

# Effects of Storm Surge Barriers on the Hudson River Estuary: Final Workshop Summary and Scope of Future Work

Location: Center for the Urban River at Beczak, Yonkers, New York

Date: January 28, 2020

## 1. Introduction

This report summarizes the final workshop for the project, “Effects of Storm Surge Barriers on the Hudson River Estuary” (The “Estuary Effects Project”)<sup>1</sup>. The New York and New Jersey Harbor and Tributaries (HAT) Focus Area Feasibility Study is examining measures to reduce future flood risk, while contributing to the resilience of communities and important infrastructure. It is led by the U.S. Army Corps of Engineers (USACE or Corps), in cooperation with the New York State Department of Environmental Conservation (NYSDEC), New Jersey Department of Environmental Protection (NJDEP) and City of New York. Cross-estuary gated storm surge barriers are among several options being considered within the New York/New Jersey (NY/NJ) Harbor Estuary, and their potential environmental effects were the topic of the workshop.

The workshop included project updates for the (HAT) Study, as well as for the Estuary Effects Project and other relevant studies. Through a series of plenary and small-group discussions, participants contributed ideas for a Future Scope of Work for research on the estuary effects of gated storm surge barriers, addressing topics that are not yet planned under any of these studies. Participants included a mix of federal, state and city agencies, researchers and non-governmental organizations. The agenda is included as **Appendix A**, a list of participants is given in **Appendix B**, and the box below lists the workshop objectives.

### **Purpose of Final Workshop**

- Share, discuss and confirm results from September 2019 Surge Barrier Environmental Effects and Empirical Experience Workshop
- Present recent research results, including work from the Harbor and Tributaries Focus Area Feasibility (HAT) Study, NERRS- and NYSERDA-funded efforts, HRF and other related work
- Develop future research agenda priorities related to the potential environmental effects of storm surge barriers on the region’s estuaries
- Identify potential future funding needs and sources and opportunities for broader research collaboration

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<sup>1</sup> This project is funded by the National Estuarine Research Reserve System (NERRS) Science Collaborative and the NY State Energy Research and Development Authority (NYSERDA)

The workshop and Estuary Effects Project were identified repeatedly as a valuable opportunity for academia and other partners to share their knowledge in ways that can more deeply inform the science behind a federal study, in particular, the HAT Study. The project team's [full slide deck PPT](#) is available on [the project website](#), as are the Corps of Engineers slides.

The Estuary Effects Project is a one-year “catalyst” project designed to clarify interests and support research over a longer timescale. Accomplishments include a Scoping Session in March 2019 (35 attendees), the Surge Barrier Environmental Effects and Empirical Experience Workshop in September 2019 (35 attendees), ongoing research into the effects of sea level rise on surge barrier management and the effects of management strategies, and this final workshop (44 attendees). All major activities have been advised by a 14-member Project Advisory Committee. The formation of future research priorities may extend beyond the original Estuary Effects Project area of the Hudson River estuary in the future to other regional estuaries where surge barriers are being studied.

