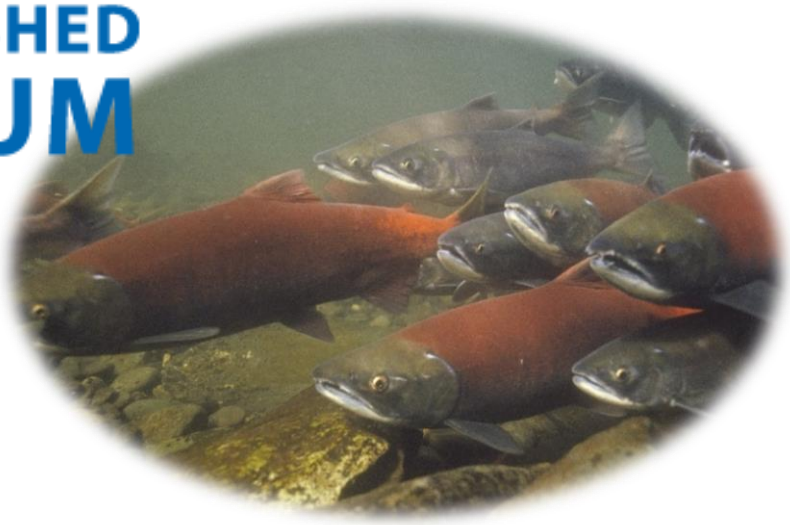
KENAI RIVER WATERSHED ZINC AND COPPER POLLUTION: A SUMMARY OF DATA ANALYSIS, LITERATURE REVIEW RESULTS, AND SUGGESTED ACTIONS

KENAI WATERSHED FORUM



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Prepared by:

Jeff Sires

Environmental Scientist

Kenai Watershed Forum

(907) 260-5449 x1207

www.kenaiwatershed.org

The Kenai Watershed Forum (KWF) is a 501(c)(3) non-profit and is recognized as the regional watershed organization of the Kenai Peninsula, successfully identifying and addressing the environmental needs of the region by providing high quality education, restoration and research programs. KWF is a dynamic organization dedicated to protecting the streams, rivers, and surrounding communities on the Kenai Peninsula.

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PURPOSE

This document serves as the final report for Alaska Clean Water Actions (ACWA) grant 17-06 provided to the Kenai Watershed Forum by the Alaska Department of Environmental Conservation. Its purpose is to summarize work completed under this grant, which included an analysis of Kenai River watershed zinc and copper data collected from 2000 through 2014, and a literature review intended to highlight potential sources of zinc and copper within the Kenai River watershed. This report will provide an overview of project findings, as well as recommendations for future study and actions that could mitigate zinc and copper pollution in the Kenai River watershed. For further information on data analysis that was conducted, or for a full explanation of literature review findings, please reference the *Supplemental Analysis of Recent Zinc and Copper Concentrations in the Kenai River Watershed* and *A Review of Potential Zinc and Copper Pollution Sources in the Kenai River Watershed*, also submitted as deliverables for this grant.

EXECUTIVE SUMMARY

In recent years, water quality sampling coordinated by the Kenai Watershed Forum (KWF) has demonstrated a substantial rise in dissolved zinc and copper concentrations within the Kenai River watershed. An assessment of available data, along with a literature review, was conducted in order to display these elevations, and to highlight potential sources of zinc and copper in this geographic region. Elevated concentrations of these two water quality components occurred primarily at sites in the lower Kenai River watershed. Additionally, the highest sample results, and greatest deviations from previous years' averages, were found during spring (as opposed to summer) sampling events. While these results indicate some amount of naturally or environmentally influenced fluctuation in zinc and copper concentrations, the prevalence of elevated levels in developed regions of the watershed points towards a significant contribution from anthropogenic sources. The literature review provided valuable information on potential point and nonpoint sources of these pollutants. In general, anthropogenic development, deforestation of riparian areas, increased impervious surface coverage, and traffic intensification have been shown to impact a wide variety of water quality constituents, including zinc and copper. Additionally, numerous point sources are likely depositing zinc and copper on a regionally significant scale. While their varying extents of influence are unknown at this time, KWF recommends the following sources be assessed further as they relate to one or both of these pollutants:

Zinc

- Tire wear and traffic intensification
- Galvanized metals including roofing, fences, culverts, drain pipes, construction materials, etc.
- Fertilizer, pesticides, and fungicides
- Natural and environmental variables including flow rates, air and water temperature, water hardness, dissolved oxygen, and other water quality parameters related to the development of site-specific zinc standards
- General urbanization, anthropogenic development, prevalence of impervious surfaces, deforestation, etc.

Copper

- Copper brake pads and traffic intensification
- Municipal wastewater discharges
- Fertilizers, pesticides, herbicides, and fungicides
- Boat hull coatings and anti-fouling paints
- Natural and environmental variables including flow rates, air and water temperature, water hardness, dissolved oxygen, and other water quality parameters related to the development of site-specific copper standards
- General urbanization, anthropogenic development, prevalence of impervious surfaces, deforestation, etc.

In addition to continued and potentially expanded water quality monitoring, it would be beneficial to establish site specific standards for zinc and copper in the Kenai River watershed. Such information, coupled with an assessment of recent anthropogenic expansion, would help inform decisions made by local agencies in their approach to water quality protection, and further development of the region. Educational materials should be provided to developers and landowners regarding their potential impact on water quality, and the detrimental effects of certain products. Finally, KWF recommends that state of Alaska lawmakers consider legislation, similar to that which has already been passed by the states of Washington and California (citing concern over the effect of copper pollution on salmonids and other aquatic species), to phase out copper brake pads.

INTRODUCTION

The Kenai River is a glacially-fed system running 82 miles from Kenai Lake in Cooper Landing, to its mouth on the Cook Inlet in Kenai. Several major tributaries flow into the Kenai at various points along its path. The river is commonly divided into three sections known as the Upper River (from Cooper Landing at River Mile (RM) 82 to Skilak Lake at RM 65), Middle River (from RM 50 after Skilak Lake to the Sterling Highway Bridge in Soldotna at RM 21), and Lower River (from RM 21 to the mouth in Kenai at RM 0) (Figure 1).

Despite the river's close proximity to the Sterling Highway from RM 82 to RM 69, large portions of the Upper River watershed remain relatively undeveloped. The community of Sterling (RM 37), the City of Soldotna (RM 21.5), and the City of Kenai (RM 0) represent the most developed areas of the Kenai River watershed, and the Kenai Peninsula in general. The most recent census population estimates for Sterling, Soldotna, and Kenai are 5,617 (US Census Bureau, 2010), 4,163 (US Census Bureau, 2010), and 7,100 (US Census Bureau, 2010) respectively. In addition, several thousand residents live outside the legal boundaries of these communities. The most recent data provided by the Alaska Department of Labor and Workforce Development (Alaska DOLWD) estimates the total population of the Kenai Peninsula Borough (KPB) at 58,060 (Alaska DOLWD, 2016). An interactive map of the KPB and its geographic features is available at http://mapserver.borough.kenai.ak.us/kpbmapviewer/.

