GUIDELINES FOR THE CULTURE OF STRIPED BASS AND PALMETTO BASS

by

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Introduction

Striped bass *Morone saxatilis* is one of the most popular sport fishes in the state of Texas. Populations of striped bass in Texas reservoirs are maintained through stocking of hatchery-reared fingerlings because natural reproduction is negligible. Texas Parks and Wildlife Department has been stocking striped bass fingerlings into public waters since the early 1970's. Production of striped bass and palmetto bass fingerlings is the primary focus of two of the five state freshwater hatcheries. These hatcheries produce in excess of three million *Morone* fingerlings annually.

Techniques for successful production of fingerling striped bass have evolved over the years through research and personal experiences of culturists. Improvements in all phases of *Morone* fingerling production have been documented as culture guidelines to provide a resource to culturists. These culture guidelines serve several purposes including consolidation of information for easy access, manual for practicing culturists, and source of issues or methods for further investigations and improvements.

This document is an update of the *Striped Bass Culture Guidelines* prepared in 2003 and includes improvements made in culture techniques since then. In addition to the latest production methods, strategies for preventing *Prymnesium parvum* ichthyotoxicity have been emphasized. The *P. parvum* management plans for Dundee and Possum Kingdom hatcheries are provided in separate appendices for easy reference. Likewise, a list of relevant department publications on striped bass is provided.

CHAPTER 1

Brood Fish Management

Brood Fish Procurement and Handling

Male white bass (*Morone chrysops*) for palmetto bass (female *M. saxatilis* x male *M. chrysops*) production are collected from the Brazos River above Lake Granbury near the Horseshoe Bend area. Historically, collections occur in mid-March to April 1. The main source of male and female striped bass (*M. saxatilis*) has been at the dam below Lake Livingston. Alternative collection sites are at the dams below Inks, Buchanan, and Toledo Bend reservoirs. Collection from Lake Livingston is scheduled for mid-April. Records indicate that striped bass adults have been collected from various locations in Texas during the months of April and May (Appendix A).

Distribution of brood fish to hatcheries for spawning may vary from year to year. For example, in recent years the A. E. Wood Fish Hatchery has received brood fish to produce fry for out-of-state trades. The number of striped bass females allocated to each hatchery is based on weight of females and egg incubator capacity. The weight of females needed to fill incubators with eggs is calculated using the number of eggs/kg female table (Appendix B). To ensure that the annual brood fish collections go smoothly, adequate preparations are made including the following:

- Participating hatcheries prepare and bring fish identification tags to the collection site.
- Routine maintenance schedules are implemented for all collection equipment.
- Equipment is checked for good condition and safe operation.
- Electrofishing boat and all associated equipment are checked for proper operation.
- Holding tanks on electrofishing boats are equipped with compressed oxygen.
- Electrofishing boat collection tanks are not overloaded with brood fish.
- Fresh water is added to collection tank as needed.
- Handling of brood fish is kept to an absolute minimum.

Verification of Ovulation

Females are "tubed" to determine eligibility for strip spawning. This is done by inserting a glass catheter into the urogenital opening and removing a small sample of eggs. Egg samples may also be taken from the ovaries using a 2.2-mm OD flexible tube. Eggs are examined under a light microscope to determine the level of development. A striped bass egg development reference may be used for guidance (Harrell et al. 1990). Fish that are ≥15 h from ovulation are considered ineligible. For ease of handing during strip spawning, 5-11-kg females are preferred. Exceptionally larger or smaller females are released back into the water. Eligible females are given an intramuscular injection of human chorionic gonadotrophin (HCG) at a rate based on size (Appendix C). Males are also injected at a lower rate (Appendix D) to sustain or induce milt production.

Because brood fish must be genetically certified after spawning or productivity data are used for program planning, proper record keeping is essential. The following data are recorded at the collection site:

- Collection site and date.
- Water temperature at collection site.
- Collection method.
- Sex and weight of fish.
- Egg stage.
- Brood fish ID number and tag color.
- Time of injection and amount of HCG injected.
- Trailer location (compartment) for fish.

See Appendix E for broodfish data sheet.

Fish Transportation and Water Quality

A routine maintenance schedule should be implemented for all transportation equipment, and all pieces of equipment associated with transportation of brood fish must be checked and tested before use. Compressed oxygen must be supplied to all compartments of transport tanks, and agitators should be available as backup should the oxygen delivery system fail. Clean transport tanks must be filled with water from the collection site. Salt is added to transport tanks just before or during pumping of water to fill tanks for proper mixing. Striped bass brood fish is transported in 1% salt solution with No-Foam®. Dissolved oxygen in transport tanks is maintained above 6 mg/L and below saturation.

Brood fish should be handled with extreme care from the boat to the transport truck. Fish should never be held out of the water for any longer than necessary and should never be dropped or laid on the ground for any reason. The destination hatchery for the brood fish should be contacted just after the truck is loaded and the following information provided:

- Number, total weight, and average weight of females.
- Water temperature at collection site.
- Estimated time of arrival at the hatchery.

The program leader will transmit the broodfish collection data forms to the receiving hatchery shortly after the fish collection is completed for the day. Each transport truck will be equipped with a cell phone. Multiple trucks going to the same destination will travel together and will provide cell phone numbers to each other and the receiving hatchery.

All equipment associated with holding striped bass brood fish at the hatchery must have a routine, annual maintenance program. The broodfish holding system should be tested and any problems resolved before brood fish are scheduled to arrive. The optimum water temperature range for holding striped bass brood fish is 17.7-18.8°C (64-66°F). Temperatures outside this range can reduce egg hatch rate. The holding tank water should be maintained in this temperature range with the use of either heaters or chillers before the brood fish arrive. Water temperature should be continuously monitored and recorded every hour. Dissolved oxygen in

broodfish holding tanks should be maintained above 6 mg/L and below saturation. Total un-ionized ammonia nitrogen should not exceed 0.025 mg/L in broodfish holding tanks. Water from broodfish holding tanks should never be mixed with incubation water in re-circulating systems. Six-foot-diameter circular fiberglass tanks or fiberglass troughs (3.3 m x 0.6 m x 1 m) are used for holding striped bass females. Water should be added to the holding tanks to create a gentle, circular motion or linear flow for the brood fish to swim against.

When transport trucks arrive at the hatchery, temper the brood fish by exchanging the transport water with the same water the brood fish will be held in. Temper for a minimum of 30 min regardless of water temperature differences. This will allow brood fish time to acclimate to the new water quality. If fish are to be injected with HCG at the hatchery, the following procedure should be followed:

1. Quickly weigh the female or male.
2. Take brood fish immediately to a circular holding tank and hold in water with a net.
3. Tag the fish.
4. Inject and carefully release fish into a designated tank.

Prediction of Ovulation

Back at the hatchery, egg samples for predicting ovulation (i.e., staging of eggs) should be taken 15-24 h after the initial injection depending on the temperature of the water from which the fish was collected and the time of season. At this phase of egg staging, females should be separated by egg stage into different holding tanks to minimize future handling during palpation.

The following spawning information should be recorded for each female:

- Collection date and site.
- Water temperature at collection site.
- Fish weight, tag number and color.
- Time of injection.
- Time of egg staging and egg stage.
- Time of spawning, numbers of males (striped bass or white bass) used with the female.
- Number of eggs.
- Percent fertilization.
- Percent hatch.
- Number of fry.
- Distribution of fry (i.e., where they went) of each male and female.

See Appendix F for data form.

Note: Do not return any fish injected with HCG to the wild.

CHAPTER 2

Spawning Procedures

Determination of Ovulation

The first manual palpation of females should begin 2 h before the predicted time of ovulation. When ovulation has begun, very slight pressure to the abdominal area will cause eggs to flow freely. At this time, the eggs are ready to be removed. There is a maximum of approximately 60 min between ovulation and over-ripeness. The female must be manually spawned within this time period.

Egg Removal and Fertilization

Eggs are manually spawned using the wet fertilization method. The female is anesthetized using 100 mg/L MS-222 (tricaine methane sulphonate). The MS-222 can be sprayed on the gills or administered as a bath. More often, the female must be incapacitated very quickly by efficient and humane means. Males can be anesthetized with 20 mg/L MS-222 and used more than once. Do not return brood fish anesthetized with MS-222 to the wild.

