

Saginaw Bay Multiple Stressors and Beyond Workshop Summary Report

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SAGINAW BAY MULTIPLE STRESSORS AND BEYOND WORKSHOP

Summary Report

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1. INTRODUCTION

Saginaw Bay of Lake Huron touches five Michigan counties: Arenac, Bay, Huron, Iosco, and Tuscola, covering 1,143mi² in area. Its waters and coastal areas are used for drinking water, swimming, boating, and fishing by roughly 500,000 people making it a significant tourism and recreational area for the state of Michigan. The bay is well known as a fishing location, especially around the towns of Oscoda and Au Gres, and the Saginaw Bay area is home to three municipal centers Midland, Saginaw, and Bay City, with Bay City being the largest city on the Lake Huron shore. Each center features many attractions for residents and tourists. More than 3 million waterfowl migrate through Saginaw Bay annually, making it an important waterfowl and bird migration resting place. The bay and surrounding area hosts many natural features such as parks and trails, including the Tobico Marsh wildlife refuge and Frank Andersen Nature Trail, lighthouses, county fairs and musical festivals, boating and fishing, and there are 28 beaches along the coast stretching from Tawas to the tip of the Thumb. The Saginaw Bay watershed is home to 83 public beaches and access areas, with 54 of the public beaches and access areas located inside the 1987 designated area of concern (AOC). These human use benefits for local residents and tourists as well as housing values in the Saginaw Bay area constitute an important aspect of the Saginaw Bay society and economy.

Saginaw Bay has been and continues to be exposed to many stressors from anthropogenic activities, including toxic contaminants, nutrients, sediments, overfishing, exotic species, and declining water levels. In response, the NOAA Great Lakes Environmental Research Laboratory (GLERL), the Cooperative Institute for Limnology and Ecosystems Research (CILER), and other partner institutions began a five-year Saginaw Bay Multiple Stressors Project sponsored by the Center for Sponsored Coastal Ocean Research (CSCOR) in 2007, evaluating the impacts of these stressors and their combined effects on Saginaw Bay and their management implications. With the project coming to an end in 2012, a dialogue with the scientists and representatives from the Michigan Departments of Natural Resources (DNR) and Environmental Quality (DEQ), Michigan Sea Grant, and other organizations was necessary in order to decide how to best convey the project results and prioritize next steps for future research in Saginaw Bay. This dialogue was conducted through an all-day needs assessment workshop with the goal of receiving input and feedback on remaining research and outreach needs in Saginaw Bay and gaining recommendations for continued research to build upon the Multiple Stressors Project. Additionally the workshop aimed at identifying any remaining gaps in research and outreach efforts in Saginaw Bay and to determine where NOAA and Michigan Sea Grant should begin prioritizing research and outreach and education programs. This report describes the results of the workshop including remaining issues and needs identified as well as priorities for future research, and strategies and recommendations for next steps.

2. METHODS

The seven-hour workshop was held on May 22, 2013 in Lansing, MI, at Constitutional Hall. The overarching objective of the workshop was to identify and discuss remaining research and outreach gaps to assist in prioritize future research, outreach and education programs over the next few years through participant input and feedback. The morning session opened with presentations of key findings and policy

and management implications from the Saginaw Bay Multiple Stressors Project. The presentations were organized under water quality findings, muck findings and remaining issues, and fisheries and invertebrates findings. The afternoon was devoted to the need assessment where two facilitated breakout groups were held on the following theme areas “Fisheries and Invertebrates” and “Water Quality”. Each breakout discussion was facilitated by a Michigan Sea Grant Extension educator and included scientists and decision-makers with relevant expertise in the discussions. The groups were asked to answer the following questions within the context of their theme:

2.1 State of the Issues

1. *Issues:* What are some remaining issues in relation to this topic?
 - a. *What could be done to mitigate these issues?*
2. *New Issues:* What new issues have emerged since the project began in 2007?
3. *Local Knowledge:* What have you heard from your constituents in terms of their knowledge of and magnitude of these issues?
4. *History:* From your perspective, how long have these issues been impacting Saginaw Bay?
5. *Capacity:* What information, tools, and technology do you currently have to address these issues and what is your current capacity to employ these resources?
 - a. *What information, tools, and technology do you need to address these issues?*

2.2 Information and Research Needs

1. *Info gaps:* What are the remaining data, information, and research gaps and needs relative to this topic?
2. *Priorities:* What do you see as the major priority, immediate research needs in this theme area?
3. *Policy/Management:* What research needs remain in this theme area in order to better inform policy and management?
4. *Ecosystems/Food Webs:* What ecosystem services or food web connections still remain unknown?
5. *Products:* What products, materials, and services should NOAA and Michigan Sea Grant develop to help you address these research needs?

2.3 Information and Communication Needs

1. *Info gaps:* What are your communication and outreach needs relative to this topic?
2. *Priorities:* What do you see as the major priority, immediate outreach and communication needs in this theme area?
3. *Stakeholder Communication:* What upcoming meetings/events could Michigan Sea Grant attend and what particular stakeholder groups could Michigan Sea Grant speak to in order to gain information from and get information out to priority end-user groups?
4. *Products:* What are some ways that Michigan Sea Grant can help with these communication needs through the development of materials, products, and services?

Following the needs assessment breakouts, groups reconvened and briefly presented their breakout findings to the workshop participants. There was open discussion for workshop participants to bring up any remaining questions or needs that were not captured in the breakouts. The workshop concluded with a survey allowing participants to rank what they deemed to be the top three remaining issues, research and communication needs, and product and material priorities, as well as to evaluate the success of the workshop and make suggestions for improvement.

3. RESULTS

The workshop provided participants an opportunity to inform scientists, federal agencies, and Michigan Sea Grant of what remain as issues and gaps in the bay and research and communication needs, as well as the products, materials, and services that Michigan Sea Grant could develop in order to help address these needs to more effectively to manage water quality and fisheries and invertebrate issues.

Workshop findings from breakout discussions are summarized below, followed by the next steps discussed at the end of the workshop. The survey responses as well as the detailed notes from the breakout discussion sessions can be found in Appendix A and B respectively.

3.1 State of the Issues

3.1.1 Policy and Programmatic Context

Provide context for GLWQA 1970s nutrient mitigation strategies. In September 2012, the United States and Canada signed an amended Great Lakes Water Quality Agreement (GLWQA). Under this updated GLWQA, the two nations renewed their commitment to work together in order “to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes.” Furthermore, the revised version modernized their commitment to reflect current knowledge and understanding and broadened its range to include the entire extent of factors affecting Great Lakes water quality, with the addition of 10 new annexes including areas of concern (AOCs), lake-wide management, chemicals of mutual concern, nutrients, discharges from vessels, aquatic invasive species (AIS), habitat and species, groundwater, climate change impacts, and science. In order to be successful, the amended protocol necessitates that the Great Lakes Executive Committee (GLEC) deal with the matters of the notice and response provision, development of numeric standards for nutrients, prioritization of chemicals of emerging concern, and partnership with coastal communities in preparing to confront climate change. This revised GLWQA provides a driving force for new domestic policies to allow for successful implementation of the new protocol and protection of the Great Lakes, including Saginaw Bay. Of particular concern due to its impetus for further research in Saginaw Bay is the need for numeric standards for nutrients and Great Lakes assessment protocols established by the updated GLWQA in Annex 4. Many Great Lakes states are still in need of numeric standards for nutrients as insisted by the EPA, especially phosphorus, and lack any standards or employ ambiguous standards, causing inefficient distribution of resources and protection of water quality. The GLWQA calls for a timeline for determining concentration and loading targets and allocations for open water and nearshore phosphorus, and other nutrients as required, as well as novel methodologies for successful implementation of these goals. In order to conserve the resources of the state agencies, the GLEC has the capacity to make regional recommendations for numeric standards for nutrients, such as for Saginaw Bay. The GLWQA carried forward interim substance objectives for phosphorus concentration in the open waters of Lake Huron and loading targets for Saginaw Bay of 5 µg/L and 440 metric tons per year respectively, though no interim substance objectives have been set for Saginaw Bay. However, these interim objectives and targets must be reviewed for sufficiency and updated as necessary, and substance objectives for nearshore phosphorus concentration must be established.

The amended GLWQA also calls for the US and Canada to revisit and promote measures required to clean, restore and delist AOCs. Saginaw Bay was listed as an AOC in 1987, identified as having 12 of the possible 14 beneficial use impairments (BUIs). Since first designated, two of the BUIs have been removed, and conditions have improved, however 10 BUIs still remain. The renewed GLWQA commits the US and Canada to periodically revise remedial action plans (RAPs) developed for each AOC in order to implement a systematic methodology for removing BUIs. Thus, the 2012 GLWQA provides drive for persistent review of the RAP, revised in 2012, to continue to move towards removing the remaining BUIs and move forward on the path towards delisting Saginaw Bay as an AOC. Additionally, the Great Lakes Restoration Initiative (GLRI) proposed for annual funding at \$475 million/year from 2010-2015 has a focus on cleaning up AOCs. Three priority BUIs are targeted including eutrophication, beach closings, and fish and wildlife habitat and populations. A 2010 assessment of beach closings in Saginaw Bay identified two beaches and two public access areas within the AOC as not meeting BUI targets due to frequent and continued closures from bacterial contamination, including Veterans Park North, Kawkawlin River Boat Launch, Twining Road, and Singing Bridge. The assessment further found that Whites Beach needs additional monitoring to determine whether it is meeting its designated use target. However, the review suggested that 95% of public beaches and access areas in the Saginaw Bay area, and 93% of

beaches and access areas within the AOC meet current restoration targets, and thus significant progress towards restoration goals has been achieved. The study indicated that the beach closing BUI could be removed within a span of 10-12 months if MDEQ confirms that monitoring supports delisting. In addition, in 2010, GLRI shifted focus on three Priority Watersheds for reduction of nutrients, one of those priority Watersheds is in Saginaw Bay to help with the mitigation of harmful algal blooms and nuisance algae. The emphasis on nutrient reduction within GLRI is intended to ameliorate growth of muck as well as harmful algal blooms.

