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 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 manger 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 theraputants 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 hornorum. 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 hornorum 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 methyltestosteroneorethyltestosterone. 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.

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)

TM C2

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

TM C4

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

TM C5

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

TM C7

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

Quiz for Section C

Name:

Date:

Quiz on Obtaining Seed for Stocking

Directions: Answer in the space provided.

1. Which is the most common hatchery system used to produce Tilapia?

2. What are three efficiency factors affecting hatchery production?

3. What are three biological or environmental factors affecting hatchery production?

4-5. What is the best way to produce all male progeny for stocking if you are a commercial Tilapia producer in the United States? Defend your answer.

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.

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 60,00 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:

Size of Fish	Times Fed/Day
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.

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.

Tilapia Salinity Tolerances:	0-8 ppt	0-36 ppt
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. Mossarnbica 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 deoxygenization 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 CO_2 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

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 reduced, however at this level.

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

	Lethal Estimate	Operating Optimum
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).

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

	Lethal Estimate	Operating Optimum
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.

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 Ammonnia (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.