Gulf Killifish (*Fundulus grandis*) Egg and Fry Production at Low Level Salinity

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INTRODUCTION

The saltwater recreational fishing industry in coastal Mississippi (MS) generates a sizable economic impact to the state. In 2001, there were 106,000 state resident and non-resident saltwater anglers 16 years and older whose total fishing expenditures were $26,429,000 (United States Department of the Interior, et al. 2001). In addition, saltwater recreational fishing industry provides 1,003 jobs, $22,521,341 in wages/salaries, $98,274,976 in outputs, $50 million in retail sales, $3,997,176 in sales/fuel taxes, $820,213 in state income taxes, and $2,377,908 in federal taxes (American Sportfishing Association 2001).

Gulf killifish (*Fundulus grandis*), locally referred to as "bull minnows", are in great demand as a live bait for several of the Gulf Coast's most popular sport fisheries. Local bait dealers must almost exclusively rely upon harvest of wild stocks to supply the area market. The bulk of the native harvest in coastal MS is in the fall and again in spring. The demand for the bait fish is year-round. Supply is irregular and continually falls short of demand. The supply deficit runs throughout the summer months. Commercial pond production of this species would help to stabilize supply deficits.

Initial investigations on the production of bull minnows were carried out at the Alabama Marine Resource Division's Claude Peteet Mariculture Center (CPMC). Tatum et al. (1982) provided a firm foundation for the culture of bull minnows through their work at CPMC. Others continue to build upon this foundation. For example, Waas and Strawn (1982) were able to enhance production through their work with supplemental diets. Perschbacher and Strawn (1983) were able to enhance production and lower production costs through fertilization practices. McIwain (1977) demonstrated the ability to successfully spawn and hatch bull minnows in tanks.

In 2000, Mississippi State University's Coastal Aquaculture Unit initiated gulf killifish culture demonstrations to address expressed interest from the local bait fish industry. The overall goal of this project was to evaluate the development of an economically viable, small-scale production and marketing system capable of providing a year-round supply of live bait, especially during spring and summer months. The specific objectives were as follows:

1. Design, build and operate a small scale recirculating tank production system.
2. Monitor critical technical and biological parameters of the entire production system.
3. Monitor egg and fry yield at low level salinity.

METHODS

Spring Egg and Fry Production

Different salinities were evaluated to determine the effect on brood success and fry survival. The salinities to be evaluated were 0 ppt, 3 ppt, 6 ppt, and 9 ppt. Four 757 L (200 gal) fiberglass tanks were filled with water from a neighboring pond with a salinity of 12 ppt. The pond was filled from the Mississippi Power Company Plant Jack Watson warm water discharge canal fed from Biloxi Bay. The tanks were diluted to the different salinities with well water. The salinities were checked at least once per week. If needed the salinity was adjusted with seawater or well water.

The tanks were maintained as re-circulating systems. Bio-filters were utilized to remove organic waste from each system. The bio-filter was constructed from a 114 L (30 gal) plastic drum. The container was one-third filled with oyster shell. A circular piece (53 cm diameter)

(21 in diameter) of plastic air conditioning filter material (3 cm thick) (1 in thick) was placed on top of the shells. It was used to collect suspended solids and as supplemental surface area for the colonization of nitrifying bacteria. The water was pumped from the bottom of the fiberglass tank into the bottom of the filter. The water was returned to the top of the glass aquaria and fiberglass tank via gravity. The system was constructed and activated 21 days prior to the stocking of fish. Organic material from the oyster shells provided nutrients to acclimate the bio-filter.

A 76 L (20 gal) glass aquarium (91 cm x 31 cm x 41 cm)(36 in x 12 in x 16 in) was placed into each of the four fiberglass tanks. The aquaria sheltered the fry from the piscivorous broodstock. Each aquaria was fitted with a screened (1000 micron) side drain (1.9 cm)(0.75 in) near the bottom. The side drain was needed for water circulation through the aquaria.

Broodstock were harvested locally from the wild. Females averaged 8.0 g each and males averaged 7.4 g each. Each tank was stocked with twenty-seven bull minnows. The female to male ratio was 2:1 respectively. The bull minnows were fed a commercially available floating catfish fingerling diet (40% protein) equivalent to 3% of their total body weight per day.

