**Final Report Narrative**

**Title page**

1) Project title

**Catalyzing a deeper understanding of the effects of storm surge barriers on the Hudson River estuary**

2) Project lead

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4) Name of reserves involved in the project

The Hudson River National Estuarine Research Reserve (HRNERR)

5) Project period

September 1, 2018 to February 28, 2020

**Abstract**

Storm surge barriers are one of the most effective approaches for avoiding damage and loss of life during floods at harbors and cities. However, the environmental effects of surge barriers are poorly understood, and there is a strong consensus that further study is needed, with participation from a broad range of scientific disciplines. When their gates are open, their fixed infrastructure reduces the flow cross-sectional area of an inlet or estuary channel, leading to some degree of continuous physical changes throughout the estuary. When gates are closed to prevent flooding, all water flow past the cross-section is blocked including tidal exchange and storm surge, and therefore closure has a very strong influence on estuary conditions and processes.

The U.S. Army Corps of Engineers, states of New York and New Jersey, and New York City are partnering under the Harbor and Tributaries Focus Area Feasibility (HAT) Study to evaluate surge barriers and other options to manage coastal storm risks. The National Estuarine Research Reserve Science Collaborative funded a "Catalyst" project for one year with the following goals: (1) to facilitate development of a collaborative research agenda that can help interested parties better understand potential barrier effects on nearby estuaries (specifically addressing a Hudson River NERR site's research need), and (2) to undertake targeted research in close collaboration and with information-sharing among scientists and key end-users such as the U.S. Army Corps of Engineers and its partners.

Research on the effects of sea level rise (SLR) on surge barrier closure frequency and duration was deemed to be of crucial importance in the Scoping Session because it strongly influences any environmental impacts on the enclosed estuaries. This research helped quantify how the surge barriers do not solve the problem of SLR, enabling stakeholders to better understand and advocate for the USACE to address this problem in the HAT Study. It has been completed and submitted for peer-reviewed publication.

Engagement through three project workshops focused on better understanding stakeholders' concerns and priorities related to further scientific measurements or studies. Major outcomes of the completed project were (a) a substantially improved understanding of the potential effects of surge barriers on the Hudson River and its NERR sites, helping inform the HAT Study, (b) broadening of the research community, further expanding the scientific personnel and scope of expertise, (c) collaborative development of future research priorities, and (d) stronger integration and understanding across the research community and key end users, thereby providing a more robust and trusted foundation for future collaboration on surge barrier-related topics. Owing in part to strong leveraging of funding from two other projects, a student doctoral dissertation is also anticipated to result from the project research.

In conclusion, the project amplified existing collaborative science, and was identified repeatedly as a rare and valuable opportunity for academia and other partners to share their knowledge in ways that could more deeply inform the science behind a federal study, in particular, the HAT Study.

## 1. Project Background and Approach

Repeated record-setting years for hurricane damages are accelerating interest in engineering approaches for coastal flood risk reduction, including closable storm surge barriers or tide gates. Storm surge barriers are one of the most effective approaches for avoiding damage and loss of life during floods at harbors and cities (NRC, 2014; Deltacommissie, 2009). They typically span the opening to a harbor or river mouth and include gates that are only closed when storm surges are expected. When gates are open, their fixed infrastructure reduces the flow cross-sectional area of an inlet or estuary channel, leading to some degree of continuous physical changes throughout the estuary (Du et al., 2017; Orton & Ralston, 2018). When gates are closed to prevent flooding, all water flow past the cross-section is blocked including tidal exchange and storm surge, and therefore closure has a very strong influence on estuary conditions and processes.

The environmental effects of surge barriers are poorly understood, and there is a strong consensus that further study is needed, with participation from a broad range of scientific disciplines (e.g., Brand et al., 2016; Swanson et al., 2013; Orton et al., 2019). Surge barrier systems can reduce estuary tide range, flushing and vertical mixing, which can cause increases in stratification, salt intrusion and pollution trapping, and reductions in dissolved oxygen concentrations (e.g., Orton and Ralston, 2018; Fischbach et al., 2018; Kirshen et al., 2018; Du et al., 2017; Swanson et al., 2013).

