Joint Monitoring Meeting of the
Science & Technical Advisory Committee (STAC)
& Monitoring Advisory Committee (MAC)

March 5, 2014

Heinz Tinicum National Wildlife Refuge

8601 Lindbergh Blvd., Philadelphia, PA 19153

Workshop Outcomes

1. The STAC/MAC will have an annual joint meeting focused on monitoring and indicators
    a. Action approved by the EIC on 3/16/14
2. Action & Needs from the 2012 TREB report (Appendix C) were reviewed to help identify monitoring gaps
3. The group discussed and ranked monitoring priorities for Living Resources, Habitats, Water Quality, and Water Quantity. Results appear in Appendix B.
4. Subsequent to the meeting, Coral Collier (Exec. Director of DRBC) issued a letter to McDermott (Exec. Director at the Philadelphia Regional Port Authority) to protest the Port Authority's withdraw of funding for the NOAA PORTS system in the Delaware Estuary (See Appendix A).

Attendance

Name	Organization	Name	Organization
Angela Padeletti	PDE	Ken Strait	PSEG
Bob Schuster	NJDEP	Lance Butler	PWD
Dave Wolanski	DNREC	Megan Mackey	EPA R3
Des Kahn		Moses Katkowsky	TNC
Erik Silldorff	DRBC	Priscilla Cole	PDE
Fred Stine	Del. Riverkeeper Net.	Renee Searfoss	EPA R3
Gregory Breese	USFWS	Ron MacGillivray	DRBC
Jacob Gibs	USGS - RET	Stefanie Kroll	ANS
John Jackson	Stroud	Thomas Fikslin	DRBC
John Yagecic	DRBC		

Welcome & Introductions

- Welcome : Danielle Kreeger (PDE)
- Welcome: Gary Stalson (Director of Refuge)

- New USFWS project is Urban Initiative to get urban city children connected to environment. In final competition for $1million/yr grant Urban Initiative. They are looking for new partners/audiences and new ideas, out of the box.
- Events at Refuge: Saturday 20th of September Festival
  Earth Day - Saturday April 26th
  Friday April 25th- Telescopes on board walk with Science Festival

Orientation to Monitoring Gaps - *Danielle Kreeger, PDE*

See Powerpoint on Goals, Indicators and Monitoring at PDE - History

- Environmental Management System- As a NEP, PDE has a CCMP (1996). There are a variety of actions and needs. PDE's main goal is to implement the CCMP. PDE has updated the CCMP with a new Strategic Plan. PDE has also worked with the EIC and STAC to inventory what actions in the CCMP have been completed, what is still relevant, and what is not relevant. Currently working on a method and process for periodically updating the CCMP via web tools. PDE has also worked with the STAC and EIC to formulate Measureable Goals for the Estuary. Two years were spent developing these goals, now completed. All goals have been adopted by Steering Committee for the Delaware Estuary Program, which includes all partners, not just PDE. The next step is to develop a plan to roll out the goals, and to think of strategies to implement them.
- Question: For the purpose of this STAC-MAC workshop, are we updating sections of the CCMP devoted to monitoring?
  - Goal for today is not to update monitoring of CCMP, but today feeds into it.
- In 2008, the State of the Estuary Report had indicators, but the STAC/MAC worked after that report to develop better indicators, the next gen wish list. From this list of ideal indicators, many were subsequently chosen and used for the 2012 State of the Estuary Report/TREB. The 2012 SOE was the best to date with 50 indicators. Importantly, the TREB also had actions and needs per indicator, and any actions related to monitoring should be discussed today. Of those, what would we prioritize for future monitoring coordination/implementation?
- Besides TREB, we also take inspiration for monitoring coordination from the National Water Quality Monitoring Network Pilot Study. This was developed in 2007-2008, led by DRBC. This intended to connect USGS-type watershed monitoring systems to NOAA-type ocean observing systems, and also intended to connect main channel monitoring to enhancements in flanks (e.g. wetlands, reefs, tributaries). Many partners were involved in the report. This was branded the Delaware Estuary Watershed to Ocean Observing System (DEWOOS). There were "gap analysis" tables in the report that differentiated what is currently monitored and what would need to be added or enhanced o reach the DEWOOS vision. Little funding directly resulted from the reporting effort, and DEWOOS remains a concept. But many subsequent programs resulted from the overall design. For example,

PDE pulled out the wetlands module, wrote proposals with partners, and started the Mid-Atlantic Coastal Wetlands Assessment Program, MACWA. There was also a small amount of money that went to supplement the boat run monitoring.

- Recently solid progress on goal-setting and indicator reporting has been accomplished. But integrated monitoring coordination has not really been a focus at PDE since the DEWOOS report was completed in 2008. There are some new groups interested in facilitating broader monitoring, such as the William Penn Foundation. While we don't intend to update the DEWOOS vision currently, we should continue to work together to at least communicate what elements are being worked on, avoid any redundancy, and help each other prioritize and collaborate to grow out the concept while also addressing emerging needs.
- <u>The Goals for Today</u>; To answer the following questions:
  - Can the STAC and MAC review TREB actions/needs, the DEWOOS vision, and any recent developments to set some priorities that the various Estuary Program partners can work together to address in the next several years?
  - What examples of monitoring coordination and niche-filling have occurred in the past 1-5 years, subsequent to the DEWOOS report?
  - What monitoring needs are currently of highest priority?
- This could be a year-long process and we might want to meet again periodically. But we can hopefully make a start today and lay the foundation for more regular monitoring coordination between the STAC, MAC, and any other groups seeking similar outcomes.
- <u>Discussion by All</u>: There are many reasons for monitoring besides simply supporting status and trends tracking; for example, there are regulatory programs where monitoring is required. There are commitments for various programs for monitoring not just indicators. We need to think of "monitoring" on a broader view.
  - Also need to think about opportunities to collect diverse types of samples for different entities/purposes while in the field, for instance. Monitoring coordination happens both here and at the project level.
- Des, others: This is a large order to fill to get toward system-wide monitoring coordination. First, we should list what is being monitored for regulatory needs, and then add a layer on top for what indicators are needed for TREB and general science inquiry.

  Action: Get Des the DEWOOS and DEBI reports; put online
- Moving from monitoring to indicators needs more analysis. With some seed money this could be better defined. Both methods and interpretation could benefit from this analysis. Historically this is a weak link. A goal could be to strengthen this link. Let's challenge ourselves to not limit to the current climate of funding constraints. Let's gather around priorities to push them to the top.
  - We could use our analysis resources more within the STAC and MAC instead of outside.

        - William Penn with ANSD is trying to establish a research wiki-page to link a learning community together to match data with analysis services, etc.
        - How do we chase down other programs that collect data? Data access issues and data comparability, data sharing restrictions, management. No funding to maintain the data available.
    - Lance: the regulatory community is required to monitor and there are loads of data. The data are only used to report to regulators. PWD doesn't have resources to analyze, and its data doesn't go into STORET. It's all digitized and QAQC'd.
    - DRBC does 305b assessment each year. This year data came from national data (STORET and WQX). You can now pull data in one shot. DRBC puts data into STORET and WQX. It's not perfect but it's better than before. But biological data does not fit well.
    - The PDE Information Gateway was one earlier idea to gather and maintain data, similar to what the Chesapeake does, but we had no funding to maintain the database. Similarly DuPont funded a geospatial Delaware River Database with URS, but PDE was unable to take over maintenance due to funding.

State of the Monitoring – update from the MAC - *John Yagecic, DRBC*

See Powerpoint by John Y.

- MAC meetings usually discuss project by project such as station location and parameters and such. Today, we want to think on a higher level thinking. Want to think about estuary health, natural gas and effective monitoring coordination.
- New resolution in June for MAC which will include that the MAC supports PDE/STAC, and emphasize coordination role of the MAC and update membership.
    - MAC serves both DRBC as well as PDE, now as well as historically
- Estuary Heath
    - Multiple drivers converging on DO and nutrients (nutrient criteria development plan, river keeper petition, WQAC resolution, and STAC DO brief)
    - What does a healthy estuary mean exactly? What monitoring needs to be added? Follow up studies such as Copper, PAHs, ambient toxicity and emerging contaminants.
- Natural Gas Monitoring-currently work is on baseline monitoring (conductivity, biological, radiochemistry, mayfly). If NG development commences an expanded monitoring effort is needed. This would include larger in scale, real-time, plus add groundwater component. Such as USGS real-time monitoring where you can set limits and get alerted when that is breached.
    - STAC did a brief on natural gas. One of the top questions in that was what is the cumulative impact on forest fragmentation, water budget, ect.
- Is DRBC thinking larger? If they cannot is that a niche that still needs to be filled? MAC does not always look at the larger picture but the WQAC looks more at the view. DRBC with William

Penn is looking at headwaters and other data, and if a facility was located at a specific spot how would it affect other areas. Bill Lellis is involved in the fragmentation type of issue from USGS.
    - What do we have to do? Then what should we add on top. Then funnel resources at those. But also collaboration between agencies and partners.
    - It all boils down to priorities. There are more questions than there is funding, and smart investment is partnering with required monitoring to collect data or perform analysis to address the larger questions.
    - Ports are changing with shifts in oil and gas production and waste water disposal industry development. We need to be aware of these shifts to predict new impacts.
- Monitoring coordination – What is the MAC's role? Competing visions?
    - COOPERATIVE MONITORING – is the future of DRBC and the MAC
    - The Fish & Wildlife Coop is a good model – rather than getting funding, they asked partner organizations to dedicate people-time of experts to participate.
    - Other partnerships with EPA, USGS, adding metrics to the boat run, supporting PWD dye studies, partner on radiochemistry monitoring, RARE monitoring, marsh coring

