

MISSOURI POLLUTION AND FISH KILL INVESTIGATIONS 2014



Report compiled by
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Missouri Department of Conservation
November 2015



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Resource Science Division

November 2015

Missouri Department of Conservation
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 photograph: dead fish in an unnamed oxbow lake by Lake of the Ozarks, Benton County, 6/26/2014, cause-natural algae bloom: low dissolved oxygen. Photo taken by Mike Bayless, 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 2014, MDC personnel investigated 84 water quality and pollution incidents. Animal mortality was associated with 70 of these incidents. Overall, at least 140,029 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: agricultural, industrial, municipal, transportation, and other. There were 31 regulated incidents, of which 20 involved a kill. An estimated 128,587 animals valued at \$142,170.88 were killed during regulated source pollution incidents. Municipal pollutants were the most common cause of regulated incidents. Fifty non-regulated incidents occurred during 2014. Non-regulated incidents are attributable to natural causes, such as disease, spawning stress, and low dissolved oxygen. All but 3 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 3 kills (unknown cause). At least 1,112 animals were lost due to unknown causes.

Cause	Number Incidents	Number Kills
Regulated		
<i>Agriculture</i>	8	7
<i>Industry</i>	7	4
<i>Municipal</i>	9	6
<i>Transportation</i>	2	1
<i>Other</i>	5	2
Subtotal	31	20
Non-Regulated	50	47
Unknown	3	3
Totals	84	70

The spring season had the greatest number of incidents (31), followed by summer (22), fall (19), and winter (12). Most incidents occurred in lakes and ponds (48), followed by streams (31), and wetlands (3). MDC staff assisted with 2 incidents that did not impact waterways.

DNR and the Attorney General enforced the incidents described in this report. Four cases were resolved during 2014 through legal agreements, which included reimbursements for fish and wildlife damages, reimbursements for investigative time, and civil penalties. Settlement funds totaled nearly \$10,000. Penalties calculated by DNR and the Attorney General totaled over \$18,000. Twenty-eight potentially enforceable incidents have not been resolved as of December 31, 2014.

An analysis of long-term trends (1988-2014) 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.

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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 2014.

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, 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 2014, 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 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 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, 2014.

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 84 water quality problems during 2014 (Table 1). Fish kills occurred in 70 of the incidents. An estimated 140,029 fish and aquatic organisms valued at \$142,170.88 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 2014. Number of animals killed includes other animals in addition to fish.

Cause	Number Incidents	Number Kills	Number Animals Killed	Value of Animals Killed
Regulated				
<i>Agriculture</i>	8	7	11,758	\$8,968.47
<i>Industry</i>	7	4	109,733	\$131,167.83
<i>Municipal</i>	9	6	4,311	\$429.08
<i>Transportation</i>	2	1	2,720	\$1,605.50
<i>Other</i>	5	2	65	Undetermined
<i>Subtotal</i>	31	20	128,587	\$142,170.88
Non-regulated	50	47	10,330	Undetermined
Unknown	3	3	1,112	Undetermined
Totals	84	70	140,029	\$142,170.88

Regulated Cause

Incidents falling in this category are broken down by the source of pollution: agricultural, industrial, municipal, transportation, and other sources. There were 31 regulated incidents, which accounted for over one third of the incidents (Figure 1). Of the 31 regulated incidents, 20 resulted in the death of fish and wildlife. An estimated 128,587 animals valued conservatively at \$142,170.88 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 2014, accounting for 29% of all regulated investigations (Figure 1).

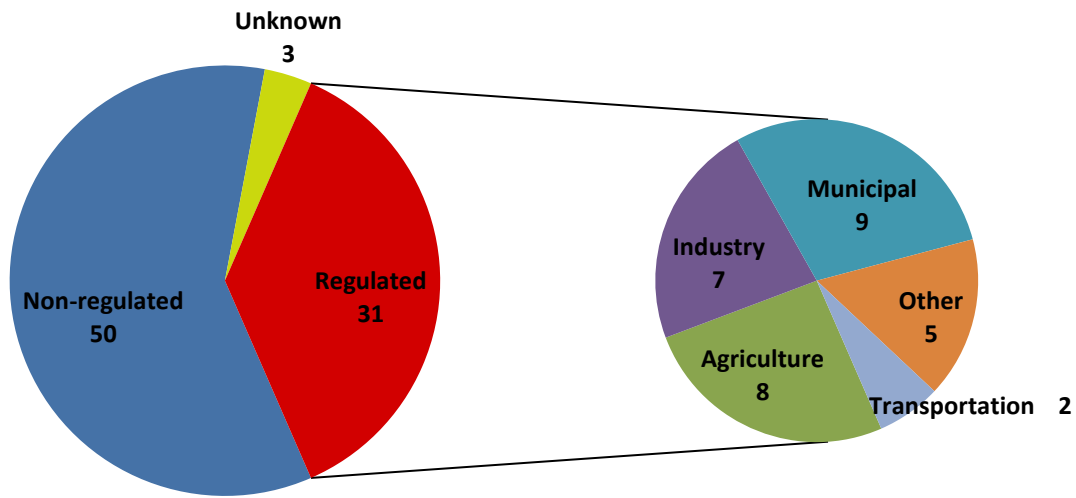


Figure 1. Number of incidents by pollution source in 2014.

Agricultural Source

Agricultural source pollutants include, but are not limited to animal waste, fertilizer, and pesticides. During 2014, agricultural source pollution represented 8 incidents, of which 7 resulted in the loss of an estimated 11,758 aquatic organisms valued at \$8,968.47 (Table 1).

For agricultural incidents, the most fish mortality occurred in University of Missouri Dairy Farm Lake #3 in Boone County on July 3, 2014. Land application of manure resulted in excessive algal growth which caused oxygen depletion. At least 3,945 fish valued at \$7,808.26 died during the incident. Fish kills in this reservoir and nearby Dairy Farm Lake #1 are recurring due to routine land application of dairy farm manure. Installation of an effective water aerator in both reservoirs is needed to prevent future fish kills.

Industrial Source

Industrial source pollutants include but are not limited to chemical, petroleum, and gravel mining operations. Industrial source pollutants were involved in 7 incidents, of which 4 resulted in the loss of at least 109,733 fish, crayfish, and mussels valued at \$131,167.83 (Table 1).

