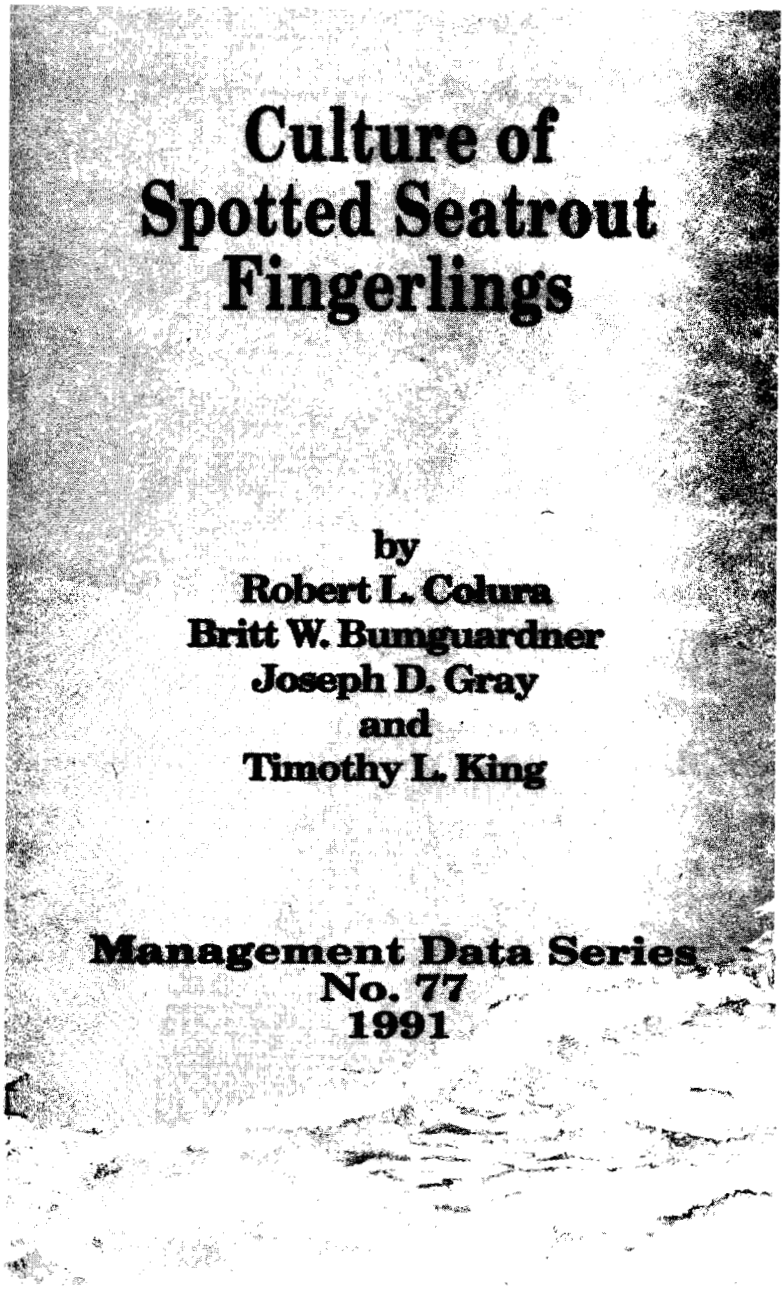


Culture of Spotted Seatrout Fingerlings

by
Robert L. Colura
Britt W. Bumguardner
Joseph D. Gray
and
Timothy L. King

Management Data Series
No. 77
1991

TEXAS
PARKS & WILDLIFE
DEPARTMENT

FISHERIES & WILDLIFE
DIVISION

4200 Smith School Road
Austin, Texas 78744

CULTURE OF SPOTTED SEATROUT FINGERLINGS

by

Robert L. Colura
Britt W. Bumguardner
Joseph D. Gray
and
Timothy L. King

MANAGEMENT DATA SERIES
NO. 77
1991

Texas Parks and Wildlife Department
Fisheries and Wildlife Division
Coastal Fisheries Branch
4200 Smith School Road
Austin, Texas 78744

Table of Contents

ACKNOWLEDGEMENTS

This study was conducted with partial funding from the U.S. Department of the Interior, Fish and Wildlife Service under D.J. 15.605 (Project F-36-R).

ABSTRACT

The Texas Parks and Wildlife Department has investigated spotted seatrout culture since 1973. Using hormones and photoperiod and temperature manipulation to induce spawning, and fingerling culture in earthen ponds, personnel at the Perry R. Bass Marine Fisheries Research Station obtained an average 37% survival of spotted seatrout from larvae to fingerlings (25 to 30-mm total length) from 1984-1988.

INTRODUCTION

The Texas Parks and Wildlife Department (TPWD) has been investigating the culture of spotted seatrout for the purpose of supplementing natural stocks or developing aquaculture since 1973 (Colura 1974). Efforts were originally directed at spawning (Colura 1974, Arnold 1976) followed by attempts to culture fingerlings in earthen ponds at the TPWD Perry R. Bass Marine Fisheries Research Station (MFRS) (Colura et al. 1976). By 1986 TPWD personnel were obtaining mean returns of fingerling from ponds of up to 67% (Colura et al. 1990a), similar to that reported for red drum (McCarty et al. 1986).

The purpose of this paper is to describe procedures currently used by the MFRS to spawn spotted seatrout and to rear the fingerlings in earthen ponds. Step by step procedures describing care and spawning of broodfish, egg and larva care, and pond culture of larva to about 25 to 30-mm total length (TL) fingerling are provided. The paper is intended for use by the practicing fish culturist but will also be of use to those interested in acquiring a general knowledge of spotted seatrout culture.

MATERIALS AND METHODS

Spawning procedures were adapted from the general methods of Colura (1974) and Arnold et al. (1976). Pond culture methods are modifications of procedures described by Colura et al. (1976). All pond culture was conducted in 0.1 to 0.8-ha earthen ponds located at the MFRS (Colura et al. 1976, Porter and Maciorowski 1984, Colura et al. 1990a).

RESULTS AND DISCUSSION

The procedures described in Appendix A resulted in an average 37% return from ponds of approximately 25 to 30-mm TL spotted seatrout during the years 1984-1988. Methods described in Appendix A are a synthesis of 18 years of research by the TPWD. Also incorporated, where appropriate, are culture methods developed by other researchers. It provides the reader with a detailed description of equipment and procedures currently used by MFRS to spawn and rear spotted seatrout.

LITERATURE CITED

Arnold, C. R., J. L. Lasswell, W. H. Bailey, T. D. Williams, and W.A. Fable, Jr. 1976. Methods and techniques for spawning and rearing spotted seatrout in the laboratory. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies. 30:167-178.

Bowen, J. T., and N. Studdard. 1970. English and metric length-weight relationships for rainbow, brown and brook trout. Appendix A, part 1. Manual of Fish Culture. Bureau of Sport Fisheries and Wildlife. Washington, District of Columbia.

Brown-Peterson, N., P. Thomas, and C. R. Arnold. 1988. Reproductive biology of the spotted seatrout, Cynoscion nebulosus in south Texas. Fishery Bulletin. 86(2): 373-388.

Bumguardner, B. W., and A. F. Maciorowski. 1989. Short-term growth of juvenile spotted seatrout and snook at selected temperatures. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies. 80-89.

Bumguardner, B. W., R. L. Colura, A. Henderson-Arzapalo, and A. F. Maciorowski. In Review. Culture of spotted seatrout, orangemouth corvina, and their hybrids. California Fish and Game. In Review.

Colura, R. L. 1974. Induced spawning of the spotted seatrout Cynoscion nebulosus (Cuvier) Proceedings of the World Mariculture Society. 5:319-330.

Colura, R. L., B. T. Hysmith, and R. E. Stevens. 1976. Fingerling production of striped bass (Morone saxatilis), spotted seatrout (Cynoscion nebulosus), and red drum (Sciaenops ocellatus) in saltwater ponds. Proceedings of the World Mariculture Society. 7:79-92.

Colura, R. L., C. W. Porter and A. F. Maciorowski. 1984. Preliminary evaluation of the scale method for describing age and growth of spotted seatrout (Cynoscion nebulosus) in the Matagorda Bay system, Texas. Management Data Series Number 57. Texas Parks and Wildlife Department, Coastal Fisheries Branch, Austin, Texas.

Colura, R. L., A. F. Maciorowski, and A. Henderson-Arzapalo. 1987. Spotted seatrout fingerling production at different stocking densities. Study 1 Segment 2 Report, Federal Aid Project F-36-R, Marine Fisheries Resource Culture and Enhancement. Texas Parks and Wildlife Department, Coastal Fisheries Branch. Austin, Texas.

Colura, R. L., A. F. Maciorowski, and A. Henderson-Arzapalo. 1988. Gonadal maturation, fecundity and strip-spawning of female spotted seatrout. Proceeding of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies. 42:80-88.

