

MISSOURI POLLUTION AND FISH KILL INVESTIGATIONS 2015



Report compiled by
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Missouri Department of Conservation
March 2016



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March 2016

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Central Regional Office and Conservation Research Center
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USE OF DATA

Data and information in this report are distributed for the purpose of 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: Left: Disalvo Lake, Bismarck Conservation Area, St. Francis County, 9/3/2015, cause-natural low dissolved oxygen. Photo taken by Mike Reed, Fisheries Management Biologist. Top-right: Tipton City Park Lake, Moniteau County, suspected blue-green algae bloom. Photo taken by Scott Williams, Fisheries Management Biologist. Bottom-right: Table Rock Lake, Barry County, 8/14/2015, cause-natural low dissolved oxygen kill, protruded swim bladder. Photo taken by Shane Bush, Fisheries Management Biologist.

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 2015, MDC personnel investigated 57 water quality and pollution incidents. Animal mortality was associated with 40 of these incidents. Overall, at least 97,207 animals 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: agricultural, industrial, municipal, transportation, and other. There were 21 regulated incidents, of which 12 involved an animal mortality event. An estimated 74,614 animals valued at \$57,884.23 were killed during regulated source pollution incidents. Municipal pollutants were the most common cause of regulated incidents. Thirty-two non-regulated incidents occurred during 2015. Non-regulated incidents are attributable to natural causes, such as disease, spawning stress, and low dissolved oxygen. All but 6 non-regulated incidents involved a fish kill. Monetary values (damages) for non-regulated fish kills were not calculated because damages for these kills are not reimbursed. Personnel could not determine the cause of 4 incidents (unknown cause). At least 1,040 animals died due to unknown causes.

Cause	Number Incidents	Number Fish Kills
Regulated		
<i>Agriculture</i>	2	2
<i>Industry</i>	0	0
<i>Municipal</i>	7	6
<i>Transportation</i>	6	2
<i>Other</i>	6	2
Subtotal	21	12
Non-Regulated	32	26
Unknown	4	2
Totals	57	40

The summer season had the greatest number of incidents (34), followed by spring (15), fall (7), and winter (1). Most incidents occurred in streams (27), followed by lakes (16), ponds (10), and wetlands (2). One incident occurred in both stream and pond habitat. MDC staff assisted with 1 incident that did not impact waterways.

The DNR and the Missouri Attorney General (AG) enforced the incidents described in this report. Eight cases were resolved during 2015 through legal agreements, which included reimbursements for natural resource damages, reimbursements for investigative time, and civil penalties. Settlement funds totaled over \$300,000. Penalties calculated by DNR and AG totaled over \$600,000. Thirty-three potentially enforceable incidents have not been resolved as of December 31, 2015.

An analysis of long-term trends (1988-2015) shows the number of incidents for most pollution types peaks in the mid- to late 1990s and declines thereafter. Across pollution types, municipal pollutants are historically and currently the dominant cause of pollution incidents.

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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 agencies¹; 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 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 2015.

¹ Other agencies involved during investigations include: 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, the MDC Aquatic Health Unit (AHU) 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 2015, 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 AHU extrapolates the total number of dead fish and wildlife. These methods are labor intensive and therefore are not typically 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 AHU 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, 2015.

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 57 water quality problems during 2015 (Table 1). Fish kills occurred in 40 of the incidents. An estimated 97,207 animals valued at \$57,884.23 were killed during these incidents. 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.

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, non-regulated, and unknown cause incidents can be found in appendices B, C, and D.

Table 1. Summary of fish kill and pollution investigations conducted by MDC staff during 2015. Number of animals killed includes terrestrial and aquatic animals.

Cause	Number Incidents	Number Kills	Number Animals Killed	Value of Animals Killed
Regulated				
<i>Agriculture</i>	2	2	41,273	\$16,233.29
<i>Industry</i>	0	0	0	\$0
<i>Municipal</i>	7	6	28,746	\$40,769.43
<i>Transportation</i>	6	2	238	\$51.52
<i>Other</i>	6	2	4,357	\$829.99
<i>Subtotal</i>	21	12	74,614	\$57,884.23
Non-regulated	32	26	21,553	Undetermined
Unknown	4	2	1,040	Undetermined
Totals	57	40	97,207	\$57,884.23

Regulated Cause

Incidents falling in this category are broken down by the source of pollution: agricultural, industrial, municipal, transportation, and other sources. There were 21 regulated incidents, which accounted for over one third of the incidents (Figure 1). Of the 21 regulated incidents, 12 resulted in the death of aquatic life. An estimated 74,614 fish and aquatic organisms valued conservatively at \$57,884.23 were killed during regulated incidents (Table 1). Municipal source pollutants (e.g. municipal wastewater, drinking water, and electric facilities) were the leading cause of regulated incidents in 2015, accounting for one third of all regulated investigations (Figure 1).

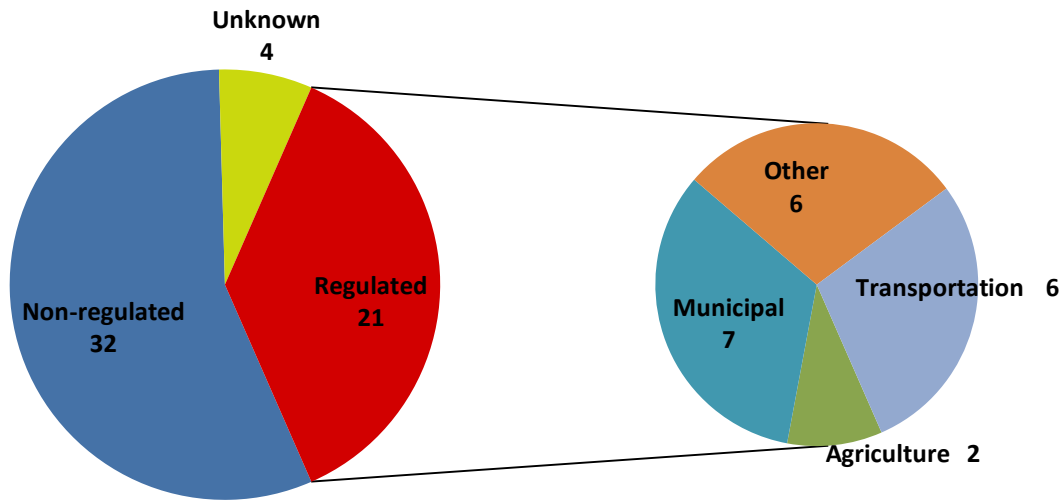


Figure 1. Number of incidents by pollution source in 2015.

