Report on St. Louis AOC water quality sampling, 2011

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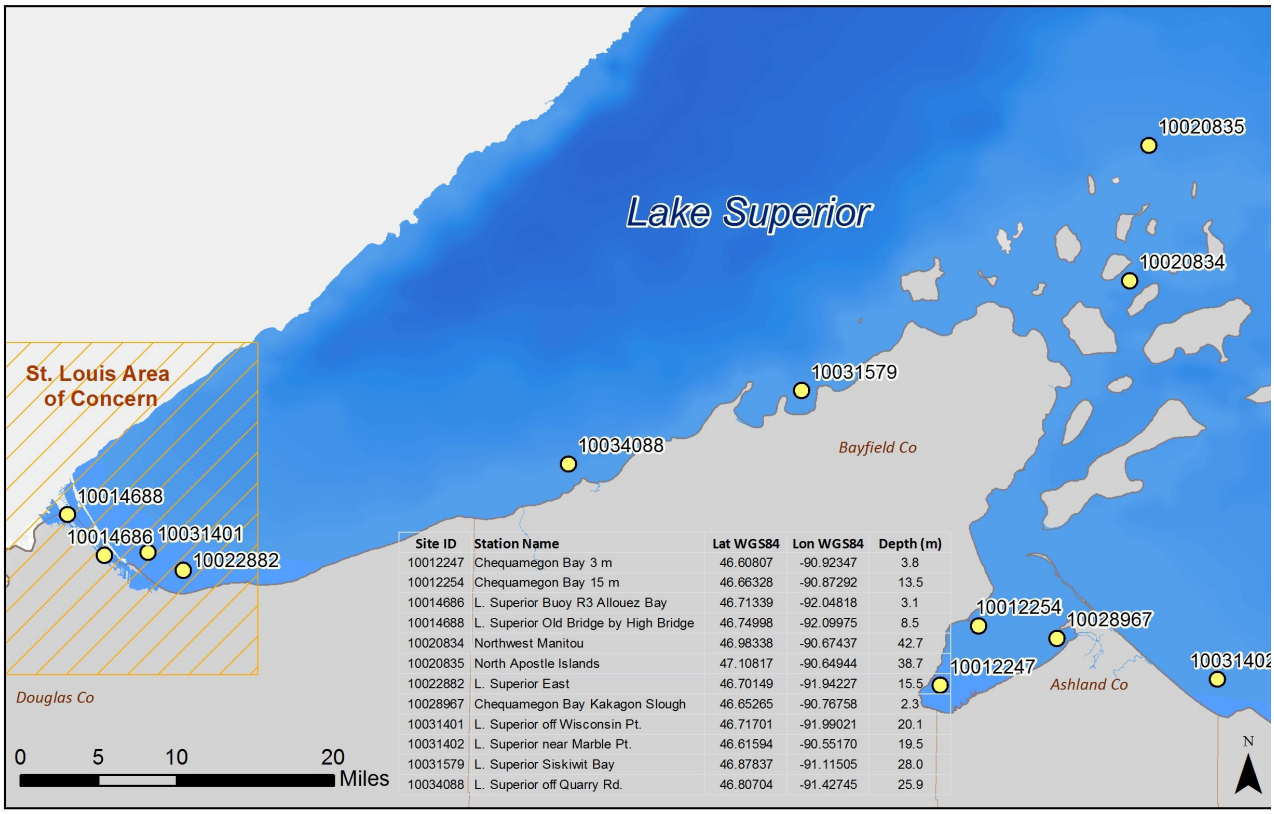
Introduction

The western end of Lake Superior including the cities of Duluth, MN and Superior, WI where the St. Louis and Nemadji rivers discharge into the lake has been designated as an Area of Concern because of the elevated pollutant loads that are delivered to the lake. In 2011 this study collected and analyzed selected water quality data within the AOC as well as other sites in the nearshore area in the Wisconsin portion of Lake Superior. The results are compared between the AOC and non-AOC sites as well as data collected in 2010 as similar sites.

Methods

During the week of 15 August 2011, samples were collected at 4 sites in the AOC (Figure 1). Two of the sites were in the Superior Harbor and 2 sites were in the lake itself, outside the harbor area. Eight sites outside the AOC were sampled the same week. Three of the sites were in Chequamegon Bay. These sites are expected to be more similar to the Superior Harbor sites, especially the shallow water sites. The other non-AOC sites in the nearshore area of the lake in water depth less than 45 meters.



Site ID	Station Name	Lat WGS84	Lon WGS84	Depth (m)
10012247	Chequamegon Bay 3 m	46.60807	-90.92347	3.8
10012254	Chequamegon Bay 15 m	46.66328	-90.87292	13.5
10014686	L. Superior Buoy R3 Allouez Bay	46.71339	-92.04818	3.1
10014688	L. Superior Old Bridge by High Bridge	46.74998	-92.09975	8.5
10020834	Northwest Manitou	46.98338	-90.67437	42.7
10020835	North Apostle Islands	47.10817	-90.64944	38.7
10022882	L. Superior East	46.70149	-91.94227	15.5
10028967	Chequamegon Bay Kakagon Slough	46.65265	-90.76758	2.3
10031401	L. Superior off Wisconsin Pt.	46.71701	-91.99021	20.1
10031402	L. Superior near Marble Pt.	46.61594	-90.55170	19.5
10031579	L. Superior Siskiwit Bay	46.87837	-91.11505	28.0
10034088	L. Superior off Quarry Rd.	46.80704	-91.42745	25.9

Figure 1. Sites sampled in 2011. All but one of these sites was sampled in 2010. The 2 sites at the western end of L. Superior are in the St. Louis River AOC.