## 2. Project-Related Updates

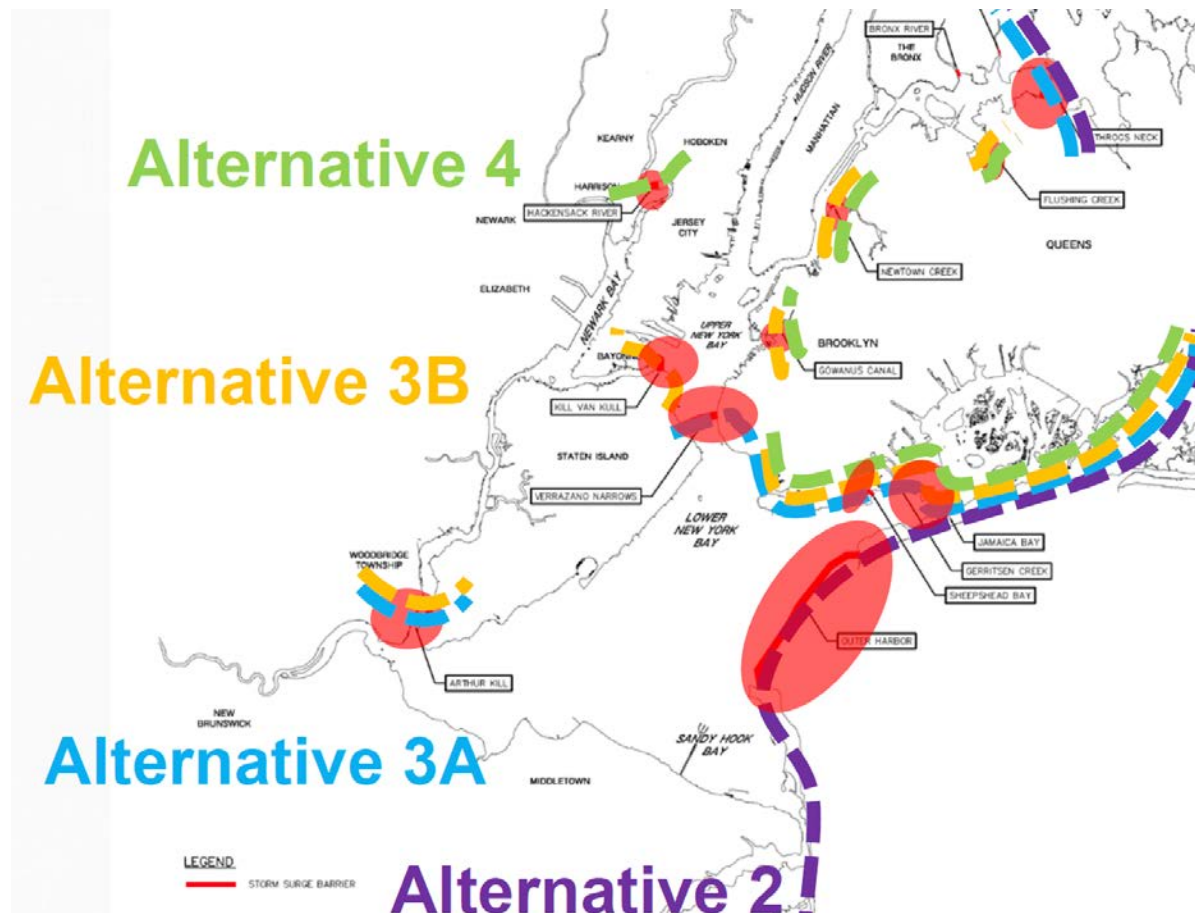
Updates were provided on relevant projects to provide context for the day's workshop discussions.

USACE (Bryce Wisemiller) provided an update on the [Harbor and Tributaries Focus Area Feasibility \(HAT\)](#) Study, and a summary of environmental studies they expect to conduct in 2019. The workshop agenda (**Appendix A**) has URL links to all presentation slides. The study time horizon is to 2105, and it will utilize the USACE intermediate sea level rise projection. It will also do a sensitivity analysis with a more extreme sea level rise scenario (the New York City Panel on Climate Change 90<sup>th</sup> percentile). The study is evaluating a range of flood risk reduction “alternatives” from primarily shore-based measures to primarily surge barrier-based measures. The alternatives that include storm surge barriers are all shown in **Figure 1**.

All surge barrier designs in the HAT Study have large and/or multiple gate openings, with the goal of minimizing obstruction and change in estuary conditions when they are open. Larger numbers of gates increase costs. The Study considers design alternatives that have an open (gated) cross-sectional area of 55-60% and permanent obstruction area of 35-40% (e.g. the islands or other fixed infrastructure surrounding the gates). This range of cross sectional areas can lead to small reductions in tide ranges (less than 5%) in the interior estuaries. However, the tide range reduction can be larger for spring and king tides. The height of the base of a gate section (the sill) is an important factor for estuary and sediment flows.

The Corps is currently assuming that any surge barrier under consideration would be closed on average no more than once per year. This is based on a management plan for closures being triggered by a water level pertaining to a 2-year or 10-year storm (Annual Exceedance Probability (AEP) of 0.5 or 0.1 respectively). As sea level rises, this trigger water level will need to be updated periodically, perhaps once per decade, or the frequency of closure will increase dramatically, along with operation and maintenance costs. Results are still preliminary, and much modeling and assessment still needs to be done including further barrier design iterations, cases with smaller and larger barriers closing at different AEP, effects and mitigation for port operations, a possible new location for the Verrazzano barrier, and costs of dealing with interior stormwater behind seawalls.

A major driver of the decision on a Tentatively Selected Plan will be the net dollar benefit (benefit of reduced flooding minus costs). In the most recent results from summer 2019, the net benefit for a 0.5 AEP trigger threshold was best for Alt3A (\$130 billion). The net benefits for a 0.1 AEP trigger threshold were similar for Alt3A, Alt3B and Alt4 (\$65-80 billion), the latter two of which do not include cross-harbor barriers affecting the Hudson.