The U.S. Army Corps of Engineers, states of New York and New Jersey, and New York City are partnering under the Harbor and Tributaries Focus Area Feasibility (HAT) Study to evaluate surge barriers and other options to manage coastal storm risks. Of the project's five risk reduction strategies being evaluated, two include cross-harbor surge barrier systems that would influence the Hudson River estuary and its National Estuarine Research Reserve sites. The HAT Study is currently on pause due to a funding gap, but given that the effort has completed 4.5 years of its 7-year process, it is likely that the USACE will at some point complete (at least) its present year of work and provide a Tentatively Selected Plan.

Scientists and engineers are increasingly recognizing the need for collaboration on research that more fully explores the advantages and disadvantages of large surge barriers. The National Estuarine Research Reserve Science Collaborative funded a "Catalyst" project for one year with the following goals: (1) to facilitate development of a collaborative research agenda that can help interested parties better understand potential barrier effects on nearby estuaries (specifically addressing a Hudson River NERR site's research need), and (2) to undertake targeted research in close collaboration and with information-sharing among scientists and key end-users such as the U.S. Army Corps of Engineers and its partners. The project's primary End Users in the project are listed in **Table 1**, all of whom were members of a larger Project Advisory Committee representing 14 organizations.

**Table 1**: The project's primary End Users

| Organization | Lead | Role in Project | How shaped project | How benefitted from Project |
|---|---|---|---|---|
| Hudson River NERR | Sarah Fernald/ Heather Gierloff | Team/PAC member (Sarah) | Helped develop project, participated in all major project activities and decisions | Helped them understand possible changes and ecological impacts for NERR sites and the Hudson |
| NY State Department of Environmental Conservation, Hudson River Estuary Program | Kristin Marcell / Fran Dunwell | Team/PAC member (Kristin) | Helped develop project, participated in all major project activities and decisions | Helped them understand possible Hudson changes and ecological impacts; created an opportunity to consider policy ramifications |
| NY/NJ Harbor Estuary Program | Rob Pirani | PAC member | Participated in workshops, advised most major decisions | Helped them understand possible Hudson changes and ecological impacts |
| NYC-ORR | Adam Parris | PAC member | Participated in workshops, advised most major decisions | Helped them understand possible Hudson changes and ecological impacts; created an opportunity to consider policy ramifications |
| US Army Corps of Engineers | Bryce Wisemiller | PAC member | Participated in workshops, advised most major decisions | Gathered technical and policy feedback to inform and provide wider understanding of the HAT study; provided a platform for sharing relevant research |
| Hudson River Foundation | Dennis Suzkowski/ Jim Lodge | PAC member | Participated in workshops, advised most major decisions | Helped inform their research program; helped them understand possible impacts; provided a platform for sharing relevant research |
| NJ Department of Environmental Protection, Office of Engineering and Construction | Clay Sherman/ Kunal Patel | PAC member | Participated in workshops, advised most major decisions | Helped them understand possible changes to estuary and possible impacts; created an opportunity to consider policy ramifications |

To address the project's overriding goals of helping assess potential estuary effects of surge barriers and integrating perspectives across a diverse set of organizations and stakeholders, the project focused on the following specific tasks:

a) Providing unique estuary physical process modeling and related scientific analyses of surge barrier benefits and impacts
b) Organizing and reporting on several workshops with scientists, stakeholders and decisionmakers
c) Sharing results with the current Corps study and inform Environmental Impact Statements
d) Further expanding the engaged scientific community to include such topical expertise as chemistry, ecology, biology and sedimentology.