At all the sites profiles were collected with a Hydrolab DS5X multiple probe sensor. Measurements for temperature, pH, dissolved oxygen, and conductivity were made at 1 meter intervals from surface to 10 m and then at 2 m intervals to 1 m above the lake bottom or 29.5 m which was the total length of the line. Water samples from 1 m below the surface were collected for chlorophyll *a*, total Kjeldahl nitrogen (TKN), nitrate + nitrite N (NO_3 + NO_2), total phosphorus (TP), total dissolved phosphorus (TDP), total manganese (Mn) dissolved Mn, and total residue. All samples were analyzed at the Wisconsin State Laboratory of Hygiene in Madison, WI. Duplicate sampling was performed at the Chequamegon Bay 15 m site. An underwater video was taken at most of the sites to provide a visual record of the bottom.

Results

The duplicate samples taken at the Chequamegon Bay 15m site agreed well across all of the parameters. The only element that was at all different was TKN. One sample had a concentration of 0.17 while the other was below the detection limit of 0.14 mg L^{-1}. If it is assumed that the second sample has a concentration just below 0.14 mg L^{-1} the duplicate values are acceptable.

All of the chemical concentrations were highest in the Superior Harbor compared with all of the sites (Table 1) with the exception nitrate N. Even the shallow sites in Chequamegon Bay had much lower concentrations. The highest chlorophyll concentrations in the AOC and non-AOC areas occur at the sites with the lowest nitrate concentrations. The lower nitrate concentrations are likely the result of algal assimilation. The 2 sites in the AOC area but outside the harbor had much lower concentrations of all elements except nitrate. In fact the concentrations at these sites was similar to the non-AOC sites (Table 1). The exception to the similar concentrations in the AOC sites outside the harbor with the non-AOC sites was water clarity. Secchi depth was considerably less at these sites because of the silt delivered from the St. Louis and Nemadji rivers.

Although not shown, profile data was similar in 2010 and 2011. The one exception was the 3 sites in Chequamegon Bay. Conductivity and pH values were lower in 2011. This likely is because in 2010 it had been windy prior to sampling which suspended the bottom sediments. In 2010 all of the sites, with the exception of site, L. Superior East (0022882), was sampled in a similar manner as 2011, as part of the EPA National Coastal Condition Assessment. One of the problems with the 2011 sampling was that the phosphorus results from all but the shallowest sites, were below the detection limit of 0.005 mg L^{-1}. The 2010 sampling had lower detection limits and none of the samples had undetectable concentrations, even though most levels were very low. Concentrations for chlorophyll and TKN were higher in 2011 compared with the year before at most sites (Table 2). Nitrate levels were similar in both years. It is not possible to compare phosphorus levels between the years because the concentration in 2011 was below the detection limit of 0.005 mg L^{-1} at all but the shallowest sites. At these 4 sites the total phosphorus concentrations were higher in 2011. Since chlorophyll concentrations in 2011 were generally higher in 2011 it is reasonable to assume that phosphorus concentrations were probably slightly higher in 2011.

Table 1. Results of chemical analysis, water clarity, and water depth at the stations.

SITEID		DATE	Water Depth (m)	Secchi Depth (m)	Chl-*a*	TKN
					(µg L^{-1})	(mg L^{-1})
10022882	L. Superior East	08/15/2011	15.5	4.5	0.88	0.14
10031401	L. Superior off Wisconsin Pt.	08/15/2011	19.5	4.3	1.19	0.17
10014688	L. Superior Old Bridge by High Bridge	08/15/2011	8.5	0.7	14.5	1.44
10014686	L. Superior Buoy R3 Allouez Bay	08/15/2011	3.2	0.8	16.7	0.99
10034088	L. Superior off Quarry Rd.	08/16/2011	25.0	6.8	0.63	0.18
10031579	L. Superior Siskiwit Bay	08/16/2011	28.3	6.9	0.69	<0.14
10031402	L. Superior near Marble Pt.	08/16/2011	18.5	6.4	0.86	0.18
10028967	Chequamegon Bay Kakagon Slough	08/17/2011	2.3	VAB	1.44	0.27
10012254	Chequamegon Bay 15 m	08/17/2011	13.5	7.4	0.83	0.17
10012254	Chequamegon Bay 15 m	08/17/2011	13.4	7.4	0.80	<0.14
10012247	Chequamegon Bay 3 m	08/17/2011	3.9	2.5	2.74	0.18
10020834	Northwest Manitou Island	08/18/2011	42.7	11.3	0.58	0.19
10020835	North Apostle Islands	08/18/2011	38.7	12.0	0.53	<0.14
	Mean of AOC sites			2.56	8.32	0.69
	Mean of non-AOC sites			7.04	1.01	0.16
	AOC sites outside harbor			4.40	1.04	0.16