Another driving force is the Clean Water Act (CWA), which calls for states to implement water quality standards (WQS) that classify the designated uses for each body of water, such as recreation, to protect US waters including the Great Lakes. However, many of the nation's waters, including those of the Great Lakes like Saginaw Bay, fail to meet one or more of their designated uses presently due to point and nonpoint source pollution. Once one or more designated uses is identified as not attained and the cause or responsible pollutant is determined, a plan is developed to determine how much of a certain pollutant/nutrient the water body can assimilate before adverse effects occur. A Total Maximum Daily Load (TMDL) is the greatest sum of permissible loads to a body of water of a certain pollutant from all point and nonpoint sources that allows the water body to still meet WQS. The calculation requires the inclusion of a margin of error to be sure that the body of water can still meet its state designated uses. The TMDL process requiring water quality data less than five years old could be applied to Saginaw Bay in order to determine the maximum daily amount of pollutants in Saginaw Bay allowing the water body to still meet its WQS and designated uses, and allocating the load to specific point and nonpoint source discharges. Although there is no regulatory authority to enforce these loading targets, once drafted and approved by the EPA, the state would identify steps to ensure attainment of the concentration levels identified through existing programs and additional programs such as reward incentives, additional monitoring, and local participation by organizations to implement the TMDL so that the bay will meet WQS and designated uses. Local participation is important so that the process can be continued by organizations in the area in the future with DEQ support.

Saginaw Bay is currently listed as not meeting its fish consumption designated use due to dioxin, mercury in fish tissue, and PCB in fish tissue. Additionally, a few drinking water intake Critical Assessment Zones (CAZs) in Bay City are listed for nutrients, phosphorus, and taste and odor as 4b, meaning that available data and/or information indicate that at least one designated use is not being supported or is threatened, but a TMDL is not needed because other approved pollution control mechanisms are in place and are reasonably expected to result in attainment of the designated use within a practical time frame. Muck has caused "insufficient information" listings for the shoreline, but nothing is listed as "not supporting." Furthermore, Singing Bridge beach is listed as "not supporting" for total body contact due to *E. coli*.

3.1.2 Fisheries and Invertebrates History

Some issues have been affecting Saginaw Bay for almost 60 years, yet the target issue has been changing over time. There are currently new specific issues, but the fish community, for instance, is always changing. Some issues, however, have been long-term. For example, invasive species have been impacting the bay for years, though the specific invasive species causing the impacts have changed. Additionally, land use has been affecting the bay and its food web and ecosystem over the years.

Partnerships in Restoration Progress	Non-point Source Restoration and Assessment		Habitat Restoration	
	Partnership/Program	Focus/Initiative	Partnership/Program	Focus/Initiative
Pre-GLRI	Conservation Reserve Enhancement Program (2000-Present)	Financial program that provides incentives and technical assistance	GM Natural Resources Damage Assessment Funding	Monitoring indicates PCBs in fish are on a downward trend
	Saginaw Bay Coastal Initiative (2006-Present)	Workgroups and reports on: Combined Sewer Overflows, E. coli in Muck, Phosphorus Policy, among others	Lake Huron Binational Partnership Funding	Phragmites Demonstration Project and Landowners Guide
	DEQ's Water Resources Division Programs	Targeted Technical Assistance, Beach sanitary surveys and monitoring	Dept. of Natural Resources, Ducks Unlimited, and Others	Wildfowl Bay Coastal Wetland Acquisition
	Bay County Drain Commissioner Office	Army Corps of Engineer's Remedial Action Plan project	The Nature Conservancy	Lake Huron Biodiversity Conservation Strategy
			DEQ's Coastal Management Program	Coastal protection, assessments, and restoration projects
			Saginaw Bay Coastal Initiative	Methodology Report for Prioritizing Saginaw Bay Watersheds
			Saginaw Bay Watershed Initiative Network Program Funding	Shiawassee National Wildlife Refuge restoration
2010 GLRI	Michigan Beach Program and Local Health Depts	Sanitary surveys and enhanced testing at Saginaw Bay beaches	Ducks Unlimited and Partners	Shiawassee National Wildlife Refuge-1st GLRI project completed, Nayanquing Point State Wildlife Area Coastal Wetland Project, Van Hove Coastal Wetland Restoration, Michigan
	DEQ's Office of the Great Lakes	Review and Statewide Assessment of Three BUIs in Michigan AOCs	The Conservation Fund	"Fish Wish"-Fish Passage at the Frankenmuth Dam
	Michigan Dept. of Agriculture and Rural Development and Natural Resources Conservation Service (USDA-NRCS)	Technical assistance and Best Management Practices	University of Michigan	Lake Huron invasions, food webs, and fisheries
	Michigan State University-Land Policy Institute	Saginaw Bay/Lake Huron Land Policy Program		
	Huron Pines	Rifle River Watershed Nonpoint Implementation Project		
	Pigeon River Intercounty Drain Drainage Board	Best management practices for streambank stabilization and soil erosion control project		
	Shiawassee Conservation District	Great Lakes Soil Erosion and Sedimentation Program project		
2011-12 GLRI	Genesee Conservation District	Restoration of Flint's Urban Forests and Street Trees, Chevy in the Hole	US Fish and Wildlife Service and US Forest Service	Cooperative Weed Management Area designation for Saginaw Bay
	DEQ's Water Resources Division	Targeted Phosphorus Reduction in the Pigeon River Watershed	Michigan State University	Breeding Birds in the Great Lakes Region as influenced by climate and land cover change
	Michigan Dept. of Agriculture and Rural Development	Sediment Reduction in the Swartz Creek and the Sebawing River Watersheds	US Fish and Wildlife Service and Partners	Evaluating fish as vectors of contaminants in the Saginaw River/Bay Area of Concern
	US Corps of Engineer	Western Lake Huron Basin Study	Huron Pines	Restoration of a Blue Ribbon Trout Stream
	Michigan Technical University	Harmful Algal Bloom Mapping for the Great Lakes	Bay County	54-Acre Pinconning Park coastal wetland land acquisition

3.1.3 Water Quality History

Amendments to the Great Lakes Water Quality Agreement (GLWQA) in 1978 set targets for the bay including 440 ton/year total phosphorus loading, and a phosphorus conference the following year to establish a management strategy for the Great Lakes recommended a maximum spring average total phosphorus concentration in the Bay of $15\mu\text{g/L}$ as well as a maximum $3.6\mu\text{g/L}$ chlorophyll concentration and a minimum 3.9 m secchi depth. However, workshop participants discussed that these targets have never been met in the Bay.

“Muck”, or shoreline algal mats composed of accumulated, decomposing benthic algae with the potential to harbor harmful bacteria, has been washing up on the shoreline for decades, though few detailed historical observations exist about its composition. Some participants remember the bay area having nice beaches with many visitors, but not everyone remembers the same history; others recall the area of being comprised primarily of coastal wetland areas rather than sandy beaches, which brought up the question of is the natural landscape of the bay? Has an alteration in the nearshore area contributed to this muck problem? Workshop participants noted visitation to the area beaches is decreasing in popularity potentially due to cultural shifts or avoidance of nature, skin care/ UV exposure worries, and discomforts. With respect to Saginaw Bay beaches in particular, the decline in water quality may be affecting attendance. For example, from 2007 to 2011 Bay City state park visitation generally decreased from 267,612 to 225,803 visitors. Thus a remaining question is what is the potential for Saginaw Bay beaches? If the area were restored, how popular would the beaches be?

Limited management of the muck has been conducted in the bay with respect to its history, except for discrete cases of raking and manual removal, though muck clean up has been carried out in other parts of the Great Lakes, such as Green Bay. However, a lack of information exists to address how best to manage the muck in Saginaw Bay. Further there’s been limited research on understanding and addressing some of the contributing factors to muck growth.

3.1.4 Local Knowledge and Perceptions of Fisheries and Invertebrates Issues

The overarching theme discussed was there is a lack of knowledge and understanding of the uncertainty and complexity of the issues among the locals. The local communities ask why do we need research? State agencies discussed the interest from local communities for action to take place, the problem to be solved, and for one solution to the problem to exist. The local communities’ and constituencies’ perspective is there must be a scapegoat; there must be one single thing responsible for the decline of things they care about. However, the science behind the issue shows that it is much more complex than that. For example, the locals want to know why the perch are gone and what is being done about that. Participants discussed the need for locals to understand the changes in the food web and the individual pieces of the food web, including cormorants and contaminants in fish. Local communities seem to be unaware of certain complexities in the system; for example, participants have found that only the most knowledgeable fishermen know about *Bythotrephes*.

Participants discussed the need for resources on how to educate the community on a local level and make knowledge of the complexity and uncertainties of issues more accessible and easily understood. It is clear to the participants that there is a lack of belief in the science and that the public is not as conversant with scientific information on these issues. The challenge is that if this information does not agree with the locals’ preconceived ideas/thoughts on the issues, they may reject this new information. Additionally, participants discussed that the locals differ and alter their needs over time. For example, in the past walleye were not big enough; now local anglers feel they cannot catch enough. What is needed is to determine the best methods of education and communication and tailor these methods to meet the different audiences of this information.