A clean, shallow, plastic pan is used for receiving and fertilizing eggs. About 1-2 L of incubation water is added to the pan. Eggs from a female are manually stripped into the pan and milt from two males is added simultaneously and gently stirred into the eggs for approximately 3 min. Do not cut open females to remove eggs unless the vent is plugged. If the vent is plugged, an incision can be made to enlarge the vent to remove the plug. The volume of eggs spawned is determined by water displacement. The staff at Dundee State Fish Hatchery (DFH) enumerates egg samples using a Jensorter egg/fry counter to determine the number of eggs/mL/female whereas the staff at Possum Kingdom State Fish Hatchery (PKH) uses an established number of 660 eggs/mL of displaced water. Eggs are then placed into McDonald jars up to a maximum of 200,000 eggs per jar. Eggs from a large female may required as many as four jars. Excess water and milt should be removed from the fertilization pan before eggs are placed into incubation jars.

Brood Fish Certification

All spawned striped and white basses are genetically certified by the Fish Health and Genetics Laboratory (FHGL) in San Marcos. This is done to ensure the genetic purity of the fingerlings produced. Furthermore, the genetic certification ensures that reservoirs designated for palmetto bass receive only palmetto bass fingerlings and those designated for pure striped bass do not receive palmetto bass.

After spawning, approximately 1.0 g of white muscle tissue from approximately 25 mm below the dorsal fin is extracted from all male and female striped bass. For the production of palmetto bass, tissue samples are collected from all white bass males and striped bass females. Each tissue sample is placed in a separate sample vial, marked with the fish's identification (ID) number and frozen immediately. All vials are kept in plastic zip-lock bags. For shipment, bags are placed in an insulated container packed with dry ice and shipped overnight delivery ASAP to the FHGL for genetic analysis. Personnel at the FHGL should be contacted by the shipping

hatchery at least 24 h prior to shipment so they can schedule personnel to analyze the samples upon arrival.

Eggs, fry or fingerlings should not be shipped or stocked without genetic certification. Timely shipment of tissue samples to the FHGL is therefore essential. Be aware that reservoirs could be stocked with 3-d-old fry and out-of-state shipments are 3- to 5-d-old fry.

CHAPTER 3

Eggs and Fry

Egg Incubation

All components of the egg incubation system must be maintained and tested before use. The incubation system should be completely tested three weeks prior to the first scheduled brood fish collection.

Measures must be taken to prevent *Prymnesium parvum* contamination of incubation systems. Incubation equipment should be disinfected, washed, and rinsed before use and between batches of egg incubation. Personnel should be assigned to continuously monitor all phases of egg incubation, and the incubator should never be left unattended. The optimum water temperatures for striped bass egg incubation are 17.7-18.8°C (64-66°F). These temperatures should be maintained with either water heaters or chillers. The dissolved oxygen for striped bass egg incubation should be above 6 mg/L and below saturation. Water temperature and dissolved oxygen in an incubator should be monitored continuously. The pH of the incubator should be 7.5-8.5, and un-ionized ammonia nitrogen should not exceed 0.02 mg/L. Enough makeup water should be added to re-circulating systems to maintain adequate water quality. Striped bass eggs should never be exposed to direct sunlight. The preferred method for hatching striped bass eggs is the standard 6-L McDonald-type hatching jar. Approximately 200,000 fertilized eggs is the maximum for each McDonald hatching jar. Too many eggs in a jar can result in poor egg circulation and diminished hatch rate.

Hatching jars must be continuously monitored and water flows adjusted, as necessary, to keep the eggs gently rolling inside the jars. These eggs must be checked frequently since changes in buoyancy may cause them to flow out of the jars. Live eggs should never be allowed to float out of jars into other areas of the incubation system and then put back into the jars. Because of continuous water pumping to keep the incubation water circulating, gas bubbles may adhere to eggs and cause them to float out of the jars. This can be corrected by passing pumped water through packed columns or by mechanical agitation of the water in the header box. Usually, there is a minor die-off of unhealthy eggs at approximately 18 h post spawn. Dead eggs should be removed from the incubation system, which can be achieved by siphoning or placing egg catchers below the jar out-flows. As the fry begin to hatch, it may be necessary to slightly increase the water flow to assist the fry in hatching and exiting the jar. Be sure standpipes are secure in the fry incubators and the egg catchers are removed prior to egg hatching. After most of the fry have swum out of the jars, the few that remain in the hatching jars are either deformed or unhealthy and should be discarded.

Egg fertilization rate and viability: Four to six hours after fertilization, take a sample of 300-500 eggs from each egg batch and determine percent fertilization by examining the eggs microscopically. Multiply the percentage of fertilized eggs by the total number of eggs in the batch to determine the number of viable eggs.

Note: Determination of egg fertilization rate and number of viable eggs is optional.

Fry Incubation

All fry incubation equipment should have a routine, annual maintenance program implemented, followed by testing of the entire incubation system a few days prior to the first scheduled collection of brood fish. Additionally, all fry incubation equipment must be disinfected and cleaned between batches of brood fish. The optimum water temperature range for incubation of striped bass or palmetto bass fry is 17.7-18.8°C (64-66°F) which should be maintained by the use of heaters or chillers. The water temperature and dissolved oxygen should be continuously monitored. Dissolved oxygen in fry incubators (hatching jar and fry vats) should exceed 6 mg/L but below saturation. Un-ionized ammonia nitrogen should not exceed 0.02 mg/L in fry incubators. Higher levels of un-ionized ammonia nitrogen must be ameliorated by adding fresh water to the system. When pumping water, passing it through packed columns or using agitators in the header box should eliminate supersaturated gases from the fry incubators. Water flows into fry incubators must be adjusted to keep fry suspended and to maintain water quality. However, excessive water flow can result in injury to the fry. Standpipes in incubators should be equipped with porous tubing at each base to provide an air-bubble curtain around the filter screen to keep fry or other materials from stopping up the filter and causing the water to overflow out of the fry incubator. Standpipes should be continuously monitored and cleaned as needed. All fry holding containers should be appropriately labeled: "STB" for striped bass or "WXS" for palmetto bass.

To inflate swim bladder, striped bass or palmetto bass fry must gulp air; therefore, containers must be well aerated but not excessively. In addition to insufficient aeration, surface oil film accumulated from egg oil globules can cause reduced swim bladder inflation. To alleviate this problem, oil absorbent paper towels can be used to remove oil film from the surfaces of the water and containers. At PKH, a standpipe in a lower header box was shortened to act as a skimmer to get rid of surface oil film. This is done just prior to and during egg hatching. To control fungus, break down dead egg shells, and dissolve oil from eggs, fry can be given a daily static bath of Formalin-F (125 mg/L) ® for 30-45 min. This procedure is optional and requires appropriate record keeping. Dissolved oxygen levels should be monitored during formalin treatments and oxygen supplied as necessary. Do not use any chemicals unless an Investigational New Animal Drug (INAD) permit is obtained or they have been registered for fisheries use. Fungus should not be a problem if incubators are disinfected prior to each use. Proper water temperature control will also reduce fungus infection.

Fry Enumeration and Stocking

Fry are enumerated using methods described in the fish culture enumeration methods manual (D. R. Wade, Texas Parks and Wildlife Department, unpublished). Essentially, when fry are in vats with known quantities of water, grab samples of a known volume are taken and the fry densities in the vats back calculated with the sample data. The DFH verifies these sample estimates with a Jensorter fry counter. Knowing fry densities in vats, the volume of water (and thus number of fry) for stocking each pond is determined. Ponds are stocked at rates of 494,000-555,750 fry/ha. However, given the current shortage of pond space and improved fish feeding strategies, there is a need to investigate higher pond stocking densities. The ideal stocking time is just before sunrise.

If excess fry are to be stocked into reservoirs or ponds at other hatcheries, the fry should not be exposed to direct sunlight. The bags should be floated in the receiving water for several minutes (and shaded from the sun) until the temperatures inside and outside the bag are similar. After temperatures equalize, the bags are opened and slow water exchanges are conducted, followed by slow release of the fry into the receiving water. At the hatchery, the ideal stocking time is just before sunrise. Coordination between producing and receiving hatcheries should be done so that fry arrive at the optimum stocking time.