Given its environmental and economic significance to the region, the Kenai River watershed has been the focus of inspiring conservation efforts, as well the bearer of significant anthropogenic pressures. The Kenai Watershed Forum established the Kenai River Baseline Water Quality Monitoring project in 2000 to track water quality changes over time throughout the Kenai River watershed. Several sites were chosen along the Kenai River mainstem and in its major tributaries with the goal of providing information on overall watershed health twice per year. Kenai River and tributary sampling sites are labeled in Figure 1 and will be referred to throughout this report.

Baseline water quality monitoring within the Kenai River watershed indicated a potential increase in dissolved zinc and copper concentrations. Analysis performed as part of this project demonstrated that zinc and copper concentrations at several sites on the Kenai River mainstem and in Kenai River tributaries were significantly higher than average. Given the deleterious effects that copper (Hecht, et al., 2007) and zinc (Bowen, Werner, & Johnson, 2006) can have on salmonids and the ecosystems they rely on, these elevations warrant concern and further investigation.

In addition to data analysis, a literature review was conducted in order to determine potential sources of zinc and copper in the Kenai River watershed. Many literature sources were selected based on their relevance to the geographic, geologic, hydrologic, or anthropogenic characteristics of the Kenai River watershed. Numerous articles and reports concerning areas in the western United States, especially those with salmon-bearing streams and rivers,

were given highest priority. Some consideration was also given to literature which did not focus specifically on these characteristics, but still provided pertinent information. The literature review aimed to account for a wide range of possibilities, eventually narrowing the field of potential contributors based on local conditions.

Using the analyzed data, literature review results, and more recent monitoring results, this report will make suggestions for future study, and actions that can be taken to mitigate continued rises in zinc and copper concentrations.

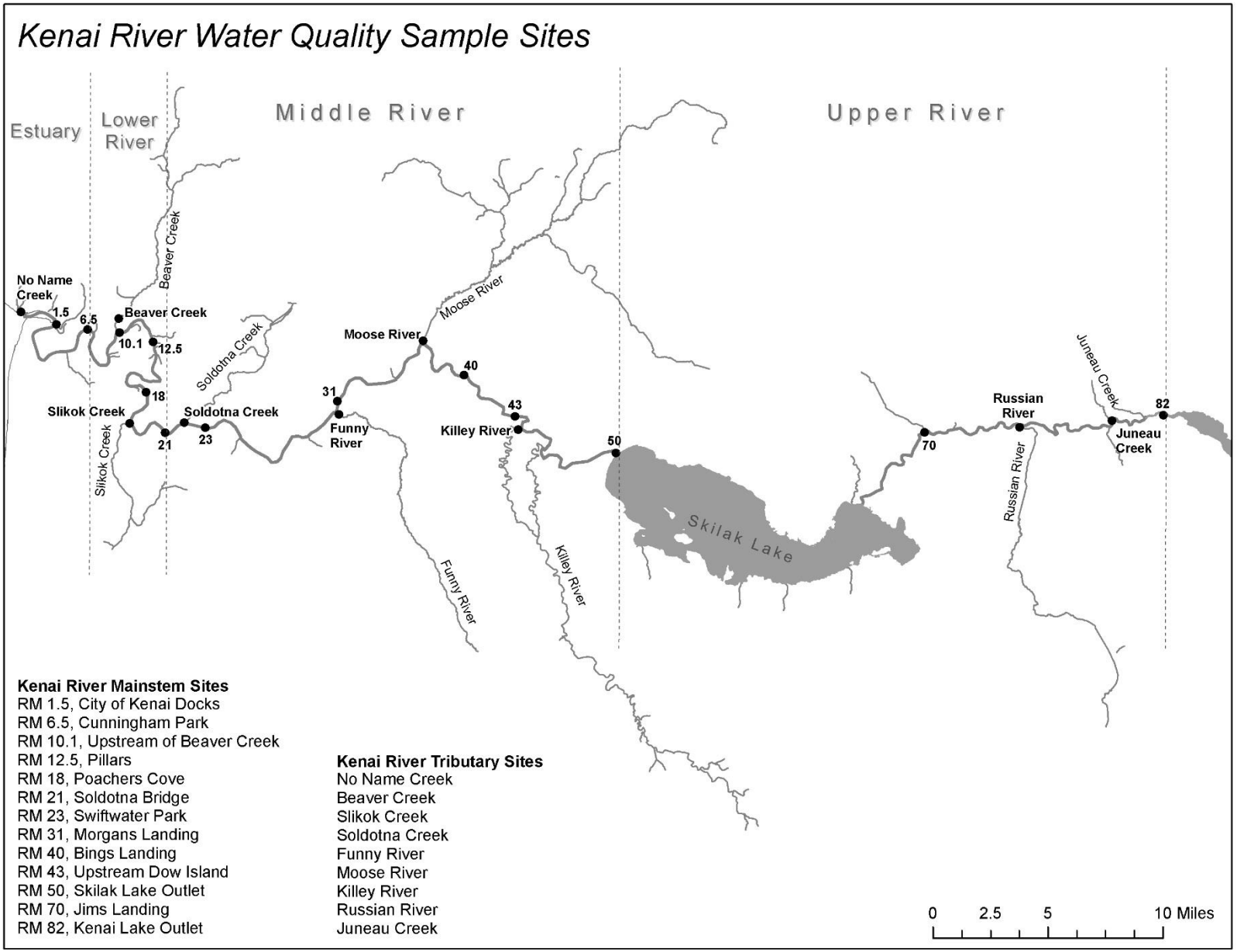

FIGURE 1: KENAI RIVER WATERSHED DIVISION AND WATER QUALITY SAMPLING SITES

INCREASED ZINC AND COPPER CONCENTRATIONS

As discussed in *A Supplemental Analysis of Recent Zinc and Copper Concentrations in the Kenai River Watershed* (submitted to DEC as a deliverable for this project), zinc and copper concentrations in the Kenai River watershed, especially at sites below Skilak Lake, were significantly higher on average from 2010 through 2014, as compared with previous years' sampling results. This trend been shown through sampling conducted as part of KWF's water quality monitoring program. The most recent sampling data, as displayed below (Figure 2 through Figure 9), shows that this trend has continued since 2014. Average zinc and copper concentrations have remained above average, and have increased at some sites. It is worth noting that spring concentrations for both parameters are higher, and have shown a greater increase on average, than those found in summer sampling events. Because the 2017 summer sampling event has yet to occur, and due to a lack of usable data for summer 2016, 2015 through 2017 summer copper results are not displayed. In addition, dissolved metals sampling was discontinued upstream of River Mile 30.0 in 2014 to better prioritize program funding.

