MISSOURI POLLUTION AND FISH KILL INVESTIGATIONS 2017

Report compiled by
Rebecca O'Hearn and James Baker
Missouri Department of Conservation
April 2018

MISSOURI POLLUTION
AND FISH KILL INVESTIGATIONS
2017

Compiled by
Rebecca O'Hearn
James Baker

Environmental Health Unit
Resource Science Division

2018

Missouri Department of Conservation
Central Regional Office and Conservation Research Center
3500 East Gans Road
Columbia, Missouri 65201

USE OF DATA

Data and information in this report are distributed for communicating incidents of water quality problems and injuries to fish and wildlife throughout the state of Missouri. By doing so, we hope to increase awareness of water pollution and natural causes of mortality in aquatic life. The reader may choose to use the data for other purposes, but the appropriateness of the data for those purposes must be evaluated by the user.

Cover photographs: Top-left: Lake of the Ozarks below Truman Dam, Benton County, May 2017, Tim Bruce (Aquatic Animal Health Specialist) examines a decapitated paddlefish, cause-blunt force trauma from spillway discharges, photo taken by Rebecca O'Hearn (Water Pollution Biologist). Top-right: Tributary of Half Moon Bayou, Pemiscot County,1/9/2017, cause-sewage pipe break, photo taken by Brian Shelton (Conservation Agent). Bottom-left: Niangua River, Camden County, 7/11/2017, dead macroinvertebrates left stranded after sudden reduction in flow from Tunnel Dam, photo taken by Greg Stoner (Fisheries Management Biologist). Bottom-right: Private Pond, Moniteau County, 10/31/2017, depicted-Euglena sanguinea algal bloom, photo taken by land owner.

EXECUTIVE SUMMARY

The Missouri Department of Conservation (MDC) conducts fish kill investigations under the authority of the *Wildlife Code of Missouri* (Section 252.210, RSMo) and has maintained a Fish Kill and Pollution Program since the 1940s. The overarching goals of the program are to protect aquatic resources and to maintain high-quality fishing and recreational opportunities. We work towards these goals by 1) conducting fish kill and water pollution investigations so pollution abatement and mitigation is achieved and 2) increasing awareness of water pollution and mortality in aquatic life through reporting of incidents. The program is a partnership among multiple resource agencies; however, the Missouri Department of Natural Resources (DNR) is the primary partner.

During 2017, MDC personnel investigated 73 water quality and pollution incidents. Animal mortality was associated with 52 of these incidents. Overall, at least 91,430 fish and other organisms were killed during these incidents. Incidents were placed into one of three major categories: regulated, non-regulated, and unknown cause. Regulated incidents are sub-categorized by pollution source: municipal, agricultural, industrial, transportation, and other. There were 33 regulated incidents, of which 21 involved a kill. An estimated 86,551 animals valued conservatively at $194,700.18 were killed during regulated source pollution incidents. Municipal pollutants were the most common cause of regulated incidents. Thirty-two non-regulated incidents occurred during 2017. Non-regulated incidents are attributable to natural causes, such as disease, spawning stress, and low dissolved oxygen. All but 5 non-regulated incidents involved a fish kill. All 5 of these incidents were attributed to algal blooms. Personnel could not determine the cause of 8 incidents (unknown cause). At least 308 animals died due to unknown causes. Monetary values (damages) for non-regulated and unknown fish kills were not calculated because damages for these kills are not reimbursed.

Cause	Number Incidents	Number Fish Kills
Regulated		
Municipal	15	12
Agriculture	9	8
Industry	2	0
Transportation	2	0
Other	5	1
Subtotal	33	21
Non-Regulated	32	27
Unknown	8	4
Totals	**73**	**52**

The summer season had the greatest number of incidents (38), followed by spring (17), winter (11) and fall (7). Most incidents occurred in streams (40), followed by lakes (19) and ponds (14).

The DNR and the Missouri Department of Agriculture (MDA) enforced the incidents described in this report. Ten cases were resolved during 2017 through compliance and enforcement actions. Four of these cases involved legal agreements, which included reimbursements for natural resource damages, reimbursements for investigative time, and civil penalties. Settlement funds totaled over $10,290.81. Penalties calculated by DNR amounted to $21,000. Fifty potentially enforceable incidents have not been resolved as of December 31, 2017.

An analysis of long-term trends (1988-2017) shows the number of incidents for most pollution types peaks in the mid- to late 1990s and declines thereafter. Across pollution types, municipal pollutants were historically and are currently the dominant cause of pollution incidents.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

INTRODUCTION

The Missouri Department of Conservation (MDC) holds the authority to enforce the *Wildlife Code of Missouri* (Chapter 10, 3 CSR 10). According to the *Wildlife Code of Missouri*, it is illegal to cause or allow any deleterious substance to be placed, run, or drained into any waters of the state in quantities sufficient to injure, stupefy, or kill fish or other wildlife which may inhabit such waters. Under this mandate, MDC maintains a Fish Kill and Pollution Program. The goals of the program are to protect aquatic resources and maintain high-quality fishing and recreational opportunities. We work towards these goals by conducting fish kill and water pollution investigations so pollution abatement and mitigation is achieved and by increasing awareness of water pollution and mortality in aquatic life through reporting of incidents. The program is a partnership among multiple resource agencies[1]; however, the Missouri Department of Natural Resources (DNR) is the primary partner.

During the investigation, MDC determines the size of the affected area, estimates the number of organisms killed, calculates a monetary value for those organisms, and distributes collected information to interested personnel and agencies. Although MDC has the authority to prosecute responsible parties for killing fish under the *Wildlife Code of Missouri* (Section 252.210, RSMo), compliance and enforcement action is usually deferred to DNR who holds the authority to enforce *Missouri Clean Water Law* (Chapter 644, RSMo). Two additional roles of DNR during investigations are overseeing the clean-up of spills and acting as the incident command center (Missouri's Spill Bill, sections 260.500-260.550, RSMo).

This report is a summary of all fish kills and pollution investigations conducted by MDC during 2017.

[1] Other agencies involved during investigations include: Missouri Department of Natural Resources, Missouri Department of Health and Senior Services, Missouri Department of Agriculture, U.S. Environmental Protection Agency, U.S. Coast Guard, U.S. Fish and Wildlife Service, and U.S. Army Corps of Engineers.

METHODS

MDC conducts fish kill investigations under the authority of the *Wildlife Code of Missouri* (Section 252.210, RSMo). This is communicated to all MDC staff through a memo distributed by the Fisheries, Protection, and Resource Science division chiefs. The memo states that all MDC employees are responsible for reporting water quality problems, water pollution, and fish kills that are noted during the performance of their normal job duties and for assisting with the investigation, if needed.

MDC and DNR have a cooperative agreement which streamlines investigations. Under the cooperative agreement, the DNR-Environmental Emergency Response (EER), which operates a 24 hour a day environmental emergency spill line, notifies MDC staff statewide during fish kills and water pollution events which have potential to injure fish and wildlife. As part of the cooperative agreement, MDC Environmental Health Unit (formerly Aquatic Health Unit) supplies EER with contact lists of MDC regional staff for use during normal business hours and a contact list of Protection District Supervisors for use after normal business hours. All MDC staff learning of or discovering a fish kill are to notify the EER spill line as soon as possible as a precautionary measure.

MDC's Conservation Agents and Fisheries Division staff are trained to respond to fish kill and pollution incidents where there is potential for fish and wildlife injury. The presence of Conservation Agents in each county of the state allows for an immediate assessment of the incident and action which may prevent greater injury to the resource. During an investigation when time is crucial and/or DNR personnel cannot respond, these procedures minimize environmental damage and ensure useable evidence that may otherwise be lost.

The objectives of the MDC investigator are to determine the likely cause of the fish kill or water pollution incident, prevent additional damage by containing the pollution (if possible), and to determine the extent of the damage to the resource. The MDC investigator conducts water chemistry screening at the source of the pollution, upstream, and downstream of the pollution source. This procedure aids in determining the cause of the fish kill or water quality problem. Water chemistry measurements include temperature, pH, dissolved oxygen, and unionized ammonia. Water samples are also collected in these three locations if DNR has not arrived on-scene.

During 2017, fish counting procedures outlined in *Investigation and Monetary Values of Fish and Freshwater Mussel Kills* (Southwick and Loftus 2003) were followed. The species and size of dead fish are recorded within the affected area. If the affected area is subsampled, the Environmental Health Unit (EHU) extrapolates the total number of dead fish and wildlife. These methods are labor intensive and therefore are not usually used for natural fish kills (*non-regulated*) where investigative costs are not reimbursed. Once the total number of dead fish and wildlife is determined, the EHU calculates a monetary value (damage). Damages are not usually calculated for cases with an unidentified responsible party or those occurring in private waters. A report of investigative activities, findings, and damages is compiled for each *regulated* incident (incidents with identified pollution sources) and incidents with *unknown* causes. Copies of these reports are distributed to DNR and other interested agencies.

Fish kill and pollution cases with a responsible party are typically enforced by DNR under the *Missouri Clean Water Law* (Chapter 644, RSMo) or the *Clean Water Act*. By holding the offender responsible, restitution is achieved. Restitution consists of reimbursements for fish damages and investigative costs, and through payment of penalties, which DNR may also assess. Damages are directed to two separate funds: ninety percent of damage reimbursements are directed to projects benefiting aquatic resources

through the Fish Kill Grant fund and ten percent of damage reimbursements are directed to the Chemical Emergency Preparedness Fund (Section 640.235, RSMo). Penalty monies are transferred to the county school system in which the pollution event occurs. This report contains information on case status and reimbursements received as of December 31, 2017.

MDC tracks information on fish kills and pollution incidents in a central database, including incidents that have not been directly reported to MDC. However, the focus of this report is incidents where MDC personnel were directly involved in the investigation. Reports of false kills (e.g. angling mortalities) are not included in this report. Additionally, the main body of this report does not summarize other activities of the Fish Kill and Pollution Program. Highlights of these activities can be found in Appendix A.

RESULTS AND DISCUSSION

MDC personnel investigated 73 water quality problems during 2017 (Table 1). Fish kills occurred in 52 of the incidents. An estimated 91,430 fish and other organisms were killed. Monetary damages were only calculated in 15 of the 52 incidents involving a kill. Fish and other organisms killed during these incidents were valued at $194,7010.18. The remainder of the results and discussion is broken down by incident causes, temporal trends, spatial trends, enforcement status, projects funded by fish kill grants, and long-term trends.

Table 1. Summary of fish kill and pollution investigations conducted by MDC staff during 2017. Data on animals killed are not limited to fish.

Cause	Number Incidents	Number Kills	Number Animals Killed	Value of Animals Killed
Regulated				
Municipal	15	12	70,479	$167,655.57
Agriculture	9	8	15,932	$27,044.61
Industry	2	0	0	$0.00
Transportation	2	0	0	$0.00
Other	5	1	140	Undetermined
Subtotal	*33*	*21*	*86,551*	*$194,700.18*
Non-regulated	32	27	4,571	Undetermined
Unknown	8	4	308	Undetermined
Totals	**73**	**52**	**91,430**	**$194,700.18**

INCIDENT CAUSES

Incidents are placed into one of three major categories: regulated cause, non-regulated cause, and unknown cause. For purposes of this report, incidents with *regulated* causes are those which have a known source of pollution, incidents with *non-regulated* causes are attributable to natural processes, and incidents with *unknown* causes are those which investigators could not determine the source or cause of the problem. A list of regulated incidents, non-regulated incidents, and incidents with unknown causes can be found in appendices B, C, and D.

Regulated Cause

Incidents falling in the *regulated* category are broken down by the source of pollution: municipal, agricultural, industrial, transportation, and other sources. There were 33 regulated incidents, which accounted for over 45% of the incidents (Figure 1). Of the 33 regulated incidents, 21 resulted in fish and wildlife mortality. An estimated 86,551 dead fish and wildlife were recorded for 16 of these fish kills. Monetary damages were calculated for 15 regulated fish kills and totaled $194,700.18 (Table 1). Delays in notification of the initial kill and, in the case of private ponds, a lack of jurisdiction over privately-owned fish, prevented MDC staff from accurately assessing injuries and damages for 6 of the 21 regulated fish kills. Municipal source pollutants (e.g. municipal wastewater, drinking water, and hydro-electric facilities) were the leading cause of regulated incidents in 2017, accounting for over 45% of all regulated investigations (Figure 1).