Colura, R. L., B. W. Bumguardner, and J. D. Gray. 1989. An evaluation of photoperiod and temperature induced spawning of spotted seatrout for routine hatchery production. Study 1 Segment 3 Report, Federal Aid Project F-36-R, Marine Fisheries Resource Culture and Enhancement. Texas Parks and Wildlife Department, Fisheries Division, Coastal Fisheries Branch. Austin, Texas.

Colura, R. L., A. F. Maciorowski, and A. Henderson-Arzapalo. 1990a. A review of spotted seatrout culture at the Perry R. Bass Marine Fisheries Research Station: 1983-1985. Management Data Series Number 38. Texas Parks and Wildlife Department. Fisheries Division, Coastal Fisheries Branch. Austin, Texas.

Colura, R. L., B. W. Bumguardner, A. Henderson-Arzapalo, and J. D. Gray. 1990b. Red Drum Culture Manual. Management Data Series Number 22. Texas Parks and Wildlife Department, Fisheries Division, Coastal Fisheries Branch. Austin, Texas.

Colura, R. L., A. F. Maciorowski, and A. Henderson-Arzapalo. 1990c. Induced spawning of spotted seatrout with selected hormone preparations. The Progressive Fish-Culturist. 52:205-207.

Colura, R. L., T. L. King, J. D. Gray, and B. W. Bumguardner. In Review. Analyses of six years of spotted seatrout pond culture trials. Aquaculture. In Review.

Daniels, H. V., C. E. Boyd, and R. V. Minton. 1987. Acute toxicity of ammonia and nitrite to spotted seatrout. Progressive Fish-Culturist. 49:260-263.

Farquhar, B. W., and J. G. Geiger. 1984. A portable zooplankton sampling apparatus for use in hatchery rearing ponds. Progressive Fish-Culturist. 46:209-211.

Geiger, J. G. 1983a. A review of pond zooplankton production and fertilization for the culture of larval and fingerling striped bass. Aquaculture. 35:353-369.

Geiger, J. G. 1983b. Zooplankton production and manipulation in striped bass rearing ponds. Aquaculture. 35:331-351.

Gray, J. D. and R. L. Colura. 1988. A preliminary analysis of the effects of temperature and salinity on hatching of spotted seatrout. Management Data Series Number 148. Texas Parks and Wildlife Department, Coastal Fisheries Branch. Austin, Texas.

Gray, J. D., T. L. King, and R. L. Colura. 1991. The effect of temperature and hypersalinity on hatching success of spotted seatrout eggs. The Progressive Fish-Culturist. 53:81-84.

Henderson-Arzapalo, A. 1990. Red drum egg and larva incubation. Pages 51-52 In: G. W. Chamberlain, R. J. Miget, and M. G. Haby, editors. Red drum aquaculture. Sea Grant College Program, Texas A&M University, Galveston, Texas.

Hoff, F., C. Powell, and T. Pulver. 1972. Artificially induced spawning of the Florida pompano, Trachinotus carolinus under controlled conditions. Proceedings of the World Mariculture Society. 3:53-69.

Johnson, S. K. 1990. Recognition and control of diseases common to growout aquaculture of red drum. 113-130. In: G. w. Chamberlain, R. J. Miget, and M. G. Haby, editors. Red drum aquaculture. Sea Grant College Program, Texas A&M University, Galveston, Texas.

King, T. L., B. W. Bumguardner, L. S. Procarione, and R. L. Colura. In Review. Growth, relative condition, and survival of spotted seatrout fry fed commercially prepared starter diets. The Progressive Fish-Culturist. In Review.

Kuo, C. M., E. E. Nash, and Z. H. Shehadeh. 1973. The grey mullet (Mugil cephalus L): Induced breeding and larval rearing research 1972-73. Volume II. Report Number OI-73-128. The Oceanic Foundation, Oceanic Institute. Waimanala, Hawaii.

Maceina, M. J., D. N. Hata, T. L. Linton, and A. M. Landry, Jr. 1987. Age and growth analysis of spotted seatrout from Galveston Bay, Texas. Transactions of the American Fisheries Society. 116:54-59.

Matlock, G. C., C. E. McCarty, and R. R. Vega. 1986. Accuracy of estimated number of red drum fry stocked into rearing ponds. Management Data Series Number 113. Texas Parks and Wildlife Department, Coastal Fisheries Branch. Austin, Texas.

McCarty, C. E., J. G. Geiger, L. N. Sturmer, B. A. Gregg, and W. P. Rutledge. 1986. Marine finfish culture in Texas: A model for the future. Pages 249-262. In: R. Stroud, editor. Fish culture in fisheries management. The proceedings of a symposium on the role of fish culture in fisheries management at Lake Ozark, Missouri, March 31 - April 3, 1985. Fish Culture Section and Fisheries Management Section of the American Fisheries Society. Bethesda, Maryland.

Meyer, F. P. 1968. Dylox^{R} as a control for ectoparasites of fish. Proceedings of the Twenty-Second Annual Conference Southeastern Association of Game and Fish Commissioners. 22:392-396.

Porter, C. W., and A. F. Maciorowski. 1984. Spotted seatrout fingerling production in saltwater ponds. Journal of the World Mariculture Society. 15:222-232.

Rubright, J. S., J. L. Harrell, H. W. Holcomb and J. C. Parker. 1981. Responses of planktonic and benthic communities to fertilizer and feed applications in shrimp mariculture ponds. Journal of the World Mariculture Society. 12:281-299.

Spotte, S. H. 1970. Fish and invertebrate culture water management in closed systems. Wiley-Interscience. New York, New York.

Thomas, P., and N. Boyd. 1988. Induced spawning of spotted seatrout, red drum and orangemouth corvina (Family: Sciaenidae) with luteinizing hormone-releasing hormone analog injection. Contributions in Marine Science Supplement to Volume 30:43-48.

Tucker, J. W., Jr. 1988. Growth of juvenile spotted seatrout on dry feeds. The Progressive Fish-Culturist. 50:39-41.

Ulmer, R. 1990. Pond design and construction. Pages 147-153. In: G. W. Chamberlain, R. J. Miget, and M. G. Haby, editors. Red drum aquaculture. Sea Grant College Program, Texas A&M University, Galveston, Texas.

Weber, C. L. 1973. Biological field and laboratory methods for measuring the quality of the surface waters and effluents. United States Environmental Protection Agency, National Environmental Research Center, 67014-13-001. Cincinnati, Ohio.

Appendix A - Procedures for culturing spotted seatrout fingerlings.

Procedures for Culturing Spotted Seatrout Fingerlings

OVERVIEW

Introduction

The primary purpose of this paper is to provide prospective spotted seatrout culturists with step by step procedures used by the MFRS to spawn and rear spotted seatrout fingerlings.

Specific Objectives

- Describe a tank and filter system in which mature spotted seatrout may be held and spawned.
- Describe the care of broodfish.
- Describe procedures for induced spawning of spotted seatrout.
- Describe care of the eggs and prolarvae.
- Describe procedures for rearing fingerlings to 25 to 30-mm TL.
- Provide the prospective spotted seatrout culturist with current rules and regulations concerning culture of spotted seatrout.

Metric Measurements

All measurements used in this manual are metric. As an aid to those readers unfamiliar with metric measurement, conversion tables are provided in Appendix B.

BROODFISH TANK SYSTEMS

Introduction

A properly working broodfish tank system, consisting of the tank, assorted filters, heaters, and chillers, etc., is essential for successful induced spawning of spotted seatrout using photoperiod and temperature manipulation. The system should be installed and operating before broodfish are collected. Systems ranging from 9,500-30,000 liters have been used to spawn spotted seatrout (Arnold et al. 1976, Colura et al. 1989). The following description is of a general broodfish tank design used for spawning marine fish at the MFRS (Colura et al. 1990b). Where appropriate, specific information on equipment used at the MFRS is included. The use of brand names does not imply endorsement by TPWD.

Design

The system should be of a recirculating design (Figure 1) with water flowing in the following order:

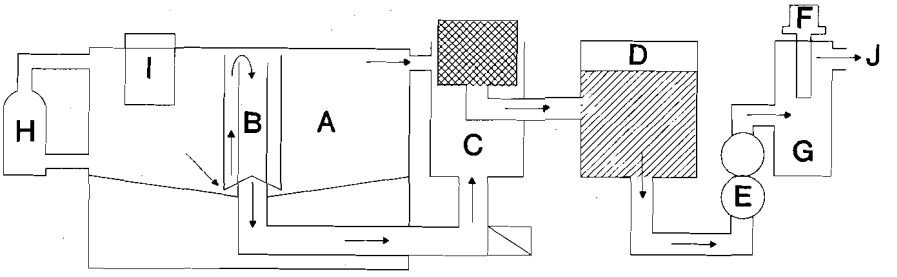
- Broodfish tank
- Egg collector
- Bio-filter
- Ultraviolet-Germicidal lamp
- Chiller reservoir (optional)
- Return to the broodfish tank by pump

Water is cycled through the system approximately 3-8 times per day, using either an airlift or centrifugal pump system.