3.1.5 Local Knowledge and Perceptions of Water Quality Issues

A remaining issue is misconceptions of what the problem is regarding water quality and the complexity of the water quality issues. These misconceptions lead to an assumption that there is a simple solution or fix to water quality issues in the bay, in particular to get rid of the ‘muck’ problem. There is a lack of awareness among the communities of, for example, water dynamics and the inputs from the lakes as well as the bay and their interaction. Due to this lack of understanding, there is a perception that locals seem to mistrust the government, believing that the government is not taking any action on these complex issues, which is resulting in communities taking matters into their own hands. Residents see beaches as a potential economic stimulus and want to see the bay developed more, with one suggestion of a Santa Monica style pier with restaurants for example. This economic incentive is a driver for beach clean ups and temporary fixes that may treat the symptoms rather than the causes of recreational water quality. However, state parks and beaches need to meet multiple needs for multiple users such as economic development, access to and enjoyment of nature, and preserving nature. The public beaches serve as some of the only access points to the bay due to the abundance of private property in the area, and thus the locals want their beaches clean. The locals’ method of recreation affects how they want the beach to look, however popular modes of recreation seem to be changing and differ based on the user, which can lead to varying ideas on how the beaches should be managed or how they should look.

3.1.6 Capacity

In order to address the issues impacting the bay, current tools available include existing data and models from the Saginaw Bay Multiple Stressors Project, including LimnoTech’s Saginaw Bay Aquatic Ecosystem Model (SAGEM), which is an integrated model incorporating nutrients, contaminants, five phytoplankton and one benthic algal group, zooplankton and three groups of zebra mussels. However, this model is based on *Cladophora*, and does not account for the changing sources of muck so may not be effective in modeling and predicting muck movement. An updated model may need to be developed or SAGEM may need to be improved to help with evaluating different management scenarios of nutrient and muck growth and proliferation, taking into account the variation of algal species that comprise Saginaw Bay muck. Additionally, the EcoSim analysis to the EcoPath model that focuses on community ecology and food web dynamics was applied to Saginaw Bay (Kao et al., 2014), and a geospatial database is one year away from being completed, which could be used for preservation and restoration areas. Participants suggested using this database to look at different scenarios for best management practices. Hydro-acoustic tagged fish, specifically walleye, as well as jaw tags for evaluating ecosystem changes are also available for use. In addition, potentially looking at and running various scenarios for nutrient concentrations and phytoplankton growth can be done through the EcoSim analysis of the EcoPath model (Kao et al., 2014).

3.2 Priority Research and Communication Issues/Needs

3.2.1 Models and Decision and Visualization Support Tools

Decision and visualization support tools incorporating models were high on the list of primary needs for workshop participants, as 100% of survey participants prioritized this need. The group discussed the need for a way in which to visualize all of the parameters through a tool much like the Great Lakes Water Level Dashboard (GLWLD): <http://www.glerl.noaa.gov/data/now/wlevels/dbd/>; a visualization and communication tool tied to model and management scenarios through output graphs and translation tools that is user friendly in which the user, for example, could input what kinds of impact an increase in phosphorus loading could have on fish recruitment. This type of simulation that the public, local managers, and project team use to determine the potential results and what is happening with different scenario situations would be especially useful for managers who are responsible for policy development and enforcing existing environmental and natural resource laws. This learning tool could apply the models from the Multiple Stressors project and show historic trends, and then see what happens under different scenarios with respect to the complex situation.

Similarly, participants discussed the need for a decision support tool, for making informed decisions based on what will happen with perch. For the purpose of decision-making, resource managers need something that puts the data, models, and results into a useful form in order to turn the results from this project into strategies and implementation for management and policy decisions. A scenario based decision-support tool could help show how to reach the desired goal if managers, for example, reduce fishing by a certain percentage. Participants want to be able to model various output scenarios and the effectiveness of different possible management scenarios to help frame expectations and decision options. For example, if filamentous algae need to be reduced, what could be done to do so? What level of nutrient reduction, such as 50% phosphorus reductions, would lead to reduction in muck? A model that helps broadly predict environmental outcomes by changing inputs was highly articulated as a need. This visual tool with a user-friendly interface could possibly be linked to a geospatial database for converging project results and leading to implementation.

Participants also suggested improving existing models to look at different management scenarios. In order to improve and develop these models, quantification and better characterization of muck is needed including its composition, volume, timing, and seasonality. Currently, models are lacking approximations of the amount of detrital material washing onto the beaches as well as predictive power with respect to the timing and magnitude of muck events. These models could be used for decision-making, such as developing site-specific criteria for total maximum daily loads (TMDL) from watersheds. Furthermore, high resolution, near-real time hydrodynamic models are currently being developed. These hydrodynamic models could be combined with beach surveys in order to predict muck events and thus serve as a decision-making tool for managers.

Table 1. Modeling Scenarios / Simulations

Modeling Scenarios/ Simulations	
<i>Input</i>	<i>Output</i>
Reduce Phosphorus by 50% or 25%	Impact on Filamentous Algae
Shut off Phosphorus Loading	- Benefits to tourism/ economics - Impact on Filamentous Algae
Reduce Fishing by 25%	- Impact to Fishery - Economic Impacts

3.2.2 Communication Opportunities

Due to the lack of understanding of the issues among the local communities, there is much need for communication efforts. One-hundred percent of survey participants prioritized the need for public communication. These needed efforts include addressing public perceptions of what Saginaw Bay should be since the bay has not responded the way other Great Lakes areas have, as well as controlling expectations for what can be realistically achieved through different management actions. Additionally, workshop participants mentioned the need to explain to the locals what has already been done and clarify the history of the issues. Some potential methods suggested for addressing communication needs include fact sheets to distill the scientific presentations and publications information down to easily interpretable snippets and vignettes and target specific topics like muck, for example. Continuing with the Beach Manager’s Manual series and developing a manual for muck as well as producing informational videos and documentaries to explain the uniqueness and value of Saginaw Bay, especially for wildlife, and illustrate concepts such as how a coastal wetland works would be useful educational and communications products.

A remaining question is how does this information help towards project goals? Does it help along in one direction or help with management decisions? Workshop participants want to help advise resource managers to determine how to use the information from this project. Participants also discussed the need

to explain the meaning of the nutrient models and outcomes to the public through visualization methods, and the need to communicate the effect of the combined disposal facility (CDF) impact on the circulation and deposition of muck; researchers say the CDF does not have an effect, though the community believes that it does.

Workshop participants also emphasized the need to bridge the gap between the local communities and management on communication and information on the costs of different management options, and get research out to the communities. There is a need to encourage consistent information and time spent with the community, including possibly a “water fellow for Saginaw Bay” (<http://www.cws.msu.edu/waterfellows.htm>). More local university involvement would be valuable as these universities have a good relationship with the communities may assist in being a ‘neutral’ information provider on the complexity of issues in the Saginaw Bay and the reasons why certain areas of the bay are focused on for restoration/ mitigation/ remediation. Some opportunities for increased involvement discussed include the development of a new speaker series partnership with DNR, DEQ, Michigan Sea Grant, and possibly the Office of the Great Lakes (OGL) with more promotion, one-on-one or group meetings and conferences, and small-scale demo research. Securing funds for pilot management projects with community members would help control public perception, as this would provide a way for the locals to see that their issues are cared about and are being worked on. The group also suggested holding workshops for the public, potentially with DNR since the agency connects with fisheries around Saginaw Bay. Additionally, participants mentioned engaging regional partners in communication efforts such as the Partnership for the Saginaw Bay Watershed, the Saginaw Bay Coastal Initiative (SBCI), Saginaw Valley State University (SVSU), Delta College, and the Saginaw Bay Watershed Initiative Network (WIN). Furthermore, due to the difference in opinions among agency and stakeholder groups as well as local politics, more synergy is needed among experts and agency groups.

This past year, Saginaw Valley State University (SVSU) established its Saginaw Bay Environmental Science Institute (SBESI) in order to consolidate all of SVSU’s Saginaw Bay watershed related work under one umbrella, strengthen its activities, and facilitate future work. The SBESI will build upon SVSU’s existing research activities and partnerships, such as that with Delta College, provide interdisciplinary learning with faculty from several fields of study, and offer research opportunities for the scientific study of the watershed for the students and faculty of SVSU. In 2012, the Michigan Department of Environmental Quality (DEQ) awarded a grant of \$26,185 to SVSU to continue its research on the Kawkawlin River in Bay County, and will be used to investigate northern sections of the river and evaluate why it fails to meet water quality standards (WQS) for dissolved oxygen in Michigan. In September 2013, SVSU received a grant of \$413,234 from the University of Michigan Water Center for the SBESI, which will be used to support additional ecological studies of Saginaw Bay and the development of priorities to guide continued conservation efforts in the area. The institute will provide oversight for these projects and more as well as provide an external advisory committee composed of professionals and scientists from the region. Additionally, it will work to improve communication between researchers and regional stakeholders through a web site, printed materials, and regular workshops.

Michigan Sea Grant (MSG) was awarded funding for the 2013-2014 round to conduct an Integrated Assessment (IA) entitled “Where People Meet the Muck: An Integrated Assessment of Beach Muck and Public Perception at the Bay City State Recreation Area, Saginaw Bay, Lake Huron.” This IA will summarize the current state of knowledge on the causes and consequences of muck at the Bay City State Recreation Area (BCSRA) and its socio-economic impacts at the park and on the Saginaw Bay region as a whole. The IA will implement models and surveys to understand public perception of muck-related issues and identify a series of short-term and long-term management actions that could help alleviate and better manage the impact of muck. The results will provide stakeholders with a shared understanding of the current state of the knowledge related to muck and the options for effectively managing the impacts of muck.

