EFFECTS OF TURBO SCOURING ON STRIPED BASS EGGS IN THE SAVANNAH RIVER

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Abstract. Golder Associates monitored turbo-scouring effects on water quality and striped bass (*Morone saxatilis*) reproductive success at the CITGO Asphalt Refinery in the lower Savannah River, Georgia. The majority (67-70%) of entrained eggs and gum pellets were partially damaged or completely destroyed by entrainment. Water quality monitoring showed that scouring increased turbidity levels only along the river bottom up to 160 ft from the Turbo-scour unit. Scouring did not appear to alter salinity or dissolved oxygen throughout the water column. Physical destruction of entrained eggs may be the most detrimental impact of turbo-scour operations on the striped bass fishery. Egg destruction rates from a single scour system are insignificant when compared to overall natural mortality. However, future installation of scouring systems could have an additive effect on egg and larval mortality.

INTRODUCTION

CITGO Asphalt Refining Company (CITGO) operates a commercial berthing facility on the Savannah River near Savannah, Georgia. In estuarine berthing areas, such as CITGO's facility, siltation occurs at rates of 1-4 ft per month, creating fast-growing shoals that impede ship movement. Due to high siltation rates, CITGO must continually remove riverbed sediments in order to maintain the permitted 42-ft depth.

Scour Systems, Inc. is installing a Turbo-scour system to maintain CITGO's berth depth. The Turbo-scour system is a series of j-shaped, large diameter tubes with hydraulic impellers. Water enters the unit approximately 20 ft from the surface through a 62" diameter cylindrical screen at 2 ft per second (fps). Water is discharged near the river bottom through a 42" diameter opening at approximately 11.5 fps or 50,000 gallons/minute. Up to eight units will be attached to support structures. The units will operate sequentially, each for 20 minutes, and will produce a scour zone 900 ft long and 120 ft wide (Scour Systems, Inc., 1997). The system will operate with the ebb tide to ensure effective downstream sediment transportation.

The primary concern of the State and Federal agencies was that the striped bass fishery might be harmed due to fish entrainment, egg destruction, or water quality changes. Therefore, a monitoring plan to investigate potential environmental effects was requested by the U.S. Fish and Wildlife Service (USFWS) and Georgia Department of Natural Resources (GADNR).

STUDY OBJECTIVES

The objectives of this study were to:

- Examine the effects of rapid pressure changes on egg hatching success;
- Evaluate physical damages to entrained egg analogues and previously frozen, dead striped bass eggs; and
- Estimate the probability of striped bass eggs and larvae being captured by a Turbo-scour Unit.

METHODS

One of the original objectives of the project was to examine the hatching success of entrained eggs. However, the prototype Turbo-scour unit was not operational until late May 1998. By this time, the spawning season was over and the state hatchery at Richmond Hill, which is essential for egg procurement and egg incubation, was closed for the season. Therefore, egg entrainment was partially simulated by examining the effects of pressure increase on egg survival. Pressure effects were examined because entrained eggs would drop from a depth of 20 to 40 ft during entrainment, experiencing a rapid increase in pressure of approximately 10 pounds per square inch.

The pressure increase experiment was conducted on April 9, 1998, with subsequent egg hatching trials conducted at GADNR's Richmond Hill Fish Hatchery, Richmond Hill, Georgia between 8-11 April, 1998. The egg analogue entrainment study was conducted at the CITGO terminal and berth on 23 and 24 September, 1998.

Pressure Increase Study

Striped bass eggs, consisting of 100% Savannah River genetic stock, were split into three groups: Treatment, Control 1 and Control 2. Control 2 eggs were returned to a hatching jar and left at the hatchery. Treatment and Control 1 eggs were transported to the terminal berth at the CITGO Asphalt Refinery when the eggs were approximately 20 hours old. The Control 1 container was dropped to a depth of 20 ft, while simultaneously the Treatment container was dropped to a depth of 40 ft. Both egg containers descended to their target depths for approximately 5.3 seconds, then were immediately retrieved to the surface. Before eggs were returned to their respective hatching jars at the hatchery, a depth profile of salinity, temperature, dissolved oxygen and specific conduction in the river water was measured from the CITGO dock.

