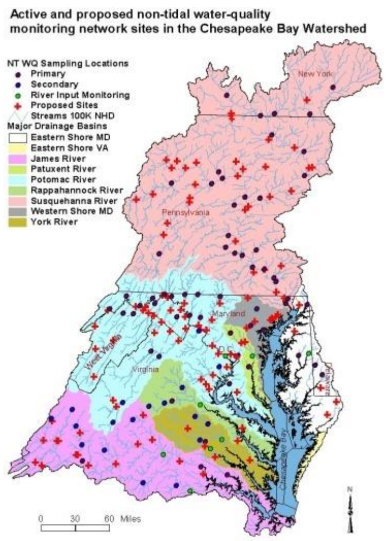
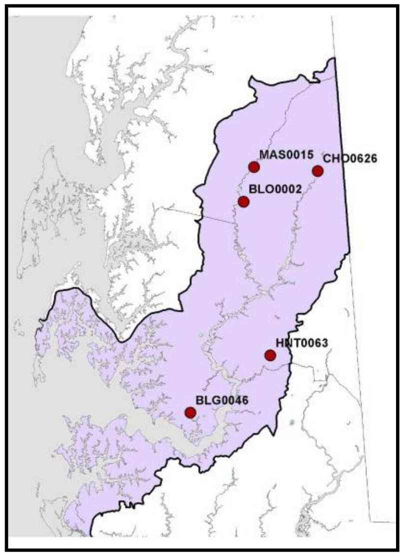
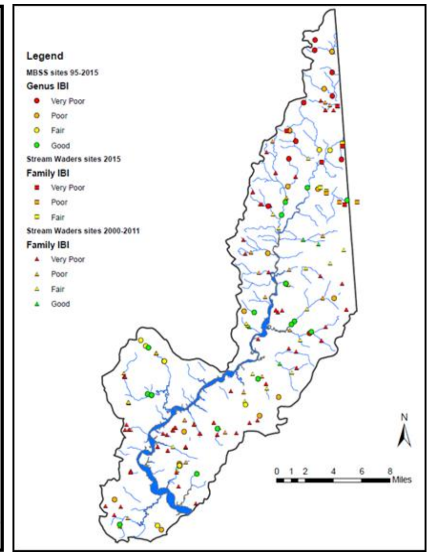
Integrating and Leveraging Monitoring Networks to Support the Assessment of Outcomes in the Chesapeake Bay Watershed Agreement







STAC Workshop Report
April 12-13, 2016
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STAC Publication 17-003

About the Scientific and Technical Advisory Committee

The Scientific and Technical Advisory Committee (STAC) provides scientific and technical guidance to the Chesapeake Bay Program (CBP) on measures to restore and protect the Chesapeake Bay. Since its creation in December 1984, STAC has worked to enhance scientific communication and outreach throughout the Chesapeake Bay Watershed and beyond. STAC provides scientific and technical advice in various ways, including (1) technical reports and papers, (2) discussion groups, (3) assistance in organizing merit reviews of CBP programs and projects, (4) technical workshops, and (5) interaction between STAC members and the CBP. Through professional and academic contacts and organizational networks of its members, STAC ensures close cooperation among and between the various research institutions and management agencies represented in the Watershed. For additional information about STAC, please visit the STAC website at www.chesapeake.org/stac.

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Executive Summary

The 2014 Chesapeake Bay Watershed Agreement (hereafter referred to as Bay Agreement) outlines a Chesapeake Bay Program (CBP) partnership community-based vision for ecosystem recovery. The combined conservation and restoration efforts of the CBP partners are envisioned to support an environmentally and economically sustainable Chesapeake Bay watershed with clean water, abundant life, conserved lands, access to water, a vibrant cultural heritage, and a diversity of engaged citizens and stakeholders. The Bay Agreement contains 10 goals and 31 outcomes that expands the work of the partnership beyond the water quality focus of the 2010 Chesapeake Bay Total Maximum Daily Load (TMDL). Tracking and accountability of progress towards achieving the Bay Agreement goals and outcomes requires a broad range of indicator assessments. During 2015, a CBP Indicator Action Team (IAT), operating under the Scientific, Technical Assessment and Reporting Team (STAR), coordinated with the Goal Implementation Teams (GITs) to evaluate the status of their indicator development. The IAT coupled its indicator evaluation with documenting the monitoring support needed for reporting on the indicators. To address resource limitations of the CBP partnership that will impact the support for all its indicator data collection needs, the CBP STAR collaborated with the Scientific and Technical Advisory Committee (STAC) to host a workshop on integrating and leveraging monitoring networks.

Creating an integrated monitoring network that would simultaneously optimize all resources supporting the indicator assessment needs of all Bay Agreement outcomes would be an unwieldy task. Therefore, this workshop focused on 1) a single watershed, the Choptank River, MD, and 2) a subset of 7 of the 31 outcome areas under the Bay Agreement (i.e., oysters, fish habitat, forage fish, submerged aquatic vegetation (SAV), water quality (both in the watershed and tidal waters), stream health, and toxic contaminants). Focusing the meeting on a single geographic region allowed for a compilation of existing monitoring efforts and an opportunity to evaluate potential coordination among regional partners. This approach served as a case study to develop strategies that could be applied to other watersheds, and eventually scaled up to the entire Bay. Participants also advocated that promoting integrated monitoring networks:

- Strengthens support for adaptive management (including the use of models and indicators),
- Promotes alignment of diverse monitoring programs under common objectives,
- Assesses the compatibility of sampling and analytical techniques between programs monitoring the same parameters, and
- Provides consideration and direction for modifying existing network designs that facilitate their integration.

Key findings included:

- Workshop participants viewed promoting integrated monitoring that will address diverse but interrelated assessments at restoration sites (e.g., Harris Creek Oyster Restoration site) as helpful to filling gaps in monitoring that support mutually beneficial information needs.
- There were many barriers identified that can potentially limit monitoring program integration. The top three barriers recognized by the workshop participants were: 1) misaligned objectives between programs, 2) communication gaps regarding existing work among many regional partners, and 3) limited funding resources.
- Additional capacities identified to support gap filling monitoring needs included federal labs and citizen monitoring.
- Creating successful 'networks of networks' hinges on a variety of strategies, including: 1) minimizing differences in monitoring protocols, and 2) identifying time frames needed for trend detection, and spatial scales required.

Recommendations:

The potential for expanding monitoring program networks by working with a wide variety of monitoring efforts underway across the Chesapeake Bay and its watershed was recognized and acknowledged in 2009 by the CBP (MRAT 2009). The CBP should continue expand its approaches to remove barriers to integrating monitoring networks in order to address multiple Bay Agreement outcomes. In order to leverage the findings of the MRAT report, workshop participants recommended the CBP partnership pursue the following to achieve this goal:

1) Align objectives.
    a. Achieving alignment of objectives fosters better program integration by establishing a common vision. A common vision can be defined using conceptual models.
    b. Conceptual models define the elements of the ecosystem and their interactions that CBP partners deem important for understanding restoration progress and effectively targeting limited monitoring and management resources.
2) Organize strategic consortia to pool and prioritize monitoring funding based on a common vision.
    a. Use conceptual models further to organize partners' integrated programs and the considerations given to the work necessary to support the common vision.
3) Synthesize and communicate monitoring results to diverse stakeholders to overcome communication gaps.
    a. Communication products need to be as diverse as their audiences - ranging from short and public-friendly overviews to data intensive, highly technical reports and journal articles.
4) Apply decision-oriented, place-based interactive workshops.

a. Tributary-scale face-to-face workshops with maps of participants' active monitoring networks support opportunities for partners to improve their coordination and collaboration under the same objective.