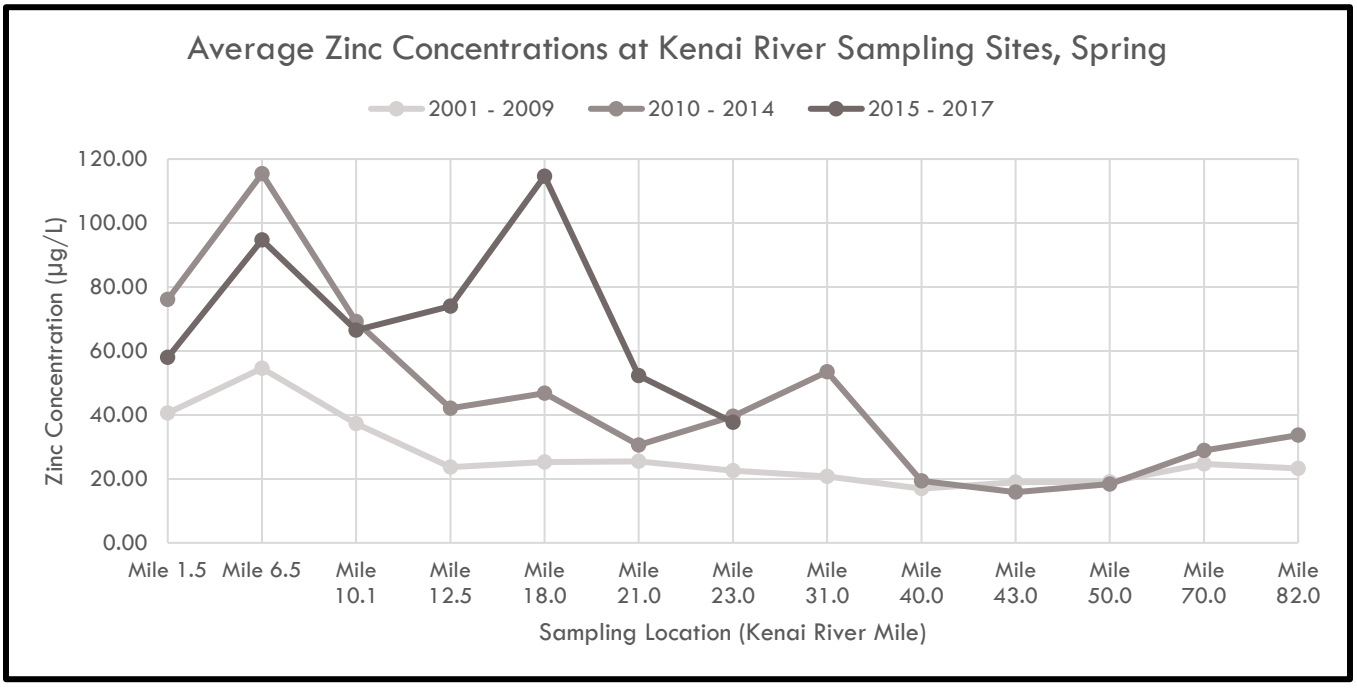

FIGURE 2: AVERAGE ZINC CONCENTRATIONS AT KENAI RIVER SAMPLING SITES, SPRING

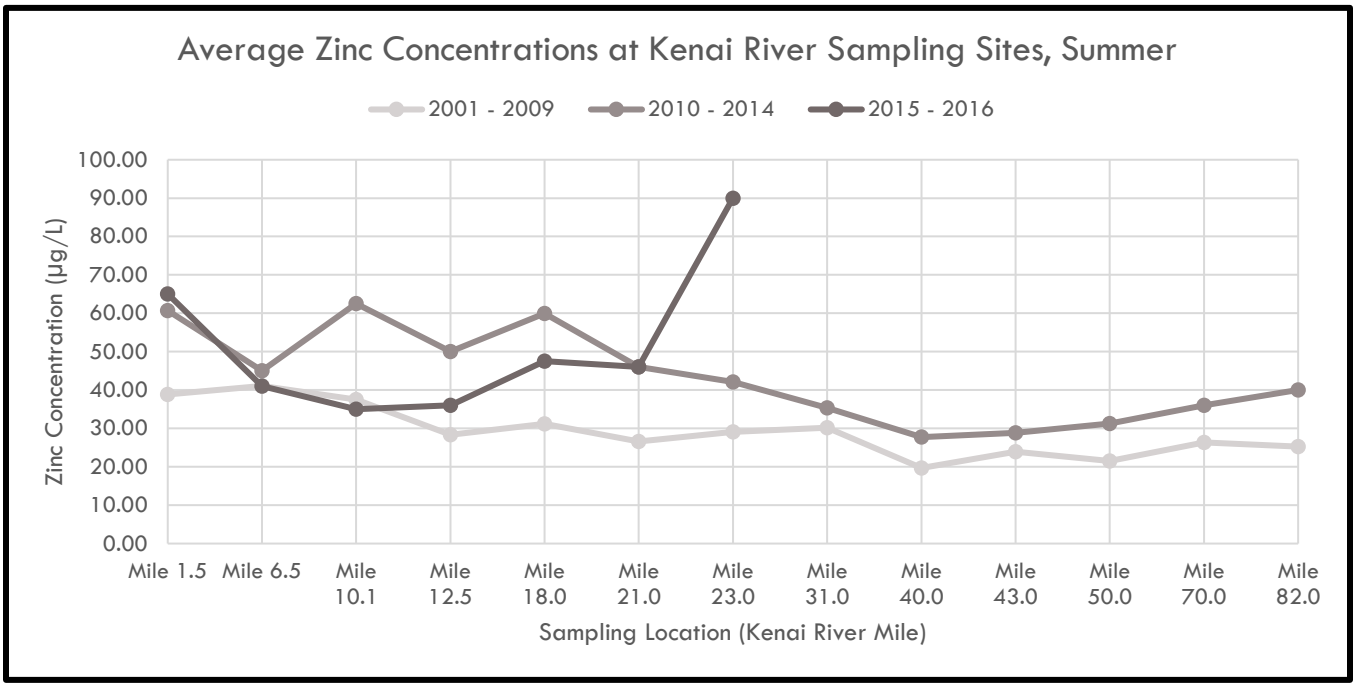

FIGURE 3: AVERAGE ZINC CONCENTRATIONS AT KENAI RIVER SAMPLING SITES, SUMMER

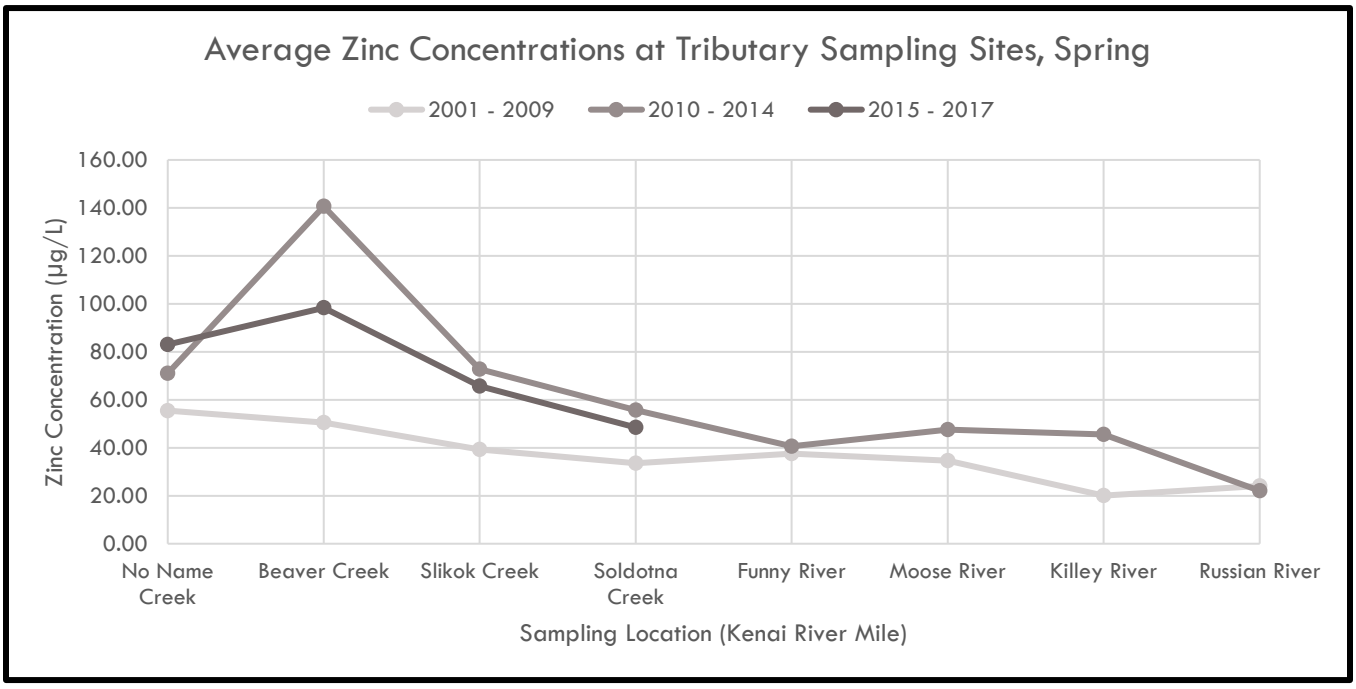

FIGURE 4: AVERAGE ZINC CONCENTRATIONS AT TRIBUTARY SAMPLING SITES, SPRING

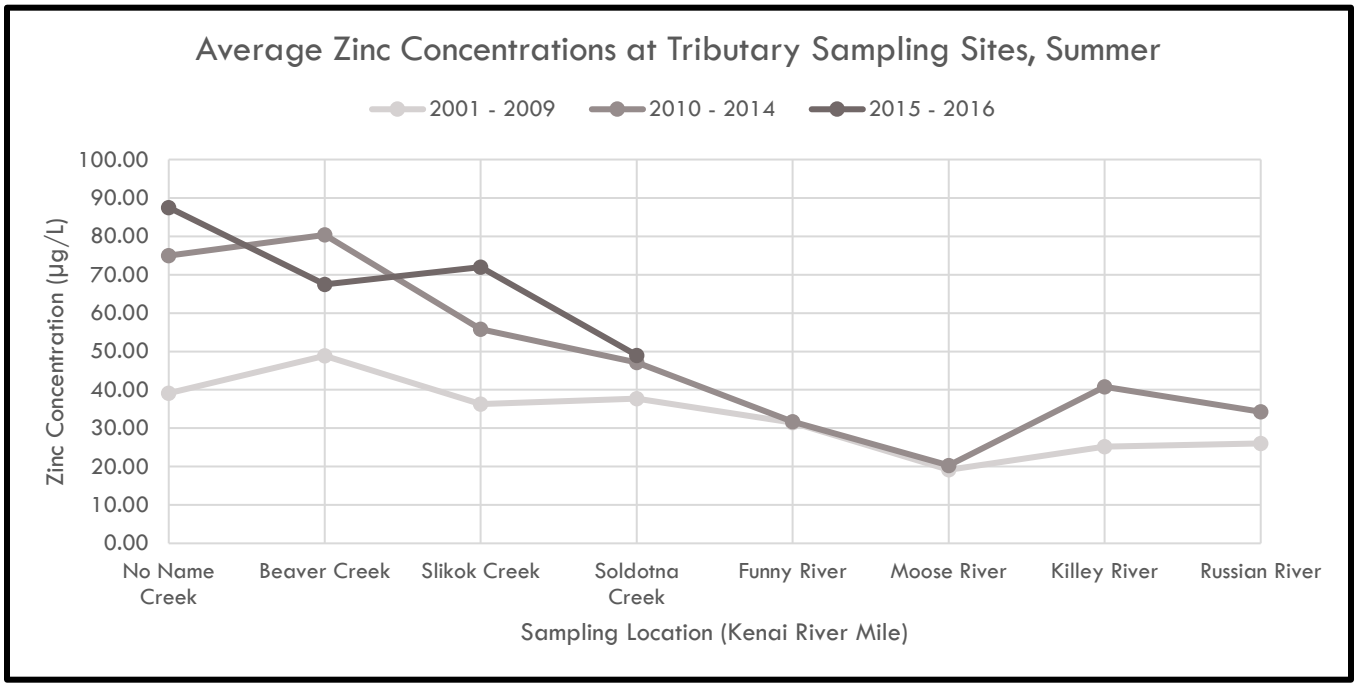