Agricultural Source

Agricultural source pollutants include, but are not limited to animal waste, fertilizer, and pesticides. During 2015, agricultural source pollution was associated with 2 incidents. Both incidents resulted in a fish kill. Agricultural incidents accounted for the death of an estimated 41,273 fish and aquatic organisms valued at \$16,233.29 (Table 1).

The most significant agricultural incident occurred in Long Branch and Muddy creeks in Johnson and Pettis counties. Elevated ammonia levels resulted in a complete kill for much of the affected zone. At least 17,474 fish, 23,363 benthic invertebrates including mussels and snails, and 26 tadpoles died during the incident. MDC measured levels of ammonia that were toxic to aquatic life in 16 miles of stream over the course of 7 days. The suspected source of ammonia is the release of chicken waste water and manure from Johnson County Egg Farm. This facility was the source of ammonia during a nearly identical kill during 1989 in this same location. Findings during the MDC fish kill investigation have been provided to DNR, but no enforcement action has been taken to date.

Industrial Source

Industrial source pollutants include but are not limited to chemical, petroleum, and gravel mining operations. MDC did not investigate any incidents that involved industrial source pollutants during 2015.

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 7 incidents. Six of these resulted in the death of at least 28,746 fish valued conservatively at \$40,769.43 (Table 1). Municipal pollutants were the leading cause of regulated incidents in 2015, accounting for one third of all regulated investigations (Figure 1).

The most significant incident falling in this category occurred on August 8, 2015 below Clarence Cannon Dam which impounds Mark Twain Lake. At least 21,950 fish worth \$38,570.43 died below the dam due to low dissolved oxygen levels from dam operations. Clarence Cannon Dam, operated by the US Army Corps of Engineers, has a history of causing fish injury and mortality. During 2015 there were a total of 4 incidents at Clarence Cannon Dam that killed at least 23,274 fish worth more than \$40,687.11 from power generation. There have been ongoing efforts to mitigate fish injury for low dissolved oxygen levels below the Clarence Cannon Dam; however, a permanent long-term solution is still needed.

Transportation Source

Incidents falling within this category involve pollutants originating from pipelines, aviation, rail, and road vehicle sources. Transportation source pollutants were involved in 6 regulated incidents. Two incidents resulted in the death of fish and aquatic life (Table 1).

The most significant incident falling in this category occurred on July 17, 2015 in Lafayette County. Pesticide, fungicide, and fertilizer chemicals from a trailer accident entered Dyer Rock Creek. The contamination killed all fish, crayfish, tadpoles, and frogs for 2 miles of stream. The loss of aquatic and amphibious life and damages was significant; however an assessment was not possible for this incident due to hazardous chemicals and the inaccessibility of the stream.

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 6 incidents, 2 of which resulted in a fish kill (Table 1). An estimated 4,357 fish valued at \$829.99 were killed in these incidents.

The most significant incident falling in the "other" source category occurred on August 29, 2015 in Cooper County. Glycerin, methanol, and propane tanks caught fire at the Missouri Better Bean Company. Chemicals and chlorinated fire suppression run-off entered Stephen's Branch Creek which killed at least 4,332 fish worth \$829.99.

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 56% of all incidents during 2015 (Figure 1). Twenty-six of these incidents were fish kills. At least 21,553 aquatic organisms died during non-regulated incidents. 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; and animals were counted for only 17 of 26 non-regulated incidents. The most significant non-regulated fish kill occurred on Disalvo Lake in St. François County on September 3, 2015. An estimated 13,500 fish died due to low dissolved oxygen.

More suspected blue-green algae blooms were reported during 2015 compared to previous years. It is unclear if this increase is attributed to increased vigilance or changing climate and environmental conditions. In the summer of 2015, a total of six incidents were attributed to blue-green algae blooms. Algal toxins were detected in three of the six blue-green incidents.

Unknown Cause

Personnel were unable to identify the cause of the problem for four incidents, two of which involved the loss of fish and wildlife (Table 1, Figure 1). For these incidents, a cause was suspected, but investigators were unable to confirm the cause. Additionally, a responsible party was not identified for these incidents, which hindered the investigation. At least 1,000 fish and 40 birds died due to unknown causes. The monetary values for these animals were not calculated.

The most significant incident falling in this category occurred in Callaway County on March 13, 2015. At least 40 bird carcasses were found. The birds looked as though they had fallen from their roosts and had been dead for several days. No cause was identified.

TEMPORAL DISTRIBUTION

In general, the distribution of kills throughout the year exhibited a bell-shaped pattern (Figure 2). This is similar to previous years (O’Hearn and Martin 2014). Across seasons, the most incidents occurred during summer (June through August), followed by spring (March through May), fall (September through November), and winter (December through February). The number of regulated and non-regulated incidents also followed this pattern.

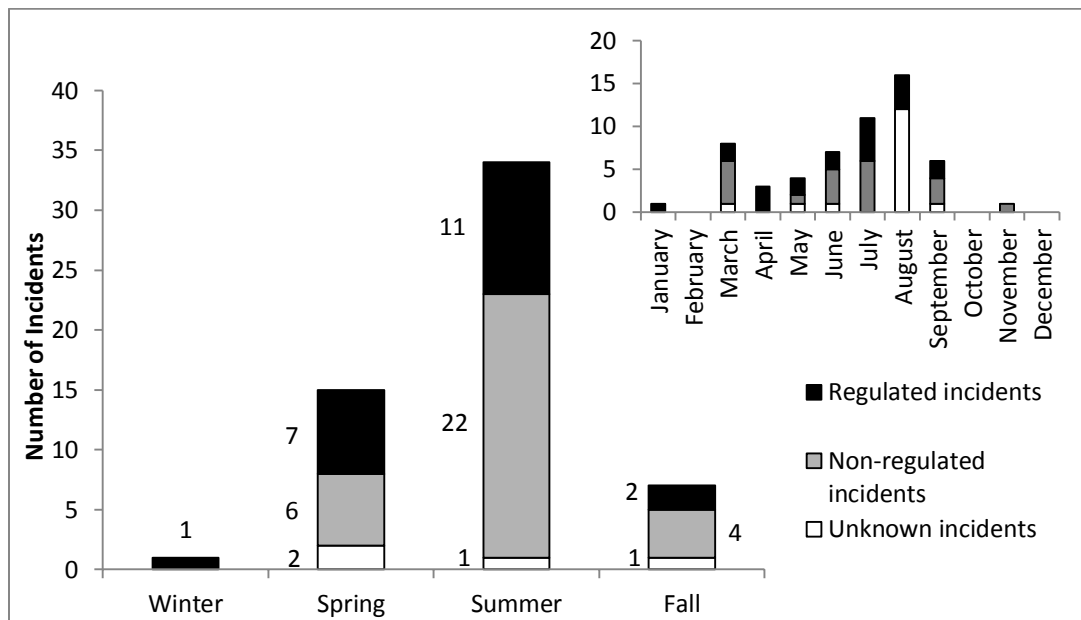


Figure 2. Monthly and seasonal distribution of regulated, non-regulated, and unknown source incidents during 2015.