Further programmatic recommendations:

1) The combined efforts of CBP-STAC and STAR should continue to provide venues for the tributary and regional scale networking necessary to support solution-oriented monitoring program integration.
2) The CBP should continue to support STAR and its workgroups (e.g., Integrated Monitoring Networks Workgroup) in organizing networking and discovery workshops that promote monitoring network collaborations.
3) CBP Workgroups should continue to use a geographic-based approach to move around the watershed with network building activities.
4) CBP Workgroups should consider a sufficiently long planning horizon when dealing with network integration efforts. An extended planning horizon should include pre-workshop meetings of small groups focusing on specific collaborations, then build upon the successes of the small group meetings for a regional scale collaborative workshop.
5) The CBP should continue to foster the integration of citizen science and other nontraditional partner data collection activities. Feedbacks to the citizen science community regarding the use and utility of their data is an important element of the data sharing process.

Introduction and Overview of the Workshop

Leveraging and integrating existing monitoring networks is one approach to help the Chesapeake Bay Program (CBP) partners address gaps in data needs in order to evaluate progress towards meeting outcomes in the 2014 Chesapeake Bay Watershed Agreement (hereafter referred to as Bay Agreement). Currently, the majority of the federally supported, U.S. EPA-based CBP monitoring programming is focused on water quality assessment. However, other environmental monitoring programs are, for example, measuring status and supporting trend assessments for living resources and their habitats. Optimizing a more integrated CBP partner monitoring program that would simultaneously address the needs of all Bay Agreement outcome indicators would be a huge task. This workshop focused on the Choptank River watershed as a microcosm for the Bay system and centered on the potential to integrate programs within the watershed that could support data collection for a subset of 7 of the Bay Agreement outcome indicators (see Workshop Agenda, Appendix A).

During 2015, the CBP Indicator Action Team (IAT) conducted an indicator gap analysis to understand Goal Implementation Team (GIT) needs for indicator development and monitoring support (Table 1). The gap analysis provided a road map where the Scientific, Technical

Assessment and Reporting Team (STAR) and Scientific and Technical Advisory Committee (STAC) could be used to assist the CBP GITs in meeting their needs. Gaps for indicator support ranged from enhancing explanatory understanding with information on factors influencing progress measures to the development of new metrics and indicators. Monitoring program needs were identified to support progress tracking and accountability for each indicator and outcome.

Table 1. IAT CBP Office gap analysis of indicator needs and subsequent monitoring support associated with tracking progress towards achieving the 31 outcomes of the 2014 Bay Agreement. May 2015 status report (developed by Mindy Ehrich, CBPO).[1]

Green (Established)	Yellow (Advanced Progress)	Red (Undeveloped)
Fish Passage	Oyster	Forage Fish
SAV	Forest Buffer	Fish Habitat
Water Quality	Tree Canopy	Black Duck
Protected Lands	Brook Trout	Toxic Contaminants Research
Public Access	Environmental Literacy	Toxic Contaminants Policy and Prevention
		Healthy Watersheds
		Citizen Stewardship
		Local Leadership
		Diversity
		Climate Resiliency

Unclassified indicator status at this time:
Blue Crab, Stream Health, Wetlands, Land Use Options, Land Use Metrics & Methods

Workshop Process

On April 12-13, 2016, representatives from the CBP partnership's monitoring community gathered for a workshop to discuss monitoring assets and program integration (Appendix C). The workshop explored the possible alignment of work efforts that would address monitoring gaps, enhance collaborations, pilot new sampling methods, evaluate redundancies, and improve monitoring programming efficiencies. The workshop centered on recognizing barriers to program integration and brainstorming solutions to integrating the existing monitoring networks. The understanding gained through conducting this workshop is anticipated to help support and inform improved monitoring integration efforts. Continued efforts to integrate monitoring networks are expected to address the full range of monitoring needs for tracking the Bay Agreement outcomes, supporting accountability, and informing adaptive management.

[1] For an updated assessment of indicator development status, see Appendix B, Indicator needs of CBP. March 2017 update.

The workshop planning committee generated a list of oft-discussed barriers to monitoring network integration that was presented during the workshop. Workshop participants reviewed and prioritized the list of barriers based on their unique perspectives and local experience in program management. The workshop participants were asked to focus on opportunities to better integrate monitoring efforts across partners' programs. Major issues explored during the workshop discussions included:

- Monitoring support for adaptive management (including the use of models and indicators)
- Aligning objectives between monitoring programs
- Assessing compatibility of sampling and analytical techniques between programs, and
- Modifying network designs to achieve greater cross-monitoring program efficiencies.

In the weeks prior to the workshop, pre-workshop preparation included engaging workshop participants to submit sampling station coordinates from their organizations' monitoring programs operating in the Choptank River watershed. Poster-sized work maps were created for breakout groups to use when reviewing, discussing, and developing recommendations on cross-program monitoring network integration (Figure 1). Maps were used to focus discussions on each group's vision for an ideal integrated water quality and living resource monitoring program using the existing resources operating in the region. The maps were also useful tools in creating awareness about what groups were active in the watershed and facilitated a collective vision for collaborations (Figure 2).

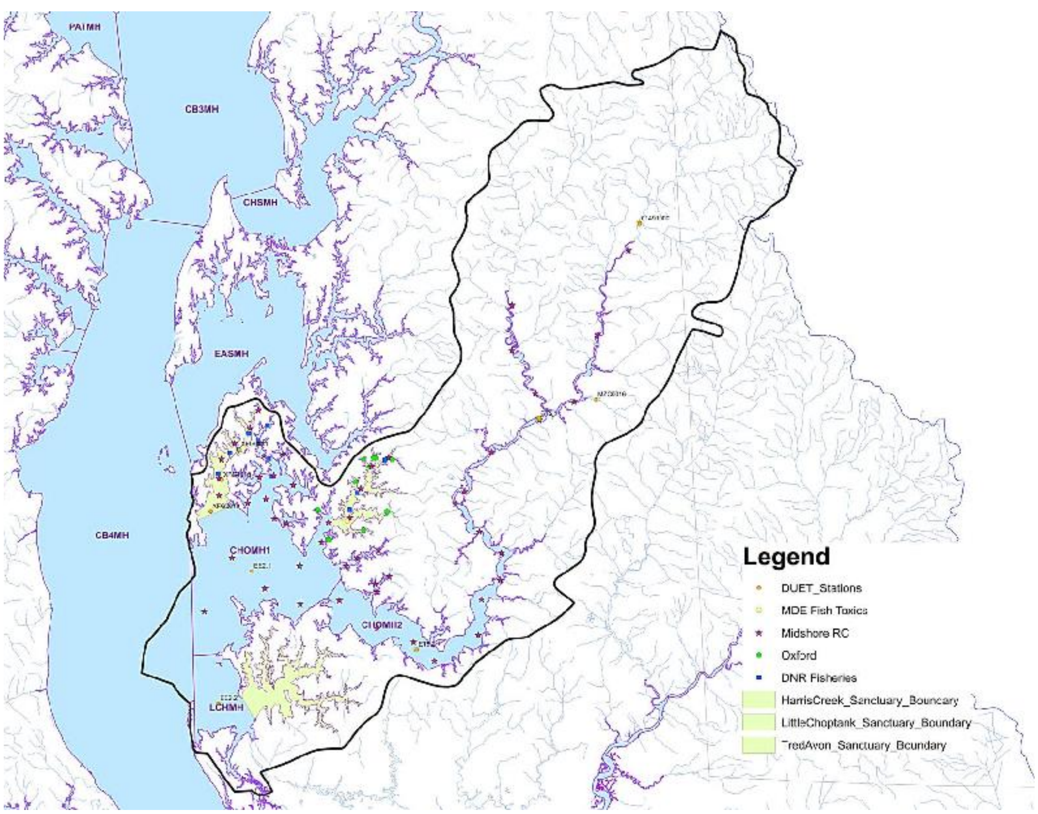


Figure 1. Choptank River watershed and monitoring asset distribution for groups sharing their monitoring locations for the collaboration discussions.