Eggs and Fry Shipping

Fry that are shipped to other locations are transported in sealed plastic bags with approximately 9.5 L (2.5 gal) of water and enough oxygen to fill the bag when sealed. Transit temperatures should be 17.7-18.8°C (64-66°F). Bags should be double-sealed with elasticator bands. Before fry are bagged, water samples are taken from fry holding containers to verify absence of *P. parvum* cells. If live cells are present, fry should not be shipped to other agencies or lakes that do not have a history of *P. parvum*. Fry should be shipped for stocking into lakes when they are actively swimming (3-5-d old), and they should be genetically certified before shipping. Fry can be shipped at rates of up to 100,000 and 50,000 per bag for short and long periods of time, respectively. Striped bass larvae have been successfully transported at densities of 105,669/L (40,000/gal) for up to 48 h (Piper et al. 1989). The number, species, and age of the fish and its destination should be clearly written on the exterior of each shipping box before shipping.

The above procedures for shipping fry also apply to eggs except that eggs should be concentrated at densities of no more than 20,000 per bag after water hardening for a minimum of 6 h.

CHAPTER 4

Fingerling Rearing Procedures

Pond Preparation

Prior to pond filling, harvest boxes or kettles should be cleaned of mud or other debris. Complete removal of pond bottom sentiments has always been optional and indeed some pond managers like having some sediment in plastic ponds. However, with the persistence of *P. parvum* at the two striped bass producing hatcheries, it is advisable to remove sediments that may contain *P. parvum* cells. Valves for water supply, air supply, and pond draining should be checked for proper working condition prior to the production season. All hatcheries must place 500-micron socks on pond fill lines to prevent unwanted nuisance organisms from entering ponds. This filtering protocol serves two purposes: To eliminate organisms which may reduce fish production and to prevent entry of organisms into the system that inadvertently may be transported with fingerlings to other locations in the state (Hazard Analysis and Critical Control Point {HACCP} program). At PKH the HACCP concerns are *P. parvum* and the Asian mud crab *Rhithropanoeus harrisii.*

Under ideal conditions, pond filling begins approximately 3-10 d before fry stocking, and ponds should continue to fill as fry are stocked (Appendix G). There is some indication that the optimum pre-filling time is 7-9 d before stocking. Local conditions may alter filling time or strategy, including the number of ponds to be filled in relation to water supply. At DFH where water pressure may vary considerable, ponds may be filled beginning 14 d prior to stocking. The presence of *P. parvum* in the source water for both striped bass producing hatcheries dictates that ponds be filled early to allow treatment to eradicate *P. parvum* cells and toxicity before fry stocking. Pond management techniques to be employed when *P. parvum* is present are described in Barkoh and Fries (2005).

Water Quality Management

Proper water quality management is essential for good fry and fingerling survival; therefore, water quality should be monitored and the data used to make sound management decisions. The key to a successful water quality management program is to monitor water quality just before sunrise and around 1500 hours. Water quality monitoring instruments should be calibrated daily or according to manufacturer's instructions since accurate measurements are extremely important for management decision-making. Listed below are some general rules:

- Consistent measurement of water quality parameters.
- Proper recording of water quality data.
- Proper interpretation of water quality data.
- Proper use of the data to anticipate problems and to make management decisions.

Pond water pH should not exceed 9.0 for striped bass up to 20 d old or exceed 8.5 for palmetto bass up to 20 d old. Dissolved oxygen concentration should never fall below 4.0 mg/L in rearing ponds. Fresh water should be added to ponds that are projected to have low dissolved oxygen levels. Un-ionized ammonia nitrogen should not exceed 0.3 mg/L in rearing ponds.

Water quality data should be taken at the appropriate times and recorded on the appropriate forms.

Zooplankton Management

Survival of larval striped bass and palmetto bass and production of their fingerlings are directly related to the types and quantities of zooplankton available in rearing ponds. It is important that sufficient quality and quantities of zooplankton be present at stocking and throughout the production period. To obtain accurate zooplankton samples, personnel should sample ponds prior to sunrise. Sampling should commence prior to pond stocking and continue least twice a week.

Zooplankton population data can be used to:

- make adjustments to pond fertilization rates,
- adjust supplemental feeding rates,
- predict zooplankton crashes, and
- predict the time to harvest fish.

A pond to be used as source of zooplankton for inoculating production ponds should be filled and fertilized 14-21 d prior to filling the first production ponds. Zooplankton collection and enumeration methods are provided in Appendix H (G. Kurten, Texas Parks and Wildlife Department, unpublished).

Pond Fertilization

The following fertilization rates are **ONLY RECOMMENDATIONS!** Dissolved oxygen concentrations, zooplankton populations, water quality, water temperature, fish growth, productivity differences between hatcheries and among ponds, and fish condition are considerations for determining fertilizer application rates and frequency. Decisions on how much and when to fertilize must be based on data.

Fertilization programs are further complicated by *P. parvum* management strategies. Historically, striped bass production pond management excluded the use of inorganic fertilizers in the early 1990s. Now ammonium sulfate, a common fertilizer, is applied to ponds as part of *P. parvum* management plans. Some general rules for applying organic fertilizers (e.g., cottonseed meal) are as follows:

- The fertilizer should never be applied in or near the harvest box or kettle, or in the pond drain channel.
- Fertilizer application data should be recorded on appropriate forms and in the Fish Hatchery Database.

Recommended organic fertilization rates are as follows:

- At time of pond filling use 280 kg/ha (250 lb/ac).
- For follow-up applications use 56 kg/ha (50 lb/ac) 3 d after stocking and again 12 d after stocking.

Fry Stocking

Fingerling production ponds are stocked at 494,000 fry/ha (200,000 fry/ac). Fry should be stocked when they are actively swimming horizontally, have inflated swim bladders and are developing mouthparts. This usually occurs when fry are 3-5 d old depending on water temperature. Fry are very susceptible to stress so handling should be kept to an absolute minimum. Fry holding and stocking containers should always be supplied with compressed oxygen or air during the stocking process. Fry should never be exposed to direct sunlight or sudden changes in light intensity. Stocking should be done early in the morning before sunrise. Ponds should be stocked when:

- dissolved oxygen readings are above 4.0 mg/L,
- pond temperatures are 18-22°C,
- pH values are 7.5-8.5,
- un-ionized ammonia nitrogen is below 0.25 mg/L, and
- ponds are verified to be free of *P. parvum* cells and toxicity.

Proper tempering at time of stocking is critical for fry survival. Ideally, tempering can be done in the incubator by slowly adding supply water over a period of time. Alternatively, a slow exchange of pond and fry container water may be used to temper the fry at the ponds. Tempering should take a minimum of 10 min or should continue until pond and fry container temperatures are similar (i.e., 45-60 min). After tempering is completed, the fry should be slowly released into the receiving water.

Initial Fry Survival

After pond stocking, estimating initial fry survival is recommended. If fry survival is poor, the pond may be restocked or drained. Listed below are some common methods of sampling fry:

- Cages: These can be stocked with a few fry and floated in ponds to determine survival if water quality is suspect.
- Dip net: A fine-mesh dip net can be used to catch fry near a fresh water inflow. The net is pulled through the water in the harvest box or kettle. This method is not usually effective until 10-14 d after stocking.
- Seine: A fine-mesh seine is pulled through the pond to collect fry. This procedure is quite effective and should begin 10-14 d after stocking and weekly thereafter.
- Light: Floating light traps can be used at night. This procedure is effective 10-14 d after stocking. The use of a flashlight to determine survival just after stocking is commonplace but has not been standardized. Complicating the reliability of this method is pond turbidity and zooplankton density.

Supplemental Feeding

Beginning 14 d after fry stocking, artificial high protein trout/salmon feed (#00, starter) is offered to the fish three times daily at the rate of 4.5 kg/ha (4.0 lb/ac) for a total of 13.5 kg/ha (12.0 lb/ac). At the appropriate time (based on sample size or age of fish), feed size is increased to #1. This usually occurs around week four. Staffs at PKH and DFH have experimented with

providing a #2 feed later in the production cycle. The time to begin feeding, frequency of feeding, amount of feed offered, and size of feed offered depend on:

- stocking survival,
- size of fish,
- water quality, and
- zooplankton quantity and quality.

