

Inexpensive Apparatus to Rapidly Collect Water Samples from a Linear-Design, Plug-Flow Hatchery Raceway

JAMES D. BOWKER,* DANIEL G. CARTY, AND MOLLY P. BOWMAN

U.S. Fish and Wildlife Service, Aquatic Animal Drug Approval Partnership Program,
4050 Bridger Canyon Road, Bozeman, Montana 59715, USA

Abstract.—In July 2001, we conducted a study to determine whether a target concentration of chloramine-T (a waterborne chemical) could be achieved and maintained for 60 min in linear-design, plug-flow hatchery raceways (devoid of fish) via a “charged” flow-through treatment methodology. In each of four independent trials, a raceway was charged to achieve the target concentration by turning off the inflow water (creating a static bath) and manually mixing in a premeasured volume of chloramine-T stock solution. Water inflow was then turned on, and the target concentration was maintained by metering additional chloramine-T stock solution into the inflow water via a calibrated chicken-watering system. To help verify chloramine-T concentrations during treatment, we built an apparatus to rapidly collect many water samples from throughout a raceway. The apparatus comprised three fixed sampling stations, each of which was equipped with 9 water collection devices (i.e., nine 60-mL plastic syringes fitted with fixed-length “suction needles” made of rigid polyvinyl chloride pipe threaded with flexible vinyl tubing) and 9–11 plastic bottles for storing the collected samples. During each of the four 60-min trials, water samples were collected at elapsed times of 0, 30, and 60 min; thus, 12 sampling events were conducted during the study. During each sampling event, three people (working simultaneously but independently) collected a total of 29 water samples (27 for chloramine-T dose verification and 2 for quality control). The time for one person to collect 9–11 water samples (50–60 mL per sample) from one sampling station averaged 1.5 min (SD = 0.382; $n = 36$) and ranged from 0.9 to 2.5 min. The apparatus was inexpensive, easy to build and use, and portable; it ultimately helped us verify the spatial and temporal distribution of chloramine-T in linear-design, plug-flow hatchery raceways during 60-min charged flow-through treatments.

Waterborne chemicals are commonly used in aquaculture to control or prevent mortality of fish caused by external bacteria, parasites, or fungi. For example, chloramine-T has been used to control mortality of salmonids diagnosed with bacterial gill disease (BGD; Bullock et al. 1991; Bowker and Erdahl 1998; Bowker et al. 2007, this issue). Hydrogen peroxide has been used to control BGD (Lumsden et al. 1998; Rach et al. 2000a), parasites (Rach et al. 2000b), and fungus

(Waterstrat and Marking 1995; Howe et al. 1999) in a variety of fish species. Formalin is approved for use in a static bath to control mortality caused by external parasitic infestations of fish (Winton 2001).

Many factors affect the efficacy of waterborne chemical treatments administered in flow-through systems, including the delivery (i.e., achievement and maintenance) of a target concentration from the start of the treatment to the finish. In linear-design raceways that are rectangular, water tends to travel in a plug-flow manner, that is, from inlet (head) to outlet (tail) at a relatively slow, nearly uniform velocity across the entire cross-sectional area of the raceway (Van Wyk 1999). There is little mixing in such raceways, and water quality tends to decline from raceway head to tail (Van Wyk 1999). If linear-design, plug-flow raceways are linked serially, steadily increasing amounts of organic matter (e.g., fish food, fecal waste, and decaying vegetation) can decrease chemical concentration because of decomposition of the therapeutant (Rach and Ramsey 2000). Delivering a constant target concentration from treatment start to finish is especially problematic when strong oxidizing chemotherapeutants (e.g., hydrogen peroxide) are administered (Rach and Ramsey 2000; Saez and Bowser 2001); thus, Rach and Ramsey (2000) stressed the value of collecting water samples and analytically verifying concentrations of waterborne chemicals during flow-through treatments. Unfortunately, such verification is rarely done because it requires specialized equipment, reagents, staff, time, and money.

