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WHAT'S KILLING THE FISH?

What's Being Done to Save Them?
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The salty Pecos River, which trickles through such small west Texas towns as Iraan, Pandale, and Shumla before entering International Amistad Reservoir, wouldn't seem to have much in common with the turbid Trinity River, a waterway that passes through urbanized Dallas and Fort Worth before progressing downstream.

For at best the past two years these rivers have shared one dubious distinciton: large numbers of fish have been dying in them. The Trinity has claimed more than 1 million fish since 1970, 274,000 in the test two years. Best estimates place the number of fish killed in the Pecos River during 1985 and 1986 at more than 625,000.

Fish kills in the Trinity aren't a new development, however. They have been reported ever since slaughterhouses began operating in Fort Worth at the turn of the century. Sketchy reports indicate that fish kills along the Pecos have never been as potent as they are now.

Apparently, causes of these two fish kills aren't closely related. Wastewater, toxic chemicals, and urban runoff are suggested as possible causes of the Trinity River kills, while poisonous algae are linked to fish kills on the Pecos.

It's frustrating that no one has yet been able to authoritatively stab that the Trinity River fish kills, for example, were caused by urban or agricultural runoff, or to determine why the deadly algae on the Pecos are suddenly surfacing. There are a lot of theories, even more questions, but not very many answers.

Fortunately, there has been a recent impetus on researching the Trinity River fish kill events. The investigations are being conducted and sponsored by state, federal, and local governments; universities; and river authorities. Already, there are some promising results. A study sponsored by the Trinity River Authority (TRA) offers possible ways to allow more fish to survive a kill event. Other studies are investigating the effects of bottom sediments, toxins, and nonpoint source pollution on oxygen levels in the Trinity River.

TRINITY RIVER FISH KILLS

Much of the information concerning fish kill events after 1970 has been compiled in a 1987 report (in press) being published by the Texas Water Commission (TWC). This report (Reference 1) is a comprehensive summary of many theories and much data concerning fish kill events and is cited heavily in this newsletter.

The documentation of the Trinity River fish kills really began with an event that destroyed 200,000 fish in July of 1970 near State Highway 19 (see Figure 1). Since that time, 12 other fish kills along the Trinity have been reported including kills of more than 100,000 fish in 1971,1978,1979, 1981,1984, and 1985. The majority of kills between 1970 and 1978 were centered between U.S. Highway 79 and Lake Livingston. Fish kills after 1978 hit closer to Dallas, between South Loop 12 and State Highway 7.

Why have the recent kills moved closer to Dallas? One theory is that improved water quality has enhanced the fishery in that part of the river, making fish there vulnerable to kill events. In other words, poor quality water sufficient to cause kills probably has been surging down the entire upper Trinity during high-flow periods since 1970. It only started causing fish kills in the upper reaches after the water quality during low-flow periods improved enough to allow fish to survive there.

The existence of a healthy fishery is a matter of speculation. The best information on the health of the fishery is a 1974 study by the Texas Parks and Wildlife Department (TPWD). That report indicated that the number of all species and the percent of game fish species increased downstream from Dallas. Because the report used only electrofishing as a means to estimate the fishery, species may have been missed or estimated incorrectly. A new study employing electrofishing and other techniques has been proposed by TPWD since many experts believe the 13-year-old study no longer reflects conditions in the current fishery.

A summary report published by TPWD (Reference 2) detailed that 184,050 fish were killed between FM 85 and U.S. Highway 287 during a fish kill from July 3 through July 6, 1985. It noted that 54 percent of the kill were channel catfish and 26 percent were smallmouth buffalo. The remaining species killed were carp, flathead catfish, white bass, bluegill, freshwater drum, and spotted gar. Another kill later that month resulted in the death of 85,959 fish. Smallmouth buffalo were reported as the main species that perished in this kill (84 percent). They were probably one of the few varieties that survived the first kill.

CAUSES OF FISH DEATHS

Fish deaths in the Trinity can almost all be attributed to low levels of dissolved oxygen (DO) in the river. The fish simply don't have enough oxygen to breathe. High oxygen demands may be the result of high temperatures and biochemically oxygen demanding (BOD) materials such as toxins, algae, urban runoff, bottom sediments, and raw or inadequately treated sewage.