FIGURE 5: AVERAGE ZINC CONCENTRATIONS AT TRIBUTARY SAMPLING SITES, SUMMER

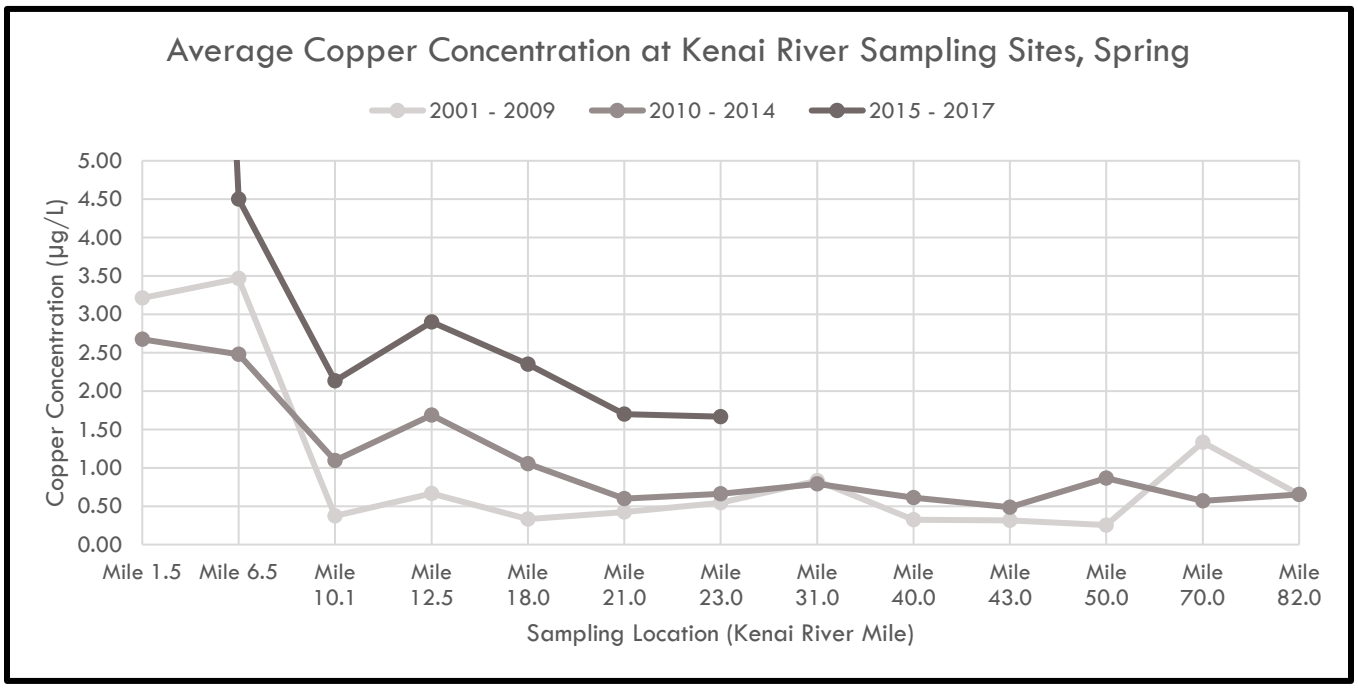

FIGURE 6: AVERAGE COPPER CONCENTRATIONS AT KENAI RIVER SAMPLING SITES, SPRING

Note: The average spring copper concentration from 2015 – 2017 at RM 1.5 was 30.70 µg/L, largely resulting from a result of 52.00 µg/L in April 2017. The sample result at this site for 2015 was 9.40 µg/L, while 2016 sample analysis reported a value of less than 10.0 µg/L.