In terms of additional products and services, the development of educational work for public schools, at the high school level, such as for students taking AP Environmental Science (APES) was discussed. Participants suggested designing a unique and novel project or lesson based on these complicated issues and specifically developing Teaching With Great Lakes Data (TWGLD) lesson plans (<http://www.miseagrant.umich.edu/lessons/>) to get teachers to incorporate this information in their lessons, as well as using this information with Project FLOW (<http://www.miseagrant.umich.edu/lessons/>). These lessons could discuss, for example, how to pass this information onto potential future resource managers.

Table 2. Communication Opportunities

Communication Opportunities				
	<i>Product/Service</i>	<i>Who's Involved?</i>	<i>Notes</i>	<i>Contact</i>
1	Demo Research/Pilot Projects	Community members	Small-Scale, Help control public perception	
2	Speaker Series	DNR, DEQ, MSG, OGL	More promotion	Charlie Bauer or Laura Ogar
3	Informational Videos/Documentaries	MSG	Explain value of the Bay, illustrate concepts	
4	Educational Work for Public Schools	MSG/NOAA GLERL	At the high school level, TWGLD, Project FLOW	
5	Meetings/Conferences/Workshops	Various agencies and academic institutions		
6	Beach Manager's Manual Series	MSG	Informational handbook/ Field guide on emerging issues: One developed for harmful algal blooms	Sonia Joseph Joshi Sonia.Joseph@noaa.gov 734-741-2283
7	Fact Sheets	MSG	Distill information/target issues	
8	Water Fellow for Saginaw Bay	MSU?		Erin Dreelin (MSU)
9	Where People Meet the Muck (IA)	MSG, NOAA, MDEQ, MDNR, UM, Limno Tech, MSU, WSU	Understand public perception of muck-related issues	Donna Kashian (WSU) dkashian@wayne.edu 313-577-8052
10	Saginaw Bay Environmental Science Institute (SBESI)	SVSU	Interdisciplinary research for SVSU students and faculty	David Karpovich (SVSU) dsk@svsu.edu 989-964-4349

3.2.3 Spawning Habitat Limitation

Fifty-percent of workshop survey participants prioritized understanding if there are reef limitations for fish in Saginaw Bay. Participants would like to understand what the critical habitats are for fish, specifically spawning and nursery, and the distribution and limitation of these habitats. A remaining question is, are reefs significant sources of walleye larvae in the current ecosystem? The Saginaw Bay tributary the Tittabawassee River seemed to contribute the majority of walleye production in the bay in the 1990s, and reefs in the bay may have also supplied walleye in the past. Other studies have found that additional areas such as other Saginaw Bay river systems may now be contributing to larval walleye. Thus, in order to determine whether spawning and nursery habitat limit walleye production in the bay, future research should assess possible sources of walleye in different areas of the Bay and its tributaries. In general, participants want to know if there is value in the construction of new reefs and discussed looking at riverine habitats in addition to bay reef habitats with respect to spawning habitats and the potential construction of new reefs. Future research should determine what the critical habitats are and if fish production can be improved especially for walleye, lake whitefish, and possibly Cisco through reef construction and restoration or dam removal.

3.2.4 Fish and Invertebrate Community Changes

The discussion of remaining and new issues included understanding why and what is shaping how the fish and invertebrate communities have changed over time, since the 1970s and 1980s appear to be different from the 1990s and 2000s. Forty-percent of survey participants prioritized understanding the drivers of fish and invertebrate community changes, especially within the food web, such as how climate, nutrients and invasive species impact fish, particularly walleye and perch. Specifically, participants discussed understanding the effect of zooplankton on the shift of fish. The question was posed, does a pattern exist similar to the fish community with the zooplankton community and could the zooplankton data be used with fish data? Addressing this question, the group discussed the need for the same environmental explanatory variables aligned year-by-year in order to use the zooplankton data and fish data together, thus posing a seven year limit. To avoid this limitation, the participants suggested conducting an analysis of zooplankton without relating it to fish data as another option.

Participants noted that *Bythotrephes* are also a piece of the puzzle with respect to fish and invertebrate community changes. They discussed defining more what this reappearance has done in terms of understanding fish and invertebrate community changes over time; has this reappearance triggered a zooplankton reaction? The group explained that the *Bythotrephes* reintroduction appears to force zooplankton down trophically, inserting a new trophic level between zooplankton and fish.

3.2.5 Monitoring Plans

A regular monitoring plan throughout all seasons to prevent major gaps such as those that already exist in the data and obtain more long-term data was also high on the list of primary needs, as 30 percent of survey participants prioritized this need. Participants suggested the need for more monitoring buoys that GLRI could possibly help contribute. A long-term monitoring plan is needed especially for the lower food web and zebra and quagga mussels. Specifically, continued monitoring of the forage base supporting the walleye production in Saginaw Bay throughout the year as well as the development and application of models to evaluate plausible responses of walleye and forage fish populations to potential future ecosystem changes was discussed. Participants mentioned the need to tie this information together with water quality information; what is happening with the fisheries and invertebrate communities based on phosphorus and chlorophyll data? More water quality samples are needed such as during rain events, and especially for tributaries. The most recent data for tributary sampling is from the early 1990s. Tributary monitoring is necessary in order to evaluate phosphorus loadings and to identify problematic subwatersheds for prioritization. Additionally, more monitoring is needed for the local sources of phosphorus such as drains in order to determine their impact on more localized problems.

This monitoring plan developed must complement the accuracy necessary for decision-making. The Multiple Stressors Project produced a loading estimation method appropriate for an annual time scale; however, other methods suitable for finer time scales should be investigated and developed.

Additionally, monitoring is necessary in order to evaluate success. What metrics should be used as a measure of success? Though some metrics are already in place, walleye for example, participants discussed the need to further define these metrics.

3.3 Other Information and Research Needs

3.3.1 Relationship between the Inner and Outer Bay

Participants discussed that the project currently has an inner bay focus for most issues examined. However, there is movement between the inner and outer bay, such as with fish. Participants would like to understand the movement of fish and invertebrates between the inner and outer bay, and thus in general, understand the relationship between the inner and outer bay.

3.3.2 Dreissenids

There is currently a lack of understanding of dreissenid dynamics and impacts. What is happening with mussels in the bay? Participants discussed the need to understand what controls the distribution of mussels; do currents play into this? Specifically there is a need to understand the density and population distribution of mussels on soft-substrates rather than just on hard substrates, which is better studied. In general, due to the roughly 11-year data gap, participants are unsure if mussel densities are decreasing over time or if they vary through time. Additionally, the relationship between mussels and benthic algae is not clear and thus, participants question the impact of this relationship if phosphorus loading is further decreased. Furthermore, participants suggested that quagga mussels may filter more in the winter and thus asked, 'is there a change in siphoning seasonally for dreissenids?' In order to mitigate these issues, participants discussed the need for using existing studies while also conducting new studies.

3.3.3 Yellow Perch

Yellow perch production and recruitment in Saginaw Bay seem to be controlled differently in recent years (since 1995) than historically, and since 1970, brood stock biomass has been at its lowest levels. However, high numbers of age-0 yellow perch recently suggest that brood stock may not be the only contributor to low yellow perch recruitment levels. Rather, it seems to participants that high predation by walleye of later-stage age-0 yellow perch in addition to slow growth resulting in over-winter mortality and greater vulnerability to predation may be limiting recruitment.

It is clear that many potential factors limiting yellow perch recruitment in the bay remain unknown. More research is needed to answer the question, is yellow perch brood stock limited? If the answer is yes, one potential strategy of increasing brood stock is to overwhelm predators with more forage; participants discussed that more perch may be needed now because of walleye predation pressure. The group suggested using existing data on stock recruitment to help address this need, as there is a different stock recruitment relationship in recent years than historically. Participants also discussed the need to understand the over-winter mortality of perch; perch lose energy over winter, and getting eaten is likely the main source of mortality. Resource managers need to understand the limitation on yellow perch production to determine how to manage yellow perch so that they can be abundant at the same time as walleye; how can the two be balanced? Thus, additional research should assess the relationship between walleye predation, slow growth, density-dependence, and recruitment.

3.3.4 White Perch Impacts

An additional information gap mentioned is a lack of knowledge of white perch impacts. Most of the young of the year (YOY) never make it through the winter due to either starvation or predation. Participants discussed findings of white perch predation by yellow perch in the middle of winter. White perch are not as abundant now as they used to be; however, participants are unsure if the lower abundance of white perch is an issue. Does this issue need to be followed up on? To mitigate this research need, Lori Ivan has trawl data; the group also suggested using diet data to help answer this question.

3.3.5 Fisheries' Diet Shift to Benthics

Workshop participants want to understand what is impacting the fisheries' ontogenetic niche diet shift to benthics; could this be due to goby-perch interactions? Could mussels also be impacting the diet shift? To mitigate this issue, the group suggested looking at historical data to see what the young of the year (YOY) were eating before the invasive gobies entered the Great Lakes.