(Continued)

BROODFISH TANK SYSTEMS (Continued)

Design (Cont.)



A	Tank	F	Chiller
B	Venturi Drain	G	Chiller Tank
C	Egg Collector	H	DE Filter
D	Bio-Filter	I	Heater
E	UV-Germicidal Lamp	J	Return to Tank

Figure 1. Schematic of spotted seatrout broodfish conditioning and spawning system used at the MFRS. Arrows show direction of water flow.

Broodfish Tank

A general description of spotted seatrout broodfish tanks used by MFRS are as follows:

- Volume at least 9,500 liters
- 1 to 1.5 m deep
- Circular fiberglass construction with a central drain 75-100 mm in diameter is preferred by the MFRS but not mandatory.
- Water level may be controlled with a central standpipe or outside standpipe.
- With a central standpipe a venturi may be used to help clean the tank. This method is used at the MFRS.

Egg Collector

The egg collector may be of special fiberglass construction or built from any available tank at least 185 liters volume. A 0.5-mm mesh net must be placed between the incoming water and the discharge from the collector to retain the eggs.

(Continued)

BROODFISH TANK SYSTEMS (Continued)

Bio-filter	A biological filter should be placed in-line after the egg collector. Numerous designs of biological filters are available (Spotte 1970, Arnold et al. 1976, McCarty et al. 1986). Selection of the filter to be used usually will be determined by space available. Regardless of design, the filter must have: • sufficient surface area for the growth of adequate amounts of bacteria which will break down nitrogenous waste produced by the fish, • sufficient water flow and air to prevent the filter from becoming anaerobic. A simple system used at the MFRS consists of a 110 to 185-liter polyethylene barrel filled with bulk air conditioning filter material to provide surface area for bacterial growth.
Ultraviolet-Germicidal Lamp	An ultraviolet-germicidal lamp should follow the bio-filter. Size of the lamp to be used will depend on the flow rates. The manufacturer's literature should be consulted before purchase and installation to insure the lamp is of proper size to effectively treat the water. The ultraviolet-germicidal lamp should never be run overnight when the fish are spawning. The MFRS uses an Aquanetics model 60IL (Aquanetics, San Diego, California).
Diatomaceous Earth Filter	A diatomaceous earth (DE) filter is useful for removing organic colloids, suspended micro-organisms, and maintaining water clarity. The system need not be placed in-line with the biofilter. Operate the DE filter at least 1 to 2 days/week. The DE filter should never be run overnight when the fish are spawning.

(Continued)

BROODFISH TANK SYSTEMS (Continued)

Diatomaceous Earth Filter (Cont.)	The MFRS uses a Turbo^{R} Model 44 (Pac-Fab Incorporated, Sanford, North Carolina).
Temperature Control	Two methods are commonly used for temperature control: • Water temperature is controlled by room air conditioning and heating. • Separate thermostatically controlled heaters and chillers are used. This method is used at the MFRS. The MFRS uses 4,500-W Glo-Quartz Model 3N45-222-CH quartz heaters (Glo-Quartz, Mentor, Ohio) mounted in the tank and controlled with a Glo-Quartz Series 400 temperature controller. To cool, the MFRS uses a one horsepower chiller (Frigid Units Model BHL-1089-2, Frigid Units, Incorporated, Toledo, Ohio). The chiller is placed in a reservoir tank in-line with and immediately after the filter system.
Photoperiod Control	Lighting is controlled by an electric time switch. Lighting may be from either: • standard room lighting, fluorescent or incandescent • each tank may be lighted separately The MFRS lights each tank separately. A 100-W incandescent and a 15-W fluorescent light mounted on a beam which is placed across and rests on the side of the tank. The tank is then covered with sheets of 100-mm thick styrofoam to shield the tank from extraneous light.
Airlift Pump	The MFRS employs a 3 hp Rotron DR6KJ72 regenerative blower (Rotron Incorporated, Saugerties, New York) to operate an airlift pump located in the chiller reservoir which cycles water back to the brood fish tank. The blower also provides aeration to maintain dissolved oxygen levels.

(Continued)

BROODFISH TANK SYSTEMS (Continued)

Emergency Power

Fish culture facilities are typically located in coastal areas and are subject to periodic power failures due to storms. Therefore, provision should be made for an alternate source of electrical power to insure tank aeration and circulation are not interrupted and to prevent death of broodfish.

Water Supply

A water supply system with tanks capable of holding 2-3 days supply of water should be available. If the source of the water supply is from a bay it should be filtered to remove parasites and fouling organisms and allowed to settle to clarify the water before it is used.

The system in use at the MFRS (Figure 2) includes the following:

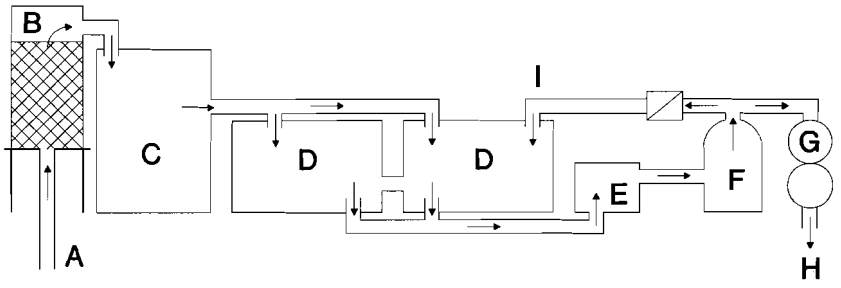
- 1.7-m^3 slow sand filter
- 22,700-liter settling tank
- two 26,500-liter storage tanks
- ultraviolet germicidal lamp (Model 240 IL, Aquanetics, San Diego, California)
- 0.65-m^2 rapid sand filter (Model TR-140, Aquanetics, San Diego, California)

Water is pumped from the bay into the bottom of the slow sand filter and overflows into the settling tank. From the settling tank water gravity feeds to the holding tanks. Water pumped from the holding tanks to the broodfish systems or egg incubators first passes through an in-line rapid sand filter and an in-line ultraviolet germicidal lamp before entering the water distribution system.

(Continued)

BROODFISH TANK SYSTEMS (Continued)

Water Supply
(Cont.)



A	Water From Bay	F	Rapid Sand Filter
B	Slow Sand Filter	G	UV-Germicidal Lamp
C	Settling Tank	H	To Laboratory Tanks
D	Storage Tanks	I	Excess Water Return
E	Pump		

Figure 2. Schematic of water filtration system used at the MFRS. Arrows show direction of water flow.

BROODSTOCK PROCUREMENT

Collection	Broodstock are typically wild fish preferably collected with hook and line. MFRS holds captured fish in 60 cm diameter X 60 cm deep holding pens constructed of 2.5 cm stretch-mesh net material until it is time to move the fish from the field to the hatchery.
Transport to the Hatchery	An approximately 122-liter plastic bag (e.g. plastic garbage bag) is placed around the outside of the holding pen to prevent water circulation. A commercial fish calmer (e.g. Hypno^{R}, Jungle Laboratories, Cibolo, Texas) is added until fish are anesthetized. Fish are then removed and placed in a transport tank for the trip to the hatchery.
Transport Tank	Fish may be transported in any commercially available transport tank. Tanks should be supplied with compressed oxygen.
Size of Broodfish	Broodfish should be at least 321 mm TL. Some female spotted seatrout in Matagorda Bay reach sexual maturity at approximately 1 year of age (second summer) and 321 mm TL, (Colura et al. 1988); therefore, most fish > 321 mm TL could be used as brood stock. Average batch fecundity of spotted seatrout is estimated as 467 eggs/gram of body weight regardless of size (Colura et al. 1988). Therefore, total fecundity is a function of size so larger females would provide a greater number of eggs. Care should be taken to insure adequate numbers of males are retained when collecting broodfish. Males generally are not as large as females (Colura et al. 1984, Maceina et al. 1987), therefore, selection of broodfish solely on the basis of size would provide a preponderance of females. The use of large females (2-3 kg) would also make cannibalism of smaller males a possibility.
Determination of Sex	Males • Males usually produce a drumming sound when captured during the spawning season (April - September). • The male vent exhibits an anteriorly located anus and posteriorly located urogenital pore. • Applying light pressure along the sides and belly during the spring and summer will cause milt to be extruded and confirm identification of sex.