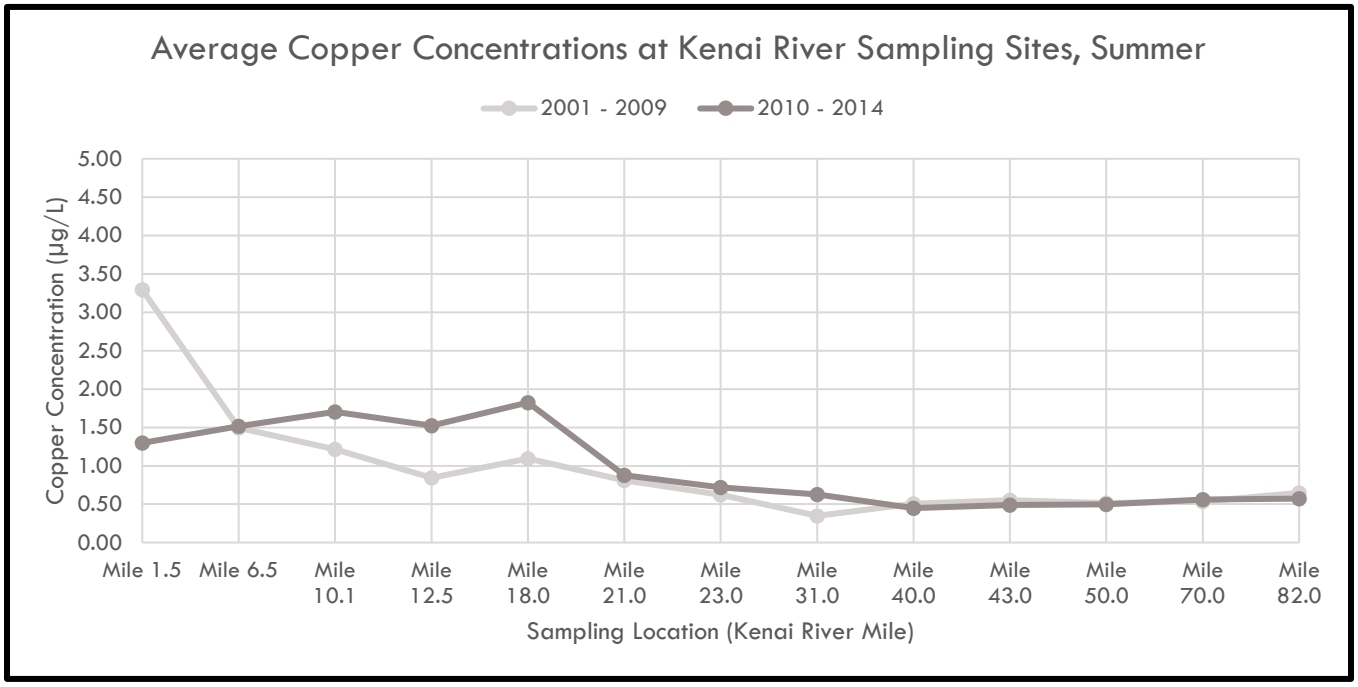

FIGURE 7: AVERAGE COPPER CONCENTRATIONS AT KENAI RIVER SAMPLING SITES, SUMMER

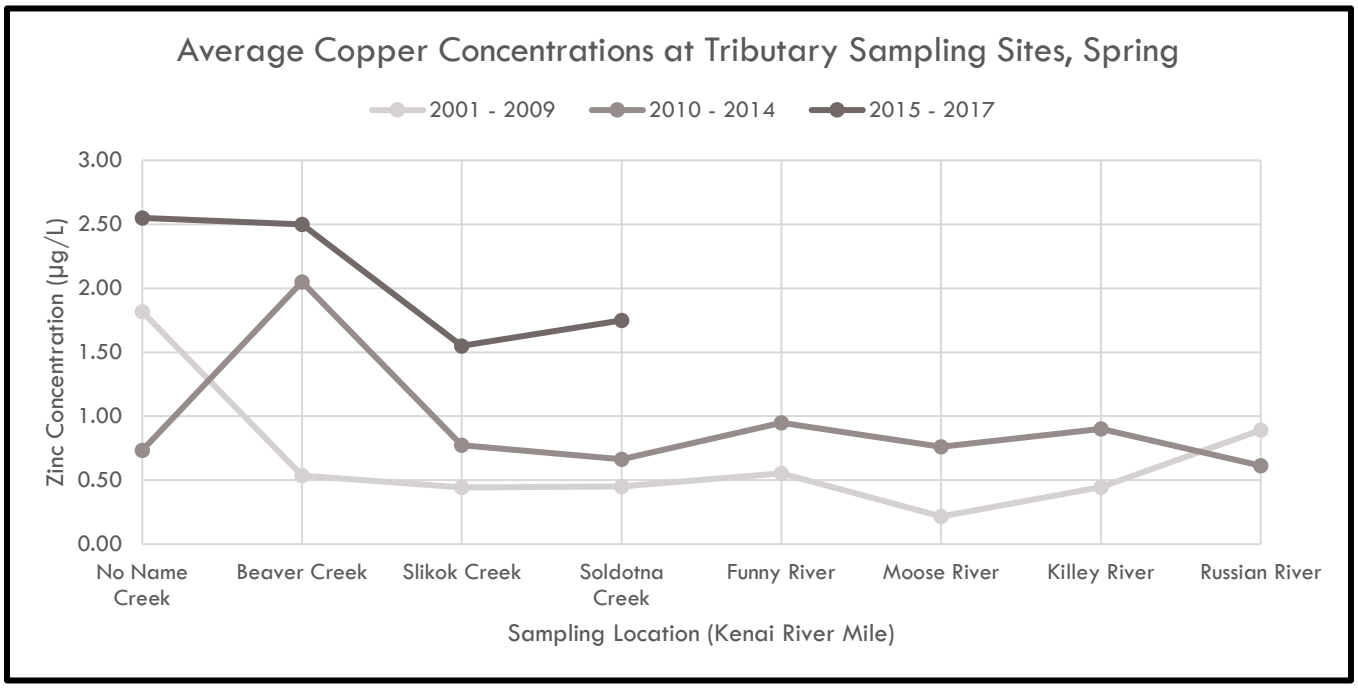

FIGURE 8: AVERAGE COPPER CONCENTRATIONS AT TRIBUTARY SAMPLING SITES, SPRING

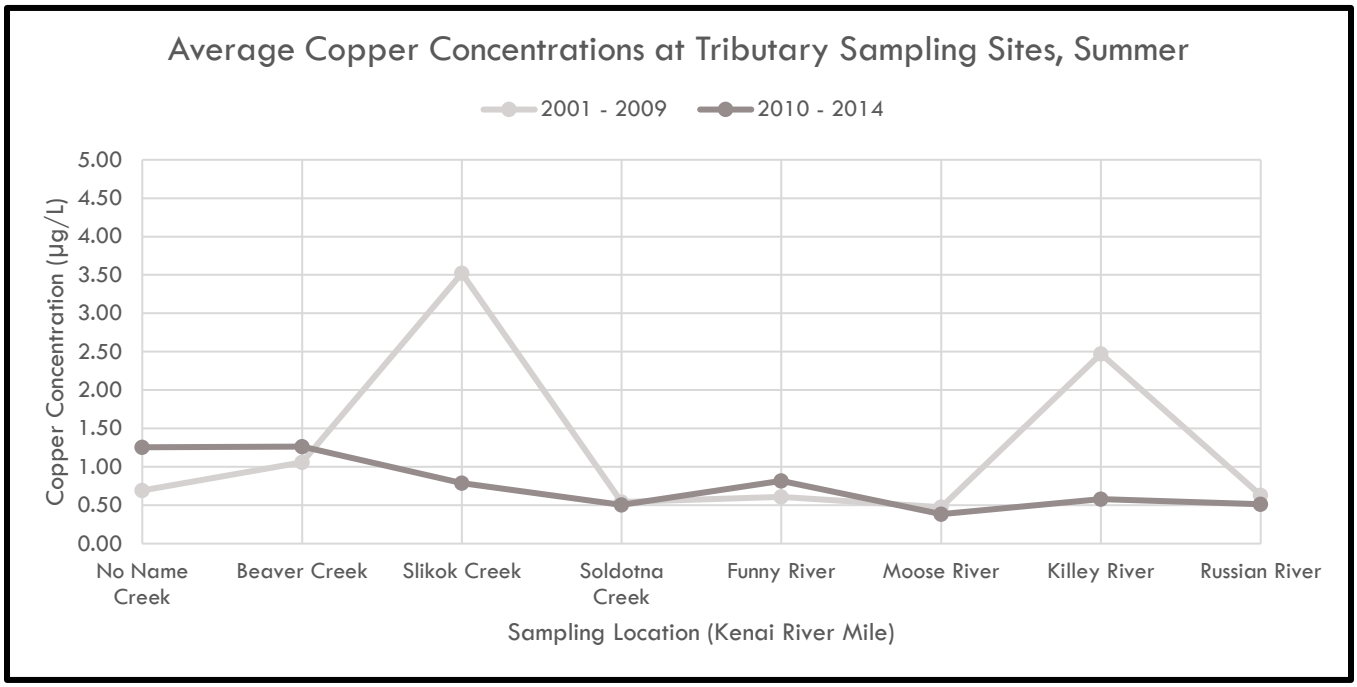

FIGURE 9: AVERAGE COPPER CONCENTRATIONS AT TRIBUTARY SAMPLING SITES, SUMMER

Note: To this point, it does not appear that there have been widespread increases in summer copper concentrations for Kenai River tributaries.

The charts above present clear evidence that zinc and copper concentrations in the Kenai River watershed have risen in recent years. This phenomenon was most apparent during spring sampling events at lower Kenai River sites, and in tributaries that feed into the lower Kenai River. While elevations in zinc concentrations have remained fairly consistent, the last three years of sampling (from spring 2015 through spring 2017) have shown more notable increases in spring copper concentrations at lower Kenai watershed sites.

While temperature, discharge, snowmelt, and related seasonal variables are a definite factor in water quality fluctuations, the patterns demonstrated by recent zinc and copper concentrations (higher concentrations and greater increases in developed regions of the watershed) indicate a significant influence from anthropogenic factors. A better understanding of natural variations in these parameters could be gained through a more comprehensive monitoring program. Using the current dataset, it is also difficult to determine whether zinc and copper concentrations are within or outside of acceptable ranges, as these parameters require the establishment of site specific standards. Such