Stephanie from ANSD – working with William Penn Foundation

- Delaware Watershed Conservation Program
    - First step – prioritize where to do conservation work which lead to the clusters
    - Outreach, monitoring, restoration, preservation
    - Focused on measurable results – did you implement project, is it helping larger goal?
    - Collecting data to answer long-term questions
    - Fish, chemistry, geomorphology, etc - relating to landscape characteristics
- Doing first report for William Penn
    - Getting groups together to work together to improve water quality and conservation
    - There are 5-8 organizations within each cluster
    - working to standardize monitoring across the clusters
    - Larger research and learning community is being fostered
    - Participating in communications strategy
- Temporary storage of data & GIS being hosted at ANS – data publically available
    - do we need a data-portal?
    - look at other great American watersheds for examples
    - USGS real time data is highly used by recreational users
    - similar discussions in other groups, but the key is to reach out to sailors, fishers, surfers, kayakers, American Indian ancestral lands, etc to find out real uses.
    - Key effort in DNREC to check out.
    - MARCO, surf rider – look at uses of the oceans. Sarah Cooksey is a key contact
    - NOAA data portal, Eyes on the Bay, DEOOS
    - It's always an issue in the Delaware Estuary that there's no one-stop shop to get data

- NFWF & Open Spaces Institute are accepting applications currently to fund projects aligning with William Penn clusters.
- TNC Conservation Planning efforts for the Delaware Basin
    - TNC is in a couple of the clusters
    - Those plans mostly driving TNC priorities at this time

Orientation to Afternoon Breakout Groups

- Four years ago the MAC/STAC made a list of indicators; only a few of them were selected to be included in the TREB
    - There are actions and needs for the indicators in the TREB
    - For the expertise in the room; a start will happen today for prioritization of the list
    - Divide up to 2 groups, water and living resources - have 20 minutes
    - Prioritize indicators; no need to get into weeds. Is it important indicator? Reference Actions and Needs and expand if things are now known or if things are missing. Thinking about what needs to be sustained and or added.

At-Risk Monitoring

- USGS gages are always on chopping block. But it varies by state.
    - PORTS
        - *SUBSEQUENT TO MEETING: See Appendix A for DRBC letter to the Port Authority about these funding withdrawals – provided by John Yagecic*
    - Early warning system real time model now uses NOW CAST model.
    - Gauging stations in Philly and north of are safe for funding for the next 25 yrs.
- Ship Johns is used for vibrio monitoring in oysters by NJDEP.
- What is the monitoring that is on chopping block that we need to sustain?
    - Main stem gages no longer have turbidity on them because the USGS funding ended. So that no longer exists.
    - Tide gages on the NJ side maybe in danger of losing funding up in the DE estuary.
    - NJ funds Sandy Hook to Cape May and just around the tip of Cape May gages. But not sure who funds others.
    - DRBC boat run has been scaled back. No longer do March run. Metals are done at every other station instead of every. There are also a list of parameters that have never been sampled that would like to be done. But there is still the same amount of funding
    - PWD boat run is up in the air currently (working with EPA). They can more easily provide boat and staff but maybe not the lab metrics.
    - EPA is currently looking further into the shallows of the bay. Specifically at nutrient waste load allocations. That work also is partnering with DRBC on this work.
    - DEWOOS had a focus on the shallows of the estuary not just the main channel.

- EPA working with RARE funding to look at nutrient samples throughout the shallows of the estuary. Up to 400 samples during the 2014. From the mouth up to Ft. Mifflin, PA. Also getting ocean acidification samples during this program. Randomized stratified by salinity zones.
- Oysters- Rutgers Haskin Shellfish lab maintains a comprehensive data set. Funding for oyster monitoring is unknown. Ask Bushek
- Integrated wetlands work- currently short term, but would like to continue it to a long term data set. There seems to be no linking to long term funding.
- Fish are generally ok because the states do monitoring for most commercial fisheries.
- Atlantic sturgeon monitoring- long term monitoring but they ran out of money in 2013. Potentially problem with permit getting since they have been listed.
- Sequestration should not be a hurdle for 2014 and 2015. But budgets will remain steady which means it can translate into cuts because costs go up each year.
- Mussel watch- possibly been cut?
- NJ USGS CO-OP for streams is going to be redesigned. Not fiscally at risk but the components are going to be redesigned.
- EPA's NCC is in 2015, which will mean additional resources. EPA is open to partnering if anyone needs samples taking.
- NFWF has $100million total for post Sandy work. Some of it will generate monitoring but it is not the long term monitoring

Breakout Group Reports

- Consumption-regulated already, mass balance
- Per capital water use-ranks less than other things,
- Surface water flow/statistics-waste load allocation; mass balance issues; knowing loads
- Groundwater availability- NJ, lower DE, agriculture…run off.. water quality, i.e. Cohansey- salt water intrusion, does not change dramatically, groundwater is no active management, monitor and report; in this region not as high priority
- Water supply and demand-compared to other things may not be a resource issue, but drinking water import, good to know the aggregate, ties into salt line water
- Salt line location-oysters, drinking water, could predict what predators survive, but it does not affect headwaters, human health-vibrio, chlorides, we can control, affects living resources, indicator
- Source water-protection?? Drinkable
- USGS gauging stations-goes with surface water flow and mass balance
- Flooding-ties back into gages, when it happens politically it changes on things, so needs to be monitored, run-off
- Dam-above tide zone it's more important,

- Stormwater-it's hard to monitor, often major sources of sedmiments and is important in mass balance- may not have enough info currently, expensive to collect data, when doing TMDL's
- Shell budget-not important for water quality
- DO- specifically minimal? Or range. Highly needed
- Nutrients-concern about nutrients is not a prominent as DO
- Contaminants- sometimes you don't need monitoring as many as possible, concentrate on mentals, a lot of questions, very generic topic- one or two might be more impotant than others
- Fish contaminant levels-very important
- Salinity-its' there, if you need to do models you need that to QA, easy to monitor
- pH-kind of like salinity, easy to do, might depend on where monitoring, site specific?, can be a by-product, could be affected by ocean acidification, complicated
- Temperature-easy, everything is related, DO saturation, chlorophyll reactions, biotics impacted
- Sediment Chemistry-do we need to monitor every year? Natural or dredging? Baseline is good but not sure how much it changes
- Chl-a-related to nutrients or not?? Depends on site specific and timing, also shallows. Many limiting factors are in play so hard to isolate
- Organics-large category, can get from fish, total organic carbon is important, but does it fit in here. Organic contaminatns, needs clarification – or DOC, TOC??
- Bacteria-not just fecal but vibrio is important, but other than that it's middle of the ground
- Emerging Contaminants-not sure of criteria, this needs to be done first, need to deal with unknown not just blindly doing the same old thing over again and again. Like the spill in West Virginia… no one had ever done study. Paulsboro also has issues with PFNA that is in the ground water contaminants, but no human health issues are on the books, no epidemiology factors
- Chloride-cause it's easy, same as saline, important for monitoring, site specific might be important but other areas not
- TDS-
- Spec Conductivity-

Pulling it all together

Subsequent to Meeting: Summary scores for priority ranking of project topics in Appendix B.

- Living Resources report out-
    - #1 Atlantic Sturgeon -Sustain telemetry studies, continue to investigate DO for sturgeon

  - #2 Oysters- monitor salinity over seed beds,
  - #3 HSC-needs more funding for monitoring
  - #4 American Shad-monitoring is being done,
  - #5 Tie Macroinverts-states use different methods and FW Mussels-more surveys for presence absence but also their functional importance, quantitative abundance
  - All those were done in last TREB.
  - Note done prioritization of needs, those are next steps.
- Habitat-
  - Tidal wetlands acreage- wetland monitoring has been underfunded, NWI is under funded, need more work on stressor response relationships
  - Coastal wetland condition-not in TREB, do not have enough data, need standardized data across the area as well as increase coverage
  - Freshwater wetland acreage-
  - Riparian corridor condition- no clear monitoring needs based on TREB, maybe get regular intervals data to have a long term evaluation

Concluding Thoughts

- PDE would eventually like this STAC-MAC assembly to prepare would be a list of top monitoring needs, similar to the top 10 list of general needs in the 2006 white paper. That was then used to prepare grants for an array of top priorities.
  - After TREB, what comes next? And how can we make next TREB better by meeting those actions and needs? Specifically, what actions and needs are associated with monitoring? Once we have this list, we would want to prioritize.
- Is this helpful for the MAC as well as the STAC?
  - Historically, the MAC has been focused on water chemistry. But that does not mean that it is not interested in broader monitoring, especially when there is a nexus to water chemistry. The STAC and MAC should not be repetitive, but should support each other. The Fisheries Co-Op fills another role, and a rep sits on the STAC. Biology at DRBC is dealt with in sub-committee.
- Many of the issues are large enough that one agency or tech workgroup cannot possibly address all areas. But continued partnering between the STAC and MAC makes sense, especially when larger issues are at hand.
- It was good to see the different prospective of the MAC/STAC within the different groups.