The most significant industrial fish kill was caused by Tyson Foods in Barry County. During mid-May, Tyson Foods disposed of a low pH solution of Alimet through the Monett waste water treatment plant which killed denitrifying microbes within the plant. Without the plant microbes, denitrification was not taking place in the plant resulting in a high concentration of ammonia in the plant's discharge effluent. This caused a heavy to total kill for over 5 stream miles. Fish morbidity and mortality were observed for several days. Approximately 108,711 fish and 98 crayfish valued at \$130,988.26 died of ammonia toxicity. Based on fish counts this is the largest fish kill in 2014 and the third largest fish kill within the past 20 years in Missouri.

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 9 incidents. Six of these resulted in the death of at least 4,311 aquatic organisms valued conservatively at \$429.08 (Table 1). Municipal pollutants were the leading cause of regulated incidents in 2014, accounting for 29% of all regulated investigations (Figure 1).

The most notable municipal fish kill during 2014 occurred below Clarence Cannon Dam which impounds Mark Twain Lake. At least 1,019 fish died due to low dissolved oxygen levels from power generation. This fish kill is significant because of the long standing history of fish injury and mortality resulting from operation of the dam. In recent past there have been efforts to mitigate fish injury for low dissolved oxygen levels below the 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 2 regulated incidents. One incident resulted in a fish kill (Table 1). On February 13, 2014 a tractor trailer from Wallis Oil Company overturned dumping 7,600 gallons of ethanol. The ethanol and fire suppression foam used to extinguish a vehicle entered Fourche a Du Clos Creek in Ste. Genevieve County. At least 2,460 fish, 250 crayfish, and 10 frogs valued at \$1,605.50 died during the incident.

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, 2 of which resulted in a fish kill (Table 1). An estimated 65 aquatic organisms were killed in these incidents. Values were not calculated for these incidents because site conditions prevented an accurate fish count.

The most significant incident falling in the "other" source category was related to land disturbance in Boone County. Grading and filling for development off Gans and Discovery roads in southern Columbia caused sediment to enter Phillip's Lake at a rate more than 2 to 3 times what is typical for Missouri reservoirs. Deposited sediments were observed in the floodplain areas of both Phillip's Lake and Gans Creek, an outstanding state resource water. Gans Creek flows into Devil's Icebox, a rare cave system in central Missouri. Deposited sediment served as a source of water pollution during rain events. Excessive sedimentation has numerous ecological consequences that ultimately impact the health and quality of the fishery.

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.

Fifty non-regulated incidents occurred, which comprised 60% of all incidents during 2014 (Figure 1). Forty-seven of these incidents were fish kills. Estimates for fish counts were made for 26 of 47 non-regulated fish kills and totaled 10,330 fish. 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 Perry County Lake on February 20, 2014. Several thousand shad died due to winter icing conditions.

Most notable for the non-regulated category during 2014 were the number of blue-green algae incidents. Blue-green algal blooms potentially contain toxins which can pose health risks to animals and people coming in contact with or ingesting water. Three blue-green incidents were reported to MDC during the summer of 2014. One incident occurred in Spur Pond, Adair County on August 4, 2014. The presence of blue-green algae and toxins were confirmed, however, toxin levels were low and did not pose a significant risk for animals coming in contact with the water. Presence of blue-green algae was not confirmed for the remaining two incidents.

Unknown Cause

Personnel were unable to identify the cause of the problem for 3 incidents, all 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 through necropsy and chemical analysis. Additionally, a responsible party was not identified for these incidents, which hindered the investigation. At least 1,040 fish and 72 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 Boone County on March 13, 2014. At least 72 bird carcasses, some migratory species, were observed over the span of one week at a private residence. Several days later hundreds of additional bird carcasses were found in a nearby park. The suspected cause is pesticide poisoning. After MDC's initial investigation, the case was handed over to the U.S. Fish and Wildlife Service who has authority to enforce the Migratory Bird Act.

TEMPORAL DISTRIBUTION

In general, the distribution of kills throughout the year presented no pattern (Figure 2). This differs from previous years that exhibit a bell-shaped pattern (O’Hearn and Martin 2014). Across seasons, the most incidents occurred during spring (March through May), followed by summer (June through August), fall (September through November), and winter (December through February). Among causes of incidents, non-regulated incidents were the most common type of incident for all seasons. Across months, the number of non-regulated incidents peaked in February and March and varied between 1 and 6 incidents from April through November; March while the number of regulated incidents was consistent from February through November, varying between 1 and 5 incidents.

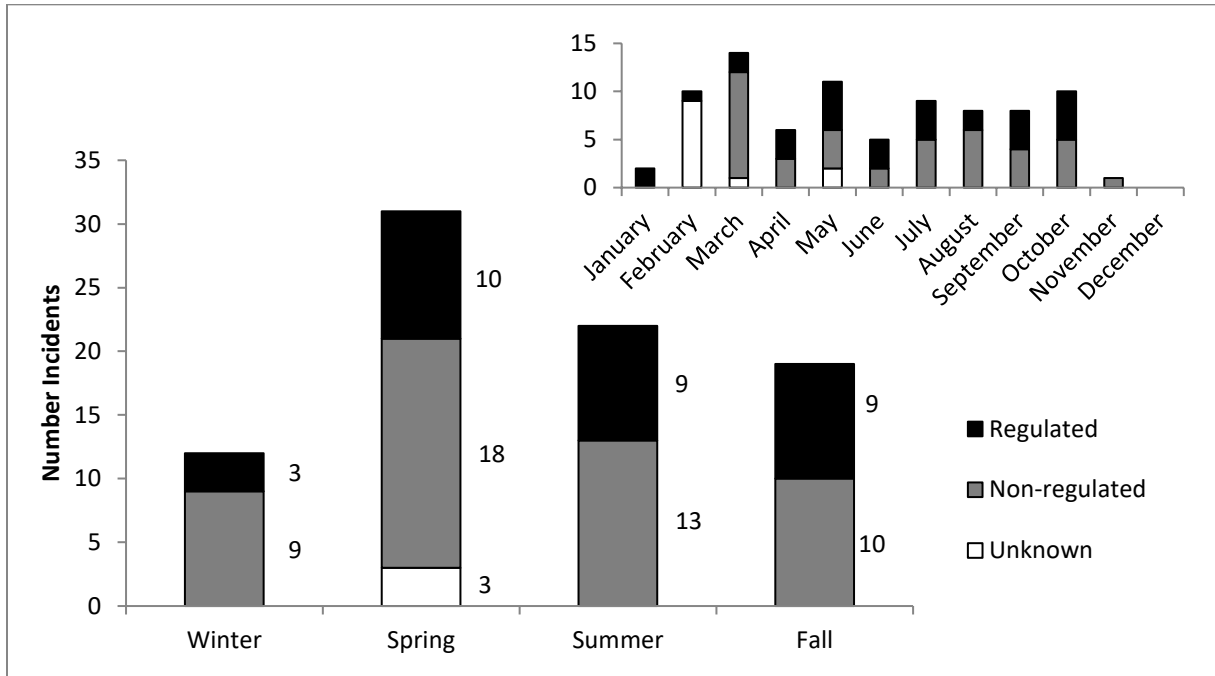


Figure 2. Monthly and seasonal distribution of regulated, non-regulated, and unknown source incidents during 2014.