The project approach was designed to foster close collaboration and information-sharing among scientists and key end users. Project Advisory Committee webmeetings were convened six times to help ensure that data analyses and workshop plans were responsive to the needs of end users, such as the Army Corps of Engineers (**Figure 1**) and relevant city and state agency offices in **Table 1**. The Consensus Building Institute (CBI) conducted a series of confidential one-on-one conversations with eight end users and critical project partners at the project outset to bring forward any potential issues or concerns that could undermine the validity and credibility of the project's work later in the process.

***Figure 1**: Bryce Wisemiller, USACE Project Manager for the HAT Study, presenting to regional and international scientists assembled for the Catalyst project Surge Barrier Environmental Effects and Empirical Experience workshop, September 2019. He attended all project workshops and PAC meetings.*

The project team organized a series of three workshops that focused on framing the group's collective understanding of the benefits and impacts of barriers, highlighting areas for future research or discussion, and catalyzing new collaborative research efforts. In addition to key end users and project advisors, the team invited additional experts on estuaries and surge barriers to a scientific workshop in September 2019 to help address several specific topics –empirical experience from constructed gated storm surge barriers and potential surge barrier effects on tidal wetlands and migrating organisms – that were identified at the first workshop as important areas of uncertainty. The project team summarized workshop presentations and discussions in reports, with the last one including a crowd-sourced future scope of work that listed many possible future research needs.

Concurrently, the team conducted statistical analyses and hydrodynamic modeling to better understand the physical effects of a surge barrier on the Hudson River estuary and provided the Army Corps with information that helped inform its study. Historical storm tide data and computational models were used to address specific questions of interest to end users, such as how surge barriers would affect tidal range, salinity, stratification, wave impacts, and rain-driven flooding behind a closed barrier. These analyses are summarized in a manuscript that has been submitted to a peer-review publication, along with data and codes for reproducing the research.

## 2. Key Findings

The key findings of the study are summarized below in terms of engagement and research. Engagement through the project's workshops focused on better understanding stakeholders' concerns and priorities related to further scientific measurements or studies; the discussions led to a revised project scope and a future scope of work. The project was identified repeatedly as a rare and valuable opportunity for academia and other partners to share their knowledge in ways that could more deeply inform the science behind a federal study, in particular, the HAT Study.

### *Stakeholder Engagement results*

The primary engagement efforts were a project Scoping Session and Final Workshop, both with 35-45 participants including a mix of federal, state and city agencies, researchers and non-governmental organizations. The Scoping Session included broad summary presentations and audience questions on what is known and what research has been done on the estuary physical effects of gated storm surge barriers. The Final Workshop included presentations and audience questions on scientific results from the HAT Study, this study, and other research funded by New York State Energy Research and Development Authority and the Hudson River Foundation. Audience small-group discussions and report-outs were used to gauge stakeholder concerns and interests related to the potential environmental concerns regarding surge barriers. The audiences learned of and shared their perspectives on possible plans for near-term research and workshops and also helped identify potential

future prospects for funding for deeper science and a broader involvement from the research community.

### *Scientific collaboration and assessment results*

A workshop was held in September 2019, titled Surge Barrier Environmental Effects and Empirical Experience (**Figure 1**). The workshop 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 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-maker End Users within the HAT Study.

Based on inputs from the Scoping Session and guidance from the PAC, three main focus topics for the 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, as well as areas where future research is needed. Several key takeaways and research needs are listed in Section 9, but highlights include:

- Examples of constructed storm surge barriers show that the degree of environmental impacts (post-construction) scales with the degree of obstruction of tidal flows, and suggest that by minimizing flow obstruction, it is possible to avoid severe environmental degradation.
- Globally, little physical and very little biological data are available to describe the pre-construction condition of riverine and estuarine systems where surge barriers have been constructed. This makes it difficult to (1) comprehensively assess the effects of barriers on these systems or to know how the ecological systems have changed or (2) apply the lessons to the NY/NJ Harbor-Estuary.
- A more complete set of baseline environmental measurements is needed for the NY/NJ Harbor-Estuary, including data on what organisms are present, when, and how.
- More research is needed into the region's estuarine and tidal river sedimentary systems and to identify the types of events that are important to sediment deposition in tidal marshes.
- If a gated barrier system is built to protect against storm surge, then significant expenditures will still be required in future decades for adaptive management of sea level rise (e.g. through raised shoreline seawalls) and likely also for unexpected environmental effects.