DISTRIBUTION OF INCIDENTS THROUGHOUT THE STATE

Investigations took place in 38 of 115 counties. The Central Region experienced the most incidents (15, Figure 3), while the Northwest Region experienced only 1 incident. Among counties, Boone County had the highest number of incidents (6) followed by Jackson County (5). Among major source categories, the most regulated incidents occurred in Ralls County (4) followed by St. Louis County with two regulated incidents (Figure 4). One regulated incident occurred in both Johnson and Pettis counties. The most non-regulated incidents occurred in Boone County (5) followed by Jackson County (3). One non-regulated incident occurred in both Barry and Stone Counties.

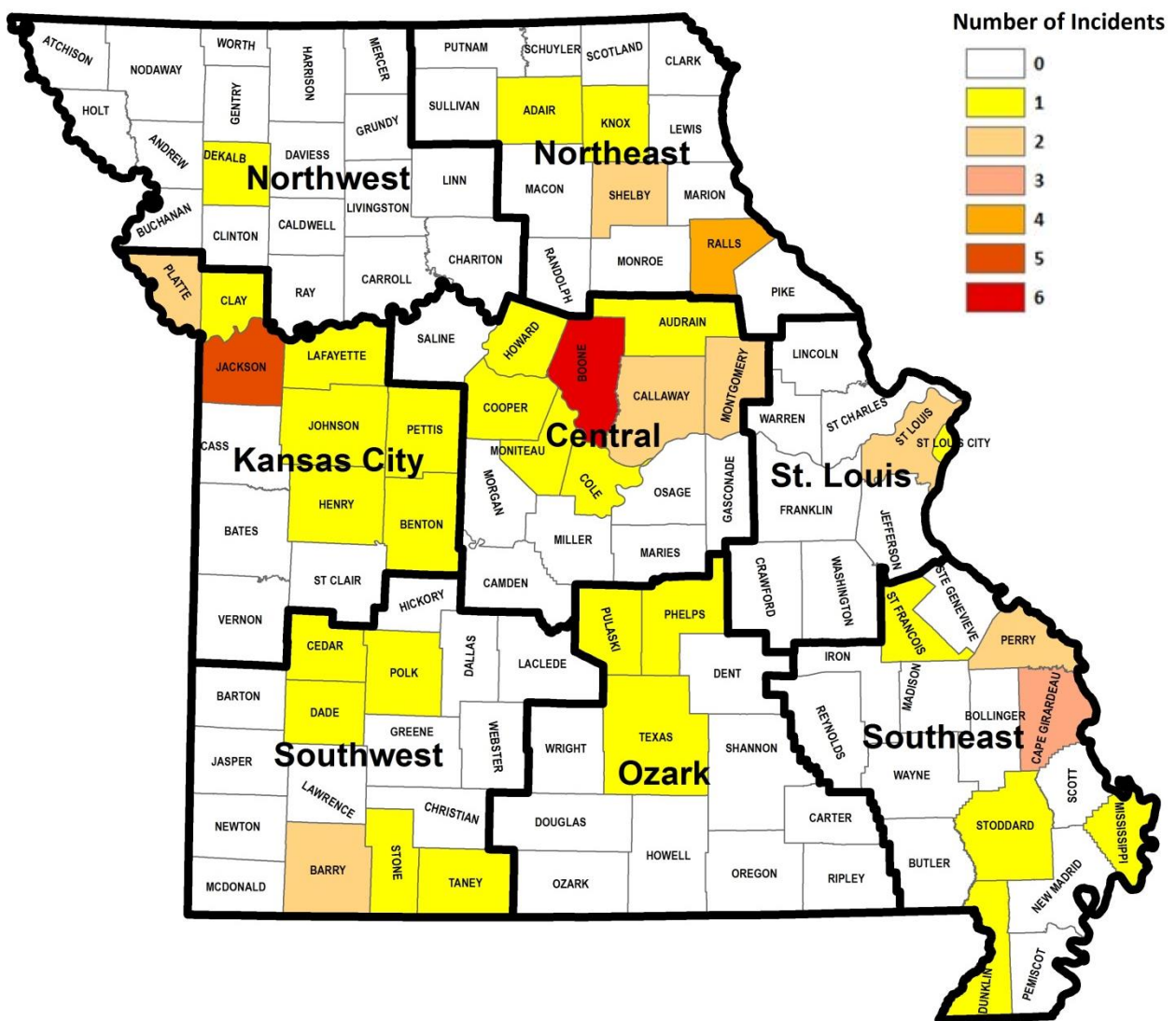


Figure 3. Map of number of incidents during 2015 per county. The eight regions for the Missouri Department of Conservation are outlined in bold

