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Comparison of Surficial Sediment Quality in the St. Louis River Area of Concern, MN/WI, with Other North American Sites

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Abstract—The distribution of surficial sediment contaminants within the St. Louis River Area of Concern (AOC), MN/WI, was compared to levels of contamination that have been measured at other AOCs in the Great Lakes basin, and in areas elsewhere in North America. Mean probable effect concentration quotients (PEC-Qs), which provide an indicator of ecosystem health by using a mixture of sediment chemistry data, were used to evaluate the potential toxic effects of contaminated sediments on benthic invertebrates in the selected areas of interest. The results of this evaluation indicated that sediment quality conditions in the St. Louis River AOC varied widely. Twenty-six percent of samples in the St. Louis River AOC were associated with low risk (i.e., mean PEC-Qs of <0.1), 56% of samples were associated with moderate risk (i.e., mean PEC-Qs of 0.1 to 0.6), and 18% of samples were associated with high risk to sediment-dwelling organisms (i.e., mean PEC-Qs of >0.6).

Among the Great Lakes AOCs that were considered, the highest levels of chemical contamination were observed in surficial sediments from the Grand Calumet River AOC, IN. Based on the median of the mean PEC-Q values calculated, the St. Louis River AOC ranked sixth in terms of chemical contamination among the eight AOCs considered in this analysis. Among the six other geographic areas in the United States included in this analysis, the highest levels of contamination were observed in sediment samples from the Willamette River, OR and Anacostia River, DC. The St. Louis River AOC ranked fourth in terms of chemical contamination when compared with the areas located outside the Great Lakes basin. When both the Great Lakes AOCs and other areas in the United States were considered, the St. Louis River AOC ranked ninth highest among the 14 areas. Interpretation of the results of this screening assessment should be made in the context of the uncertainties identified for this analysis.

Introduction

The St. Louis River Area of Concern (AOC) includes the Duluth-Superior Harbor, which is one of the largest fresh-water ports in the world (Figure 1). At several locations within this AOC, particularly in the harbor, the sediments have been contaminated with a mixture of pollutants which may include metals (such as mercury and zinc), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, and/or dioxins and furans (PCDDs and PCDFs). The presence of contaminated sediments in this AOC has resulted in a variety of use impairments, including restrictions on dredging, fish advisories, and the impairment of benthic habitats for bottom-feeding organisms. In addition, the release of sediment-derived contaminants to the water column is an important consideration in the development of total maximum daily loads (TMDLs) for the following contaminants in portions of the St. Louis River: DDT, dieldrin, dioxins, PCBs, and toxaphene.

The Minnesota Pollution Control Agency (MPCA), Wisconsin Department of Natural Resources (WDNR), Fond du Lac Band, U.S. Army Corps of Engineers, consultants for government agencies and responsible parties, and other federal and academic organizations have conducted a number of investigations to assess sediment quality conditions in the lower St. Louis River AOC, particularly since 1990. As part of the Remedial Action Plan (RAP) process for the St. Louis River AOC, stakeholders identified a need to compile the sediment quality data collected from the St. Louis River in a database format. A matching sediment chemistry and toxicity database was completed in 2000 to support an evaluation of the predictive ability of numerical sediment quality targets (SQTs) in the St. Louis River AOC

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(Crane *et al.* 2000, 2002). In 2003, the matching sediment chemistry/toxicity database, as well as additional sediment chemistry, sediment toxicity, bioaccumulation, and physical parameter data collected since 1990 were compiled into the Phase I GIS-based Microsoft™ (MS™) Access 2000 sediment quality database. Due to the large amount of post-1990 sediment quality data available for the St. Louis River AOC, funding is being obtained by the MPCA and its collaborators in a phased approach to continue the GIS-based sediment quality database. Phase II of the database has recently been completed to include additional sediment quality data from the federal navigation channels and from sites located along the Wisconsin side of this AOC (Smorong and Crane 2004; Smorong *et al.* 2004). Phase III of the database is underway to include more sediment quality data sets from the Minnesota side of the AOC, including benthic invertebrate community data.