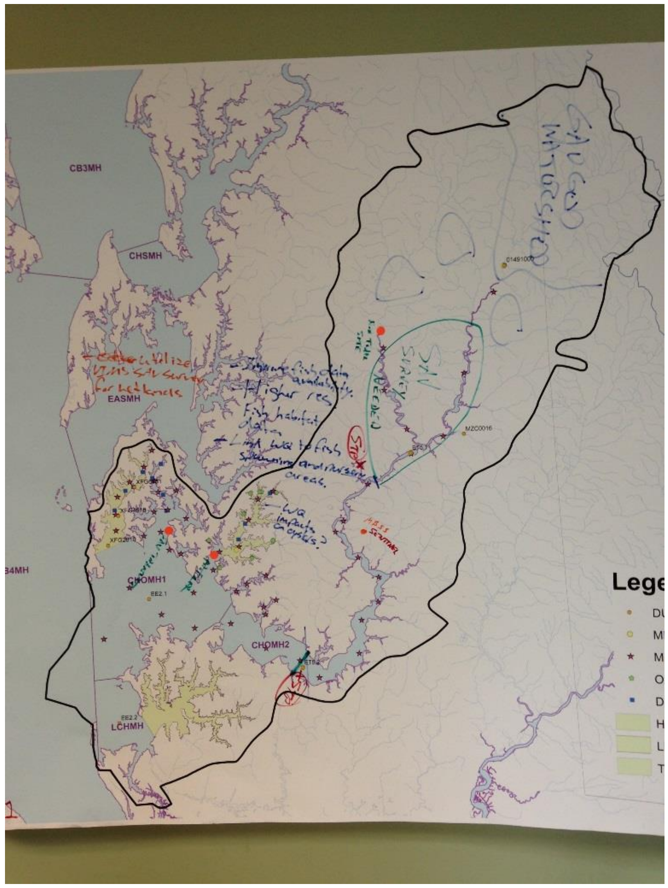


Figure 2. A well-worked map highlighting areas for potential collaborations.

Workshop Structure

The workshop was organized into three main sessions. Session one reviewed monitoring programs and assets related to our selected subset of Bay Agreement outcomes operating within the Choptank River watershed (oysters, fish habitat, forage fish, submerged aquatic vegetation (SAV), water quality (both in the watershed and tidal waters), stream health, and toxic contaminants). Workshop objectives were introduced by Dr. Peter Tango (USGS-CBPO), highlighting that the meeting would focus on the barriers and opportunities to integrating the existing monitoring networks to support CBP partnership assessments of progress towards meeting these outcomes. The first day's plenary session was provided by Dr. Tom Fisher, who overviewed the physical landscape of the Choptank River watershed, long-term water quality trends from the watershed downstream to its lower estuary, and provided references to growing monitoring partnerships in the region. The session continued with a suite of presentations serving as a foundation of information on each of the 7 selected focus outcome areas of the Bay Agreement.

Additional presentations provided an overview of the different monitoring networks operating in the Choptank River watershed. Monitoring programs included the Virginia Institute for Marine Sciences (VIMS) Submerged Aquatic Vegetation (SAV) annual survey, toxics, water quality in non-tidal areas, and stream health assessments. Abstracts are available for a subset of the individual presentations (Appendix D). Additionally, we asked each partner to provide their program-specific sampling protocols. Numerous water quality and aquatic living resource monitoring networks operating throughout the watershed were identified (Table 2).

Table 2. Monitoring programs and assets presented in the workshop.

Monitoring Parameter	Programs
Bay grasses	• VIMS SAV aerial photography • MD DNR SAV transects
Water quality	• MD DNR tidal water quality monitoring • Cooperative Oxford Lab on the Tred Avon River • Dr. Thomas Fisher (UMCES) watershed BMP effectiveness • NOAA Satellite with Total Suspended Solids • Mid-Shore River Keeper Conservancy water quality
Fisheries	• Cooperative Oxford Lab fish community composition in the Tred Avon River • NOAA oyster restoration sites • NOAA fish sampling
Toxic contaminants	• MDE fish tissue sampling
Benthic communities	• MD DNR Maryland Biological Stream Survey sites

Session two consisted of facilitated group-directed activities guided by Dr. Bill Dennison. These activities were intended to shape and motivate the community into thinking in an integrated networks frame of mind while coincidentally considering a set of barriers to the integration effort.

Session three moved the workshop firmly into addressing opportunities and solutions that support monitoring network integration. Breakout groups used their time to consider how best to leverage programs in mutually beneficial assessments, generating efficiencies in cost and labor. The second day plenary session by Dr. Britta Bierwagen reviewed the status of the U.S. EPA Climate Change Network (CCN). The story behind the development of the CCN embodied the concept of creating an integrated monitoring program over a region of networks. Dr. Bierwagen's overview presentation illustrated a behind-the-scenes look at a new, relevant, and regional example of the process to build a multi-partnership network through a strategic sharing of resources across networks. The plenary formed a reference for what we asked the workshop breakout groups to consider in their mapping exercise (Figure 2). Breakout groups were directed to show where they could recommend enhancements for collaborations that would fill needs and gaps in monitoring assessments.

The workshop concluded with presentations by each group providing a review of suggestions for monitoring advancements from their final mapping exercise. The suggested advancements helped highlight recommendations for overcoming barriers to integration and enhancing monitoring networks across the Choptank River watershed and estuary.

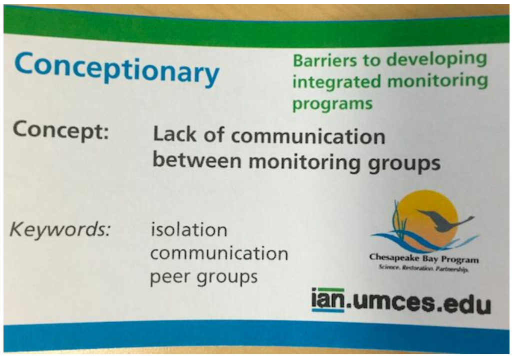
Major Barriers to Integrating Monitoring Programs

Prior to the workshop, the planning committee developed a list of barriers often encountered when working on program integration efforts (Table 3). Workshop participants engaged in an interactive exercise to prioritize the barriers to cross-partner program integration by voting on what they believed to be their most challenging barriers. Votes were tallied to identify the top 3 barriers considered as the most challenging to address. Breakout groups were then challenged to highlight their understanding of these three barriers. Groups were further asked to highlight potential paths toward addressing the challenges in a "Conceptionary" activity framework (Figure 3).

Table 3. Recognized barriers to monitoring network integration, determined prior to workshop.

- Different protocols in use between programs for monitoring that same parameter(s)
- Unaware of what other groups are doing and what each other needs
- Different instrumentation sensitivity limits
- Overcoming vested interests
- "This is how we always do it"
- Lack of aligned objectives
- Establishing the validity and integrity of data collected by different programs
- Lack of rewards to keep people engaged
- Funding
- Database compatibility

a.