**Figure 1:** Conceptual alternative layouts showing features involving storm surge barriers (red areas) being considered in the HAT Study

A summary was provided by Philip Orton, Sarah Fernald and Kristin Marcell of the Estuary Effects Project's September 2019 scientific workshop titled Surge Barrier Environmental Effects and Empirical Experience (see separate [workshop report](#)). That workshop's goals were to: (1) identify the present scientific understanding regarding surge barrier environmental effects, highlighting both areas of consensus and divergence; (2) identify key additional data, research and models; (3) build collaboration among people involved in the topic around the world, including sharing empirical data and experience from past surge barrier projects, as well as approaches for evaluating environmental effects in present studies; and (4) improve the scientific foundation for decision-makers and end users of the HAT Study.

Three main focus topics for the scientific workshop were (a) empirical experience from constructed gated storm surge barriers, (b) potential surge barrier effects on migrating organisms, and (c) potential surge barrier effects on tidal wetlands. The workshop's presentations and break-out sessions identified key areas of agreement, but also areas where research is needed. Key takeaways and research needs were summarized by the speakers, to inform the day's discussions of future research needs. Several audience members asked for clarifications, and these are generally incorporated in the texts above. Further considerations are briefly summarized here.

Further considerations:

- Larval adaptations are keyed into two things: spring tides and vertical structure of salinity. This is an important life/species stage in the Verrazano Narrows, where one barrier is under consideration, and needs to be considered. Read Steve Morgan's writings on larval migrations (Chapter 12 in Levinton and Waldman, 2006).
- Some eggs are semi-buoyant, and the HAT Study should consider impacts to those species.
- The HAT Study must consider species that have recently returned to the region (e.g. whales) or recent arrivals due to ocean warming. The USACE indicated that their study will seek to evaluate what species are presently using the harbor and estuaries.
- Separate future questions into research vs. monitoring, and consider how much the modeling depends on the quality and completeness of the data for the region.

### **3. Update on Research Results and Ongoing Studies**

Updates were provided on related research efforts, both recently undertaken work and planned future studies.

### ***3.1 Estuary Effects Study research update***

Philip Orton and Ph.D. student Ziyu Chen provided an update on the Estuary Effects Project.

The following research areas have been covered by Stevens:

1. Preliminary evaluation of the physical influences of storm surge barriers on the estuary
2. Modeling of how barriers with open gates influence estuary physical conditions (Orton and Ralston, 2018)
3. Quantification of gate closure frequency and duration, with two management strategies:
  - a. Strategy #1: Constant trigger water level, resulting in a rise in gate closure frequency, duration with sea level rise (SLR)
  - b. Strategy #2: Constant trigger AEP, requiring a rise in waterfront elevations with SLR
4. Quantification of trapped water levels and how they change with SLR
5. Modeling of the influence of various closure durations and frequencies on estuary physical conditions (in progress)

Results for research topics 2-4 above are expected this spring and will be presented to this community via webinar. Preliminary results of research areas #2 and 3 above were presented by Ziyu and are summarized below.

Gate closure frequency and duration both strongly influence the effects of a surge barrier system on the enclosed estuaries. We used historical empirical data to represent water level variability, and then computed the gate closure frequency and duration for events above the National Weather Service (NWS) major flood threshold. Impacts of forecast uncertainty were evaluated by synthesizing 95th percentile forecast peak water levels.

Results demonstrated that the future decade of arrival of a 0.5 AEP (or 0.1 AEP) of the major flood level has high uncertainty due to sea level rise, even if emissions trajectory uncertainty is ignored. If closures are managed by a constant water level trigger, sea level rise causes both increasing closure frequency and duration. If closures are managed by a maximum gate closure frequency (e.g. 0.5/year), seawalls will need to be raised on a regular basis to manage risk in future decades.

During a storm surge, closed gates may trap streamflow and cause trapped river water flooding. However, the probability of trapped river water flooding will be very low in the coming decades. Rising sea levels increase the probability of trapped river water flooding, but closure frequency is a much bigger challenge and will exceed 0.5 AEP well in advance of the trapped water becoming a probable event.

Lastly, Orton presented preliminary modeling results for topic #4 showing how the estuarine water level, salinity and stratification change in response to barrier closures. One example simulation was shown -- a month-long estuary simulation with only tides (no wind) and average river streamflows and a 3-day gate closure. The vertical salinity stratification more-than-doubled (from 10 to >20 ppt) and the salt intrusion moved about 40 km up-estuary. The salt front moved up-estuary due to the along-estuary gradient in water density and resulting up-estuary force on bottom water, along with the lack of tidal mixing to vertically mix this saline deepwater current. However, once the gates were reopened, the tides and mixing returned and the estuary returned to nearly normal conditions within a few weeks. Chen and Orton are in the process of testing model uncertainties/sensitivities and the importance of river streamflows (drought vs mean). They are planning to run the model for about 30 different scenarios spanning closure frequency, duration, storm type and streamflow.