The USACE said that it has a variety of studies underway that will address several of the issues raised in the forum, including the development of an ecological model of the NY Bight system.

***Research results***

Research on surge barrier closure frequency and duration was deemed to be of crucial importance in the Scoping Session because it strongly influences any environmental impacts on the enclosed estuaries. This research has been completed and a manuscript has been submitted for publication (Chen et al., submitted). It is included with this report and a brief summary of these results is included below.

Surge barrier gates are only closed when storm tides exceeding a specific "trigger" water level might occur in a storm, typically a water level that would cause significant flooding. Sea level rise (SLR) is a major factor that can lead to increased closure requests, raising management challenges because SLR will lead to the increase of water level exceedances above coastal flooding thresholds. For example, **Figure 2** shows that the present-day exceedance probability above the "moderate" National Weather Service (NWS) flood threshold is very small, but it will become much larger with 60 cm SLR (50$^{th}$ percentile, RCP 4.5) later this century.

Gate closure frequency and duration both strongly influence the physical and environmental effects on enclosed estuaries. In this research, we use historical observations to represent future storm tide hazard, and we superimpose local relative sea level rise (SLR) to study the potential future changes to closure frequency and duration. We account for the effects of forecast uncertainty on closures, using a relationship between past storm surge and forecast uncertainty from an operational ensemble forecast system.

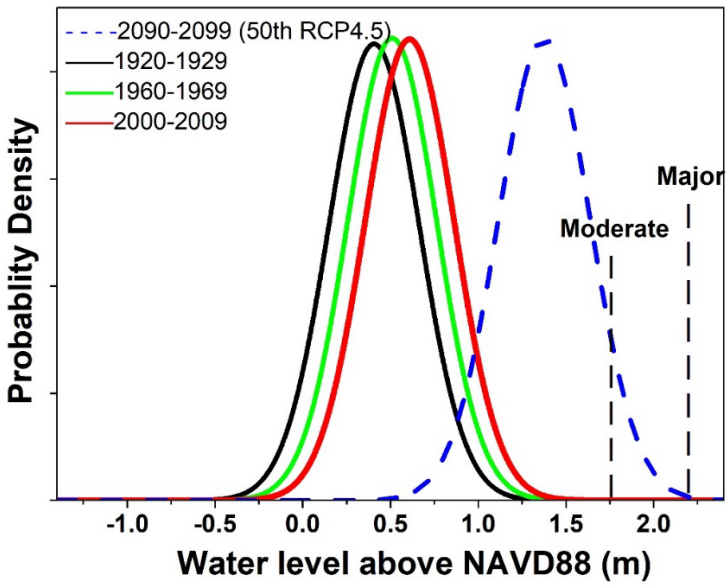


***Figure 2**: Illustration of how the probability of water levels exceeding National Weather Service flood thresholds (Moderate, Major) increases with SLR. Probability density functions are based on historical water level data from The Battery, NYC, and with 50th percentile regional SLR projections to 2090-2099 for a moderate emissions pathway (RCP 4.5) (Chen et al., submitted).*

The results show that SLR causes an exponential increase of the gate closures frequency (**Figure 3**) and a lengthening of the closure duration (**Figure 4**). The USACE has proposed

to prevent these SLR-driven increases by periodically raising the trigger water level (e.g. to match a prescribed storm return period). However, this alternative management approach for dealing with SLR requires waterfront seawalls to be raised at a high, and ongoing, additional future expense. For seawalls, costs and benefits will likely need to be weighed on a neighborhood-by-neighborhood basis, and in some cases retreat or other non-structural options may be preferable.