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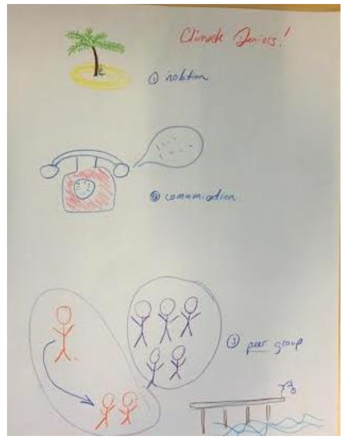

Figure 3. Example of a "Conceptionary" card (3a) provided to breakout groups, where group participants were challenged to visualize a translation of the key issues associated with the primary barrier concept (3b)

Solutions to Barriers to Monitoring Program Integration

Solution 1. Alignment of Objectives

- **Create a common vision through agreement on a conceptual model of the system.**
- **Facilitate familiarity with other programs and their work in order to leverage common efforts through -**
    - **Conducting tributary scale, face-to-face workshops with maps**
    - **Providing data visualization support**
    - **Examining outcome indicators and their data to support multiple outcome information needs**
    - **Examining programs to evaluate redundancies and create program efficiencies.**

A common idea expressed among participants was that a good first step in promoting program integration is organizing meeting or workshop opportunities such as this STAC-sponsored event. Similar events have been used to foster awareness for groups involved in similar work. While the CBP partnership's long-term tidal water quality monitoring program was designed over 30 years ago as an integrated water quality and living resources monitoring effort, new expectations for tracking and accountability were created with the 2014 Bay Agreement. The greater range of monitoring needs to support decision-making and adaptive management represents a new opportunity to look across program activities for synergies on information sharing and efficiencies in acquiring data.

There have been several workshops or meetings in our region in recent years directed at creating greater awareness among monitoring entities to highlight program integration opportunities. In particular, the diversity of water quality monitoring assets operating in the Bay region have been presented in local forums (e.g., Baltimore area and the Urban Waters Workshops https://www.epa.gov/sites/production/files/2015-07/documents/urban-water-monitoring-assets_091014.pdf) or at a State level (e.g., Maryland Water Monitoring Council (MWMC) annual Monitoring Roundtable http://dnr2.maryland.gov/streams/Pages/MWMC/roundtable.aspx). During our workshop, the Integrated Monitoring Network Workgroup (IMN WG) of the CBP was recommended as an active group that should continue creating these meeting opportunities to help develop strong monitoring connections across diverse partners. Such partnerships are envisioned as continuing to develop through leveraging work off of existing networks. Collaborations are encouraged to address coincident monitoring needs and support the acquisition of mutually beneficial data. To that end, participants suggested holding frequent, regular meetings that discuss monitoring program objectives, reviews of monitoring assets, and past and ongoing data collections.

A strength of this workshop was involving as many agencies and institutions as could be accommodated with vested interests in monitoring within the selected region. The workshop attendees included federal, state, local, academic, non-governmental, and citizen-based organizations to network and foster collaborations. To the degree feasible, it was suggested that future workshops include as many programs as could be accommodated with interrelated monitoring efforts. Such efforts called for referencing a monitoring inventory of who was doing what work in the region. Developing such a reference inventory and making it publicly available was a recommended step to advance integrated, collaborative monitoring efforts. Participants recommended that future meetings be assembled under common themes (e.g., water quality, stream health).

Creating a common vision with scale-specific direction for any similar integration effort was deemed important. The common vision could come in the form of a conceptual model of the study system (e.g., Figure 4). Agreeing on a conceptual model provides a foundation that can be used to guide and focus discussions of common objectives, data needs, and sampling designs. Pre-communicating these forms of information before a face-to-face workshop effort commenced was further encouraged by our participants as an important planning step. Pre-workshop homework was supported as a means of promoting stronger collaboration and networking activities.

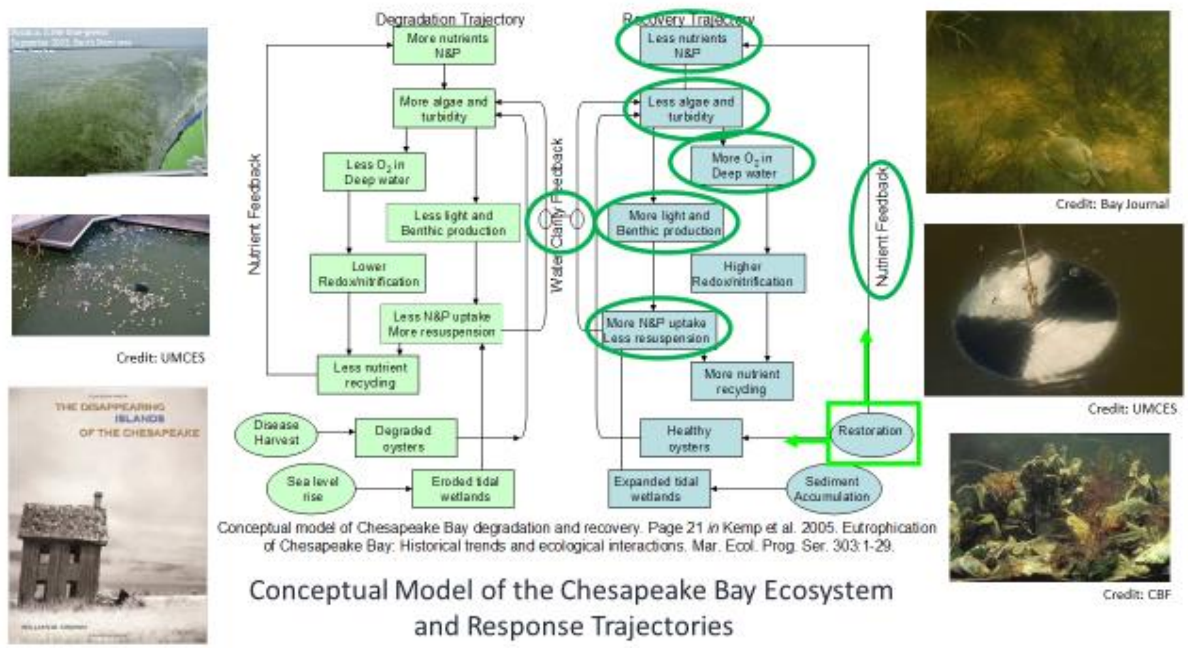

Figure 4. An example of a conceptual model that provides a reference framework for envisioning key elements and processes operating within the Chesapeake Bay ecosystem, with eutrophication and restoration response trajectories (Kemp et al. 2005)

Conceptual models support the alignment of objectives, however, aligning objectives can further be fostered through developing written agreements to guide partner commitments on collaborated monitoring efforts. Signing on to a written agreement promotes trust between programs. Shared agreements such as a Memoranda of Understanding (MOU) formalize responsibilities and establish limits and expectations for two or more partners working on related data collection efforts. Such agreements as the 2004 MOU among the Chesapeake Watershed states within the Chesapeake Bay Program partnership were discussed in this workshop because they formalized the commitments for operations of a long-term non-tidal water quality monitoring network. The commitments involved application of consistent protocols that supported region-wide data comparability and sustained program integrity across the common constraint of political borders. Development of similar types of agreements supporting consistency in objectives and assessments are already being considered by the Chesapeake Monitoring Cooperative (CMC) under the Alliance for the Chesapeake Bay (ACB) (https://allianceforthebay.org/our-work/connecting-people/chesapeake-monitoring-cooperative/).

Social networking was discussed as a means to aid the alignment of individual or program effort objectives and information needs across programs. The growth of citizen science monitoring programs like 'eBird' or the Community Collaborative Rain, Hail and Snow Network (CoCoRAHs) (see Bowser and Shanley 2013) are just two examples where individuals are contributing data that is being used by researchers and decision-makers. Participation is fostered and the user experience enhanced through their involvement in scientific and management efforts and where the work is depicted through social media.

One more suggestion for aligning objectives involved efforts to mimic a big research organization or environmental sampling cruise approach, similar to an approach taken by the NOAA Sentinel Site Cooperative (http://oceanservice.noaa.gov/sentinelsites/chesapeake.html). The Cooperative represents an effort where an established program invites others to participate in monitoring at the same sites. Such coincident work then fulfills additional data needs that complement and enhance the information needs already produced by the foundation network. Again, a conceptual model of system behavior, response, and factors affecting responses can be important. Working from a common conceptual model framework as programs leverage one another will help direct alignment in a manner that provides mutual benefits through coordinating gap filling needs in a shared monitoring network.