SITEID	NO3 + NO2-N	TP	TDP	Total Mn	Diss. Mn	Total Residue
	(mg L^{-1})	(mg L^{-1})	(mg L^{-1})	(µg L^{-1})	(µg L^{-1})	(mg L^{-1})
10022882	0.349	< 0.005	< 0.005	1.1	< 1.0	< 2
10031401	0.313	< 0.005	< 0.005	< 1.0	< 1.0	< 2
10014688	0.149	0.072	0.045	117	61.100	5
10014686	0.182	0.063	0.031	64.6	7.8	6
10034088	0.320	< 0.005	< 0.005	< 1.0	< 1.0	< 2
10031579	0.318	< 0.005	< 0.005	< 1.0	< 1.0	< 2
10031402	0.318	< 0.005	< 0.005	< 1.0	< 1.0	< 2
10028967	0.120	0.007	< 0.005	4.6	< 1.0	< 2
10012254	0.306	< 0.005	< 0.005	< 1.0	< 1.0	< 2
10012254	0.308	< 0.005	< 0.005	< 1.0	< 1.0	< 2
10012247	0.210	0.009	< 0.005	4.2	< 1.0	2
10020834	0.329	< 0.005	< 0.005	< 1.0	< 1.0	< 2
10020835	0.323	< 0.005	< 0.005	< 1.0	< 1.0	< 2
Mean of AOC sites	0.248	0.035	0.021	60.9	17.5	3
Mean of non-AOC sites	0.284	< 0.005	< 0.005	1.4	< 1.0	< 2
AOC sites outside harbor	0.331	< 0.005	< 0.005	1.1	< 1.0	< 2

Summary

The sites in Superior Harbor had higher chemical concentrations, except for nitrate-N, compared with all the non-AOC sites, even the shallow sites in Chequamegon Bay. The 2 AOC sites outside the harbor generally had similar concentrations to the non-AOC sites. The one exception was water clarity which was worse at these sites because of sediment particles. The higher concentrations in the harbor likely reflect the elevated pollutant load from the St. Louis River. Nutrient levels were generally slightly higher in 2011 compared with the previous year.

Table 2. Comparison of concentrations in 2010 and 2011.

SITEID		Chl-*a*		TKN	
		(µg L^{-1})		(mg L^{-1})	
		2010	*2011*	*2010*	*2011*
10022882	L. Superior East	N/A	0.88	N/A	0.14
10031401	L. Superior off Wisconsin Pt.	0.83	1.19	0.24	0.17
10014688	L. Superior Old Bridge by High Bridge	0.87	14.5	0.88	1.44
10014686	L. Superior Buoy R3 Allouez Bay	4.57	16.7	0.76	0.99
10034088	L. Superior off Quarry Rd.	0.38	0.63	0.07	0.18
10031579	L. Superior Siskiwit Bay	0.78	0.69	0.07	<0.14
10031402	L. Superior near Marble Pt.	0.46	0.86	0.19	0.18
10028967	Chequamegon Bay Kakagon Slough	1.23	1.44	0.16	0.27
10012254	Chequamegon Bay 15 m	0.87	0.82	0.21	0.15
10012247	Chequamegon Bay 3 m	1.02	2.74	0.23	0.18
10020834	Northwest Manitou Island	0.49	0.58	0.22	0.19
10020835	North Apostle Islands	0.49	0.53	0.22	<0.14
	Mean of AOC sites	2.09	8.32	0.63	0.69
	Mean of non-AOC sites	0.72	1.04	0.17	0.19

SITEID	NO3 + NO2-N		TP		TDP	
	(mg L^{-1})		(mg L^{-1})		(mg L^{-1})	
	2010	*2011*	*2010*	*2011*	*2010*	*2011*
10022882	N/A	0.349	N/A	< 0.005	N/A	< 0.005
10031401	0.346	0.313	0.006	< 0.005	0.001	< 0.005
10014688	0.173	0.149	0.041	0.072	0.019	0.045
10014686	0.206	0.182	0.046	0.063	0.012	0.031
10034088	0.357	0.320	0.002	< 0.005	0.001	< 0.005
10031579	0.339	0.318	0.002	< 0.005	0.001	< 0.005
10031402	0.327	0.318	0.002	< 0.005	0.001	< 0.005
10028967	0.077	0.120	0.005	0.007	0.001	< 0.005
10012254	0.249	0.307	0.002	< 0.005	0.001	< 0.005
10012247	0.216	0.210	0.004	0.009	0.001	< 0.005
10020834	0.291	0.329	0.002	< 0.005	0.001	< 0.005
10020835	0.291	0.323	0.002	< 0.005	0.001	< 0.005
Mean of AOC sites	0.242	0.248	0.031	0.035	0.011	0.021
Mean of non-AOC sites	0.268	0.281	0.003	< 0.005	0.001	< 0.005