3.3.6 Nearshore Zone

The development of a decision support tool specifically for nearshore zone specific processes and development issues was also discussed. NOAA's Great Lakes Environmental Research Laboratory through the Great Lakes Coastal Forecasting System (<http://www.glerl.noaa.gov/res/glcfs/sb/>) has developed real-time and forecasted circulation models, which may be expanded. This management tool could help determine the type of nearshore habitats that need to be protected and thus how important

certain nearshore and resulting fish communities are. Participants discussed the need to give management the ability to protect these areas. To mitigate this research need, the group suggested using existing isotopic data on what fish inhabit nearshore areas, as the fish acquire the isotopic signature of the area that they stay in as adults, as well as diet data since prey pathways are different and yellow perch, for example, in different parts of Saginaw Bay are eating different things. Thus, this data could inform development such as where to allow dredging. Participants also discussed the need to understand how Great Lakes water levels are affecting near shore habitat. Does the impact change depending on where you are in the Great Lakes?

3.3.7 Lake Whitefish

There is currently little information on the YOY lake whitefish. Participants want to understand the reproductive importance of lake whitefish in Saginaw Bay for the Lake Huron population. How much of the lake whitefish production in Lake Huron is dependent on Saginaw Bay? How much of a source of production is Saginaw Bay and how does lake whitefish in the bay influence Lake Huron whitefish?

3.3.8 Watershed Modeling

Participants discussed the development of a landscape based loading model. How can land use changes be measured to determine whether they are making a difference? Resource managers need to know how land use change will affect the Saginaw Bay food web and ecosystem. More research is needed on Saginaw Bay hydrology and non-point source phosphorus loading, as point sources constitute a low amount of the total annual phosphorus loading and currently non-point source estimates from the watershed are unknown.

3.3.9 Muck and Bacteria

Some remaining questions discussed by participants are, what is the relationship between bacteria and muck, what is the source of this fecal bacteria associated with muck, and what is the health risk of the bacteria associated with muck? Bacteria, specifically *E. coli*, is measured in knee to chest deep water such as in the swash zone, and is always high in bacteria though never tested for its correlation with and impact on human health. Additionally, *E. coli* is high in muck but is currently not monitored nor is there a standard to sample in the muck. Thus, research is needed in order to evaluate this relationship and investigating more monitoring and sampling of bacteria in muck and in the swash zone, as well as the development of criteria for health standards.

Some additional questions that remain include the debate over whether or not the muck is natural. Muck and algae are part of the food web, but was the muck always here? Furthermore, workshop participants discussed whether there are any water quality measures to enact that would reduce the muck and control the sources, for example measures addressing total maximum daily loading (TMDL). The participants asked what would be the time frame for controlling the muck and what are strategies for controlling the muck with respect to its changing composition throughout the seasons?

3.3.10 Muck Control Technology

Workshop participants discussed options for various muck control technologies. These options included what participants described as a muck machine for cleaning suspended muck from the water, wetland restoration, as well as a pier built to simply pass over the muck. Also mentioned were Gunderboom nets to serve as a blockade; however, participants suggested that these nets would be a challenge to maintain. If the muck were to be removed, another remaining question discussed is what should be done with the muck once removed. The workshop participants discussed the possibility that the muck to be potentially used as fertilizer.

3.3.11 Short and Long Term Management

Much discussion took place regarding options for short- and long-term fisheries/invertebrates and water quality management. Primarily, the discussion focused around the question, what should be done about

the muck? A remaining research need is to identify depositional areas for muck and determine whether the sources of these areas are localized or systematic as this could influence management and ways in which to address the muck depositional areas. Short-term solutions must be identified as well as whether or not the muck is natural. If the muck is natural yet the bay areas should remain in use as beaches, then management options must be determined that are responsible but also satisfy the users and public. More research is needed on the effectiveness of and costs associated with different management actions and options including beach grooming and muck removal. With respect to grooming, how long would it take for the muck to return, how successful would beach grooming really be, and how aggressive would it need to be for success? Workshop participants discussed the potential cost of beach grooming, for example the Bay City Recreation Area (BCRA) which is the site of most severe shoreline fouling as shown in Figure 1, and the economic threshold of a groomed beach or the residents' willingness to pay for a certain amount of groomed beach area. Remaining questions regarding beach grooming include, who will pay whether state, local, or private and who has the power to allow beach grooming?

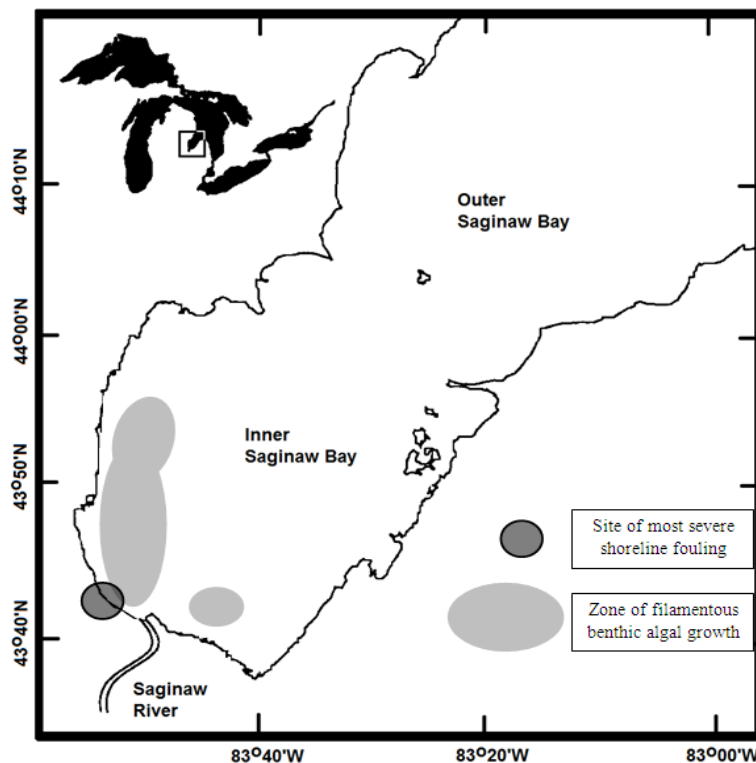


Figure 1. Locations of benthic algal growth as well as the location of the most severe shoreline fouling.

Participants also discussed the need for an active Adaptive Management Framework to reduce future uncertainties with consistently updated modeling and pilot studies in order to evaluate management options and slowly move towards a realistic picture of what can be done. One example is evaluating the option of only solving the filamentous algae problem in the short-term since macrophytes are only 1 in 4 years. Another example is fisheries managers determining a management action such as for the yellow perch population and then evaluating that option by examining outcomes of the yellow perch populations. The group discussed the need to identify possible actionable areas such as focusing on short-term solutions if modeling shows long-term solutions may not effect changes. Coastal dynamics need to be considered when evaluating options. Additionally, a remaining issue is determining where to expend time and resources whether on the causes or symptoms of water quality issues.

3.3.12 Socioeconomic Analysis

Workshop participants discussed the need for a socioeconomic analysis of the impacts of the shifts in fisheries. For example, what is the consequence of having more walleye? This type of analysis could help

answer the question, who do you placate? For example, should harvest rates of walleye be increased to decrease predation pressure on yellow perch? Additionally, participants want to understand the socioeconomic impacts of other issues including muck, water quality, and recreation as well as the economic impacts of remediation.

3.3.13 Emerging Issues

Workshop participants discussed some emerging issues regarding fisheries/invertebrates and water quality. These included the potential impacts of climate change, sparking questions such as if there would be a change in water transport and the impact of flooding. Other issues recently exposed include the relationship between nutrient cycling and bacteria, and the composition changes of muck. Since it serves as an indicator of good water quality, another research need is a *Hexagenia* study in order to determine why the mayflies are not recovering in Saginaw Bay as in other Great Lakes areas. Furthermore, more research is needed to determine whether there is hypoxia at the sediment-water interface where phosphorus may be released without detection, which could be promoting algal growth.

4. CONCLUSIONS, RECOMMENDATIONS AND NEXT STEPS

Following the discussion of findings from the breakout groups, the workshop came to a close with a wrap-up and conversation regarding the next steps for the project. Sonia Joseph Joshi (Michigan Sea Grant/NOAA GLERL), Lynn Vaccaro (Michigan Sea Grant), and Felix Martinez (NOAA CSCOR) led the closing discussion, reiterating that the Saginaw Bay Multiple Stressors Project final report including the key findings discussed during the morning session would be completed and available for reference and use in the near future. The three emphasized the need for future research and communication programs and their implementation. Additionally, they suggested following an Adaptive Management Framework in order to research short- and long-term management and communication options as well as potential pilot projects to evaluate some of the proposed management options. This workshop provided participants with the opportunity to discuss remaining research, communication and outreach gaps and needs as well as to establish where NOAA and Michigan Sea Grant should begin prioritizing their efforts.

Key Needs and Gaps:

- Models and Decision and Visualization Support Tools
- Communication Opportunities
- Access to scientific information
- Human Dimensions work: bridging gap between research, policy, and public concerns and public perception
- Spawning Habitat Limitation
- Fish and Invertebrate Community Changes
- Monitoring Plans
- Relationship between the Inner and Outer Bay
- Dreissenids
- Yellow Perch
- White Perch Impacts
- Fisheries' Diet Shift to Benthics
- Near Shore Zone
- Lake Whitefish
- Watershed Modeling
- Muck and Bacteria
- Muck Control Technology
- Short and Long Term Management
- Socioeconomic Analysis
- Emerging Issues

5. REFERENCES

Kao, Y.C., S.A. Alderstein, and E.S. RUTHERFORD. The relative impacts of nutrient loads and invasive species on a Great Lakes food web: An Ecopath with Ecosim analysis. *Journal of Great Lakes Research* 40(Supplement 1):35-52 (DOI:10.1016/j.jglr.2013.11.012) (2014).