These results can help the Corps understand potential management regimes and better estimate costs and benefits for the surge barriers. For example, the results showed that the USACE Intermediate SLR projection is below the IPCC's central estimate (RCP4.5) and well below the IPCC's 90% percentile. Therefore, HATS may underestimate the cost of seawalls (and the benefit of reduced flood damage) in its cost-benefit analysis.

It was requested that the USACE and Stevens models be compared, and this is planned in the Estuary Effects Project.

### ***3.2 HAT Study science update***

Kyle McKay presented an overview of the Corps' recent and future environmental studies. He provided a brief summary of the New Jersey Back Bays (NJBB) Feasibility Study, to give a broader perspective on regional surge barrier studies being considered for New Jersey and Long Island estuaries. He showed how the hydrodynamic model (AdH) is being used to study water speeds around open surge barrier gates. He explained the process of the Tiered Environmental Impact Assessment and its various topical considerations.

McKay addressed how the Corps will apply the New York Bight Ecological Model (NYBEM) to inform the process going forward. The HAT Study is working toward building conceptual models of all components of the ecosystem. The goal is to at least qualitatively, and in some cases quantitatively, capture all potential impacts and potential mitigation requirements and costs. A series of workshops is being held to obtain expert input and iteratively develop NYBEM, with research and synthesis between meetings. Its sub-models will be developed iteratively and applied to the project. Data will be available at each phase of project planning for the entire project area (greater than 2,000 square miles). McKay expressed interest in collaborating with workshop participants as his modeling moves forward.

McKay also laid out a page of additional near-term and long-term study needs and key questions that could potentially inform the afternoon discussion on priorities. This list can be found on the last slide in his deck, available on the project website.

Audience questions centered on understanding the level of complexity of NYBEM's ecological functions, and the importance of capturing how pollution or sewage spill events evolve with closed barriers. One concern was that ecological impacts of closed barriers during a storm could have a long duration. Another was that trapped pathogens during a gate closure could become attached to sediment particles and remain trapped for a much longer time than water modeling alone would suggest.

### ***3.3 New Hudson River Foundation studies***

Jim Lodge summarized two new studies funded by the Hudson River Foundation. The first was "East River Transit, Long Island Nurseries, and Striped Bass Production" (David Secor, PI). The central research topics to be studied are: (1) potential consequences of an East River storm surge barrier on HR striped bass recruitment, and (2) understanding the importance of "extra-HR" nurseries in western Long Island Sound to striped bass recruitment. The second was "Assessing the Impacts of Storm Surge Barriers on Physical Conditions and Sediment Transport in the Hudson River Estuary" (David Ralston, PI). This project builds on the preliminary study of impacts of storm surge barriers on physical conditions (Orton and Ralston, 2018). It will apply higher-resolution nested grids to better resolve flow near the barriers and represent currently conceptualized barrier configurations, use a broader range of seasonal to interannual forcing conditions, and characterize a wider array of potential physical impacts. The study will also assess changes in sediment transport processes associated with different barrier configurations, both near the barriers and in the estuary overall.

## **4. Identifying Future Research Needs and Priorities**

Through a series of presentations and plenary and small-group discussions guided by Bennett Brooks with the Consensus Building Institute, the audience was asked to help identify the research topics that should be moved forward in the next three years and beyond.

### **4.1 Science Workshop Top Priority #1: Tidal marsh sediment supply**

First, Orton recapped some of the present state-of-knowledge regarding tidal marsh sediment supply, from the September 2019 workshop (Orton et al. 2019). Tides, low-frequency water level, salinity and sediment are primary factors in wetland stability and evolution, as well as their response to sea level rise. Estuaries are excellent sediment traps, focusing sediment deposition and resuspension in the region around the salt front. Coastal storm events provide a large source of sediment to the NY/NJ Harbor region and its wetlands. The location of a tidal wetland is a critical factor in how estuary physical changes would affect any given wetland. A small tide range and lack of sediment supply can lead to ponding and collapse. Storm erosion

occurs primarily in high-frequency events via wave energy. In larger low-frequency storms the water is too deep to cause edge erosion.

Surge barrier related changes to the estuary would be expected to include reductions in high-tide levels and elimination of extreme storm surge events. Climate-related changes are likely to trigger changes to mean sea level, salt intrusion and streamflow. Two major research needs identified in the September workshop were:

- What is the spatial relationship of existing wetlands relative to sediment reservoirs and their variability?
- How do tides and surges affect accretion in geomorphically-relevant events for tidal wetlands?