(Continued)

BROODSTOCK PROCUREMENT (Continued)

Determination of Sex (Cont.)	Females • Females generally do not drum. • Examination of the vent of the female will reveal, anteriorly to posteriorly, the anus, genital pore, and urinary pore, respectively. • If not immediately apparent, the genital pore may be located by probing with a 1-mm ID (inside diameter) flexible plastic tube. • Intra-ovarian samples of eggs may be taken to confirm sex of the animal. Samples are taken by inserting a 1-mm ID flexible tube (150-200 mm length) mounted on a dull 2-4 cm hypodermic needle attached to a plastic syringe (Hoff et al. 1972) into the ovary through the genital pore and oviduct. A small amount of ovarian tissue is removed by carefully withdrawing the plunger to create a vacuum. Crimp the plastic tubing before withdrawing the sample to prevent drawing the sample into the syringe. The sample is then examined microscopically to confirm the presence of ova and sex of the animal. See Hormone-Induced Strip-Spawning pages 21-25 for description of ova.
Quarantine	Newly captured fish should be quarantined for 10-14 days to prevent introduction of disease into the hatchery.
Prophylactic Treatment	The tank water may be treated with 0.25 parts per million (mg/l) Cu^{++} (eg., Cutrine, Applied Biochemist, Incorporated, Mequon, Wisconsin) from a chelated copper compound to reduce the chances of disease caused by external parasites.
COMMENT	**BEFORE USING ANY CHEMICAL OR MEDICATION ON FISH THAT MAY ULTIMATELY BE USED FOR HUMAN CONSUMPTION, FDA REGULATIONS CONCERNING REGISTRATION OF THE CHEMICAL FOR FOOD-FISH USE SHOULD BE CONSULTED.**

BROODFISH CARE

Feeding

Frequency:

- Three to seven times/week at 2-3% of body weight.

Food types:

- Frozen or live shrimp (Penaeus sp.)
- Frozen fish, for example mullet (Mugil sp.), shad (Dorosoma sp.) and menhaden (Brevoortia sp.)
- Live goldfish (Crassius auretas)

Live goldfish are the preferred feed and are fed until the fish are satisfied. However, when goldfish are unavailable, the MFRS feeds equal amounts of chopped shrimp and fish 5-7 days/week at 3% of body weight.

Water Quality

Critical levels for most water quality parameters have not been adequately identified. The following water quality standards have been used at the MFRS with good results.

- Salinity 28-35 parts per thousand (o/oo). May be controlled by the addition of fresh water or artificial sea salts.
- pH 7.0-8.5. May be controlled by water exchange or the addition of 50 mg/l sodium bicarbonate (Na_2CO_3) will raise pH ~ 0.5.
- Total ammonia-N less than or equal to 0.5 mg/l; preferred total ammonia-N less than or equal to 0.2 mg/l. High levels of ammonia-N may be reduced by flushing with clean salt water.
- Dissolved oxygen greater than or equal to 5 mg/l. In a properly designed tank system, dissolved oxygen concentration should not be a problem.

Diseases

Diseases of parasitic or bacterial origin are encountered occasionally in captive spotted seatrout but few have been identified. The most common diseases encountered at the MFRS and their treatment are presented below.

Other diseases common to culture of other warm-water marine fish (e.g. red drum) might also be expected. Identification of potential diseases and their treatment are reviewed by Johnson (1990).

(Continued)

BROODFISH CARE (Continued)

Amyloodinium ocellatum

Amyloodinium ocellatum is the most common protozoan parasite affecting spotted seatrout.

It's affect on the fish is characterized by:

- rapid gasping
- irregular opercular beat
- mouth not closed
- scratching on side and bottom of tank; scrapings of gill filaments will reveal ovoid-shaped trophonts when examined with a microscope (Figure 3).

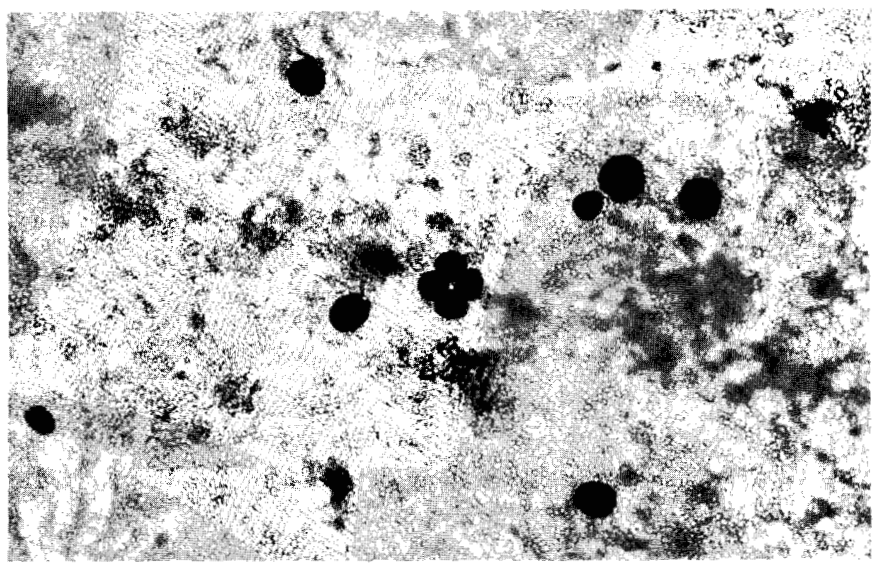


Figure 3. Amyloodinium ocellatum in marine fish gill tissue.

Amyloodinium ocellatum Treatment

- Treat the tank with 0.2-1.0 mg/l of Cu^{++} from a chelated copper compound (e.g., Cutrine, Applied Biochemists, Incorporated, Control Mequon, Wisconsin) (Johnson 1990).
- Flush the tank 2 days after treatment and repeat the treatment 7 days after initial treatment.

(Continued)

BROODFISH CARE (Continued)

Treatment for Bacterial Infections

Following handling, spotted seatrout are susceptible to bacterial infection, generally thought to be Vibrio sp. It is characterized by ulcers and redness of the body and fins.

Antibiotics, primarily oxytetracycline hydrochloride (OTC), can be used in several different ways to treat infections.

Treatment for Bacterial Infections

- Injection - Broodfish can be injected with 0.5 ml/kg body weight of OTC (100 mg active ingredient/ml) after handling to decrease the likelihood of bacterial (Cont.) infection; or infections can be treated with OTC injections at the same rate.
- Feed - injectable OTC (100 mg active ingredient/ml) can be placed in cut fish or shrimp fed to broodfish. Each food item is injected with 0.1-0.2 ml OTC and about 10 ml of OTC is added to the feed daily for 7-10 days.
- Immersion - immerse in 10-20 mg/l OTC for 2 hours.

Parasitic Copepods

Parasitic copepods representing several genera and often called anchor parasites or anchor worms frequently attach to spotted seatrout and feed on blood. The addition of 0.25 mg/l Dylox^{R} (Chemargo Corporation, Kansas City, Missouri) or any brand of pesticide with 80% trichlorfon as the active ingredient will kill anchor parasites (Meyer 1968).

Fish lice

Caligus sp., a copepod and Argulus sp., a branchiurian, collectively known as fish lice, are found moving freely over the body of the fish and can be seen without the aid of a microscope. They puncture the skin and feed on blood. The addition of 0.25 mg/l Dylox^{R} will kill fish lice (Meyer 1968).

WARNING

No product containing 80% trichlorfon (Dylox^{R}) is approved by the FDA for use on spotted seatrout.

COMMENT

BEFORE USING ANY CHEMICAL OR MEDICATION ON FISH THAT MAY ULTIMATELY BE USED FOR HUMAN CONSUMPTION, FDA REGULATIONS CONCERNING REGISTRATION OF THE CHEMICAL FOR FOOD-FISH USE SHOULD BE CONSULTED.

PHOTOPERIOD AND TEMPERATURE INDUCED SPAWNING

Introduction

Photoperiod and temperature manipulation has been used to spawn spotted seatrout (Arnold et al. 1976, Colura et al. 1989).

Photoperiod and Temperature Regime

The following photoperiod temperature regime is used by the MFRS to spawn spotted seatrout.

PHOTOPERIOD - TEMPERATURE REGIME

Day	Temperature (C)	Hours of light/day
0-30	16	9
31-45	18	10
46-60	20	11
61-75	22	12
76-90	24	13
91-105	26	14
106-315	28	16

Egg Number Estimation

Eggs are removed from the egg collector the morning following the spawn at the MFRS and enumerated as follows:

- Remove eggs from egg collector with dip net
- Place eggs in an aquarium with a known volume of water
- Mix eggs thoroughly
- Remove at least three 5-ml samples from the mixture and count the number of eggs in each sample
- Calculate the mean number of eggs/ml
- Extrapolate the number of eggs using the formula:

  NE = V x ME

  where:

  NE = Total number of eggs
  V = Total volume (ml) water containing eggs
  ME = mean number eggs/ml (as sampled)

(Continued)

PHOTOPERIOD AND TEMPERATURE INDUCED SPAWNING (Continued)

Alternate Method of Estimating Egg Numbers

An alternate method reported by Henderson-Arzapalo (1990) may also be used to estimate numbers of eggs. This method, which is less time consuming, is generally used in production hatcheries.

- Collected eggs along with sufficient water to allow the eggs to float are poured into a graduate cylinder.
- The mixture is allowed to sit undisturbed for several minutes.
- Eggs will float to the surface and the separation between eggs and water will become visible.
- The volume (ml) of eggs is measured.
- The volume of eggs is multiplied by 1,300 eggs/ml to estimate the total number of eggs.