DISTRIBUTION OF INCIDENTS THROUGHOUT THE STATE

Investigations took place in 46 of 115 counties. The Central Region experienced the most incidents (22, Figure 3), while the Ozark Region experienced no incidents. Among counties, Boone County had the highest number of incidents (11) followed by St. Louis County (7). Among major source categories, the most regulated incidents occurred in Boone County (5) followed by Cape Girardeau, Cass, and Vernon counties, which all had two regulated incidents (Figure 4). The most non-regulated incidents occurred in St. Louis County followed by Boone County. Two of the three “unknown” source incidents also occurred in Boone County.

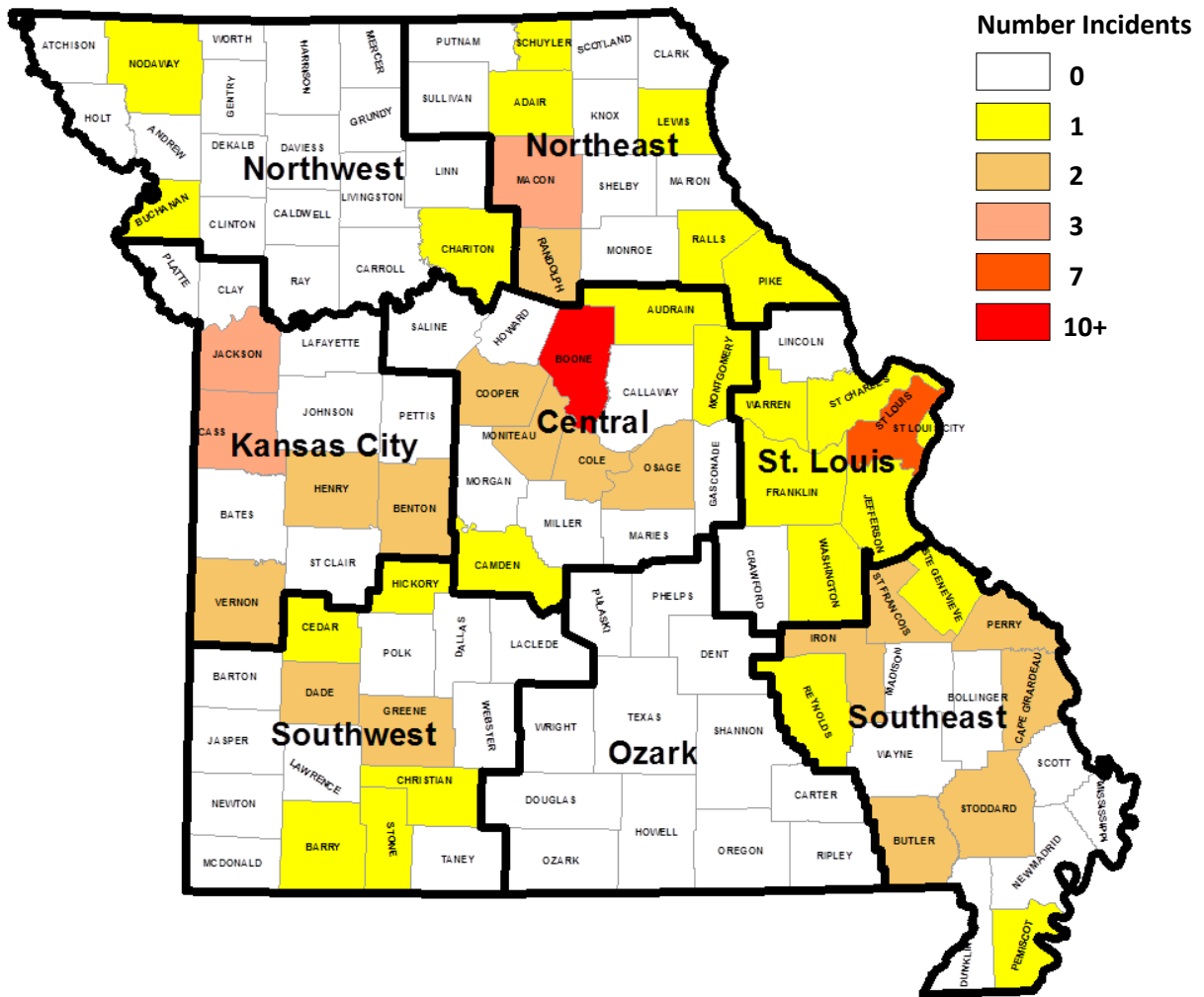


Figure 3. Map of number of incidents during 2014 per county. The eight regions for the Missouri Department of Conservation are outlined in bold.