When zooplankton population densities are significantly reduced, the feeding rate should be increased. Feeding should be discontinued when dissolved oxygen levels are below 4.0 mg/L or data trends indicate possible dissolved oxygen depletion. Feed should be evenly distributed along the entire upwind side of the pond but never in the harvest box area. Feeding information should be recorded on the appropriate form.

Pond Harvest

Weekly fish length samples should be taken in production ponds to predict fish harvest dates and plan for pond draining, fingerling stocking tasks, and fish transportation equipment needs. See Appendix G for a sampling schedule. The minimum fingerling size for harvesting production ponds is 38.1 mm (1.5 in) total length, and the fish should be harvested and stocked into assigned reservoirs when they reach this length as soon as possible.

Successful pond harvest depends on good planning and communication. All harvest equipment should be tested before harvest operations begin. Handling of fish during harvest should be kept to an absolute minimum. Striped bass fingerlings do not tolerate high water temperatures as well as other warmwater fishes, and they also tend to have an aversion to direct sunlight. Harvest operations should be planned to be completed as early in the morning as possible. Fresh water should be added to the pond overnight so the fish are attracted to the harvest area. The addition of fresh water also helps maintain acceptable dissolved oxygen levels. There are two options for harvesting fish from ponds:

1. Load fish directly from the pond into transport tank (hauling unit), and transport and stock the fish the same day. This option allows flexibility in scheduling fish deliveries and accelerates harvest operations when fish in several ponds reach target size at the same time. This is the preferred method because there is minimal handling of fish.
2. Load fish into a harvest tank, transfer the fish to a holding area for overnight holding; then load, transport and stock the fish the next morning. This method is more stressful on the fish.

To reduce temperature stress, water in the harvest and transport tanks should be at or just below water temperatures in the pond. It is forbidden to ship fingerlings in water that has *P. parvum*. Water in fish delivery units should be *P. parvum*-free, and fish should be rinsed prior to being placed into the hauling unit. The hauling unit should contain a 1% salt solution and No-Foam. Oxygen should be supplied to the hauling unit through porous tubing. Before placing fish into the hauling unit, the oxygen delivery system should be turned on for several minutes to allow the oxygen level to reach saturation. The dissolved oxygen level should be continuously monitored in any tank holding high densities of fingerlings. Condition of the fish should also be

continuously monitored. Fish transport tanks should never be overloaded. Track loading densities by keeping track of the weight of fish loaded into a tank. When using the harvest tank method, it may be necessary to use fresh water between trips to the holding area. The number of fingerlings harvested may be estimated as follows:

- Take 3 samples of 30-100 fish each.
- Weigh each sample and count the number of fish.
- Compute the following: total fingerlings harvested = (total number of fish in 3 samples /total weight of 3 samples) x total weight of fish harvested.

The objective of this enumeration method is to get the estimate as close as possible to the true number of fish (population size) from the pond. It is important to take representative samples by using a randomization approach. For ponds with catch basins such as the Kansas kettles at DFH, allow the fish to concentrate in the kettle and take one sample each from the front, the middle and the end of the kettle. For pond without catch basins, take the fish samples after all the fish has been loaded into a hauling unit. If all three compartments on the hauling unit have fish, take a sample from each compartment. As a general rule when harvesting a pond, smaller fish come into the catch basin or harvest box first and larger fish come in last. Therefore, if fish must be sampled some time during the harvest, it is best to do that around the mid-point of the harvest operation. All harvest data should be recorded on the appropriate form and entered into the Fish Hatchery Database.

All hauling units with fish should be certified *P. parvum*-free before leaving the hatchery.

CHAPTER 5

Fish Transportation

Loading

Routine maintenance should be performed on all transportation equipment, and they should be tested the day before use so any repairs can be made. Transportation tanks should contain a 1% salt solution and No-Foam®. Before loading fish, the oxygen delivery system should be turned on and the dissolved oxygen level allowed to reach saturation (>12 mg/L). Each transport truck should be equipped with a cellular phone. Drivers are to take the most direct routes to stocking locations.

Loading densities are dependent on size of fish (number per kilogram), condition of fish, and water temperature. Appendix I shows the loading densities in relation to driving duration. The cooler the water in the transport tank, the higher the loading density can be. Loading rates should be reduced for higher temperatures. The optimum transport temperature is 18-20°C (64.4-68.0°F). To reduce transport water temperature:

- calculate desired loading density,
- load fish into hauling unit to achieve the density for the desired water temperature and anticipated drive time,
- if necessary, after loading density is reached, slowly add ice or chilled water until the desired transport temperature is reached,
- do not add ice or chilled water too quickly to avoid shocking the fish,
- ice can be added at the rate of 0.60 kg/L (0.5 lb/gal) for each 5°C (9°F) decrease desired.

Stocking

Coordinate fish stocking with management biologists:

- When hatchery managers receive lake stocking assignments, they should make initial contacts with management biologists to provide a general production status and to inquire about any special considerations regarding stocking locations.
- The management biologists should be contacted again 1-2 weeks prior to harvest and stocking activities. At this time, hatchery personnel can advise management personnel of the stocking schedule.
- Another contact can be made by hatchery personnel the day before stocking to confirm stocking details.
- Hatchery managers should be aware of stocking assignment changes from the program director and notify all staff of changes.

Fish should be acclimated slowly from the water in the transport tank to the water into which they are stocked. Tempering is accomplished by pumping lake water into the hauling unit. Tempering should continue until the tank and the lake water temperatures are similar. In some situations, the tank and the lake water temperatures will be the same or close. In this situation,

water should be pumped from the lake into the transport tank for a minimum of 20 min to acclimate the fish to water quality differences between the transport tank and the lake.

Boats used for open-water stocking should be equipped with compressed oxygen injected by a porous device in order to maintain proper dissolved oxygen levels. A medical-type regulator should be used for constant delivery of oxygen at a desirable rate. Oxygen levels should be monitored in holding containers at all times. Dissolved oxygen levels should not be allowed to fall below 4.0 mg/L. Holding containers should never be overloaded. A rate of 120 g of fish/L of water (1.0 lb/gal) should not be exceeded in boat containers. If fish show signs of oxygen stress, they should be released immediately. A soft, non-knotted nylon net should be used to net fish.

Note: To ensure that all assigned lakes get some fish, the larger water bodies that require a lot of fish are stocked at half the requested stocking rates first. The remaining fish are stocked after all other sites are stocked. The Program Leader decides when to implement this strategy.

CHAPTER 6

Data Reporting

Trip Sheets

Trip sheets and the protocol for data entry have changed since 2003. Staffs that make deliveries are required to conduct a pre-trip check (checklist) on the back of the trip sheet, which is helpful in ensuring a successful trip. All trip sheet information should be completed by the driver in a timely manner. The trip sheet should be passed along to the individual responsible for entering data into the Fish Hatchery Database. These data should be entered into the database within 7 d of fish delivery. Another individual verifies the data entered into the database no later than 7 d after information has been entered.

Fish Length Data

Harvest data are very important not only for trip sheet (delivery) records but also for hatchery use as a measure of pond management success. Thus, harvest data can be used for justifying the need for changing management strategies. For these reasons accurate fish length data is important. Representative samples of harvested fish need to be taken and can be accomplished by using the procedure described above under "pond harvest." After a sample is taken, 30 randomly selected fish are measured to the nearest millimeter and the average recorded. If a pond has multiple partial harvests, re-sampling each time may be necessary. A weighted mean length is then reported. When reporting fish lengths on harvest data sheets or for reports, oftentimes deficiencies in production may be hidden by reporting "pond averages." This practice is discouraged. Whenever multiple ponds or multiple harvests (i.e. multiple data sets) are involved in the estimation average length, a weighted mean length must be reported.

Water Quality Data

Accurate recording and timely entry of water quality data into the Fish Hatchery Database is strongly encouraged since it is a resource for management decisions. At PKH, for example, water quality information is downloaded and printed from the database early in the morning so that pond management decisions can be made based on it. Data entry into the database is accomplished weekly.

Spawning Data

Spawning data must be comprehensive. Information on spawning data sheets include, but are not limited to, fish weight, spawning partners, egg stage at collection, pertinent dates, number of eggs produced, number of fry produced, and the destination of the fry.

