NCCOS Great Lakes Mussel Watch: Contamination Monitoring and Assessment for Restoration of the Great Lakes

Ed Johnson[1], Annie Jacob[2] ,Kimani Kimbrough[1], Erik Davenport[1]and Michael Edwards[1]
[1]National Centers for Coastal Ocean Science, National Oceanic and Atmospheric Administration, Maryland
[2]Consolidated Safety Services-Dynamac, Virginia

Introduction

Under the President's Great Lakes Restoration Initiative launched in 2009, NCCOS Mussel Watch Program (MWP) expanded and enhanced its monitoring efforts by adding numerous sites within highly impacted areas and conducting targeted monitoring and contamination assessments using newer techniques and approaches in partnership with universities and other federal agencies.

Enhanced efforts include the:

- Deployment of caged mussels where extant mussel beds are not found.
- Incorporation of effects- based monitoring (cellular biomarkers, genomics and metabolomics) to link contaminant exposure to bioeffects.
- Deployment of additional matrices such as passive samplers and Hester Dendy along with caged mussels.
- Assessment of contaminants of emerging concern (CECs).

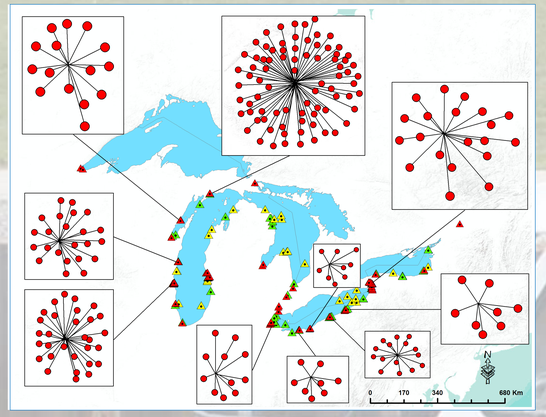

Figure 1. Basin-wide map of offshore (▲),nearshore (▲), river-harbor(▲) sites. Callout boxes show locations where intensive assessments were conducted to support monitoring and modeling efforts.

Methods

- Dreissenid mussels are harvested from the harbor breakwater and deployed in cages at pre-determined stations in Areas of Concern (AOCs) of interest.
- Mussels are collected after 5 -10 weeks of deployment and analyzed for relevant contaminants.

Figure 2. Caged mussels are deployed in minnow traps and placed on cinder blocks or a mooring that suspends them approximately 12 inches off the sediment. Mussels have been deployed with Hester-Dendy, Polyethylene Devices (PEDs), and Polar Organic Chemical Integrative Samplers (POCIS).

Results

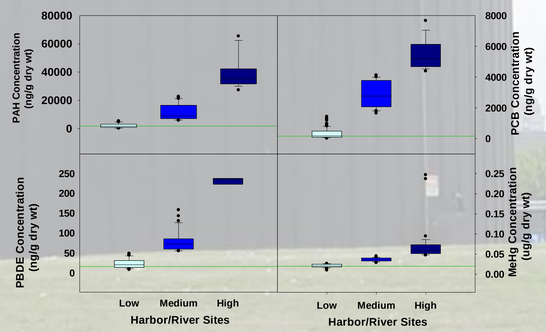

Figure 3. Box and whisker plots of contaminant concentrations in mussel tissue from MWP river-harbor sites in the Great Lakes obtained from 2009-2015. The contaminant concentrations were grouped into Low, Medium and High using k-means cluster analysis. Green line indicates the basin-wide mean concentration in mussels from offshore and nearshore sites.

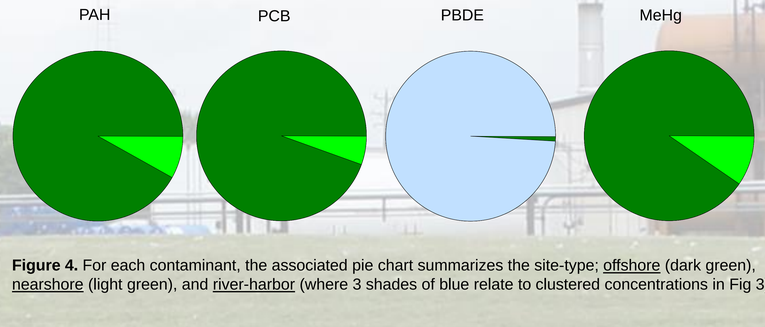

Figure 4. For each contaminant, the associated pie chart summarizes the site-type; offshore (dark green), nearshore (light green), and river-harbor (where 3 shades of blue relate to clustered concentrations in Fig 3).

