Assessment of Ecological Condition in Ashtabula and Milwaukee AOCs, Great Lakes: February 2014 Overview

Objectives:

- To assess status of ecological condition and potential stressor impacts throughout targeted Areas of Concern (AOCs) within Great Lakes coastal waters.
- To provide coastal managers with information needed for evaluating changes in the quality of these water bodies relative to Beneficial Use Impairment (BUI) designations and corresponding AOC Remedial Action Plan (RAP) goals.

Methods:

- Surveys were conducted in August 2012 in two of the 24 AOCs listed within U.S. waters -- Ashtabula River on Lake Erie and Milwaukee estuary on Lake Michigan (Fig. 1).
- Specific station locations – 12 in Ashtabula and 18 in Milwaukee – were selected using a Generalized Random-Tessellation Stratified (GRTS) design. This is a probabilistic sampling framework from which resulting data can be used to make unbiased statistical estimates (with confidence intervals) of the spatial extent and magnitude of condition relative to various measured indicators and corresponding management thresholds. This method has been used widely in EPA's EMAP and National Coastal Assessment programs and is very good for achieving both a random and spatially balanced coverage.
- Multiple ecological indicators were sampled synoptically at each station:
  - General habitat characteristics: DO, T, conductivity, pH, depth, sediment grain-size and TOC.
  - Stressor levels: Chemical contaminants in sediments, hypoxia/anoxia, organic over-enrichment.
  - Sediment toxicity: Microtox (organic extract & solid-phase assays), amphipod (*Hyalella azteca*) assay, reporter gene assay (not reported here).
  - Health of resident benthic infaunal communities (animals sampled with 0.04 m2 grab, sieved on 0.5 mm screen, and identified to species (wherever possible); data used to calculate #taxa, density, diversity (Shannon H' and Hill's N1), and benthic condition based on species-level modified Hilsenhoff Benthic Index (HBI) (Hilsenhoff 1982, 1987; Mandaville 2002). HBI scores range from 0 (high percentage of pollution-sensitive species) to 10 (high percentage of pollution-tolerant species).
  - Human-health risks and aesthetics: Water clarity; incidence of noxious sediment odor, oily sediment, trash; mussel tissue contaminants (fixed stations only) (not reported here).
- The synoptic measurement of sediment contaminants, sediment toxicity, and condition of ambient benthic fauna support a Sediment Quality Triad approach (Chapman 1990).

Preliminary Results:

- Sediment Contaminants:
  - Individual contaminant concentrations in a sample were compared to corresponding Effects Range Low (ERL) and Effects Range Median (ERM) sediment quality guidelines (Long et al. 1995) and Mean ERM Quotients (mERMQ, Long et al. 1998) were calculated to provide a single measure of the mixture of multiple contaminants present.
  - ERL exceedances ranged from 4 to 17 and 6 to 19 in the Ashtabula and Milwaukee AOCs, respectively and averaged 11 for both of the AOCs (Table 1).
  - ERM exceedances ranged from 0 to 1 and 0 to 17 in the Ashtabula and Milwaukee AOCs, respectively and averaged 0 and 7, respectively (Table 1).

- mERMQs ranged from 0.07 to 0.28 and 0.08 to 2.39 in the Ashtabula and Milwaukee AOCs, respectively and averaged 0.162 and 0.865, respectively (Table 1).
- The dominant contaminant classes at both AOCs were polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs).
- Total PAH concentrations ranged from 1,941 to 10,069 ppb and from 3,038 to 115,567 ppb in the Ashtabula and Milwaukee AOCs, respectively, and averaged 4,784 and 42,259 ppb, respectively.
- Total PCB concentrations ranged from 8.8 to 693 ppb and from 22 to 2002 ppb in the Ashtabula and Milwaukee AOCs, respectively and averaged 162 and 547 ppb, respectively.
- Overall contaminant concentrations at each station were classified as low (green in Figure 1), moderate (yellow), high (orange), and very high (red). Contaminant concentrations were much lower at the remediated Ashtabula AOC than at the Milwaukee AOC and tended to be lower in more open-water areas of both AOCs.