Plastic air conditioner filters (25 cm x 17 cm x 3 cm) (10 in x 7 in x 1 in) were used as spawning mats. The mats were suspended vertically in the water column. This was accomplished by attachment of a lead weight on one of the 25 cm (10 in) ends of the mat and a styrofoam float on the opposite 25 cm (10 in) end. Once the optimum spawning temperature was reached ($13^{o}C$-$28^{o}C$) ($55^{o}F$-$82^{o}F$), the mats were placed into the tank outside of the aquaria. Ten mats were used per tank. The mats from the four treatments were exposed to the broodstock for 7 days. The mats from each treatment were removed from the tank and placed into the associated glass aquarium. Two of the ten mats from each treatment were collected at the end of the 7-day period. The mats were soaked in a 1% Rose Bengal aqueous solution for 4 hours to color the eggs. The mats were illuminated and the colored eggs were counted. The remaining eight mats in each treatment were kept in its respective aquaria for a two-week hatching period. The mats were then removed from each aquaria. The fry were grown-out for seven days. The grow-out time was implemented to minimize stress to the fry during quantification. The tanks were subsequently drained and the fry counted.

There were two consecutive spawning runs completed during spring. The first run started April 15 when the mats were exposed to spawning fish and ended May 16 with the counting of fry. The second run started May 13 when the mats were exposed to spawning fish and ended June 13 with the counting of fry.

Spring Water Quality

The dissolved oxygen and temperature of each tank were measured with a Yellow Spring Instruments (YSI) model 55 dissolved oxygen meter. These two parameters were measured once per day (a.m.). The salinity in each tank was measured with a model A366ATC Vista refractometer. The salinity was measured at least once per week. Several water quality parameters were measured with model 25 Accumet pH/ion meter following methods described by Eaton et al. (1995). The parameters were percent hydrogen (pH), total ammonia nitrogen (TAN), nitrate (NO_3), nitrite (NO_2), and alkalinity (ALK). These parameters were measured April 5 and May 30.

Fall Egg and Fry Production

Different salinities were evaluated to determine the effect on brood success and fry survival. Culture techniques were established as previously described under spring egg and fry production. However, due to the low salinity level (0 ppt) in water supply canal the four 757 L

(200 gal) fiberglass tanks were filled from the on-site fresh-water well. The salinities were adjusted with a mixture of synthetic sea salt. In addition, the system was activated 24 hours prior to the stocking of fish. This was achieved with the use of a commercially available bio-filter acclimating water treatment.

Broodstock were harvested locally from the wild. Females averaged 19.7 g each and males averaged 20.5 g each. Each tank was stocked with twenty-seven bull minnows. The female to male ratio was 2:1. The bull minnows were fed a commercially available 40% protein floating catfish fingerling diet at the ration of 3% of their total body weight per day.

There were two consecutive spawning runs completed during Fall. The first run started September 12 and ended October 23. The second run started October 23 and ended November 20.

Fall Water Quality

Water quality techniques were established as previously described under spring water quality. In addition to TAN, NO_2, NO_3, and pH, the parameters total phosphorus (PO_4) and hardness (HARD) were measured. All parameters were measured August 27 and October 22.

RESULTS

Spring Egg and Fry Production

An adult bull minnow and multiple dragonfly larvae (Anisoptera) were noticed in the fry nursery aquaria at harvest. Both bull minnows (Tatum et. al. 1982) and dragonfly larvae (Borror and Delong 1971) are piscivorous. Mortality of the eggs or the fry could not be quantified. Therefore, no production results were reported.

Spring Water Quality

Dissolved oxygen concentrations (Figure 1) were variable until aeration equipment was installed halfway through the second run. Temperature readings (Figure 2) were in the optimal range for the spawning of bull minnows. The salinity measurements (Figure 3) remained relatively constant throughout the Spring. The average salinity for the 0 ppt treatment was 1 ppt [standard deviation (STD) = 0]. The oyster shells that were used as bio-filter media retained sea salt. The sea salt elevated the tank salinity to 1 ppt. The average salinity for the 3 ppt treatment was 3.1 ppt (STD = 0.7). The average salinity for the 6 ppt treatment was 6 (STD = 0.6). The average salinity for the 9 ppt treatment was 8.9 (STD = 0.7). All other parameters measured (Table 1) were in tolerable ranges for the bull minnow.