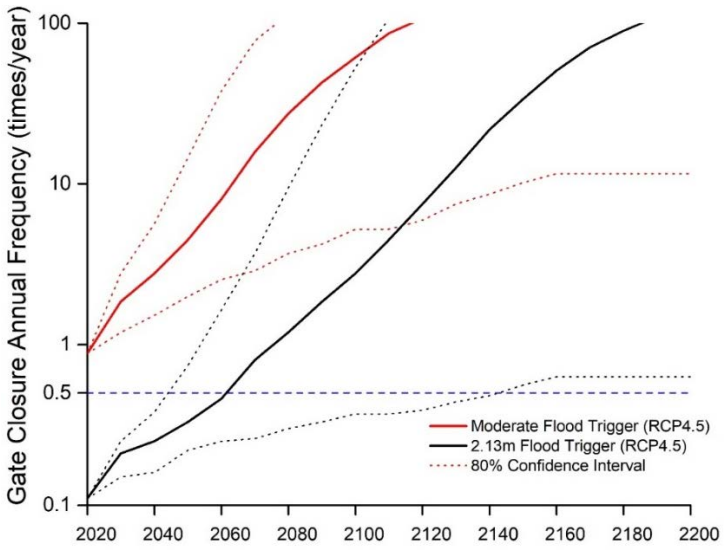


***Figure 3.*** *Gate closure frequency analysis results based on constant water level triggers and RCP 4.5 future greenhouse gas emissions trajectory; Red lines are using moderate flood trigger (1.74 m NAVD88), black lines are using 2.13 m flood trigger. The horizontal dashed line is the given maximum closure frequency (0.5 year$^{-1}$). The y-axis is cut off at 100 year$^{-1}$ since the closure frequency above 100 year$^{-1}$ is far beyond our research interest.*

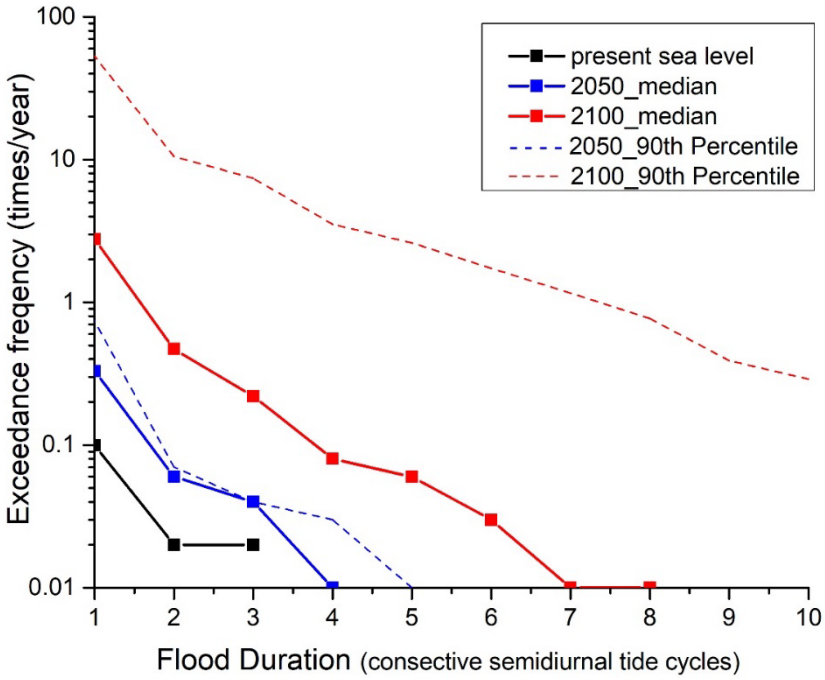


***Figure 4.*** *Gate closure frequency-duration analysis results based on constant 2.13 m flood trigger and RCP 4.5 future greenhouse gas emissions trajectory; Red lines are using the SLR projection at 2100; Blue lines are using the SLR projection at 2050; Black line is using present day sea level.*

### 3. Outputs

All outputs in our project were completed with only minor modifications from the original proposed plan. Brief descriptions of the products, their applications, and who will be using them, include:

- A Scoping Session workshop report– this was useful for the End Users listed above during the project, to review the broad interests of the community.
- A revised Scope of Work – this was used by the project team to guide activities and tasks.
- A science workshop report – Surge Barrier Environmental Effects and Empirical Experience: Workshop Report (Orton et al., 2019) – this focused scientific workshop was useful to the Corps of Engineers (four attendees were present) and other End Users, and will remain useful for those interested in surge barrier estuary effects worldwide.
- A final workshop and future scope of work report synthesizing current science about barrier benefits and impacts and identifying key remaining research needs. This can be used by End Users and anyone interested in surge barriers worldwide, as it records a broad range of stakeholder interests and concerns about surge barrier estuary effects.
- A preproposal and then full proposal were submitted to the NERR Science Collaborative, to seek funding to study the topic area summarized above, surge barrier impacts on tidal wetlands.
- Workshops -- the project ran a series of three workshops, engaging a range of end users and relevant scientific experts.
- The project resulted (so far) in partial completion for one student of a PhD program and doctoral dissertation (expected graduation: December 2020)

One project output that was planned that isn't explicitly available is a technical report on the science research. It was determined, in discussion with Lynn Vaccaro, that this is just the submitted peer-review publication, so there was no need to duplicate the paper as a report.

Several project-related presentations were given:

Fernald, S.H., Orton, P., Brooks, B. and Marcell, K., Catalyzing a deeper understanding of the effects of storm surge barriers on the Hudson River Estuary. Poster presented at the NERRS Annual Meeting, 2018. 300 poster session participants.

Orton, P., Bond, C., Fisher, K., Sanderson, E., Talke, S., Zhang, F. and Chen, Z., Separability of hurricane surge and sea level rise adaptation, oral presentation at the American Geophysical Union Fall Meeting, December 2018. 50 audience members.

Preliminary Evaluation of the Physical Influences of Storm Surge Barriers on the Hudson River Estuary and Long Island Sound, February 15, 2019, Long Island Sound Study (National Estuary Program). 50 attendees.

Fernald, S.H., Orton, P., Brooks, B. and Marcell, K., Catalyzing a deeper understanding of the effects of storm surge barriers on the Hudson River Estuary. Poster presented at the Hudson River Environmental Society 2019 Hudson River Symposium, May 8, 2019. 150 poster session participants.

Fernald, S.H., Orton, P., Brooks, B. and Marcell, K., Collaboratively assessing the effects of storm surge barriers on the Hudson River Estuary. Poster presented at the NERRS Annual Meeting, 2019. 300 poster session participants.

Orton, P., Assessing the Effects of Storm Surge Barriers on the Hudson River Estuary, guest lecture for Isaac Wirgin's ecotoxicology class, December 5, 2019. Lecture and discussion with 15 students.

Chen, Z., Orton, P. and Wahl, T., Storm Surge Barrier Closure Frequency, Duration and Trapped River Flooding Analysis, oral presentation at the 18th Symposium on the Coastal Environment at the American Meteorological Society Annual Meeting, Boston, January 12, 2020. 50 audience members.

Orton, P. and Chen, Z., Assessing the Effects of Storm Surge Barriers on the NY/NJ Harbor Estuary, presentation to the New York / New Jersey Harbor-Estuary Program (HEP) water quality workgroup, at the Hudson River Foundation and by webinar, New York City, February 6, 2020. 20 participants.

Orton, P. and Chen, Z., Storm Surge Barrier Closure Frequency, Duration and Trapped River Flooding Analysis, webinar on final research results (planned for 6/30/2020). Expected: 50-100 attendees.

*Two proposals were submitted:*

Orton, P., Influence of Storm Surge Barrier Closures on Estuary Physical Conditions, proposal submitted to New York State Energy Research and Development Authority in November 2019, successful for obtaining $42500 in additional funding.