- Sediment Toxicity:
  - Amphipods-*Hyalella azteca* (whole-sediment bioassays)
    - Survival in amphipods exposed to field-collected sediments was compared to that in synthetic control sediments.
    - Sediments were considered toxic when survival relative to the controls was significantly different ($p \leq 0.05$) and less than 80% of control survival.
    - Sediments from 11/12 Ashtabula and 14/18 Milwaukee sites were toxic relative to controls.
  - Microtox-Solid Phase Tests
    - Measures light output in bioluminescent bacteria exposed to sediment extracts.
    - Contaminant exposure causes reduced light output.
    - Microtox assays were conducted using standardized solid-phase test protocols.
    - EC50s (for light output) were determined for Ashtabula, Milwaukee, and Reference site sediments.
    - Ashtabula and Milwaukee sediments were considered toxic when EC50s were significantly ($p \leq 0.05$) lower than Reference site sediments.
    - Sediments from 3/12 Ashtabula and 5/18 Milwaukee sites were determined to be toxic relative to Reference sediments.
  - Microtox-Solvent Extract Tests
    - Measures light output in bioluminescent bacteria exposed to sediment solvent (methylene chloride extracts).
    - Assays were conducted using standardized solvent-extract test protocols.
    - Ashtabula and Milwaukee sediments were considered toxic when EC50s were significantly ($p \leq 0.05$) lower than Reference site sediments.
    - Sediments from 5/12 Ashtabula and 9/18 Milwaukee sites were determined to be toxic relative to Reference sediments.
  - Overall sediment toxicity at each station, based on the three bioassays, was characterized as low (none of 3 assay hits = Green in Figure 1), moderate (1 of 3 hits = yellow), high (2 of 3 hits = orange), and very high (3 of 3 hits = red). In both AOCs, 50% of the stations were coded red or orange and 50% were coded green or yellow (particularly in the more open waters in the latter case).
- Benthos:
  - HBI scores ranged from 8.9 to 9.6 and from 8.5 to 9.9 in the Ashtabula and Milwaukee AOCs respectively, and averaged 9.3 and 9.5 respectively, indicating poor to very poor sediment quality (orange to red in Fig. 1) at all stations in both systems based on the structure and composition of

benthic communities. High HBI scores resulted from a predominance of pollution-tolerant taxa, with 85% having scores of 6 or higher on a scale of 0 (most sensitive) to 10 (most tolerant).

  - Although HBI scores reveal the presence of impaired benthic communities throughout both AOCs, there are indications of recovery in the remediated Ashtabula AOC compared to the Milwaukee AOC. Mean # taxa, H', and Hill's N1 diversity were all higher in Ashtabula compared to Milwaukee (Table 1). Mean density and HBI scores were higher in Milwaukee reflecting the higher densities of pollution-tolerant taxa compared to Ashtabula.

- Combined results of the sediment quality triad (SQT) provide evidence of poor sediment quality and impaired benthic condition at most stations in both the Ashtabula and Milwaukee AOCs, although to lesser degrees in some portions of each system (e.g., in the more open-water areas). Also, multiple biological and chemical-contaminant indicators revealed better/improved conditions in the remediated Ashtabula AOC compared to the Milwaukee AOC though both show persistent signs of stress.