standards could be generated through the Biotic Ligand Model. Given the increases that have been seen in recent years, and the demonstrated toxicity of these elements at levels slightly above normal (Hecht, et al., 2007; Eisler, 1993), a review of potential pollution sources in the Kenai River watershed was conducted.

LITERATURE REVIEW RESULTS

Shown in the pie charts below are breakdowns of the most mentioned sources of zinc and copper in the articles and papers selected for the literature review. In total, 27 sources were reviewed. 10 primarily discussed copper sources, 8 primarily discussed zinc sources, and 9 discussed potential sources of both trace elements. Some articles discussed sources of zinc and copper in more general terms (e.g. runoff, traffic, urbanization), while many sources pointed to specific items, industries, products, and practices that can contribute zinc or copper to a waterbody. Several papers highlighted not only the sources of these metals, but their ability to harm fish at relatively low concentrations.

While these charts show that there are numerous potential sources of zinc and copper in the environment, several papers highlighted a few sources as the major contributors for each trace metal. Additionally, as expected, the noted sources of zinc and copper were found to be highly dependent on the level of development in the vicinity of the sampled waterbodies. The general nonpoint source factors found to influence zinc and copper concentrations were urbanization, increased percentage of impervious surfaces, accelerated storm water transport, traffic intensification, and deforestation/devegetation – all processes which are typically associated with one another.