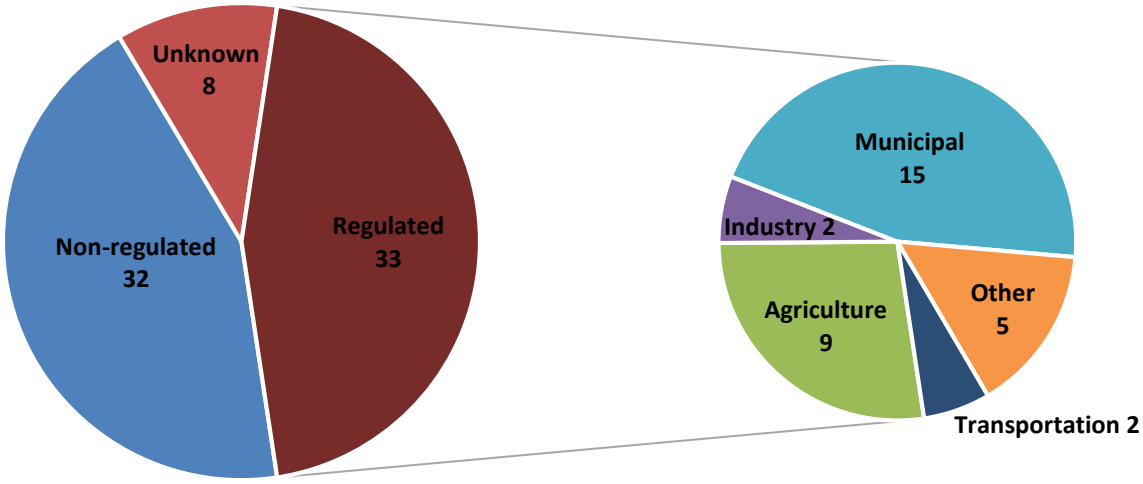

Figure 1. Number of incidents by pollution source in 2017.

Municipal Source

Incidents falling in the municipal source category include, but are not limited to municipal waste, drinking water, and hydropower dams. Municipal pollutants were involved in 15 incidents. Twelve of these resulted in the death of at least 70,479 fish and aquatic life valued at $167,655.57 (Table 1). Municipal pollutants were the leading cause of regulated incidents in 2017, accounting for over 45% of all regulated investigations (Figure 1).

The most significant incident falling in this category was a two-month long fish kill during May and June 2017. Increased spillway discharges from Truman Dam in Benton County resulted in blunt force trauma to at least 239 fish, primarily paddlefish, valued at $146,760.60[2]. Thirty-five fish kills valued at over 3 million dollars have been observed by MDC since 1978 at this location. MDC staff continue to monitor fish injuries, and the magnitude and frequency of fish kills at this location. Since 2013, the U.S. Army Corps of Engineers, who operates and owns the dam, have expressed renewed interest in mitigating fish injuries. However, a permanent solution for spillway mortality and turbine entrainment has yet to be identified.

Agricultural Source

Agricultural source pollutants include, but are not limited to animal waste, fertilizer, and pesticides. During 2017, agricultural source pollution represented 9 incidents. Eight incidents resulted in fish and wildlife mortality. Damages in these fish kills accounted for the loss of an estimated 15,932 fish and

[2] MDC staff actively searched for injured and dead fish for only 37 hours during the months of May and June, thus injuries and damages are likely underestimates.

other organisms valued at $27,044.61 (Table 1). Injuries and damages were not assessed for 2 fish kills which occurred in private ponds because MDC does not have jurisdiction over privately-owned fish.

For agricultural incidents, the most fish mortality was observed in McKinney Creek and Maddox Branch in Callaway County on June 4, 2017. A leak in in a liquid nitrogen storage tank on the Atkinson Farm entered McKinney Creek resulting in ammonia toxicity to killed aquatic life. The pollution was extensive, impacting over 8 stream miles for at least 2 weeks after the initial release. At least 7,485 fish, crayfish, macroinvertebrates, aquatic worms, and tadpoles were killed. These organisms are valued at $19,351.60. Aquatic life in this stream is not expected to fully recover for several years due to the severity of the kill.

Other noteworthy agricultural incidents during 2017 were linked to the aerial application of pesticides. Reports of fish kills resulting from aerial application of pesticide have been rare for MDC. However, in 2017 MDC responded to 3 of these incidents, all involving private ponds. Discussions with MDA indicate aerial pesticide applications may be increasing throughout the state.

Industrial Source

Industrial source pollutants include but are not limited to chemical, petroleum, and gravel mining operations. During 2017, two incidents were attributed to industrial pollution. On August 8, 2017, runoff from a caustic chemical spill originating at Gateway Extrusions entered Flat Creek in Franklin County. Few dead organisms were reported, but at least 25,000 gallons of impacted water were removed from the site during cleanup efforts. In the second event, a hose failure at Mississippi Lime Company on July 22, 2017 resulted in a spill of diesel fuel to South Gabouri Creek in Ste. Genevieve County. Responders observed a sheen of fuel in the creek, but did not observe fish mortality.

Transportation Source

Incidents falling within this category involve pollutants originating from pipelines, aviation, rail, boat, and road vehicle sources. Transportation was linked to 2 incidents in 2017, neither of which involved a fish kill.

Other Source

Other regulated sources of pollution include, but are not limited to dewatering, fire suppression run-off water, and pesticide application in residential areas. “Other” source pollution was associated with 5 incidents, 1 of which resulted in a fish kill (Table 1). On June 26, 2017 MDC staff noted a fish kill below DiSalvo Lake dam in St. Francois county. High temperatures and a lack of water flowing over the dam resulted in oxygen depletion downstream and the death of at least 140 fish.

Non-Regulated Cause

Incidents within this category include those occurring due to natural causes such as lake inversion, summer and winter kill, disease, and spawning stress. Kills caused by non-point source nutrient pollution often cannot be differentiated from natural dissolved oxygen kills. Therefore, eutrophication from non-point sources is included in this category. Non-regulated incidents commonly present multiple related causes of death. For example, non-point source nutrient enrichment causes algal blooms, which deplete dissolved oxygen at night resulting in fish kills.

Thirty-two non-regulated incidents occurred, which comprised 44% of all incidents during 2017 (Figure 1). Twenty-seven of these incidents were fish kills. An estimated 4,571 dead fish and aquatic organisms were observed during non-regulated incidents. However, this is an underestimate: thorough fish counts

and damage assessments are not conducted for most non-regulated incidents because investigative time and damages are not reimbursed.

The non-regulated incident with the most mortality occurred in a Barton County private pond on July 7, 2017. At least 1,173 fish were killed due to low dissolved oxygen conditions during an algal die-off.

Most notable during 2017 for non-regulated incidents were the number of suspected harmful algal blooms (HABs). HABs contain toxins which can pose health risks to animals and people coming in contact with or ingesting water. Recently researchers have detected HAB toxins in fish fillets, which may indicate a risk to those consuming fish while a HAB is present. A total of 6 incidents during 2017 were attributed to suspected HABs. Many of these blooms were on private ponds and no water tests were conducted to confirm the presence of algal toxins. Although not presented in this report, other Missouri agencies reported additional HABs during 2017, for some of which water testing confirmed the presence of algal toxins. If a suspected HAB is observed, the Missouri Department of Health and Senior Services recommends avoiding contact with the water and considering not eating fish for at least two weeks after the HAB is no longer visible.

Unknown Cause

Personnel were unable to identify the source or cause of the water quality problem for 8 incidents, four of which involved the death of fish (Table 1, Figure 1). For these incidents, investigators were unable to confirm the suspected the cause. Additionally, a responsible party was not identified for many of these incidents, which hindered the investigation. At least 308 fish died due to unknown causes.

TEMPORAL DISTRIBUTION

In general, the distribution of kills throughout the year presented a bell-shaped pattern similar to previous years (Figure 2, O'Hearn and McAteer 2015 and 2016). Across seasons, the most incidents occurred during summer (June through August), followed by spring (March through May), winter (December through February), and fall (September through November). Across seasons, the most regulated incidents occurred in summer, followed by winter, spring, and fall. Eight regulated incidents occurred in winter, significantly more than typical years. Three of these incidents were related to pipeline breaks. The most non-regulated incidents also occurred in summer, followed by spring, fall, and winter. Across months, the number of regulated incidents was fairly consistent, most months varying between 2 and 4 incidents with the most incidents occurring in June (7 incidents). The monthly distribution of non-regulated incidents presented a bell-shaped pattern, peaking in July (13 incidents).

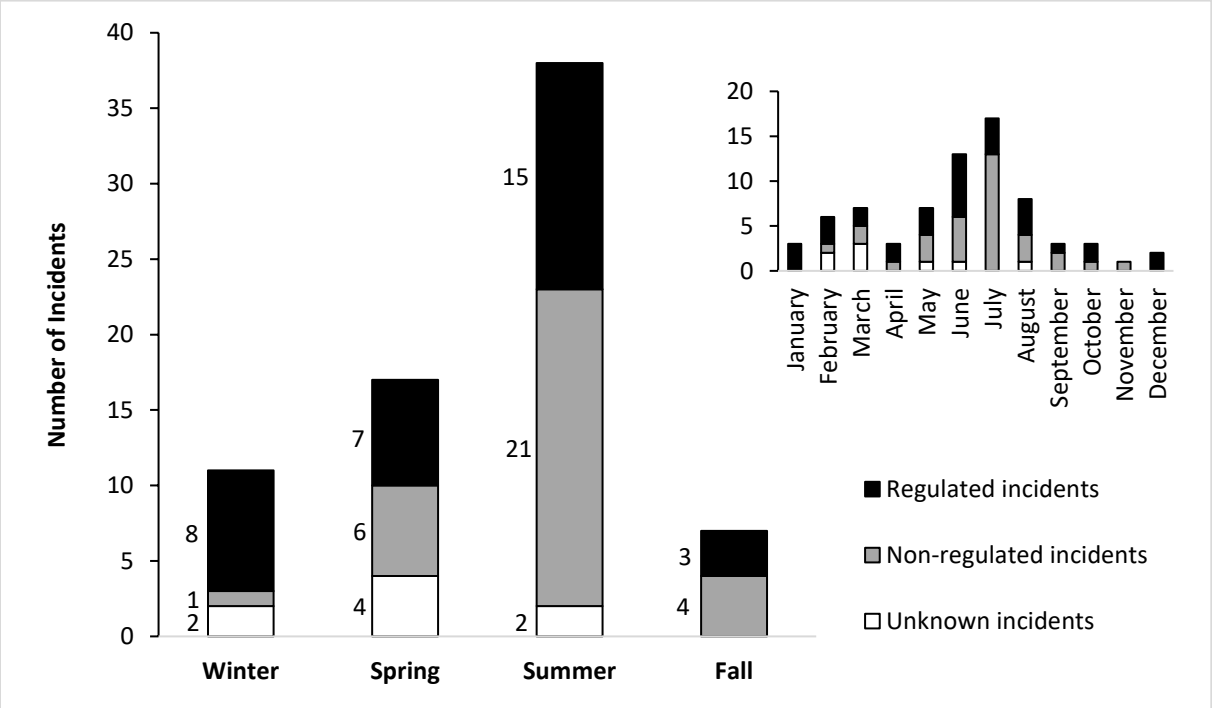

Figure 2. Monthly and seasonal distribution of regulated, non-regulated, and unknown source incidents during 2017.