With the completion of the Phase II database, an opportunity exists to evaluate the distribution of surficial sediment contaminants within the St. Louis River AOC and to compare these results to the levels of contamination that have been measured at other AOCs in the Great Lakes basin, and in other areas located elsewhere in North America. This bulletin presents the results of analyses that were conducted to facilitate such comparisons and, in so doing, to better understand the severity and potential effects of sediment contamination in the St. Louis River AOC.

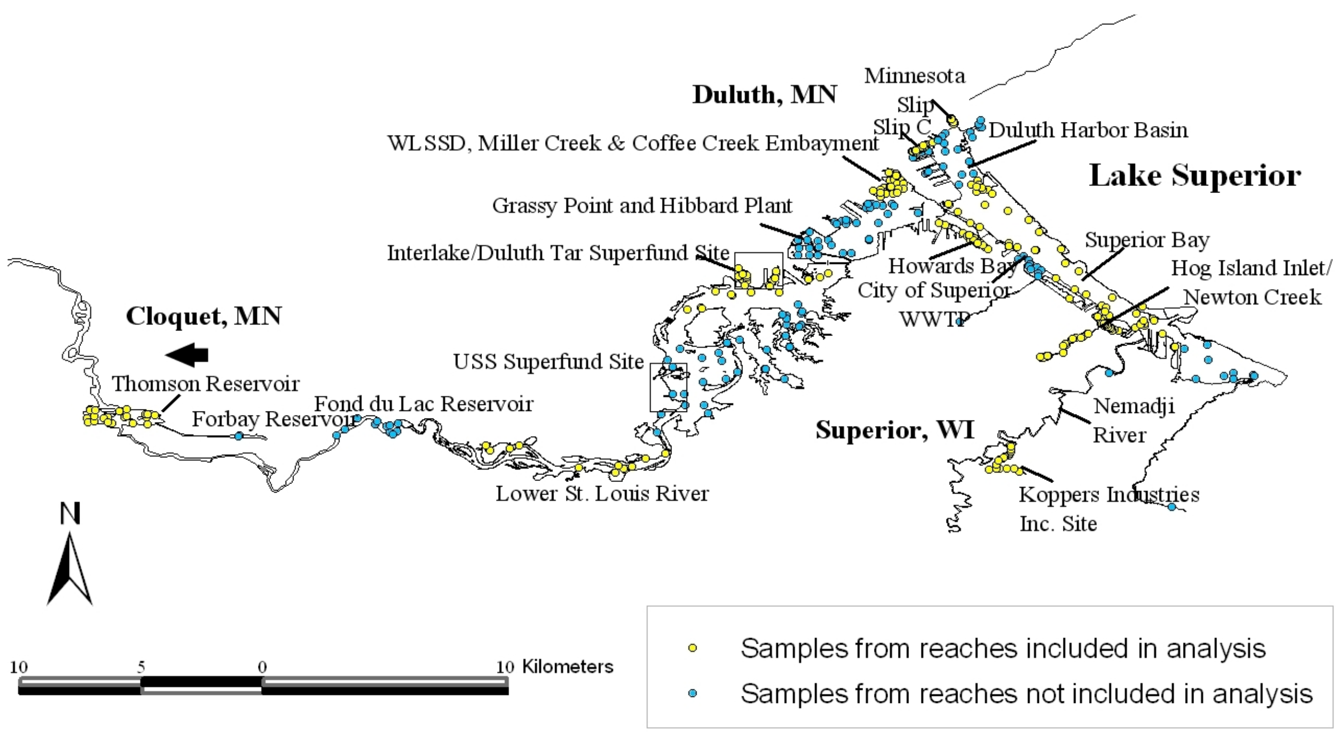
Methods

A step-wise approach was used to compare sediment chemistry data in surficial samples (0-30 cm) from the St. Louis River AOC with that in surficial sediments from other AOCs in the Great Lakes basin and other freshwater or estuarine (salinity less than 10 ppt) areas located elsewhere in North America. The steps included:

- Identifying areas of interest;
- Collating the sediment chemistry data;
- Calculating summary statistics for each geographic area;
- Evaluating the distribution of a mixture of sediment contaminants for each area; and,
- Assessing the effects of chemicals of potential concern (COPCs) on benthic invertebrates.