Annual MAC/STAC meeting to cross pollinate partnering

- Based on the outcomes from today and earlier joint meetings of the STAC and MAC, the group agreed that it would make sense to begin meeting jointly once per year. The focus of this annual meeting would be monitoring coordination and sharing. Regular agendas would include:

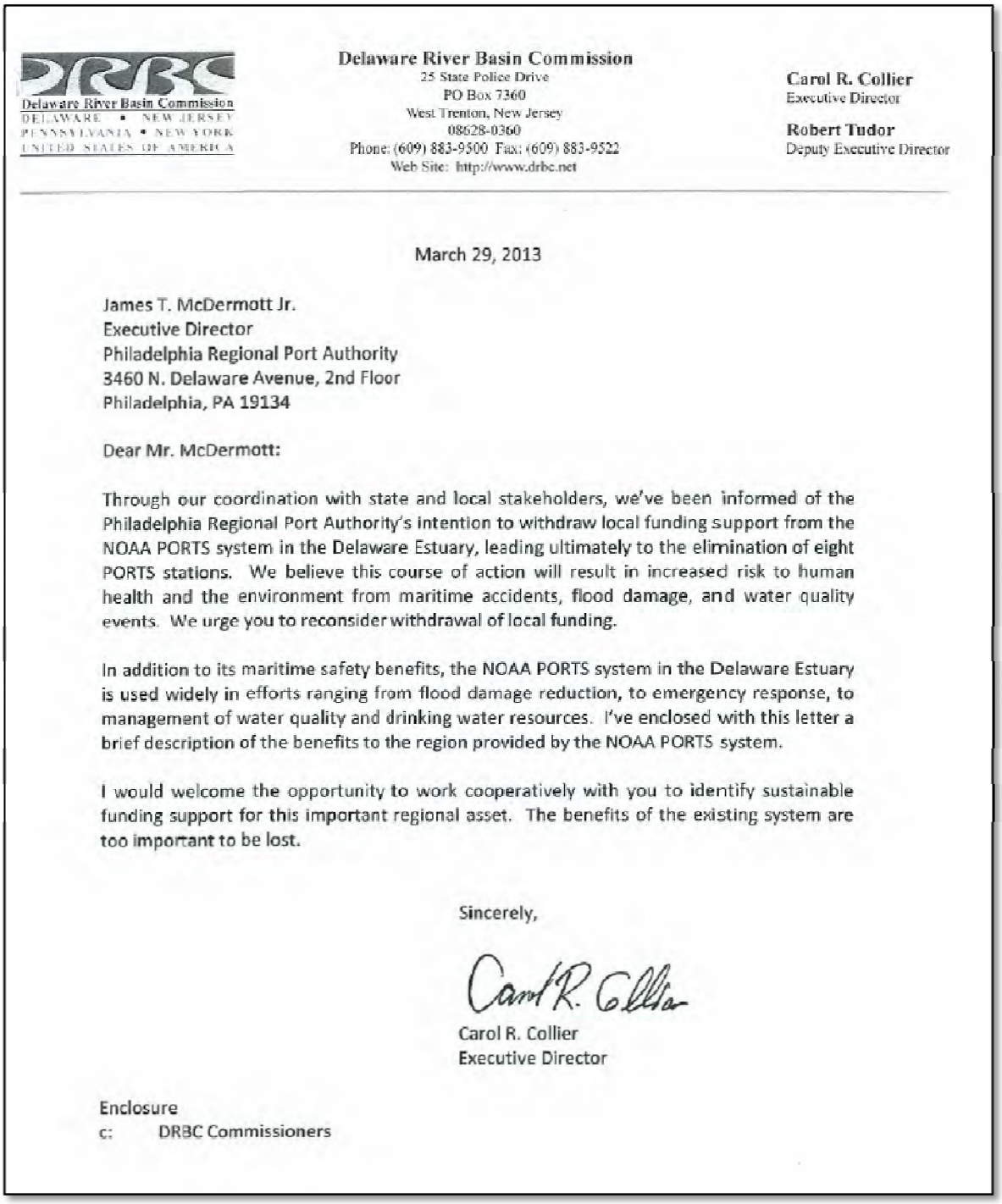
  - Sharing
  - Changes since last year
  - Needs
  - Opportunities
- STORET is an ok way to go for sharing data. If we can encourage getting water quality data into STORET, for instance PWD does not currently put it in. Then we could do a exercise to get out the data in various forms.
- Both the STAC and MAC agreed to continue to look for opportunities to do collaborative work

Appendix A. Letter from Coral Collier to McDermott listing the benefits from NOAA PORTS.

Appendix B. List of resources/topics reviewed and ranked by the STAC-MAC regarding their priority for monitoring.

Appendix C. Actions and needs listed in the 2012 TREB.

APPENDIX A. Subsequent to Meeting: Dissemination of letter from Coral Collier (Exec. Director of DRBC) to McDermott (Exec. Director at the Philadelphia Regional Port Authority) and list of benefits from NOAA PORTS (Fig. 1); followed by enclosures referred to within the letter.



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Carol R. Collier
Executive Director

Robert Tudor
Deputy Executive Director

March 29, 2013

James T. McDermott Jr.
Executive Director
Philadelphia Regional Port Authority
3460 N. Delaware Avenue, 2nd Floor
Philadelphia, PA 19134

Dear Mr. McDermott:

Through our coordination with state and local stakeholders, we've been informed of the Philadelphia Regional Port Authority's intention to withdraw local funding support from the NOAA PORTS system in the Delaware Estuary, leading ultimately to the elimination of eight PORTS stations. We believe this course of action will result in increased risk to human health and the environment from maritime accidents, flood damage, and water quality events. We urge you to reconsider withdrawal of local funding.

In addition to its maritime safety benefits, the NOAA PORTS system in the Delaware Estuary is used widely in efforts ranging from flood damage reduction, to emergency response, to management of water quality and drinking water resources. I've enclosed with this letter a brief description of the benefits to the region provided by the NOAA PORTS system.

I would welcome the opportunity to work cooperatively with you to identify sustainable funding support for this important regional asset. The benefits of the existing system are too important to be lost.

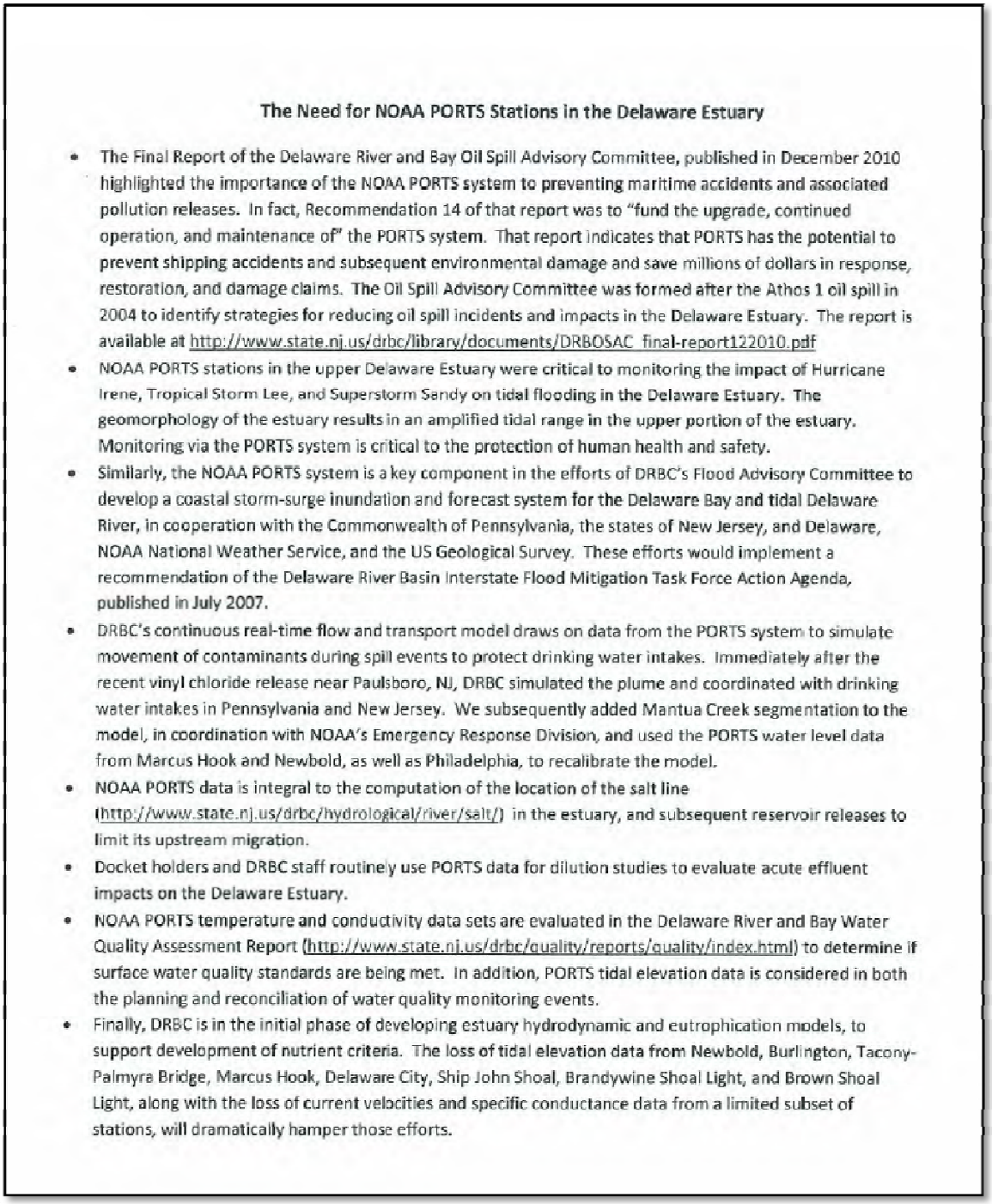
Sincerely,

Carol R. Collier

Carol R. Collier
Executive Director

Enclosure
c: DRBC Commissioners

Figure 1. Letter from DRBC to Philadelphia Regional Port Authority Regarding the importance of NOAA PORTS