Three themes were highlighted in the workshop as approaches to consider for leveraging existing monitoring network resources. The first theme was to focus on visualizing approaches where information gathered under one monitoring program might serve to address cross-program objectives. One example provided in this workshop was to consider expanding the use of aerial imagery resources acquired and analyzed during VIMS' annual SAV assessments. Specifically, the potential was discussed for using the aerial photo collection for deriving a method that helps track wetland change or creating a higher temporal resolution data set that tracks status of, and changes in, shoreline hardening. By combining diverse programming objectives under one umbrella the overall costs of administering multiple programs information needs may be reduced. Such work recognizes the potential co-benefits across programs with different objectives working in the same areas and cost benefits of joining efforts. A second suggested theme was to focus on visualizing approaches where one indicator may serve multiple objectives that foster alignment between monitoring programs. Shoreline hardening, for example, has been correlated with habitat health for water bird habitat, fish habitat, fish forage and bay grasses (see Jordan 2016 STAC presentation). Therefore, unifying support where possible across programs for addressing status and progress assessments of Bay Agreement outcomes was considered a means to help align monitoring program efforts and resources. Finally, a third theme suggested a focus on evaluating disparate programs for operational data collection redundancies. If there are redundant locations for the same data collections in separate monitoring programs, consider the value of two or more programs collecting these same data. An analysis of the messages resulting from the assessment of data from two or more co-located monitoring efforts is recommended to determine the inherent value of investments. If an analysis of work from two programs yields the same status and trend results, resources might be realigned in one program while encouraging data sharing between programs. However, if the data analyses yield contradictory findings, then investing in a deeper assessment of the data and the monitoring programs to understand the differences is more prudent than reducing monitoring at the site.

Solution 2. Synthesize and communicate monitoring results to diverse stakeholders to overcome 1) communication gaps and 2) create awareness of the work of other groups and complementary needs to understand the impact of their individual and collective work.

- **Address syntheses across a gradient of communication needs recognizing the range of audiences in need of the information generated from monitoring programs. Messaging includes public friendly issue overviews to data intensive, highly technical, and management or policy-oriented support products.**
- **Establish a living monitoring inventory. Include who is monitoring, what they are monitoring, where and when they monitor, and importantly document why they are monitoring.**
- **Data/database management provides greater opportunities for supporting synthetic products across diverse scales and geographies of interest within the CBP partnership.**

In order to effectively continue to use the place-based approach to further integrating monitoring efforts across the CBP partnership, participants called for the creation of a monitoring inventory. The inventory would be the "who's-who" of monitoring: what groups exist, what work is being done, how the work is being done, what data is being collected, and where are the data and meta-data are housed. Two such inventories are currently under development and highlighted in this workshop. The first is through the MWMC. Monitoring sites are mapped across Maryland in a web accessible mapping tool (http://dnr2.maryland.gov/streams/Pages/MWMC/roundtable.aspx) and forms of this mapping tool have been available as it has evolved. However, an updated, interactive map tool was demonstrated in its draft form at the 2016 MWMC Monitoring Roundtable. The mapping tool is now accessible and available through the following website link: http://dnr2.maryland.gov/streams/Pages/MWMC/mapper.aspx. When the interactive map is displayed on the screen, clicking on a monitoring site will identify what is being collected there, by whom, and contact information about the data owner. The second such effort is a Chesapeake Bay watershed-wide inventory being developed by the CMC. In 2009, the CBP

Monitoring Realignment Process documented nearly 300 programs involved with water quality, fisheries, or aquatic habitat monitoring (MRAT 2009). The new CMC watershed-wide inventory effort is building off the MRAT 2009 documented list. The CMC is evaluating programs' data and data collection procedures, assessing data integrity, and building a more robust regional monitoring inventory. The CMC report will be available in 2017.

Suggestions were mixed regarding data and data management to facilitate the closing of communication gaps. Participants generally agreed that finding useful data for addressing management questions often means exploring and investigating many disparate databases containing data of unknown quality and integrity. One suggestion was to build a "one-stop shopping" single database to access environmental data. Another suggestion was to develop a data warehouse group to facilitate data search and consolidation needs of the CBP partnership. The CBP's Chesapeake Information Management System (CIMS) network is a data warehouse for a subsegment of all the Bay environmental data. CIMS continues adapting and growing to accept new data streams, however, it is far from "one-stop shopping" for a wide range of data that CBP partners may be interested in for their analyses. Nationally, the EPA Storage and Retrieval Data Warehouse (STORET) has been a data resource for diverse, mostly water quality related environmental data. More recently, the National Water Quality Monitoring Council (NWQMC) has supported a virtual data warehouse known as the Water Quality Portal (WQP). The WQP integrates publicly available water quality data, through use of the Water Quality eXchange (WQX), from the USGS National Water Information System (NWIS), STORET, and USDA-ARS Sustaining the Earth's Watersheds, Agricultural Research Data System (STEWARDS). To address access to an even broader variety of data and datasets that can be used in assessments to support decision-making scenario analyses, a big data approach (e.g., IBM Watson for supporting the health and other fields, see (http://www.ibm.com/smarterplanet/us/en/ibmwatson/health/)) may help address increasingly complex management questions.

Access to and analysis of broader forms of data support the CBP partnership's efforts to tell more complete management and recovery response stories. Telling more complete stories was considered important to fostering better communication throughout the partnership at all levels. Synthesis projects that focus on clear messaging are considered highly desirable. Specific examples include the development of publications on SAV under Technical Synthesis I, II (Batiuk et al. 1992, 2000) and now the nearly complete, SAV Technical Synthesis III. The synthesis process is an important tool for continuing to involve more partners in contributing to a common understanding of stressor-response patterns and trends in the Bay ecosystem. This shared understanding supports effective communication of our management and restoration challenges and successes (Figure 5).

Figure 5. Conceptual model of product development that balances data intensity with complexity of the story lines when addressing communication needs of diverse stakeholders.

However, the challenge to developing such informative scientific syntheses is twofold. First, workshop participants highlighted the challenge in finding partners that are willing to make the issue of communication and messaging a priority. There is an ongoing need and appreciation for greater visualization of science that effectively communicates the messages. Most agencies have the support of communications teams. For example, the EPA CBP Office (CBPO) has a Communications Office that has routinely published a status and trends document on Bay management and health known as the Bay Barometer. The CBPO Communications Office also engages the public through many other forms of information sharing via diverse social media outlets. Additionally, the University of Maryland's Center for Environmental Science (UMCES) Integration and Application Network (IAN) (http://ian.umces.edu/ecocheck/) represents a group that works at the cutting edge of enhancing the communication experience in messaging science and management themes and issues. Second, there are often limited resources available to invest in communications support. Resource limitations present funding issues; funding challenges were our third highest priority barrier in the workshop discussions.

Solution 3. Create strategic consortia to prioritize funding based on a common vision

- **Diversify sources of funding**
- **Realign existing resources**
- **Budget for integration (e.g., Chesapeake Bay Submerged Aquatic Vegetation Syntheses)**
- **Improve access to funding to support integration and communication needs of the collective partnership.**

Workshop participants highlighted economic pressures as a barrier to program integration efforts. Even sustained funding is subject to reduced buying power due to near constant inflationary pressures. However, participants considered solutions to addressing funding challenges and reviewed funding sources and distributions (Figure 6).