To identify the geographic areas to be included in the analysis, the information contained in the Phase II GIS-based sediment quality database was screened to identify the areas in the St. Louis River AOC for which sediment chemistry data were available for 20 or more surficial sediment samples. Similarly, the information in the geographically-broader SedTox database (a proprietary data-

Figure 1: Map showing surficial sampling locations and reaches within the St. Louis River AOC



base owned by MacDonald Environmental Sciences Ltd. and containing matching sediment chemistry and toxicity data from numerous locations in North America; Ingersoll *et al.* 2001) was screened to identify the areas in the Great Lakes basin and elsewhere in North America for which 20 or more surficial sediment samples were available on the chemical characteristics of surficial sediments. The sediment chemistry data that were included in the SedTox database underwent a similar screening procedure to assess data quality as the data sets included in the Phase II GIS-based sediment quality database.

To support subsequent data analyses, the available surficial sediment chemistry data for the selected areas of interest were collated. Mean probable effect concentration quotients (PEC-Qs) were calculated to provide an integrative metric for assessing sediment quality in each area. The MPCA has adopted consensus-based probable effect concentrations (PECs) for 28 chemicals as Level II sediment quality targets (SQTs) for the St. Louis River AOC (Crane *et al.* 2000, 2002). These mean PEC-Qs were calculated using the procedures recommended by USEPA (2000) and outlined in Crane *et al.* (2000, 2002) for the integration of total PAHs, total PCBs, and selected metals. In brief, mean PEC-Qs were calculated as follows:

$$\text{PEC-Q} = \frac{\text{chemical concentration (dry wt.)}}{\text{corresponding PEC value}}$$

$$\text{Mean PEC-Q} = (\text{mean PEC-Q}_{\text{metals}} + \text{PEC-Q}_{\text{Total PAHs}} + \text{PEC-Q}_{\text{Total PCBs}})/n$$

Where n = number of classes of chemicals for which sediment chemistry data were available (i.e., 1 to 3).

The mean PEC-Q data for the selected areas of interest were extracted from the two databases and compiled in MS™ Excel spreadsheets for further data analyses.

The distribution of mean PEC-Qs was determined for selected areas within the St. Louis River AOC, for the entire St. Louis River AOC, for other AOCs within the Great Lakes basin, and for other areas located elsewhere in North America. The distributions of mean PEC-Qs were determined for each of the selected areas of interest by calculating the arithmetic mean, standard deviation, and median values. Other summary statistics and statistical analyses (i.e., cumulative distribution frequency plots) are provided in the project report (Crane *et al.* 2004).

Mean PEC-Qs, in the form of Level I and Level II SQTs, were used to evaluate the potential effects of contaminated sediments on benthic invertebrates in the selected areas of interest. The Level I SQTs are intended to identify contaminant concentrations below which harmful effects on sediment-dwelling organisms are unlikely to occur. Crane *et al.* (2000) recommended a Level I SQT of 0.1 for mean PEC-Qs. The Level II SQTs are intended to identify contaminant concentrations above which harmful effects on sediment-dwelling organisms are likely to occur frequently or always. Crane *et al.* (2000) recommended a Level II SQT of 0.6 for mean PEC-Qs.

The potential for observing adverse effects on benthic invertebrates was evaluated by dividing the sediment samples for each geographic area into three groups. Samples with mean PEC-Qs below 0.1 were included in a low risk group. Samples with mean PEC-Qs of $\geq$0.1 and $\leq$ 0.6 were included in a moderate risk group, while those with mean PEC-Qs of $>$ 0.6 were included in a high risk group. Subsequently, the percentage of samples within each group for each area of interest was calculated.

Results and Discussion

Areas of Interest in the St. Louis River AOC and Elsewhere

The Phase II MS™ Access 2000 sediment quality database for the St. Louis River AOC contains data on the concentrations of COPCs for a total of 567 surficial sediment samples from 36 reaches within the AOC. Of these reaches, 10 had sufficient data (i.e., $\geq$ 20 sediment samples) on the chemical characteristics of surficial sediments to support subsequent data analyses, including the St. Louis River Interlake/Duluth Tar (SLRIDT) Superfund site, Minnesota Slip, Slip C, the embayment encompassing the Western Lake Superior Sanitary District (WLSSD) and Coffee and Miller Creeks, lower St. Louis River, Thomson Reservoir, Superior Bay, Koppers Industries Inc. site, Hog Island Inlet/Newton Creek and Howard's Bay (Figure 1). Insufficient data were available to support the assessment of sediment quality conditions in several other areas of interest that are known or suspected to contain elevated levels of COPCs, including the USS Superfund site, the City of Superior wastewater treatment plant, area near Grassy Point, Fond du Lac Reservoir, and Forbay Reservoir.