DISTRIBUTION OF INCIDENTS THROUGHOUT THE STATE

Investigations took place in 42 of 115 counties. The Department's Central Region experienced the most incidents (24 incidents), while the Ozark Region experienced the least incidents (1 incident, Figure 3). Among counties, Callaway County had the highest number of incidents (5 incidents). Among major source categories, the most regulated incidents occurred in Callaway county (4 incidents) followed by Camden and Montgomery counties with two regulated incidents (Figure 4). The most non-regulated incidents occurred in Moniteau County (3).

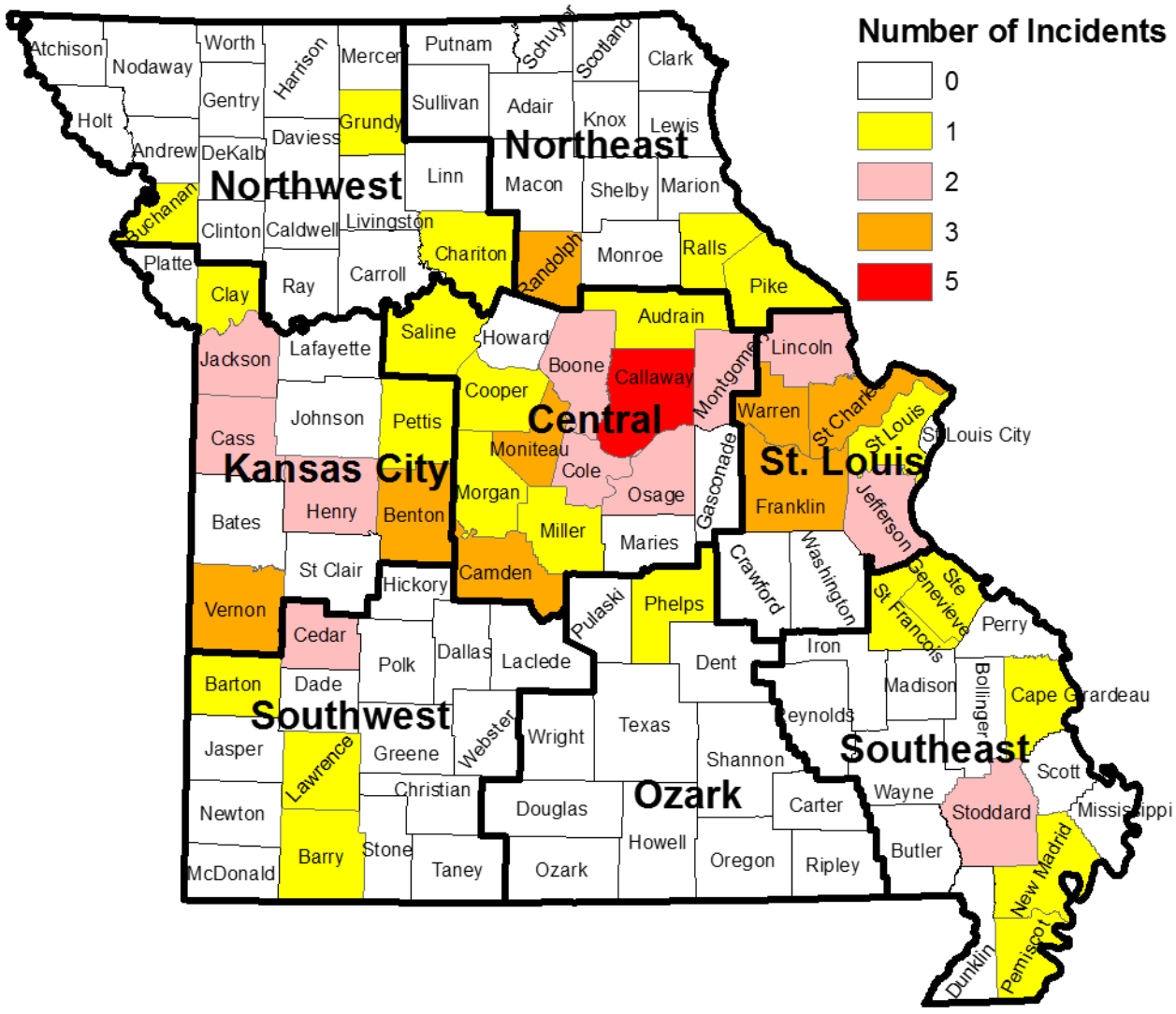

Figure 3. Map of number of incidents during 2017 per county. The eight regions for the Missouri Department of Conservation are outlined in bold.

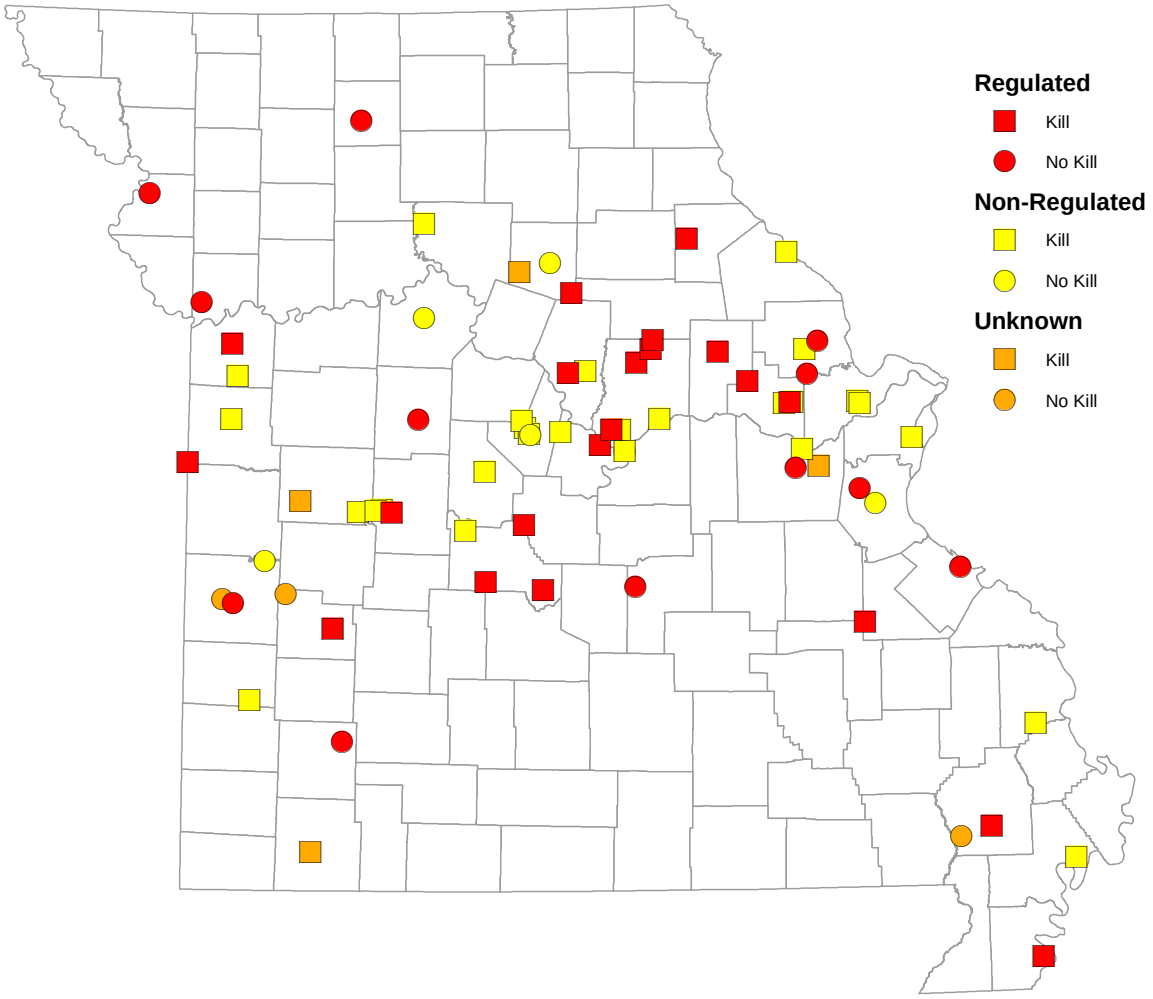

Figure 4. Map of regulated, non-regulated, and unknown source investigations conducted by Missouri Department of Conservation personnel during 2017. Points are located at the most upstream portion of the affected zone for incidents occurring in streams. Squares indicate fish kills and circles indicate investigations without fish kills.

DISTRIBUTION BY HABITAT TYPE

Among habitat types, incidents occurred more often in streams than in ponds and lakes (Figure 5). This is consistent with trends from recent years where streams were the most common habitat for incidents (O'Hearn and McAteer 2015 and 2016). Regulated source pollutants were the leading cause of stream incidents (70%). Non-regulated causes were the most common type of incident in lakes and ponds (71%-74%).

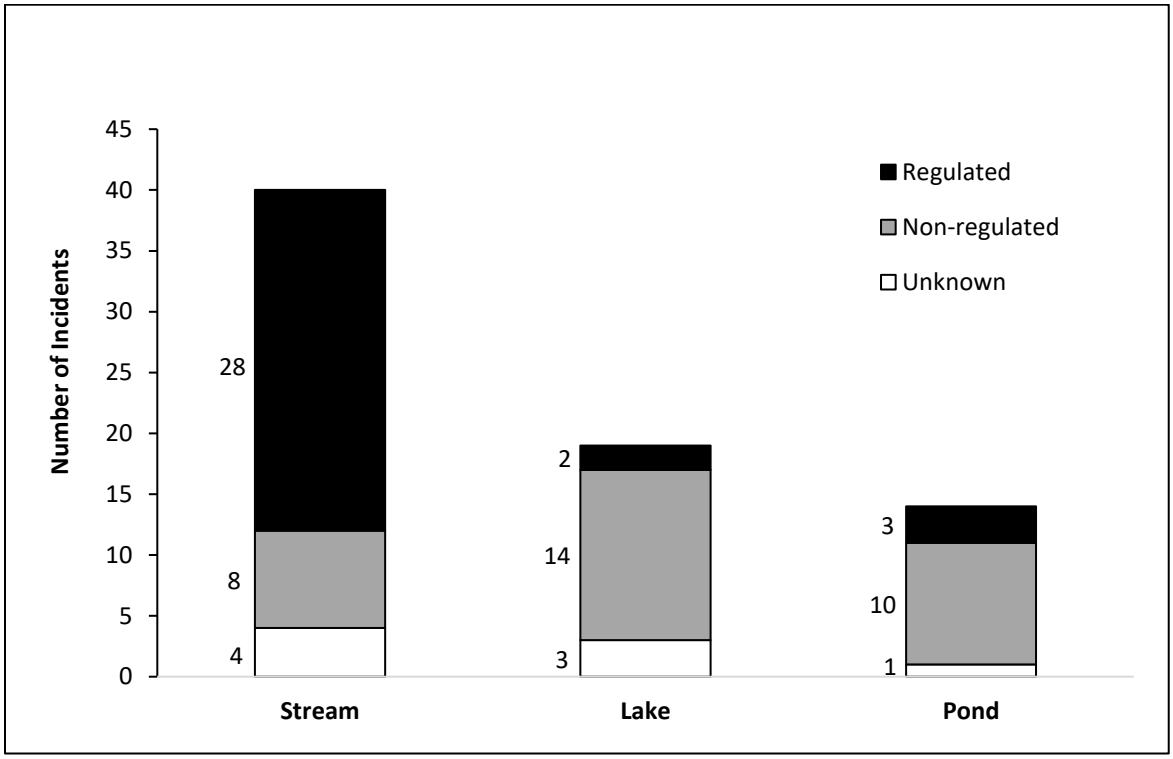

Figure 5. Distribution of incidents during 2017 by habitat type.

ENFORCEMENT STATUS OF FISH KILL AND POLLUTION CASES

Ten incidents were resolved through compliance and enforcement actions during 2017. One of these incidents occurred during 2012, one in 2015, two in 2016, and six in 2017. DNR and MDA enforced the cases described in this section. Four of these cases were resolved through civil legal agreements, which included reimbursements of natural resource damages, reimbursements of investigative costs, and civil penalties.