Fall Egg and Fry Production

Dragonfly (Anisoptera) larvae were noticed in the fry nursery aquaria at harvest. Dragonfly larvae are piscivorous larvae (Borror and Delong 1971). Estimates of egg or fry mortality could not be quantified. Therefore, no production results were reported.

Fall Water Quality

Dissolved oxygen concentrations (Figure 4) remained above stressful limits in all treatments. Temperature readings (Figure 5) were in the optimal range for the spawning of bull minnows. The salinity (Figure 6) remained relatively constant throughout the Spring. The average salinity for the 0 ppt treatment was 0 ppt [standard deviation (STD) = 0]. The average salinity for the 3 ppt treatment was 2.7 ppt (STD = 0.483.). The average salinity for the 6 ppt treatment was 5.3 (STD = 0.675). The average salinity for the 9 ppt treatment was 8 (STD = 1.155). All other water quality parameters measured (Table 2) were in tolerable ranges.

IMPLICATIONS

The need exists for the protection of fry from predacious insect larvae during Spring and Fall production. Adult dragonflies were observed laying eggs in the tanks. More predator control measures should be exercised by perhaps covering tanks or housing the tanks indoors.

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Figure 1. Bull minnow salinity study oxygen data Spring 2002.

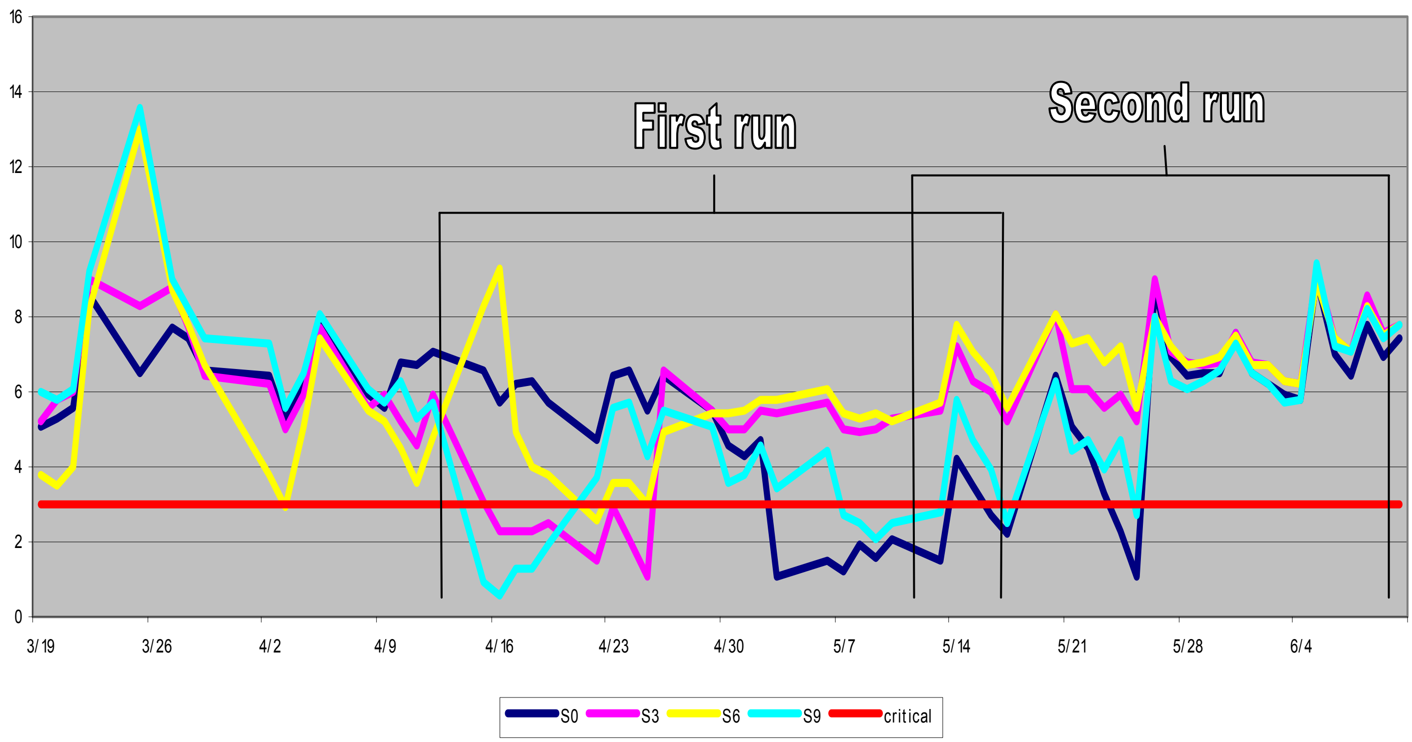

Figure 2. Bull minnow salinity study temperature data Spring 2002.