Orton summarized a pre-proposal that was submitted to the NERRS Science Collaborative for a research project similar to the Estuary Effects Project, but with an additional focus area on tidal marsh sediment supply. The proposed three-year project would begin in fall 2020 and have two main objectives: (1) continue this current collaborative process among scientists and end-users to broadly assess surge barrier effects, and (2) conduct field measurements, analyses and modeling to assess how climate change and possible surge barriers will influence sediment delivery to tidal wetlands. It would have the same project team but also include additional researchers at Stevens Institute and Brian Yellen and Jon Woodruff of University of Massachusetts Amherst.

The central scientific questions of the proposed work include: What magnitude of tides and surges are important for long-term accretion on the Hudson's tidal wetlands? How will climate change and possible surge barriers affect sediment delivery to tidal marshes? How do these answers vary with distance from the marsh edge or distance up the estuary?

These questions will be addressed with an observation and model-based study of Piermont and Tivoli North Bay marshes. Specific task areas include the following:

- (1) Analysis of existing turbidity and water level data,
- (2) Full water column monitoring at Piermont Marsh and Tivoli North Bay,
- (3) Sediment coring and surveys, and
- (4) Detailed estuary-marsh modeling of storms and tides.

The team has reached out and plans to work with several outside collaborators in the study, including David Secor, Neil Ganju, Gregg Kenney, David Ralston, Kyle McKay and Bryce Wisemiller. Full proposals are due in April 2020.



The audience was prompted with specific questions: Did we miss anything? What else could be studied related to this topic? Are there researchers, other than those we have contacted, who could add their expertise to answering these questions?

Audience inputs included:

- How will the salt front moving northward affect the vegetation in the northern estuary wetlands systems? What is the ground state of the biotas in both areas (literature review) and how could it change as salinity changes? How will this affect the distribution of the common reed in wetlands in the region? Will a “Piermont condition” (in terms of salinity and resulting flora) increasingly be observed up north? How will that affect biota?
- The Upper Hudson has locally rare tidal marshes and has lost significant spawning sites. How will reduction in tidal range affect fish habitat in these marshes – like Stockport Flats? Consider extending the geographic reach further northward.
- Tom Grothues (Rutgers) was suggested as a researcher interested in creation of near-shore habitat – how could these protective structures be used to increase near-shore habitat and upland vegetation?
- Marshes in NYC will be the first loss, as they are crumbling from the edges. Need to recognize that and study the effects on them.
- Building on the conceptual model and data we are collecting – play out a range of “sensitivity thought experiments” on possible future marsh trajectories. Cover a wide variety of scenarios of sea level rise, riverine flooding, extreme events, etc. – play these out and evaluate marsh sedimentation.
- Consider winds and waves that would now occur with lower estuary water levels – how will this affect edge erosion for tidal wetlands, and sediment movement?
- Given the recent, post-Katrina and post-oil spill spate of coastal structures and predictive sediment transport modeling in Louisiana, is there anything we can learn from what they have done? Can we learn from collaborating with those researchers, or from their successes or failures with similar modeling efforts?

#### **4.2 Science Workshop Top Priority #2: Comprehensive survey of migrating organisms**

Kristin Marcell recapped the summary points, the research needs and questions identified in the September workshop (Orton et al. 2019).

Summary Points

- The Hudson is one of the principal nurseries on Atlantic coast, and a key corridor for a variety of resident and migratory species.
- It is unclear how other barrier systems in the world have affected aquatic populations (lack of data).
- There are very large uncertainties for ecological effects.

- There is limited knowledge of species life cycle use of Harbor Estuary below Battery compared to the Hudson River.
- The key scientific needs identified were
  1. A more complete set of baseline measurements – What species use the areas where barriers are under consideration? Where in the water column? How do they use it?
  2. Hydrodynamic modeling of larval transport; and
  3. Research on how construction, structure and operation of barriers will affect animals.

Additional questions included:

- What is relative importance of the Hudson vs. other regional habitats?
- How could obstructions like barriers change species assemblages, phenology, migration behavior?
- Could gate structures make populations increasingly discrete?
- Will the effects of obstructions work against species adaptations to climate change by curtailing connectivity?
- Can we see evidence of species migration northward to understand movement due to climate change?

The following were identified as existing information to consider in the Harbor region:

- Utility survey – harbor going back to 1980, winter trawl (SUNY Stony Brook); may cover Verrazano region.
- Sonic tag data demonstrates that the Rockaways provide important habitat for Atlantic sturgeon. Populations stage there in the fall and possibly spring.
- Ralston/Levinton paper on oysters – Tappan Zee and Verrazano are important regions for oysters and larvae. Fish larvae use temperature and salt to determine where they are and where they are heading. Tappan Zee population of oysters is likely distinct and an indigenous population. Oyster population in NY Harbor is still struggling and we don't know why.
- Ken Able – Rutgers Univ Marine Field Station. Has 30-year data sets on fish, but outside the harbor.
- We should be linking and connecting data sets across the region.
- Ask Long Term Environmental Research stations in the region if they have high-quality long-term data sets for this region.
- Wildlife Conservation Society – Mary Camhi, shark research in NYS, oversees all their work on fish.
- Start with local data sets in the migration corridor. Work to make the data sets comparable.