The Need for NOAA PORTS Stations in the Delaware Estuary

- The Final Report of the Delaware River and Bay Oil Spill Advisory Committee, published in December 2010 highlighted the importance of the NOAA PORTS system to preventing maritime accidents and associated pollution releases. In fact, Recommendation 14 of that report was to "fund the upgrade, continued operation, and maintenance of" the PORTS system. That report indicates that PORTS has the potential to prevent shipping accidents and subsequent environmental damage and save millions of dollars in response, restoration, and damage claims. The Oil Spill Advisory Committee was formed after the Athos 1 oil spill in 2004 to identify strategies for reducing oil spill incidents and impacts in the Delaware Estuary. The report is available at http://www.state.nj.us/drbc/library/documents/DRBOSAC_final-report122010.pdf
- NOAA PORTS stations in the upper Delaware Estuary were critical to monitoring the impact of Hurricane Irene, Tropical Storm Lee, and Superstorm Sandy on tidal flooding in the Delaware Estuary. The geomorphology of the estuary results in an amplified tidal range in the upper portion of the estuary. Monitoring via the PORTS system is critical to the protection of human health and safety.
- Similarly, the NOAA PORTS system is a key component in the efforts of DRBC's Flood Advisory Committee to develop a coastal storm-surge inundation and forecast system for the Delaware Bay and tidal Delaware River, in cooperation with the Commonwealth of Pennsylvania, the states of New Jersey, and Delaware, NOAA National Weather Service, and the US Geological Survey. These efforts would implement a recommendation of the Delaware River Basin Interstate Flood Mitigation Task Force Action Agenda, published in July 2007.
- DRBC's continuous real-time flow and transport model draws on data from the PORTS system to simulate movement of contaminants during spill events to protect drinking water intakes. Immediately after the recent vinyl chloride release near Paulsboro, NJ, DRBC simulated the plume and coordinated with drinking water intakes in Pennsylvania and New Jersey. We subsequently added Mantua Creek segmentation to the model, in coordination with NOAA's Emergency Response Division, and used the PORTS water level data from Marcus Hook and Newbold, as well as Philadelphia, to recalibrate the model.
- NOAA PORTS data is integral to the computation of the location of the salt line (http://www.state.nj.us/drbc/hydrological/river/salt/) in the estuary, and subsequent reservoir releases to limit its upstream migration.
- Docket holders and DRBC staff routinely use PORTS data for dilution studies to evaluate acute effluent impacts on the Delaware Estuary.
- NOAA PORTS temperature and conductivity data sets are evaluated in the Delaware River and Bay Water Quality Assessment Report (http://www.state.nj.us/drbc/quality/reports/quality/index.html) to determine if surface water quality standards are being met. In addition, PORTS tidal elevation data is considered in both the planning and reconciliation of water quality monitoring events.
- Finally, DRBC is in the initial phase of developing estuary hydrodynamic and eutrophication models, to support development of nutrient criteria. The loss of tidal elevation data from Newbold, Burlington, Tacony-Palmyra Bridge, Marcus Hook, Delaware City, Ship John Shoal, Brandywine Shoal Light, and Brown Shoal Light, along with the loss of current velocities and specific conductance data from a limited subset of stations, will dramatically hamper those efforts.

Figure 2. Enclosure Contents for letter to Philadelphia Regional Port Authority from DRBC (Fig. 1)

Pertinent Amendments/Changes to the List in Figure 2 (provided by John Yagecic, DRBC):

- Under periodic high river discharge, the ecology of the Delaware Bay is greatly altered (Voynova, Y.G. and J.H. Sharp. 2012. Anomalous Biogeochemical Response to a Flooding Event in the Delaware Estuary: A Possible Typology Shift Due to Climate Change. Estuaries and Coasts 35: 943-958. online at doi: 10.1007/s12237-012-9490-2). Such alteration of the ecology is necessary to understand for effective management of the Delaware Bay resources. Data from the PORTS stations in the bay are critical for documenting the changes.

Joint STAC and MAC Meeting March 5, 2014

APPENIX B. List of Topics Reviewed and Ranked.

Those participating scored topics from 5 to 1— 5 being top priority. Individual scores were averaged, the means are listed in the table below. Topics voted as highest ranking priorities are bolded red. Standard deviations are given to highlight topics were agreement was high (green; low st. dev.), or where there was a broad range of opinion on the importance of the topic (orange; high st. dev.).

Living Resources + Habitat Break-Out Priority Rankings

Organismal		
Topic	**Mean**	**St. Dev.**
Atlantic Sturgeon	**4.75**	**0.463**
Oysters	**4.50**	**0.756**
Horseshoe Crabs	**4.38**	**1.061**
American Shad	**4.25**	**0.707**
Macroinvertebrates	**4.00**	**0.926**
FW Mussels	**4.00**	**0.756**
Blue Crabs	3.88	0.641
Ospreys	3.75	1.035
Striped Bass	3.50	0.535
American Eel	3.50	0.926
Amphibians	3.25	1.035
Bald Eagles	3.13	0.991
Sharks	3.13	1.126
Terrapins	2.88	1.126
Invasives	2.88	1.246
Weakfish	2.75	0.707
Brook Trout	2.75	1.581
Willets	2.63	1.061
Periphyton	2.38	0.916
White Perch	2.25	1.165
Muskrats	1.63	0.518

Habitat/Environmental		
Topic	**Mean**	**St. Dev.**
Tidal Wetland Acreage	**4.88**	**0.354**
Tidal Wetland Condition	**4.63**	**0.518**
FW Wetland Acreage	**4.50**	**0.756**
Riparian Corridors	**4.13**	**0.991**
Benthics	4.00	1.069
Sturgeon Habitat	4.00	0.926
Total Reed Area	3.88	1.126
Shoreline Structures & Hardening	3.88	1.126
Fish Passages	3.88	0.835
Buffer Integrity	3.86	1.069
Tidal Wetland Buffers	3.75	1.035
Hydrological Impairment	3.29	0.951
Tidal Gates	2.43	0.976
Total Intertidal Area	2.38	0.916
Total Subtidal Area	2.25	0.707

Water Quality/Quantity		
Topic	**Mean**	**St. Dev.**
DO	**5.00**	**0.000**
Nutrients	**4.57**	**0.787**
Temperature	**4.57**	**0.535**
Fish Contaminant Levels	**4.43**	**0.787**
USGS Gauaging Station	4.33	0.816
Specific Conductivity	4.33	0.816
Surface Water Flow/Statistics	4.29	0.951
pH	4.29	0.756
Chlorophyll-a	4.29	0.756
Contaminants	4.14	0.690
Salinity	4.14	1.215
Stormwater	3.86	0.900
Emerging contaminants	3.67	1.506
Sediment Chemistry (Shellfish Health)	3.57	0.535
Bacteria	3.50	0.837
TDS	3.50	1.049
Water Supply & Demand/Water Withdrawals	3.43	0.535
Salt Line Locations & Movement	3.43	1.272
Chloride	3.17	1.169
Flooding	3.00	1.291
Organics	3.00	0.632
Source Water	2.57	1.397
Groundwater Availability	2.43	0.976
Consumptive Use	2.29	1.380
Dams (Hydrologic Impairment)	1.86	0.690
Shell Budget	1.71	0.756
Per capita Water Use	1.29	0.488

Priorities (Ranked Highest)
Highly Agreeable Scoring
Highly Variable Opinions

APPENIX C. Excerpts from the Technical Report for the Delaware Estuary and Basin, 2012, that pertain to "actions and needs" for each indicator. This list is not culled for monitoring activities, but was presented for the STAC-MAC workshop to stimulate dialogue.

Watersheds & Landscapes

1 –Population

To accommodate the projected population growth, 5-year watershed master plans should be prepared for each of the 10 watersheds in the basin. The master plans should incorporate population projections and impact on drinking water demands, wastewater treatment, water quality, storm water, and flood control.

2 – Land Use/Land Cover

To accommodate the projected population growth, 5-year watershed master plans should be prepared for each of the 10 watersheds in the basin. The master plans should incorporate population projections and impact on drinking water demands, wastewater treatment, water quality, stormwater, and flood control.

3 – Land Use/ Land Cover Change

- Coordinated geospatial data and technologies to better inform and assist local governments in land use decision making.
- Improved mapping, assessment and tracking of forested wetlands.
- Identification and mapping of forested areas critical to water resources and habitats – and incorporation into land use planning and regulation.
- Prioritization of areas for protection (see current work by The Nature Conservancy for the National
- Fish and Wildfe Foundation).
- Identification of areas where forest loss is occurring in each Region, and its cause.
- Public action to protect priority forested areas, especially headwaters, in the basin.
- Local ordinances to manage forested areas and protect and improve tree canopy.

4 – Impervious Cover

Calculations of impervious cover are most useful at scales smaller than those used for reporting here. The use of land use information with a finer resolution that satellite imagery would be a more robust source for useful impervious cover calculations at the community or catchment scale. Furthermore, since impervious cover is an indicator cause of several potential impacts, additional indicators should be developed to address the conditions most necessary to report.

• Impervious cover estimates at a finer resolution to be helpful at community-level planning & mitigation efforts.
• An indicator of urban "forest" and mitigation of the "heat island" effect, for example: ratio of tree canopy to impervious cover.

5 – State & Federal Protected Lands

Each of the four basin states and the federal government should plan to achieve a goal of 20% protected land in the Delaware Basin by 2020 or a 2% increase from 2010. This increase would add 240 square miles (153,600 ac, 62160 ha) by 2020. A strategic initiative should be established by the Delaware River Basin Commission and the Partnership for the Delaware Estuary to track open space inventory by GIS and recommend prioritized acquisition or conservation of land on a watershed basis.

6 – Public Access Points

Public access points should be acquired to achieve a density of one site per mile compared to the present 2 sites per mile along the Delaware River and Bay. Gaps where public river access sites should be acquired include:

* Between RM 1 and 11 (Lewes to Cedar Creek)
* Between RM 11 and 22 (Bowers Beach)
* Between RM 29 and 41Woodland Beach)
* Between RM 65 and 81 (Chester)
* Between RM 138 and 147 ((Lambertville)
* Between RM 198 and 212 (Delaware Water Gap)
* Between RM 315 and 322 (Long Eddy)

7 – Natural Capital Value

Continued investment is needed to support the multi-billion dollar economic value of the Delaware Estuary and Basin.

Water Quantity

1 – Water Withdrawals

Reporting of water withdrawals has improved in recent years due to electronic, web-based reporting, although state agencies are adopting this approach at different speeds and there is still room for improvement.

Withdrawals for the agriculture sector are still estimated based on agriculture census data as the individual water withdrawals for the Basin are not complete or reliable. A better understanding of water use by this sector, which starts with accurate data reporting and collection, is needed in order to improve planning and management for this type of use.

Continued study of the potential growth in water demand for the thermoelectric sector is required due to the impact that large power generating facilities can have on water resources.

Water use for natural gas development in the Delaware River Basin is likely to become an additional water demand on the system in future years. Initial projections estimate that during peak natural gas development (10 years in the future) water demand for this new sector may be 20mgd (0.88 CMS). Although the magnitude of estimated withdrawals in not large in a Basin-wide context, the water is likely to be sourced from the basin headwaters where this increase in demand will represent a significant increase compared to existing demand.