HORMONE-INDUCED STRIP-SPAWNING

Introduction	Hormone-induced strip-spawning typically involves the capture of mature broodfish, injection of hormones to induce ovulation, followed by the collection of the spawn by hand stripping.
Collection	Fish for hormone-induced strip-spawning should be hook and line collected from May through August (Colura et al. 1988) and transported to the hatchery as described under Broodfish Procurement page 14.
Treatment on Arrival at Hatchery	Upon arrival at the hatchery fish are generally injected with 0.5 ml oxytetracycline hydrochloride (100 mg active ingredient/ml) to reduce bacterial infection and transferred to a holding tank.
Description of Holding Tank	Holding tanks can be of any design. At the MFRS 6.1-m long X 0.6-m wide X 0.8-m deep fiberglass raceways are used to hold fish. Water is continuously exchanged to maintain water quality. If desired and a biological filter is available, water may be recirculated. The tank is partitioned with plastic screens so that fish may be easily isolated and identified during spawning.
Determination of Sex	Determination of sex is as previously described under Broodfish Procurement pages 14-15.
Sampling of Ova	Intra-ovarian samples of eggs are taken by inserting a 1-mm ID flexible tube (150-200 mm length) mounted on a dull 2-4 cm hypodermic needle attached to a plastic syringe (Hoff et al. 1972) into the ovary through the genital pore and oviduct. A small amount of ovarian tissue is removed by carefully withdrawing the plunger to create a vacuum. Crimp the plastic tubing before withdrawing the sample to prevent drawing the sample into the syringe. Ova are examined microscopically to confirm sex of the animal and determine maturity.
Evaluation of Broodstock Maturity	Intra-ovarian samples collected during the spawning season will contain three distinct oocyte stages (Kuo et al. 1973).

(Continued)

HORMONE-INDUCED STRIP-SPAWNING (Continued)

Evaluation of Broodstock Maturity (Cont.)

- Primary oocytes - transparent in appearance and nucleated, approximately 0.1 mm in diameter (Figure 4).
- Yolk vesicle stage - granular cytoplasm surrounds the germinal vesicle, approximately 0.15 - 0.30 mm in diameter (Figure 4).
- Yolk globule stage - yolk vesicles occupy the entire ooplasm, approximately 0.30-0.60 mm in diameter (Figure 4). Fish with ova ≥ 0.45 mm in diameter are eligible for hormone-induced strip-spawning (Colura et al. 1988).

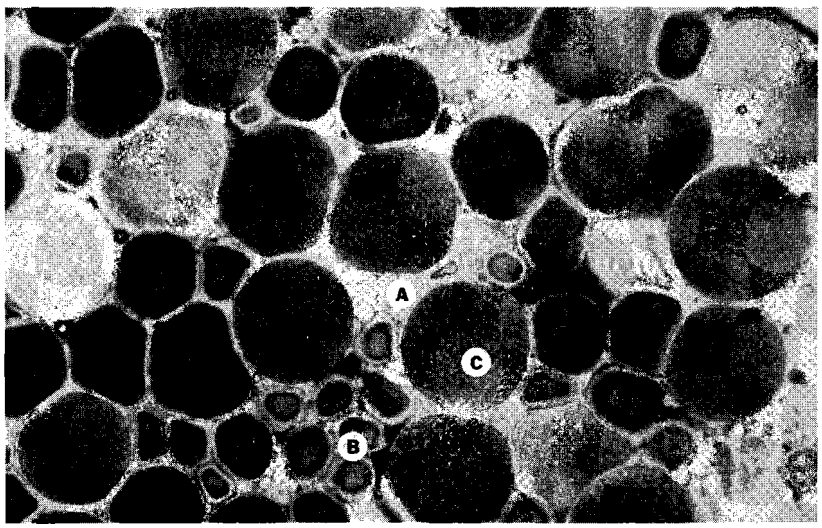


Figure 4. Photomicrograph of spotted seatrout eggs showing, (A) primary oocytes, (B) yolk vesicle stage oocytes, and (C) yolk globule stage oocytes.

Hormone Treatment

When yolk globule stage oocytes ≥ 0.45 mm in diameter dominate the sample, the fish are intramuscularly injected with approximately 1,100 IU/kg body weight of human chorionic gonadotropin (HCG).

Piscine hormones (Colura et al. 1990c) and luteinizing hormone releasing hormone (Thomas and Boyd 1988) have also been used to spawn spotted seatrout; however, cost of these hormones is much greater.

Males may also be injected with approximately 500 IU/kg body weight (HCG).

(Continued)

HORMONE-INDUCED STRIP-SPAWNING (Continued)

Ovulation

Intra-ovarian samples should be collected from each female between 20 and 24 hours after injection. Eggs should be found in the final stages of maturation the ooplasm clearing and the egg growing to 0.8-0.9 mm diameter (Figure 5).

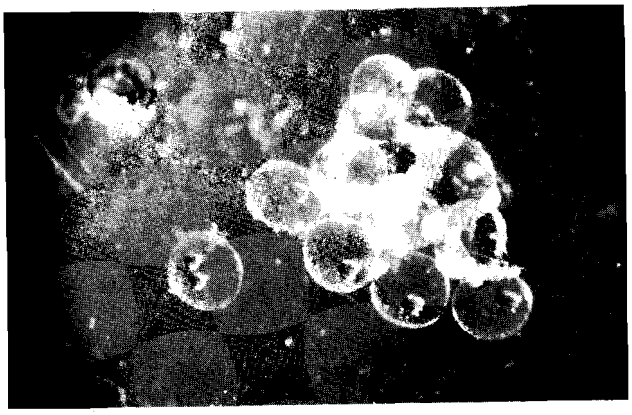


Figure 5. Photomicrograph of spotted seatrout eggs prior to ovulation. Note ovarian tissue surrounding eggs.

Ovulation (Continued)

Ovulation begins between 25 and 32 hours after injection (Colura 1974). During this time period fish should be examined at least once per hour.

Ovulation can be detected by applying gentle pressure to the abdomen. Ova will flow easily when ovulation begins (Figure 6)

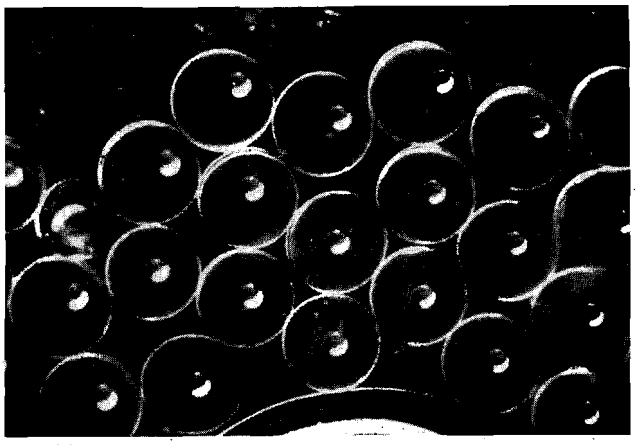


Figure 6. Ovulated ova of spotted seatrout.

(Continued)

HORMONE-INDUCED STRIP-SPAWNING (Continued)

"Stripping eggs" The following procedures are used to strip and fertilize spotted seatrout eggs:

Step	Action
1.	Dampen a glass 2-liter bowl with salt water by filling the bowl and draining the excess water.
2.	Anesthetize the female and male fish in a 50-100 liter tank using a commercial anesthetic (e.g. Hypno^{R} Jungle Laboratories, Cibolo, Texas).
3.	Remove the anesthetized fish from the anesthetic and rinse the animal's body with clean salt water to remove any residual anesthetic which might contaminate the eggs.
4.	Strip the eggs from the fish by either: • Pressing on the abdomen to extrude the eggs into the bowl or; • sacrifice the fish, remove the ovaries and strip the eggs from the excised ovaries into the bowl.
5.	Strip the milt from male by either: • Pressing on the abdomen to extrude the milt into the bowl or; • sacrifice the fish remove and mash the testes then place the mashed testes in the eggs.
6.	Add 1 liter of salt water (28-32 o/oo) to the mixture of eggs and milt.
7.	Stir the mixture gently for approximately 1 minute.
8.	Estimate size of spawn by: • Measure the volume of eggs and water, remove at least 3 1-ml samples with a Hensen-Stemple pipette, calculate a mean then extrapolate the number of eggs spawned (See page 19) or;

(Continued)

HORMONE-INDUCED STRIP-SPAWNING (Continued)

"Stripping Eggs" (Cont.)	Step	Action
		• measure the volume of eggs in a graduate cylinder and multiply the volume by 1,300 eggs/ml (See page 19).
	9.	Place mixture in an aquarium containing approximately 25 liters of saltwater (28-30 o/oo) and aerate vigorously for approximately 1 hour.
	10.	Remove three samples of approximately 100 eggs and estimate percent fertilization.
	11.	Discontinue aeration for approximately 5 minutes. This allows dead material to sink. Live material will float.
	12.	Remove dead material with a siphon.
	13.	Pour live eggs into an incubator for hatching.