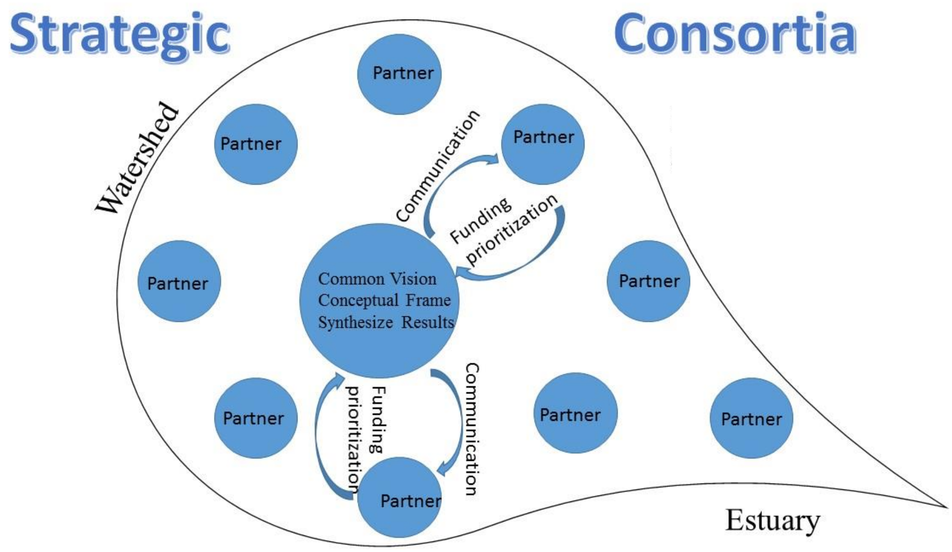

Figure 6. Visualizing the development of strategic consortia to enhance monitoring collaboration and integration.

Three suggestions for overcoming funding needs with monitoring program integration were: 1) diversify funding sources for each monitoring program, 2) realign existing resources to address priorities, and 3) include a budget line item to support monitoring integration. In the first case, diversifying funding is viewed as an approach that provides mutual benefits to all data users while reducing the burden and associated risk of a single-funder support approach. Alternatively, the CBP partnership has effectively employed the approach of strategically realigning existing resources to support management community priorities. The 2009 Monitoring Realignment (MRAT 2009) involved a two year evaluation of the CBP partnership's long-term water tidal and non-tidal quality monitoring. The CBP community used the process to examine the ability of the water quality monitoring network to guide a rebalancing of program funding. The rebalancing of funding targeted managers' needs for essential monitoring of water quality standards in the Bay while expanding spatial resolution for monitoring nutrients and sediments throughout the watershed. Earlier CBP partnership examples of resource realignment include the cessation of a zooplankton monitoring program and re-investment in nearshore, shallow water monitoring in the mid-2000s. Additionally, by combining diverse programming objectives under one program the overall costs of administering the information needs of multiple programs may be reduced. The example provided in this workshop was to consider expanding the use of the extensive aerial imagery used in VIMS' annual SAV assessment. The aerial image time series is a rich dataset that supports SAV assessment but may also be used to track other key indicators of bay health like changes in wetland acres or shoreline hardening. Such work recognizes the potential co-benefits of working across programs with different needs while realizing the cost saving benefits of joining efforts to extract more information out of existing data collection investments. Lastly, beginning in 2015, the EPA CBPO made a competitive pool of funding available to the CBP partnership's GITs to foster program work that 1) targets integration, 2) supports information needs that support adaptive management, and 3) simultaneously considers information needs that address decision-support for multiple Bay Agreement outcomes. This funding pool is competed annually contingent upon availability. However, as benefits accrue, the value of the investments represent an opportunity for agencies and institutions to apply for funding that supports enhancing integration across monitoring program efforts.

Solution 4. Conduct decision-oriented, place-based, interactive workshops

- **The combined efforts of CBP-STAC and STAR can continue to provide venues for the tributary and regional scale networking necessary to support solution oriented monitoring program integration.**
- **Develop a workshop rotation to other watershed locations through STAR-GIT discussions. Mutually define objectives, data and sampling needs, to support their goal and outcome assessments and tracking indicators.**
- **Preplanning should once again use homework and collaboration for work maps to prepare for supporting effective workshop that focus participants on network integration opportunities.**

The place-based workshop approach was viewed as important model for networking and discovery about who is active and doing what type of monitoring work in a particular region (Figure 7). These efforts bring together diverse monitoring programs where assets were mapped, program objectives were shared and discussed, and break out groups evaluated the potential for collaboration on new monitoring efforts or expanding existing data collection activities. Along with collecting objectives of each program represented in the workshop, pre-workshop contributions that produced monitoring location maps for the break-out group collaborations were recommended for continued use to prepare for effective workshops focusing the participants on network integration opportunities.

Future workshops will continue to create opportunities for extending collaborations. GITs, working through STAR, have identified information gaps and data needs that direct partners toward understanding additional needs for monitoring support. Working with STAR provides the GITs the opportunity to help set the agenda and prioritize watershed regions to target further workshop collaborations.

Figure 7. Interactive workshop networking facilitated by using an effective mapping exercise showing monitoring activities for diverse groups in a region.

Findings and Recommendations

1. Summary of Findings

Many barriers were recognized by the workshop participants as limiting factors to more integration across disparate monitoring programs. The top three barriers recognized were 1) misaligned objectives between programs, 2) communication gaps among many partners working in the same region that could lead to better opportunities for collaborations, and 3) limited funding resources.

- Creating successful 'networks of networks' hinges on a variety of factors. Key factors included:
    - Minimizing the differences in monitoring protocols to support consistent assessments and basis for analyses when forming regional monitoring networks from previously disparate networks, and
    - Sampling plan details that affect time to trend detection were noted:
        - With climate change effects as the example reviewed during this workshop, it was noted that there is a trade-off such that a once-in-5-years

sampling program tends to double the time to trend detection for the same trends as compared to an annual assessment program on the same parameter.

        - The application of high temporal density monitoring, aka continuous monitoring, is very desirable for detecting change over time, e.g., temperature sensors.

- Promoting integrated monitoring across programs to support diverse but interrelated assessments at restoration sites (e.g., Harris Creek Oyster Restoration site) was viewed as beneficial to filling gaps in information needs that help tell a more complete management story. By better accounting for factors affecting change in the ecosystem, the story lines can be improved. Greater integration can promote analyses that support a better understanding the land to water ecosystem linkages, upstream and downstream influences, and bay effects on the success of the restoration effort at a site.
- The workshop highlighted additional capacities that are available to potentially support gap-filling monitoring needs with water quality assessments. Gap-filling capacities were identified with key examples that included:
    - U.S. EPA Laboratory at Ft. Meade, MD (i.e., present or growing capacity for assessments of novel toxic compounds, endocrine disrupting compounds, microplastics and more),
    - Region 3 U.S. EPA is working on some R computer code packages to help map high temporal density (i.e., continuous) water quality monitoring data sets that are becoming increasingly common, and
    - Citizen science is widespread and a major force in support of diverse data collection efforts. Highlighted at this workshop was the Mid-Shore Riverkeepers – a group of citizen scientists doing substantive, high quality work at greater spatial resolution along the Choptank River system than the CBP's long-term water quality monitoring program. Protocols appear to differ but alignment of methods could be discussed to help support better assessments at the local scale and could further be used in regulatory settings. There is interest across our communities to collaborate on a variety of monitoring needs.
- Science that supports better understanding to direct decision-support on appropriate management actions is needed at many scales.

2. Summary of Recommendations

The CBP should expand its toolbox where it can remove barriers to monitoring network integration. This report addresses approaches for support of 1) aligning objectives between previously disparate programs, 2) overcoming communication gaps, and 3) methods and considerations to address funding limitations. Furthermore, workshop participants recommended

4) creating an effective process that promotes opportunities for the removal of barriers to monitoring program integration.