APPENDIX A: WORKSHOP SURVEY RESULTS

The following figures and subsequent text represent summary results from the workshop survey in which participants were asked to prioritize important remaining research and communication issues and needs, rank various aspects of the workshop and its overall success, as well as comment on important topics omitted from the presentations and discussions and make suggestions for improvement.

Table 3. Workshop survey participants were asked to prioritize their top three remaining issues, research needs, and communication needs. This table presents summary prioritization results from the ten completed surveys including the percentage of survey respondents who listed each issue/need as a priority.

Priority Remaining Research and Communication Issues/Needs	
<i>Issue/Need</i>	<i>Percentage of Survey Respondents who listed as Priority</i>
Models/Decision/Visualization Support Tools	100%
Public Communication	100%
Spawning Habitat Limitation	50%
Fish and Invertebrate Community/Food Web Changes	40%
Monitoring Plans	30%
Socioeconomic Analysis	20%
Muck Source, Transport, and Deposition	20%
Yellow Perch Limitations	20%
Watershed Modeling	20%
Short and Long Term Management/Pilot Projects	20%
Near Shore Specific Processes	10%
Dreissenids	10%
Lake Whitefish	10%

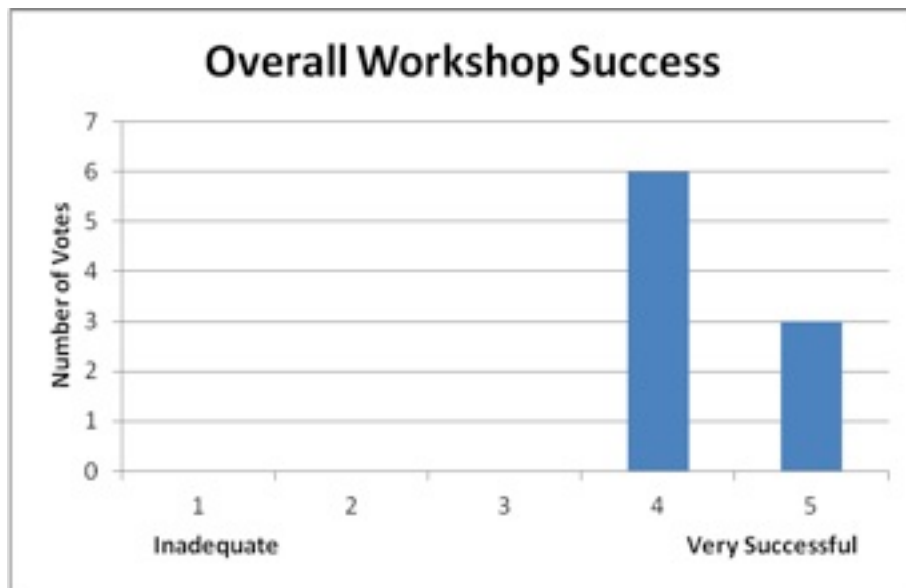


Figure 2. Participants were asked to answer the question: Overall, how would you rate this workshop?

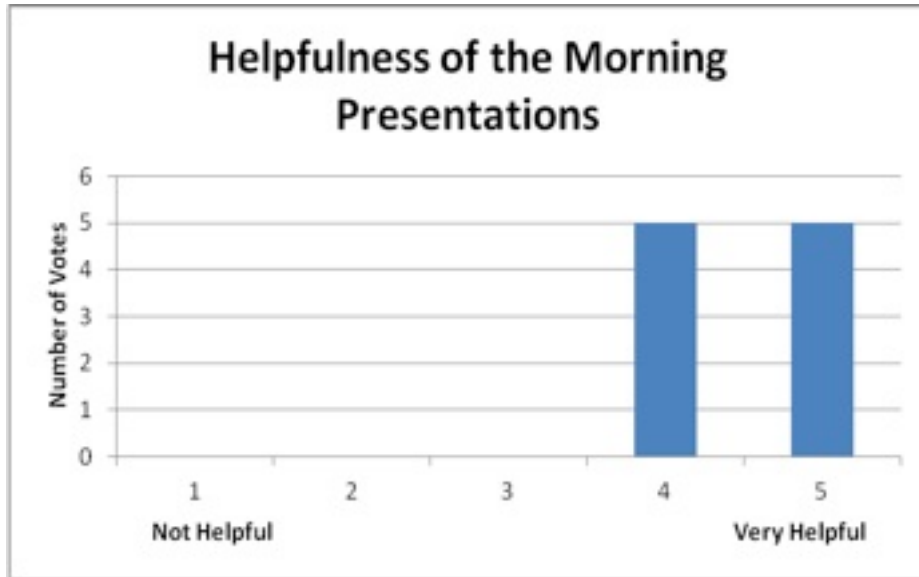


Figure 3. Participants were asked to answer the question: How would you rate the helpfulness of the morning presentations in terms of understanding project findings and results?

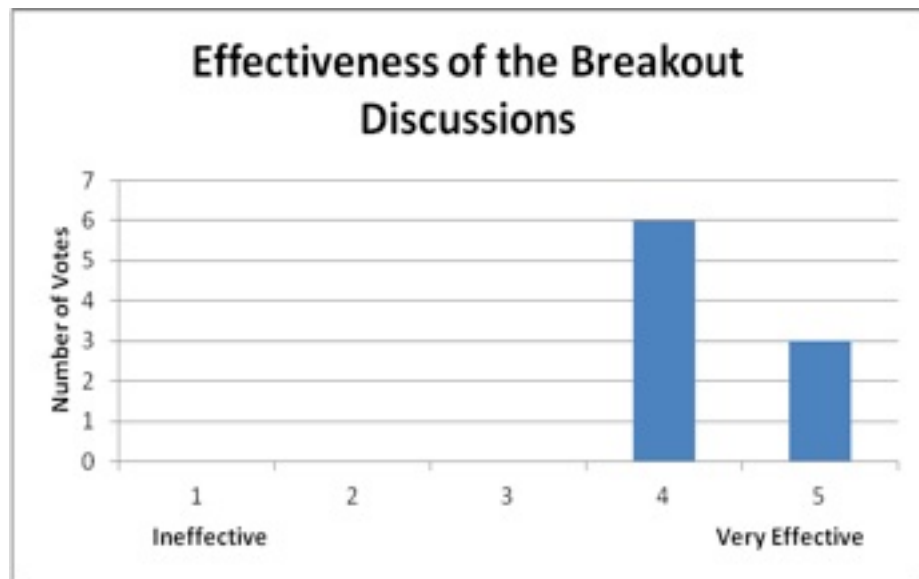


Figure 4. Participants were asked to answer the question: How would you rate the effectiveness of the breakout discussions?

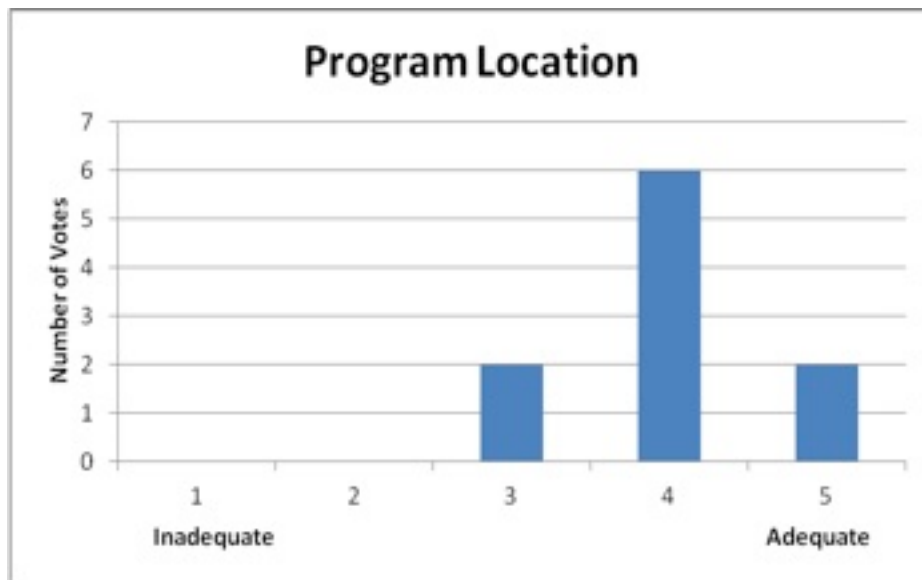


Figure 5. Participants were asked to answer the question: How would you rate the location of this program?

Overall Workshop Improvements

With respect to the overall workshop, survey respondents suggested providing an abstract to participants for future workshops, explaining the purpose and goals of the workshop to prevent any ambiguity.

Morning Presentation Topics

Some topics survey respondents wished had been presented on in the morning session include lake levels, invasive species, and migratory bird population impacts on Saginaw Bay and its ecosystem. Additionally, respondents would have liked to see model outputs of nutrients, climate change, and economic impacts. Respondents also would have liked to see presentations on the local residents' perceptions of science as well as management perspectives and needs and how these managers could potentially use this information.

Breakout Discussion Topics

Regarding the breakout discussions, some survey respondents commented that they would have liked to participate in both breakout sections in order to contribute to both conversations to help determine the important issues and needs. More specifically, survey respondents would have liked more discussion of the education and psychological components of these Saginaw Bay issues, noting that the few points discussed under these topics were highly beneficial.