Settlement funds totaled over $10,000. Settlement funds include damages for natural resources, including injured animals, and investigative costs. Damages totaled $751.68 for these cases, of which $48.17 was reimbursed to the state of Missouri. Of the reimbursed damage funds, $43.35 was transferred to the MDC Fish Kill Grant Fund, which will be spent on projects benefiting aquatic resources in Missouri. The remaining damage funds were transferred to the DNR Chemical Emergency Preparedness Fund and Natural Resources Damages Fund. MDC received $623.53 in reimbursements for investigative costs, which was also transferred to the MDC Fish Kill Grant Fund. Penalty monies assessed by the DNR amounted to $21,000. Penalty monies were transferred to the school district of the county in which the pollution occurred.

Fifty cases remain open: three from 2010, 2011, and 2012, six from 2013, four from 2014, eight from 2015, nine from 2016, and twenty from 2017. Nine entities caused fish kills or pollution events on multiple occasions: US Army Corps of Engineers (12 incidents), Birk farm in Cape Girardeau County (3 incidents), City of Columbia (3 incidents), University of Missouri (3 incidents), City of Jefferson (2 incidents), City of Kansas (2 incidents), and Missouri American Water (3 incidents).

A breakdown of settlement funds and brief descriptions of open and closed cases are located in appendices E and F.

PROJECTS FUNDED BY FISH KILL GRANTS

Reimbursements for MDC investigative costs and 90% of fish and wildlife damages are directed to a Fish Kill Grant Fund that is administered by the Fisheries Division. Project proposals are solicited in July on an annual basis from Fisheries, Protection, and Resource Science divisions. Eligible projects benefit aquatic resources. No proposals were awarded during 2017.

LONG-TERM TRENDS

Data are presented in this section to examine long-term trends dating back to 1988. The Fish Kill and Pollution Program stores information for incidents occurring prior to 1988; however, data for events prior to 1988 are not completely digitized. Two major categories of incidents are not included in this section. The "unknown" category is not included because it contains incidents with wide ranging pollution sources and causes. Non-regulated incidents are not included because temporal variability for these incidents has been due to changes in reporting procedures (O'Hearn and Martin 2013). Additionally, incidents falling in the regulated-other category are not included because this category contains incidents with miscellaneous pollution sources.

Overall, municipal pollutants were and continue to be the dominant cause of regulated incidents over time (for 23 out of 30 years, Figure 6). In general, the number of incidents for all pollution sources peaked in the mid- to late 1990s and has declined since (figures 6 and 7A-C, Appendix G).

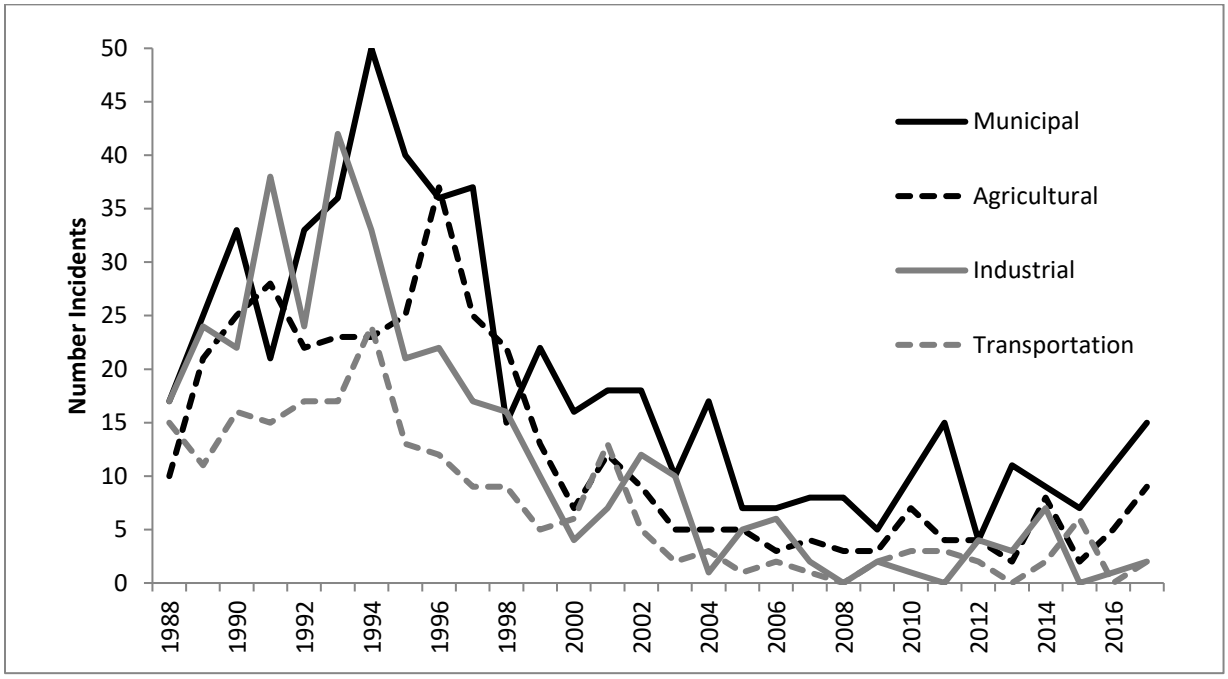

Figure 6. Long-term (1988-2017) trends in regulated incidents. The "other" source category involves miscellaneous pollution sources and is not included in the figure.

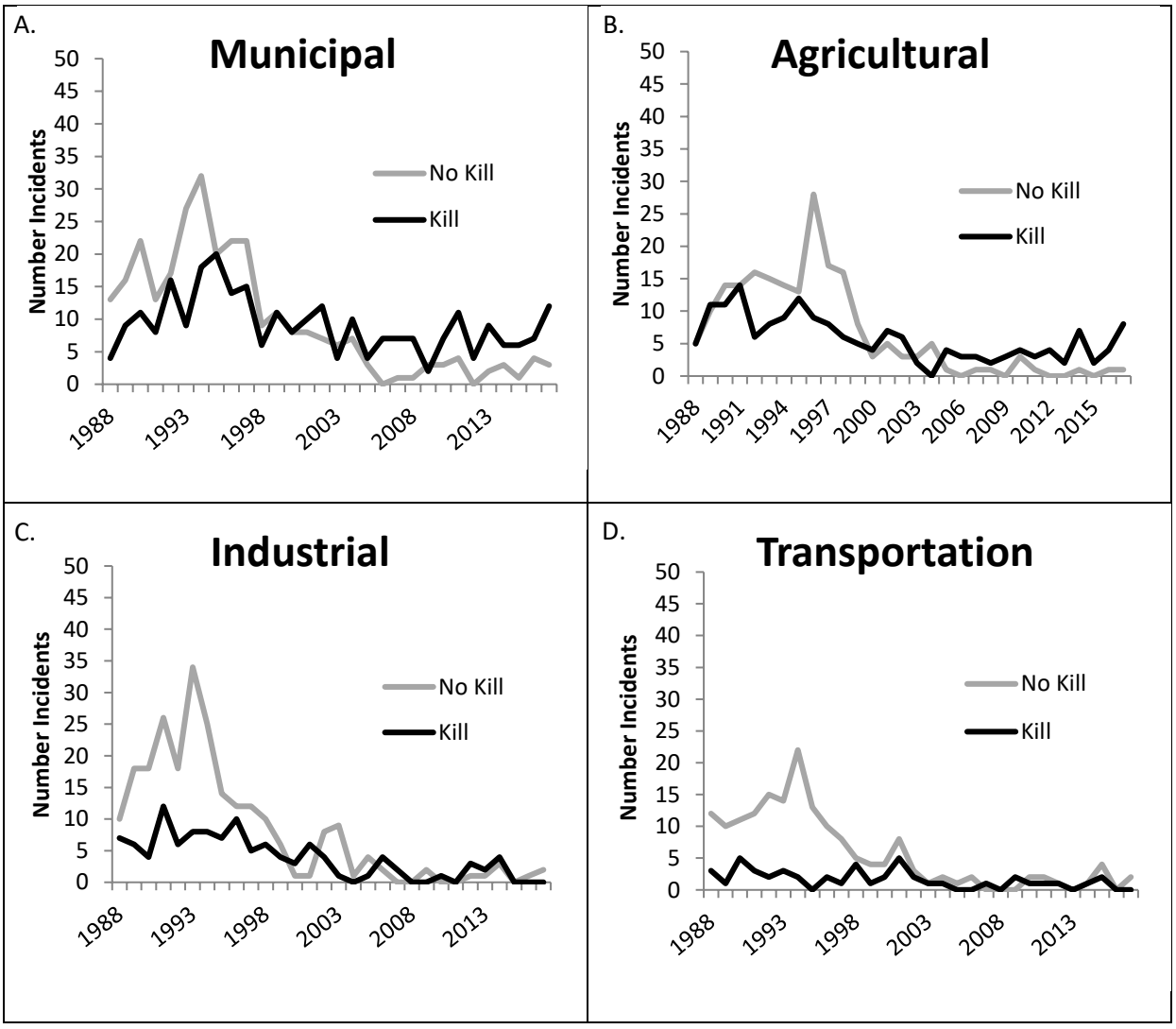

Figure 7. Long-term (1988-2017) trends for regulated fish kill and pollution incidents caused by municipal (A), agricultural (B), industrial (C), and transportation (D) sources. The "unknown" and "other" categories are not included in this figure because they contain incidents with wide ranging pollution sources and causes. Non-regulated incidents are not included because trends reflect changes in reporting procedures (O'Hearn and Martin 2013).

CONCLUSION

MDC has a statutory responsibility and authority to protect fish, forest, and wildlife in Missouri. Conducting fish kill and pollution investigations is an activity that partially fulfills this responsibility. The success of the Fish Kill and Pollution Program relies on partnerships with state and federal resource agencies, especially the DNR (the clean water authority in Missouri). MDC's strong partnership with DNR plays a crucial role during all stages of the investigative process, from initial notification, on-scene response, damage and penalty assessment, enforcement, and finally appropriating reimbursed funds to benefit natural resources. Without this partnership, many polluters would not be held responsible for damaging Missouri's aquatic resources.

During 2017, MDC was involved in 73 water quality and pollution investigations. Over 91,430 fish and other animals valued at $194,700.18 were killed during these incidents. Four incidents which occurred during previous years and six 2017 incidents have been resolved through compliance actions and civil legal agreements. Settlement funds from civil agreements totaled over $10,000.

Despite the partnership's successes, there remain areas of concern. Municipal pollution (i.e. waste water, chlorinated drinking water, and hydro-electric power generation) continues to be the leading cause of fish pollution-related mortality in Missouri, followed by agricultural pollution (i.e. fertilizers, animal wastes, and pesticides). Similar to previous years, during 2017 both municipal and agricultural sources caused extensive damage to Missouri aquatic resources, most notably the two-month long paddlefish kill caused by Truman Dam operations (Appendix B and pages 5, 17 and 29) and the 8-mile-long fish kill caused by a liquid nitrogen spill in Callaway County (Appendix B and pages 6 and 30).

The paddlefish kill caused by Truman Dam is not a new nor an uncommon occurrence. According to MDC records, fish kills caused by hydro-electric dams have been an ongoing issue in Missouri since the 1930s. Fish kills at Truman Dam in Benton County, Clarence Cannon Dam in Ralls County (Appendix B and page 33), Stockton Dam in Cedar County (Appendix B and page 31), and Tunnel Dam in Camden County (Appendix B and page 30) are described in this report. To date, lasting solutions have not been implemented to stop fish kills at these locations.

An emerging issue involves pollution-related kills related to aerial application of pesticides. Aerial application of pesticides proves challenging for enforcement agencies due to difficulties in locating responsible parties and identifying the pesticide involved. During fall 2017, enforcement agencies with jurisdiction over clean water, fish and wildlife, and pesticides developed a notification and response plan in anticipation of increased water pollution and fish kills caused by aerial pesticide application.