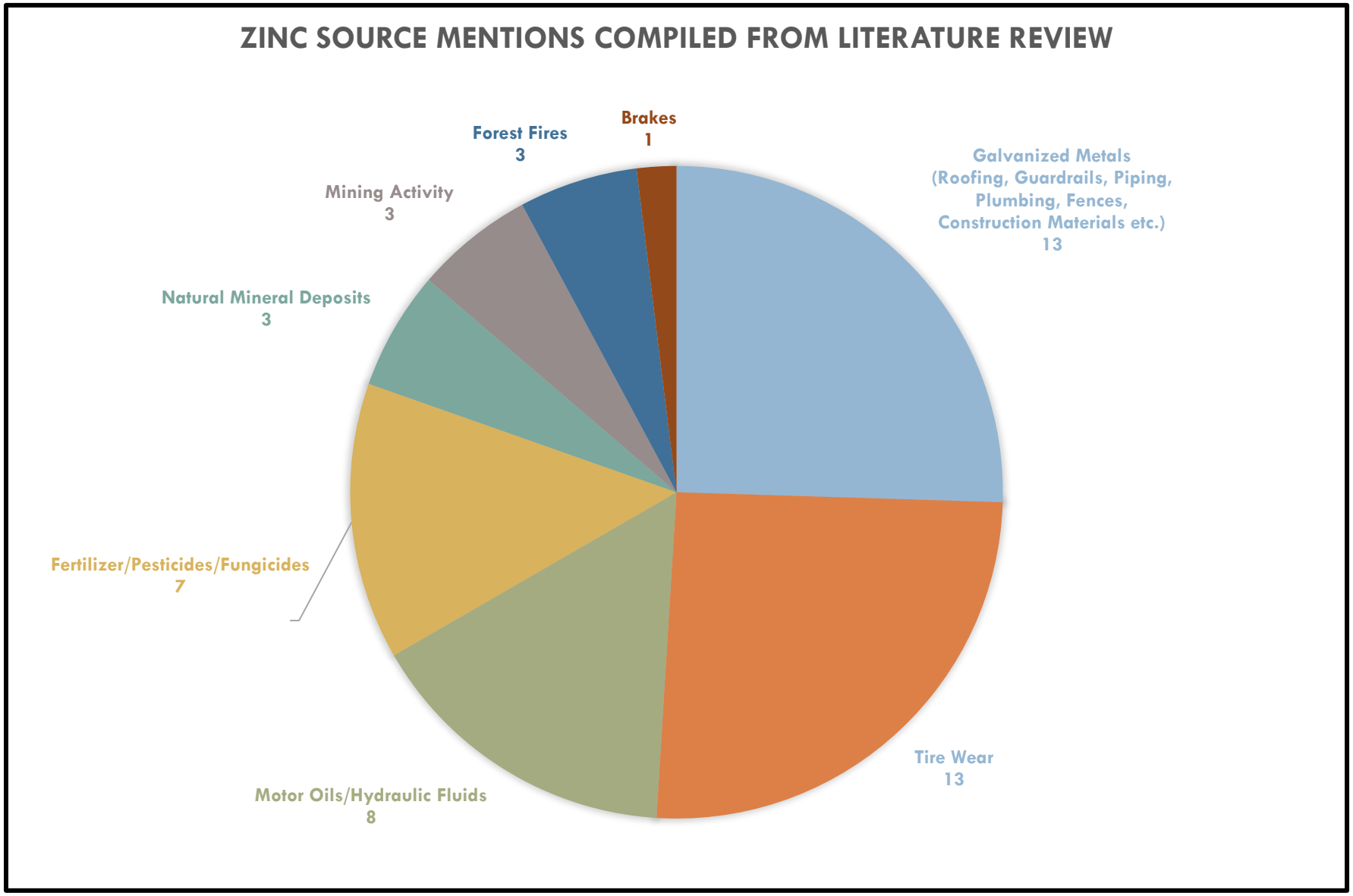

FIGURE 10: ZINC SOURCE MENTIONS COMPILED FROM LITERATURE REVIEW

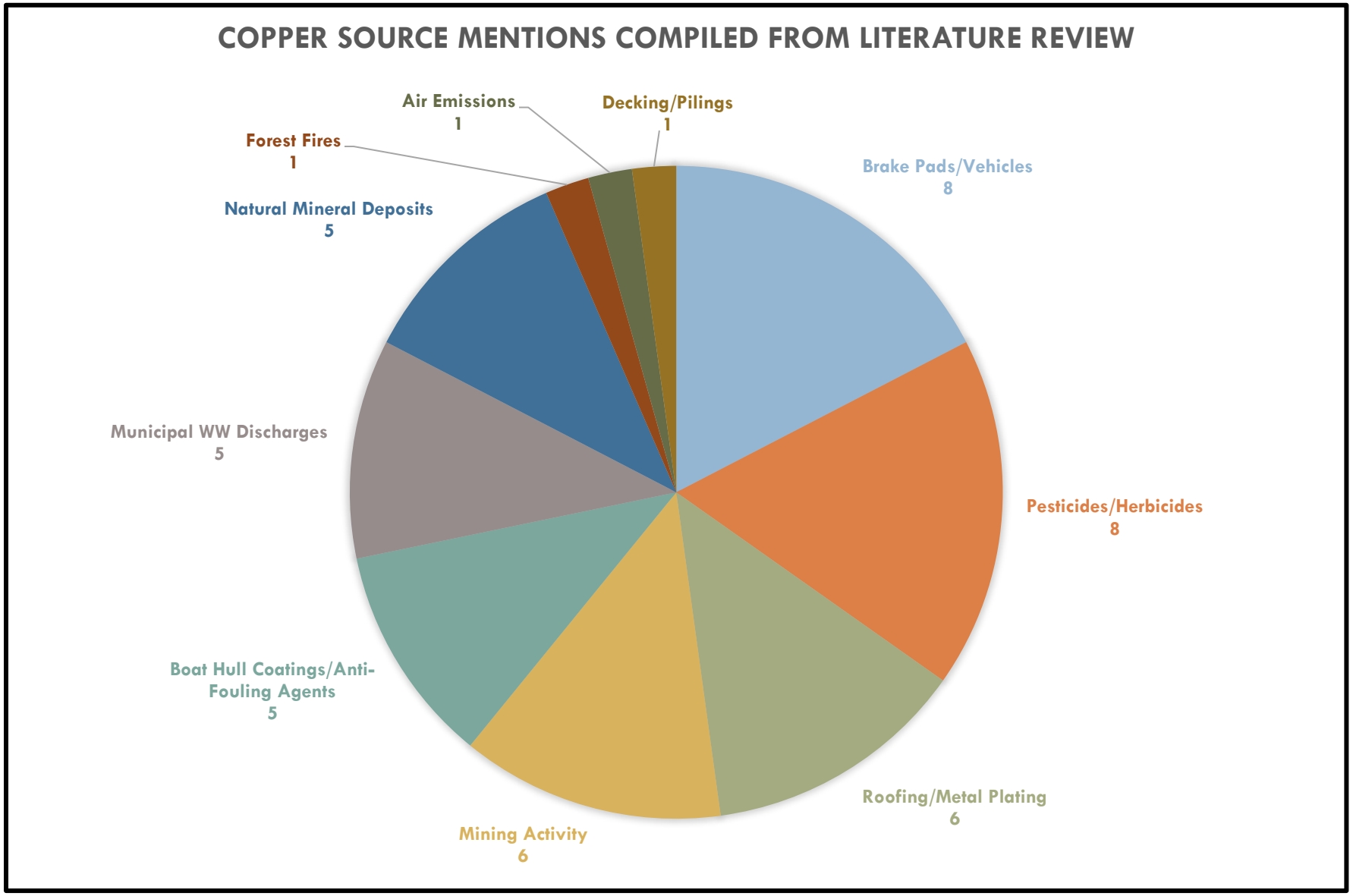

FIGURE 11: COPPER SOURCE MENTIONS COMPILED FROM LITERATURE REVIEW

LITERATURE REVIEW CONCLUSIONS

A full discussion of literature review results, along with a list of references, can be found in *A Review of Potential Zinc and Copper Pollution Sources in the Kenai River Watershed*, which was submitted as a deliverable for this project. The discussions of potential zinc and copper sources in that report allowed for the prioritization of further investigations as they relate to the Kenai River watershed. While the current data do not provide an accurate picture of the degree to which each of these sources affect water quality, KWF recommends that the following potential sources and factors are highlighted and assessed in future studies and/or water quality sampling:

Zinc

- Tire wear and traffic intensification
- Galvanized metals including roofing, fences, culverts, drain pipes, construction materials, etc.
- Fertilizer, pesticides, and fungicides
- Natural and environmental variables including flow rates, air and water temperature, water hardness, dissolved oxygen, and other water quality parameters related to the development of site-specific zinc standards
- General urbanization, anthropogenic development, prevalence of impervious surfaces, deforestation, etc.

Copper

- Copper brake pads and traffic intensification
- Municipal wastewater discharges
- Fertilizers, pesticides, herbicides, and fungicides
- Boat Hull Coatings and Anti-Fouling Paints
- Natural and environmental variables including flow rates, air and water temperature, water hardness dissolved oxygen, and other water quality parameters related to the development of site-specific copper standards
- General urbanization, anthropogenic development, prevalence of impervious surfaces, deforestation, etc.

There are numerous studies assessing the impact of these potential sources, which could be drawn on to develop a similar plan for the Kenai River watershed. While it may be a resource consuming endeavor to attempt to quantify each source's relative effect on zinc and copper concentrations, a better understanding would likely be gained by taking more frequent samples at strategic sites, and from urban runoff sources nearby. In addition, it would be helpful to develop area specific standards for these metals (through the EPA's Biotic Ligand Model), such that the impact of current concentrations on water quality, the environment, and specific species can be assessed.

FINAL CONCLUSIONS AND RECOMMENDATIONS

Despite the difficulty associated with determining relative contributions to zinc and copper pollution from various point and nonpoint sources, there are a few important conclusions and suggestions that can be made regarding these water quality constituents in the Kenai River watershed.

Average zinc and copper concentrations have been consistently higher than average for several of the most recent Kenai River water quality samplings. The elevations at some sites are substantial enough to warrant concern, regardless of whether site specific standards for these parameters have been established. Both zinc and copper, even at concentrations slightly above normal, have the potential to negatively impact local fish species and ecosystems.

In addition, based on the data available, the patterns displayed through these data, and the results of the literature review, it is probable that anthropogenic factors are playing a large role in the demonstrated elevation of zinc and copper concentrations. A growing population, increases in near-river development, traffic intensification, and devegetation can all contribute to a general decrease of water quality for a given watershed. Nearly all of the most significant rises in zinc and copper concentrations during the time period being discussed occurred at lower Kenai River watershed sampling sites, in areas where anthropogenic development and urbanization are most prominent. This, coupled with potential point sources that were discussed in the literature review (the Soldotna Waste Water Treatment Plant, copper brake pads, tire wear, lawn chemicals, etc.), suggests that practices and regulations within developed regions of the Kenai River watershed should be reviewed as they relate to zinc and copper pollution.