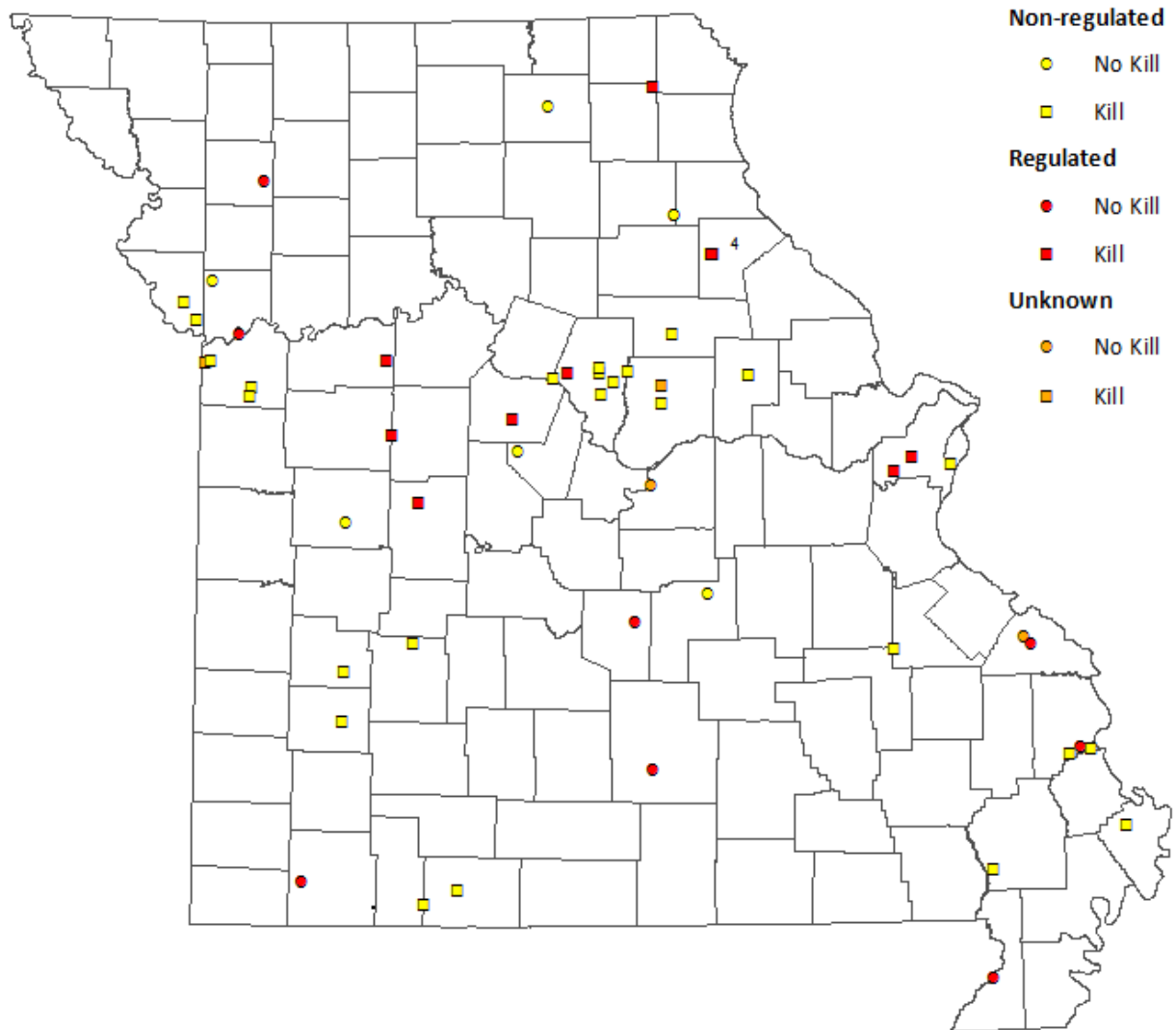


Figure 4. Map of regulated, non-regulated, and unknown source investigations conducted by Missouri Department of Conservation personnel during 2015. Points are located at the most upstream portion of the affected zone for incidents occurring in streams. Squares indicate fish kills and circles indicate investigations without fish kills. The square to the left of the “4” in Northeast Missouri represents the four fish kills occurring below Clarence Cannon Dam.

DISTRIBUTION BY HABITAT TYPE

Among habitat types, incidents occurred more often in streams than in lakes, ponds, and wetland habitats (Figure 5). This is consistent with trends from past years where streams were most common habitat for incidents (O’Hearn and Martin 2014). Regulated source pollutants were the leading cause of stream incidents (70%). Non-regulated causes were the most common type of incident in lakes, ponds and wetland habitats (93%-100%). One regulated incident occurred in both stream and pond habitats. One incident did not involve waterways.

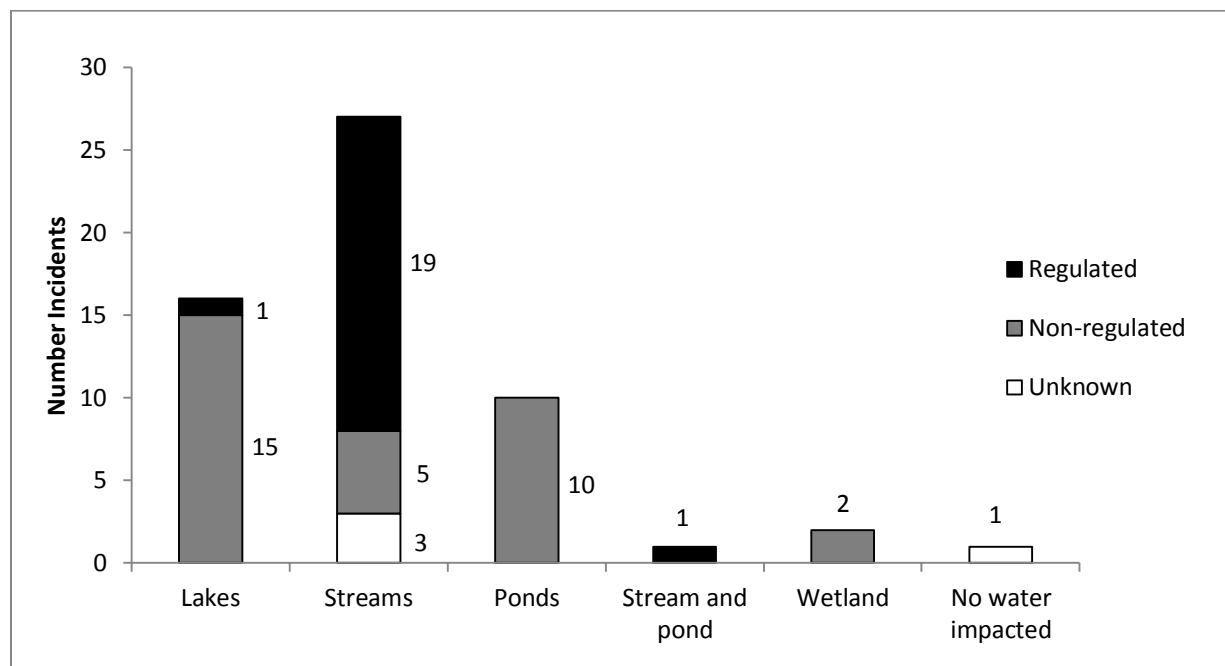


Figure 5. Distribution of incidents during 2015 by habitat type.

ENFORCEMENT STATUS OF FISH KILL AND POLLUTION CASES

Eight incidents were resolved during 2015. Three of these incidents occurred during 2011, one in 2012, one in 2013, and three in 2014. The Missouri Department of Natural Resources and the Missouri Attorney General enforced the cases described in this section. The majority of cases were resolved through settlement agreements, which included reimbursements of natural resource damages, reimbursements of investigative costs, and civil penalties.

Settlement funds totaled over \$300,000. Settlement funds include damages for natural resources, including injured animals, and investigative costs. Damages totaled \$247,880.83. Of the damage funds, \$132,818.56 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 Chemical Emergency Preparedness Fund and Natural Resources Damages Fund outside of MDC. MDC received \$39,102.33 in reimbursements for investigative costs, which was also transferred to the MDC Fish Kill Grant Fund. Penalty monies and costs for supplemental environmental projects and mitigation projects were assessed by the DNR and totaled over \$600,000. Penalty monies were transferred to the school district of the county in which the pollution occurred.