LITERATURE CITED

Cooperative Agreement between the Missouri Department of Natural Resources and the Missouri Department of Conservation for investigating fish kills in Missouri waters. From Missouri Department of Conservation SharePoint*

Fish Kill and Water Pollution-Procedures for Notification and Action. From Missouri Department of Conservation SharePoint*

O'Hearn, R. and R. Martin 2013. Missouri pollution and fish kill investigations 2007-2011. Missouri Department of Conservation. 48 pp. From Missouri Department of Conservation SharePoint*

O'Hearn, R. and S. McAteer 2015. Missouri pollution and fish kill investigations 2014. Missouri Department of Conservation. 28 pp. From Missouri Department of Conservation SharePoint*

O'Hearn, R. and S. McAteer 2016. Missouri pollution and fish kill investigations 2015. Missouri Department of Conservation. 27 pp. From Missouri Department of Conservation SharePoint*

Southwick, R. I. and A. J. Loftus, editors. 2003. Investigation and monetary values of fish and freshwater mussel kills. American Fisheries Society, Special Publication No. 30, Bethesda, Maryland.

∗ For readers outside MDC that desire a copy, please contact the Fish Kill Program Manager at 3500 East Gans Road, Columbia, Missouri 65201.

Appendix A. Program accomplishments during 2017.

As part of a continuous effort to achieve complete and thorough investigations, more efficient and rapid response to pollution incidents by MDC personnel, and enhanced protection of the fish and wildlife resources of the state, the following accomplishments were achieved by the Fish Kill Program during 2017:

Monitoring

Clear Creek Recovery Monitoring

Clear Creek in Barry and Lawrence counties experienced a heavy to total fish kill in May 2014. The fish kill was caused by Tyson Foods, who discharged a solution of Alimet to the Monett wastewater treatment plant which killed the plant's denitrifying microbes. This resulted in the discharge of waste water with a high ammonia concentration to Clear Creek. The ammonia caused a fish kill for over 5 stream miles, and fish morbidity & mortality was observed for several days. At least 108,809 fish and crayfish valued at $130,988.26 died during this incident. Due to the severity of the kill, MDC began monitoring for live fish shortly after the kill. One year after the kill, MDC observed fish recolonization occurring throughout the entire 5 mile kill zone. However, the number of fish, species richness, and size composition indicate the stream is far from fully recovered. Total recovery of the fish community will take several more years. Monitoring will continue for one more year.

Flat Branch Creek Recovery Monitoring

Flat Branch Creek in Columbia experienced a severe fish kill in April 2012. The kill was caused by a fire at an auto parts store in the headwaters of the stream. Portions of the stream experienced a complete kill. A standard fish kill assessment was conducted during the event. Two days following the event, MDC began monitoring for recolonization of macroinvertebrates and fish. The U.S. Geological Society also began monitoring toxicity of the sediments. Monitoring was completed during 2016. Macroinvertebrate lab processing and data analysis will be completed in 2018.

Long Branch Creek Monitoring

Long Branch Creek and Muddy Creek in Pettis County experienced a severe fish kill in in 2015. MDC measured levels of ammonia that were toxic to aquatic life in 16 stream miles over the course of 7 days. The source of ammonia originated from the area around Johnson County Egg Farm. Elevated ammonia levels resulted in a complete kill for much of the affected zone: 17,474 fish, 23,363 benthic invertebrates including mussels and snails, and 26 tadpoles were found dead. A nearly identical fish kill occurred in this location in 1989, in which MDC determined natural recovery of the fish community would require more than five years. During 2016, MDC and DNR began monitoring in this area to determine possible pollution sources that could have caused this significant fish kill and to evaluate the health of aquatic life in this stream. Data collection was completed during 2017 and data analysis will be completed in 2018.

Truman Dam Fish Injury Monitoring

Fish kills have been documented below Truman Dam for decades. The most recent large fish kill occurred in 2015. Another kill occurred within the dam infrastructure a few months after this first kill in 2015. These two events prompted MDC to inquire about fish kill mitigation with the U.S. Army Corps of Engineers at Truman Dam. In April 2016, MDC began a pilot project to determine an appropriate sampling design to assess the severity of fish injury and mortality caused by the dam and to inform future mitigation efforts. Information collected during the pilot project indicates the dam turbines are causing physical trauma to fish. Data also indicates some fish are experiencing barotrauma as they travel from the depths of Truman Lake, through the dam, and into the surface waters of Lake of the Ozarks.

More data is needed to determine the severity of mortality caused by turbine trauma and barotrauma and to confirm that low dissolved oxygen levels are not contributing to fish mortality below the dam. In May of 2017 MDC was alerted to an extensive fish kill, primarily paddlefish, below Truman Dam. Field investigations indicate paddlefish mortalities were caused by blunt force trauma as paddlefish were swimming from low turbulence conditions on the turbine portion of the dam to high turbulence conditions on the spillway side of the dam. U.S. Army Corps of Engineers, MDC, and DNR plan to continue mitigation discussions in the spring of 2018, and MDC will continue to monitor through the 2018 paddlefish migration season.

Tunnel Dam Project
The Environmental Health Unit will be monitoring water quality in Lake Niangua and the Niangua River to assess baseline conditions prior to potential changes to management of Tunnel Dam during Federal Energy Regulatory Commission relicensing. Changes to management of Tunnel Dam may impact the federally listed Niangua Darter in the river and sports fisheries in Lake Niangua.

Predictive Modeling of Algal Toxins in Fish and waters in Missouri
The Environmental Health Unit began collaborating with the University of Missouri, DNR, and Missouri Department of Health and Senior Services to monitor for algal toxins in fish tissues and waters in Missouri. During 2017 we initiated a pilot project in University of Missouri's hyper-eutrophic Dairy Farm Lake number 1. The objective of the pilot project is to determine if Missouri needs to conduct statewide monitoring for algal toxins in fish to set fish consumption advisories. Data will be collected in 2018.

Publication
Investigation and Monetary Values of Fish and Freshwater Mollusk Kills
The Fish Kill Program Coordinator assisted with editing and reviewing an American Fisheries Society Publication used by many state agencies, including Missouri, to assess injuries and damages of freshwater fish and mussel kills. The publication was completed in December 2017 and will be used by MDC starting in January 2018.

Training
Fish Kill Procedures Training
Training on water pollution and fish kill investigation procedures was given to Conservation Agent trainees during summer 2017. This training is conducted to familiarize MDC field staff with investigation procedures which must be followed during investigations to ensure reliable collection of evidence and legal defensibility. MDC Protection and Fisheries divisions are invaluable to MDC's ability to respond to pollution problems statewide in a professional and timely manner. Without their assistance, the task would be overwhelming.

Limnology Training
The Fish Kill Program partnered with University of Missouri's Limnology staff to give Limnology 101 training to MDC staff in the summer of 2017. Freshwater limnology is the study of the structural and functional interrelationships of fresh water organisms as they are affected by their dynamic physical, chemical, and biotic environments. This was the second year limnology training was offered to MDC staff since the 1990s. A solid understanding of basic limnology and aquatic ecology assists fisheries management and hatchery staff with data interpretation and with troubleshooting water quality issues on the job.

Staffing & Organizational Changes

Organizational Structural Changes

During 2017 the Aquatic Health Unit was combined with the Aquatic Systems Unit under the supervision of Doug Novinger. After the reorganization, the Aquatic Health Unit became part of the new Aquatic Systems and Environmental Health Unit.

In July 2017 Katrina Knott was hired as the new Contaminants Biologist to replace Mike McKee who had been in the position for 13 years. Katrina adds strong physiological and terrestrial perspectives to the Unit.

Appendix B. Summary of regulated source incidents during 2017. Data is listed alphabetically by county. ND= not determined, NC= not calculated

County	Waterbody Name	Incident Date	Source	Cause	Number Animals Killed	Value
Benton	Lake of the Ozarks	5/6/2017	Municipal	blunt force trauma from high spill discharge	239	$146,760.60
Boone	Mill Creek	9/1/2017	Municipal	chlorine toxicity- water main break	1,934	$584.30
Buchanan	Missouri River	5/19/2017	Municipal	permitted CSO sewage bypass	0	-
Callaway	McKinney Creek & Maddox Branch	6/4/2017	Agricultural	ammonia toxicity- liquid nitrogen discharge	7,485	$19,351.60
Callaway	Brown Pond	7/28/2017	Agricultural	pesticides toxicity (suspected)- aerial application	ND	NC
Callaway	Tributary of Rivaux Creek	1/3/2017	Municipal	low dissolved oxygen/ammonia toxicity (suspected)- raw sewage from manhole overflow	30	$6.20
Callaway and Audrain	South Fork Salt River	12/3/2017	Agricultural	low dissolved oxygen & ammonia toxicity (suspected)- lagoon overflow	330	$774.42
Camden	Sellars Creek	4/11/2017	Agricultural	rotenone toxicity- treatment of hatchery ponds	1,001	$442.82
Camden	Niangua River	7/11/2017	Municipal	fish and mussel stranding from dewatering- insufficient water releases from Tunnel Dam	60,666	$7,954.92
Cass	Tributary of North Sugar Creek	2/17/2017	Municipal	Domestic sewage (alleged)	ND	NC
Cedar	Sac River	6/9/2017	Municipal	mussel stranding from dewatering- insufficient water releases from Stockton Dam	ND	NC
Clay	Tributary of Shoal Creek	6/6/2017	Municipal	odor & sludge- sewage lift station discharge	0	-
Cole	Tributary of Wears Creek	12/19/2017	Municipal	chlorine toxicity- potable drinking water discharge	160	$345.00
Franklin	Flat Creek	8/8/2017	Industrial	caustic chemical	0	-
Grundy	Tributary of Muddy Creek	3/19/2017	Agricultural	filter media & dead fish (alleged)- tilapia farm discharge	0	-
Jackson	Camp Creek	6/14/2017	Municipal	chlorine toxicity- fire hydrant rupture	4,411	$4,780.93
Jefferson	Big River	2/17/2017	Other	Extreme CAFS foam- firefighters training activities	0	-

Appendix B. continued

County	Waterbody Name	Incident Date	Source	Cause	Number Animals Killed	Value
Lawrence	Turnback Creek	1/14/2017	Transportation	Crude oil- pipeline leak	0	-
Lincoln	Bobs Creek	8/12/2017	Municipal	gray water- sewage release	0	-
Miller	Osage River	5/25/2017	Municipal	turbine entrainment (suspected) from Bagnell Dam power generation	ND	NC
Montgomery	Little Bear Creek	4/11/2017	Agricultural	low dissolved oxygen & ammonia toxicity- lagoon discharge	26	$9.72
Montgomery	Private Lake	10/6/2017	Agricultural	low dissolved oxygen- crop residue runoff	ND	NC
Pemiscot	Tributary of Half Moon Bayou	1/9/2017	Municipal	ammonia toxicity (suspected)- raw sewage from line break	351	$2,986.46
Pettis	Tributary of Flat Creek	10/16/2017	Other	Pink dye from Tough Mudder sporting event	0	-
Phelps	Tributary of Little Piney Creek	3/29/2017	Transportation	diesel fuel- truck wreck	0	-
Ralls	Salt River	6/14/2017	Municipal	low dissolved oxygen- insufficient water releases from Clarence Cannon Dam	1,994	$3,951.23
Randolph	Private Pond	8/14/2017	Agricultural	pesticide poisoning (suspected)- Asana XL Insecticide & fungicide (aerial application)	2,661	$2,950.50
St. Charles	Big Creek	6/13/2017	Other	tires used as fill on stream bank	0	-
St. Francois	Saint Francis River	6/26/2017	Other	Low dissolved oxygen- insufficient water releases from dam	140	NC
Ste. Genevieve	South Gabouri Creek	7/22/2017	Industrial	hose failure- diesel fuel discharge	0	-
Stoddard	Main Ditch	8/10/2017	Agricultural	low dissolved oxygen- eutrophication & low flow from irrigation draw down	4,429	$3,515.55
Vernon	Birch Branch	2/24/2017	Other	land disturbance & landfill leachate (suspected)	0	-
Warren	Charrette Creek	7/3/2017	Municipal	Ammonia toxicity/low dissolved oxygen (suspected)- sewage discharge	694	$285.93