Program Location Suggestions

Some suggestions from survey respondents regarding other program locations include somewhere in the Saginaw Bay area since that is the location of interest and could encourage better participation by local invitees and gain show-and-tell benefit of meeting in the location being discussed. Specifically, respondents suggested such locations as Saginaw Valley State University (SVSU), Delta College, or other local venues to support local breakout sessions with local residents. Depending on pertinent participants, other respondents suggested the same location, the Michigan Department of Environmental Quality (DEQ), or Ann Arbor for engaging certain staff members.

APPENDIX B: BREAKOUT DISCUSSIONS NOTES

Section A: Fisheries and Invertebrates

Saginaw Bay: Multiple Stressors and Beyond Workshop

Breakout Discussions

May 22, 2013

Objective: Identify and discuss remaining research and outreach gaps and prioritize research, education, and outreach programs

State of the Issues

Remaining Issues and New Issues

- We want to **understand why the fish and invertebrate communities have changed over time**. We also want to understand the affect of zooplankton on the shift of fish. Is there a pattern similar to the fish community with the zooplankton community? Could we use this zooplankton data with fish data? We would need the same environmental explanatory variables to do so. The data would need to be matched up year-by-year and thus we would be limited to 7 years. However, we could do an analysis of zooplankton and not relate it to fish data as another option. We want to know what is shaping how the community has changed over time since the 70's and 80's are different from the 90's and 2000's.
 - Is there a change in the siphoning seasonally for dreissenids? Quagga mussels may filter more in the winter.
 - *Bythotrephes* are also a piece of the puzzle. We want to define more what this reappearance has done in terms of understanding fish and invertebrate community changes over time. Has this triggered a zooplankton reaction? *Bythotrephes* appear to come in and force zooplankton down trophically, inserting a new trophic level between zooplankton and fish.
- We currently have an inner bay focus for most issues here. However there is movement between the inner and outer bays, such as with fish. We would like to understand the movement of fish and invertebrates between the inner and outer bay, and thus, **understand the relationship between the inner and outer bay**.
- We would like to understand **what controls the distribution of mussels**? Do currents play into this? What is happening with mussels in the bay?
- How have **spawning habitats (reefs) limited our fish**? Is there value in the construction of new reefs?
- We could use a **socioeconomic analysis of the impacts of the shifts in the fisheries**. For example, what is the consequence of having more walleye, etc? We need this socioeconomic analysis to help answer the question, who do you placate? For example, do we increase harvest rates of walleye to decrease predation pressure on yellow perch?

Local Knowledge: What have you heard from your constituents in terms of their knowledge of and magnitude of these issues?

- The locals want to know **why the perch are gone** and what we are doing about that.
- There is a **lack of knowledge and understanding of the complexity** of the issues. How do we educate the community on a local level? We need to make this knowledge more accessible to locals to help them understand the complexities and uncertainties.
- The locals ask **why do we need research**? We need to find a way to explain this to them. People just want the problem solved and want us to **do something**.

- We have found that most locals don't know about *Bythotrephes*. Only the most knowledgeable fishermen know about *Bythotrephes*. We need to educate the locals. The challenge is that if what we tell them doesn't agree with their preconceived notions, they reject this new information. They need to understand the **changes in the food web** and the individual pieces of the food web, including **cormorants and contaminants in fish**. To the constituents there must be a scapegoat; there must be something, one single thing, responsible for the decline of the things that they care about. The public is not as in tune with the science as they should be. It is clear there is too much uncertainty and a lack of belief in the science. The public needs to understand the concept of uncertainty and complexity. We need to employ the help of environmental psychologists.
- The people **want one answer** for what the solution to the problem is.
- The challenge is that people **will complain no matter what the situation is**. The locals used to complain that walleye weren't big enough. Now the locals complain that they can't catch enough.

History: From your perspective, how long have these issues been impacting Saginaw Bay?

- **Something has been affecting the Bay for almost 60 years.** It has just been a different problem over time. There are new specific issues, but the fish community is always changing. The target issue changes. We have had some long-term issues. For example, invasive species have been impacting the bay long-term, though the specific invasive species causing the impacts have changed. What we've been doing on the landscape has been affecting the bay over the years.

Capacity: What information, tools, and technology do you currently have to address these issues and what is your current capacity to employ these resources?

- We currently have the **Saginaw Bay Multiple Stressors data and models**, including LimnoTech's water quality model that we can use.
- We have the **ECO SIMM model**, which is almost complete. We could apply this model to Saginaw Bay.
- We are one year away from creating a **geospatial database**, which could be used for preservation and restoration areas. We could use this to look at different scenarios.
- We also have hydro-acoustic tagged fish, specifically walleye, as well as jaw tags.

What info, tools, and technology do you need to address these issues?

- **Visualization of Data (ex. Great Lakes Water Level Dashboard).** We need a way to visualize all of the parameters. We need a data visualization tool much like the Great Lakes Water Level Dashboard (GLWLD). We need some manner in which to "throw all the balls in the air". Something that is user friendly. A tool in which we could increase phosphorus loading and see what it does to fish recruitment, so that the public can see what's happening with different scenario situations. We could apply the models. We could show historic trends and then can see what happens under different scenarios. This could be used for informed decisions based on what will happen with perch, etc. We want a way in which to combine all the models. However, we would need to use this as more of a learning tool since the situation is so complex. We would need to be careful with how it's used.
- **Decision Support Tool.** We also need a decision support tool, such as for **perch**. We need something that puts our data and models and results into a form that managers can use for decision-making.
- We also need a **regular monitoring plan** throughout all seasons to prevent major gaps in data like we already have. We need more monitoring buoys, ideally everywhere in Great Lakes! Though everywhere is likely not feasible right away. We could get GLRI to kick in more data buoys.

Information and Research/Communication Needs

Info Gaps: What are the remaining data, information, and research/communication gaps and needs relative to this topic?

- We need to understand the **density of mussels on soft-substrates** rather than just on hard substrates. In order to mitigate this issue we can use existing studies and also conduct new studies.
- Is **yellow perch brood stock limited**?
 - One potential strategy of **increasing brood stock** is to swamp predators with more forage. We may need more perch now because of the walleye population. We could use **existing data on stock recruitment** to address the situation as there is a different stock recruitment relationship in recent years than historically.
- We have a lack of knowledge of **white perch impacts**. Most of the young of the year (YOY) never make it through winter. The YOY either starve and the rest get eaten by something. We have found white perch inside of yellow perch and that eight inch yellow perch are eating white perch in middle of winter. We have few adult white perch but not many of them (from millions to hundreds of thousands). We have seen the white fish though so we are not sure if it's an issue. Does this issue need to be followed up on?
 - To mitigate this issue, Lori has **trawl data**. White perch are not as abundant now as they used to be. We also could use **diet data**.
- What is **impacting the ontogenetic niche diet shift to benthics**? Could this be due to **goby-perch** interactions? Could **mussels** also be impacting the diet shift?
 - To mitigate this issue we could look at historical data to see what the YOY were eating before gobies came.
- We would like to develop a **decision support tool for near shore zone development issues**. This could help determine the type of near shore habitats that need to be protected and thus how important certain near shore and resulting fish communities are. We need to give management the ability to protect these areas.
 - We have some isotopic data on what fish we are seeing in near shore areas that we could use to mitigate this issue. We also could use diet data since we have yellow perch in different parts of Saginaw Bay eating different things. The prey pathways are different. The fish acquire the isotope signature of the area that these perch stay in as adults. Thus, we could use this data to inform development in terms of where to allow dredging, etc.
- **Lake Whitefish reproductive importance in Saginaw Bay for the Lake Huron population**. How much of the lake whitefish production in Lake Huron is dependent on Saginaw Bay? How much of a source of production is Saginaw Bay? We have little information on the YOY white fish.
- We need to understand the **over-winter mortality of perch**. They lose energy over winter, and getting eaten is probably the main source of mortality. However, we don't have these numbers. We do, though, have the data from the fall.
- We also want to **understand how Great Lakes water levels are affecting near shore habitat**. Does the impact change depending on where you are in the great lakes?
- We would also like to develop a **landscape based loading model**.
- We may want to look at **riverine habitats in addition to bay reef habitats** with respect to spawning habitats and the potential construction of new reefs.

Products: What are some ways that Michigan Sea Grant can help with these research/communication needs through the development of materials, products, and services?

- We would like to develop **management strategies** based on the data.
- We could hold a **workshop for the public**. Workshops could be held with DNR since they connect with fisheries around Saginaw Bay.
- Michigan Sea Grant could create **two page factsheets** to distill the presentation and journal information down. These would be geared towards **public and resource managers**. We could get the science down to bite size chunks. We want to answer, how does this information we have help us? Does it help us along in one direction or help us with management decisions? We want to help advise resource managers to determine how to use the information from this project.

- We could develop **educational work for public schools**, at the high school level, such as for students taking AP Environmental Science (APES). We could design a cool project or lesson based on this complicated issue.
- We could develop **Teaching With Great Lakes Data (TWGLD) lesson plans** to get teachers to incorporate this information in their lessons, as well as use this information with **Project FLOW**. These lessons could discuss how to pass this information onto your future managers, etc.
- *Priorities*: What do you see as the major priority, immediate research/communication needs in this theme area?
- We need **decision support tools** in order to turn data into implementation for management. These tools could help show how to get to the goal we want (#'s) if we, for example, reduce fishing by X%; how long until we get back to X number. We could apply the data in strategies for management for **resource managers and policy decisions**.
- **Spawning reefs and perch**. We need to understand if there are spawning habitat (reefs) limitations for fish in the bay and how to manage yellow perch so that they can be abundant at the same time as walleye. How do we balance the two? Are perch limited by brood stock?
- We need to develop a **monitoring plan**, especially for the lower food web (forage base) and zebra and quagga mussels. We don't have long-term data on too many variables. We need to tie it all together with water quality info; what's happening based on phosphorus data and chlorophyll data. How do we measure whether we are making a difference in terms of land use changes (watershed approach)? We need monitoring in order to **evaluate success**. What **metrics** can we use as measures of success? We need to know how land use change will affect the ecosystem. We need to define what our metrics are for measuring success; some metrics are already in place (walleye for example).