The SedTox database was used to identify seven other Great Lakes AOCs, including: Grand Calumet River AOC, IN; Maumee River AOC, OH; St. Mary's River AOC, ON/MI; Waukegan Harbor AOC, IL; Cuyahoga River AOC, OH; Oswego River AOC, NY; and St. Clair River AOC, ON/MI. Six areas of interest from outside the Great Lakes basin were also selected for evaluation in this investigation, including: Willamette River, OR; Anacostia River, DC; Calcasieu River, LA; Lower Savannah River, GA; Homestead Air Force Base, FL; and Trinity River, TX.

Distributions of Sediment Chemistry Data

The summary statistics that were used to describe the distribution of mean PEC-Qs for the selected areas of interest within the St. Louis River AOC are presented in Table 1. These results show that, on average, the highest levels of sediment contamination occurred at the Koppers Industries, Inc. site (average and maximum mean PEC-Qs of 109 and 2330, respectively; n=42) and the SLRIDT Superfund site (average and maximum mean PEC-Qs of 7.62 and 72.2, respectively; n=20). Elevated levels of COPCs were also observed in surficial sediments from Minnesota Slip and Slip C [i.e., average mean PEC-Qs of 1.03 (n=39) and 0.553 (n=29), respectively]. Relatively lower average mean PEC-Qs (i.e., 0.137 to 0.342) were measured in the other six areas of interest within the St. Louis River AOC (n=22 to 103). Overall, the mean PEC-Qs for surficial sediments from the St. Louis River AOC averaged 8.68 and ranged from 0.00764 to 2330 (n=567). However, the median of the mean PEC-Q values for the entire AOC was 0.198 (Table 1). As indicated by the high standard deviation in the average mean PEC-Qs for the Koppers Industries Inc. site (SD = 390) and for the entire St. Louis River AOC (SD = 109), contaminant concentrations vary substantially, both within and among reaches. Accordingly, these high standard deviations may limit the value of the arithmetic mean as an accurate estimate of central tendency, particularily when multiple areas are being compared. In addition, average values of mean PEC-Qs may not necessarily provide an accurate estimate of the distribution of the data when sediment chemistry data from stratified random and gradient-type designs are included in the data sets for these areas of interest. Therefore, comparisons between the St. Louis River AOC with other areas in the Great Lakes basin and United States will be based on the median of the mean PEC-Qs for each area.

The levels of COPCs in surficial sediments from AOCs elsewhere in the Great Lakes basin were highly variable (Table 2). Among the AOCs considered, the greatest range of mean PEC-Qs (0.000636 to 23,800, n=821) was observed in surficial sediments from the Grand Calumet River AOC. Five other AOCs had higher median values of the mean PEC-Qs than observed for the St. Louis River AOC, including the Grand Calumet River AOC (2.49, n=821), St. Mary's River AOC (1.02, n=38), Cuyahoga River AOC (0.939, n=21), Waukegan Harbor AOC (0.518, n=23), and Maumee River AOC (0.278, n=25). The median of the mean PEC-Q values for the St. Clair River AOC (0.153, n=44) and Oswego River AOC (0.0763, n=22) were lower than for the St. Louis River.

Table 1: Distribution of mean PEC-Qs in surficial sediments for selected areas in the St. Louis River Area of Concern

Reach/Site	n	Mean	SD	Median
Koppers Industries Inc. Site	42	109	390	1.91
SLRIDT Superfund Site	20	7.62	16.6	1.40
Minnesota Slip	39	1.03	0.402	0.988
Slip C	29	0.553	0.393	0.496
Howard's Bay	34	0.342	0.151	0.340
WLSSD, Miller Creek and Coffee Creek Embayment	27	0.331	0.167	0.335
Lower St. Louis River	31	0.328	0.672	0.148
Hog Island Inlet/Newton Creek	103	0.280	0.260	0.236
Superior Bay	59	0.152	0.0978	0.153
Thomson Reservoir	22	0.137	0.0423	0.146
St. Louis River AOC	567	8.68	109	0.198