Numbers of hatched larvae were estimated on 11 April 1998, approximately 56 hours after they were fertilized and 8 hours after they hatched. Total numbers of dead eggs and live larvae in each of the three egg groups were calculated based upon the percent of eggs and larvae in sub-samples.

A chi-squared test was used to determine whether hatching success rates were different for groups dropped to 40 ft (Treatment) or 20 ft (Control 1) or eggs which remained at the hatchery.

Entrainment Study

Previously frozen eggs and egg surrogates (gellan gum pellets from the drink product "Orbitz™" manufactured by Clearly Canadian Beverage Corporation) were introduced into the scour unit at full power. The Turbo-scour unit was run for 5 seconds after the eggs were released. Eggs and surrogates were captured in a 20 ft long nylon plankton net temporarily attached to the unit discharge.

Egg Entrainment Modeling

The magnitude of entrained egg destruction was modeled to determine how the scour unit might affect the entire population of eggs in the river. The rate of instantaneous egg destruction by entrainment was calculated by combining the percentage of river water passing through a scour unit at any moment in time and the experimentally observed egg destruction. The equation for calculating instantaneous entrained egg destruction is:

Instantaneous egg destruction = $(Q_1/Q_2)*(D)*100\%$

where Q_1 = scour unit intake in cubic ft per second (cfs) = 110 cfs

Q_2 = average daily discharge of the Savannah River at Clyo, Georgia = 14,477 cfs

D = gum pellet destruction rate observed during the egg entrainment test = 0.70

Because the units will not operate continuously, it is more useful to consider a daily egg destruction rate based upon the fact that eight Turbo-scour units operate sequentially twice a day, for twenty minutes each. Accordingly, the daily egg destruction rate was calculated by the following means:

Egg destruction /day = (Instant. egg destruction)*((8 units*0.33 hours*2 times/day)/(24hours))

Water quality study

The water quality study was performed at the CITGO berth on the Savannah River on 23 and 24 September, 1998. On 23 September, the scour unit was operated approximately an hour after predicted high tide. However, on 24 September, scouring was delayed by lingering high river level nearly two hours after predicted high tide.

Water quality was monitored at the following four stations:

- Approximately 50 ft upstream of the predicted impact area, (Station 1);
- Predicted vicinity of maximum impact, approximately 105 ft from unit (Station 2);
- Predicted vicinity of farthest perpendicular scouring effect, approximately 160 ft from unit (Station 3); and
- Predicted vicinity of farthest downstream scouring effect, roughly 300 ft from unit (Station 4).

At each of the four stations, water quality was measured at three depths; river surface (2.7-4.6 ft), mid-column (17.0-26.1ft) and river bottom (36.3-43.1 ft).

Physico-chemical parameters were measured using a DataSonde4 water quality multiprobe manufactured by Hydrolab Corporation. The following parameters were measured: Date, Time (hrs, secs.), Temperature (°F), Depth (ft), pH, Total Dissolved Solids (g/l), Turbidity (NTU), Dissolved Oxygen (mg/l), Specific Conductivity (μmhos), and Salinity (ppt).

Ambient conditions were measured 8 to 64 minutes prior to scouring on 23 and 24 September. Post-scouring readings of water quality were 1-20 minutes after scouring.

RESULTS

Pressure Increase Study

Hatching success of live eggs dropped to river bottom (95%) was slightly lower ($\chi^2 = 15.31$, $\underline{df} = 1$, $\underline{P} = 0.5$) than eggs that were dropped to 20 ft (96%). Hatching success of both groups of eggs dropped into the Savannah River was higher ($\chi^2 = 31.4$, $\underline{df} = 2$, $\underline{P} = 0.5$) than eggs that were kept at the hatchery (93%).

The highest salinity, 3.2 ppt, occurred at 40 ft but was only 2.1 ppt higher than salinity at 20 ft. Dissolved oxygen levels were relatively high (5.5 - 5.2 mg/l) and nearly identical at both depths.