On a small scale, Saez and Bowser (2001) demonstrated that a target concentration of hydrogen peroxide could be achieved and maintained for 60 min in a flow-through system only when the tank water was first dosed (as a standing bath) to the desired concentration. However, we know of no studies in which enough water samples were collected to verify whether a target dose of a waterborne chemical was delivered throughout a production-size raceway during a flow-through treatment. Therefore, we conducted a study to determine whether a target dose of chloramine-T could be delivered for 60 min in a linear-design, plug-flow raceway via a “charged” flow-through treatment methodology (herein defined as pretreatment under

* Corresponding author: jim_bowker@fws.gov

Received August 14, 2006; accepted May 29, 2007
Published online December 27, 2007

static-bath conditions to achieve a target concentration followed immediately by administration of flow-through treatment to maintain the target concentration; Piper et al. 1982). As part of the study, we designed and built a sampling apparatus to rapidly collect water samples from many raceway locations.

Methods

The study was conducted July 24–27, 2001, at the U.S. Fish and Wildlife Service's Bozeman Fish Technology Center, Bozeman, Montana. Two linear-design, plug-flow raceways were used in the study. Both raceways were rectangular (18.3 m long \times 1.8 m wide \times 1.1 m deep) and made of concrete. Single-pass, flow-through spring water was supplied to the head end of each raceway by gravity flow at a rate of 680 ± 38 L/min (>2.5 exchanges/h). Effluent water drained from each raceway through a standpipe. With standpipes in place, each raceway had an approximate water depth of 0.51 m and a total water volume of 16.7 m^3 . The bottom of each raceway sloped down; thus, the water in the tail end of each raceway was about 0.13 m deeper than that in the head end. During the 4-d study, mean water temperature and dissolved oxygen concentration were 7.5°C and 9.4 mg/L , respectively. Based on past BFTC records, water hardness was approximately 180 mg/L (as CaCO_3), alkalinity was approximately 170 mg/L (as CaCO_3), and pH was approximately 7.8.

Each raceway was dosed twice with chloramine-T; thus, four independent, 60-min trials were conducted. To simulate minimal mixing conditions (a worst-case scenario), each trial was conducted without fish in the raceway. A raceway was "charged" to achieve the target concentration by turning off the inflow water (thus creating a static bath) and manually mixing in a premeasured volume of chloramine-T stock solution. The inflow water was then turned on to a predetermined flow rate, and the target concentration was maintained by metering a premeasured volume of chloramine-T stock solution into the inflow water with a calibrated chicken-watering system.

To verify the chloramine-T concentrations throughout each raceway during each trial, we devised a water sampling plan and designed and built a sampling apparatus to collect a predetermined number of water samples. For practical purposes, we divided each raceway into three sections (head, middle, and tail) and located one sampling station within each section (Figure 1). At each sampling station, we established 9 fixed sampling sites; thus, 27 fixed sampling sites were located in each raceway. We presumed that 27 sampling sites, properly located, would provide representative raceway profiles. Looking "upstream" from the tail end of each raceway, the 27 sampling sites

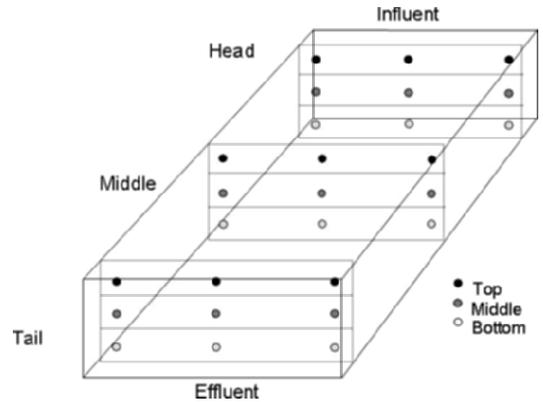


FIGURE 1.—Schematic of raceway sampling sites located on a three-dimensional grid comprising the near-right side, midline, and near-left side and the near-surface, mid-depth, and near-bottom areas.

were located on a three-dimensional grid comprising the near-right side, midline, and near-left side of the raceway and the near-surface, mid-depth, and near-bottom areas (Figure 1).