SD = standard deviation
SLRIDT = St. Louis River Interlake/Duluth Tar
WLSSD = Western Lake Superior Sanitary District

Among the areas of interest located outside the Great Lakes basin (Table 3), the Willamette River in Oregon showed the greatest range of chemical contamination. Mean PEC-Qs for the surficial sediment samples from this location ranged from 0.00671 to 190 (n=60). The median of the mean PEC-Qs was greater for the Anacostia River, DC (0.517, n=53), Willamette River, OR (0.487, n=60), and Lower Savannah River, GA (0.298, n=48) than for the St.

Table 2: Distribution of mean PEC-Qs in surficial sediments for selected Great Lakes Areas of Concern

Area of Concern	n	Mean	SD	Median
Grand Calumet River, IN	821	54.1	867	2.49
St. Louis River, MN/WI	567	8.68	109	0.198
Maumee River, OH	25	8.09	35.8	0.278
St. Mary's River, MI/ON	38	5.58	11.1	1.02
Cuyahoga River, OH	21	1.08	0.748	0.939
Waukegan Harbor, IL	23	0.575	0.249	0.518
St. Clair River, MI/ON	44	0.398	1.44	0.153
Oswego River, NY	22	0.0941	0.0545	0.0763

SD = standard deviation

Louis River AOC (0.198, n=567). The other three geographic areas included in this analysis had median values of the mean PEC-Qs that were less that that observed in the St. Louis River AOC, including the Calcasieu River, LA (0.181, n=631), Trinity River, TX (0.166, n=64), and Homestead Base, FL (0.0865, n=88).

Table 3: Distribution of mean PEC-Qs in surficial sediments for selected areas elsewhere in the U.S.

Geographic Area	n	Mean	SD	Median
Willamette River, OR	60	10.8	33.6	0.487
St. Louis River AOC, MN/WI	567	8.68	109	0.198
Anacostia River, DC	53	0.710	0.594	0.517
Calcasieu River, LA	631	0.497	3.30	0.181
Lower Savannah River, GA	48	0.289	0.0835	0.298
Homestead Airforce Base, FL	88	0.198	0.256	0.0865
Trinity River, TX	64	0.180	0.0797	0.166

SD = standard deviation

Potential Effects of Contaminated Sediments on Benthic Invertebrates

Risks to benthic invertebrates were considered to be low if mean PEC-Qs were <0.1, moderate if mean PEC-Qs were between 0.1 and 0.6, and high if mean PEC-Qs were >0.6. Based on the results of these analyses (Table 4), whole sediment samples collected in the vicinity of the SLRIDT Superfund site and Minnesota Slip appear to pose the highest risks to benthic invertebrates within the St. Louis River AOC. Approximately 85% and 90% of the samples from the SLRIDT Superfund site and the Minnesota Slip site, respectively, had mean PEC-Qs of >0.6. However, the magnitude of the exceedance of the Level II SQT was more than a factor of ten greater at the SLRIDT Superfund site than for Minnesota Slip. The frequency of high risk samples tended to be lower at the other eight areas considered, ranging from 0% for the Thomson Reservoir and Superior Bay to 57% for the Koppers Industries, Inc. site. Overall, 18% of the surficial sediment samples from the St. Louis River AOC had concentrations of total PAHs (based on the 13 parent low molecular weight and high molecular weight PAHs), total PCBs, and/or metals (i.e., arsenic, cadmium, chromium, copper, lead, nickel, and/or zinc) sufficient to pose high risks to benthic invertebrates. The majority (56%) of surficial sediment samples in the St. Louis River AOC were associated with moderate risk to benthic invertebrates, whereas 26% of samples were of low risk to benthic invertebrates (Table 4).