Solutions to Removing Barriers and Improve Monitoring Network Integration are:

- Aligning objectives.
    - Defining a common vision supports a clear path forward toward decisions on program integration. Creating a conceptual model for the issue, and declaring the boundaries of the system of interest illuminates gaps in our understanding. The collaborations that work to address gaps can focus on helping collect data that supports analyses that removes unknowns, reduces uncertainty, and can tell a more complete management and recovery response story.
    - Sampling needs should be effectively documented and highlighted during the pre-planning phase of workshops to facilitate networking in and beyond the workshop.
    - Using tributary scale face-to-face workshops with maps of participant's active monitoring networks generates awareness of program capacities and elevates discussion towards leveraging resources through aligning complementary monitoring efforts.
        i. Participants suggested meetings be organized around common themes to facilitate progress on developing collaborations and furthering program integration in the workshop (e.g., water quality, stream health).
- Synthesize and communicate monitoring results to diverse stakeholders to overcome communication gaps.
    - Establish a living environmental monitoring inventory. Include who is monitoring, what they are monitoring, where and when they monitor, and importantly, document the objectives behind why they are monitoring.
    - Enhance data/database management to provide greater opportunities for supporting the development of synthetic products across diverse scales and geographies of interest within the CBP partnership.
    - Address syntheses at different information-delivery scales across a gradient of communication needs. Recognize the range of audiences in need of the information generated from monitoring programs. Messaging needs range from a summary that takes the form of 1-3 bulleted messages for a citizen to use in engaging a government official to the more data intensive, highly technical and management or policy-oriented support reports and journal articles.
- Organize strategic consortia to prioritize monitoring funding and effort based on a common vision.
    - Use a conceptual model to organize partners and their work.
    - The CBP should continue to foster the integration of citizen science activities into delivering data supporting the collective information needs of the partnership.

Feedbacks to the citizen science community on the use and utility of their data is an important element of the data sharing process.
    - Diversify funding sources.
    - Realign existing funding resources when conditions suggest the need to do so.
    - Budget for integration of monitoring programming exercises that support decisions to modify one or more established programs (e.g., SAV Technical Syntheses I, II, and III).
- Apply decision-oriented, place-based interactive workshops.
    - The combined efforts of CBP-STAC and STAR can continue to provide venues for the tributary and regional scale networking necessary to support solution oriented monitoring program integration.
    - Develop a workshop rotation to other locations prioritized through STAR-GIT discussions. Use the discussions to highlight objectives, outline data and sampling needs, and apply the workshop findings to help support status and tracking of progress on achieving Bay Agreement goals and outcomes.

3. Further CBP programmatic recommendations:

- The workshop participants provided an initial set of suggestions for specific collaborations the CBP can pursue that support gap-filling monitoring needs and address resource limitations in the near term:
    - Enhance bay grass species assessments across the tidal water of the Chesapeake Bay and its tributaries through an expanded coordination of riverkeeper activities.
    - Leverage citizen science activities to support the additional bay grass species assessment needs. Coordinate the field sampling work of the citizen scientists with opportunities to pilot a fish forage sampling program in the nearshore waters of the tidal Bay. Assessment of nearshore fish forage sample results are viewed as important to the CBP partnership in providing guidance on future fish forage management.
    - Communicate with the Mid-Shore Riverkeeper Conservancy and others about aligning water quality sampling designs for dissolved oxygen data collections with the regulatory water quality assessment needs of the States in their Clean Water Act 303d listing assessments. The riverkeepers have a strong sampling program and complementary work would provide more robust local understanding for the Choptank River and coincidentally support greater temporal and spatial resolution in the State of Maryland regulatory water quality assessments.
- The CBP should continue to support STAR and its workgroups (e.g., Integrated Monitoring Networks Workgroup) in organizing networking and discovery workshops that promote monitoring network collaborations.

- CBP workgroups should continue to use a geographic-based approach to move around the watershed with monitoring network building activities.
- CBP workgroups should consider a sufficiently long planning horizon that allows for pre-workshop meetings of small groups focusing on specific collaborations, then build upon the small group meetings for a region-scale collaborative activity at similar workshops. Pre-workshop homework activities were deemed essential to strong outcomes at the workshop.

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Appendix A: Workshop Agenda

Integrating and Leveraging Monitoring Networks to Support the Assessment of Outcomes in the New Bay Agreement

Scientific and Technical Advisory Committee (STAC) Workshop

April 12-13, 2016

Aquaculture and Restoration Ecology Laboratory

UMCES Horn Point Laboratory, 2020 Horns Point Rd. Cambridge, MD. 21613

http://www.chesapeake.org/stac/workshop.php?activity_id=259

Workshop Objective: Better integrating and leveraging existing monitoring networks is one approach to help address outcomes in the new Bay Agreement. Currently, the majority of the CBP monitoring is focused on water-quality but other monitoring exists for selected living resources and habitats. Discussing integrated monitoring across the Bay watershed would be a huge task, so the workshop will focus on the Choptank River, as a microcosm for the Bay system. Even with the focus on the Choptank, we will still discuss implications for applying new ideas to the Bay and its watershed. We are focusing on several inter-related outcomes to explore if existing monitoring can be better integrated. The primary outcomes include: oysters, fish habitat, forage fish, SAV, water quality (both in the watershed and tidal waters), stream health, and toxic contaminants. The meeting will focus on the barriers and opportunities to integrating the existing monitoring networks related to these outcomes. Some of major items to explore include:

- Supporting adaptive management (including use of models and indicators)
- Aligning monitoring program objectives,
- Modifying network designs,
- Assessing compatibility of sampling and analytical techniques.

After the barriers to these items are identified, the workshop will focus on opportunities to better integrate monitoring with discussion including 1) adding measures to existing stations, 2) bringing in other monitoring partners or citizen scientists, and/or 3) more efficiency monitoring. The results will be summarized in a report on how to better integrate monitoring in the Choptank system and implications for entire Bay and watershed.

Day 1: April 12, 2016

9:30 AM	Coffee
10:00 AM	Welcome & Introductions
10:10 AM	Introduction to the Workshop (*Peter Tango, USGS-CBPO*)

Session 1: Overview of Existing Monitoring Networks in the Choptank River Basin related to Chesapeake Bay Agreement outcomes (oysters, fish habitat, forage fish, SAV, water quality (both in the watershed and tidal waters), stream health, and toxic contaminants. (Moderator: Peter Tango)

10:30 AM Plenary: Water Quality (*Tom Fisher, UMCES-HPL*)

11:15 AM Beyond Nutrients: Factors important for understanding, measuring, and tracking non-tidal stream biological condition (*Scott Stranko, MD DNR*)
Based on lessons learned from the Maryland Biological Stream Survey, indicators used to assess stream biological condition in Maryland will be discussed, as well as important stressors and efforts to track trends.

11:35 AM SAV in the Bay – Going Beyond the "What" to the "Why" (*Bob Orth and Ken Moore, VIMS*)
SAV in the Bay and tributaries has been monitored annually since 1984, producing one of the most extensive SAV data sets in the world, and resulting in numerous publications in the scientific literature. SAV is one of the key resources being used by the Bay Program in their assessment of improving conditions in the Bay and SAV restoration targets are now part of Virginia and Maryland's water quality standards. In addition, many NGO's and federal and state agencies utilize these data in everyday management decisions, e.g. aquaculture leases, dredging projects, etc. Here, we demonstrate through the integration of intensive habitat and environmental monitoring and basic research the drivers of change for SAV in one particular region that has implications for not only the Choptank River but the entire Chesapeake.

11:55 AM Fisheries (*Bruce Vogt, NOAA*)

12:15 PM **Lunch (provided)**

1:00 PM Toxic Contaminants – MDE Fish Tissue Monitoring Program (*Charlie Poukish and Matthew Stover, MDE*)

1:15 PM EPA Ft. Meade Laboratory Capacities and Opportunities (*Jennifer Gundersen, USEPA*)

1:35 PM Review: Summary and mapping of monitoring (*Bill Dennison, UMCES-HPL*)

2:00 PM Break

Session 2: Barriers to integration of these networks and initial solutions to overcome barriers. Prioritize and discuss the types of barriers to better monitoring integration to include: Different protocols, Unaware of other groups are doing, Instrumentation limits, Overcoming vested interest, "This is how we always do it", Lack of alignment of objectives (Moderator: Bill Dennison)

2:30 PM 'Conceptionary' Activity

3:00 PM Report Out of Conceptionary Drawings

3:30 PM Break

3:45 PM Brainstorming of Solutions to Barriers

4:15 PM Report Out

4:45 PM Wrap Up Discussion (All)

5:00 PM **Dinner & Social Hour (provided and encouraged)**

Day 2: April 13, 2016

8:30 AM **Light breakfast (provided)**

Session 3: Opportunities and Solutions to Better Integrating Networks (Moderators: Peter Tango and Mindy Ehrich)

9:00 AM Recap Day 1, Intro to Day 2.