Appendix C. Summary of non-regulated source incidents during 2017. Data is listed alphabetically by county. ND=not determined

County	Waterbody Name	Incident Date	Cause	Number Animals Killed
Barton	Private Pond 1	7/7/2017	low dissolved oxygen (algae crash from overcast conditions)	1,173
Benton	Truman Lake	8/29/2017	low dissolved oxygen (algae bloom and stratification-related)	30
Benton	Truman Lake	9/11/2017	low dissolved oxygen (algal respiration suspected)	1,000
Boone	Private Pond	7/28/2017	low dissolved oxygen (overcast conditions)	ND
Callaway	Auxvasse Creek	3/21/2017	*Aeromonas* infection and secondary fungal infection (environmental stressors suspected)	1,001
Callaway	Hale Lake	7/28/2017	spawning-related	ND
Camden	Lake of the Ozarks	6/11/2017	low dissolved oxygen & motile *Aeromonas/F.columnare* infection	95
Cape Girardeau	Tributary of Hubble Creek	5/23/2017	Low dissolved oxygen from receding flood waters and high biomass	500
Cass	Harrisonville North County Lake	2/22/2017	natural- winter kill	ND
Chariton	Yellow Creek & Elk Creek	7/12/2017	low dissolved oxygen from decaying vegetation	2
Cole	Private Pond	9/21/2017	low dissolved oxygen (algal respiration suspected)	ND
Cooper	Private Pond 3	7/7/2017	low dissolved oxygen	ND
Franklin	Busch Creek	4/15/2017	low dissolved oxygen from receding water	20
Henry	Truman Lake	8/1/2017	low dissolved oxygen from overcast conditions (suspected)	100
Jackson	Jackrabbit Lake	5/16/2017	disease, stress from shifting temperatures and spawning	150
Jefferson	Private Pond	6/28/2017	green film, dog sick (suspected harmful algal bloom)	0
Lincoln	Private Lake	6/8/2017	Spawning-related	ND
Moniteau	Private Pond 1	7/7/2017	low dissolved oxygen	200

Appendix C. continued.

County	Waterbody Name	Incident Date	Cause	Number Animals Killed
Moniteau	Private Pond 2	7/7/2017	Low dissolved oxygen	100
Moniteau	Private Pond	10/31/2017	*Euglena sanguinea* from eutrophication	0
Morgan	Private Pond	6/16/2017	blue-green algae bloom and low dissolved oxygen suspected	ND
New Madrid	Saint Johns Bayou	6/14/2017	Low dissolved oxygen (natural)	ND
Osage	Lower Osage River	3/18/2017	natural (species-specific)	ND
Pike	Lower Salt River & Mississippi River	7/19/2017	natural (species-specific)	200
Randolph	Rothwell Lake	8/28/2017	Blue Green Algae (suspected)	0
Saline	Private Pond	11/13/2017	discolored water (suspected harmful algal bloom)	0
St. Charles	Private Pond	7/27/2017	Natural Kill	ND
St. Charles	Private Pond	7/28/2017	Natural kill	ND
St. Louis	Kenrick Manor Lake	7/28/2017	natural kill	ND
Vernon	McKenzie Creek	5/23/2017	blue-green algae	0
Warren	Aspen Lake	7/13/2017	Natural kill	ND
Warren	Alpine Lake	7/13/2017	Natural Kill	ND

Appendix D. Summary of incidents caused by unknown sources during 2017. Data is listed alphabetically by county. ND=not determined, NC=not calculated

County	Waterbody Name	Incident Date	Suspected Cause	Number Animals Killed	Value
Barry	Flat Creek	3/24/2017	Sewage suspected	ND	NC
Cedar	Tributary of Walnut Creek	5/31/2017	biochemicals (alleged)	0	-
Franklin	Subdivision Lake	2/6/2017	Unknown	254	$0.00
Henry	Montrose Lake	6/30/2017	Low dissolved oxygen from warmwater discharge from power plant (suspected)	ND	NC
Osage	Lower Osage River	3/28/2017	Large masses of brown algae/ongoing pollution (alleged)	0	-
Randolph	Private Pond	8/7/2017	Unknown, possibly low dissolved oxygen or king glufosinate 280 herbicide toxicity	54	NC
Stoddard	Cypress Lake	3/20/2017	latex paint (suspected)	0	-
Vernon	Little Dry Wood Creek	2/15/2017	Unknown	0	-

Appendix E. Summary of Clean Water Law settlements reached by the State of Missouri during 2017 from incidents involving MDC, including penalties and damages (monetary value of animals). Data is listed alphabetically by county. This table does not include investigative costs for DNR. Cr=creek, trib=tributary.

County	Waterbody	Date	Responsible Party	Cause	Reimbursements			Penalty (MDC does not calculate)**
					Fish Damages*	MDC Investigative Costs	MDC Total	
Boone	Hominy Cr	6/1/12	City of Columbia	Sewage line break	$441.26	$459.34	$0.00+	$15,000
Boone	Harmony Cr	9/5/16	West Broadway Swim Club	Chlorinated pool water	$48.17	$623.53	$666.88	$6,000
Miller	Blythes Cr	10/2/16	Rose Hill Swine Production	Hog waste	$210.73	$863.60	$0.00+	$3,500
St. Louis	Meramec River, trib	6/9/15	Union Pacific	Cornmeal	$51.52	$473.48	$0.00+	$2,500

*Ten percent of fish damages are transferred to an emergency response fund at DNR.

**includes suspended penalties.

+ As of December 2017 MDC has not received reimbursements for damages or MDC-incurred expenses for investigative time.

Appendix F. Brief descriptions of closed and open cases listed alphabetically by county for 2017.

Closed Cases (Resolution)

Cases closed after resolution was reached.

Boone County (6/1/12), City of Columbia

Sewage line construction led to the release of raw sewage in Hominy Creek. Low dissolved oxygen levels caused the death of 1,164 aquatic animals valued at $441.26 in a 1,500-foot reach of the stream. The City of Columbia attempted to flush the system and pump out some of the sewage. An abatement order on consent was signed in February 2017. The abatement order covered numerous sewage spills in which the City of Columbia was the responsible party. The City of Columbia paid a $15,000 penalty under the order.

Boone County (9/5/16), West Broadway Swim Club

West Broadway Swim Club in the City of Columbia discharged chlorinated swimming pool water into a tributary of Harmony Creek killing 273 fish, aquatic worms, and crayfish valued at $48.17. An abatement order on consent was signed in May 2017 which included a penalty of $6,000, with $4,200 of that suspended for two years if the terms of the order are not violated. Under the order, the responsible party also faces stipulated penalties up to $250 per day if the terms of abatement order are not met.

Buchanan County (5/19/17), City of St. Joseph

MDC received a complaint from the public about sewage being discharged from the St. Joseph waste water treatment plant into the Missouri River. MDC forwarded the complaint to DNR who informed that this discharge was permissible.

Cedar County (5/31/17), undetermined responsible party

EPA received a tip from the public about biochemicals in water and most fish dying in creek by El Dorado Springs Community Center. EPA forwarded the tip to DNR who notified MDC's Protection Division. The MDC Conservation Agent found nothing to lead him to believe there is or was a chemical spill or fish kill.

Clay County (6/6/17), City of Gladstone

MDC staff observed (on a few occasions) sewage discharges and odors originating from a City of Gladstone lift station that were impacting Maple Woods Natural Area. These complaints were submitted to the DNR. DNR worked with the City of Gladstone to correct the issue.

Jefferson County (2/17/17), local fire department

MDC received a report of dead minnows on the Big River in Cedar Hill, Missouri. MDC did not observe dead fish on site, but observed white foam originating from a culvert. The MDC responder identified the source of the foam as the local fire department that had been training with foam the previous two days. Enforcement action was not taken on this case because a fish kill was not observed. It is unknown what compliance action was taken by the regional DNR for this case.

Lincoln County (8/12/17), Brussel Valley Estates, Inc.

MDC was notified of a potential sewage discharge and fish kill in Bobs Creek. MDC responded on site and confirmed leakage from a manhole, but did not observe dead fish. Follow up with DNR regional office indicated compliance actions were being taken to abate pollution.

Miller County (10/2/16), Rose Hill Swine Production
MDC received a call about dark colored water that smelled of hog waste and dead fish in Blythes Creek. Based on observations of stream color in the tributaries of the area, MDC investigators identified Rose Hill Swine Production facility as the source of pollution. Hog waste lowers dissolved oxygen and raises ammonia levels in water resulting in aquatic life mortality. MDC observed over 1,135 dead fish valued at $210.73 as a result of this discharge. An abatement order on consent was signed in February 2017, which included a civil penalty of $3,500 and $1,466.49 in investigative costs.

Pettis County (10/16/17), Tough Mudder Corp.
MDC staff from the Sedalia office observed bright pink water in a tributary to Flat Creek that runs just outside of their office. Staff identified the source of the pink color was dye used by the Tough Mudder Corporation. The corporation dumped the dye after the completion of a sporting event. This case was forwarded to DNR's Kansas City Regional Office who followed up with the responsible party.

Randolph County (8/7/17), Kertz Farm
MDC received a fish kill complaint from a private landowner. The landowner suspected a neighbor had applied herbicide that had drifted or run into his pond causing a fish kill. MDC investigated and could not determine if the kill was natural or caused by the herbicide. The complaint was forwarded to Missouri Department of Agriculture who investigated and detected herbicide on vegetation near the pond. The Department of Agriculture did not detect herbicide in the pond water. There was not evidence directly linking the fish kill to the herbicide. However, there was a letter of warning issued for improper use of the herbicide.

St. Charles County (6/13/17), private landowner
MDC received a complaint from the public concerning a landowner using old tires as fill on a stream bank on Big Creek. MDC referred the case to the regional DNR office for compliance and enforcement evaluation.

St. Louis County (6/9/15), Union Pacific
A train carrying cornmeal derailed near Eureka, Missouri. Cornmeal entered a tributary of the Meramec River and began decomposing which caused the dissolved oxygen to reach levels lethal to fish. MDC observed at least 238 dead fish valued at $51.52. An abatement order on consent was signed March 2017, which included investigative costs and damages of $2,146.63 and a civil penalty of $2,500.

Vernon County (2/24/17), 3M
MDC's El Dorado Springs office received a call from the public about a potential water quality violation. The caller had concerns over the landfill at this location leaching contaminated water into Birch Branch which flows through his property. MDC forwarded the concern to the DNR regional office who inspected the site and found no violations.

Closed Cases (No Resolution)
Cases closed due to lack of evidence and unidentified pollutant and/or responsible party.

Barry County (3/24/17), responsible party unknown
MDC received a call from the public reporting a fish kill in Flat Creek starting at the sewage line that crosses the creek just north of the city park in Cassville. MDC responders confirmed the fish kill, but were unable to verify the cause and source of pollution due to thunderstorms during the investigation.

Cass County (2/17/17), Drexel Waste Water Treatment Lagoon (alleged)
MDC received notification from DNR of dead fish in a stream below the Drexel waste water treatment plant. DNR had been on site investigating a bypass on Friday. MDC responded on site Saturday and was unable to verify the presence of dead fish. Although the case status is closed at MDC, this case may remain open at DNR.

Grundy County (3/19/17), Quixotic Farming
MDC received a report from DNR of dead fish and a discharge of filter media originating from a tilapia farm near Trenton, Missouri. MDC did not observe dead fish or discharge on site.

Stoddard County (8/10/17), responsible party unknown
MDC received a report of a fish kill on Main Ditch. The water level in the stream was very low possibly indicative of irrigation draw down. Water remaining in the channel was dark green in color. Conditions recently were overcast suggesting a hypoxia kill. Dissolved oxygen equipment failed while on site and responders were unable to confirm a hypoxia event. An estimated 6 miles of stream were impacted and over 4,400 dead aquatic animals were observed. Responders were unable to identify a responsible party.