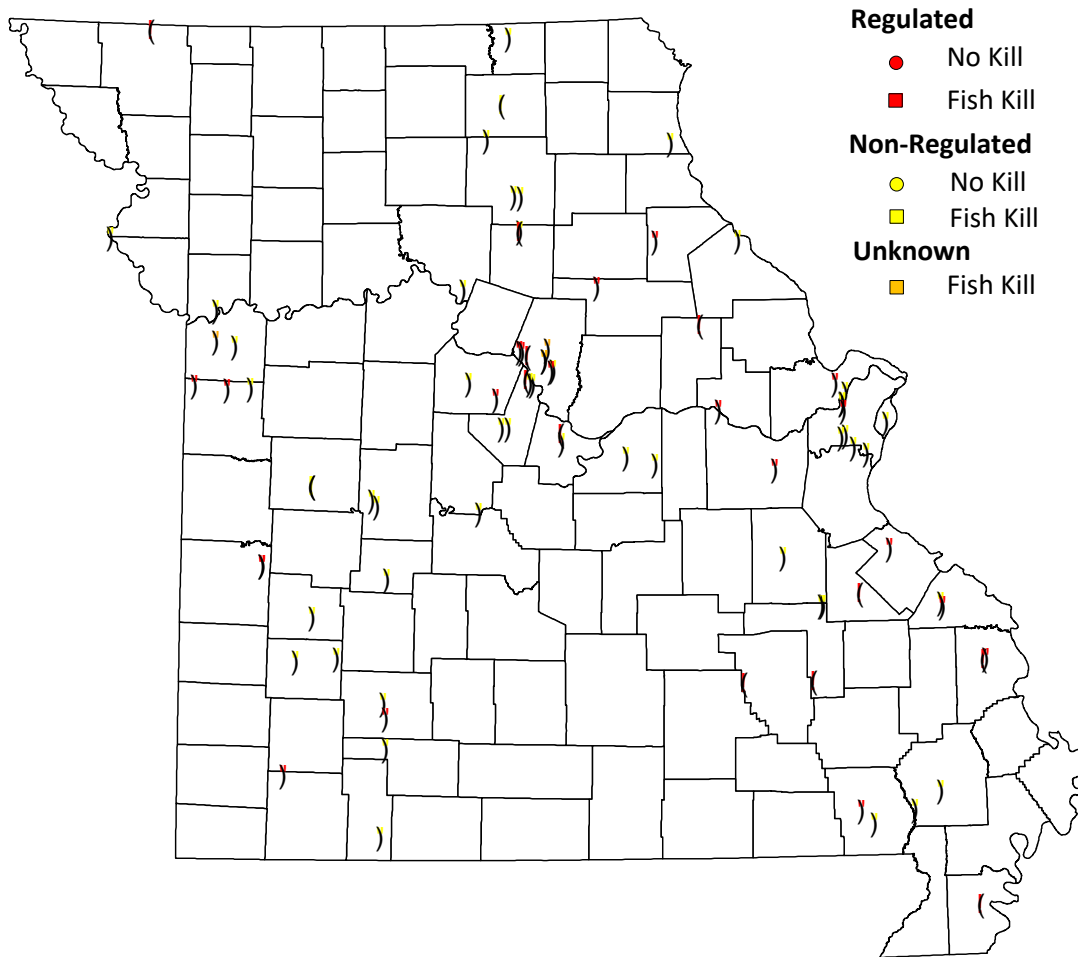


Figure 4. Map of regulated, non-regulated, and unknown source investigations conducted by Missouri Department of Conservation personnel during 2014. Points are located at the most upstream portion of the affected zone for incidents occurring in streams. Squares indicate fish kills and circles indicate investigations without fish kills.

DISTRIBUTION BY HABITAT TYPE

Among habitat types, incidents occurred more often in lakes and streams (65) than in ponds and wetland habitats (17, Figure 5). The number of incidents in lakes and streams were nearly equal (33 and 31, respectively), which is inconsistent with trends from recent years where streams were most common habitat for incidents (O’Hearn and Martin 2014). Regulated source pollutants were the leading cause of stream incidents (71%). Non-regulated causes were the most common type of incident in lakes, ponds and wetland habitats (79%-100%). Two incidents did not involve waterways.

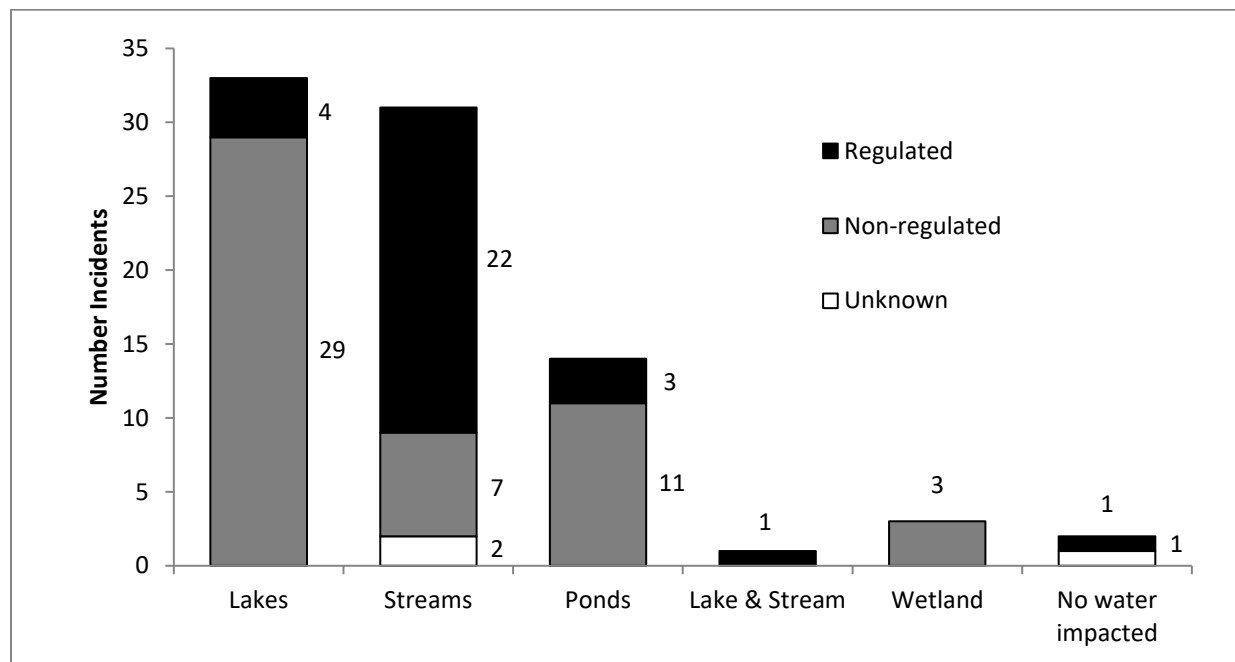


Figure 5. Distribution of incidents during 2014 by habitat type.

ENFORCEMENT STATUS OF FISH KILL AND POLLUTION CASES

Six incidents were resolved during 2014. Three of these incidents occurred during 2012, two in 2013, and one in 2014. DNR and the Attorney General enforced the cases described in this section. Four cases were resolved through settlement agreements, which included reimbursements of damages to fish and wildlife, reimbursements of investigative costs, and civil penalties.