Pond Production Data

Pond production data including, but not limited to, water quality data, *P. parvum*-related data (see Barkoh and Fries 2005, and Appendices J and K), zooplankton data, feeding records, sampling records, and harvest data must be entered into the database in a timely manner.

P. parvum-related information should be entered a soon as possible; however, other production data should be entered no later than the end of the production season.

Status Reports

Status reports are usually given to the Regional Director in the form of monthly bullets. Annual reports for *Morone* production are due by September 1.

Program Summary Report

The timing and distribution of the program summary report is at the discretion of the Program Director. The program summary, consisting of annual reports on all cultured fish species, is usually circulated in October and discussions of program accomplishments and needs take place at staff meetings shortly thereafter. See Appendix L for striped bass program and related reports.

REFERENCES

Barkoh, A, and L. T. Fries, editors. 2005. Management of *Prymnesium parvum* at Texas State Hatcheries. Texas Parks and Wildlife Department, Management Data Series 236, Austin.

Harrel, R. M., J. H. Kerby, and R. V. Minton, editors. 1990. Culture and propagation of striped bass and its hybrids. Striped Bass Committee, Southern Division, American Fisheries Society, Bethesda, Maryland.

Piper, R. G., I. B. McElwain, L. E. Orme, J. P. McCraren, L. G. Fowler, J. R. Leonard. 1989. Fish hatchery management. U. S. Fish and Wildlife Service, Washington, D. C.

APPENDIX A

Optimum Collection Periods for Striped Bass Adults in Texas

Location	Collection period	Peak run
Livingston	April 10 - May 2	April 15
Granbury	April 17 - May 5	April 28
Buchanan	April 14 - May 12	?
Toledo Bend	April 04 - May 04	?

APPENDIX B

Number of Eggs/kg Striped Bass Females From Texas Waters

Collection location	Eggs/kg female
Buchanan	119,000
Granbury	108,000
Livingston	116,000
Possum Kingdom	89,000
Toledo Bend	61,333

APPENDIX C

Striped Bass Female Injection Rate at 68 IU/kg (150 IU/lb)

Weight (lb)	Weight (kg)	HCG to inject (cc)
8	3.6	1.2
9	4.1	1.3
10	4.5	1.5
11	5.0	1.6
12	5.4	1.8
13	5.9	1.9
14	6.4	2.1
15	6.8	2.2
16	7.3	2.4
17	7.7	2.5
18	8.2	2.7
19	8.6	2.8
20	9.1	3.0
21	9.5	3.1
22	10.0	3.3
23	10.4	3.4
24	10.9	3.6
25	11.3	3.7
26	11.8	3.9
27	12.2	4.0
28	12.7	4.2
29	13.2	4.3
30	13.6	4.5
31	14.1	4.6
32	14.5	4.8
33	15.0	4.9
34	15.4	5.1
35	15.9	5.2
36	16.3	5.4
37	16.8	5.5
38	17.2	5.7
39	17.7	5.8
40	18.1	6.0

APPENDIX D

Striped Bass Male Injection Rate at 34 IU/kg (75 IU/lb)

Weight (lb)	Weight (kg)	HCG to Inject (cc)
3	1.4	0.2
4	1.8	0.3
5	2.3	0.4
6	2.7	0.5
7	3.2	0.5
8	3.6	0.6
9	4.1	0.7
10	4.5	0.8
11	5.0	0.8
12	5.4	0.9
13	5.9	1.0
14	6.4	1.1
15	6.8	1.2
16	7.3	1.2
17	7.7	1.3
18	8.2	1.4
19	8.6	1.5
20	9.1	1.5
21	9.5	1.6
22	10.0	1.7
23	10.4	1.8
24	10.9	1.9
25	11.3	1.9
26	11.8	2.0
27	12.2	2.1
28	12.7	2.2
29	13.2	2.2
30	13.6	2.3
31	14.1	2.4
32	14.5	2.5
33	15.0	2.5
34	15.4	2.6
35	15.9	2.7

APPENDIX E

STRIPED BASS BROODFISH DATA SHEET

Capture in _____ Departure Time _____(AM) (PM)
Date of Capture_____/20__ Arrival Time_____(AM) (PM)
Capture Method _____ Hatchery _____
Water Temp. At Loading _____(F) or _____(C); at End _____
Driver(s) _____

Tag color	Fish no.	Sex (M/F)	Egg stage	Weight (lb or kg) Circle	Injection time	HCG amount	Compartment (F,M,R*)

* F = Front, M = Middle, R = Rear

APPENDIX F

STRIPED BASS/HYBRID CULTURE WORK SHEET

LAKE INFORMATION PRODUCTION YEAR: 20___

STB Female Brooder No. _____ Weight (kg) _____ I.D. Code _____

Source* _____ (TR) (OW) Date collected_____

Collection Site Temp _____ (F or C) Collection Method **: EF / GN / H-L

Date Injected _____ Primary Egg Stage _____ Time Injected _____(AM) (PM)

Secondary Egg Stage _____ at _____ hrs Post-Injection

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HATCHERY INFORMATION

STB ___ OR HYB ____ Date Spawned _____ Time Spawned _____ (AM) (PM)

Egg Vol. _____ at _____ eggs/ml = No. of Eggs _____

% Fert. at _____ hrs X No. of Eggs = _____ Viable Eggs

STB _____ or WHB _____ Male I.D. Numbers: _____ _____ _____ _____

_____

Make note if male did not flow (NF)

Spawned: Tank or Strip Header Rack: A B C Other

_____

==========

HATCHING INFORMATION

Date Hatched _____ Time Hatched _____(AM) (PM)

No. of Fry _____ @ _____ days old Avg. Incubation Temp _____

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STOCKING INFORMATON

Date _____ Time _____ (range) Avg. Tempering Time _____

Ponds _____ _____ _____ _____ _____ _____ _____

Temp. _____ _____ _____ _____ _____ _____ _____

DO/pH _____ _____ _____ _____ _____ _____ _____

==========

COMMENTS

* TR = Tail Race, OW = Open Water
** EF = Electrofishing, GN = Gill Netting, H-L = Hook-and-Line

APPENDIX G

Pond Management: Filling 10 Days Pre-Stocking (Example Only)

Days pre-stock	Activity*
	Organics = organic fertilizers **Zoo = zooplankton** **Temp. = water temperature**
10	Brood fish are collected, start up ponds, apply initial organics at 280 kg/ha (250 lb/ac). Apply 10 mg/L ammonium sulfate
9	Take D.O; temp; pH. Parvum/ammonia check
8	Take D.O; temp; pH, zoo
7	Take D.O; temp; pH Parvum/ammonia check
6	Take D.O; temp; pH, organic, zoo
5	Take D.O; temp; pH Parvum/ammonia check
4	Take D.O; temp; pH, zoo
3	Take D.O; temp; pH Parvum/ammonia check
2	Take D.O; temp; pH, organic, zoo
1	Take D.O; temp; pH Parvum/ammonia check, bioassay
0	Take D.O; temp; pH Parvum/ammonia check stock fry
Days post-stock	**Activity***
1	Take D.O., temp., pH Parvum/ammonia check
2	Take D.O., temp., pH
3	Take D.O., temp; pH Parvum/ammonia check
4	Take D.O., temp., pH, apply organics at 56 kg/ha (50 lb/ac)
5	Take D.O., temp., pH, Parvum/ammonia check
6	Take D.O., temp., pH
7	Take D.O., temp., pH, zoo sample
8	Take D.O., temp., pH Parvum/ammonia check

Days post-stock	Activity (continued)*
9	Take D.O., temp., pH
10	Take D.O., temp., pH, Parvum/ammonia check
11	Take D.O., temp., pH
12	Take D.O., temp., pH, apply follow-up organics, Parvum/ammonia check
13	Take D.O., temp., pH
14	Take D.O., temp., pH, zoo and fish samples, begin supplemental feeding
15	Take D.O., temp., pH,
16	Take D.O., temp., pH, Parvum/ammonia check
17	Take D.O., temp., pH
18	Take D.O., temp., pH, Parvum/ammonia check
19	Take D.O., temp., pH
20	Take D.O., temp., pH, Parvum/ammonia check
21	Take D.O., temp., pH, zoo and fish samples
22	Take D.O., temp., pH, Parvum/ammonia check
23	Take D.O., temp., pH
24	Take D.O., temp., pH, Parvum/ammonia check
25	Take D.O., temp., pH
26	Take D.O., temp., pH, Parvum/ammonia check
27	Take D.O., temp., pH
28	Take D.O., temp., zoo and fish samples, pH, Parvum/ammonia check
29	Take D.O., temp., pH
30	Take D.O., temp., pH, Parvum/ammonia check
31	Take D.O., temp., pH
32	Take D.O., temp., pH, Parvum/ammonia check
33	Take D.O., temp., pH
34	Take D.O., temp., pH, Parvum/ammonia check
35	Take D.O., temp., pH

* D.O. = dissolved oxygen, temp = temperature, ammonia = total ammonia nitrogen, Parvum = *Prymnesium parvum*, zoo = zooplankton, (all samples according to protocol) organic = cottonseed meal.