Egg Entrainment Study

Thirty-three of 100 entrained striped bass eggs were recovered intact without evidence of damage (67% damaged). Seventeen eggs were partially damaged. The remaining 50 eggs were damaged beyond recovery. Gum pellets incurred rates of entrainment damage and loss similar to the thawed striped bass eggs. In the first trial, 31 of 100 entrained pellets were recovered without damage (69% damaged) and 4 pellets were partially damaged. In the second trial, 30 of 100 entrained pellets were recovered intact (70% damaged) while 5 partially damaged pellets were recovered.

Egg Entrainment Modeling

If the egg destruction rates observed in the entrainment studies are extrapolated to the total population of eggs in the river and the eggs are assumed to be evenly distributed and moving downstream uniformly, instantaneous entrained egg destruction for one unit could be as high as 0.5% during scouring operations. However, the percentage of time that a system operates during one day (22.2%) must be taken into account to calculate the daily entrainment destruction. Therefore, daily mortality from the Turbo-scour system could be as high as 0.1% (0.005*0.222) of the total population of striped bass eggs in the Savannah River.

Water Quality

Turbidity generally increased with increasing depth at all four stations. High turbidity (> 10 NTUs) occurred only at depths greater than 35 ft. Stations 1 (upstream) and 4 (downstream), which should have exhibited least impact, had lower ranges in turbidity (2.1 to 7.9 NTU) compared to stations 2 (mid-scour zone) and 3 (scour zone edge) (2.1 to 16.8 NTU).

Dissolved oxygen generally remained stable over time regardless of scouring. All four stations for September 23 and 24 show the same pattern: decreasing dissolved oxygen with increasing depth. The ranges were 2.65 to 5.02 mg/l and 2.9 to 5.25 mg/l for September 23 and 24.

All four stations for September 23 and 24 show the same salinity pattern: increasing salinity with increasing depth regardless of scouring. The ranges were 2.55 to 15.64 ppt and 3.67 to 16.76 ppt for September 23 and 24, respectively.

DISCUSSION

Eggs and larvae that enter a unit would rapidly accelerate from a velocity of 2 fps at the intake to 11 fps when discharged at the outlet. Striped bass have been reported in currents with velocities up to 8.9 fps (Crance 1984). Crance (1984) reported that previous investigators estimate water velocities of 7.9 fps approach the damaging range for eggs, and velocities of 13.1 fps may be the maximum for survival. Shear velocities in a Turbo-scour unit are likely to be within the reported damaging range for striped bass eggs.

During the operation of the scour unit, the river bottom turbidity was the only parameter showing noticeable shifts. This was expected, since the unit is designed to scour sediments from the bottom which decreases the water clarity. However, these results are difficult to interpret because the tide and other natural river conditions constantly alter the water column causing small shifts in water quality. Theoretically, the scour unit might drive highly turbid water further up the water column than would naturally occur, although this was not observed. The data indicates that turbid waters do not occur above 25-35 ft.

Eggs and larvae cannot tolerate salinity concentrations greater than 9 ppt (Winger and Lasier, 1994). The April and September ranges for salinity were 0.4 to 3.2 ppt and 2.6 to 16.8 ppt, respectively. However, the data was taken at one point in time and does not fully describe what the salinity will be throughout the entire spawning period. For example, Reinert et al. (1994) found salinities up to 25 ppt near the river bottom, even as far upstream as River Mile 19, two miles upstream of the CITGO berth, during the 1994-1996 spawning season. It is possible that Turbo-scour operation could transport eggs and larvae to lethally saline water on the river bottom.

CONCLUSIONS

This study indicates that the CITGO Turbo-scour system is unlikely to adversely impact the striped bass fishery in the Savannah River. Although mortality of eggs that pass through a scour unit is potentially high due to physical destruction, the overall probability of entrainment by the CITGO Turbo-scour system is relatively low (less than 1%). Egg destruction rates from a single scour system are insignificant when compared to overall natural mortality. However, future installation of scouring systems could have an additive effect on egg and larval mortality.

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