EGG AND PROLARVAE CARE

Incubator

An approximately 1,900-liter tank with a 45° cone bottom has been used most often to incubate eggs and hold prolarvae at the MFRS. More recently incubators as small as 100 liters have been used experimentally with good results.

A center stand pipe (50 mm diameter) maintains depth and is covered with 0.33-mm mesh filter so that water may be exchanged without loss of eggs or prolarvae.

One to several air stones are placed around the perimeter of the tank and light aeration used to increase circulation and prevent the buoyant eggs from rafting.

Stocking Density

Several spawns can usually be incubated in a 1,900-liter tank. If smaller incubators are used, several may be required for each spawn. Usually about 1,000 eggs can be held for each liter of incubator capacity.

Egg Transfer

Eggs are gently poured into the incubator from the aquarium in which they were placed for enumeration.

Water Quality

The following water quality parameters should be maintained:

- Temperature 23-32 C. Best temperature for hatching at Salinity ≤ 40 o/oo is 23 C (Gray et al. 1991).
- Salinity approximately 30 o/oo. Best salinity for hatching and 24 hour survival is 30 o/oo (Gray and Colura 1988).
- Total ammonia-N less than 0.28 mg/l (Daniels et al. 1987).
- Dissolved oxygen greater than or equal to 5.0 mg/l.

To help maintain water quality approximately 3 liters of water per minute are exchanged as soon as hatching begins and continues until fry are removed from the incubator.

Dead eggs are siphoned from the incubator daily or whenever they concentrate in the cone bottom.

(Continued)

EGG AND PROLARVAE CARE (Continued)

"Harvest" of Incubator	Larvae are maintained in the incubator until the alimentary tract is complete (approximately 48 hours after hatching at 25 C). The incubator is then drained slowly into a "harvest" tank.
"Harvest" Tank Description	A general description of the "harvest" tank is as follows: • 60-80 liters capacity. • Equipped with a 25-mm diameter internal stand pipe to drain overflow. • Place a screen constructed with 0.33-mm mesh filter cloth around the stand pipe to prevent loss of larvae during draining.
Estimation of Larvae	Procedures for estimating the number of larvae are as follows: • When draining is complete adjust water level in the "harvest" tank to a known volume (e.g. 20 liters) by siphoning through a 0.33-mm mesh sieve. • Apply gentle aeration to mix the larvae. • Collect 3 to 10, 1- to 5-ml samples depending upon relative density of larvae. • Count the number of larvae in each sample. • Calculate the mean number of larvae/ml. • Extrapolate the number of larvae using the formula: NL = V x ML where: NL = Total number of larvae V = Total volume (ml) of water in harvest tank ML = mean number of larvae/ml (as sampled).

(Continued)

EGG AND PROLARVAE CARE (Continued)

Comment

The above described method of estimating numbers of larvae for stocking may overestimate the true number of larvae being stocked. Matlock et al. (1986) found that estimating the number of red drum larvae using a full 48.5-liter aquarium and counting ten 10-ml samples resulted in overestimating by 28.6% when stocking 50,000 larvae. The percent of overestimation decreased as the number to be stocked increased. For example, the overestimate was only 5.8% when stocking estimate was 350,000.

TRANSPORTATION OF LARVAE

Plastic Bag Method

The following procedures are used to transport larvae in plastic bags:

- Add about 10 liter of water to a 37-liter plastic bag. Water should be the same salinity and temperature as that from which the larvae are to be taken.
- Place approximately 100,000 larvae in the bag by dipping the estimated volume of water from the "harvest" tank that would contain that number of larvae. Base this on the mean number of larvae/ml in the harvest tank.
- Fill the remaining volume of the bag with oxygen and seal the bag. MFRS uses elastic bands to seal the bags.
- Transport the bag to stocking site and float the bag for sufficient time to allow temperature within the bag to equal that of the water at the stocking site.
- If salinities of transport water and water at the stocking site differ by more than 5 o/oo, slowly add water from the stocking site to the bag for 15-30 minutes until the salinities between transport water and stocking site water are within 5 o/oo.

LARVA TO FINGERLING CULTURE

Introduction

Procedures described in this section are used to rear spotted seatrout in ponds to 25 to 30-mm TL. This is the smallest size at which fingerlings will survive handling stress and transport. Larger fingerlings may be produced by these methods but the quantity produced will generally be reduced.

Description of MFRS Ponds

A general description of ponds at the MFRS is as follows:

- 0.1 to 1.2 hectares.
- Levee slope 3:1. A 4:1 or 5:1 slope is currently recommended in windy coastal areas to reduce erosion (Ulmer 1990).
- Approximately 1.2-2.0 m maximum depth.
- Clay lined.
- A single fill line goes to each pond. Fill lines are 10-25.4 cm depending on size of pond.
- Each pond is constructed with a single concrete drain box with a 10-61 cm drain pipe depending on pond size. (Figure 7).
- Dam boards inserted in 5-cm vertical slots located approximately 90 cm in front of the drain pipe retain water.
- A screen placed in a second set of vertical slots located approximately 15 cm in front of the dam boards prevents loss of fish. A 0.5-mm mesh screen is used for the first 2 weeks of the culture period. An 8-mm mesh screen is used during the final weeks of culture.

LARVA TO FINGERLING CULTURE (Continued)

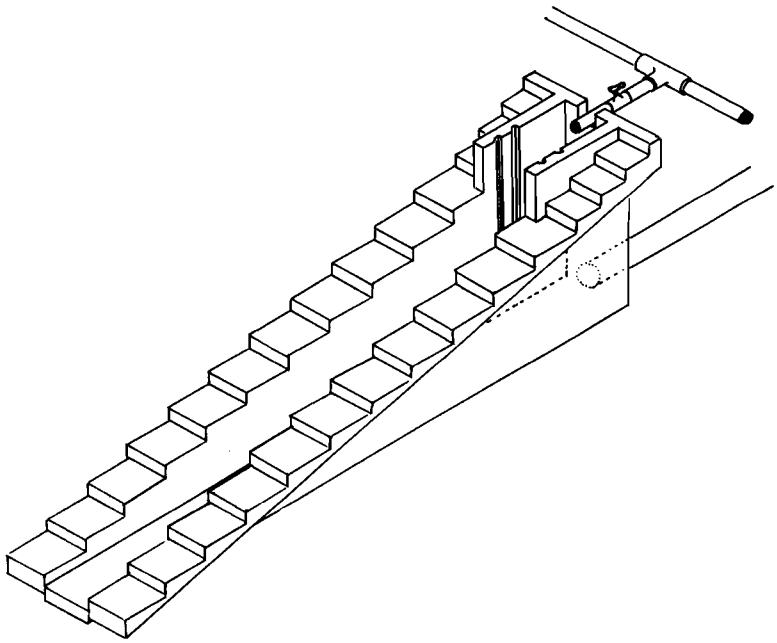


Figure 7. Concrete drain structure used at the Perry R. Bass Marine Fisheries Research Station.

Pond Filling

Begin filling approximately 4 weeks before anticipated stocking.

Filter all incoming water with 0.5 mm mesh filter.

Salinity range of incoming water should be 10-45 o/oo with 20-35 o/oo preferred.

Water temperature should be at least 23 C.

Pond Fertilization

The following spotted seatrout pond fertilization schedule is used at the MFRS. All fertilizer rates are calculated on a per hectare basis.

(Continued)

LARVA TO FINGERLING CULTURE (Continued)

Pond Fertilization (Cont.)

POND FERTILIZATION SCHEDULE
PERRY R. BASS MARINE FISHERIES RESEARCH STATION

Day	Action
1	Spread 282 kg cottonseed meal (CSM) on the dry pond bottom. Fill to approximately 1 m depth.
3	Continue filling. Add 9.0 liters phosphoric acid and 4.6 kg urea[a].
7	Add 31.3 kg CSM
10	Add 31.3 kg CSM
12	Add 31.3 kg CSM, 3.0 liters phosphoric acid, 4.6 kg urea
15	Add 31.3 kg CSM
17	Add 31.3 kg CSM
19	Add 31.3 kg CSM, 3.0 liters phosphoric acid, 4.6 kg urea
21	Add 31.3 kg CSM
23	Add 31.3 kg CSM
25[b]	Add 31.3 kg CSM, 3.0 liters phosphoric, 4.6 kg urea

[a]Phosphoric acid 55% P_2O_5, Urea 45% N
[b]Additional fertilizer may be added if fry stocking is late or growth is slow.

Comment

Fertilization should be discontinued and water added or exchanged if pond dissolved oxygen is less than or equal to 4 mg/l.

Zooplankton Forage Base

Culture of spotted seatrout in ponds to about 30-mm TL is dependent upon the zooplankton forage base. In ponds, the fish feeds extensively on copepods (Colura et al. 1976), however, studies of historical data at the MFRS has revealed that the presence of high polychaete larvae densities (>500/l) especially during the latter half of the culture period was associated with harvests of 23-65% (Colura et al. In Review). Ponds with polychaete larvae densities of approximately 200/l or less had survivals of 0-15%.