Vernon County (2/15/17), unknown
MDC El Dorado Springs office received a complaint about the sewage plant in Nevada, Missouri leaking untreated sewage into streams [Little Dry Wood Creek]. The DNR-EER group was contacted. Water quality data was inconclusive.

Open Cases

The following cases are currently being evaluated by DNR Compliance and Enforcement group in the Water Pollution Control Branch of the Water Protection Program or are still under investigation.

Benton County (5/29/13), U.S. Army Corps of Engineers under direction of Southwest Power Administration
A hypolimnetic release of low dissolved oxygen water caused a fish kill in Lake of the Ozarks. Trauma from passing through Truman Dam and physical injury from flood gate releases also contributed to the kill. An estimated 2,723 fish valued at $15,196.71 died.

Benton County (8/26/13), U.S. Army Corps of Engineers
An emergency shutdown and dewatering of a turbine chute in Truman Dam caused the death of at least 3,368 fish worth $4,950.97. The trapped fish likely died from overcrowding and subsequent low dissolved oxygen.

Benton County (5/25/16), U.S. Army Corps of Engineers under direction of Southwest Power Administration
A U.S. Army Corps of Engineers employee notified MDC of a fish kill below Truman Dam consisting of approximately 40 fish. The fish were primarily hybrid striped bass. Lengths were not recorded for these dead fish; therefore, we were unable to calculate a monetary value.

Benton County (5/6/17), U.S. Army Corps of Engineers under direction of Southwest Power Administration

There was a large fish kill below Truman Dam caused by releases of flood waters. Paddlefish were the most commonly observed injured and/or dead fish during this fish kill. The fish kill lasted nearly two months. Preliminary estimates of damages are over $146,000. This should be considered an underestimate because MDC staff actively searched for only 36 hours during this two-month period.

Boone County (4/2/14), Unknown construction company and City of Columbia

Land disturbance in southern Columbia caused a substantial amount of sediment to enter Phillip's Lake, at a rate more than 2-3 times what is typical for reservoirs in Missouri. Significant sedimentation may have a negative impact to fish communities via more frequent and severe algal blooms, lower survival of larval fish, and irritation of the gills. A substantial amount of sediment was also deposited in the floodplain areas of Phillip's Lake and Gans Creek. Gans Creek is an outstanding state resource water and flows into a cave system where rare species have been documented. Deposited sediment in the floodplain areas of both Phillip's Lake and Gans Creek acted as a source of water pollution during rain events. Sediment found in the floodplain of Gans Creek may have a negative impact to stream macroinvertebrates and fish in the stream. Sink holes are also present in the area and likely contain sediments from this activity.

Boone County (6/9/16), City of Columbia

A City of Columbia drinking water lift station malfunctioned discharging 320,000 gallons of chlorinated water into Mill Creek. The release of chlorinated water killed over 10,000 fish and aquatic worms valued at $3,295.36.

Boone County (9/1/17), City of Columbia

A drinking water line ruptured discharging an unknown volume of chlorinated water into Mill Creek. Staff observed nearly 2,000 dead fish and tadpoles valued at $573.69. It is unlikely the fish community in this stream had recovered since the previous kill in June 2016.

Boone County (5/18/14 & 8/22/15), University of Missouri

Runoff from land applied manure in the areas adjacent to Dairy Farm Lake No. 1 depleted oxygen. MDC staff observed 50 dead fish valued at $150.46 during May 2014 and 410 dead fish valued at $822.42 during August 2015. There is a history of kills of this nature at this lake and Dairy Farm Lake No. 3 dating back to 2005 in our records. These two incidents are two of five fish kills resulting from land application of manure at this site. An effective aeration system and a vegetated buffer zone, or removal of nutrient-rich sediments is needed to avoid future fish kills. MDC awarded money from the Fish Kill Grant Fund to purchase and install an efficient aeration system at lakes 1 and 3. MU did not accept funding for the purchase and installation at Lake No. 1, but has accepted funding for Lake No. 3. MU proposed conducting phytoplankton control research on Lake No. 1 which involved the use of an additive to the water. MDC in collaboration with the Missouri Department of Health and Senior Services proposed research evaluating the presence and concentration of algal toxins in fish to evaluate the need for statewide monitoring for the fish consumption advisory program.

Boone County (7/3/14), University of Missouri

Runoff from land applied manure in the areas adjacent to Dairy Farm Lake No. 3 depleted oxygen. MDC staff observed 3,945 dead fish valued at $7,808.26. There is a history of kills of this nature at this lake and Dairy Farm Lake No. 1 dating back to 2005 in our records. MDC awarded money from the Fish Kill Grant Fund to purchase and install an efficient aeration system at lakes 1 and 3. MU has not accepted

funding for the purchase and installation at Lake No. 1, but has accepted funding for Lake No. 3. MU proposed conducting phytoplankton control research on Lake No. 1 which involved the use of an additive to the water. MDC in collaboration with the Missouri Department of Health and Senior Services proposed research evaluating the presence and concentration of algal toxins in fish to evaluate the need for statewide monitoring for the fish consumption advisory program.

Callaway County (1/3/17), City of Holts Summit

The City of Holts Summit reported a grease blockage caused a manhole overflow sometime on January 3rd or 4th resulting in a discharge of 134,000 gallons of raw sewage into a tributary of Rivaux Creek. MDC was notified of the overflow and fish kill on January 10th, six to seven days after the initial spill. The MDC responder found very few dead fish during the investigation due to the delay in notification, ice cover, and leaf litter in the stream. Thirty darters and minnows were observed and valued at $6.20.

Callaway County (6/4/17), Frederick Kerr Atkinson

A large volume of liquid nitrogen was discharged into McKinney Creek killing all aquatic life for 8 stream miles. Dead fish, crayfish, macroinvertebrates, aquatic worms, and tadpoles were observed during the investigation. These animals are valued at $19,351.60. During follow up visits, toxic levels of ammonia were detected for miles downstream of the initial kill zone and for weeks after the initial discharge. Based on previous kills of this severity, the aquatic life in this stream will not fully recover for several years.

Callaway County (7/28/17), unknown responsible party

MDC received a call from a landowner about aerial application of pesticides for Japanese beetles causing a fish kill in his pond. The caller's neighbor had his property sprayed and either the applicator did not turn off the sprayer when going over his ponds or there was drift into the ponds. There were kills in the caller's pond and the neighbor's pond. MDC notified the DNR-EER who alerted the Missouri Department of Agriculture.

Callaway County and Audrain County (12/3/17), Dale Brinkler

A livestock lagoon overflowed into a tributary of the South Fork Salt River on November 30th and was not discovered until December 2nd. Notifications from EER indicate that around 300,000 gallons of lagoon waste had been discharged over the course of a few days. MDC responders observed at least 330 dead fish and tadpoles in South Fork Salt River and its tributary (a total of 2.5 stream miles). Dead fish and tadpoles were valued at $774.42. These numbers should be considered conservative given the volume of waste discharged, observations of scavenged fish remains, and the lag time between the spill date and the date the Department was notified.

Camden County (4/11/17), Ozark Fisheries

Ozark Fisheries applied Rotenone (a piscicide) to their hatchery ponds on April 11th. Measures to prevent the migration of rotenone from the ponds into waters of the state were ineffective resulting in a fish kill in Sellars Creek. Over 1,000 fish valued at $442.82 were killed as a result of the discharge.

Camden County (7/11/17), Sho-Me Power

MDC staff observed mussel and fish stranding while conducting normal work duties in the Niangua River below Tunnel Dam. The stranding was caused by an abrupt reduction in flow over Tunnel Dam for a spillway inspection. Stranded mussels were translocated to water, but many fish and stream macroinvertebrates died as the result of this dewatering event (60,666 dead fish valued at $7,954.92). Survival of the translocated mussels in the days and weeks following this event are unknown.

Cape Girardeau (7/5/16), Kevin Birk
Manure was discharged from the Birk cattle farm into Foster Creek on July 5th. The discharge negatively impacted over 3 miles of stream. MDC investigators observed 7,023 dead fish valued at $2,182.05. MDC suspects this discharge resulted in a heavy to total kill in this stream.

Cape Girardeau (7/12/16), Kevin Birk
Black manure laden water was discharged from the Birk cattle farm into a tributary of Hubble Creek on July 12th. The discharge depleted oxygen in the stream forcing a migration of low dissolved oxygen tolerant aquatic worms out of the stream sediment. MDC investigators observed 1,170 dead fish, snails, and crayfish valued at $173.55. MDC suspects this discharge resulted in a total kill of this tributary.

Cape Girardeau (12/27/16), Kevin Birk
MDC received a call from a concerned local citizen regarding a discharge of manure from the Brik cattle farm into a tributary of Hubble Creek after a rain event. A similar incident occurred in this same location in July 2016. The caller did not report any observations of dead aquatic life. MDC forwarded the report to DNR Compliance and Enforcement Section.

Cedar County (6/9/17), United States Army Corps of Engineers
MDC received a call from a private citizen on June 12th concerning Stockton Dam lowering water levels in the receiving waters of the Sac River and its tributaries. The private citizen lives on Bear Creek, a tributary of the Sac River and reported that when generation was altered on the 9th that mussels were left stranded out of the water in Bear Creek. The caller indicated this had occurred on other occasions.

Clay County (11/15-16/12), City of Kansas
A sewage sludge release from a Kansas City sewage treatment facility caused a heavy fish kill in 5.5 miles of Fishing River. Low dissolved oxygen conditions and suspected ammonia toxicity led to the death of at least 1,520 fish. Total fish damages were $8,055.52.

Cole County (8/21/11), Jefferson City Wastewater Utility Services
A sewage overflow occurred in a tributary to Moreau Creek due to a power failure at a pumping station. At least 1,289 fish valued at $173.13 were killed.

Cole County (2/14/13), City of Jefferson
Roughly 3,500 gallons of raw sewage flowed from a manhole into Wears Creek. At least 376 fish valued at $52.19 died in a 2,000-foot section of stream.

Cole County (2/18/16), Missouri American Water
A water line broke in Jefferson City which discharged chlorinated water into a tributary of Wears Creek. Chlorine is extremely toxic to gill breathing aquatic organisms. Our Conservation Agent observed 266 dead fish as a result of this discharge. The dead fish were valued at $34.78.

Cole County (12/19/17), Missouri American Water
MDC was notified by DNR-EER of a fish kill in a tributary of Wears Creek near Central Dairy in Jefferson City. Chlorine was detected by DNR in the tributary. MDC observed 160 fish valued at $345 as a result of this chlorinated water discharge.

Cooper County (8/29/15), Missouri Better Beans
A fire at the Missouri Better Beans facility resulted in the release of 50,000 gallons chlorinated water and over 27,000 gallons of various chemicals, including glycerin. This release resulted in oxygen depletion in Stephen's Branch for at least 16 days. MDC observed 4,332 dead fish valued at $829.99 during this incident.

Franklin County (3/7/13), local manufacturer
A dark brown oily chemical was found in the city of Union's wastewater treatment plant. Sorbent booms were placed at the treatment plant outfall on Bourbeuse River as a preventative measure. No dead fish or mussels were found.

Franklin County (8/8/17), Gateway Extrusions
MDC was notified by DNR-EER regarding a caustic chemical spill that had been discharged into Flat Creek. EER reported that frogs were observed dead in the creek. MDC responded on site and observed a pH of 14 in the stream. MDC did not observe dead fish or dead animals while on site.

Green County (10/1/16), City of Springfield
A manhole malfunction resulted in a sewage discharge into Pea Ridge Creek. MDC observed 1,027 dead fish as a result of this discharge. Fish were valued at $270.92. Reported fish injuries and values should be considered underestimates because cleanup activities flushed fish downstream into inaccessible areas prior to MDC being notified about the incident.