Settlement funds totaled nearly \$10,000. Settlement funds include damages for injured animals and investigative costs. Damages totaled \$124.18. Of the damage funds, \$112.35 was transferred to the MDC Fish Kill Grant Fund, which is allocated to projects benefiting aquatic resources in Missouri. The remaining \$11.84 of the damage funds were transferred to the Chemical Emergency Preparedness Fund outside of MDC. MDC received \$2,102.33 in reimbursements for investigative costs, which was also transferred to the MDC Fish Kill Grant Fund. Penalty monies and costs for supplemental environmental and mitigation projects were assessed by DNR and the Attorney General and totaled over \$18,000. Penalty monies were transferred to the school district of the county in which the pollution occurred. Four cases were closed during 2014 due to a lack of evidence and other reasons. Twenty-eight cases remain open: one from 2010, five from 2011, three from 2012, eight from 2013, and eleven from 2014. A breakdown of settlement funds and brief descriptions of these 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 on an annual basis from Fisheries, Protection, and Resource Science divisions. Eligible projects benefit water quality and aquatic habitat. No proposals were awarded during 2014 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 27 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).

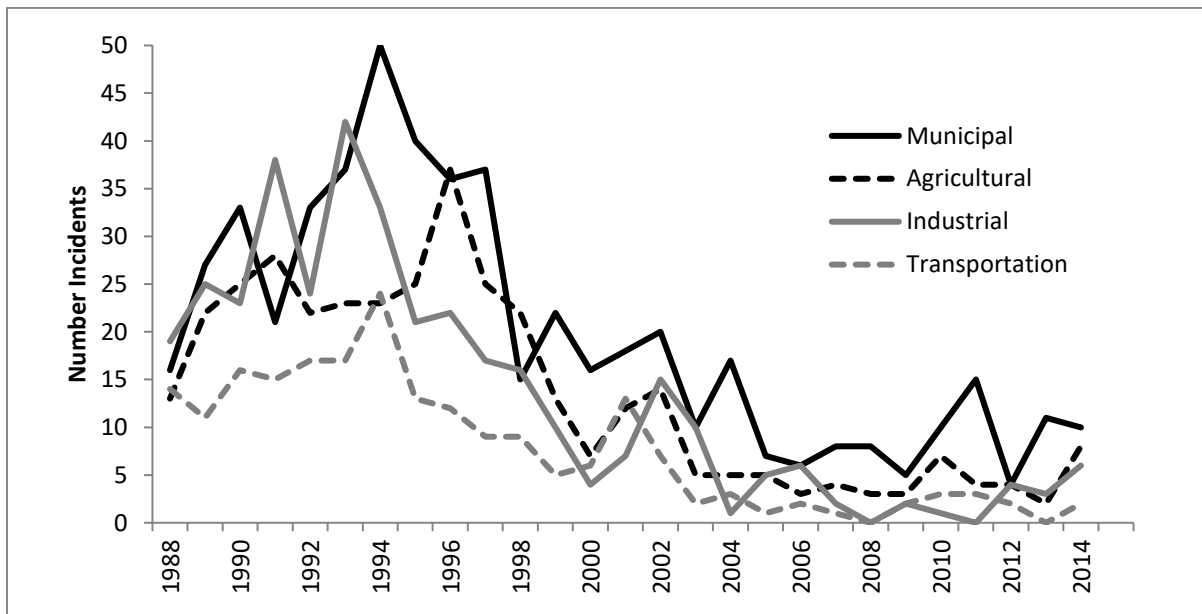


Figure 6. Long-term (1988-2014) trends in regulated incidents. The “other” source category involves miscellaneous pollution sources and is not included in the figure.