Among the seven Great Lakes AOCs considered, three AOCs had mean PEC-Qs sufficient to pose high risks to benthic invertebrates in at least 60% of the sediment samples collected from each respective site (Table 4). These AOCs included the Cuyahoga River AOC (76% of samples), the Grand Calumet River AOC (70% of samples), and the St. Mary's River AOC (61% of samples). Lower frequencies of high risk samples were observed for the Waukegan Harbor AOC (35% of samples), Maumee River AOC (28% of samples), St. Clair River AOC (5% of samples), and Oswego River AOC (0% of samples). The Oswego River AOC had the greatest percentage of samples (68%) with mean PEC-Qs <0.1, followed by the St. Clair River AOC (25%). The frequency of low, moderate, and high risk samples in the St. Clair River AOC was the most similar of the other Great Lakes AOCs to the distribution observed in the St. Louis River AOC.

Among the areas located elsewhere in the United States, the frequency of high risk samples tended to be lower than was observed for the other Great Lakes AOCs (Table 4). The greatest frequency of high risk samples was observed for the Willamette River (43% of samples) and the Anacostia River (40% of samples). The potential for observing adverse effects was much lower for the other four areas considered, ranging from 0% high risk samples for the Trinity River and Lower Savannah River to 8% high risk samples for the Homestead Airforce Base. Of the six areas considered, only the Willamette River and the Anacostia River had frequencies of high risk samples higher than the frequency that was determined for the St. Louis River AOC. Homestead Airforce Base had the greatest percentage of samples with mean PEC-Qs <0.1 (i.e., 56%), followed by the Calcasieu River (18%). Over 50% of the samples at five of the six geographic areas considered had surficial sediments that were sufficiently contaminated to pose a moderate risk to benthic invertebrates.

While these statistical analyses provide a useful screening assessment of sediment quality conditions in the surficial sediments of numerous areas in North America, these analyses must be considered in the context of the following uncertainties.

- The databases used for these analyses were not inclusive of all the surficial sediment chemistry data available for the areas of interest, but were nevertheless assumed to be representative of the available data. Therefore, these analyses should be updated as the GIS-based sediment quality database for the St. Louis River AOC and the SedTox databases are updated and expanded.

- The mean PEC-Qs may not include all COPCs for a particular area. For example, diesel range organics and a number of other PAHs contribute to ecological risk at the Hog Island Inlet/Newton Creek site in the St. Louis River AOC (SEH Inc. 2003a,b), and mercury is an important COPC at many contaminated sediment sites across the United States.

- Use of the mean PEC-Qs should take into consideration variations in physical, chemical, and biological factors in the sediment environment that may complicate and introduce uncertainty into their use. For example, certain chemicals can be present in relatively unavailable forms (such as in slag, paint chips, and tar). Use of the mean PEC-Qs may not be applicable in depositional wetlands (due to high organic matter and sulfides), oil and gas production environments, in highly modified depositional systems, and in nondepositional and erosional systems (Wenning and Ingersoll 2002).

Table 4: Frequency of low, moderate, and high risk samples for the St. Louis River AOC, other AOCs in the Great Lakes basin, and other areas located in the U.S.

		Percentage (%) of Samples Within Ranges of Mean PEC-Qs		
Area/Reach	**n**	**<0.1 (low)**	**0.1 to 0.6 (moderate)**	**>0.6 (high)**
St. Louis River AOC				
Koppers Industries Inc. Site	42	21	21	57
SLRIDT Superfund Site	20	0	15	85
Minnesota Slip	39	0	10	90
Slip C	29	10	55	34
Howard's Bay	34	3	91	6
WLSSD, Miller Creek and Coffee Creek Embayment	27	7	85	7
Lower St. Louis River	31	42	48	10
Hog Island Inlet/Newton Creek	103	17	79	5
Superior Bay	59	37	63	0
Thomson Reservoir	22	27	73	0
St. Louis River AOC	**567**	**26**	**56**	**18**
Other Great Lakes AOCs				
Grand Calumet River, IN	821	7	23	70
Maumee River, OH	25	0	72	28
St. Mary's River, MI/ON	38	8	32	61
Cuyahoga River, OH	21	0	24	76
Waukegan Harbor, IL	23	0	65	35
St. Clair River, MI/ON	44	25	70	5
Oswego River, NY	22	68	32	0
Other Areas in the U.S.				
Willamette River, OR	60	2	55	43
Anacostia River, DC	53	2	58	40
Calcasieu River, LA	631	18	75	7
Lower Savannah River, GA	48	0	100	0
Homestead Airforce Base, FL	88	56	36	8
Trinity River, TX	64	9	91	0

SLRIDT = St. Louis River Interlake/Duluth Tar
WLSSD = Western Lake Superior Sanitary District

- Sediments are often heterogeneous, resulting in patchy distributions of contaminants, grain size, sulfide levels, and organic carbon type at varying levels of scale.

