the manager of a fish farm, and she knows that your class is studying new and emerging agricultural technologies. To keep from offending her, you agree to take the fingerlings. She tells you that she will deliver them to the school in 3 weeks. You hang up the phone and realize that you know nothing about raising Tilapia and you should have refused the contribution.

Now that you have agreed to take the fingerlings, what is your class going to need to know to keep the fingerlings alive? What are the questions that need answering? Answers should include the following: What do Tilapia eat? How much do they eat? What kind of facility will be needed to house them? What water quality is required? What temperature do they require? Ask the class where do we find the answers. In this module, you will learn how most Tilapia are cultured and what recent developments may change the way they are cultured.

A. What are the different environments in which Tilapia are cultured?

Use TM D1 to show culture systems.

1. Worldwide, the most common way Tilapia are cultured is in pond systems. After pond systems, the literature discusses tank, cage, and raceway culture. Finally, there are a number of producers and researchers experimenting with indoor, intensive, closed recirculating systems.

2. If an intensive system, such as tanks, raceways, or indoor systems is to be used it must have the following characteristics: smooth interior, self-cleaning, ability to supply high water quality, made of nontoxic material, easily sterilized if needed, low construction cost, good feed distribution, water flow, and adaptable to various stages of growth of the fish. See Year One materials for details.

3. As explained in Section A, Tilapia exist naturally in fresh and brackish water in the tropical regions of the world. When they are cultured, it is most often through pond systems and cage culture. At a subsistence level, Tilapia are cultured in a polyculture situation with other fish species or in a monoculture situation. Some research suggests that intensive polyculture of catfish and Tilapia is feasible.

4. From the standpoint of commercial production of food fish, ponds with monoculture, monosex, management is the most common. With proper management monosex culture is not as important. Polyculture with other species, such as catfish, also shows much promise.

B . What type of fingerlings should be procured for stocking?

Use TM D2 to explain characteristics of fingerlings.

1. The best fingerlings to stock in ponds, raceways, cages, or tanks have proved to be all-male hybrids. Second best is all males of the same species, and third is culture of mixed sexes. Fingerlings are ready for stocking at 2-4 inches in length or about 30-50 g in weight.
2. Fingerlings may be produced by the same person who will grow them out or they may be purchased. Fingerling production was presented in Section C. When purchasing fingerlings it is important to specify what you want and to purchase them from a reputable producer.

C. At what rates are Tilapia stocked in the various grow out systems?

Use TM D3 to discuss stocking rates.

1. Stocking rates for Tilapia will vary according to the type of grow out system they will be placed in. In pond systems, stocking rates range from 5,000-30,000 per ha in some parts of the world. Some producers stock at a high rate and then transfer fish as they grow to rearing ponds to effectively cut the stocking rate as the fish grow. One example is to stock 60,000 20-g fingerlings per ha. When they grow to 50 g, they are divided into two ponds to attain the 30,000 per ha rate. Most U.S. producers stock at a lower rate (3,000-5,000/acre) in ponds and feed a higher protein ration for increased weight gain; however, some producers stock up to 12,000/acre in constantly aerated ponds. In cages stocked at the recommended rate of 300 lbs per cubic meter of tank space, the total stocking density for the entire pond should not be greater than 2,000 lbs per acre.
2. In systems other than ponds, it is difficult to determine "average" or "recommended" stocking rates. Much research is being conducted on this subject and the best answer lies with each specific system being used. Some producers suggest that in tanks the rate is about 2-5 lbs per cubic foot if liquid oxygen is supplied. With blown air or surface agitation, no more than 1/3 lb of fish per gallon of water is recommended. With pure oxygen injection, a normal stocking density is 2/3 lb per gallon of water in the tank.
3. The question is not how many fish can be stocked in a given system but what is the most economical stocking density for the system employed and the level of management used. For tank systems, the question is how much feed can be fed on a daily basis without destroying water quality. When the stocking density is increased in a pond, the existing natural food supplies are depleted faster and water quality is stressed. On the whole, Tilapia react well to stress, but also respond well to good management and good nutrition. The limiting factor often is DO (dissolved oxygen), followed by ammonia toxicity, then social factors/crowding.

D. What do Tilapia eat and how are they fed?

Use TM D4 to discuss nutrition.

1. In a low stocking density situation (500 lb/acre) there often is enough natural food for Tilapia to survive. They eat plankton and/or detritus. On a dry weight basis, natural food can contain about 55% protein. To encourage natural food growth, ponds are often fertilized with organic and/or inorganic fertilizers. There is no agreement among researchers and producers as to the amount of fertilization necessary or desirable. Research is being conducted on this subject. As the stocking density is further increased, there is not enough natural food available and supplementary feeding becomes necessary.