Thirty-three cases remain open: one from 2010, two from 2011, two from 2012, nine from 2013, eight from 2014, and eleven from 2015. The US Army Corps of Engineers has been identified as the alleged responsible party for eight of these open cases. Three of the thirty-three open cases were caused by eutrophication from University of Missouri Dairy Farms in Boone County. 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 ninety percent 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 water quality and aquatic habitat. No proposals were awarded during 2015 due to limited funds available.

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 22 out of 28 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). The exception to this generalization is fish kills caused by transportation sources, which have fluctuated between 0 and 5 incidents per year since 1988 (Figure 7D).

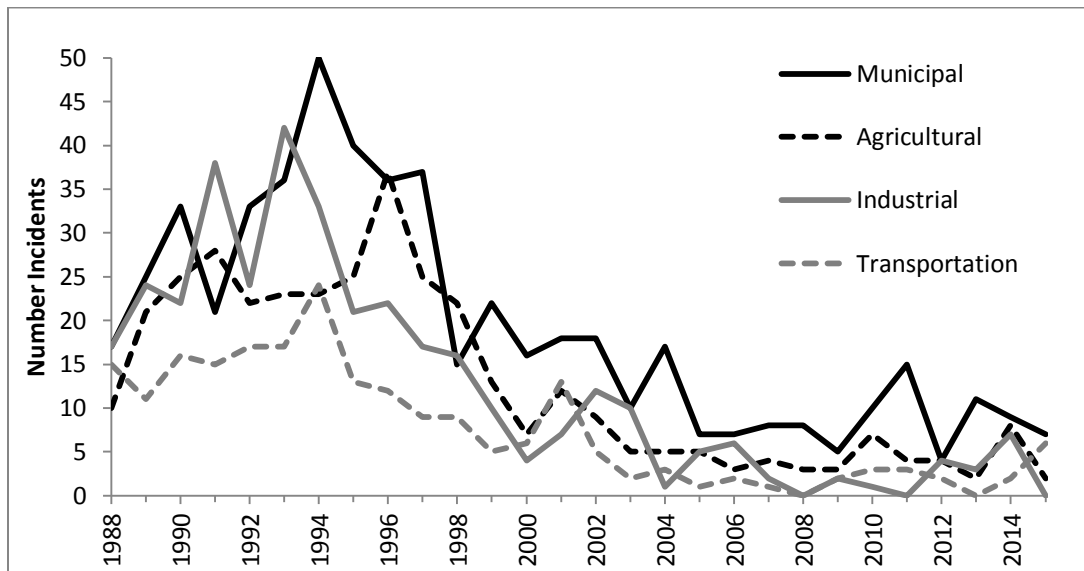


Figure 6. Long-term (1988-2015) trends in regulated incidents. The “other” source category involves miscellaneous pollution sources and is not included in the figure

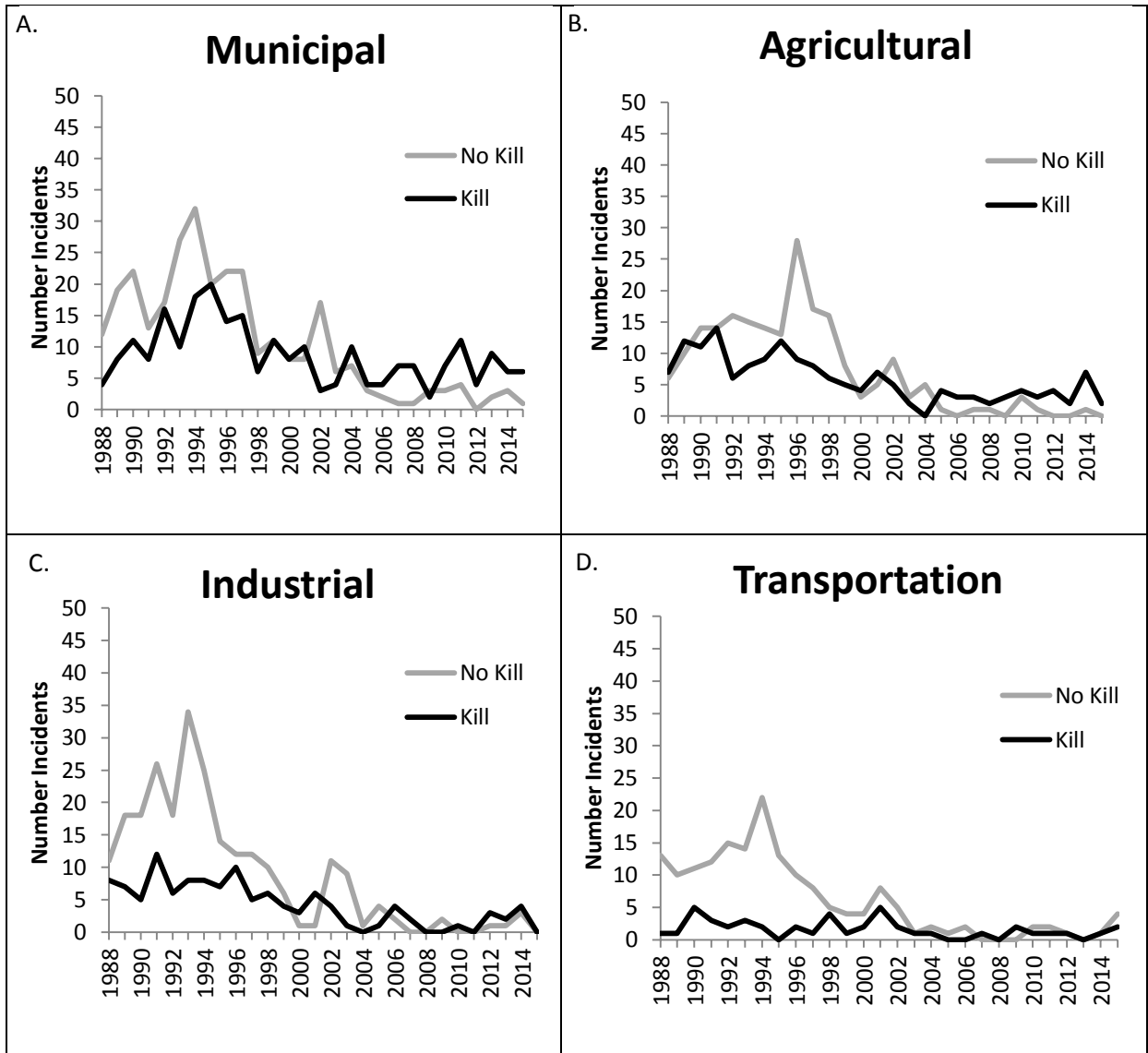


Figure 7. Long-term (1988-2015) trends for regulated fish kill and pollution incidents caused by municipal (A), agricultural (B), industrial (C), and transportation (D) sources. The “unknown” and “other” categories are not included in this figure because they contain incidents with wide ranging pollution 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 2015, MDC was involved in 57 fish kill and pollution investigations. Over 97,207 fish and other animals valued at \$57,884.23 were killed during these incidents. Eight incidents which occurred during previous years have been resolved through settlement agreements. Settlement funds totaled over \$300,000.