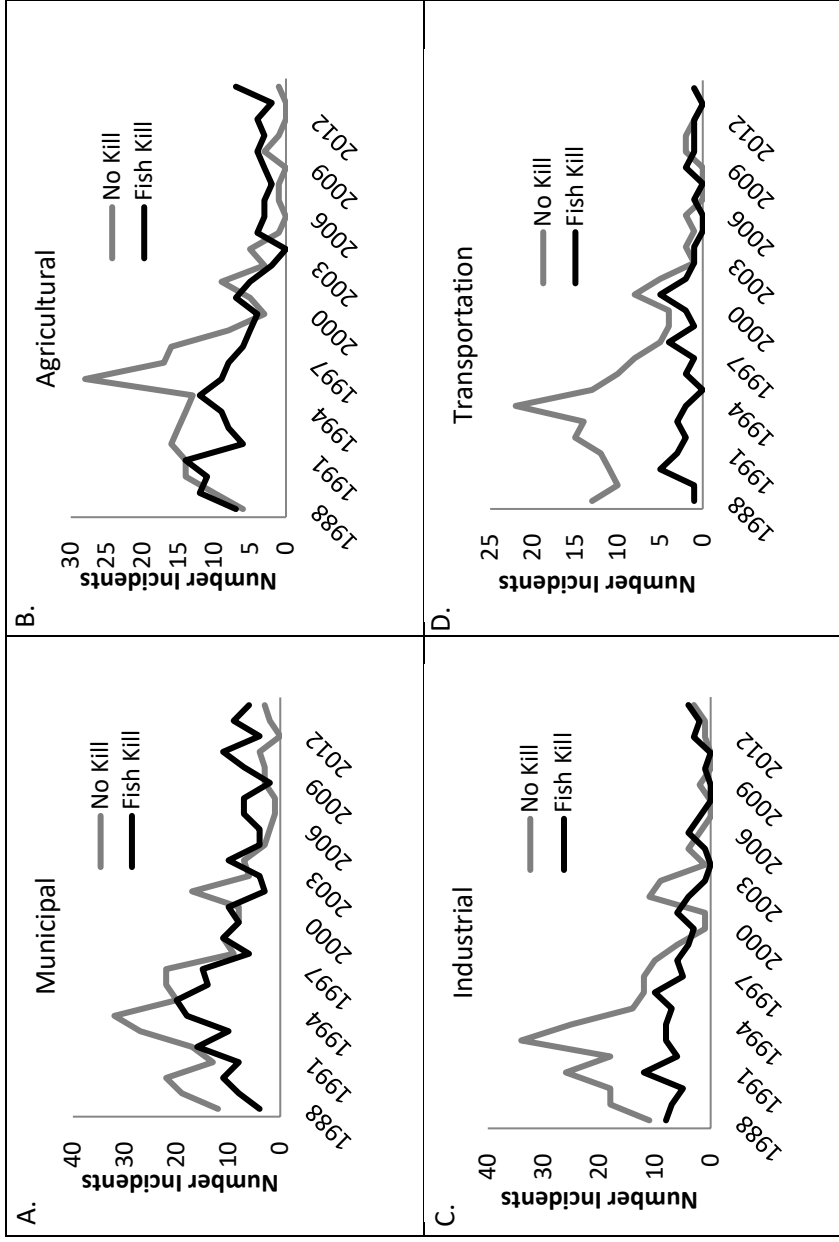


Figure 7. Long-term (1988-2014) trends for regulated fish kill and pollution incidents caused by municipal (A), agricultural (B), industrial (C), and transportation (D) sources. The “unknown” and “other” categories are not included in this figure because they contain incidents with wide ranging pollution 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 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 2014, MDC was involved in 84 fish kill and pollution investigations. Over 140,029 fish and other animals valued at \$142,170.88 were killed during these incidents. Four incidents occurring during 2012 and 2013 have been resolved through settlement agreements. Settlement funds totaled nearly \$10,000.

Despite the program's successes, there remain areas of concern. 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 18 and 27), Truman Dam in Benton County (page 25), and Montrose Dam in Henry County (page 27). Operations at these three facilities have caused fish kills since the late 1970s to early 1980s. To date, long-term solutions have not been implemented to abate fish kills at these locations.

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* 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 2014.

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 2014:

Damages

Macroinvertebrate Values

During 2014, macroinvertebrate values were re-assessed in order to reflect current market values. Data inputs that were considered include bait shops, production facilities (hatcheries), and values in outside states' codes of regulation.

Fish and Mussel Values

MDC utilizes AFS Special Publication 30 (Southwick and Loftus 2003) to investigate kills of aquatic life and to assess monetary values of fish and mussels resulting from pollution. The publication provides a standardized and legally defensible protocol for conducting investigations and assessing monetary damages resulting from these incidents. The publication has been updated every 10 years since it was first published in 1970. These updates are important because they incorporate the most current information and data available. The Pollution Committee of the Southern Division of the American Fisheries Society (SDAFS) has been primarily responsible for facilitating updates. After the last publication was completed in 2003 participation in the committee declined. This was further exacerbated by the economic downturn in 2009. In 2013 the Pollution Committee was formally disbanded by SDAFS. Because MDC relies on this publication for assessing values of fish and mussels, the Fish Kill Program Manager gained permission from the SDAFS President to form an ad-hoc Pollution Committee during 2014 to work on an update to the publication. The projected publication date is December 2016.

Monitoring

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 the stream for macroinvertebrates, fish, and water quality. Overall, species richness and abundance have increased since the kill. All but one species found dead during the fish kill have been observed during monitoring. The slender madtom, which is the most sensitive species in Flat Branch Creek, has not been observed since the fish kill. The U.S. Geological Society also began monitoring toxicity of the sediments. Shortly after the fish kill sediments were toxic. The most toxic sediments were located closest to the spill site. Follow up monitoring in the fall of 2013 demonstrated sediments were still toxic. Fish and macroinvertebrate populations, water quality, and habitat conditions will be monitored until fish populations return to baseline condition or until April 2017.

Watershed Water Quality Monitoring

Recently, priority watersheds were identified where Fisheries field staff could focus stream management activities in an effort to improve or maintain stream health. The Aquatic Health Unit and the Resource Assessment and Monitoring Program are frequently asked to help with monitoring activities. In response to these requests, the two programs drafted *Watershed Water Quality Monitoring Guide (Interim)* as a menu of options for designing a stream monitoring program for priority watersheds. The guidance document includes basic monitoring designs, statistical tests for analysis, and options for field methods.

Training

Fish Kill Procedures

Training on water pollution and fish kill investigation procedures was given to Conservation Agent trainees during summer 2014. 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.

Other Miscellaneous

Missouri pollution and fish kill investigations 2012-2013 report was completed during March 2014.

Appendix B. Summary of regulated source incidents during 2014. Data is listed alphabetically by county. ND= not determined, NC= not calculated

County	Waterbody Name	Incident Date	Source	Cause	Number Animals Killed	Value
Audrain	Youngs Creek	5/10/2014	Agricultural	Hog lagoon effluent	7,180	\$1,002.58
Barry	Clear Creek	5/23/2014	Industrial	Ammonia, Alimet	108,809	\$130,988.26
Boone	Dairy Farm Lake #1	5/18/2014	Agricultural	Excessive application of manure	50	\$150.46
Boone	Henderson Branch	3/19/2014	Other	Truck stop lagoon	ND	NC
Boone	Dairy Farm Lake #3	7/3/2014	Agricultural	Excessive application of manure	3,945	\$7,808.26
Boone	Eagle Bluffs (no water impacted)	7/10/2014	Transportation	Petroleum product	ND	NC
Boone	Phillips Lake & Gans Creek	4/2/2014	Other	Grading and filling land for development	15	NC
Butler	Cravens Ditch	7/11/2014	Agricultural	Low water and vegetative clipping decomposing	500	NC
Cape Girardeau	Cane Creek	1/30/2014	Industrial	Wastewater release from meat processing facility	ND	NC
Cape Girardeau	Cane Creek	10/16/2014	Industrial	Animal processing waste	917	\$171.65
Cass	Carroll Pond	3/27/2014	Municipal	Broken transmission valve	17	NC
Cass	Oil Creek	8/21/2014	Municipal	Raw sewage	520	\$421.89
Cole	Wears Creek	10/10/2014	Municipal	Raw sewage	ND	NC
Cooper	Pisgah Creek, tributary	5/30/2014	Agricultural	Hog manure	50	NC
Franklin	Bourbouse River	9/2/2014	Industrial	Gravel mining	7	\$7.92
Greene	Jordan Creek	9/24/2014	Industrial	Cream, condensed skim milk and sugar	ND	NC
Iron	Big Creek	10/23/2014	Municipal	Treated water from lagoon	0	
Montgomery	West Fork Cuivre River	4/21/2014	Industrial	Clay mining operations	0	
Nodaway	102 River, tributary	6/12/2014	Agricultural	Herbicides	0	
Pemiscot	Drainage Ditch	8/7/2014	Municipal	Pesticide Premise 75	0	
Perry	Hunt Branch	9/30/2014	Municipal	Raw Sewage	30	\$7.19
Ralls	Salt River (Clarence Cannon Dam)	7/21/2014	Municipal	Power generation	1,019	NC
Randolph	Unnamed ditch	5/7/2014	Other	Paint waste	0	
Reynolds	Adair Creek and Logan Creek	10/30/2014	Industrial	Mine leak of lead and heavy metals	0	
St. Charles	Deerfield Village Pond	10/6/2014	Municipal	Water main break	700	NC
St. Francois	Wolf Creek, tributary	1/27/2014	Other	Fire suppression water	0	
St. Louis	Vicino on the Lake	6/26/2014	Municipal	Water main break	2,025	NC
Ste. Genevieve	Fourche a Du Clos Creek	2/13/2014	Transportation	Tanker accident & fire suppression	2,720	\$1,605.50
Vernon	Kitten Creek, tributary	6/8/2014	Agricultural	Dairy manure	12	\$2.61
Vernon	Coal Branch	4/23/2014	Agricultural	Lagoon waste from dairy farm	21	\$4.56
Warren	Redfern Pond	9/13/2014	Other	Herbicide Garlon 4 Ultra	50	NC