Orton, Brooks, Marcell, Fernald, Hauser, Miller, Marsooli, Yellen, Woodruff, "Effects of Surge Barriers and Climate Change on Hudson River Tidal Marshes and Ecosystems". Proposal to NOAA NERR Science Collaborative Research Grants Program, submitted in April 2020.

## 4. Sharing with the NERRS

1) Philip presented as a panelist in the NERR-SC webpanel, "Accelerating Collective Learning and Action for Enhanced Resilience", on September 9, 2019

2) A manuscript has been submitted to a peer-reviewed journal (Chen et al., submitted)

3) We collaborated and Sarah Fernald presented two posters at NERRS Annual Meetings (fall 2018 and fall 2019)

4) Bennett Brooks attended the December 2018 NERR Science Collaborative Project Workshop

## 5. Students

| ***Degree level (undergraduate, master's, PhD)*** | ***Project role*** | ***Any associated theses or dissertations (expected or completed)*** |
|---|---|---|
| *Ph.D.* | *Research assistant* | *Paper submitted to the Journal of Marine Science and Engineering*<br>*Dissertation proposal expected August 2020*<br>*Dissertation and defense expected December 2020* |

## 6. Number of Individuals Engaged

| ***Project team*** | ***Users engaged (e.g., advisory group members not on team)*** | ***Attendees of project workshops or other presentations*** | ***Volunteers*** | ***K-12 Students*** | ***Teachers*** |
|---|---|---|---|---|---|
| *5* | *15 for PAC* | *35 for Scoping Session*<br>*35 for science workshop*<br>*45 for final workshop*<br>*80 expected for final research webinar*<br>*1015 total for presentations in Section 3 above* | *0* | *0* | *0* |

## 7. Leveraging

The NOAA RISA-funded project "Consortium for Climate Risk in the Urban Northeast" provided funding for a majority of Ziyu Chen's work (graduate stipend, not tuition) on the project: 50% of spring 2020 semester ($6500) and 100% of summer ($14000) and fall ($13000) 2020, the funding in spring 2020 covered research explicitly under the project (his first paper/chapter), and the summer/fall funds cover his remaining dissertation research and writing.

A new $42,500 project was funded by New York State Energy Research and Development Authority (NYSERDA) to add more research tasks to the project that were highly-ranked in the Scoping Session (not summarized in this report).

## 8. Outcomes

Proposed outcomes and results:

*A. A substantially improved understanding of Barrier Benefits and Impacts (BBI) on the Hudson River and its NERR sites.*
This outcome was realized with regard to the Hudson River (research and scientific workshop) and for the NERR tidal wetland sites (scientific workshop and new research proposal)

*B. A strong foundation and broadening of the BBI research community with formalized interactions and outputs, further expanding the scientific personnel and scope of expertise to include such topical expertise as chemistry, biology and sedimentology.*
This outcome was realized, with more than 100 people in our email distribution list, including several dozen scientists, and with the science workshop and new Science Collaborative proposal.

*C. Collaborative development of future research priorities by securing additional funding to expand and extend this project, including a NERR Collaborative 3-year study.*
This outcome has been partially realized so far, with the additional NYSERDA funding and the submitted proposal to the Science Collaborative. We also wrote a letter committing to assist another proposed project to the Hudson River Foundation (D. Ralston, PI) which was funded.

Also, our team received broad community (and Corps of Engineers) enthusiasm and nine letters of support for a new Science Collaborative Research Proposal submitted in 2020. We actually turned down offers of letters, due to having an overabundance and not wanting to inconvenience stakeholders like New York City, during the COVID-19 epidemic.

*D. Improved knowledge of BBI informing the HAT Study and other studies, through interaction and coordination with the growing regional BBI research community.*

This outcome was realized, through our research and workshops, and through our very close collaborative relationship with the US Army Corps of Engineers (with 5 in-person interactions, over 10 scientific discussions by email, and many more project advisory committee communications). Our science workshop also contributed to this outcome.