APPENDIX H

Zooplankton Collection and Enumeration Standard Procedures

Sample Collection

Collect zooplankton samples by an oblique tow of an 80-μm-mesh Wisconsin plankton net of known diameter (e.g., 4.5 in or 11.43 cm). Toss the net the full length of the rope such that the knot at 4 m just touches the water surface. Allow the net to sink to the bottom while the knot remains at the water surface. Then pull it in quickly (about 30 seconds) ensuring that the net surfaces where the 4-m knot was.

The volume of water sampled (Total sample volume) is calculated by as follows:

Volume of a cylinder = $\pi r^2 h$ (i.e., pi x Radius^2 x Height)
$\pi = 3.14$
Radius = ½ diameter = 5.715 cm
Height = tow length = 400 cm

Total sample volume = 3.14 x $(5.715)^2$ x 400 cm = 41,023 cm^3

The zooplankton sample is prepared by rinsing the collected organisms into the net chamber and then into a 100-mL capped specimen container, such as a urine specimen container. Dilute all samples to a similar volume (concentrate volume), usually 90 mL.

If the samples will be enumerated that day, label each sample with the pond number. Samples collected for later processing should be labeled with pond number, sampling date, concentrate volume, tow length and the initials of the person collecting the sample. Samples can be preserved with Lugol's solution and stored for later counting, if necessary.

Sample Counting

The sample container is stirred thoroughly. While the organisms are suspended, a 1-mL aliquot (counting volume) is withdrawn using an Oxford macro-set pipette and placed within the groove of an acrylic plankton-counting wheel.

Organisms are identified and counted into the following groups: rotifers, copepod nauplii, adult copepods and cladocerans. Any other significant organisms are identified, counted, and documented on the datasheet. For each sample the pond number, sampling date, total sample volume, concentrate volume, and counting volume should also be recorded on the datasheet.

Concentrate volumes can be adjusted to accommodate high or low densities of organisms, so the actual volume used should be recorded.

Data Entry

Once counting is completed, the data should be entered into the Fish Hatchery Data System (FHS). The data entry window is accessed by selecting Data Entry/On-line/Zooplankton. Density calculations are made automatically when fields are entered. The calculation method is available from the "Help" menu of the system.

Within the FHS zooplankton data entry window, the following cells have these meanings:

- **Species** - species of fish being cultured in the pond from which the sample came.
- **Concent. Volume (mL)** - volume of sample in the specimen container, usually 90 mL.
- **Actual counted volume (mL)** - volume of sample placed on the counting wheel, usually 1 mL.
- **Total sample volume (mL)** - calculated volume of the plankton tow.

APPENDIX I

Loading Densities for Striped Bass Fingerlings in Relation to Transport Duration

Loading rate		Transport duration
kg/L	lb/gal	(h)
0.060	0.50	1 – 4
0.040	0.33	4 – 8
0.030	0.25	8 +

APPENDIX J

Dundee State Fish Hatchery *Prymnesium parvum* Management Plan

DENNIS G. SMITH

Abstract

This management plan was prepared as a guide to control the toxic alga *Prymnesium parvum* and its ichthyotoxin and eliminate, or at least minimized, its adverse impact on fish production. The plan includes monitoring presence and abundance of *P. parvum* and concentration of un-ionized ammonia nitrogen, and application of effective chemical treatments. Ammonium sulfate is applied at concentrations to raise the un-ionized ammonia nitrogen concentrations to 0.2-0.4 mg/L when water temperatures are 15°C or higher, and copper sulfate (or Cutrine-Plus) is applied at 0.2-0.4 mg Cu^{2+}/L when water temperatures are up to 15°C. The selected target concentrations of un-ionized ammonia nitrogen and copper depend on the tolerance of the fish that would be exposed to the treatments.

Introduction

The Dundee State Fish Hatchery is located in Archer County, Texas below Lake Diversion which supplies water to the hatchery. The hatchery has 97 ponds: 73 are plastic-lined totaling 24 ha (59.5 acres) and 24 are earthen ponds totaling 9.3 ha (23 acres) of surface water. Other culture units include four outdoor raceways and indoor 12, 1.8-m fiberglass round tanks, 90-jar egg incubation system and 4-trough (970-L) rearing system. All indoor culture systems can be operated as flow-through or closed systems. The spawning and rearing building which houses the indoor culture units also is equipped with an ozone generator and UV system for treating lake water containing *Prymnesium parvum* cells or toxins.

Fish species cultured at this facility include striped bass *Morone saxatilis*, palmetto bass (striped bass ♀ × *M. chrysops* ♂), channel catfish *Ictalurus punctatus*, black basses *Micropterus* spp., koi carp *Cyprinus carpio*, rainbow trout *Oncorhynchus mykiss*, walleye *Stizostedion vitreum* and saugeye (female walleye × male *S. canadense*).

In 2001 fishes on the hatchery suffered substantial mortality from *P. parvum* ichthyotoxicity. Losses included 5.1 million striped bass and palmetto bass, 1,500 black basses, and thousands of channel catfish, rainbow trout and koi carp. Through the efforts of hatchery staff and the Hatcheries Golden Alga Task Force, strategies have been developed to control *P. parvum*. These strategies form the basis of the *P. parvum* management plan described herein. This plan continues to evolve and modifications are made to it as more effective or efficient solutions to the *P. parvum* toxicity problem are discovered.

Prymnesium parvum Management Plan

Pond Management

- Fill ponds well in advance of fish stockings to allow water temperatures to rise so treatment with ammonium sulfate, if needed, can be effective.
- Avoid flushing ponds too rapidly and decreasing temperature if ponds must be flushed. If possible avoid pond flushing.
- Treat ponds at least two days prior to anticipated stockings to allow treatments to work and toxins to decompose.
- Perform bioassays and check for cells any time *P. parvum* toxicity is suspected and on the days before fish stockings.
- Maintain a minimum of 0.18 mg/L un-ionized ammonia nitrogen (UIA-N) or 2 mg Cu^{2+}/L in ponds depending on treatment option.

Prophylactic Treatments of P. parvum in Ponds

- Measure pond water temperature and pH
- If pond water temperatures are consistently above 28°C
    - *P. parvum* may be absent or present in very low numbers and ichthyotoxicity is unlikely. Treatment should be unnecessary.
    - Monitor ponds for presence of the alga and signs of toxicity at least once per week.
- If pond water temperature is 28°C
    - Check for presence of *P. parvum* cells twice per week.
    - If cells are present measure ammonia, temperature, and pH.
    - Calculate concentration of UIA-N.
    - Apply ammonium sulfate to raise UIA-N to 0.3 mg/L if UIA-N is less than 0.18 mg/L.
- If pond temperatures are below 28°C, consult an ammonia ionization table (Piper et al. 1992) or hatchery ammonia spreadsheet to determine proportion of total ammonia in the un-ionized form.
    - If the proportion of total ammonia in the un-ionized form is less than 5%
        - Apply Cutrine-Plus® or copper sulfate to raise copper concentration to 0.25 mg/L.
        - Measure copper concentration once per week.
        - Maintain copper concentration above 0.2 mg/L.
        - Check for presence of *P. parvum* cells once per week for monitoring purposes.
    - If the proportion of total ammonia in the un-ionized form exceeds 5%
        - Measure ammonia, temperature, and pH once per week (twice per week for sensitive species such as striped or palmetto bass).
        - Calculate concentration of UIA-N.
        - Apply ammonium sulfate to raise UIA-N to 0.3 mg/L if UIA-N is less than 0.18 mg/L.
        - Check for presence of *P. parvum* cells once per week for monitoring purposes.