Section B: Water Quality

May 22, 2013

Facilitator – Sonia; Notes- Lynn

State of the Issues

- **Identify depositional areas for muck and why**. Identify whether Localized vs. systemic sources of muck, which could influence management. Identify areas and find ways to address them.
- Muck – Is it naturally occurring?
- **Is Saginaw Bay meeting designated uses?** Stakeholders say no, but if this is natural? MDEQ – meeting designated uses – like warm water fishing etc.
- **More research on the effectiveness of different management actions**, e.g, weekly muck removal etc.
- What are we going to do about it. Short-term solutions to manage it. If is natural, which it seems to be, and we want to use it as a beach, then we need options that are responsible but satisfy public/users.
- Not sure Sag Bay management option – others would benefit from solutions. Other states allow more aggressive grooming (Racine, WI – used to be closed 90 days, Julie Kinzelman, now a great place) but not MI.
- Who has the power to allow beach grooming? State legislatures. Rules depend on where you are on beach. Problem is suspended muck, must be removed immediately.
- **What to do with removed muck**, could it be sold as fertilizer?
- How well attended are beaches? Beaches near Chicago – 1 million visitors a day. What is the potential for Sag Bay beaches?
- Beach going is decreasing in popularity all over. Cultural shifts. Avoidance of nature and discomforts. State parks have visitor data. Water parks and pools compete with lake beaches.
- Water trails offer a different type of recreation. Unclear how popular it will be.

- Anecdotes – people remember time when beaches were really packed and much nicer. **We should capture vignettes.**
- Water depth matters - Sag Bay is very shallow.
- Boaters come and play in water and walk into beach, e.g., Caseville and BCRA
- A net, Gunderboom nets would be a challenge to maintain.
- **Residents see BCRA as economic stimulus.** Proposals of Santa Monica style pier with restaurants.
- Loading criteria for WQA – judgement of the standards set, in terms of muck, fish etc. Are they the right dashboard issues/metrics?
- Numerical nutrient criteria development? Have we met any nutrient criteria? Will it make a difference?
- GLWQA – seems to require a target.
- Retrospective analysis – 15 ppm target. How have we done? Water is constant, but biology seems to be getting better.
- **Would more P control make a difference?** Would it just shift community of plants contributing to muck
- Are there any WQ measures that would reduce the muck? TMDL? And control the sources. What would be the time to control?
- TMDL – is there a timeframe. Could require decades.
- What is the problem – muck during certain seasons?
- Maybe we should build a pool! Have we put too much into this beach that shouldn't be there.
- Resident expectations and squeaky wheel.
- If you shut off the P loading, what would change? Bay is a sediment sink for P, which could continue to be released?
- How much P comes from each tributary?
- Fertilizer is expensive, farmers are trying to be more targeted about their use of P. Remote sensing etc. to decide where to put it. How expensive?
- Muck and algae are part of the food web.
- Where are nutrients coming from that are feeding the algae source area near Linwood.
- Bring to bear coastal dynamics when choosing options.
- Sag Bay is very resilient – will remain a productive system. Will take a big hit to knock it into a low nutrient state.

1. New and emerging issues

- Flooding and Climate Change?
- High water helps.
- CDF (Combined Disposal Facility) impact on circulation and depositional areas? Seems to be a minor obstacle to flow? NEED: communicate to stakeholders that CDF doesn't matter.
- Core Myths – Muck specific factsheet? Problems are a myth. How to talk about the history and dispel mis-remembered.
- Documentary of Lake Sturgeon as an example. Video that is done in a story telling way. Talk about how a coastal wetland works. Why Sag Bay is so unique and valuable.
- Costs are important to communicate about management options.
- What has Frank Lupi contributed to this project from social sciences? WQ and bacteria levels are good at BCRA.
- Bacteria? Measured in knee to chest deep water. Bacteria is high in muck, but is not monitored regularly. *E. coli*.

2. Local knowledge and perceptions

- Perception that Govt. isn't doing anything. Very personal attacks.

- People believe that we can treat symptoms but not causes. Grad students at SBSU piloting.
- Do we know enough to model the solution- at scale, to remove the muck? Volume of muck etc?
- Short term and long term options?
- Macrophytes are only 1 in 4 years, maybe just solving the filamentous algae.
- Scott believes much is worse now than in past. Not sure we know the history. Scott believes that macrophyte part of the problem has gotten bigger. But seems to be significant in past.
- Some things are getting better – fish etc.
- Monitoring – more need for WQ samples, including tribs and rain events.
- Trib sampling – last best data early 90s.
- Believe that watershed is the source, but there is an internal dynamic. Sediment P release – not much evidence. But are we measuring the interface of water/sediment – hypoxic events that release P in an important manner for algae. Probes are just not designed to catch this interface.
- Sag Bay is a hard place to work.

3. Capacity

- What do you need in terms of information and tools? Trib monitoring – prioritize subwatersheds.
- Use existing models. If we can achieve 50% loading reduction, what would happen? Come up with scenarios.
- Need a different model for muck.
- We need calculations about volume of water, or tons of muck. Timing of contribution.
- What would it look like – spell it out – pilot needed. Move people slowly towards realistic picture.
- What are we using for tools – site specific criteria for TMDL watersheds. Doesn't apply to Sag Bay?
- We need new tools! Sag Bay is listed as impaired water. Mike not enough info to list as impaired. Many things seem to be getting better? All waters of the state have designated use – contact, fish consumption, navigation etc. Beach is listed but is about to be delisted because *E. coli* is getting better.
- Huron county did do shallow water/muck testing. Very hard to correlate *E. coli* numbers in swash zone are all high, but not correlated with health. Wet sand is a happy home for bacteria, always.
- It's more than just a technical issue. People want a clean beach and will force state to do it. Compare beach to Lake MI or FL.
- What is the economic threshold for management?
- What are the impacts of controlling P for the rest of the Bay – trade-off for fish.
- Visualization as a tool – tied to model and management scenarios, out put graphs etc., translation tools.
- SAEGM model is not adequate. It's based on cladophora growing on Lake MI, but we know SB is more.

Information Needs (low hanging fruit)

- Quantity of muck. Costs associated with management options. Timing of pulses.

Research Needs (bigger issues)

- What will be the benefits? Will people come if it becomes more pristine?

Public perceptions of what's bad or good? Need to get ahead of it. And control perceptions.

Agency groups and stakeholder groups have different opinions. Lots of local politics. People don't all get along. More synergy need among experts and agency groups etc.

Need to be able to explain what nutrient models mean to the public and outcomes people can see.

Parks –

Speaker series organized by Charlie – did seem to have an impact for interested public. More promotion would help. Most popular topic – dioxins, hot topics. Muck speaker series – identified clean up and disposal options.

Pilot projects would have value for public perceptions. Some already in place – regional funding sources. Charlie will help get things permitted and applications. People need to see that we care about their issues.

Control expectations for what Bay should be – it didn't respond the way other lakes did.

Teach people about uniqueness of bay. They have responded well in the past.

Specific Meetings – where we could be present?

Next phase of management plan – shoreline and muck issues for BCRA, Birchler Arroyo. Method of communicating is important. One on one is important. Need to understand best communication medium. SBVSU – more local stuff. More local university people. People get excited about scientists studying their stuff. Kawakalin River – Walleye Dinner, River Clean up etc. Sag Bay Environmental Science Institute. Delta College.

Partnership for the Sag Bay Watershed

Sag Bay Coastal Initiative

Opp to host a conference.

Sag Bay Watershed Initiative Network Group WIN – suite of funders. In ppt include slides about what could be done, projects to be funded.

APPENDIX C: WORKSHOP AGENDA

Saginaw Bay: Multiple Stressors and Beyond Workshop

May 22, 2013
Constitutional Hall (South Tower), 6th Floor
525 West Allegan Street
P.O. Box 30473
Lansing, MI 48909-7973

Agenda

- 9:00am: Welcome- Presentations of Key Findings from the Saginaw Bay Multiple Stressors Project
- 9:10am-10:20 am: Dr. Craig Stow, NOAA GLERL
Multiple Stressors Project Overview and Water Quality Findings
- 10:20am-11:10 am: Dr. Scott Peacor, Michigan State University
Saginaw Bay Muck: What We've Learned and What's Unknown
- 11:10am-11:30 am: BREAK
- 11:30am-12:20 pm: Dr. Tomas Höök, Purdue University
Fisheries and Invertebrate Findings Project
- 12:20pm-1:00 pm: LUNCH (Provided)
- 1:00pm-2:30 pm: Breakout Discussions: Participants will self select into one of two breakouts:
Fisheries/ Inverts and Water Quality
- GOAL OF BREAKOUT DISCUSSIONS: Identify remaining gaps related to research and outreach efforts in Saginaw Bay. Where should NOAA and Michigan Sea Grant begin prioritizing research and outreach and education programs?
- 2:30pm-3:00 pm: BREAK
- 3:00pm-3:30 pm: Report out From Breakouts
- 3:30pm-4:00 pm: Wrap up and Next Steps