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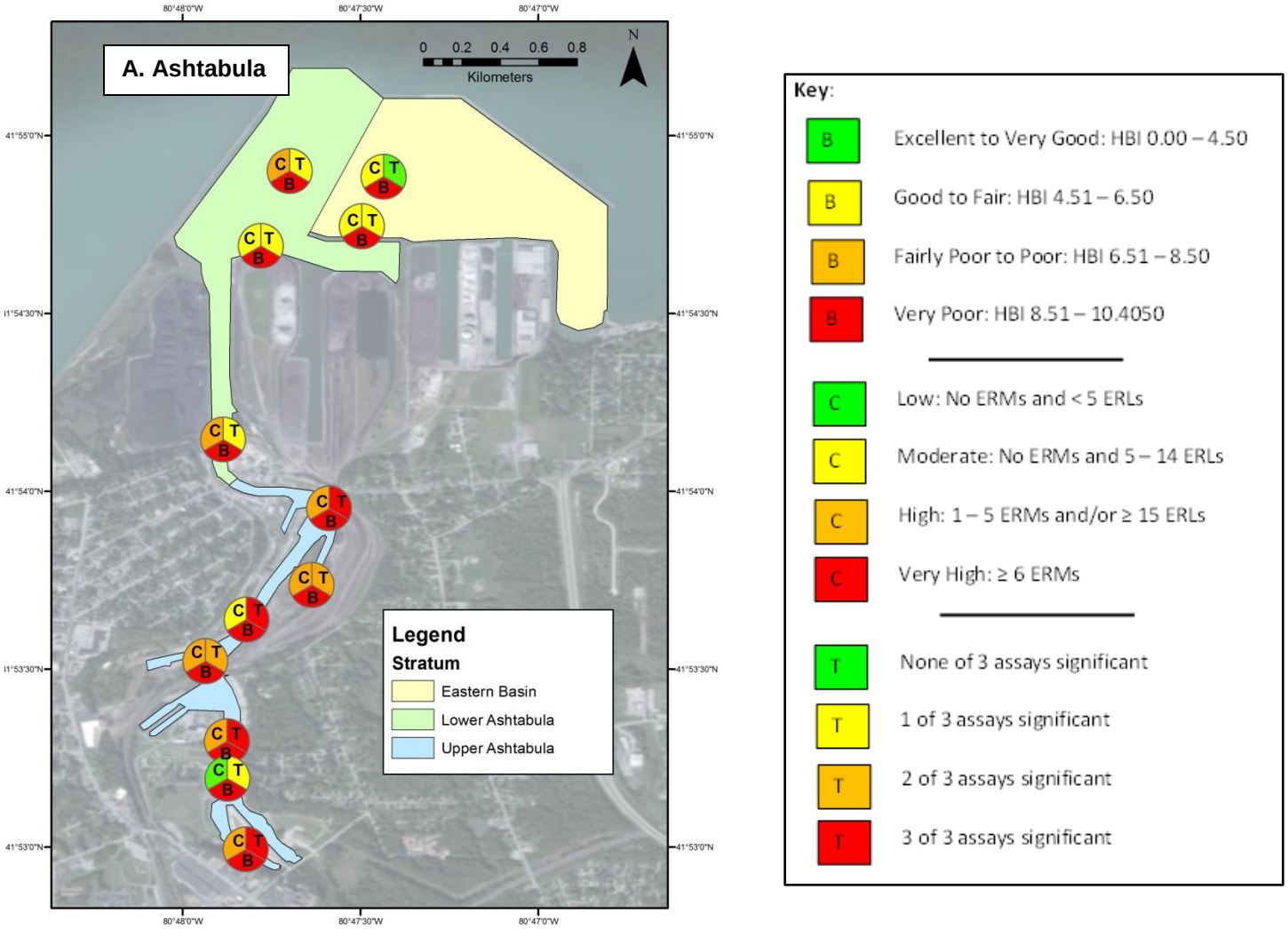
Table 1. Means of key sediment and water quality variables in Ashtabula and Milwaukee AOCs.