Advances in quantifying the in-stream needs of aquatic ecosystems are necessary for achieving a balance between in-stream and off-stream (withdrawal) water needs.

2 – Consumptive Use

An accurate consumptive use characterization for a watershed requires a detailed analysis of each water use sector to determine accurate consumptive use factors representing site specific conditions. For example, at a small watershed scale, the simple assumption of 10% consumptive use for a PWS system that withdraws from the watershed but discharges wastewater outside the watershed would be inaccurate. This would need to be modeled as 100% consumptive, or as an export from the sending watershed and an import of wastewater (minus the 10% consumptive use) to the receiving watershed. More detailed tracking models that link withdrawals volumes more explicitly to discharge volumes are being applied in the Delaware River Basin, such as by New Jersey Geologic Survey's Water Transfer Data System www.state.nj.us/dep/njgs/geodata/dgs10-3.htm and through the State Water Plan process in Pennsylvania.

3 – Per Capita Water Use

To improve the accuracy of per capita water use estimates, a detailed water use tracking model, such as that developed by the New Jersey Geological Survey, could be used to account for watershed transfers and link water withdrawals to the population served more accurately. Such a model is highly data intensive and requires a significant commitment of staff resources to populate and keep updated. However, the use of such a model, particularly in urbanized areas of the Delaware River Basin that have complex water distribution infrastructure and regional approaches to water supply management would provide a greater understanding of how water is moved and used around the watershed. Another measure to improve the accuracy and uniformity of the per

capita consumption indicator would be to identify and report on PWS water use by customer type in order to separate residential uses from other types of use.

4 – Groundwater Availability

The progress made in recent years to improve water use reporting needs to be continued in order to provide the necessary data to monitor conditions in sensitive areas such as the southeastern Pennsylvania Ground Water Protected Area and the New Jersey Water Supply Critical Area #2. The metrics used to quantify groundwater availability in the GWPA could easily be applied to other areas of the basin for assessment purposes.

5 – Salt Line Location & Movement

An investigation of additional sources of chlorides, such as from road salts and runoff, is warranted. An evaluation of the adequacy of the 3,000 cfs (84.9 CMS) target at Trenton, NJ in repelling the salt line is also warranted.

Water Quality

Tidal

1 – Dissolved oxygen

Current criteria may not be protective of existing uses in the Delaware Estuary. The uses to be protected in Zones 3 and 4, as described in the DRBC Water Quality Standards, include maintenance of resident fish and other aquatic life, and passage of anadromous fish, but not propagation. However, impingement and entrainment studies conducted at power plant water intakes, as well as aquatic living resource assessments, have demonstrated that propagation is occurring in Zones 3 and 4. Therefore, revision of criteria to protect the actual uses is necessary.

In the longer term, we recommend determination of the highest attainable use for the estuary, and subsequent DO criteria protective of that use. This effort would involve coupling estimates of population change and improvements in wastewater treatment technologies, to water quality models which take into account the dynamics of nutrients in the estuary and various forms of oxygen depleting substances, to determine the long term highest use goals.

As mentioned previously, continuous real-time DO monitors provide a better understanding of DO dynamics under a wide range of temporal conditions. The monitors at the Ben Franklin Bridge, Chester, and Reedy Island Jetty have proved instrumental in tracking DO ranges and changes and for assessing the attainment of criteria. USGS has recently installed a DO monitor in Zone 2 (at Delran), but funding for this monitor is temporary. Zone 2 represents a critical linkage between the processes of the non-tidal river, and the historically impacted urban portion of the estuary. As efforts to update criteria and understand the effects of nutrients proceed, dependable long term continuous DO monitoring in Zone 2 is essential.

Currently, important subareas of the Delaware Estuary are not monitored with continuous real time monitors. Near bottom areas, shallows over oyster beds and other important aquatic living resources, and all of Zone 6 are currently not monitored with continuous monitors. Historical spot measurements suggest that DO regimes in these subareas may be substantially different than those measured at the near surface center channel. Therefore, a full assessment of DO requires an expanded network of monitors, including monitors focused on near bottom, oyster beds, and Zones.

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2 - Nutrients

Stakeholders in the estuary, led by DRBC, need to continue the work of determining the appropriate effects-based nutrient levels for development of nutrient criteria. In addition, DRBC should commit to continuity of nutrient monitoring, to development and maintenance of a long-term record of nutrient concentrations under current conditions.

3 - Contaminants

Continuity in monitoring, continued assessments, and continued updates in criteria are all needed to maintain current contaminant levels and affect decreases where levels are elevated.

4 – Fish Contaminant Levels

The fish tissue screening evaluation raises the possibility that some water column chlorinated pesticides are likely exceeding adopted criteria. This conclusion differs from a similar, but less sophisticated, assessment presented to the DRBC Toxics Advisory Committee in 2004. Therefore, direct measurement of water column chlorinated pesticides, with comparison to DRBC water quality criteria, is necessary. Since water quality criteria are the drivers to water quality management, only this direct comparison can initiate the apparatus of reducing the inputs of these contaminants to the estuary.

Similarly, the dioxin/ furan assessment suggests that water column concentrations may exceed water quality criteria. Direct measurement and assessment is required.

Future assessments should evaluate the benefits of a tissue residue approach for toxicity assessment and determination of tissue, water, and sediment quality guidelines for aquatic organisms.

5 - Salinity

Predictive modeling to establish the linkage between sea level and resultant salinity is needed to assess the expected future salinity spatial regimes. Some level of modeling has been completed and used for this purpose, but longer term forecasts under a wider range of conditions are needed to identify critical conditions and begin to evaluate solutions.

6 - pH

A better understanding of the estuary carbon cycle and its impact on pH is needed. Models that can integrate the countervailing processes of ocean acidification and decreased microbial respiration could help elucidate the short-term and long-term likelihoods of continued changes in pH and carbon availability.

7 - Temperature

In order to gain a firmer understanding of how different temperature drivers are influencing the Delaware Estuary, and ultimately to understand how global climate change may be manifested in the estuary, a more rigorous evaluation is needed. This evaluation may need to include a temperature model that integrates the various drivers.

8 – Emerging Contaminants

Nineteen PPCP were identified for focused study based on prioritization criteria such as environmental concentration, toxicity, physicochemical properties, analytical feasibility, consumption, degradation, and persistence (Fig. 3.59). The priority PPCP compounds are triclocarban, fluoxetine, diltiazem, dehydronifedipine, metformin, codeine, acetaminophen, ranitidine, clarithromycin, lincomycin, trimethoprim, atenolol, naproxen, ibuprofen, gemfibrozil, sulfamethoxazole, erythromycin and carbamazepine, and 2-hydroxy-ibuprofen. Assessment priorities include further characterization of persistent and bioaccumulative perfluorinated compounds and a more comprehensive evaluation of potential ecological effects from pharmaceuticals.

Nontidal

1 – Dissolved Oxygen

Continued monitoring and enhancement of monitoring networks, especially in the realm of continuous real time monitors, will help ensure preservation of water quality and identify reaches where DO is less than optimal.

2 - Nutrients

The most important actions needed are the completion of the assessment to determine if EWQ has been maintained at BCPs and ICPs. In addition, the continued development of numerical nutrient criteria is needed to ensure ecological health of basin waters.

3 - Contaminants

Continuity in monitoring programs, continued assessments, and continued updates in criteria are all needed to maintain current contaminant levels and effectively decrease levels where levels are elevated. Monitoring should include parameters to assess copper by the BLM. The DRBC Toxics Advisory Committee has recommended development of water quality criteria for toxics in Zone 1 of the Delaware River.

4 – Fish Contaminant Levels

Continued and expanded monitoring and assessment of persistent, bioaccumulative, and toxic contaminants in fish tissue, aquatic biota and wildlife.

5 - pH

DRBC is reviewing its current pH criteria, with an effort to address naturally occurring diel pH swings. This effort should continue and new criteria should be adopted. Nutrient criteria development may also assist in the determining whether pH conditions are natural or have been altered through algal and plant stimulation. Continuous monitors provide the best means of comparing pH over the daily cycle to criteria, and efforts to deploy additional pH continuous monitors in the basin should therefore continue.

6 - Temperature

We need to continue the development of temperature criteria in the non-tidal portion of the Delaware River, to protect aquatic communities and allow meaningful interpretation of presently collected data. In addition, stronger linkages between meteorological drivers and resultant water temperatures are needed, so that assessors can distinguish between natural conditions and anthropogenic thermal loads.

Sediments

1 – Sediment Loading

Continued monitoring of suspended sediment discharge at the presently gaged locations is recommended.

2 – Sediment Quantity & Budget

Sediment budget research in Delaware Estuary has evolved substantially in the past decade in terms of sources of historic data, analytical approaches to the subject, and also instrumentation to directly measure relevant hydrodynamic and sediment transport parameters. Continued efforts to improve our understanding of sediment transport phenomena and the estuary sediment budget in general are recommended, including a reevaluation of localized contribution of suspended sediment from storm and sanitary sewer discharges.

3 – Sediment Organic Carbon

It is stated in the 2007 National Estuary Program (NEP) Coastal Condition Report that the "regional NEP programs have found that the problems associated with eutrophication are dwarfed by problems from other water quality stressors". This does not mean that eutrophication is not an issue in the Delaware Estuary. It simply implies that greater concerns, such as industrial inputs to the system (i.e. PCBs) are a higher priority at this time. There are still areas of the Delaware Estuary with levels of dissolved oxygen (DO) less than 5mg/L. Although the hydromorphic features of the Delaware are favorable in creating a well mixed system, low DO levels, along with levels of nitrogen and chlorophyll a comparable to the Chesapeake Bay system insinuate that additional data regarding TOC should be collected to better understand the system.

4 – Sediment Grain Size

Sediment grain size data should continue to be collected and archived in future studies and conducted concurrently with other benthic research.

5 – Dredging Activity

Continued monitoring and reporting of maintenance dredging quantities is a routine function of US ACE. It is recommended that future work on all aspects of Delaware Estuary sediment management and sediment budget investigations include regular coordination with US ACE regarding dredging quantities.