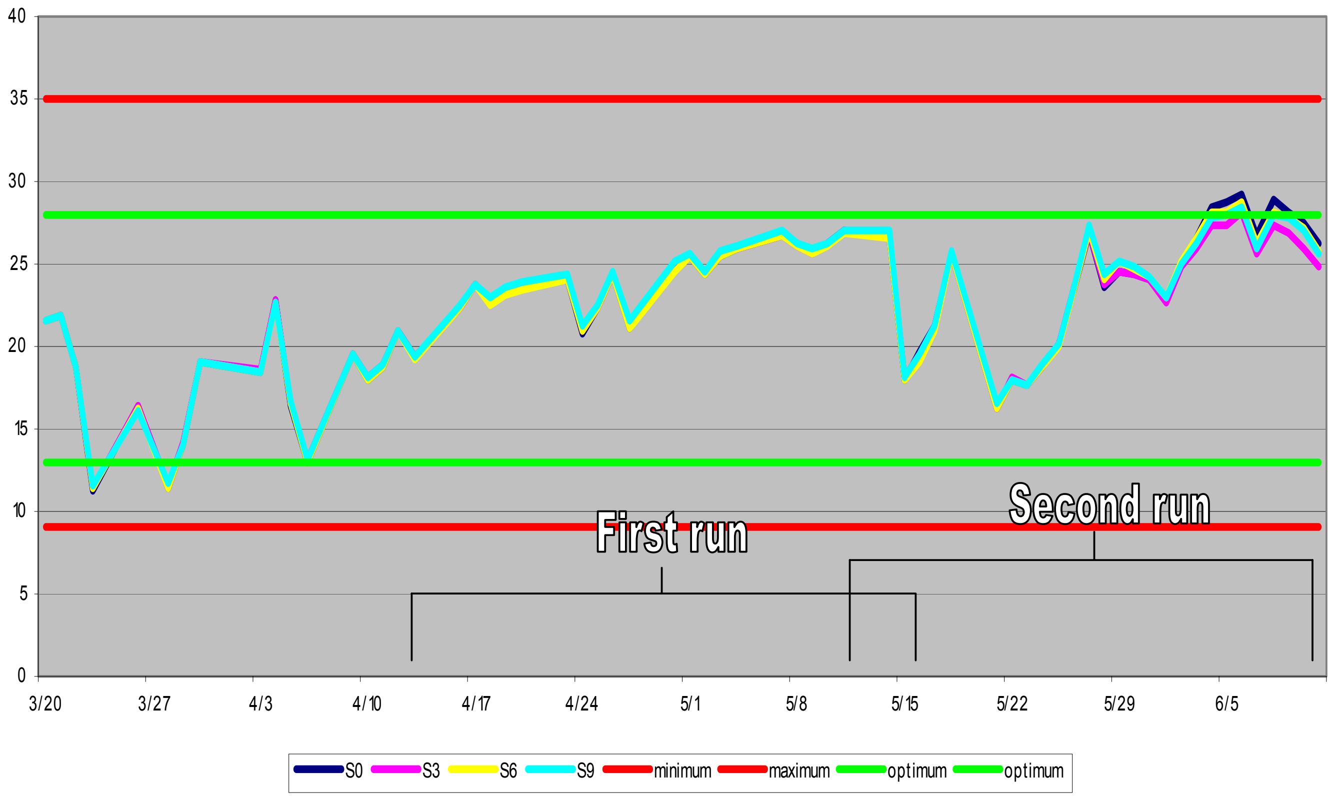

Figure 3. Bull minnow salinity study salinity data Spring 2002

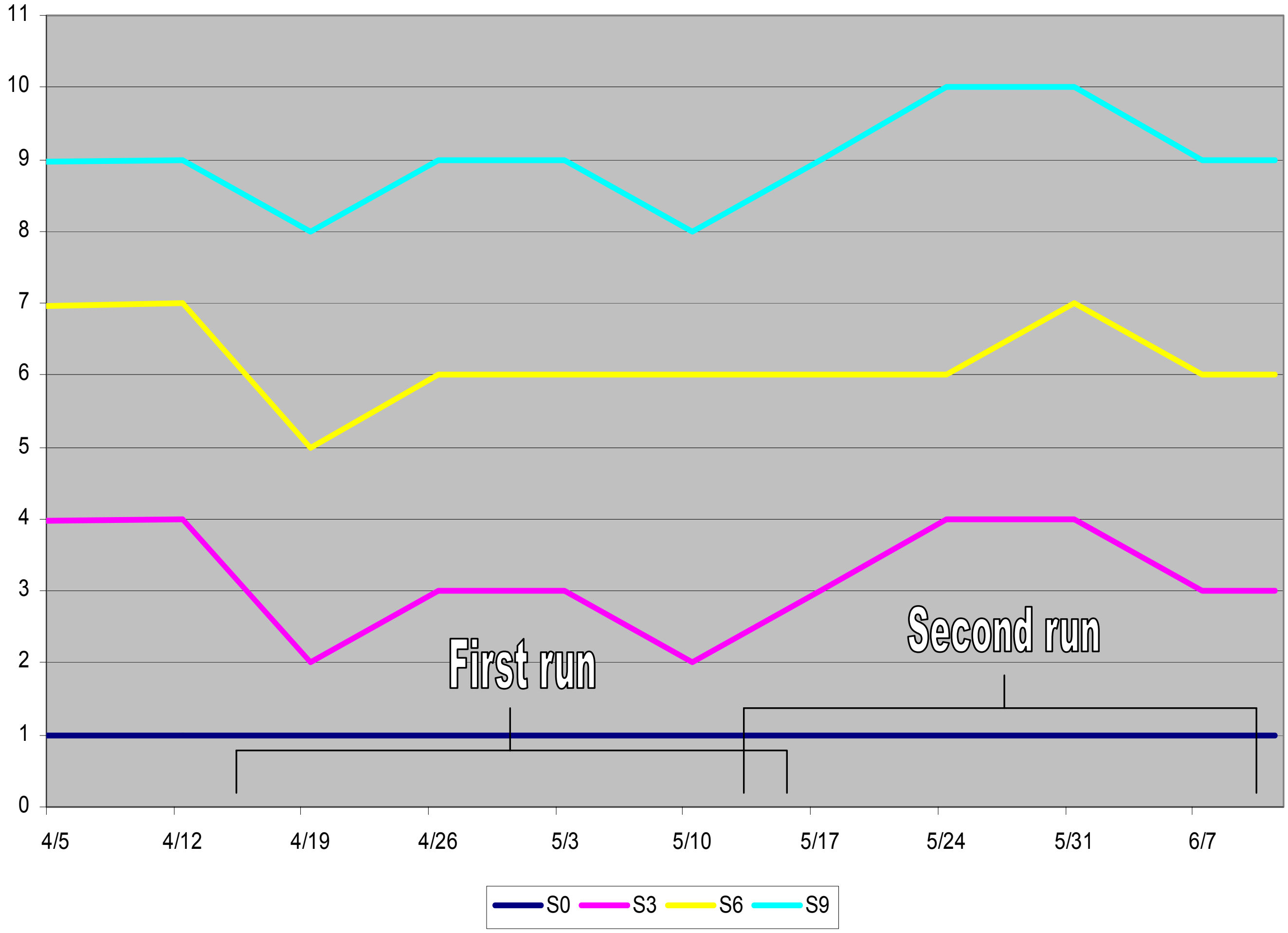

Figure 4. Bull minnow salinity study oxygen data Fall 2002

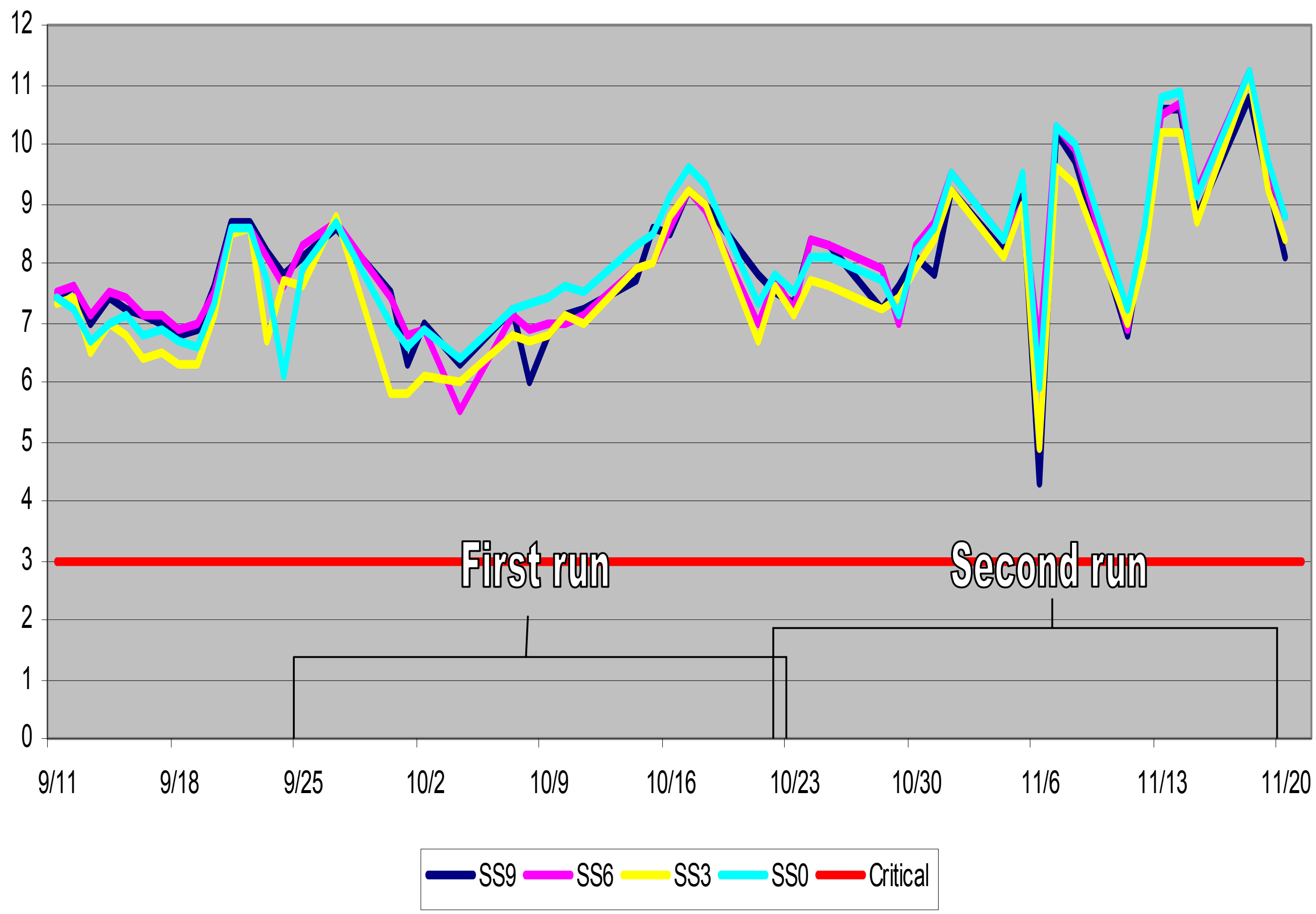