- If the proportion of total ammonia in the un-ionized form is low (5-15%) and pH is expected to increase above 8.5
  - Reduce target ammonium sulfate treatment to achieve UIA-N of 0.25 mg/L. This treatment level is high enough to control *P. parvum* but requires less ammonium sulfate and lower total ammonia. Thus, should pH rise the UIA-N generated may not be toxic to the fish. Treatments at this lower UIA-N rate may require more frequent applications.

Indoor Culture Units

- Use UV- and ozone-treated lake water (treated water) for all culture activities in the spawning and rearing building if lake water contains *P. parvum* or its toxin. High dosage UV (180 to 200 mJ/cm^2) and ozone treatment is required to eliminate *P. parvum* toxicity if toxins are present in the supply water.
  - Check treated water for presence of *P. parvum* or toxin to be sure the system is working.

Treatment of Ichthyotoxicity

- Treat ponds or other culture units with potassium permanganate at the demand rate or up to 2 mg/L above the demand rate for temporary relief if fish show signs of ichthyotoxicity.

Fish Harvest

- Check incoming lake water for toxicity and presence of *P. parvum* one day before fish harvest.
- If *P. parvum* or toxin is absent in lake water
  - Harvest fish using routine hatchery procedures.
- If *P. parvum* or toxin is present in lake water but water not toxic.
  - Do partial pond draining the day before harvest.
  - Harvest fish as scheduled within 2 hours using lake water.
  - Treat pond water with potassium permanganate if fish exhibit signs of ichthyotoxicity.
- If lake water is toxic
  - Suspend fish harvest until the condition improves.
  - If fish must be harvested, use non-toxic water from adjacent ponds or treated water and potassium permanganate treatment if fish show signs of ichthyotoxicity.

Fish Hauling Units

- Fill fish hauling units with treated water.
- Rinse fish to be transported off the hatchery with treated water before loading to avoid introducing *P. parvum* into hauling tanks and ultimately into stocked lakes.

- After fish loading check hauling unit water for *P. parvum*.
  - If *P. parvum* is absent deliver fish according to hatchery guidelines.

    - If *P. parvum* is present drain out some water, refill with treated water, and recheck for *P. parvum*. Repeat until no *P. parvum* is found.
- Upon return to the hatchery, disinfect hauling units with 10% chlorine bleach.
- Use lake water free of *P. parvum* cells or toxins, or treated water to transfer fish between hatchery culture units.

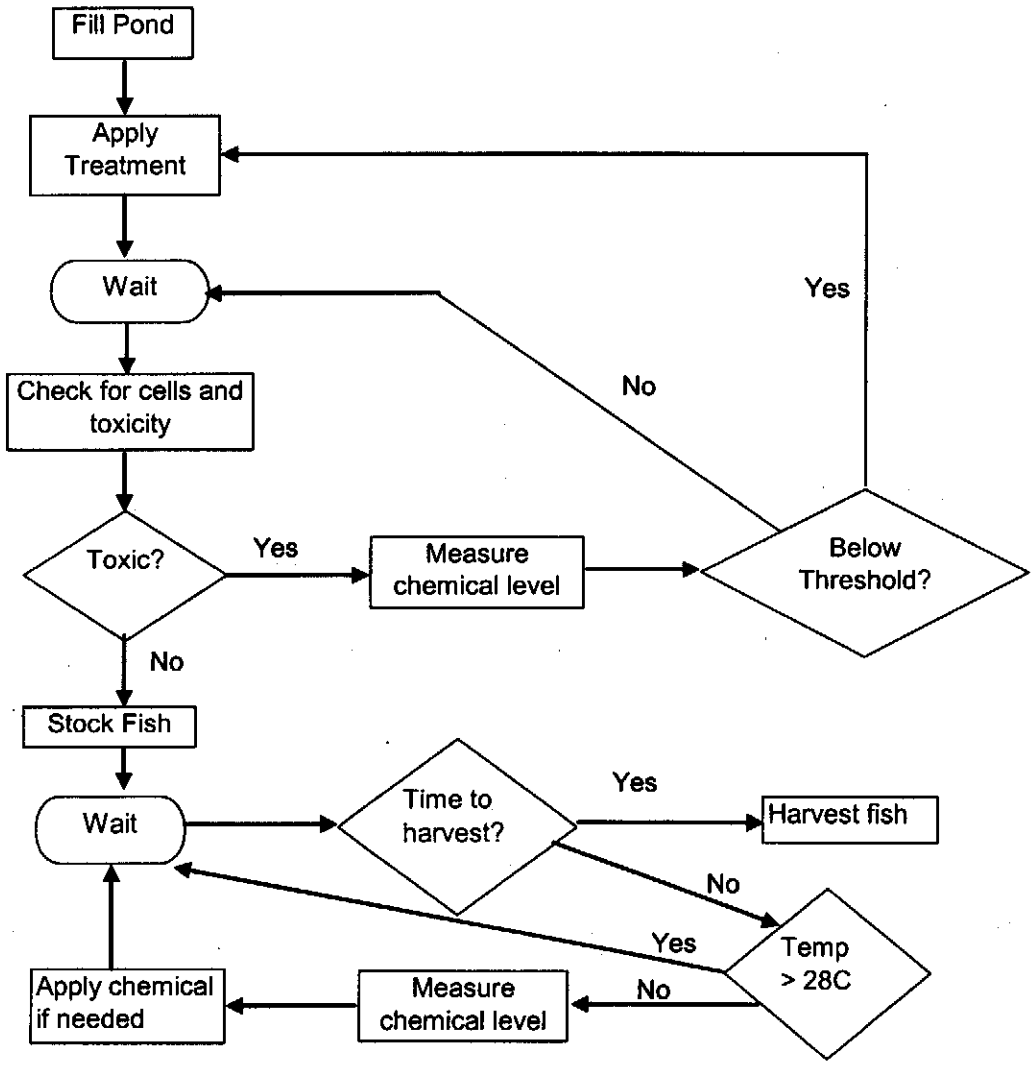

FIGURE 1.—A schematic diagram of the Dundee State Fish Hatchery pond management plan.

APPENDIX K

Possum Kingdom State Fish Hatchery *Prymnesium parvum* Management Plan

DALE D. LYON, JAKE ISAAC, AND JOHN PARET

Abstract

This *Prymnesium parvum* management plan was prepared to provide a systematic approach to controlling this toxin-producing alga to make fish production possible at the Possum Kingdom State Fish Hatchery. The essential facets of the plan are monitoring presence and density of *P. parvum* and un-ionized ammonia levels, and application of chemical treatments. Ammonium sulfate is applied at 10 mg/L or concentrations to raise the un-ionized ammonia concentration to 0.2-0.4 mg/L when water temperatures are 15°C or higher and copper sulfate or Cutrine-Plus is applied at 0.75-1.0 mg Cu^{2+}/L when water temperatures are up to 15°C. The target concentration of un-ionized ammonia or copper depends on the fish species being cultured.

Introduction

Possum Kingdom State Fish Hatchery is located in Palo Pinto County, Texas below Possum Kingdom Lake, the main source of water for the hatchery. The lake water comes to the hatchery through a 4.5-m (14.8 ft) deep intake valve (shallow water) or an 18-m (59-ft) deep intake valve (deep water). Additional water for the hatchery is provided by a well. Effluent water from ponds and indoor culture units can be reused in ponds after filtration by a re-circulation system. Culture units include 38 plastic-lined ponds (9.4 ha or 23.2 acres) and indoor raceway, 48-McDonald jar egg incubation system and six holding troughs. The incubation system can be operated as flow-through or closed system with filtration, heating and cooling capabilities. All holding troughs have flow-through capabilities but only four have re-circulation capabilities. The indoor re-circulation systems are equipped with an ultraviolet sterilizer for treating water infected with *P. parvum*.

Fish species cultured at this hatchery include striped bass *Morone saxatilis*, palmetto bass (female striped bass × male *M. chrysops*), channel catfish *Ictalurus punctatus*, smallmouth bass *Micropterus dolomieu*, koi carp *Cyprinus carpio*, bluegill *Lepomis macrochirus*, crappie *Pomoxis* spp., rainbow trout *Oncorhynchus mykiss*, and walleye *Stizostedion vitreum*.