Beginning in 2009, US ACE and several other organizations began to work collaboratively to develop a Regional Sediment Management Plan. Prior to this, there had been no systematic approach to dealing with the challenges and opportunities associated with sediment management in the Delaware Estuary region. The Regional Sediment Management initiative is intended to broaden local knowledge and facilitate watershed collaboration about how, where, and when to manage parts of the sediment system differently and more beneficially than has been previously practiced. The Plan is currently under development.

Aquatic Habitats

Subtidal

1 - Subtidal

The ready availability of extensive data clearly justifies a cross-survey analysis of the past 30 years. Additional effort will be required to determine if differences among data sets are due to a sampling design (spatial allocation of locations) or sampling gear-bias (especially sieve mesh size) or truly represents significant change in estuary conditions. Only limited, broad conclusions can be draw from the simple data summaries and plots presented here. Further analyses using multivariate methods like multi-dimensional scaling and dominance curves may reveal patterns and relationships impossible to discern among multiple possible natural variation and anthropogenic effects. Effective analysis of these benthic data will require additional effort to identify sensitive and tolerant species, reference and control sites (to develop customized and calibrated indices), and the application of more sophisticated multivariate, phylogenetic/taxonomic structural analysis or regression-based species distribution modeling.

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Intertidal

1 – Tidal Wetland Acreage

Sea level rise, salinity rise, development, outdated management paradigms, and pollutants are likely to contribute to the continued degradation and loss of tidal wetlands in the Delaware Estuary unless actions are taken to abate these impacts. Future indicator reporting would also benefit from better monitoring data on tidal wetland extent and condition.

Proactive Adaptive Management

Despite the dynamic nature of the coastline, many regulatory policies continue to treat the landscape as fixed in place. Restoration paradigms set goals based on historic conditions rather than future sustainability. As sea level rises it will be important to update management policies to encourage both the landward migration of tidal wetlands into buffers (Feature Box) and the vertical accretion of tidal wetlands in place (Fig. 5.32). It is still much easier to obtain a permit for a shoreline stabilization project that installs a bulkhead or other hard structurestructure that prevents wetlands from keeping pace with sea level rise and contribute to degradation of tidal wetlands, than it is for a living shoreline (Fig. 5.32). Ditching and filling of tidal wetlands still occur, often without proper monitoring of the effects or understanding of the consequences. To adapt to both climate change and continued watershed development, tidal wetland managers will need to adjust targets, policies and tactics to sustain existing tidal wetland habitat in the future.

In order to address the threats to the intertidal zone in the Delaware Estuary, an approach combining policy and regulatory remedies and actions on the ground is required. The Clean Water Act (1972), Coastal Zone Management Act (1972), and the Coastal Barriers Resources Act (1982), are evidence of the increasing importance of tidal wetlands in the policy and legal arena. Many states and counties have followed the lead of federal agencies and implemented their own regulations covering wetland protection measures such as buffer requirements, impervious cover limitations, and implementation of federal nutrient pollution guidelines. Continued promulgation, refinement, and enforcement of regulations and policies is a critical need, as demonstrated by the various emergency measures that are already underway or being called for in some Delaware and New Jersey areas (e.g. Prime Hook, Delaware; Sea Breeze, New Jersey; Maurice Township, New Jersey) where tidal wetland losses are contributing to the decline of coastal communities. Given accelerating development and population pressures, as well as increases in relative sea level rise, these measures will need to be augmented just to maintain the current integrity of the intertidal zone. In particular, local differences in the extent of regulatory protection provided to wetlands poses a challenge to maintaining consistently high level of wetland quality and function throughout the estuary.

Monitoring Data and Scientific Study

Complete and consistent monitoring data on wetland is a vital need to allow managers to make proper decisions and to enable assessment of wetland status and trends. Such data allows scientists and policy makers to understand the causes of wetland loss and develop approaches to address them. As discussed above, it is still impossible to accurately and consistently report changes in tidal wetland extent because of limited, sustained investment in monitoring. The National Wetlands Inventory is a program designed to address this issue, but differences in the procedures and time frames have made long-term trend analysis problematic. The State of Delaware has developed high-quality datasets, but comparison to New Jersey is not possible. Some areas of Pennsylvania have not been assessed for the NWI since the 1970s. Therefore, basin-wide coordination of NWI assessments is crucial, as is the need to update inventories at least every 5-7 years.

Since the array of ecosystem services furnished by tidal wetlands are proportional to their condition, better health assessments are also needed. For example, restoration and mitigation targets are based on acreage, and

realizing small increases in acreage can be very costly; however, investment in enhancement projects (e.g., living shorelines to stem erosion, beneficial use of dredge material to raise elevation) that boost function and save much larger tracts from being lost might yield greater net value (and acres) in the long run. More scientific studies and restoration pilot projects would contribute to knowledge and strengthen management and restoration practices to sustain greatest tidal wetland acreage.

Investment in consistent tidal marsh monitoring and science is difficult to fund at the scale of the multi-state Delaware Estuary. However, the benefits of tidal wetlands are beginning to be captured and capitalized upon (e.g. flood protection, nutrient and carbon capture, fish production). Tidal wetlands are already regarded as the most valuable natural lands (e.g. NJDEP 2007). Managers should carefully consider how a projected loss of 25-75% of the tidal wetlands in the Delaware Estuary might affect coastal communities (lives and property) and regional economies (fisheries and shellfisheries, property values, nutrient criteria). As markets for ecosystem services develop in the future, there will be increasing demand for essential information on trends in tidal wetland extent and condition. Such information will be vital in the development of strategies to protect and enhance tidal wetlands. Until then, there will continue to be a need to collaborate and leverage funds to fill vital information gaps.

Nontidal

1 – Freshwater Wetland Acreage

Many positive actions are underway and require continued vigilance by Basin management community:

1. Continued attention to quantifying ecosystem service values.
2. Continued attention to harmonizing state and federal regulatory programs.
3. Continued attention to funding conservation initiatives and wetland reserve programs.
4. Continued effort to quantify feedback loops like the USDA Conservation Effects Assessment Program.
5. Passage of the Delaware River Basin Conservation Act of 2011-- championed by Senators Carper and Coons of Delaware, Senator Schumer and Gillibrand of New York, and Senators Menendez and Lautenberg of New Jersey-- which would establish a federal program at the U.S. Fish and Wildlife Service to coordinate voluntary restoration efforts throughout the Delaware River watershed.

2 – Riparian Corridor Condition

The Water Resources Plan for the Delaware River Basin ("Basin Plan) Objective 2.3 D called for "Implementing Strategies to protect critical riparian and aquatic habitat" and established milestones for identifying, mapping and prioritizing critical habitats. It also called for development and adoption of protection and restoration strategies.

1. Action: The Final Report for the National Fish and Wildlife Foundation titled "Delaware River Basin Priority Conservation Areas and Recommended Conservation Strategies" was completed in 2011. The report includes detailed maps by Sub-basin showing watershed specific freshwater system priorities. For example, the Upper Delaware River Basin is divided into 22 watersheds and place-specific conservation strategies (Headwater Networks; Floodplain Complexes; Headwater Wetlands; and Riverine Wetlands) are identified and prioritized.
2. Action: The Conservation Plan referenced in Item #1 functions as vehicle for collaborative restoration and protection action.
3. Action: The Conservation Plan also serves as preliminary set of targets for implementation of the Delaware River Basin Conservation Act of 2011, if it is successful in becoming federal law.

4. Need: The Basin conservation community needs to work with its Congressional Delegation to continue to advocate for passage of the Delaware River Basin Conservation Act.
5. Action: The Delaware River Basin Commission Flood Advisory Committee conducted a careful assessment of Floodplain Regulations both in the basin and around the country in 2008 and 2009. In October 2009, they presented a report containing twelve recommendations for more effective floodplain regulations to the Commission. The Committee determined that minimum floodplain regulations, administered by FEMA through the National Flood Insurance Program, do not adequately identify risk or prevent harm. They also found that floodplain regulations are inconsistent from State to State and from community to community. They recommended that floodplain regulations need to be applied more consistently and comprehensively, on a watershed basis that reaches across jurisdictional boundaries.
6. Need: DRBC needs to work with FEMA to advance their Risk Mapping, Assessment and Planning (Risk MAP) strategy to work with local officials to use flood risk data and tools to effectively communicate risk to citizens and better protect their citizens. The DRBC Flood Advisory Committee recommendations could be one component of the FEMA strategy to work with communities at a watershed scale to make the Basin more flood resilient.

3 – Fish Passage

Financial resources for addressing fish passage within the Basin are limited, and there is a need for an updated comprehensive evaluation of where best to prioritize fish passage. The prioritization needs to consider the best ecological return for each location addressed as well as the suitability of potential new habitat. An effort on-going since 2008 by the Northeast Association of Fish and Wildlife Agencies and The Nature Conservancy (TNC), called the Northeast Aquatic Connectivity (NAC) Project, has developed tools and an initial assessment of opportunities for restoration of stream system connectivity across the Northeastern US. With input from the NAC workgroup, TNC calculated 72 ecologically-relevant metrics for almost 14,000 dams across the region and developed tools to allow for tailored assessment of ecological returns of reconnection projects. Tools and final products (expected by 2012) include two assessment scenarios that rank dams for benefits for anadromous fish and for benefits for resident fish, produced using a subset of metrics weighted by the workgroup. While these products and tools will help inform prioritization efforts, site-specific factors still need to be considered in project selection.

In addition to the forthcoming Northeast Aquatic Connectivity Project, Senator Tom Carper (Delaware) recently introduced the Delaware River Basin Conservation Act of 2011, which would establish a federal program at the U.S. Fish and Wildlife Service (US FWS) to coordinate voluntary restoration efforts throughout the Basin and oversee up to $5 million per year of grant funding. It is envisioned that a basin-wide fish passage prioritization project would be an ideal project worthy of funding through the Act and would help guide future distribution of grant monies.