Figure 5. Bull minnow salinity study temperature data Fall 2002

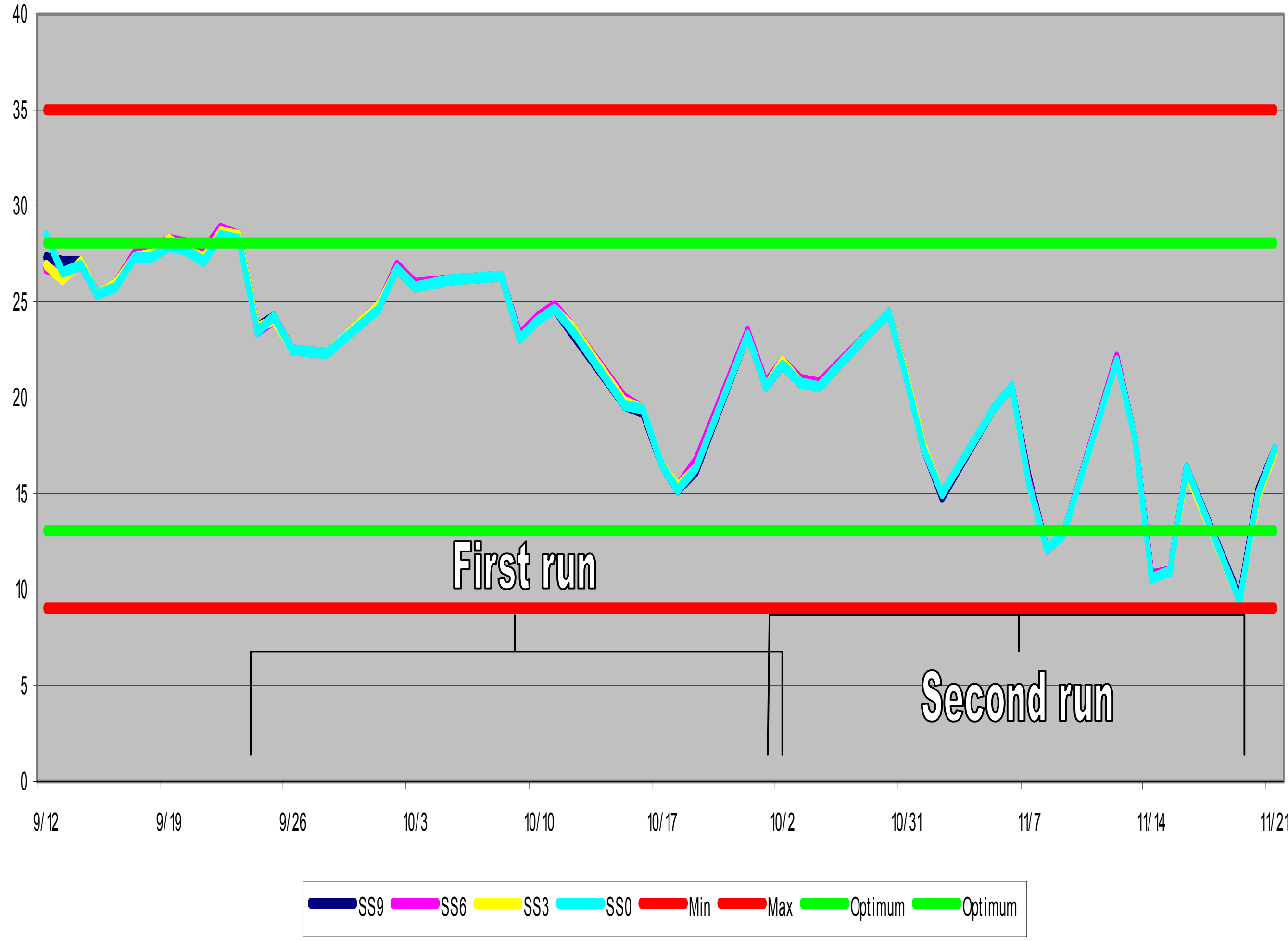

Figure 6. Bull minnow salinity study salinity data Fall 2002

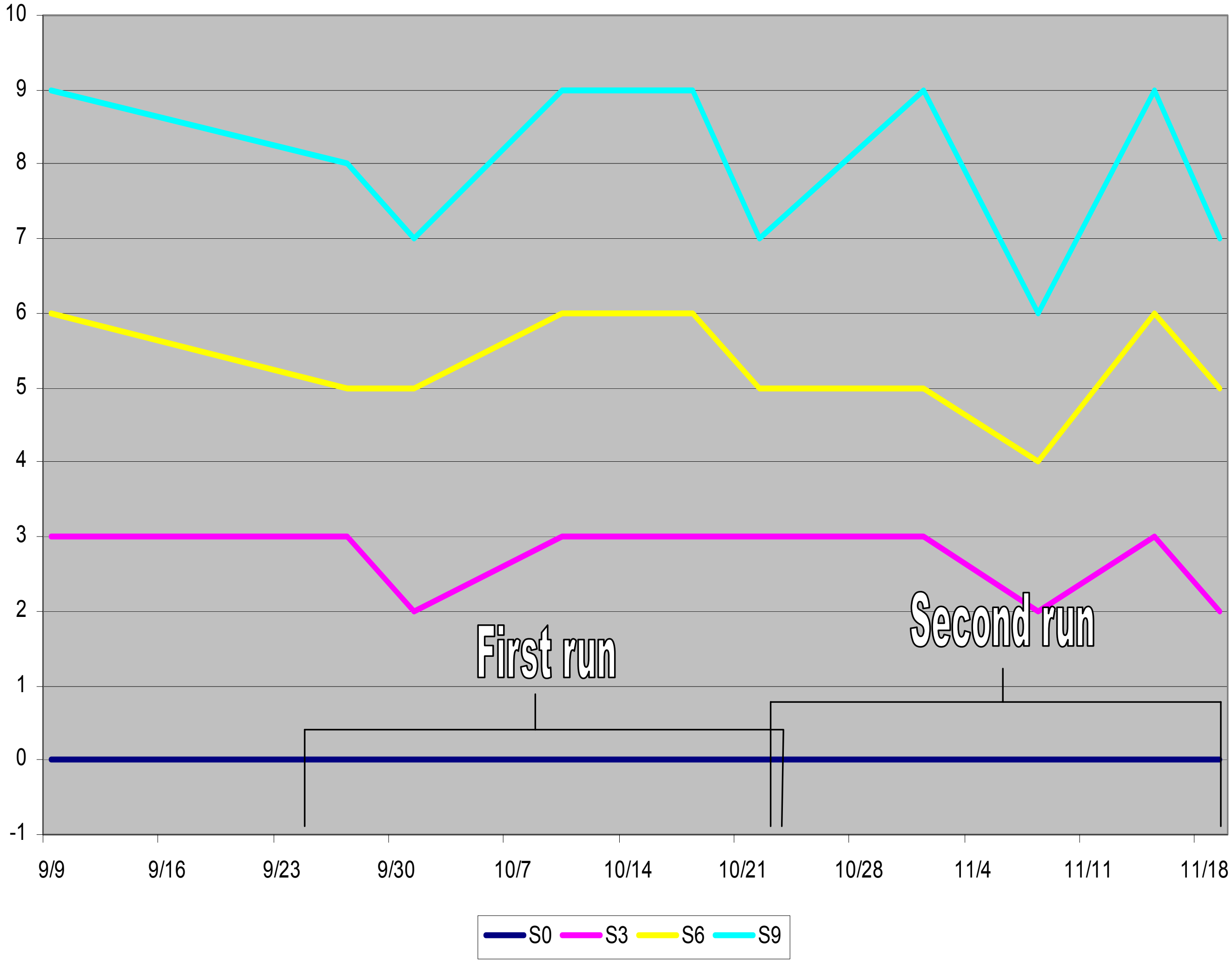

Table 1. Bull minnow salinity study average and standard deviation water quality parameters among all treatments Fall 2002.

Parameter	Date	Average (mg/l)	Standard deviation (mg/l)
Total ammonia nitrate	April 5	.06	.02
	May 30	.002	.001
Nitrate	April 5	2.349	.196
	May 30	2.296	.096
Nitrite	April 5	.015	.007
	May 30	.023	.023
Alkalinity	April 5	128.5	52.69
	May 30	125.25	43.65

Table 2. Bull minnow salinity study average and standard deviation of water quality parameters among all treatments Fall 2002.

Parameter	Date	Average (mg/l)	Standard Deviation (mg/l)
Total ammonia nitrogen	October 22	.08	.03
Nitrate	October 22	2.16	3.31
Nitrite	October 22	.26	.32
Alkalinity	October 22	94.25	35.46