Dissolved oxygen levels have dropped as low as 0.2 milligrams per liter (mg/L) during fish kill events in the Trinity. A more important factor appears to be the number of consecutive hours that DO levels consistently remain low. At DO levels between 0.5 and 1.0 mg/L, fish can apparently survive for at least 12 hours. Major kills result when these levels persist for 24 hours. Water temperatures may also increase the stress induced by low DO levels. DO concentrations of 0.5 - 1 mg/L would probably produce fish deaths in 9 or 10 hours when the water temperature is 89 degrees F. At 68 degrees F. it would take up to 18 hours to cause a fish kill at those DO concentrations. Even if low DO levels do not result in fish deaths, they can disrupt reproduction and result in abnormalities in newborn fish.

Fish are apparently not being poisoned from chemicals in the river. However, toxins may play a role in the kills. Toxic substances-including nitrites, selenium and such heavy metals as cadmium, chromium, copper, lead, silver, zinc, and mercury-have been found in bottom sediments that accumulate along pockets of the riverbed. Nitrites have been linked to anoxia during fish kill events. Toxins may also slow microbial decomposition processes. Concentrated organic solids that accumulate in sediments may not be rapidly decomposing and may have a greater than normal impact on DO levels upon resuspension.

Algae may also reduce the amount of DO in the river. Significant amounts of slimy, bluegreen green algae that attach to rocks and streambeds have been observed in the West Fork of the Trinity in Fort Worth, above major municipal treatment plants (Reference 3). After the algae die, they decompose and become a source of BOD.

PREDICTING THE KILLS

According to the TWC report, fish kills can be predicted. Information about the number of fish in the river, the time of year, and the water temperature are important. Two-thirds of the major fish kills in the Trinity from 1970-86 have occurred in May, June, and July when high temperatures make fish vulnerable to low DO levels. The first rise event of the year (usually a heavy rainfall coming after long periods of low flow) is the most likely to produce a kill. Looking back at when fish kill events had taken place will provide an idea of the extent to which the fishery had been damaged by previous kills. The first kill event of the season has historically been the worst. A very large kill in a particular year results in smaller kills in succeeding years.

Hydrological factors also influence whether kills will occur. Years with higher mean flows are less conducive for fish kill events since they produce greater dilution of wastewaters and toxins, create more aeration, and lessen sedimentation. In all four years when mean daily flows were less than 1,000 cubic feet per second (cfs), there were kills. In six of the eight years without fish kills, mean flows were greater than 2,100 cfs.

WASTEWATER: GETTING CLEANER?

The 1987 TWC report lists three elements of wastewater treatment as being responsible for high BODs in the Trinity: bypasses from sewage collection systems, bypasses from sewage treatment plants, and peak flow loading from sewage treatment plants. Normal discharges from wastewater treatment plants may also contribute to sedimentation on the riverbed.

Bypasses from sewage collection systems, where wastewaters flow directly to the river before entering a treatment plant, are not well documented. However, two recent events in the Dallas- Fort Worth area led to the spillage of 109 million gallons of raw sewage into the Trinity. Bypasses from sewage treatment plants are most likely to occur during heavy rainstorms. Because the magnitude of precipitation and raw sewage is so great, there may not be the capacity to adequately treat incoming wastewaters. From 1978 to 1985, over 21 billion gallons of sewage went untreated through wastewater plants during these events. It should be noted that no fish kills have been correlated with specific bypass events.

Peak flow loads from sewage treatment plants are increased by as much as 88 percent during rainfall events. Loading of BODs from major wastewater treatment plants was 24,249 pounds per day in April 1986 during low-flow conditions. A few days later, after a heavy rainfall, the BOD loading jumped to 45,566 pounds. According to a 1986 report by the North Central Texas Council of Governments (NCTCOG), the BOD loading for 1986 was 9,900 tons (Reference 4).

There is another side to this story, however. As a rule, wastewater treatment plants in the Dallas-Fort Worth area have been producing a cleaner effluent since 1976. The NCTCOG report noted that 35 smaller municipal and private wastewater treatment plants had been replaced with 10 larger, regional facilities. Those regional systems now have a capacity to treat 485 million gallons per day_95 percent of the wastewater in the Dallas-Fort Worth area.

BOD concentrations that are generated at the treatment plants were in the 30 to 50 mg/L range in the middle and late 1970s. In many plants those levels have now been reduced to 5 to 7 mg/L. BOD loadings have been reduced by 60 percent. Improvements in effluent quality have been made even though the wastewater plants are treating nearly twice the volumes they assimilated in 1970.