- Use of the mean PEC-Qs is enhanced when considered as part of a weight-of-evidence approach that includes other sediment quality indicators, such as sediment chemistry and geochemical characteristics, sediment toxicity, and benthic invertebrate community structure (Crane and MacDonald 2003).

- Due to uncertainties associated with bioavailability, there is not a 100% certainty that samples with mean PEC-Qs exceeding 0.6 will actually be toxic to sediment-dwelling organisms. Rather, the probability of observing chronic toxicity to amphipods (*Hyalella azteca*) in 28-day exposures is greater than 50% when mean PEC-Qs exceed a mean PEC-Q of 0.63 (USEPA 2000; Ingersoll *et al.* 2001). In the St. Louis River AOC, the incidence of toxicity to amphipods and midges (conducted as separate 10-day sediment toxicity tests) was found to increase as the mean PEC-Q ranges increased (Crane *et al.* 2002).

None of the aforementioned factors, though, preclude the general application of the mean PEC-Qs to the analyses conducted in this assessment.

Conclusions

The available surficial sediment chemistry data from the St. Louis River AOC, other AOCs in the Great Lakes basin, and other geographic areas in North America were queried, compiled, and compared from two different sediment quality databases. To facilitate comparisons of these data, mean PEC-Qs were calculated for each surficial sediment sample represented in the Phase II GIS-based sediment quality database for the St. Louis River AOC and in the SedTox database. The results of this evaluation indicated that sediment quality conditions in the St. Louis River AOC varied widely. Twenty-six percent of samples in the St. Louis River AOC were associated with low risk (i.e., mean PEC-Qs of <0.1), 56% of samples were associated with moderate risk (i.e., mean PEC-Qs of 0.1 to 0.6), and 18% of samples were associated with high risk to sediment-dwelling organisms (i.e., mean PEC-Qs of >0.6).

Among the reaches for which sufficient data were available to conduct data analyses, the SLRIDT Superfund site and Minnesota Slip had the highest levels of contamination, primarily from PAHs. More than 80% of the samples collected at each site exceeded the mean PEC-Qs of 0.6, indicating that contaminated surficial sediments pose high risks to the benthic invertebrate community at both sites. Slip C and the Koppers Industries, Inc. site also had relatively high frequencies of exceedence of the Level II SQT (i.e., 34% and 57%, respectively).

Among the Great Lakes AOCs that were considered, the highest levels of chemical contamination were observed in surficial sediments from the Grand Calumet River AOC. While the median of the mean PEC-Q values were much higher at this AOC than at the other AOCs included in this assessment, conditions sufficient to adversely affect sediment-dwelling organisms (i.e., mean PEC-Qs >0.6) were frequently observed in many of the AOCs considered, except for the St. Clair River and Oswego River AOCs. Based on the median of the mean PEC-Q values calculated, the St. Louis River AOC ranked sixth in terms of chemical contamination among the eight AOCs considered in this analysis.

Among the six other geographic areas in the United States that were considered in this analysis, the highest levels of contamination were observed in sediment samples from the Willamette River, OR and Anacostia River, DC. Much lower levels of contamination were observed at the four other sites. Based on the median of the mean PEC-Q values calculated, the St. Louis River AOC ranked fourth in terms of chemical contamination when compared with the areas located outside the Great Lakes basin. When both the Great Lakes AOCs and other areas in the United States were considered, the St. Louis River AOC ranked ninth highest among the 14 areas in terms of the medians of the mean PEC-Q values.

The statistical evaluation conducted for this study provided a useful comparison of sediment quality conditions, in the form of mean PEC-Qs, between the St. Louis River AOC and other AOCs in the Great Lakes basin and the rest of the United States. Interpretation of the results of this screening assessment should be made in the context of the uncertainties identified for this analysis. As additional updates are made to the GIS-based sediment quality database for the St. Louis River AOC and other national and North American sediment quality databases, similar analyses may be conducted to compare sediment quality conditions between sites.