The fish ladders installed in the Lehigh River have also demonstrated that not all fish passage “remedies” are equal, with some being more successful than others. In cases where a dam no longer serves a critical use such as for public water supply, the first remedial option should be removal. In addition, where regulatory opportunities exist with dam owners during permitting actions, regulatory agencies need to adopt and implement a consistent approach as to when and why fish passage needs to be addressed. Many dam owners have argued that if anadromous fish are not present downstream of their dam, then there is no need to address fish passage. For dam locations that do not have anadromous fish downstream, addressing fish passage is still important for resident species.

From the perspective of both anadromous and resident fish, assessing the degree to which road/stream crossing structures also are creating barriers to fish passage will be important, as well. While we currently lack good data, pilot field surveys conducted by The Nature Conservancy and others will provide some insight on the prevalence

of problematic culverts within select tributary watersheds in the Basin. Following ecological standards for culvert design and replacement could be helpful to restore connectivity currently hindered by these small structures.

4 – Hydrological Impairment

A study of ecological flow needs to protect species and key ecological communities for the range of habitats in the Delaware Basin is necessary in order to provide the scientific basis for any future modifications to reservoir operation plans.

Developing a strategy to deal with existing hydrological impairments due to existing impervious cover is necessary. Options range from mandatory stormwater management retrofits during the redevelopment of a site to voluntary retrofits incentivized by the implementation of stormwater runoff fees.

Living Resources

1 – Horseshoe Crab

In order to better understand horseshoe crab population trends and their interaction with shorebirds, a cooperative effort between the ASMFC, States, US Geological Survey, and the US Fish & Wildlife Service has resulted in an Adaptive Management Framework for recommending harvest levels based upon population models that link red knot populations with horseshoe crab populations. Under this framework, competing models that describe the dependence and interaction of red knots and shorebirds can be evaluated over time by monitoring the populations. Two monitoring programs are essential to implement this framework: The Horseshoe Crab Trawl Survey and the Shorebird Monitoring Program at Delaware Bay. It will be critical to ensure funding for these two monitoring programs in order to increase understanding and reduce uncertainty regarding how these two populations interact.

2 – Atlantic Sturgeon

Actions that could improve the condition of the Atlantic sturgeon population in the Delaware River include continuation of telemetry studies for discovering areas of the river used by various life stages of the species. Locations of spawning areas and early life stage nursery areas for Atlantic sturgeon in the Delaware River need to be identified so management actions, such as instituting effective dredging windows, can be used to protect fish at times when they congregate in known areas. Expanded study of ship strikes on sturgeon in the Delaware River is also needed to determine the level of population impact occurring and to determine ways to minimize that impact. Since the species is highly migratory, actions to protect, conserve, and enhance Atlantic sturgeon in the Delaware River extend far beyond the geographical limits of the Delaware Basin. These actions include: (1) reducing by-catch from near-shore and ocean commercial fisheries on the east coast by increasing the number of observers on commercial fishing vessels and reducing the use and/or soak time of anchored gill nets, (2) designing and locating future tidal turbines for power generation in a manner which would strive to minimize mortality to distant migrants, and (3) continuing the use of the Coastal Sturgeon Tagging Database as a means to promote data sharing between sturgeon researchers.

In addition, revised dissolved oxygen criteria from the Delaware River Basin Commission and improvements to wastewater treatment in the estuary could significantly improve early-stage juvenile habitat conditions in the core Atlantic sturgeon zone. The need for continued improvements in dissolved oxygen has been articulated since the late 1970s, with the elevated oxygen conditions demonstrated as achievable through a multi-agency study in the 1980s. The listing of Atlantic sturgeon as “Endangered” necessitates immediate implementation of these recommendations.

Currently, there is no funding vehicle specific for protection and enhancement of the Delaware River sturgeon population. However, the Delaware River Basin Conservation Act of 2011 would establish a federal program at the U.S. Fish and Wildlife Service to coordinate voluntary restoration efforts for numerous species and habitats throughout the Delaware River watershed. This legislation is sponsored by Senator Tom Carper (D-DE) and co-sponsored by Sens. Coons (D-Del); Schumer (D-NY), Gillibrand (D-NY), Menendez (D-NJ), and Lautenberg (D-NJ) http://carper.senate.gov/public/index.cfm/pressreleases?ID=c85f7582-af71-400f-8a2c-9e56479e29da. Proposals targeting restoration activities that would benefit Atlantic sturgeon could be considered for use of a portion of these funds should the legislation be passed.

3 – American Shad

Any improvement in restoring access to blocked habitat through dam removal or improvements in fish passage devices on existing dams would facilitate population increases for American shad in the Delaware River. In that regard, continued negotiation by the PA Fish and Boat Commission to remove dams on the Lehigh River is needed. In order to facilitate restoration of tributaries that have obstacles to fish passage, efforts to spawn wild American shad to produce larvae for stocking should be continued in those areas until shad can access sufficient historic habitat to reproduce naturally. There is also a need to re-establish the upper river juvenile abundance sampling that was once performed by New Jersey Division of Fish & Wildlife in order to monitor juvenile recruitment and compare it with existing lower river juvenile monitoring efforts. Computer modeling is also needed to determine the level of impact on the population occurring from mortality due to entrainment of eggs and larvae in industrial water intakes in the Delaware Basin. Dredging and blasting activities performed in the Basin under permit via the U.S. Army Corps of Engineers must be limited to those times of year recommended by the Co-op (dredging windows) to prevent excessive adverse impacts on all life stages of shad.

Currently, there is no funding vehicle specific for protection and enhancement of the Delaware River shad population. The four Basin States have allocated some budget resources annually for population monitoring efforts that result in data reported annually to the ASMFC. Recent budget shortfalls in most States have resulted in reduced monitoring efforts, creating a potential discontinuity in numerous population indices that are useful to determine population trends. However, the Delaware River Basin Conservation Act of 2011 would establish a federal program at the U.S. Fish and Wildlife Service to coordinate and prioritize restoration efforts for numerous species and habitats throughout the Delaware River watershed. This legislation will be sponsored by Senator Tom Carper (D-DE) who will be joined in supporting the legislation by Sens. Coons (D-Del); Schumer (D-NY), Gillibrand (D-NY), Menendez (D-NJ), and Lautenberg (D-NJ) http://carper.senate.gov/public/index.cfm/pressreleases?ID=c85f7582-af71-400f-8a2c-9e56479e29da. Study proposals already developed by the Partnership for the Delaware Estuary as well as other proposals targeting restoration activities that would benefit American shad would be valid considerations for use of a portion of these funds should the legislation be passed.

4 – Striped Bass

Continue present monitoring and conservation regulations.

5 – Blue Crab

Nothing to report.

6 - Weakfish

None

7 – American Eel

Although the main stem of the Delaware River is un-dammed, hundreds of dams still block passage along its tributaries; many are low head dams under private ownership and in poor condition. In addition, there are thousands of culverts for roads that cross the tributaries. And in many areas the riparian forested buffer along the streams has been removed, leaving the stream exposed to sun and dramatically increased non-point source sediment and pollution run off. Fish passage and riparian restoration would help improve habitat for eel by increasing connectivity and improving in-stream habitat by providing shade and structure in these tributaries.

8 – Eastern Oyster

The maintenance of the annual oyster population and oyster disease surveys is essential to management of this resource. Efforts need to be made to evaluate the Hope Creek, Fishing Creek, and Liston Range oyster bed population dynamics. Plans need to be developed to manage the likely continued rise in salinity in Delaware Bay and its importance to the long term viability of key oyster beds. At a minimum, development of a bay wide monitoring system for temperature and salinity should be implemented. As possible additional parameters such as pH, dissolved and particulate nutrients, chlorophyll and total suspended solids could be added. Plans for enhancing recruitment through shell planting need to be continued and expanded.

9 - Osprey

Volunteers are needed for monitoring nests and productivity. Since osprey readily use artificial platforms and structures for nesting, those interested in establishing nesting structures, or that have questions about osprey should contact the State agencies responsible for bird conservation (links to the right).

10 – White Perch

The 8-inch (20.3 cm) minimum size limit for white perch established by Delaware in 1995 has been effective in allowing almost all white perch to spawn once, and for many white perch to spawn several times, before recruiting to the fisheries. White perch often spawn in areas of the Delaware River and in the upper reaches of Delaware Estuary tidal tributaries that have been subject to intense development pressure in the past 30 years. These are spawning habitats for many fish species in addition to white perch and these habitats should be protected.

11 – Macroinvertebrates

Bioassessment of macroinvertebrates is a well-established practice in state environmental agencies, and it may be expected to continue for the foreseeable future. Bioassessment has become a core element of the regulatory system for protecting water quality in the United States. Over time, it may be expected that the uses of bioassessment data will be refined as the datasets grow and as organizations gain experience with the interpretation of information produced.

The fact that the states all use different methods is frustrating to anyone who is interested in making interstate comparisons. At present, there is no particular movement towards requiring the standardization of methods. However, as states gather more data and gain a better understanding of how to use it, and with continued improvements in data management, there is reason to hope that meaningful interstate comparisons may become more readily available in time.

12 Freshwater Mussels

More proactive freshwater mussel monitoring for species presence and population health is needed across the Delaware Estuary and River Basin. Freshwater mussels are not targeted in routine macroinvertebrate assessments, and so mussel surveys are rarely performed despite their value for assessing long term status and trends of aquatic health. Improved coordination and data sharing among states and PDE would also facilitate indicator development and watershed restoration planning. For the mussels themselves, there are numerous new technologies to rebuild native populations (e.g., Kreeger and Padeletti 2011), including surveys, reintroduction via relocation studies, and hatchery propagation of mussel seed for restocking. In addition,

critical habitat for mussel beds should be mapped and protected. These types of efforts should be supported to help preserve biodiversity and promote ecosystem services of freshwater mussels (Kreeger 2005), which are the most imperiled of all animals and plants.