Ironically, the efficiency of wastewater regional treatment plants may have attracted more attention to the fish kills by moving them upstream scarer to Dallas. Because the Trinity is cleaner, particularly in the reach just south of Dallas, there is a healthier fishery living in it. That makes the fishery vulnerable to kills when poorer quality water is swept down the river.

BOTTOM SEDIMENTS: THE "BLACK RISE"

The role that bottom sediments play in causing fish kills is one of the mysteries of the phenomena. In the fish kills that occurred between 1970 and 1978, "black rise"-so called because it turned the color of the river water into a murky, inkish ebony- was targeted as the prime cause.

According to the black rise theory, long periods of low flow allowed fine solids to build up on the river bottom. When these sediments were resuspended, they exerted a tremendous BOD. Evidence from recent kills indicates that low-flow periods have become shorter (from an average of 15 to 74 days for the 1970-78 period to just 9 to 16 days during 1978-85). Combined with improved wastewater quality from Metroplex treatment plants, this situation leads some to believe that black rises are now less a factor than they were in earlier kills.

Questions remain about the source of sediments (urban runoff and wastewater are suspected), the location of sediments along the riverbed, the manner in which sediments build up and erode, the chemical composition of the sediments, and the impact of sediments on DO levels during fish kills.

RESEARCH: CAN IT HELP?

Many research projects are currently underway to investigate the kills. They're aimed at 1) identifying the cause of kills and examining the interrelationships between elements that make up kills, and 2) developing techniques to lessen the impacts of kills when they take place.

The TWC and the U.S. Environmental Protection Agency (EPA) Dallas office conducted a field study to characterize the quantity, quality, and toxicity of river bottom sediments in 1985, and assessed water quality and toxicity in the river during two rise events in 1986. The TWC and EPA are planning studies for 1987 that will include high-flow and low-flow scenarios to evaluate the effects of wastewater on water quality and to identify sources of pollution.

In addition, the U.S. Fish and Wildlife Service will measure concentrations of toxic substances in fish tissues, and the TPWD is planning to evaluate the condition of the Trinity River fishery. The City of Dallas is funding a comprehensive $450,000 study that will include North Texas State University, the University of Texas at Dallas, and Southern Methodist University. That study will inventory the biology of the river and will examine bottom sediments and sources of toxins and BODs. The U.S. Geological Survey operates a continuous automated monitoring system (CAMS) that records data on DO, pH, temperature, and conductivity along the river. NCTCOG compiles and publishes CAMS data.

Some of the more innovative research has been sponsored by the TRA. ATRA-sponsored study (Reference 5) has been one of the few efforts directed at preventing fish deaths, regardless of the cause.

Alternatives identified in this report included providing aerated oxygen to all or part of the river, damming high BOD materials before they could move downstream, and releasing fresh water from reservoirs (in particular, Cedar Creek Reservoir).

The idea of creating "sanctuaries" or "islands" of high DO in parts of the Trinity has been researched by TRA. Fish have been observed trying to swim into tributaries when they sense DO levels are low in the main channel of the river. Tributaries may also have low DO levels during rises if high BOD waters from the main body of the river flow into them. If a fish kill were detected early enough, personnel could rush to an afflicted stretch of the river and raise DO levels in the tributaries by supplying aeration. This concept was tested by TRA staff members during a rise event near Cayuga in August of 1986. After compressed air was pumped into the creek, DO levels were 1 mg/L higher in the mouth of the tributary than they were in the river. The waters were too turbid to detect the fish response.

Dr. Charles Giammona, an associate research scientist in Texas ABM University's Environmental and Water Resources Engineering Division, is conducting experiments on Trinity River sediments for TRA. Giammona's work consists of collecting core samples of both water and sediments. Those samples are then resuspended and analyzed at Texas A&M using an "electrolysis cell BOD measuring system" that simulates oxygen levels and provides a continuous readout of BOD. These experiments simulate bottom sediment resuspension and may lead to a greater understanding of the impact of sediments on DO levels.

COST OF THE KILLS

The fact that thousands of fish have been killed in both the Trinity and the Pecos rivers may be unnerving to most of us. The economics of paying for the kills-replacing fish, producing higher quality water, and penalizing entities that have degraded the wafer-raise a broader question. How much is it worth to utilities, ratepayers, and sportsmen to prevent fish kills from recurring?