Each sampling station was equipped with two 2.4-m-long wooden boards, 9 water collection devices, and 9–11 plastic bottles held in a wooden rack. One board (30 cm wide \times 5 cm thick) was used as a catwalk by the person who collected water samples at that station. The other board (20 cm wide \times 2.5 cm thick) had nine 2.5-cm diameter holes drilled in it, and was placed just "upstream" of the catwalk, and was used to hold the water collection devices at fixed locations above the water surface. Marks were made on the edges of the raceways so that the boards could be removed and accurately relocated. Each water collection device consisted of a 60-mL plastic syringe fitted with a fixed-length "suction needle." Each suction needle was made from a piece of rigid polyvinyl chloride (PVC) pipe (1.3-cm diameter), a rigid PVC transition bushing (1.3- to 3.2-cm diameter), and a piece of clear, flexible, vinyl tubing (0.3-cm inside diameter and 0.6-cm outside diameter). Pipes were cut to length so that water samples could be drawn from three water depths (at ~ 5.1 cm below the surface, at mid-depth, and at 10.2 cm above the bottom of the raceway). Transition bushings were fitted to the tops of the pipes to act as holders for the syringes. Pieces of flexible vinyl tubing were cut to length so that when attached to the syringe and threaded through their corresponding pieces of PVC pipe, they extended just below the lower ends of the pipes (Figure 2). The plastic bottles (250 mL) in the wooden racks were used to temporarily store the water samples collected during each sampling event and to transport the samples to the laboratory. The approxi-

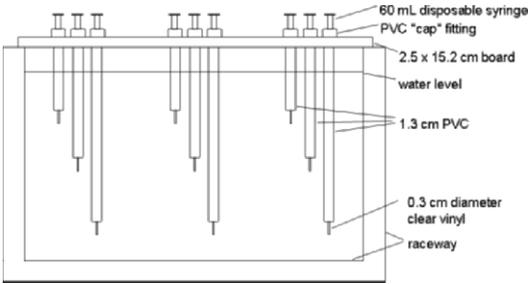


FIGURE 2.—Schematic of the apparatus used to rapidly collect water samples from a raceway. Note that the tip of each syringe is connected to vinyl tubing before being inserted through the PVC pipe; The use of rigid pipe ensures that the distal end of the vinyl tubing reaches the desired depth (i.e., that it does not curl).

mate cost to equip all three sampling stations with PVC, syringes, and tubing was \$150.

To collect a single water sample, a water collection device was placed through a hole in the 20-cm-wide \times 2.5-cm-thick board. The PVC transition bushing held the syringe steady in a position ready to use and kept the collection device from falling into the raceway. About 50–60 mL of water was drawn into the syringe, after which the syringe was lifted from the board,

disconnected from the vinyl tubing, and placed into a sample collection bottle (Figure 3). The vinyl tubing was pulled from the PVC pipe and set aside to be rinsed with clean water before reuse. The water in the syringe was emptied into the collection bottle, and the bottle was capped and taken to the laboratory, where the water samples were processed. Before reuse, the syringe was rinsed three times with clean water and refitted with a clean piece of vinyl tubing.

During each trial, 29 water samples were collected at elapsed times of 0, 30, and 60 min; thus, 12 sampling events were conducted during the study (4 trials \times 3 sampling events per trial). During each sampling event, our goal was to collect all 29 water samples as close together in time as possible. Therefore, just before each sampling event, all three 20-cm-wide \times 2.5-cm-thick boards were loaded with a full complement of water collection devices. One person (a timer) signaled when to start sampling, and three other people (samplers; one per station) simultaneously but independently collected water samples (Figure 3). Two samplers collected 9 water samples each (all for chloramine-T dose verification), and the third sampler collected 11 water samples (9 for chloramine-T dose verification and 2 for quality control). The timer recorded how long it took each sampler to collect all of the samples at his or her



FIGURE 3.—Collection of water samples at one sampling location. Note that the sampling board was preset with water collection devices at fixed locations above the water surface; a filled syringe was disconnected from the vinyl tubing and placed into a sample collection bottle held in the wooden rack for easier transportation.

station; thus, three collection times were recorded during each sampling event, and 36 collection times were recorded during the study.