Climate

1 – Air Temperature

The large corrections made to the monthly temperature data, particularly in the early part of the century, reveal a poorly constrained uncertainty in the temperature trends in the DRB. Research is needed to better quantify this uncertainty, perhaps through the identification of temperature stations that have required minimal adjustments or can be cross-calibrated.

The cause of the substantial warming observed in the DRB requires further investigation. Though numerous studies have been conducted to determine the causes of long-term temperature trends at continental and global scales, there has only been one study for the DRB (Najjar et al. 2009), which used GCMs from the 2001 Intergovernmental Panel on Climate Change report. Analysis of daily high and low temperatures may provide some insight as to the causes of long-term temperature change as these quantities respond differently to various types of radiative forcing, such as changes in greenhouse gases, aerosols, and cloudiness.

Given the Delaware River Basin's proximity to the sea and its large north-south temperature gradient, the global climate models recently used to investigate climate change in the region (Najjar et al. 2009; Kreeger et al. 2010) may be inadequate. Regional climate model simulations, which have been recently made available by the North American Regional Climate Change Assessment Program (Mearns et al. 2009), represent a substantial improvement over existing GCM simulations in terms of resolution and should be investigated in detail.

2 - Precipitation

The understanding of long-term changes in DRB precipitation is poor. Greenhouse gas emissions, at least according to the limited studies available, do not appear to be the cause of such changes. However, as noted for air temperature (Section 1.3), climate simulations that have been analyzed are of very coarse resolution and are unable to capture the fine-scale processes, particularly in summer when convective activity is high, that drive the precipitation process in the DRB. Therefore, regional climate models or statistical downscaling techniques should be considered as tools for investigating past and future precipitation change.

3 - Extremes

A more thorough analysis and literature review is needed for past trends in extremes in the DRB. A central issue is bias adjustment in daily precipitation and mean, minimum, and maximum temperature. Other studies, with different treatments of the data and different metrics (DeGaetano and Allen 2002; Brown et al. 2010) show some substantial differences with our analysis, and these need to be resolved. The science and management community in the DRB should stay abreast of regional and national climate studies that predict extreme events and storm intensity and frequency. Understanding of complex global and regional climate cycles and oceanic feedbacks is rapidly evolving but is still very limited. Nevertheless, warmer and wetter air masses are expected to provide suitable conditions to fuel stronger and more frequent weather events.

4 – Snow Cover

Snowfall depends on many factors in addition to temperature, such as the status of the NAO; therefore, the understanding of how climate affects snowfall would benefit from a more robust analysis of how local and regional weather events are affected by changing climate and associated weather patterns. For example, stronger winter storms such as occurred during the winters of 2010 and 2011 were sufficient to entrain cold air into the DRB, resulting in record snowfall despite overall warming conditions.

5 – Wind Speed

Since wind speeds are decreasing, this could have diverse effects on weather, agriculture, and other topics important to people and the environment. More study is needed to examine, for example, whether weaker winds might reduce evapotranspiration, promote slower moving thunderstorms and more persistent fog, thereby affecting the water budget and growing conditions for plants and animals.

6 – Stream Flow

Funding cutbacks threaten to diminish USGS monitoring capabilities for streamflow. Continued monitoring of stream and river flows is critically important to track changes in the water budget of the DRB, which affects estuarine salinty and freshwater availability for people and the environment.

7 – Ice Jams

More analysis is warranted to understand the connection between temperature, river flow, snowfall, and ice jam data quality and consistency. This indicator appears to serve as a useful indicator of a climate change "outcome" and should be further explored.

8 – Sea-Level Rise

Predicting rates of sea-level rise is critically important for coastal planners and resource managers due to the tremendous consequences for people and the environment, which depend on the timeline. Natural ecosystems and living resources all have tolerance limits for the rate of change to which they can adapt. Tipping points might be breached for some habitats such as salt marshes, a hallmark feature of the Delaware Estuary.
More research and monitoring is needed to track whether sea-level rise is contributing to or will contribute to increased salinity in the estuary and intrusion into groundwater. Since relative sea-level rise differs from absolute sea level rise, some of the elevation benchmarks may need to be replaced around the estuary due to past subsidence causing potential inaccuracies.

Restoration

1 – Hectares Restored Annually

Unfortunately, hundreds of thousands of hectares of natural habitats have been destroyed or significantly altered in the Delaware Estuary watershed during the past 10-15 years despite many governmental protections (see other chapters). Losses of forest area due to development (Chapter 1) and erosion of coastal wetlands (Chapter 5b) appear to far exceed any gains from restoration. Since these natural habitats purify our water, provide clean air to breathe and furnish other critical goods and services enabling the survival of both humans and natural communities, this trend in net loss of natural habitats is unsustainable, especially considering projections for human population growth (chapter 1). The Comprehensive Conservation Management Plan (CCMP) requires that restoration, protection and enhancement of natural habitats be a primary program objective of the Partnership for the Delaware Estuary, and a critical need will be to sustain funding for implementation of the CCMP as well as other core management programs that seek to reverse the declines in natural capital for the region, and to boost investment in voluntary restoration and protection of our remaining natural habitats.

Considering the limited restoration funding and high need, careful prioritization will be essential so that projects that get implemented target the most critical needs for maintaining core estuarine functions (PDE 2005, 2007,

Kreeger et al. 2006). The Delaware Estuary Regional Restoration Initiative (RRI) is an example of a prioritization program that seeks to identify the most ecologically significant species and habitats in a geospatial framework and then to direct restoration efforts to pivotal places and activities that lead to the greatest "uplift" of these resources. Ecologically significant is a designation given to natural resources which supply critical ecosystem goods and services, such as by a functional dominant species or habitats (or if they are rare then they must be threatened or a hallmark feature of the watershed). The RRI also intends to build efficient collaborations to spatially map and track restoration actions and build science-based consensus on restoration priorities.

Future monitoring and assessment reports would also be strengthened by development of enhanced tracking tools for restoration data, enabling better comparisons with land use data on habitat losses such as associated with development. One example of how tracking data can be used to inform habitat prioritization from the Schuylkill Watershed is a project by the Schuylkill Action Network and Delaware Valley Regional Planning Commission (DVRPC). The Schuylkill Watershed Priority Lands Strategy uses GIS modeling to identify areas within the Schuylkill Watershed that are the most important to preserve for both ecological and drinking water source protection, further defined by development threat over the next 20 years. Because developed land in the Schuylkill Watershed is expected to increase by 40% over the next two decades, this strategy can be used to direct inappropriate uses away from high priority resource areas as well as a guide to where restoration efforts can be most effective. The model is a series of maps that can be viewed on-line at http://www.schuylkillprioritylands.org/index.html. DVRPC has used this model to set goals for protection. See also Chapter 1, section 3.5, for actions and needs regarding land protection based changes in land cover trends.

2 – Balance of Restoration Types

In addition to setting overall goals for the amount of habitat to be restored, restoration investment should target habitat types that are deemed most critical for preserving the character and functionality of the unique Delaware Estuary watershed. New conservation and restoration prioritization tools that specify habitat types and places to be targeted should be used to guide strategic investments. To facilitate smarter restoration as well as progress tracking, data for completed projects should be entered into the PDE project Registry, along with data on unfunded project needs. Increased promotion, use, and maintenance of the PDE project registry could provide additional valuable information for continuing this effort in the future.

3 – Restoration Need

Until sufficient funding can be generated to materially stem losses of natural lands and restore critical habitats in the Delaware Estuary and Basin, management targets will need to be tempered and continued net losses of vital habitats will unfortunately still occur. There are a number of current efforts (PDE and others) to increase efficiency, implement strategic science-based priorities, and coordinate restoration activities. These include PDE's Regional Restoration Initiative and The Nature Conservancy's Delaware River Basin Conservation Initiative. However, these efforts will have limited benefits if restoration needs continue to be largely unmet because of stagnant and low levels of restoration investment across the Delaware Estuary and Basin.

Therefore, the top restoration need is funding, which can be justified by the economic value of the resources that are being eroded every day. There are several efforts underway to raise awareness of the need and to build support for directed federal investment, including an effort to pass the Delaware River Basin Conservation Act mentioned in previous sections of this report. If successful and authorized, this would provide $5 million for the entire basin. Whether these efforts will be successful and how these funds will be used/prioritized to meet the needs of the estuary and basin is not clear.

Joint STAC and MAC Meeting March 5, 2014

In its Regional Restoration Initiative, the Partnership for the Delaware Estuary proposed the concept of a *Delaware Estuary Basin Science & Restoration Trust* (Kreeger et al. 2006, PDE 2009), that with sustainable and significant funding, would be capable of addressing diverse restoration needs associated with key living resources, habitats and water resources and which is science-based and guided by strategic monitoring and assessment data. Such a Trust would be maintained and operated by Trustees representing federal and state agencies and other groups that have worked together to develop shared, consensus-driven regional restoration priorities. In 2010 the PDE Alliance for Comprehensive Ecosystem Solutions was created based on this model, but without a designated source of funding. This public-private Alliance meets annually to assesses, prioritize and begin promoting a set of priority restoration projects for the Delaware Estuary each year. Without a designated source of funding it relies entirely on the existing resources of its partners to support projects, and so has mainly been successful at drawing attention and pooling existing resources to focus on priority projects. However, it is a framework that can be quickly and easily adapted and expanded into the more comprehensive funding Trust originally envisioned, in the case that a source of funding emerges or is created.

Sources of financing for a Trust were explored by PDE with help from the Delaware Community Foundation, the Environmental Finance Center (EFC 2007), the Global Environmental Technologies Foundation, and the Keystone Conservation Trust. The funding mechanisms identified by those efforts require more policy capacity and influence that PDE has – a challenge PDE has been working to address but which has been exacerbated by economic and political conditions in recent years.

In brief, the Trust would provide a new vehicle for accepting and pooling funding from a variety of sources to meet diverse needs, including funding priority restoration and protection projects elevated through the Regional Restoration Initiative. It could include numerous operating centers where contributions could be earmarked for specific protection, restoration, monitoring or scientific activities. The vision is for the Trust to direct and fund wise investments in the future of the Estuary.