- A prior study by Hydroqual/HDR (Use and Standards Attainability Analysis) collected ecological data for two years – could be of use (needs to be cleared by NYC DEP)
- Other fish data sets are out there – DOT Tappan Zee, striped bass
- The River Project has a 25-year fish tracking data set

What questions or topics have we missed?

- How will increased salinity affect early life stages? Can study salinity range that is acceptable for anadromous fish in lab situation. Most species show strong homing notion – what is impact of fish coming up to a barrier? Will they go up through the barrier and go past or turn around and go elsewhere? How will behavior and homing fidelity be affected?
- Make sure to first understand the ecological geography of the Hudson. Consider the two major salinity/temperature realms – Haverstraw and Verrazano – need to understand that geography and how these regions isolate species and determine their migration patterns.
- Juvenile eels are poor swimmers. Will they be deflected away from the river at a barrier and head elsewhere instead of upriver via passive transport? What will they do?
- If modeling larvae, density gradients are very important for understanding larval behavior.
- Don't forget about ice jam events and their influence on circulation/salt intrusion.
- There is a lack of contaminant mapping in the NYNJ Harbor region.
- Many species of organisms are utterly dependent on Verrazano Narrows, could have major impact on organisms that depend on moving both directions (Steve Morgan is the relevant researcher on the topic)
- An emphasis should be on movement of sturgeon, flounder, bottom organisms around the sill environment
- The survey needs to go beyond migrating organisms. Analysis needs to include resident species.
- Sturgeon are not likely to use sills – they have never swum past a lock in a dam.
- Effects will be as great on resident species as migratory – surge barriers will affect success of species in the river.

Who should lead this work? Can we find a coalition of the willing? Are there researchers here today that are interested in organizing discussion or pursuing funding to answer these questions?

- Consider framing it around the five guilds – known experts in each guild, find them to frame the research. There are some known experts in various areas (eels, striped bass)
- Dawn Dittman (USGS), Len Machut – eel research in Hudson
- Consider an agent-based modeling framework. Dave Smith collects data on environments around infrastructure.

- John Waldman, Jose Anondon (sp?) should be tapped regarding their Jamaica Bay surveys

Given that few in the audience were volunteering to pursue funding and survey efforts, Bennett sought to clarify the relative importance of the survey to participants. A show of hands indicated that it is seen as an important topic. Peter Wepler said that the Corps has a similar debate going on in all the projects they are working on. Its efforts, however, are only just beginning and the Corps knows surveys are needed to predict outcomes. Peter said he would request a 3-5 year study through planning and construction funds. This could also include a regional approach, considering there are datasets in the Hudson, NJ, and Long Island. Such studies (perhaps possible in the Corps' next phase of work) will give USACE ERDC a better sense of the region.

What would the concrete next step be? For one thing, it would require a combination of large-scale geographic studies and fine-scale studies. Additionally, it would need a good understanding of animal behavior to couple with the hydrodynamic model. Uncertainty will be high for a variety of behavioral characteristics. A study could pull in collaborators from the dam research community, who would likely be interested.

#### ***4.3 Identifying future estuary effects research needs and priorities***

Small group and plenary discussions among participants were used to identify other essential research priorities. The audience was asked to focus on things that could be done in the next three years to evaluate the potential effects of barriers.

##### Overall/General

- Continue to collaborate with USACE to do work they cannot – model sunny day/nuisance flooding, ecosystem services valuation, benefit/cost analysis.
- The USACE looked at 1% AEP based on historical storms. A companion research study could look at how storms might also change in future.
- Consider an integrated approach to flood risk – how will we manage groundwater and rainfall and development in low areas?

##### Water Quality

- Need empirical data on effects over duration of barrier closure. What are the consequences for hypoxia, HABs? If these embayments are stagnant for a period of days it is likely to have large consequences for fish kills, pathogens.
- Modeling needed at small scales: Small-scale processes behind barriers (e.g., deposition and resuspension of contaminants) can have cumulative effects. Embayments should be modeled. Many models break down in the nearshore environment. This will be important for smaller barriers – like Gowanus – if advanced in the study.

- What will be the impacts of gate closures on trapping sewage, inducing stratification, etc.
- What is the potential effect of trapping of farm-derived nutrient loads?
- Consider potential benefits to the environment (e.g., residence time in Jamaica Bay). One might increase flushing with closing one side of auxiliary gates and not another.