P. parvum was first confirmed in Possum Kingdom Lake in 2001 following extensive toxin-related fish kills in the reservoir. This alga was found in our hatchery ponds in 2002 when ponds were filled with lake water following a renovation in 2001. This alga consistently appears to bloom during colder months (January-March), and

blooms are usually associated with fish kills. During summer months, when temperatures exceed 28°C, the alga usually disappears or occurs in very low density and toxin-related fish kills are rare. Spring and fall appear to be transitional periods when *P. parvum* densities fluctuate and fish kills are sporadic.

Since 2001 staffs at Possum Kingdom and Dundee hatcheries in cooperation with the Hatcheries Golden Alga Task Force have been developing strategies for controlling the alga. The strategies that seem to work best for this facility are formulated into the management plan described below. As more effective or efficient strategies are developed this management plan will be updated.

P. parvum Management Plan

This facility has adopted a prophylactic approach to managing *P. parvum* with the goal of elimination the alga from culture systems or keeping densities as low as possible. Therefore, if a single cell is detected in a water sample (i.e., 2,000 cells/mL), the infected pond is treated to control the alga. Before treatment, the un-ionized ammonia nitrogen (UIA-N) or Cu^{2+} concentration in the pond is determined and the difference needed to achieve the target treatment level is provided by applying ammonium sulfate or copper sulfate.

Brood fish Holding (striped bass or white bass)

- Fill indoor holding troughs with well water and operate as closed system
    - Check for the presence of *P. parvum* to be sure the system of free of the alga.
    - If no cells are present there should be no need for further monitoring.

Jar Rack Egg Incubation

- Fill egg incubation system with well water and operate as a closed system.
- Check system water for *P. parvum* cells.
    - If cells are present treat with UV radiation.
    - If no cells are present there should be no need for further monitoring.

Spring Fry Rearing (striped bass, smallmouth bass, koi carp, etc)

- Clean all pond bottom sediments 12-14 days before fry stocking.
- Begin filling ponds 11 days before fry stocking with deep lake water.
- Treat ponds with ammonium sulfate to achieve UIA-N level of 0.3 mg/L 6 d before stocking.
- Check ponds for presence of *P. parvum* 4 d and 1 d before fry stocking; treat if cells are present.
- For striped bass conduct 24-h survival tests on all ponds before stocking.
- Check all ponds with fish for *P. parvum* once per week.
    - If *P. parvum* is present check affected ponds twice per week

- Treat ponds containing *P. parvum* with ammonium sulfate to achieve UIA-N level of 0.3 mg/L if UIA-N is low and temperature is 15°C or higher.
- Treat ponds containing *P. parvum* with copper sulfate (or Cutrine-Plus) to achieve 0.75 mg Cu^{2+}/L if temperature is less than 15 °C.

Spawning Ponds (smallmouth bass)

- Fill ponds with deep lake water
  - Check ponds for *P. parvum* once per week; when *P. parvum* is present check twice per week.
  - If *P. parvum* is present treat with ammonium sulfate to achieve 0.4 mg/L UIA-N.

Summer-Fall Fingerling rearing (channel catfish and koi carp)

- Begin to fill ponds with lake water 7 d before stocking.
- Check ponds for *P. parvum* 2 d before stocking
  - If *P. parvum* is absent continue to fill ponds according to culture guidelines.
  - If *P. parvum* is present treat to raise UIA-N to 0.4 mg/L if temperature is 15 °C or higher, or treat to raise Cu^{2+} to 0.75 mg/L if temperature is below 15 °C.
- Check ponds for toxin 1 d before stocking and select ponds with no toxin for stocking with fish.
- After stocking fish monitor pond temperature and pH daily and *P. parvum* once per week.
  - If pond temperatures are consistently above 28°C.
    - No treatment should be necessary but monitor *P. parvum* twice per week.
  - If pond temperatures are 15-28°C.
    - Monitor UIA-N and treat to raise UIA-N to 0.4 mg/L if *P. parvum* present.
  - If pond temperatures are below 15°C.
    - Monitor Cu^{2+} and toxin, and treat with Cutrine-Plus to raise Cu^{2+} to 0.75 mg/L if toxicity is present.

Winter Holding Ponds

- Monitor ponds for *P. parvum* once per week or twice per week if *P. parvum* present.
  - If water temperatures are up to15°C treat to raise Cu^{2+} to 0.75 mg/L if *P. parvum* is present.

Raceway or Trough Culture (rainbow trout and channel catfish)

- 8 d before fish stocking fill with lake water and check for *P. parvum* cells.
  - If *P. parvum* is absent stock fish and operate raceway/trough as flow-through.
  - If *P. parvum* is present perform bioassay to test for toxicity.
    - If lake water is not toxic stock fish and operate raceway/trough as flow-through.
    - If lake water is toxic do not use raceway/trough (Go to Trout Pond Production).

Trout Pond Production

Use ponds for trout production or holding, instead of indoor raceway or troughs, when lake water is toxic.

- 8 d before stocking fill ponds with lake water.
  - Treat with Cutrine-Plus to raise Cu^{2+} level to 1.0 mg/L if temperatures are less that 15°C.
  - Treat with ammonium sulfate to raise UIA-N to 1.0 mg/L if temperatures are 15°C and higher.
- 3 d before stocking check for *P. parvum* cells
  - If *P. parvum* is present treat as above.
- 1 d before stocking check for *P. parvum*.
  - If *P. parvum* is present test for toxicity.
- Stocking day
  - Stock only ponds with no toxicity.
- After stocking
  - Check for *P. parvum* twice per week and if present treat as described above.
- If lake conditions improve harvest fish (e.g., trout) and move to indoor raceway.

Fish Harvest

- At harvest check incoming lake water for *P. parvum*
  - If *P. parvum* is absent harvest fish using lake water
  - If *P. parvum* is present perform bioassay: if negative harvest fish using lake water; if positive use well water.
  - Fish leaving the hatchery must be rinsed in well water before loading into hauling unit.
  - Fish to be transferred between hatchery culture units need not be rinsed with well water.

Fish Transportation

- Fill hauling unit with well water and check all compartments for *P. parvum* after loading fish (Note: all fish leaving the hatchery must be rinsed in well water before loading).
  - If *P. parvum* is absent deliver fish according to hatchery guidelines.
  - If *P. parvum* is present drain out some water, refill and re-check for *P. parvum*. Repeat until no *P. parvum* is found.
  - Upon return to the hatchery, disinfect hauling unit with 10% chlorine bleach.
- Use *P. parvum*-free lake water or well water to transfer fish between culture units on the hatchery.

Monitoring Sites

- Monitor *P. parvum* in lake water at the dam, hatchery intake water, and ponds and indoor culture units in use.

APPENDIX L

Department Publications Relevant to Striped Bass Culture

MDS #

46 Striped Bass Culture Program Report
Author: H. Joe Warren. (1/91) (IF)

64 Chemical Marking of Fingerling Striped Bass Otoliths
Author: Britt Bumguardner. (9/91) C

69 Striped Bass Spawning in the Lower Trinity River, Texas.
Authors: Kenneth F. Kurzawski and Henry R. Maddux. (9/91) (IF)

88 Striped Bass Culture Program Report 1990
Author: H. Joe Warren. (2/91) (IF)

89 Striped Bass Culture Program Report 1991
Author: H. Joe Warren. (2/92) (IF)

90 Striped Bass Culture Program Report 1992
Author: H. Joe Warren. (2/93) (IF)

91 Striped Bass and Hybrid Striped Bass Culture in Texas
Author: H. Joe Warren. (3/93) (IF)

108 Striped Bass Culture Program Report 1993
Author: H. Joe Warren. (3/94) (IF)

110 Striped Bass Culture Program Report 1994
Author: H. Joe Warren. (10/94) (IF)

116 Striped Bass Culture Program Report
Author: H. Joe Warren. (10/95) (IF)

131 Striped Bass Culture Program Report - 1996
Author: H. Joe Warren. (2/97) (IF)

136 Striped Bass Guidelines 1997
Author: H. Joe Warren. (4/97) (IF)

143 Striped Bass Culture Program Report 1997
Authors: H. Joe Warren. (2/98) (IF)