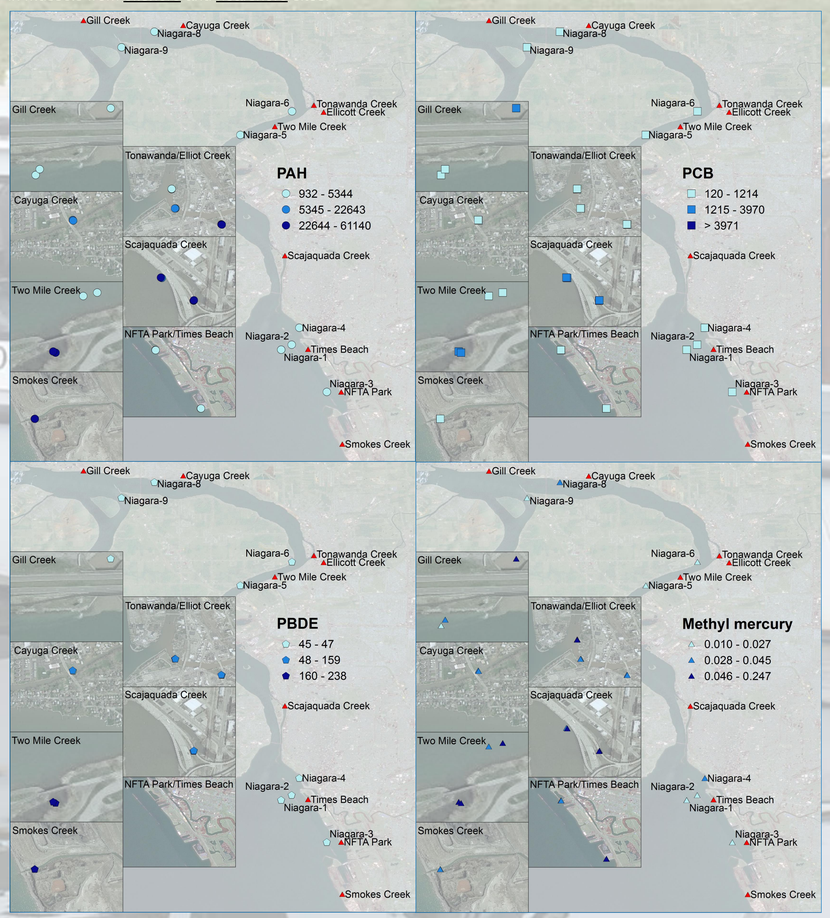

Figure 5. Summary of chemical concentrations in mussels (PCB, PAH and PBDE concentrations are in ng/g dry wt and MeHg concentrations are in ug/g dry wt) located in the Niagara River and seven tributaries, relative to the basin-wide cluster analysis (Fig. 3) obtained in 2014. Red triangles relate to the locations shown in inset maps.

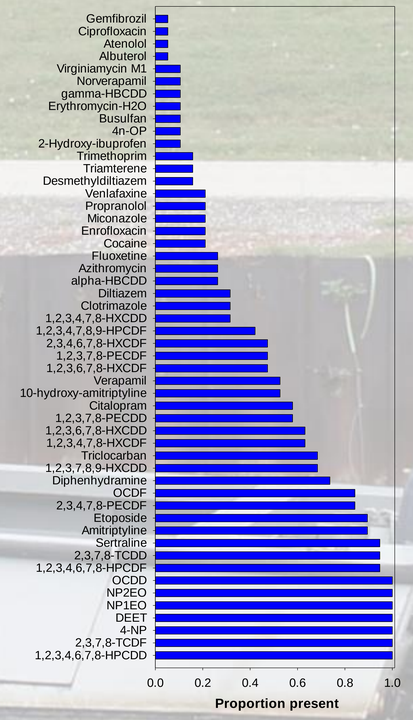

Figure 6. Proportion of measured CEC detected in mussels located in the Niagara River and seven of its tributaries.