Using a formula to estimate the state money spent rearing replacement fish, the TWC report estimated the cost of restocking more than 1 million fish killed in the Trinity at $1.36 million or about $1.31 a fish. New TPWD guidelines emphasizing recreational costs-the amount a fisherman would spend trying to catch a fish-have increased the replacement value of fish that are killed. A flathead catfish could cost as much as $163, depending on its size. In theory, TPWD could collect those costs from entities that degrade state waters and cause kills. Such fines have not been imposed for the Trinity River kills, in part because the ultimate cause of the kills has not been determined.

In the past year the TWG fined the cities of Dallas, Fort Worth, and Garland as well as the TRA more than $535,000 for discharging raw or inadequately treated wastewater into the Trinity or its tributaries.

Another price to pay is for construction of new wastewater treatment plants that may improve water quality and limit the effects of fish kills. In the Dallas-Fort Worth area, $450 million has been committed to improve sewage treatment. The ultimate cost of these fines will be borne by ratepayers in the form of higher utility bills.

Ultimately, the public, the legislature, or the courts will decide how much it's worth to improve water quality and perhaps stop the kills. On the one hand, there's no evidence that low DO levels in the Trinity are damaging to human health. On the other, toxins may pose risks to human health. Why not make the Trinity-and the Pecos-fishable, swimmable, and maybe even drinkable?

The questions are confounding. The answers are sure to be thought provoking and interesting.

PECOS RIVER FISH KILLS

Much less is known about the recent Pecos River fish kills that have usually begun near the small town of Iraan and have ended in the headreaches of Amistad Reservoir where the Pecos meets the Rio Grande River (Figure 2). The lack of information can be attributed to the remoteness of the area; many parts of this stretch of the Pecos are surrounded by steep cliffs or are only serviced by private roads. Finally, other than a game warden at Sheffield, the nearest state officials are at the TWC office in Odessa. It's difficult for them to get to a kill as soon as it develops. Still, the numbers of fish that have been killed-110,000 in 1985 and half a million in 1986 by conservative estimates-justify concern.

The 1985 kill was initially reported on Halloween Eve between Iraan and Pandale, where it remained until November 8. Dying fish were spoked again November 18 near Shumla Bend. The kills stopped when they reached the uppermost part of Amistad Reservoir November 21.

Roughly half of the fish that perished in this kill were minnows, while another 25 percent were sunfish. In areas of the river where the kill was most severe, waters displayed a reddish- orange or yellow color. A dinoflagellate (Gymnodinium) and a "golden" algae (Pyrmnesium parvum) were detected in water samples taken shortly after the kills.

TWC officials believe this kill was caused by a toxic "algal bloom." Different varieties of toxic algae are always present in the Pecos but usually in small concentrations that are not harmful to fish. When optimal conditions of sunlight, water chemistry, and temperature occur, however, algal cells reproduce rapidly and their toxicity increases to levels sufficient to kill fish.

Two points are still unclear about the 1985 kill. First, although the kills were first observed at Iraan, the algal bloom may have begun further upstream where the Pecos is saltiest. Both golden algae and Gymnodinium favor brackish to salty waters. Secondly, the kill was not completely documented between Pandale and Shumla Bend. The bloom may have gone into remission and then regained its toxicity, or no one may have been around to witness the kills.

The 1986 kill was similar. It began on Thanksgiving Day, again near Iraan. By December 1 both stressed and dead fish were observed in the Pecos River near its confluence with Independence Creek. From December 3-6 the algae had turned an orange-rust or olive color, and more dead fish were spoked at Pandale and Shumla Bend. The kill again ended in the upper reaches of Amistad Reservoir, when freshwater diluted the Pecos and weakened the algae. No specific numbers have yet been made available, but fish that were killed by this algal attack included carp, gar, bass, minnows, and catfish. This time, golden algae were attributed as responsible for the kill.

Golden algae have some identifiable characteristics. They usually favor brackish or salty water with dissolved solids concentrations in the 13,000 mg/L range but are most toxic in less salty waters. Unlike most algae, they favor cold weather and often appear after the first frost of the year when many warm-weather algae have died. Cations-positively charged ions-of calcium, sodium, and magnesium make the algae more toxic.

The golden algae produce toxic chemicals that enter the bloodstream of the fish, hemorrhage the gill filaments, and cause them to burst. This blocks oxygen transfer and the fish suffocate.

No one knows why the kills have become so much more intense in the past two years. Theories include increasing salinity of the Pecos River, dumping of oilfield brine.

Dr. Elenor Cox, a professor of biology at Texas ABM University, is trying to culture the golden algae from samples that were taken during the 1986 kill. She is studying the life cycle and toxicity of the algae.

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