Despite the program's successes, there remain areas of concern. The 16 mile long fish kill that persisted for weeks in Long Branch and Muddy creeks in Johnson and Pettis counties is deeply concerning. MDC's investigative findings have been provided to DNR, but no enforcement action has been taken to date (pages 5, 16, and 24). One area of concern highlighted in this report is ongoing fish kills caused by dams at power facilities. Fish kills at three separate power facilities are described in this report: Clarence Cannon Dam in Ralls County (pages 6, 16 and 25), Truman Dam in Benton County (page 22), and Montrose Dam in Henry County (page 24). Operations at these three facilities have caused fish kills since the late 1970s to early 1980s. To date, long-term permanent solutions have not been implemented to abate fish kills at these locations.

LITERATURE CITED

Anderson, R. O., and R. M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447-482 in B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland

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 R. Martin 2014. Missouri pollution and fish kill investigations 2012-2013. Missouri Department of Conservation. 42 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. Significant program accomplishments during 2015.

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 2015:

Monitoring

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. We are hopeful that the replacement of a bridge in December 2015 to allow for fish migration will expedite recovery in the next few years.

Water Quality Monitoring

The Fish Kill Program initiated an annual monitoring coordination meeting with DNR during October 2015. The goals of the coordination meeting are to prevent duplication of effort between the two agencies, coordinate communication with landowners when seeking permission to enter their property, communicate waters of concern or special interest to the DNR, and develop strategies to monitor or address concerns.

Training

Fish Kill Procedures

Training on water pollution and fish kill investigation procedures was given to Conservation Agent trainees during summer 2015. 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.

Organizational Changes

Although not an accomplishment, one of the more notable events during 2015 was the retirement of the Aquatic Health Unit supervisor as of December 31 and the subsequent combining of the Aquatic Health Unit and the Wildlife Health Program. The combined unit, named the Wildlife and Aquatic Health Unit (WAHU), will go into effect on July 1, 2016.

Other Miscellaneous

Missouri pollution and fish kill investigations 2014 report was completed during November 2015.

Appendix B. Summary of regulated source incidents during 2015. Data is listed alphabetically by county. Cr=creek, trib=tributary, Lk=lake, low DO= low dissolved oxygen, ND= not determined, NC= not calculated

County	Waterbody Name	Incident Date	Source	Cause	Number Animals Killed	Value
Barry	Talbert Branch trib of Shoal Cr	4/11/15	Other	Removing creek gravel	0	-
Benton	Little Tebo Cr, trib	9/8/15	Municipal	Sewage discharge & algal bloom	5,164	NC
Boone	Dairy Farm Lk No. 1	8/22/15	Agricultural	High nutrients from manure waste	410	\$822.42
Cape Girardeau	Ranney Cr	7/10/15	Other	Turf Marker Blue Colorant	0	-
Cooper	Stephen's Branch	8/29/15	Other	Chemical toxicity, low DO, fire suppression water	4,332	\$829.99
DeKalb	Grindstone Cr	4/22/15	Transportation	Diammonium phosphate, pot ash, and diesel fuel	0	-
Dunklin	St. Francois River	3/20/15	Other	Hydraulic/motor oil	0	-
Jackson	Missouri River	7/27/15	Transportation	Dirt race track chemicals (suspected)	0	-
Johnson/Pettis	Long Branch Cr and Muddy Cr	4/29/15	Agricultural	Chicken waste water and manure (suspected)	40,863	\$15,410.87
Knox	North Fabius River	5/17/15	Other	Bulldozer channelizing river	25	NC
Lafayette	Dyer Rock Cr	7/17/15	Transportation	8 gal mustang maxx, 63 gal crobkarb, 20 gal quilt xcel	ND	NC
Perry	Dry Run Branch Cr	3/25/15	Other	Unknown petroleum product waste	0	-
Pulaski	Gasconade River	5/28/15	Municipal	Sewage release	0	-
Ralls	Turbine Bay, Clarence Cannon Dam	6/22/15	Municipal	Low DO	100	NC
Ralls	Turbine Bay, Clarence Cannon Dam	8/3/15	Municipal	Low DO	1,024	\$1,621.60
Ralls	Rereg Pool, Clarence Cannon Dam	8/8/15	Municipal	Low DO	21,950	\$38,570.43
Ralls	Turbine Bay, Clarence Cannon Dam	9/8/15	Municipal	Low DO	200	\$495.08
Shelby	Hunnewell Cr	1/20/15	Transportation	Overtuned waste pumping truck	0	-
St. Louis	Meramec River trib	6/9/15	Transportation	Decaying soybean meal, train derailment	238	\$51.52
St. Louis	Grand Glaize Cr	7/13/15	Municipal	Chlorinated drinking water	308	\$82.32
Texas	Elk River and Piney River	7/8/15	Transportation	Milk truck spill	0	-

Appendix C. Summary of non-regulated source incidents during 2015. Data is listed alphabetically by county. Cr=creek, Lk=lake, low DO= low dissolved oxygen, ND=not determined

County	Waterbody Name	Incident Date	Cause	Number Animals Killed
Adair	Spur Pond	7/14/15	Blue-green algae	0
Audrain	Private Pond	8/1/15	Natural	ND
Barry/Stone	Table Rock Lk	7/27/15	Natural, low DO	1,208
Boone	Philips Lk	3/9/15	Winter Kill	238
Boone	Private Pond	8/1/15	Natural	ND
Boone	Private Pond	8/1/15	Natural	ND
Boone	Cedar Cr	8/13/15	Low flow log jam, low DO	40
Boone	Subdivision pond	9/11/15	Turnover	62
Callaway	Private Pond	8/1/15	Natural	ND
Cape Girardeau	Headwaters Division Channel	8/5/15	Natural	25
Cape Girardeau	Marquette Lk	8/7/15	Natural	50
Cedar	Stockton Lk	3/17/15	Winter kill	25
Clay	Smithville Reservoir	7/13/15	Blue-green algae	0
Dade	Turnback Cr and Sac River	7/10/15	High waters	ND
Henry	Truman Reservoir-South Grand River Arm	7/14/15	Blue-green algae	0
Howard	Diana Bend Conservation Area wetland	9/18/15	Flood waters receding	100
Jackson	Legacy Park Lk	5/11/15	Spawning stress, disease	500
Jackson	Jack Rabbit Lk	8/7/15	Algal bloom, high pH	200
Jackson	Brush Cr	8/25/15	Low DO	600
Mississippi	Beasly Park Pond	3/29/15	Natural	25
Moniteau	Tipton City Park Lk	8/31/15	Blue-green algae bloom, purple scum	0
Montgomery	Private Pond	8/1/15	Natural	ND
Montgomery	Private Pond	8/1/15	Natural	ND
Phelps	Little Prairie Lk	6/6/15	Blue-green algae	0
Platte	Berlin Reservoir	3/27/15	Low DO	25
Platte	Lake Waukomis	6/24/15	Natural, disease	1,000
Polk	Pomme De Terre Lk	3/9/15	Winter Kill	5
Shelby	Hunnewell Lk	6/19/15	Blue-green algae	0
St. Francois	Disalvo Lk	9/3/15	Low DO in plunge pool	13,500
St. Louis City	River Des Peres	7/22/15	Flood waters receding	ND
Stoddard	Otter Slough Conservation Area	6/24/15	Low DO	3,430
Taney	Lake Taneycomo	11/24/15	Low DO	520