While it is still unclear how detrimental current zinc and copper concentrations may be to ecosystems within the Kenai River watershed, it is important to recognize these pollutants as emerging threats to an extremely valuable environment. As such, it would be prudent to address zinc and copper pollution before their potential effects are more evident. Fortunately, some recommendations regarding the mitigation of this issue are practical measures that can be taken to ensure water quality in general, and need not be seen as an extra effort focused only on two particularly concerning parameters.

As shown through this project, a long record of water quality data is invaluable in providing information about local stream and river health. Consistent monitoring can highlight potential issues and allow relevant parties to respond before these issues become widespread problems. While the current Kenai River watershed water quality sampling program provides critical comparisons of past and present water chemistry and pollutant data, it is not designed to identify and quantify point sources for specific water quality constituents. Further, it does not provide the comprehensive information necessary to establish site specific standards for zinc and copper. KWF recommends

that sampling, focused on zinc and copper pollution, be conducted throughout the year at targeted sites to further inform conclusions regarding sources, variability, and toxicity of these metals in the Kenai River watershed. Ideally, this sampling would enable KWF and other stakeholders to differentiate between the influence of environmental and anthropogenic factors on a wide variety of water quality parameters.

Aside from continued and potentially expanded water quality monitoring, pertinent information could be gleaned from a general assessment of recent urbanization, riparian development, and traffic intensification in the Kenai River watershed. As noted several times in this report, nearly all of the most significant elevations in zinc and copper concentrations have been found in developed areas. Relating a growth in population, increase in traffic rates, larger percentages of impervious surfaces, and deforestation to water quality trends would be extremely helpful in understanding how to mitigate zinc and copper pollution, and how to ensure a balance between anthropogenic growth and a healthy ecosystem.

In general, one of the most important things that can be done to reduce water quality degradation in riverside communities is to provide information and educational opportunities to landowners and developers regarding their potential impact. Local codes and regulations should limit the development of riparian areas, and encourage responsible, sustainable infrastructure design that reduces runoff rates, and captures pollutants before they enter streams and rivers. With regards to zinc and copper, an effort could be made to discourage the use of certain lawn chemicals and agricultural products that may be used by waterfront homeowners, near-river golf courses, and other large landscaped areas in close proximity to streams and rivers. Finally, the states of Washington and California have already signed legislation into law that enacts a phase-out process for copper brake pads, citing the demonstrable effects of copper pollution on salmonids. Attempting to pass similar legislation in Alaska would be a logical and beneficial initiative.

All of these approaches would lead towards a better understanding of water quality cause and effect in the Kenai River watershed. With regards to zinc and copper pollution, these recommendations provide an opportunity for local and regional entities to be proactive in responding to and mitigating this important issue.

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