(Continued)

LARVA TO FINGERLING CULTURE (Continued)

Zooplankton Sampling

Because of importance of zooplankton in the culture of spotted seatrout fingerlings, zooplankton are routinely sampled. The MFRS currently samples spotted seatrout culture ponds three times weekly by collecting 25 liters of water using a flexible impeller pump apparatus (Farquhar and Geiger 1984). The water is filtered through a 64- m mesh Wisconsin plankton net to concentrate the zooplankton. The sample is then preserved in a 5% formalin solution. The preserved sample is then subsampled and major zooplankton groups identified and enumerated as follows:

- The sample is placed in a graduate cylinder and water added to yield a final volume of 300 ml (this volume has been found to dilute the sample to about 200 organisms/ml as recommended by Weber 1973).
- The sample is stirred to uniformly distribute the zooplankton and a 1-ml subsample withdrawn with a Hensen-Stemple pipette.
- The subsample is placed in a Ward plankton counting wheel.
- Using a stereomicroscope the following major zooplankton groups are identified and counted:
  - Copepods
  - Copepodids
  - Copepod nauplii
  - Rotifers
  - Polychaete larvae
  - Total zooplankton (all of the above groups plus minor taxa)

Zooplankton

- Number of organisms/liter are then calculated using the formula:

$$\text{Number of organisms/liter} = \frac{N \times \frac{300 \text{ ml}}{1 \text{ ml}}}{25 \text{ liters}}$$

where:

N = number of organisms in the subsample

Comment

Many fish culturists prefer to pull a plankton net horizontally through the pond to obtain a zooplankton sample. If this method is used, the volume of water strained should be calculated and substituted for the 25 liter volume in the above formula. All other procedures for subsampling and counting remain the same.

(Continued)

LARVA TO FINGERLING CULTURE (Continued)

Stocking

In previous studies at the MFRS, spotted seatrout were stocked 9-28 days after ponds were initially filled. Best survivals were generally associated with ponds stocked at least 25 days after initial fertilization. High survivals in these ponds were also associated with large densities of polychaete larvae and it was theorized the polychaete larvae provided additional forage to sustain growth and survival especially during the last 2 weeks of culture (Colura et al. In Review). Polychaete larvae typically reach greatest densities 4 to 7 weeks after initial filling (Rubright et al. 1981, Colura et al. In Review). Therefore, it is suggested spotted seatrout larvae be stocked about 4 weeks after initial filling of the pond. The larvae are stocked when the alimentary tract is complete. This usually occurs at 2 days of age if the water temperature in the incubator is maintained between 26-29 C.

Best stocking densities are approximately 500,000-700,000 larvae/ha (Colura et al. 1987).

Greater stocking densities (1,225,000 fry/ha) can be used but will generally result in increased numbers but percent survival is reduced and individual fish size at harvest will be significantly smaller (Colura et al. 1987).

Pond temperature at stocking should be at least 23 C. Peak spawning of spotted seatrout occurs when water temperatures reach 23 C in April. It also has been reported that 23 C is the minimum temperature for successful spawning (Brown-Peterson et al. 1988).

Pond Water Quality

Collect samples each morning beginning at sunrise. Water quality parameters to be collected and preferred levels are:

- Dissolved oxygen (DO) concentration (mg/l). Should be at least 4 mg/l. If DO is less than 4 mg/l discontinue fertilization and pump new water into pond. Emergency aeration may also be necessary.
- Salinity 10-45 o/oo. 20-35 o/oo preferred.
- Temperature at least 23 C.

Supplemental Feeding

Supplemental feeding is not necessary to produce spotted seatrout fingerlings (Colura et al. 1976, Colura et al. 1990a, Bumguardner et al. In Review). However, laboratory studies indicate spotted seatrout will accept dry salmonid feeds at 14-24 days of age (Tucker 1988, King et al. In Review). Spotted seatrout began accepting dry feed (0.6 mm-

(Continued)

LARVA TO FINGERLING CULTURE (Continued)

Supplemental Feeding (Cont.)	1.0 mm diameter) at 14 days of age and 18-21 mm total length in laboratory feeding studies at MFRS. Providing supplemental feed beginning 14 days after stocking may increase survival and production of spotted seatrout fingerlings by reducing starvation and cannibalism. Supplemental feeding rates of approximately 4 kg/ha daily have been used in a few culture trials at the MFRS.
Production Period	Fingerling spotted seatrout can be produced in approximately 21-33 days depending on temperature. Fish should be harvested as soon as they are about 30-mm TL. Delay will result in reduced survival as zooplankton forage is depleted and fish become cannibalistic.
Sampling	Twenty spotted seatrout are sampled weekly at the MFRS by either seining, or dip net to monitor growth. Collecting with a dip net is easiest. To collect fish with a dip net: • Water is pumped into the pond. • The fish are attracted to the currents created where incoming water is discharged into the pond and up to several hundred individual fish may be collected by passing the dip net through the discharge area.
Pond Inoculation	Inoculation of ponds with a suitable crustacean forage has successfully increased striped bass fingerling production in freshwater ponds (Geiger 1983 a, b). However, attempts to inoculate MFRS ponds with brine shrimp and mysid shrimp have been unsuccessful (Porter and Maciorowski 1984, Colura et al. 1990a).
Harvest	The following procedures are used to harvest ponds: • Screen the discharge with an approximately 8-mm mesh wire screen. • Drain the pond as rapidly as possible without pinning fish on the screen. • The catch basin should be cleaned of hydrogen sulfide laden mud before removing fish. This is accomplished by sweeping the box with a stiff brush during draining. A gasoline powered pump may also be used to remove the mud from the catch basin.

(Continued)

LARVA TO FINGERLING CULTURE (Continued)

Harvest (Cont.)

- Fish are harvested by concentrating them in the catch basin and removing them with a dip net.

Estimation of Numbers of Fish Harvested

The number of fish harvested is determined by either:

- mass weighing fish by taring the dip net and weighing each net full of fish or;
- transferring fish from the dip net to a bucket of water which has been previously tared and then weighing the bucket and fish.

Number of fish/kg is then determined by weighing 3 to 5 100-fish samples and calculating a mean weight/100 fish.

- Number of fish harvested is extrapolated by the formula:

$$NF = WT \times MWT \div 100$$

where:

NF = Total number of fish
WT = Total weight of harvested fish
MWT = mean weight of 100 fish

Use of Weight-Length Information

Weight-length information is frequently used by fish culturists to rapidly estimate biomass and numbers of fish harvested (Bowen and Studdard 1970). An average length is calculated and weight determined using the appropriate formula (See Weight-Length) below. Total weight of fish harvested is then divided by the calculated average weight to estimate the number of fish harvested.

Weight-Length

The weight-length relationship for 1,100, 19-39 mm total length spotted seatrout, reared at the MFRS in 1986 was:

$$\log W = -3.3184 + 3.1827 \log TL$$
$$r^2 = 0.972$$

Where:

$\log W = \log_{10}$ of weight (g)
$\log TL = \log_{10}$ of total length (mm)

(Continued)

Total length - Standard length	The total length-standard length relationship for 1,100 spotted seatrout fingerlings, 15-31 mm SL, reared at the MFRS in 1986 was: $TL = 0.5093 + 1.2294\ SL$ $r^2 = 0.983$ Where: TL = total length (mm) SL = standard length (mm)

TRANSPORTATION AND STOCKING OF FINGERLINGS

Transport Density

Spotted seatrout fingerlings may be transported to stocking sites in any commercially available fish delivery tank. The tank should be equipped with compressed oxygen.

Stocking densities should be less than or equal to 150 g of fish/liter during transport. Maximum time at which spotted seatrout can be hauled at this density is unknown.

Water Quality

Dissolved oxygen concentration should be maintained at 5-10 mg/l during transport by regulating the amount of compressed oxygen released in the tank.

Salinities should be the same as the pond water from which the fish are collected.

Comment

Many culturists use agitators to prevent supersaturation of water with oxygen. Those planning to use agitators are advised to do so with extreme caution when transporting small (about 25 to 30-mm TL) spotted seatrout. Small spotted seatrout usually are unable to resist currents created by agitators and are frequently killed.

Acclimation of Fingerlings

The following procedures are used to acclimate the fingerlings to temperatures and salinities at the release site:

- Exchange water in the hauling tank at approximately 2,600 liters/hour. This is most easily accomplished by pumping water from the release site into the hauling tank using a battery (12V) operated pump with a flow rate of approximately 90 liters/minute.
- Continue to exchange water until hauling tank water is within 5 o/oo and 2 C of the environment into which the fish will be stocked before releasing them.

ADVANCED FINGERLING CULTURE

Introduction

Spotted seatrout fingerlings have not been grown to market size in ponds at densities high enough to support commercial production. However, in a single pond trial at MFRS in the fall of 1984, spotted seatrout fingerlings grew from 25 mm to 88 mm and gained 6.15 g in 86 days. The stocking rate was 8,750 fish/ha, and survival was 46%. Also, a feeding trial conducted at MFRS with 14-day-old spotted seatrout indicated salmon starter diets are accepted by seatrout juveniles (King et al. In Review).