Appendix D. Summary of incidents caused by unknown sources during 2015. Data is listed alphabetically by county.

County	Waterbody Name	Incident Date	Suspected Cause	Number Animals Killed
Callaway	Bird Kill (no water impacted)	3/13/15	unknown	40
Cole	Osage River near Mari Osa Delta	6/5/15	sheen on river	0
Jackson	Brush Creek	5/6/15	construction or sewage over flow	1,000
Perry	Berome Moore Cave	9/4/15	spray paint odor	0

Appendix E. Summary of Clean Water Law settlements reached by the State of Missouri during 2015 for incidents involving MDC. This table includes damages (monetary value of animals) and penalties, which are not assessed by MDC. This table does not include investigative costs for DNR. Data is listed alphabetically by county. Cr=creek, trib=tributary.

County	Waterbody Name	Incident Date	Responsible Party	Cause	Reimbursements		MDC Total	Penalty (MDC does not calculate)
					Fish Damages	MDC Investigative Costs		
Barry & Lawrence	Clear Cr.	5/23/14	Tyson Foods	Alimet, ammonia toxicity	\$130,988.26	\$36,026.05*	\$167,014.31	\$330,000+
Boone	Flat Branch Cr., trib	9/21/12	University of Missouri	Sulfuric acid dump	\$130.75	\$572.03	\$689.71	\$205,500+
Cooper	Pisgah Cr., trib	5/30/14	Buschjost Farms	Hog manure, ammonia toxicity	Unable to assess	\$214.89	\$214.89	\$2,000
Crawford	Pleasant Valley Cr.	12/9/11	Ozark Mountain Technologies	Wastewater release, low dissolved oxygen	\$48.87	\$445.14	\$489.13	\$90,000
Macon	Sulfer Cr.	8/9/11	City of Bevier	Raw sewage from line break	\$4.23	\$257.71	261.94	\$0
Saline	Unnamed trib	11/7/11	Bernard Bergfrede	Swine farm wastewater, ammonia toxicity	\$0.00	\$255.39	\$255.39	\$1,500
Shelby	Tiger Fork trib	6/2/13	Danny Bevill	Land applied swine farm wastewater	\$243.83	\$1,060.99	\$1,304.82	\$7,000
Sainte Genevieve	Fourche a Du Clos Cr.	2/13/14	Wallis Oil Company	Tanker accident, ethanol & low dissolved oxygen	\$1,605.50	\$270.13	\$1,715.08	\$0

*includes future monitoring costs

+includes Supplemental Environmental Project

Appendix F. Brief descriptions of closed and open cases listed alphabetically by county for 2015.

Closed Cases (Resolution)

Cases closed after resolution was reached.

Barry County (5/23/14), Tyson Foods

Tyson Foods 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 heavy to total 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. Based on fish counts alone, this is the third most significant fish kill within the past 20 years in Missouri. A consent judgement was signed in January 2015. Tyson paid a \$110,000 civil penalty with up to \$5,000 per day in stipulated penalties. MDC was reimbursed \$36,026.05 for investigative costs, including future recovery monitoring costs, and \$130,988.26 for fish damages. Tyson also reimbursed the state for water quality damages in the amount of \$31,910.52. A supplemental environmental project (SEP) was required as part of the judgement. The SEP included a bridge replacement (\$210,000) and contribution of \$10,000 to the James River Basin Partnership. Follow-up monitoring 1 year post-kill showed recolonization of fish is occurring; however, the number of fish, number of species, and size composition indicate the stream is far from fully recovered. Total recovery of the fish community will take several more years. We are hopeful that the bridge replacement in December 2015 will expedite recovery in the next few years.

Boone County (9/21/12), University of Missouri

Twenty-five gallons of sulfuric acid was poured down a drain at a University of Missouri facility that discharged directly into a tributary of Flat Branch Creek. The pollutant flowed approximately 0.25 miles before it was contained by a sand bag dam. De-chlorinated water was pumped into the affected stream to dilute the acid and then the solution was pumped into a nearby sewer pipe. At least 32 fish, 57 crayfish, and numerous aquatic worms and other invertebrates were killed valued at \$130.75. An Abatement Order was executed in October 2015. The University paid a \$5,500 civil penalty, completed a \$200,000 supplemental environmental project, and reimbursed the state for investigative time and damages. MDC was reimbursed \$572.03 for investigative costs and \$117.68 for fish damages.

Cooper County (5/30/14), Buschjost farm

MDC responded to a reported spill of hog manure into a tributary of Pisgah Creek on May 30th. During the investigation, the responder noticed remnants of the discharge high on the stream banks indicating the spill occurred several days prior to the investigation. The DNR responder observed dead worms in the stream confirming the spill caused acute toxicity to aquatic life. The MDC responder did not observe dead fish on site. However, MDC suspects fish died as a result of the spill, but were scavenged before we were alerted to the discharge. An abatement order on consent was signed in February 2015. The responsible party paid a \$2,000 civil penalty and reimbursed the state for investigative costs and expenses. MDC was reimbursed \$214.89 for investigative costs.

Crawford County (12/9/11), Ozark Mountain Technologies

A mechanical issue at the City of Cuba's wastewater treatment plant allowed solids and partially treated wastewater to enter Pleasant Valley Creek lowering the dissolved oxygen and killing at least 146 fish. A consent judgement was signed in June 2015. The responsible party reimbursed the state \$48.87 for dead fish, \$82,948.87 for water quality natural resource damages, and \$2,002.26 for investigative time. They were also charged a \$90,000 civil penalty for the violation and faced up to \$600 per day in stipulated penalties.