2. Tilapia fry can eat powdered supplementary feed. No one really knows the nutritional requirements of Tilapia and much research is being conducted on the subject. In other countries, producers have fed rice bran, broken rice, oil cakes, wheat flour, corn meal, and a variety of plant refuse. In the United States there has been research on the use of commercial feeds such as those developed for feeding trout or catfish. Tilapia seem to respond well to both commercial feeds. Growth was increased from 200 to 1000% over fish in ponds where no supplemental feed was given.

3. Some producers begin feeding fry with a 40-50% protein feed at a rate as high as 15-20% of body weight per day (gain 300-400% in 1 week). By the time the fry weigh about 1 g they consume about 10% of body weight per day (gain 100% in 1 week). By the time they reach 100 g they are consuming about 3-5% of body weight per day. Fingerlings are fed commercial feeds (about 32% protein) at a rate of 3-4% of body weight per day. At about 1 lb they are fed at 2% of body weight per day and their feed conversion is at about 2 lbs of feed per pound of gain. Fish should be fed all they will consume in about 15 minutes. A suggested feeding chart for Tilapia:

<u>Size of Fish</u>	<u>Times Fed/Day</u>
0-.5g	8
.5 -1 g	6
1-10 g	4
10-50 g	3
50 g and up	2

Some researchers suggest that a 36% protein feed is a good choice for indoor tanks while 32% protein is adequate for ponds. There is no reliable information as to feed conversion rates. Reports of feed conversion range from 1.07 to 1.80 and above. Commercial feed companies, researchers, and producers are experimenting in this area

E. How fast do Tilapia grow and at what weight are they harvested?

Use TM D5 to discuss growth and harvest weights.

Aquaculture Curriculum Guide

1. Growth of Tilapia varies greatly with stocking density, frequency of spawning, and food supply. Other conditions such as water quality and temperature are also major factors. They have the potential to eat more feed and gain more than channel catfish under the same conditions.

2. Under ideal conditions, Tilapia can grow to 850 g in 1 year. Some producers set a goal of from egg to 500 g in 1 year. The nominal weight at which Tilapia are harvested in the United States is about 1.25-1.5 lb. This weight should yield two fillets of approximately 4-6 oz each. Theoretically this weight can be attained in one season if 40-50-g fingerlings are stocked. Practically, it may be another matter. Producers do not stock all their fingerlings on the first day of the season. They may not be able to get all they need. Producers do not sell all their fish on the last day of the season. Individual fish do not all grow at the same rate: a 1 lb average could include .50 lb fish and 150 lb fish. Fish under 1 lb are not acceptable.

F. What are the environmental parameters critical to intensive culture of Tilapia?

Use TM F6 to discuss environmental parameters.

1. No matter what type of system is used in culturing Tilapia, there remains certain environmental parameters that must be met for Tilapia to survive, grow, and reproduce. These include salinity tolerance, temperature tolerance, oxygen tolerance limits, carbon dioxide, pH and alkalinity, turbidity, and excretory products (primarily ammonia toxicity). These parameters vary for different species and crosses.

2. Salinity. Although Tilapia are considered to be freshwater fish, they are thought to have originated in brackish water. This theory results from their tolerance to brackish water and the fact that most species will adapt to brackish water. Zillii seems to be the most tolerant to brackish water and can exist in salinities up to 40-45 ppt. Growth is enhanced for mossambicus at salinities of 8.5-17 ppt.

<u>Tilapia Salinity Tolerances:</u>		<u>0-8 ppt</u>	<u>0-36 ppt</u>
t.mossambica			x
t. horonorum			x
t nilotica	x		
t.aurea	x		

3. Temperature Tolerance. Tilapia are thermophilic. They can tolerate temperatures as low as 8-10°C for short periods of time. Growth and reproduction are severely curtailed at temperatures below 20°C. If Tilapia are overwintered under cold conditions, feeding should be greatly reduced or even halted. Tilapia will tolerate temperatures up to 35-40°C (some species). Therefore, the temperature range lies between 12-40°C with the optimum range from 27-32°C. Temperature requirements vary from species to species. Mossambica require 65-105°F; aurea x nilotica require 55-95°F.

4. While Tilapia can tolerate low levels of DO, fish kills are associated with turnover of stratified water causing sudden deoxygenation and hydrogen sulfide toxification. In pond systems, prolonged oxygen depletion often causes mortality. Tilapia hemadobin seems to load oxygen at low levels. Some researchers suggest that Tilapia may respire by anaerobic means like other members of the Cichlidae family. Tilapia may be able to survive a system failure better than other cultured species for a short period. They may survive awhile with DO levels as low as 0.1 ppm, but even 1 ppm can be lethal if the condition continues for a prolonged time. For optimum growth, DO levels must be above 3.0 mg/l or 6-7 ppm.