Appendix C. Summary of non-regulated source incidents during 2014. Data is listed alphabetically by county. ND=not determined

County	Waterbody Name	Incident Date	Cause	Number Animals Killed
Adair	Spur Pond	8/4/2014	Blue-green Algae	0
Benton	Unnamed oxbow south of Warsaw	6/26/2014	Low dissolved oxygen, algal bloom	2,014
Benton	Truman Reservoir	2/24/2014	Winter kill	ND
Boone	South Farm Lake R-1	3/14/2014	Natural	ND
Boone	Eagle Bluffs	3/20/2014	Natural	ND
Boone	Eagle Bluffs Conservation Area	2/23/2014	Winter kill	7
Boone	Flat Branch	11/8/2014	Natural	120
Buchanan	Sugar Lake (Lewis and Clark State Park)	3/24/2014	Low water level	500
Butler	Ackerman Ditch	10/6/2014	Low water levels	ND
Camden	Lake of the Ozarks-Workman Hollow Cove	2/23/2014	Freezing weather	300
Cass	Church Pond	10/12/2014	Natural	ND
Cedar	Stockton Lake	2/25/2014	Low dissolved oxygen, icing	ND
Chariton	Old channel Chariton River	10/10/2014	Decaying flooded vegetation	75
Christian	Dogwood Estates retention pond	7/13/2014	Low dissolved oxygen	ND
Cole	Lakewood Subdivision Lake	7/5/2014	Bacterial infection suspected	44
Cooper	Private Pond	9/18/2014	Turnover	ND
Dade	Sons Creek	5/4/2014	Natural	12
Dade	Private Pond	8/2/2014	Natural	ND
Greene	Private Pond	8/2/2014	Natural	ND
Henry	Truman Reservoir-South Grand River Arm	6/11/2014	Suspected blue-green algae bloom	0
Henry	Truman Reservoir-South Grand River Arm	7/16/2014	Suspected blue-green algae bloom	0
Hickory	Pomme de Terre Lake	2/25/2014	Low dissolved oxygen, icing	ND
Iron	Carl DiSalvo Lake	7/20/2014	Low dissolved oxygen	200
Jackson	Blue Branch, tributary	4/24/2014	Disease suspected	1
Jackson	Unnamed oxbow lake	10/27/2014	Starvation suspected	400
Jefferson	Winter Park Lake	8/22/2014	Natural temperature increase	100
Lewis	Boulder Lake at Wakonda State Park	3/20/2014	Natural	ND
Macon	Steven Park pond	3/18/2014	Winter kill	10
Macon	old channel of Chariton River	3/12/2014	Natural kill	ND
Macon	Long Branch Lake	3/20/2014	Natural	ND
Moniteau	Private Pond	9/17/2014	Turnover	ND
Moniteau	Proctor Park Lake	3/7/2014	Winter kill	ND
Osage	Private Pond	9/17/2014	Turnover	ND
Osage	Cooper Hill Pond	5/2/2014	Natural, winter kill	17
Perry	Perry County Lake	2/20/2014	Winter kill	3,000

Appendix C continued.

County	Waterbody Name	Incident Date	Cause	Number Animals Killed
Pike	Ted Shanks Conservation Area	7/25/2014	Low dissolved oxygen	500
Randolph	Pastrovich Lake	5/7/2014	Natural	500
Schuyler	Old Lancaster City Lake	5/29/2014	Spawning stress	200
St. Francois	DiSalvo Lake	3/17/2014	Stress	32
St. Louis	Creve Coeur Lake	3/20/2014	Natural	5
St. Louis	Simpson Lake	4/17/2014	Natural	100
St. Louis	Earth City pond	2/24/2014	Low water levels, water frozen	100
St. Louis	Creve Coeur Lake	10/21/2014	Natural	124
St. Louis	Meramec River	8/29/2014	Low water levels and high temperature	100
St. Louis	Lake of the Woods	9/20/2014	Turnover kill	ND
St. Louis City	Lafayette Park Lake	3/11/2014	Low dissolved oxygen from extended snow/ice coverage	90
Stoddard	Cypress Lake (Otter Slough Conservation Area)	2/19/2014	Prolonged ice cover	704
Stoddard	Dexter City Lake	4/22/2014	Stress-related die off	1,000
Stone	Table Rock Lake	2/25/2014	Low dissolved oxygen	ND
Washington	Goodson Pond	8/19/2014	Low dissolved oxygen	75

Appendix D. Summary of incidents caused by unknown sources during 2014. Data is listed alphabetically by county. NC= not calculated

County	Waterbody Name	Incident Date	Suspected Cause	Number Animals Killed
Boone	Bird Kill (no water impacted)	3/13/2014	Pesticide poisoning	72
Boone	Flat Branch	5/9/2014	unknown	40
Jackson	Camp Creek, tributary	5/14/2014	Lawn chemicals or chlorinated water from main break	1,000

Appendix E. Summary of Clean Water Law settlements reached by the State of Missouri during 2014 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 Name	Incident Date	Responsible Party	Cause	Reimbursements		MDC Total	Penalty (DNR calculates)
					Damages	MDC Investigative Costs		
Franklin	Flat Cr.	8/8/13	Crystal Extrusion Corporation	sodium hydroxide and aluminum mixture (caustic)	\$51.02	\$461.10	\$507.02	\$4,000
Pettis	Muddy Cr., trib	11/2/12	Tyson Foods	chlorine toxicity, break in water line at plant	\$62.41	\$631.41	\$687.58	\$2,000
Saline	East Fork Salt Pond Cr.	3/5/12	Dennis Kueker	low dissolved oxygen/ammonia toxicity, hog manure	\$4.92	\$683.72	\$688.15	\$7,600
St. Charles	Dardenne Cr., trib	7/5/12	El Maguey Restaurant	Sewage/grease back up	\$5.83	\$326.10	\$331.93	\$5,000

Appendix F. Brief descriptions of closed and open cases listed alphabetically by county for 2014.