#### Wetlands

- Loss of tidal range of 5% on high end of marsh means we could lose high marsh range on land

#### Organisms

- Creating a barrier may create fish attraction devices for large predators. Where fish congregate, they will be more likely to be found by large predators. Could do research in other areas to see if this is happening, e.g. in Louisiana.
- What organisms or systems benefit from storm-driven sediment re-suspension? Catalog these and study what the effects will be. Look over large timescales – 10-year, 20-year time horizons.
- Need research on the impact of the sills associated with the barriers on benthic and demersal organisms (flounder, horseshoe crabs, sturgeon, etc.). Not just research on impacts, but also potential mitigation strategies.
- The shadow pattern of the barrier structures on the river may influence fish behavior
- What will be the impacts of changing physical conditions on organism larval stages (i.e. turbulence at barriers, changing salinity patterns, etc.)
- Consider population-level outcomes for fish not just individual migrating fishes. Evaluate entire populations and their risk.
- How can we enhance the habitat value of structures?
- Estuary salinity changes would affect many organisms and also water supplies for locations like Poughkeepsie

#### Long-term planning

- Need to identify criteria that can help evaluate which restoration and other long-term projects should be moved forward from a flood risk perspective or from a barrier implementation perspective. Similar for other long-term planning – like long-term control plans. Need to account for how the system might change.
- Climate change is a confounding variable. We must integrate our understanding of other drivers of change in chemical, physical and biological processes. Water temperature, changing precipitation patterns, and coastal acidification will all cause changes independent of the barriers, but will be confounded with climate change.
- The long time frame of construction impacts should be considered. These are long term noise and turbidity impacts. What are the changing assumptions in the 25 years to construction completion? How will this change in response to sea-level rise?

- Future of railroad rails along Hudson River and Raritan Bay, will they simply be elevated? Are there opportunities to increase habitat connectivity?

## **5. Research Funding Needs and Collaboration Opportunities**

Participants were asked to identify needs and opportunities for leveraging or finding additional funding for conducting near-term or long-term priority research on estuary effects of surge barriers taking into consideration NERRS and other funding sources.

Several excellent suggestions came in, summarized here:

- NOAA National Marine Fisheries Service possible funding – Resiliency, restoration, oyster farming. 50% funding.
- Scientists or the USACE should request that NYC-DEP consider surge barriers scenarios in its existing or planned water quality / climate change studies.
- HRF or other foundations should seek to engage other foundations with a broader purview – e.g. the Sloan Foundation can consider larger issues. Individual researchers can try, but it would be more effective for a smaller foundation or organization to approach them. Perhaps create a consortium of foundations to address this major issue in one of the great cities of the world, on a topic of relevance globally.
- National Institute of Environmental Health Sciences – has been funding work on exposure to contaminants and public health.
- NIH/NIEHS “Superfund Program” Grant – note that end point has to be human health
- EPA Rapid Grants to do data collection or modeling to help clarify HAT Study decisions
- Private foundations with interest in environmental projects, such as the Moore, Simons, Hewlett, Packard Foundations – seek a private meeting, seek to build a case that it fits their interests. Probability of failure is 95%, but if interested, they can provide significant funding.
- For a fish survey, consider seeking funding from the Pew Lenfest Oceans Program – interested in this area. Based in DC.

## **6. Conclusions and Next Steps**

A draft workshop summary report (this document) is to be created and circulated with the PAC for input. A final workshop summary report is to be provided to all workshop participants. Also, there will be a final webinar on the Estuary Effects Project’s research to present final results.

## Appendix A: Agenda

### Assessing the Effects of Storm Surge Barriers on the Hudson River Estuary

Final Workshop | January 28, 2020 | 10am - 4pm (snow date: January 30<sup>th</sup>)

Location: Center for the Urban River at Beczak, 35 Alexander Street, Yonkers, NY

#### PARTICIPANT AGENDA

##### Purpose of Final Workshop

- Share, discuss and confirm results from September 2019 Surge Barrier Environmental Effects and Empirical Experience Workshop
- Present recent research results, including work from the Harbor and Tributaries Focus Area Feasibility (HAT) Study, NERRS- and NYSERDA-funded efforts, HRF and other related work
- Develop future research agenda priorities related to the potential environmental effects of storm surge barriers on the region's estuaries
- Identify potential future funding needs and sources and opportunities for broader research collaboration

#### 9:45 AM Arrival & Greeting

#### 10:00 AM Introduction, Welcome and Background

Welcome remarks and workshop purpose (Philip Orton, Stevens Institute of Technology)  
Agenda review and session ground rules (Bennett Brooks, Consensus Building Institute)  
Participant self-introductions  
Brief project overview (P. Orton)