5. Carbon Dioxide. Concentrations between 50-100 mg/l are considered to cause stress and death after prolonged periods of time. Surface aeration of the water, vigorous aeration, or running water through a degasification column will drive off CO₂ and replace it with oxygen.

6. pH and Alkalinity. Low pH affects blood affinity for oxygen. pH levels of less than 5 affect growth negatively since it burns their gills. Tilapia can tolerate a pH level as high as 11-12 for short periods of time, although a high pH converts more ammonia to the toxic un-ionized form. A pH level between 6.5-8.0 is recommended. Tilapia

Aquaculture Curriculum Guide

are largely unaffected by levels of alkalinity and tolerate levels from 700-3000 mg/l CaCO_3 .

7. Turbidity. Turbidity is not usually a problem in intensive systems. In semi-intensive systems such as ponds, suspended colloid particles can reduce light intensity which would adversely affect phytoplankton growth. In general, the clearer the water the better. In tank systems, it is recommended that turbidity be kept below 100 mg/l provided that the turbidity is caused by phytoplankton.

8. Excretory Products. Culture systems should be designed and managed so that excretory products do not build up. In ponds, most excretory products will break down. In intensive systems, excretory products must be removed. Soluble metabolic by-products such as ammonia and by-products of organic materials breaking down to nitrites are a problem. Even though Tilapia have a high tolerance for ammonia, the system must be managed to keep below the lethal level.

Some gill damage may occur when the level of un-ionized levels of ammonia go above .5 mg/l and when other stresses are present (low DO, handling, etc.). Tilapia can also tolerate relatively high levels of nitrite (.45 mg/l). Growth can be reduced, however at this level.

9. Summary: Estimates for Water Quality Requirements for Tilapia - Limits

	<u>Lethal Estimate</u>	<u>Operating Optimum</u>
Temperature	12-40°C 52-104°F	27-32°C 80-90°F
Dissolved Oxygen	< 0.1 ppm	6-8 ppm
pH	4.0-11.0	6.5-8.0
Un-ionized Ammonia	0.8 ppm	<0.05 ppm
Nitrite	2.1 ppm	<0.5 ppm
Nitrate	500 ppm	<0.5 ppm
Turbidity	13000 ppm	<50 ppm
Carbon Dioxide	75 ppm	<50 ppm

G How are Tilapia harvested and marketed?

Use TM D7 to explain harvesting.

1. In a pond culture, harvesting is usually done by seining. Often the pond is drained.
2. In other culture systems, harvesting is done by netting, seining, or draining.

3. In most places in the world where Tilapia are cultured, they are marketed live, fresh, or iced. They are sometimes marketed frozen. In some parts of the world, Tilapia are marketed at about the same price as other common fish. In the United States, however, Tilapia are often being marketed as a gourmet item. This is appropriate as the quality of Tilapia flesh is very high and is superior to many species consumed in the United States. U.S. restaurants serve whole Tilapia or fillets. Some large food processors in the United States are beginning to market frozen Tilapia through grocery stores. It is estimated that 30-40% (1992) of the Tilapia sold in the United States were marketed live. Tilapia are also marketed in the United States as a low-priced fish. Imports seem to be influencing this trend.

Use TM D8 to discuss the U.S. market.

H. What diseases and parasites affect Tilapia?

Use TM D9 to discuss diseases.

1. Diseases and parasites are less of a problem with Tilapia than with many other cultured fishes. However, their immune system seems to be reduced when temperatures drop below 72°F and it becomes critical at temperatures below 68°F.

2. Parasites that are found on Tilapia include Trichodina, Chilodon, and Ichthyophthiriasis. Ich seems to occur when the fish have been stressed with water temperatures of 20-24°C.
3. Diseases that affect Tilapia include bacterial fin rot and Saprolegnia fungus. Bacterial fin rot seems to be associated with water temperatures that are too cold.
4. The best treatment for diseases seems to be in prevention. Water quality and temperature are vitally important in preventing diseases. Purchasing fingerlings from a reputable source is also necessary. Producers treat with salt, warmer water, and formalin (if approved by FDA).

Aquaculture Curriculum Guide

Review:

Review by having students demonstrate their knowledge and understanding of the objectives for this problem area. Lead a discussion with students by asking questions that cause the students to explain the content that goes with each objective. It may be necessary to review materials relating to culture systems and water quality parameters from Year One of the materials.

Application Activities:

Application can be addressed in several ways. If the class has access to a tank or suitable pond, a grow out project would make an excellent application. An aquarium grow out project with Tilapia should be required. Students should note that much is still unknown about Tilapia. There is great potential for further knowledge in this area. Current periodicals are a must to keep up with the developments in Tilapia culture.