Closed Cases (Resolution)

Cases closed after resolution was reached.

Franklin County (8/8/13), Crystal Extrusion Corporation

A caustic soda spill (sodium hydroxide and aluminum mixture) created white discoloration in a 1,000 foot section of Flat Creek. The elevated pH killed at least 108 aquatic organisms. An Abatement Order on Consent ordered the company to reimburse MDC \$461.10 for investigative costs and the state \$51.02 for fish damages, and to pay a civil penalty of \$4,000 with up to \$2,500 per day in stipulated penalties.

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 it was isolated on private property.

Pettis County (11/8/12), Tyson Foods

Chlorine toxicity from a water line break at a Tyson plant caused a fish kill in a tributary of Muddy Creek. At least 268 fish were killed in 0.15 miles of stream over 2 days. An Abatement Order on Consent ordered Tyson Foods to test for and schedule repairs for all leaks to underground potable water lines on Tyson property and to reimburse MDC \$631.41 for investigative costs and the state \$62.41 for fish damages, and to pay a civil penalty of \$2,000 with stipulated penalties up to \$1,000 per day of violation.

Saline County (3/5/12), Kueker SEW Farm CAFO

An internet complaint led to an investigation in East Fork Salt Pond Creek, one mile south of the Blind Pony Hatchery. Thirty dead fish were observed in a one quarter mile section of stream that had an obvious manure odor and water discoloration. The responsible party signed a consent judgement that required they submit a plan for preventing future releases and to reimburse MDC \$638.72 for investigative costs and the state \$4.92 for fish damages. The judgement also required the responsible party to pay a \$7,600 civil penalty, with \$3,800 suspended upon the condition that they do not commit further violations.

St. Charles County (7/5/12), El Maguey Mexican Restaurant

A grease/sewage backup caused a small fish kill in a tributary of Dardenne Creek. Fifteen dead fish valued at \$5.83 were found on scene. Fish were in the later stages of decay during the on-site investigation suggesting that the incident had occurred at least one week prior to the investigation. The responsible party signed an abatement order on consent and paid a \$5,000 penalty and \$796.93 for the states investigative costs and fish damages. The responsible party agreed to submit and implement a grease management plan.

St. Louis County (6/26/2014), Desco Co.

A broken water line discharged chlorinated water into Vicino on the Lake. At least 2,025 fish died from chlorine toxicity as a result of the discharge. This case was closed due to private ownership of the reservoir.

Closed Cases (No Resolution)

Cases closed due to lack of evidence and unidentified pollutant and/or responsible party.

Cooper County (9/21/11), City of Boonville

A lift station failure caused three manholes to overflow into Ream Branch. At least 1,115 fish valued at \$232.40 were killed due to the release. Fish injuries and damages are vastly underestimated because steep muddy stream banks and deep silt in the channel rendered much of the site inaccessible to responders.

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.

Jefferson County (6/11-19/12), PWSD No. C-1 (Donovan Larson, Assistant Manager suspected)

On June 9th chlorinated water from a broken pipe was released into Glaize Creek killing at least 1,208 fish and other aquatic organisms valued at \$328.34. The effects were seen for at least 2 days, and dead fish were still present more than a week after the release. This release was not reported to MDC until June 20th (11 days after the release). This case was closed due to insufficient evidence to determine the responsible party.

Wayne County (7/23/13), Windsor Foods/City of Piedmont (suspected)

Waste batter product from Windsor Foods allegedly clogged filters at the City of Piedmont waste water treatment facility, which led to a bypass of wastewater into McKenzie Creek. At least 102 fish valued at \$77.63 were killed during this incident. This case was closed due to insufficient evidence to determine the responsible party.

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.

Audrain County (5/10/14), Wilson farm

Effluent from a hog lagoon 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.

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.

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.

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 (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 reach 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.

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

Land disturbance in southern Columbia caused 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 (5/18/2014), 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. 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.

Boone County (7/3/2014), 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 (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.

Crawford County (12/9/11), City of Cuba

A mechanical issue at the City of Cuba's wastewater treatment plant allowed solids and partially treated wastewater to enter Pleasant Valley Creek killing at least 146 fish valued at \$48.87.

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.

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 slow growing and long-lived, and highly sought after sports fish.

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

A sewage line break caused a small fish kill in Sulfur Creek. Six dead bullheads were found and approximately 400 to 500 live bullheads were seen piping for oxygen at the surface.

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.

Ralls County (7/8/13, 7/21/14), U.S. Army Corps of Engineers under direction of Southwest Power Administration

On July 8, 2013 MDC observed about 40 dead and 500-1,000 stressed fish in the turbine bay at Clarence Cannon Dam prior to generation start up. About one year later, MDC observed over 1,000 dead fish under similar circumstances. 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.

Saline County (11/7/11), 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; however, MDC was not able to confirm the dead fish on site.

Shelby County (6/2/13), 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.

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.

St. Louis County (8/10/10), St. Louis Metropolitan Sewer District

Sewage overflowed from a manhole into Martigney 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.

Appendix G. Summary of pollution investigation, fish kills, and estimated mortality (1970-2014) Data are incomplete prior to 1988. 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

Appendix G. continued.

Year	MUNICIPAL			AGRICULTURAL			INDUSTRIAL			TRANSPORTATION			OTHER			NON-REGULATED		
	I	K	#	I	K	#	I	K	#	I	K	#	I	K	#	I	K	#
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
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
TOTAL	629	444	2,043,271	426	335	1,662,881	420	222	1,796,041	282	94	397,449	518	429	1,393,417	2,959	3,070	2,194,328
YEARLY AVG	20	9	45,406	14	7	36,952	14	4	39,912	9	2	8,832	17	9	30,964	98	80	57,745
Avg per kill	5,045			5,278			9,978			4,416			3,440			721		