AOC	# Taxa	Hill's N1	H'	Density (#/m^2)	HBI	TOC (mg/g)	% Silt-Clay	Mean ERMQ	#ERLs exceeded	#ERMs exceeded
Ashtabula AOC (n=12)	14	19.5	2.9	12981	9.3	15.3	90	0.162	11	0
Upper Ashtabula (n=7)	15	16.2	2.8	6546	9.2	11.0	94	0.110	9	0
Lower Ashtabula (n=3)	14	18.3	2.9	15633	9.4	14.3	87	0.157	11	1
Eastern Basin (n=2)	11	20.9	3.0	13683	9.4	16.9	90	0.179	11	0
Milwaukee AOC (n=18)	10	8.2	1.9	24538	9.5	34.0	78	0.865	11	7
Milwaukee River (n=3)	10	9.3	2.2	23661	9.6	43.7	85	1.113	11	8
Menomonee River (n=3)	12	8.1	2.0	44831	9.7	66.1	94	1.623	6	14
Kinnickinnic River (n=3)	13	8.5	2.1	40872	9.7	33.8	64	1.452	9	13
Harbor (n=9)	8	7.7	1.8	12620	9.4	20.1	74	0.334	13	2



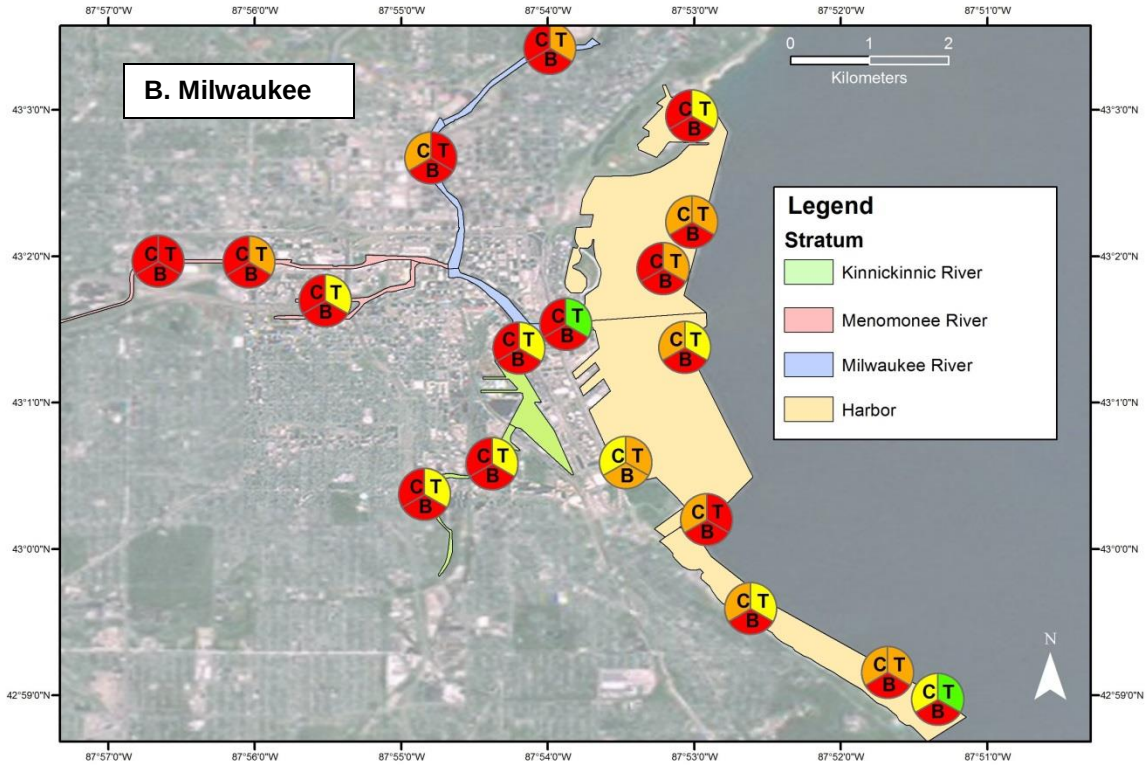


Figure 1. Sediment Quality Triad results for Ashtabula (A) and Milwaukee (B) AOCs. In the key, B = Benthic condition based on species-level modified Hilsenhoff Benthic Index (HBI); C = Contaminant concentrations in sediments; T = Toxicity based on 3 sediment bioassays (*Hyalella Azteca* amphipod assay, Microtox solid-phase assay, Microtox solvent – extract assay).