Evaluation:

Evaluation should focus on the extent to which students achieved the objectives of the problem area. Examples include oral questioning, a class debate on the merits of spawning Tilapia by one of the methods studied, written reports, and written exams. Example exam questions are attached.

Cultural Systems for Tilapia

- Pond Systems - most popular, worldwide
- Cage Systems
- Tank Systems
- Raceway Systems
- Indoor, intensive, closed recirculating systems

Tilapia Fingerlings

(2-4 inches long or 30-50 g in weight)

Best for Stocking in Ponds - In Order:

1. All male hybrids
2. All males, same species (sex-reversed or hand-sexed)
3. Mixed sex, same species

Stocking Rates

- No set answer
- Depends upon each individual system
- Depends on level of management
- Some producers stock ponds at 12,000- 14,000 lbs per acre
- Some producers stock at 15 gpm of freshwater for 1000# of fish in intensive culture systems

What Do Tilapias Eat?

- Tilapia eat plankton and detritus, which average about 55% protein.
- Water can be fertilized to encourage natural food growth. Tilapia will eat supplemental feeds. Tilapia have been fed various organic products and grain.

Many producers use a trout or catfish feed with 36% (28-36%) protein.

- Many producers feed at about 2-3% of body weight/day.

How Fast Do Tilapia Grow?

- Growth rates are highly variable.
- Hybrid male Tilapia may attain 850 g in 1 year.
- In the United States, Tilapia can reach marketable size in 1 year: 1.25-1.50 lbs.
- Tilapia can reach marketable size in about 6 months when stocked at 40-50 g.
- Length of growing season and temperature are very important.

Water Quality Parameters for Tilapia

	<u>Lethal Estimate</u>	<u>Operating Optimum</u>
Temperature	12-40°C 52-104°F	27-32°C 80-90°
Dissolved Oxygen ppm	< 0.1 ppm	6-8
pH	4.0-11.0	6.5-8.0
Un-ionized Ammonia	0.8 ppm	<0.05 ppm
Nitrite	2.1 ppm	< 0.5 ppm
Nitrate	500 ppm	< 50 ppm
Turbidity	13000 ppm	< 50 ppm
Carbon Dioxide	75 ppm	< 50 ppm

How Are Tilapia Harvested?

- A. From Ponds
 - 1. Seining or draining
 - 2. Some trapping

- B. From Tanks or Raceways
 - 1. Netting, seining, or draining
 - 2. Use of bar graders

How Are Tilapia Marketed?

- Normally sold live, fresh, or iced, whole in most parts of the world
- In the United States normally sold as live, fresh, iced, or frozen, whole or fillets, and marketed through restaurants
- Some U.S. food processors are marketing Tilapia frozen, whole and fillets, through grocery stores

Diseases and Parasites

- Diseases and parasites are less of a problem with Tilapia than with many other cultured fishes.
- Parasites that are found on Tilapia include Trichodina, Chilodon, and Ichthyophthiriasis.
- Diseases that affect Tilapia include bacterial fin rot and Saprolegnia.
- The best treatment for diseases seems to be in prevention. Water quality and temperature are vitally important in preventing diseases. Purchasing fingerlings from a reputable source is also necessary.

Aquaculture Curriculum Guide

Quiz for Section D

Name:

Date:

Directions: Circle T for True statements and F for False statements.

1. T F The most popular cultural method for Tilapia in the world is pond systems.
2. T F The best type of fingerling to stock is all males of the same species.
3. T F Fingerlings should be 4-6 inches in length before stocking.
4. T F Tilapia will consume supplemental feed when they reach .01 g in weight.
5. T F Stocking rates depend on the cultural system used and the level of management employed.
6. T F Tilapia are normally harvested from ponds by draining the pond.
7. T F In the United States, Tilapia are normally marketed when they reach about 1 pound.
8. T F Tilapia are immune to ich.
9. T F The best "treatment" for diseases is prevention.
10. T F Many producers feed fingerlings supplemental feed at the rate of 100% of body weight per day.

Fill out the chart using your notes:

Water quality requirements for Tilapia -- optimum

Temperature (F)	_____
Dissolved Oxygen (ppm)	_____
pH	_____
Un-ionized Ammonia (ppm)	_____
Nitrite (ppm)	_____
Nitrate (ppm)	_____
Turbidity (ppm)	_____
Carbon Dioxide (ppm)	_____

Key for Quiz Section D

1. T
2. F
3. F
4. T
5. T
6. F
7. T
8. F
9. F
10. F

See TM D6 for answers to chart.