Initial attempts to culture spotted seatrout to advanced size should follow the general methods below.

Stocking Density

Less than or equal to 10,000/ha initially, density may be increased as additional experience in spotted seatrout culture is gained.

Feeding Rate

Although no attempt has been made to culture spotted seatrout to market size, the following feeding schedule, adapted from a red drum feeding schedule (Colura et al. 1990b) should provide initial feeding guidelines. Either Silver Cup^{R} (Murray Elevators, Murray, Utah) or Rangen^{R} (Rangen Incorporated, Buhl, Idaho) trout diets should be of sufficient quality for spotted seatrout acceptance and growth.

FEEDING SCHEDULE

Day	Percent of estimated total biomass offered as feed
14-90	10
90-120	8
120-150	5
150-250	3

Comment

Feed size should be adjusted to be appropriate for the fish. As with any feeding schedule, when dissolved oxygen concentrations reach critically low levels, feeding should be stopped, then resumed gradually after dissolved oxygen concentrations return to safe levels (greater than 3 mg/l).

(Continued)

ADVANCED FINGERLING CULTURE (Continued)

Comment

If fish are consistently not consuming all feed offered, the feeding rate should be decreased. Conversely, if fish continue to search for food after the allotted amount is consumed, the rate should be increased.

Comment

Spotted seatrout held in aquaria will consume floating feed. If floating feed is used in the pond, the culturist may choose to feed the fish until active feeding ceases rather than use the above feeding schedule. However, the culturist should be aware that surface feeding often results in predation by birds.

Growth Rate

Spotted seatrout fingerlings stocked at 30 days-of-age and cultured in ponds for an additional 87 days at the MFRS in the fall of 1984 (Figure 8) grew 0.7 mm/day and gained 0.07 g/day. Fish were fed 10% of their estimated body weight daily when water quality was appropriate. Spotted seatrout survival was 46%, production was 0.3 kg/ha/day. Feed conversion was 5.2 kg feed/kg of fish produced.

Spotted seatrout juveniles held at 28 C gained 0.06 g/day in a laboratory growth trial. Fish held at higher and lower temperature grew significantly less than those held at 28 C (Bumguardner and Maciorowski 1989).

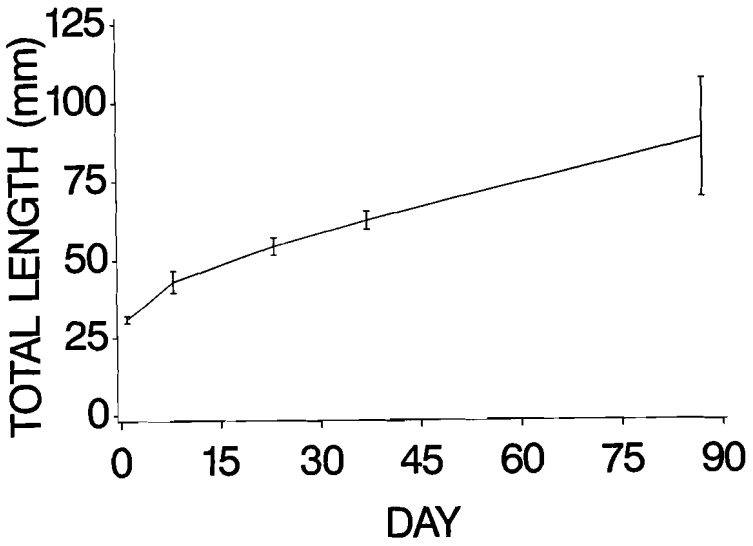


Figure 8. Growth of spotted seatrout to 88 mm TL in ponds from 14 August to 8 November 1984 at MFRS. Points represent total length, bars represent ± SD.

(Continued)

ADVANCED FINGERLING CULTURE (Continued)

Growth Rate (Cont.)

Growth in total length of spotted seatrout held in ponds in 1984 was best described by the equation:

$$\log TL = 1.436 + 0.0047 \text{ (Age)}$$
$$r^2 = 0.85$$
$$n = 340$$

where:

log TL = $\log_{10}$ of total length (mm)
Age = age of fish in days

The weight to total length relationship was:

$$\log W = -5.02796 + 2.95514 \text{ (log TL)}$$
$$r^2 = 0.99$$
$$n = 340$$

where:

log W = $\log_{10}$ of weight (g)
log TL = $\log_{10}$ of total length (mm)

REGULATIONS

Introduction	Several state and federal licenses or permits are required to culture spotted seatrout in Texas. In addition, several agencies of both the state and federal government review and comment on applications for permits. A listing of regulatory, licensing or reviewing agencies is presented below. Included are addresses where the reader may obtain detailed information on procedures for applying for permits or purchasing licenses. Applicants may also contact their local county marine extension agent for assistance in applying for and obtaining permits and licenses. Regulations affecting fish farmers are subject to change, so appropriate local, state, and federal agencies should be contacted concerning the most recent regulations.
Texas Water Commission	No permit is required to take brackish or marine water for rearing spotted seatrout, however, persons taking water must report their intention to the Commission prior to taking water. Permit is required to divert fresh water. Permit may be required to discharge water. Contact: Texas Water Commission P.O. Box 13087 Capitol Station Austin, Texas 78711
General Land Office	Permit is required for construction on state lands (i.e. bay bottoms). A Coastal easement permit is required. Contact: General Land Office Land Management Program Coastal Section 1700 N. Congress Ave. Stephen F. Austin Bldg. Austin, Texas 78701
Texas Department of Agriculture	A fish farming license is required. A permit to operate a processing plant for aquaculture products will be required if the fish are processed by the producer.

(Continued)

REGULATIONS (Continued)

Texas Department of Agriculture (Cont.)	Contact: Texas Department of Agriculture P.O. Box 12847 Austin, Texas 78711
Texas State Department of Health	Food Manufacturers Registration is required to process and package fish. Contact: Texas State Department of Health 1100 West 49th Street Austin, Texas 78756
Texas Parks & Wildlife Department	Responsible for enforcement of regulations pertaining to the sale and distribution of cultured fish. Contact the TPWD for current rules and regulations. Administrative review of the project to assess environmental impact. Permit is required to collect broodfish from public waters. If hatchery reared broodstock are available from a commercial hatchery this permit may be denied. A sand, shell, gravel, and marl permit is required if bay bottom is removed to install intake or discharge structures. Contact: Texas Parks & Wildlife Department 4200 Smith School Road Austin, Texas 78744
Texas Antiquities Committee Texas Historical Commission	Administrative review of project to assess historical significance of site. Contact: Texas Antiquities Committee Texas Historical Commission P.O. Box 12276 Austin, Texas 78711
U.S. Environmental Protection Agency	A water discharge permit may be required. The Texas Water Commission will notify the applicant if Environmental Protection Agency involvement is necessary. Contact: U.S. Environmental Protection Agency Region 6 First International Bldg. 1201 Elm Street Dallas, Texas 75270

(Continued)

REGULATIONS (Continued)

Army Corps of Engineers	A permit for locating an aquaculture related structure in navigable waters is required. A permit is required if any dredging and/or filling in navigable waters or wetlands are necessary. Contact: District Engineer U.S. Army Engineering District, Galveston Corps of Engineers P.O. Box 1229 Galveston, Texas 77553 or Corps of Engineers P.O. Box 2948 Corpus Christi, Texas 78403
U.S. Department of the Interior	Administrative review of the project to assess environmental impact. Contact: U.S. Department of Interior Fish and Wildlife Service CCSU 6300 Ocean Drive Campus Box 338 Corpus Christi, Texas 78412
National Marine Fisheries Service	Administrative review of the project to assess environmental impact. Contact: National Marine Fisheries Service Environmental Protection Service 4700 Avenue U Galveston, Texas 77550

Appendix B Metric - English measurements conversion table

Table B. 1. Conversion units for converting selected metric measurements to their English equivalent and for converting temperature from degrees Celsius to degrees Fahrenheit.

Unit	Abbreviation	Equivalent
Length		
Meter	m	39.37 inch
Centimeter	cm	0.39 inch
Millimeter	mm	0.039 inch
Micron	m	0.000039 inch
Area		
Hectare	ha	2.47 acres
Volume		
Liter	liter or l	1.057 quarts
Milliliter[a]	ml	0.21 teaspoons
Mass and Weight		
Kilogram	kg	2.2 pounds
Gram	g	0.034 ounce
Milligram	mg	0.000034 ounce
Temperature		
Celsius	C	Fahrenheit = 1.8C + 32

[a] 1 milliliter = 1 Cubic centimeter which is frequently abbreviated as cc.

PWD RP N3400–375 (7/93)

Dispersal of this publication conforms with Texas State Documents Depository Law, and it is available at Texas State Publications Clearinghouse and Texas Depository Libraries