Results and Discussion

The time for one sampler to collect 9–11 water samples from one sampling station averaged 1.5 min (SD = 0.382) and ranged from 0.9 to 2.5 min ($n = 36$). Collection times tended to decrease as the study progressed, indicating that samplers became more efficient as they gained experience. With sufficient prestudy training and practice, the mean collection time and variation in collection times would probably have been reduced. Nevertheless, during each sampling event, we were satisfied that all water samples had been collected rapidly enough to allow us to accurately describe the spatial and temporal distribution of chloramine-T in production-size, linear-design, plug-flow raceways during 60-min charged flow-through treatments.

The water sampling apparatus that we designed was inexpensive (all materials were purchased locally), easy to build and use, and portable. Other water sampling devices, such as a Bran and Luebbe (Delavan, Wisconsin) proportional pump and an American Sigma All Weather Refrigerated sampler (American Sigma, Loveland, Colorado), were considered; however, they were not used because of such issues as cost, relatively slow pump-flow rates, inability to pump water samples over relatively long distances (in excess of 7.5 m), and the time required to purge and rinse tubing in preparation for the next sampling event. We recommend our sampling apparatus to other biologists who need to rapidly collect water samples from many raceway locations.

Acknowledgments

We thank Bonnie Johnson, Russ Barabe, and Kelly Kupetz for field-testing the sampling apparatus.

References

- Bowker, J., and D. Erdahl. 1998. Observations of the efficacy of chloramine-T treatment to control mortality in a variety of salmonids. *Progressive Fish-Culturist* 60:63–66.
- Bowker, J. D., D. Carty, L. Telles, B. David, and D. Oviedo. 2007. Efficacy of chloramine-T to control mortality in freshwater-reared salmonids diagnosed with bacterial gill disease. *North American Journal of Aquaculture*.
- Bullock, G. L., R. L. Herman, and C. Waggy. 1991. Hatchery efficacy trials with chloramine-T for control of bacterial gill disease. *Journal of Aquatic Animal Health* 3:48–50.
- Howe, G. E., W. H. Gingerich, V. K. Dawson, and J. J. Olsen. 1999. Efficacy of hydrogen peroxide for treating *Saprolegniasis* in channel catfish. *Journal of Aquatic Animal Health* 11:222–230.
- Lumsden, J. S., V. E. Ostland, and H. W. Ferguson. 1998. Use of hydrogen peroxide to treat experimentally induced bacterial gill disease in rainbow trout. *Journal of Aquatic Animal Health* 10:230–240.
- Piper, R. G., I. B. McElwain, L. E. Orme, J. P. McCraren, L. G. Fowler, and J. R. Leonard. 1982. *Fish hatchery management*. U.S. Fish and Wildlife Service, Washington, D.C.
- Rach, J. J., M. P. Gaikowski, and R. T. Ramsey. 2000a. Efficacy of hydrogen peroxide to control mortalities associated with bacterial gill disease infections on hatchery-reared salmonids. *Journal of Aquatic Animal Health* 12:119–127.
- Rach, J. J., M. P. Gaikowski, and R. T. Ramsey. 2000b. Efficacy of hydrogen peroxide to control parasitic infestations on hatchery-reared fish. *Journal of Aquatic Animal Health* 12:267–273.
- Rach, J. J., and R. T. Ramsey. 2000. Analytical verification of waterborne chemical treatment regimens in hatchery raceways. *North American Journal of Aquaculture* 62:60–66.
- Saez, J. A., and P. R. Bowser. 2001. Hydrogen peroxide concentrations in hatchery culture units and effluent during and after treatment. *North American Journal of Aquaculture* 63:74–78.
- Van Wyk, P. 1999. Principles of recirculating system design. Pages 59–98 in P. Van Wyk, M. Davis-Hodgkins, R. Laramore, K. L. Main, J. Mountain, and J. Scarpa, editors. *Farming marine shrimp in recirculating freshwater systems*. Florida Department of Agriculture and Consumer Services, Tallahassee.
- Waterstrat, P. R., and L. L. Marking. 1995. Clinical evaluation of formalin, hydrogen peroxide, and sodium chloride for the treatment of *Saprolegnia parasitica* on fall Chinook salmon eggs. *Progressive Fish-Culturist* 57:287–291.
- Winton, J. R. 2001. Fish health management. Pages 559–640 in G. A. Wedemeyer, editor. *Fish hatchery management*, 2nd edition. American Fisheries Society, Bethesda, Maryland.