#### 10:20 AM Project-Related Updates

Updates on relevant projects to provide context for workshop discussions

- NY/NJ Harbor and Tributary Study (Bryce Wisemiller, USACE)
- September 2019 Surge Barrier Environmental Effects and Empirical Experience Workshop (P. Orton; Kristin Marcell, NYS DEC's Hudson River Estuary Program; Sarah Fernald, NEIWPC/Hudson River National Estuarine Research Reserve)

#### 11:15 AM Update on Research Results and Ongoing Studies

Opportunity for updates on related research efforts – recently undertaken work and planned future studies

- NERRS- and NYSERDA-funded research (P. Orton and Ziyu Chen, Stevens Institute)
- USACE NY/NJ Harbor and Tributary Study – Recent and future environmental studies and needs (Kyle McKay, USACE)
- Hudson River Foundation-funded studies (Jim Lodge, HRF)

**12:20 PM Lunch Break (provided on-site)**

**1:00 PM Identifying Future Research Needs and Priorities**

Discussion among workshop participants to identify top research priorities related to the environmental effects of surge barriers

- Part 1: Presentation and discussion of Science Workshop Top Priority: Sedimentation research proposal outline (P. Orton)
- Part 2: Presentation and discussion of Science Workshop Top Priority: Comprehensive survey of migrating organisms (K. Marcell)

**2:00 PM Break**

**2:15 PM Identifying Future Research Needs and Priorities (continued)**

Continue discussion among workshop participants to identify top research priorities related to the environmental effects of surge barriers

- Part 3: Small group and plenary discussions among participants to identify other essential research priorities

**3:30 PM Research Funding Needs and Collaboration Opportunities**

Identify needs and opportunities for leveraging or finding additional funding for conducting near-term or long-term priority research on estuary effects of surge barriers; consideration of NERRS and other funding sources

**3:50 PM Wrap-up, next steps**

Review key discussion points and next steps

**4:00 PM Adjourn**

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**We invite participants to join after the meeting formally adjourns for the following.....**

**4:00 - 5:00pm Informal collaboration hour - feel free to stick around, continue conversations and strike up collaborations**

**After 5:00pm: No-Host Happy Hour  
Yonkers Brewing Company, 92 Main Street, Yonkers**



## Appendix B: Attendance List

<b>First</b>	<b>Last</b>	<b>Affiliation</b>
Brett	Branco	Brooklyn College
Bennett	Brooks	Consensus Building Institute
Tracy	Brown	Save the Sound
Ziyu	Chen	Stevens Institute of Technology
Matthew	Chlebus	NY-Department of Environmental Conservation
McKenna	Coons	HR-NERR
Richard	Corman	The River Project
Patty	Doerr	The Nature Conservancy NJ Chapter
Frances	Dunwell	NY-Department of Environmental Conservation, HREP
Sarah	Fernald	HR-NERR/NYS-DEC
Stuart	Findlay	Cary Institute for Ecosyst. Studies
James	Fitzpatrick	HDR, Inc
Heather	Gierloff	Hudson River National Estuarine Research Reserve
Tom	Herrington	Monmouth University
Paul	Higgins	Port Authority of NY/NJ
George	Jackman	Riverkeeper
Marcha	Johnson	CCNY
Christina	Kaunzinger	Rutgers
Gregg	Kenney	NYS-DEC
Jeffrey	Levinton	Stony Brook University
Jim	Lodge	Hudson River Foundation
Kristin	Marcell	NYS-DEC
Steve	Mars	USFWS Field Office for NJ
Reza	Marsooli	Stevens Institute of Technology
Mike	McCann	The Nature Conservancy
Kyle	McKay	USACE WEC
Greg	O'Mullan	CUNY Queens College
Yaprak	Onat	Univ. of Connecticut
Philip	Orton	Stevens Institute of Technology
Ryan	Palmer	CURB/Beczak
Adam	Parris	NYC- Mayor's Office of Resiliency
Doug	Partridge	Arcadis Inc
Rob	Pirani	NY-NJ Harbor Estuary Program
Chris	Schubert	USGS Water Science Center
Peter	Sheng	University of Florida
Clay	Sherman	NJ DEP Office of Engineering and Construction
Dave	Smith	ERDC Environmental Lab Vicksburg
Amanda	Stevens	NYSERDA
Nava	Tabak	Scenic Hudson
Dana	Tricarico	WCS
Alison	Verkade	NOAA NMFS
Peter	Weppler	USACE New York, Environmental Analysis Branch
Isaac	Wirgin	NYU
Bryce	Wisemiller	USACE New York