Henry County (6/30/17), Kansas City Power and Light (suspected)
MDC was notified in August about a fish kill on Montrose Lake that had occurred in late June. By the time MDC learned of the fish kill, all evidence was gone. MDC suspects low dissolved oxygen discharged in the warmwater discharge channel from plant caused the fish kill. The suspected responsible party signed an agreement recently that stated any fish kill caused by dam operations would prompt installation of automated water quality equipment to measure dissolved oxygen and temperature conditions in real-time. DNR is currently evaluating this incident for compliance action.

Jackson County (6/13/17), City of Independence
A fire hydrant rupture resulted in a chlorinated water discharge to Camp Creek. MDC responders observed 4,411 fish valued at $4,780.93 as the result of the discharge.

Lafayette County (7/17/15), Cedar Ridge Aviation
A trailer containing a mixture of pesticides went off road. A large volume of its contents, which included 8-gal mustang maxx, 63 gal crobkarb, 20-gal quilt xcel reached Dyer Rock Creek and caused a severe kill of fish, crayfish, and amphibians.

Miller County (5/25/17), Ameren Missouri
Fish mortalities were reported to MDC in the Osage River below Bagnell Dam by a graduate student conducting monitoring in the area. Some fish displayed injuries consistent with barotrauma, supersaturation, and turbine entrainment. These mortalities will be discussed with Ameren Missouri during the annual Fish Protection meeting in the spring of 2018.

Montgomery County (4/11/17), Davis meat Processing LLC
On April 11th as a means to reduce the costs of a waste hauler, Davis Meat Processing disposed of lagoon waste onto their property which drained into Little Bear Creek resulting in a fish kill. Many dead fish had been scavenged by the time the Department was notified three days post-spill; therefore, damages observed by MDC responders are underestimates. During the investigation, MDC observed 25 dead fish and 1 dead frog valued at $9.72.

Pemiscot County (1/9/17), City of Caruthersville
A sewer line break near the waste water treatment plant on January 9th discharged an unknown quantity of sewage into a tributary of Half Moon Bayou. Our responders observed 351 dead fish valued at $2,986.46, and noted visibility of dead fish was limited due to ice cover and leaf litter.

Platte County (6/7/16), City of Kansas
On June 7th, a Kansas City Wastewater lift station failure resulted in the discharge of wastewater into a tributary of Rush Creek. MDC observed 108 dead fish valued at $28.29 as a result of this discharge.

Ralls County (7/8/13; 7/21/14; 2015: 6/22, 8/3, 8/8, 9/8; 6/14/17), U.S. Army Corps of Engineers under direction of Southwest Power Administration
Since the 1980s, hypolimnetic releases of poor quality water have been the cause of recurring fish kills below Clarence Cannon Dam, which impounds Mark Twain Lake. Water released from the dam does not contain enough dissolved oxygen to support aquatic life. Within the last five years MDC staff documented six fish kills at this location, four of these fish kills occurred during 2015. Dam operations during 2015 resulted in at least 23,174 dead fish valued at $40,687.11. Since 2010, there have been efforts to mitigate fish injury for low dissolved oxygen levels below the Clarence Cannon Dam; however, none of these efforts have produced a permanent long-term solution.

Randolph County (8/14/17), Production Air Services, Inc.
MDC was contacted by a private landowner whose pond experienced a large kill involving fish, invertebrates, reptiles, and amphibians. The landowner described excited and erratic fish behavior prior to and during the kill. A total of 2,661 dead animals were observed by MDC responders. MDC notified the Missouri Department of Agriculture (MDA) after learning that the pond had recently received pesticide drift from aerial applications on adjacent properties. MDA investigated and confirmed Asana XL Insecticide and fungicide had been applied. MDA is handling all compliance and/or enforcement on this case.

St. Louis County (8/10/10), St. Louis Metropolitan Sewer District
Sewage overflowed from a manhole into Martiginey Creek killing an unknown number of fish.

St. Louis County (7/9/13), St. Louis Metropolitan Sewer District
Raw sewage from a discharge pipe impacted 2,500 feet of Deer Creek causing the death of at least 546 fish valued at $386.08.

St. Louis County (7/13/15), Missouri American Water
A chlorinated water release occurred in Grand Glaize Creek. Chlorine is highly toxic to gill-breathing organisms. MDC observed at least 308 dead fish valued at $82.32.

Ste. Genevieve County (7/22/17), Mississippi Lime Company

MDC received complaints from several residents in the area about a smell and sheen in the creek near Mississippi Lime Company. Upon investigation MDC found a sheen in the waterway. Mississippi Lime was contacted and instructed to place boom in the creek. MDC did not observe any stress wildlife. The case was referred to DNR for compliance and/or enforcement action.

Warren County (5/26/16), City of Wright

A Wright City sanitary sewer overflow dry-weather bypass resulted in a discharge of 5,000 gallons of waste water into Peruque Creek. MDC documented 81 dead fish as a result of the discharge. Fish were valued at $59.45.

Warren County (7/3/17), Innsbrook estates (suspected)

On July 4, 2017 MDC was notified by DNR-EER of a fish kill in Charrette Creek. EER had been forwarded the complaint from a 911 dispatcher who had received a call from a private citizen. The initial complaint described sewage discharge and odors that were especially bad on the night of July 3rd. MDC responded on site and verified the spill and fish kill. MDC identified and counted 694 dead fish valued at $285.93 during the investigation.

Appendix G. Summary of pollution investigation, fish kills, and estimated mortality (1970-2017) Data are incomplete prior to 1985. I=number incidents, K=number kills, #=number of dead animals, N/A=not available

	MUNICIPAL			AGRICULTURAL			INDUSTRIAL			TRANSPORTATION			OTHER			NON-REGULATED		
Year	**I**	**K**	**#**	**I**	**K**	**#**	**I**	**K**	**#**	**I**	**K**	**#**	**I**	**K**	**#**	**I**	**K**	**#**
1970		7	72,850		10	353,482		8	218,075		3	605		2	6,035			
1971		9	306,050		9	93,856		6	70,050		3	40,750		10	46,081			
1972		11	9,960		8	9,322		8	494,801		5	626		2	22,171			
1973		6	46,125		4	8,203		9	49,355		3	5,455		8	11,965			
1974		10	20,242		8	13,730		10	120,637		4	4,472		6	4,145			
1975		9	43,035		9	118,564		8	109,713		6	29,500		7	10,535			
1976		10	9,323		3	2,260		6	14,400		N/A	N/A		5	3,825		1	52,000
1977		9	8,017		3	500		6	1,568		3	130,907		1	N/A		5	226,000
1978		8	436,206		12	16,739		7	13,953		3	855		8	11,008		20	16,003
1979		17	25,057		15	14,442		6	89,314		3	44,733		17	161,772		29	9,155
1980		14	114,817		10	16,476		5	98,729		N/A	N/A		10	39,953		35	26,443
1981		10	200,463		20	22,366		4	2,317		2	37,000		10	17,213		39	9,495
1982		8	4,728		12	14,693		2	4,424		1	N/A		12	20,462		18	7,074
1983		9	20,023		9	6,328		6	12,730		4	6,227		21	10,834		9	4,765
1984		13	12,433		10	65,522		3	853		3	1,285		12	43,635		11	105,578
1985	22	9	3,854	24	13	41,599	25	2	2,843	22	3	21,118	18	13	15,277	21	19	52,817
1986	40	18	68,010	25	13	12,086	26	7	4,236	28	2	N/A	44	18	955	42	41	28,848
1987	39	18	38,333	22	8	11,033	19	7	7,915	24	1	200	39	19	19,679	45	43	45,641
1988	17	4	13,006	10	5	32,263	17	7	20,925	15	3	1,112	23	10	12,286	35	35	113,016
1989	25	9	1,015	21	11	27,546	24	6	13,684	11	1	186	16	12	5,991	37	36	35,122
1990	33	11	7,462	25	11	49,983	22	4	36,496	16	5	12,334	25	14	17,089	31	28	281,161
1991	21	8	20,436	28	14	14,639	38	12	55,114	15	3	2,952	36	23	5,962	223	220	60,864
1992	33	16	16,018	22	6	14,063	24	6	31,006	17	2	57	20	8	69,211	207	203	30,934
1993	36	9	6,288	23	9	26,234	42	8	17,646	17	3	5,500	17	8	23,950	137	135	89,748
1994	50	18	78,385	23	9	59,603	33	8	106,743	24	2	9,684	23	8	247,272	206	196	83,017
1995	40	20	30,419	25	12	293,642	21	7	16,176	13	N/A	N/A	33	17	17,080	238	236	87,718
1996	36	14	10,875	37	9	54,999	22	10	373	12	2	10,875	30	11	3,899	139	136	105,031

Appendix G continued.

	MUNICIPAL			AGRICULTURAL			INDUSTRIAL			TRANSPORTATION			OTHER			NON-REGULATED		
Year	I	K	#	I	K	#	I	K	#	I	K	#	I	K	#	I	K	#
1997	37	15	8,481	25	8	1,504	17	5	2,404	9	1	14	31	22	7,127	229	222	55,984
1998	15	6	5,155	22	6	92,052	16	6	40	9	4	13,206	27	12	24,905	148	146	31,893
1999	22	11	28,841	13	5	3,038	10	4	22,993	5	1	43	18	7	31,589	192	187	42,829
2000	16	8	36,405	7	4	55,160	4	3	524	6	2	1,042	11	7	43,206	153	153	163,051
2001	18	10	22,711	12	7	1,588	7	6	1,043	13	5	4,696	10	9	14,752	233	233	68,829
2002	18	12	81,960	9	6	45,028	12	4	3,615	5	2	74	6	5	1,519	121	121	33,461
2003	10	4	1,022	5	2	8,068	10	1	523	2	1	1,374	12	9	15,821	113	113	163,179
2004	17	10	82,183	5	N/A	N/A	1	N/A	N/A	3	1	1,146	1	1	18,476	71	71	8,253
2005	7	4	73,785	5	4	12,020	5	1	3,436	1	N/A	N/A	1	1	4,334	154	154	69,466
2006	7	7	22,643	3	3	4,489	6	2	10,479	2	N/A	N/A	3	2	10,822	3	3	2,957
2007	8	7	26,582	4	3	11,599	2	2	25,796	1	1	477	4	4	3,771	5	5	1,460
2008	8	7	2,504	3	2	381	N/A	N/A	N/A	N/A	N/A	N/A	6	6	2,144	5	5	2,232
2009	5	2	2,231	3	3	509	2	N/A	N/A	2	2	116	5	5	433	4	4	3,207
2010	10	7	3,373	7	4	2,625	1	1	41	3	1	N/A	12	9	270,926	20	18	2,537
2011	15	11	4,888	4	3	11,175	N/A	N/A	N/A	3	1	4,822	15	12	13,186	28	27	11,008
2012	4	4	5,063	4	4	7,067	4	3	1,230	2	1	1,286	17	15	77,790	36	35	43,462
2013	11	9	7,703	2	2	647	3	2	108	N/A	N/A	N/A	7	6	3,154	33	31	9,760
2014	9	6	4,311	8	7	11,758	7	4	109,733	2	1	2,720	8	5	1,177	50	47	10,330
2015	7	6	28,746	2	2	41,273	N/A	N/A	N/A	6	2	238	10	4	5,397	32	26	21,553
2016	11	7	12,438	5	4	9,328	1	N/A	N/A	N/A	N/A	N/A	10	7	275	27	21	7,540
2017	15	12	70,479	9	8	15,932	2	N/A	N/A	2	N/A	N/A	5	1	140	32	27	4,571
TOTAL	**662**	**469**	**2,154,934**	**442**	**349**	**1,729,414**	**423**	**222**	**1,796,041**	**290**	**96**	**397,687**	**543**	**441**	**1,399,229**	**3,050**	**3,144**	**2,227,992**
YEARLY AVG	**20**	**9**	**44,894**	**13**	**7**	**36,029**	**12**	**4**	**37,417**	**8**	**2**	**8,285**	**16**	**9**	**29,150**	**92**	**74**	**53,047**
Avg # per kill	**4,988**			**5,147**			**9,354**			**4,142**			**3,238**			**716**		