Acknowledgments

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References

Crane, J.L. and D.D. MacDonald. 2003. Applications of numerical sediment quality targets for assessing sediment quality conditions in the St. Louis River Area of Concern. Environmental Management 32:128-140.

Crane, J.L., D.D. MacDonald, C.G. Ingersoll, D.E. Smorong, R.A. Lindskoog, C.G. Severn, T.A. Berger, and L.J. Field. 2000. Development of a framework for evaluating numerical sediment quality targets and sediment contamination in the St. Louis River Area of Concern. Great Lakes National Program Office, U.S. Environmental Protection Agency, Chicago, IL. EPA 905-R-00-008. (http://www.pca.state.mn.us/water/sediments/sqt-slraoc.pdf)

Crane, J.L., D.D. MacDonald, C.G. Ingersoll, D.E. Smorong, R.A. Lindskoog, C.G. Severn, T.A. Berger, and L.J. Field. 2002. Evaluation of numerical sediment quality targets for the St. Louis River Area of Concern. Archives of Environmental Contamination and Toxicology 43:1-10.

Crane, J.L., D.D. MacDonald, D.E. Smorong, L.J. Fisher, S.L. Hamilton, and C.A. Huntington. 2004. Phase II GIS-based sediment quality database for the St. Louis River Area of Concern (AOC): Comparison of surficial sediment contamination in the St. Louis River AOC with other areas of concern in the Great Lakes basin and other areas located elsewhere in the United States. MacDonald Environmental Sciences Ltd., Nanaimo, BC and Minnesota Pollution Control Agency, St. Paul, MN. (http://www.pca.state.mn.us/publications/tdr-fg04-04.pdf)

Ingersoll C.G., D.D. MacDonald, N. Wang, J.L. Crane, L.J. Field, P.S. Haverland, N.E. Kemble, R.A. Lindskoog, C.G. Severn, and D.E. Smorong. 2001. Predictions of sediment toxicity using consensus-based freshwater sediment quality guidelines. Archives of Environmental Contamination and Toxicology 41:8-21.

SEH Inc. 2003a. Remedial investigation report. Newton Creek, Douglas County, Wisconsin. Prepared by Short Elliott Hendrickson Inc., Chippewa Falls, WI for Wisconsin Department of Natural Resources, Bureau of Remediation and Redevelopment, Superior, WI.

SEH Inc. 2003b. Site investigation report. Hog Island Inlet, City of Superior, Douglas County, Wisconsin. Prepared by Short Elliott Hendrickson Inc., Chippewa Falls, WI for Wisconsin Department of Natural Resources, Bureau of Remediation and Redevelopment, Superior, WI.

Smorong, D.E. and J.L. Crane. 2004. Phase II GIS-based sediment quality database for the St. Louis River Area of Concern (AOC). Help section for database users. MacDonald Environmental Sciences Ltd., Nanaimo, BC and Minnesota Pollution Control Agency, St. Paul, MN. (http://www.pca.state.mn.us/publications/tdr-fg04-01.pdf)

Smorong, D.E., C.L. Mackenzie, J.L. Crane, D.D. MacDonald, L.J. Fisher, and C.A. Huntington. 2004. Phase II GIS-based sediment quality database for the St. Louis River Area of Concern (AOC). Technical documentation. MacDonald Environmental Sciences Ltd., Nanaimo, BC and Minnesota Pollution Control Agency, St. Paul, MN. (http://www.pca.state.mn.us/publications/tdr-fg04-03.pdf)

U.S. Environmental Protection Agency (USEPA). 2000. Prediction of sediment toxicity using consensus-based freshwater sediment quality guidelines. EPA 905-R-00-007. Great Lakes National Program Office, U.S. Environmental Protection Agency, Chicago, IL.

Wenning, R.J. and C.G. Ingersoll. 2002. Summary of the SETAC Pellston workshop on the use of sediment quality guidelines and related tools for the assessment of contaminated sediments; 17-22 August 2002, Fairmont, MT. Society of Environmental Toxicology and Chemistry (SETAC): Pensacola, FL. 44 pp. (http://www.setac.org/files/SQGSummary.pdf)

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