9:15 AM Plenary: Developing Regional Networks: Regional Monitoring Networks to Detect Climate Change in Streams (*Britta Bierwagen, USEPA*)

9:45 AM Creating a more integrated monitoring program: Overview for break out session (*Peter Tango, USGS-CBPO and Mindy Ehrich, UMCES*)
Mindy will provide an overview the status of indicators and monitoring pertaining to the outcomes discussed at the workshop. Peter will review the recommendations from the Building Environmental Intelligence Report on how to enhance water-quality monitoring, which can be a foundation to enhance monitoring for other outcomes.

10:00 AM Opportunities for a more integrated monitoring program (break out groups)
The groups can use the Choptank as an example but should focus on developing recommendations and implications for Bay and watershed-wide applications. Questions to be addressed include:

- What is your vision of what is needed to for a more integrated monitoring program to gather information to address multiple outcomes?
- Where can we combine efforts?
- Can we increase spatial and temporal resolution?
- Where would additional parameters be feasible?
- Short-term and long-term next steps

➢ Break out to discuss answers to these questions
➢ Report out

11:50 AM Action Items and Wrap Up

12:00 PM **Lunch (provided) and adjourn**

Appendix B: Indicator Needs at CBP, March 2017 Update

Indicators in Good Standing	Indicator in Development	Research in Progress	Indicator in Refinement	No Indicator
• Blue Crab Abundance & Management • Oyster • Wetlands Restored on Agricultural Lands • Fish Passage • SAV • Forest Buffer • 2017 Watershed Implementation Plans (WIPs) • 2025 WIPs • Water Quality Standards Attainment • Diversity • Protected Lands • Public Access • Sustainable Schools	• Environmental Literacy Planning • Student MWEEs • Citizen Stewardship • Tree Canopy	• Forage Fish • Toxic Contaminants Policy and Prevention • Healthy Watersheds • Local Leadership • Climate Resiliency	• Black Duck • Brook Trout • Stream Health	• Fish Habitat • Toxic Contaminants Research • Land Use Methods and Metrics Development • Land Use Options

Source: Laura Free, CBP Status and Trends Workgroup Coordinator, March 2017.

Appendix C: Workshop Participants

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Appendix D: Presentation Summaries Available

Editor's Note: The following summaries were provided by the presenters, and are not comprehensive of all presentations given at the workshop. Copies of each presentation and additional information can be found here.

Beyond Nutrients: Factors important for understanding, measuring, and tracking non-tidal stream biological condition (*Scott Stranko, MD DNR*)

Nutrients are important in determining the health of Chesapeake Bay. Excess nutrients inputs contribute to low dissolved oxygen "dead zones" in Chesapeake Bay. Although there is some evidence that excess nutrients can influence the ecology of non-tidal streams (Rosemond et al. 2015), nutrients tend to not be the predominant stressors to most non-tidal streams in the Chesapeake Bay watershed. The biological condition of streams is influenced by many factors. Hydrologic, geomorphic, physical, and chemical conditions must all be suitable for a stream to support a healthy, diverse ecosystem (Harman et al. 2012).

Examples of some of the most pervasive stressors to stream ecosystems include physical habitat alteration, temperature, acidity, invasive species, and fragmentation. Stream water quality is also potentially affected by other parameters that could be important for biota. Recent evidence suggests that the effects of chloride and conductivity could potentially be important (Morgan et al. 2012) and low concentrations of certain endocrine disrupting compounds may have pervasive effects, such as alterations to the reproductive organs of some fish species (Blazer et al. 2012). However, additional research is needed to better determine and quantify effects these factors may have.

There are several state and federal policies and regulations that focus on stream biological condition. Examples include Maryland's Use Class III (reproducing trout) waters and High Quality (Tier II) waters based on biological diversity of fish and benthic macroinvertebrates. Additionally, Executive Order 13508 called for fewer stream blockages to fish passage, more forested buffers, brook trout restoration, and improved stream health. The existence of these policies and regulations indicates a societal desire for the protection and restoration of healthy stream ecosystems.

In addition to site-specific fish and benthic macroinvertebrate community data that are commonly used to generate indices of biotic integrity, the distribution and abundance of certain stream dwelling species can be an important indicator of stream biological diversity. For example, based on the percentage of species listed as rare, threatened, endangered, or extirpated –stream dwelling animals tend to be the most imperiled taxa in the United States (Master et al. 1998). This includes nearly 67% of freshwater mussel, more than half of crayfish, and 37% of freshwater fish species.

Data from the Maryland Department of Natural Resources, Maryland Biological Stream Survey (MBSS) have been used to document and track stream ecological health and biological diversity since 1995. The MBSS has assessed statewide stream conditions three times over this period and initiated a fourth round of assessment during 2014. The fourth round is focused on comparing site assessments conducted 20 and 14 years ago to provide the best information for evaluating change over these time intervals. Along with round four sampling, MBSS will also continue to sample high quality Sentinel Sites. These sites have been sampled since 2000 and represent some of the least impacted streams remaining in Maryland. Data from these sites will help with temporal trend assessments by assessing influences from factors like weather and climate.

Through MBSS sampling and Stream Waders (the volunteer component of the MBSS), much data have been collected to help assess the condition of streams in the Choptank River Basin. Additionally, there is a Sentinel Site in the Choptank Basin, as well as five long-term benthic macroinvertebrate monitoring sites. Information from these sites can be acquired by contacting the Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division (http://dnr2.maryland.gov/streams/Pages/dataRequest.aspx). MBSS stream health assessments can also be found on an interactive map via the streamhealth web site (www.streamhealth.maryland.gov).

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Toxic Contaminants – MDE Fish Tissue Monitoring Program (*Charlie Poukish and Matthew Stover, MDE*)

Maryland routinely collects and analyzes fish tissue from waters of the state to determine the concentration of various contaminants, including methyl mercury, PCB’s and pesticides. The results generate fish tissue consumption advisories to protect public health and also support listing impaired waters on the 303(d) List. Since 1977 the Core Fish Tissue Monitoring network has expanded to 60 sites. More recently, special PCB source tracking investigations have been initiated using caged clam tissue (*Corbicula fluminea*) to support Total Maximum Daily Load (TMDL) development and TMDL implementation.

EPA Ft. Meade Laboratory Capacities and Opportunities (*Jennifer Gundersen, USEPA*)

The EPA Region 3 lab at Fort Meade is accredited under the National Environmental Laboratory Accreditation Program (NELAP) and supports EPA activities in Region 3 (Maryland, Virginia, DC, West Virginia, Delaware and Pennsylvania). The lab conducts organic and inorganic analyses including SDWA drinking water, NPDES wastewater, Superfund CLP equivalent methods, TCLP, RCRA solid waste, and RCRA hazardous waste characteristics. Other capabilities include grain size analysis, nutrients, TOC, and BOD. The microbiology section runs total coliforms, fecal coliforms, *E. coli*, heterotrophic bacteria as well as molecular detection of bacterial DNA (PCR) for microbial source tracking in drinking water, waste water, and ground water.

If you are interested in possible collaborations with the lab, please contact the Lab Branch Chief, Karen Costa at Costa.Karen@epa.gov.