Macon County (8/9/11), City of Bevier

A sanitary sewage system overflow caused a small fish kill in Sulfur Creek. Approximately 30,000 gallons of wastewater was discharged. Six dead bullheads were found and approximately 400 to 500 live bullheads were seen piping for oxygen at the surface. An Abatement Order was executed in November 2015 which ordered the immediate implementation of BMPs related to storm water discharge issues observed on the property and a payment of \$5,139.51 to the state for investigative costs and damages. The City was also charged \$5,000 in civil penalties, which were suspended if the City did not violate Clean Water Law for two years following the execution of the abatement order and face up to \$500 per day in stipulated penalties if they violate the terms of the order.

Saline County (11/7/11), Bernard Bergfrede, Swine farm

A hog farm had discharged a large volume of manure effluent that contaminated an unnamed tributary. The spill caused the water in the tributary to turn red. About 40-50 dead fish were reported to MDC by DNR. A consent judgement was signed in March 2015. The responsible party, Bernard Bergfrede, was required to monitor and land apply animal waste at a rate and volume that prevents runoff into waters of the state and prevents a discharge of animal waste through the tile drains into waters of the state. Mr. Bergfrede paid a penalty of \$1,500 and faced stipulated penalties of \$2,500 per pollution event in the future. The state was reimbursed \$2,745.40 for investigative costs.

Shelby County (6/2/13), Danny Bevill, Hog farm operation

Hog manure from land application run-off affected 0.75 miles of an unnamed tributary of Tiger Fork. Low dissolved oxygen levels and ammonia toxicity (suspected) killed at least 645 aquatic organisms valued at \$243.83. An abatement order on consent was signed in May 2015. Mr. Bevill was charged a \$7,000 penalty for violations and faced up to \$500 per day in stipulated penalties. The state was reimbursed \$243.83 for dead fish and \$2,759.73 for investigative costs.

Ste. Genevieve County (2/13/14), Wallis Oil Company

A tanker accident led to the release of ethanol into Fourche a Du Clos Creek. Fire suppression foam used to extinguish the vehicle fire also entered the stream. An estimated 2,720 fish, crayfish, and frogs were killed due to the spill. These animals are valued at \$1,605.50. An abatement order on consent was signed in January 2015. Wallis Oil Company reimbursed the state \$1,605.50 for dead fish and \$442.07 for investigative time.

Closed Cases (No Resolution)

Jasper County (10/3/13), Carthage Levee District

Dewatering of the Spring River-Carthage Millrace for gate repairs caused the death of at least 109 fish valued at \$517.32. This case was closed because waters of the state were not impacted.

Open Cases

The following cases are currently (as of December 31, 2015) being evaluated by DNR Compliance and Enforcement group in the Water Pollution Control Branch of the Water Protection Program or are still under investigation.

Audrain County (5/10/14), Wilson Feed Lot

Hog lagoon effluent was discharged into a tributary of Young's Creek killing at least 7,180 fish in about 1 mile of stream. Fish were valued at \$1,002.58.

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 shoot 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 (9/8/2015), City of Lincoln

Waste water discharges from the City of Lincoln's waste water treatment facility resulted in unsightly algal blooms in a tributary of Little Tebo Creek, and a private reservoir which impounds the effected tributary experienced a large fish kill as a result of the increased nutrient load from the facility.

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.

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 (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.

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.

Cape Girardeau County (10/16/14), Fruitland American Meat

Lagoon waste from the Fruitland American Meat processing plant was released into an unnamed tributary and then to Cane Creek. This release resulted in the death of at least 917 fish valued at \$171.65.

Cass County (8/21/14), City of Belton

The City of Belton discharged a large quantity of sewage while in the process of moving an active sewer line. The sewage flowed into Oil Creek killing at least 520 fish valued at \$421.89. Many species of fish were killed ranging from 1 inch to over 20 inches in body length. The kill zone extended 0.75 miles downstream of the source.

Cass County (9/30/13), City of Belton

A lift station malfunction caused a sewage discharge into East Creek and West Fork East Creek. Low dissolved oxygen and high ammonia conditions were likely the cause of death of 415 fish valued at \$556.23.

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.

Cooper County (8/29/2015), 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 (4/5/13), City of St. Clair

A bypass at a lift station caused sewage to overflow from an emergency storage basin into Birch Creek, a tributary of Bourbeuse River.

Henry County (6/13/11), Kansas City Power and Light

A fish kill in Deepwater Creek below Montrose Dam was caused by low dissolved oxygen levels from dewatering and physical trauma from subsequent spillway releases. At least 416 fish valued at \$323.84 were killed during the incident. Fish kills below Montrose Dam are a recurring problem dating back to 1975.

Henry County (5/24/13), Kansas City Power and Light

A power plant malfunction at the Montrose facility caused a low dissolved oxygen fish kill at Montrose Lake. At least 133 fish valued at \$4,582.59 died. Seventeen of these fish were memorable and trophy sized flathead catfish as defined by Anderson and Neumann (1996), which are not only slow growing and long-lived, but highly sought after sports fish.

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.

Perry County (9/30/14), City of Perryville

A lift station owned by the City of Perryville failed and was inoperable for approximately 16 hours, which resulted in a discharge of raw sewage into a tributary of Hunt Branch. Our investigator observed a small fish kill consisting of 30 dead green sunfish and stonerollers (1-3 inches in length) valued at \$7.19.

Pettis County (4/29/15), Johnson County Egg Farm (suspected)

MDC measured levels of ammonia that were toxic to aquatic life in 16 stream miles over the course of 7 days in Long Branch and Muddy creeks. 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. These animals were valued conservatively at \$15,410.87. This farm was also responsible for a nearly identical fish kill in 1989, in which MDC determined natural recovery of the fish community would require more than five years. The value stated above is conservative in that it does not include interim losses over a five year recovery period.

Ralls County (7/8/13, 7/21/14, 2015: 6/22, 8/3, 8/8, 9/8), U.S. Army Corps of Engineers under direction of Southwest Power Administration

Since the 19080s, 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.

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 (6/9/15), Arcadis (suspected)

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.

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.

Appendix G. Summary of pollution investigation, fish kills, and estimated mortality (1970-2015) Data are incomplete prior to 1985. I=number incidents, K=number kills, #=number of dead animals, N/A=not available

Year	MUNICIPAL			AGRICULTURAL			INDUSTRIAL			TRANSPORTATION			OTHER			NON-REGULATED		
	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.

Year	MUNICIPAL			AGRICULTURAL			INDUSTRIAL			TRANSPORTATION			OTHER			NON-REGULATED		
	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
TOTAL	636	450	2,072,017	428	337	1,704,154	420	222	1,796,041	288	96	397,687	528	433	1,398,814	2,991	3,096	2,215,881
YEARLY AVG	20	9	45,043	13	7	37,046	13	4	39,044	9	2	8,645	17	9	30,409	96	77	55,397
Avg per kill	5,004			5,292			9,761			4,322			3,378			719		