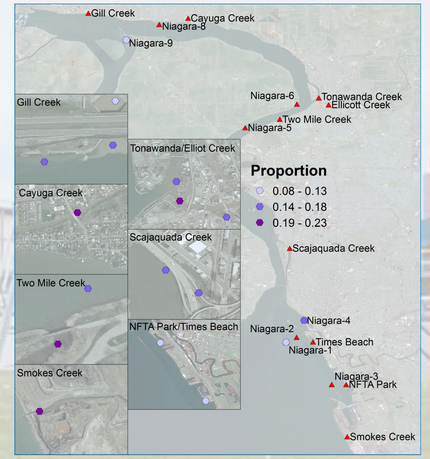

Figure 7. Proportion of measured CECs present in mussels (2014) located in the Niagara River and seven tributaries.

1,2,3,7,8,9-HXCDF	Diazepam	Oxolinic Acid
1,7-Dimethylxanthine	Digoxigenin	Oxycodone
4-Epianhydrochlortetracycline [EACTC]	Digoxin	Oxytetracycline [OTC]
4-Epianhydrotetracycline [EATC]	Doxorubicin	Paroxetine
4-Epichlortetracycline [ECTC]	Doxycycline	Penicillin G
4-Epioxytetracycline [EOTC]	Drospirenone	Penicillin V
4-Epitetracycline [ETC]	Enalapril	Prednisolone
Acetaminophen	Flumequine	Prednisone
Alprazolam	Fluocinonide	Promethazine
Amlodipine	Fluticasone propionate	Propoxyphene
Amphetamine	Furosemide	Ranitidine
Amsacrine	Glipizide	Rosuvastatin
Anhydrochlortetracycline [ACTC]	Glyburide	Roxithromycin
Anhydrotetracycline [ATC]	Hydrochlorothiazide	Sarafloxacin
Atorvastatin	Hydrocodone	Simvastatin
Azathioprine	Hydrocortisone	Sulfachloropyridazine
Benzoylecgonine	Ibuprofen	Sulfadiazine
Benztropine	Iopamidol	Sulfadimethoxine
beta-HBCDD	Isochlortetracycline [ICTC]	Sulfamerazine
Betamethasone	Lincomycin	Sulfamethazine
Bisphenol A	Lomefloxacin	Sulfamethizole
Caffeine	Medroxyprogesterone Acetate	Sulfamethoxazole
Carbadox	Melphalan	Sulfanilamide
Carbamazepine	Meprobamate	Sulfathiazole
Cefotaxime	Metformin	Tamoxifen
Chlortetracycline [CTC]	Methylprednisolone	Teniposide
Cimetidine	Metoprolol	Tetracycline [TC]
Clarithromycin	Metronidazole	Theophylline
Clinafloxacin	Minocycline	Thiabendazole
Clonidine	Moxifloxacin	Trenbolone
Cloxacillin	Naproxen	Trenbolone acetate
Codeine	Norfloxacin	Triclosan
Colchicine	Norfluoxetine	Tylosin
Cotinine	Norgestimate	Valsartan
Cyclophosphamide	Ofloxacin	Warfarin
Daunorubicin	Ormetoprim	Zidovudine
Dehydronifedipine	Oxacillin	
Demeclocycline	Oxazepam	
Diatrizoic acid		

Table 1. List of CECs not detected in mussels located in Niagara River and seven of its tributaries.

Conclusions and Next Steps

- Caged dreissenid mussels are a robust tool in identifying localized areas of contamination within an AOC.
- Offshore and nearshore contaminant measurements bring perspective to localized contamination assessments in river and harbor sites.
- Effects-based monitoring and surveillance approaches will be used to support traditional contaminant monitoring.
- Decades of MWP monitoring data will be modeled to determine baseline concentrations.