*E. Stronger integration and understanding across the BBI research community and key end users, thereby providing a more robust and trusted foundation for future collaboration on surge barrier-related topics.*
This outcome was also realized, with significant effort to connect to the broader community of surge barrier researchers with workshops and proposals, including strong connections to scientists from the Netherlands, England, Barnegat Bay and other New Jersey estuaries. Feedback from participants throughout the process underscored their appreciation for a platform that created a constructive and somewhat unique forum for engaging critical research needs. The strength of the collaboration is further evidenced by the breadth of interest in and support for a follow-up study.

One unanticipated outcome was the deep involvement of the doctoral student Ziyu Chen in the project's research. The one-year project originally only budgeted for a summer of student assistance, but the leveraged funds and good luck with timing of an excellent student resulted in one peer-review paper, and an expected doctoral dissertation.

## 9. Next Steps

If the HAT Study continues, there could be continued momentum on the scientific assessment started under this Catalyst study. Both the Science Workshop and Final Workshop revealed strong interest in conducting a "survey" of organisms using the harbor region, to support the HAT Study with improved information that addresses a major shortcoming.

A very promising potential next step is the NERR Science Collaborative Research Proposal that is in review. Our team received broad community support for the effort, and we hope it will be funded. We also see other opportunities for additional funding and research on this general topic, with the EPA National Estuary Program Coastal Watershed Grants request for proposals currently out. Regardless of funding in the near-term, storm surge barriers will continue to be proposed, and research will need to be done, so we are out ahead of an important research topic.

The dissertation research of Ziyu Chen will continue, with a second chapter/paper on the separate NYSERDA-funded research and a dissertation and defense expected in December 2020.

## 10. Other Accomplishments & Information

n/a

## References

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Orton, P. M., and Ralston, D. K.: Preliminary evaluation of the physical influences of storm surge barriers on the Hudson River estuary. Report to the Hudson River Foundation, 81pp, 2018.

Swanson, R., O'Connell, C., and Wilson, R.: Storm Surge Barriers: Ecological and Special Concerns, Storm surge barriers to protect New York City: against the deluge, New York University, USA, 30-31 March 2009., 2013.

# 2b) Final Product Inventory

**Project title:** Catalyzing a deeper understanding of the effects of storm surge barriers on the Hudson River estuary
**Project lead:** Philip Orton
**Reserve(s):** Hudson River NERR
**Date of report:** 6/19/2020

| Product name | Type (e.g., report, curriculum, tool, journal article, multimedia) | Status (indicate if complete or approximate date of availability) | Location for access (URL; otherwise, indicate M-Box folder) | Appropriate citation (title, authors, date) |
|---|---|---|---|---|
| Workshop report – scoping session summary | Report | Project webpage | Stevens Institute of Technology | Effects of Storm Surge Barriers on the Hudson River Estuary: Scoping Session Recap, April 12, 2019. |
| Final revised scope of work | Report | Project webpage | Stevens Institute of Technology | Assessing the Effects of Storm Surge Barriers on the Hudson River Estuary Scope of Work for Workshops and Research, May 20, 2019 |
| Workshop report – science workshop | Report | Project webpage | Stevens Institute of Technology | Orton et al. 2019 (see reference list) |
| Workshop report – Final workshop summary and future scope of work | Report | Project webpage | Stevens Institute of Technology | Effects of Storm Surge Barriers on the Hudson River Estuary: Final Workshop Summary and Scope of Future Work, May 14, 2020 |
| Chen et al. (submitted) | Journal article | Submitted | By request, until published | Chen et al. submitted (see reference list) |

# 3a) Final Project Dataset Inventory

**Project title:** Catalyzing a deeper understanding of the effects of storm surge barriers on the Hudson River estuary
**Project lead:** Philip Orton
**Reserve(s):** Hudson River NERR
**Date of report:** 6/19/2020

| **Dataset name** | **Metadata file name** (may or may not be unique for each dataset) | **Location for access, including URL** | **Uploaded for access or pending?** | **Location for archival, including URL** | **Uploaded for archival or pending?** |
|---|---|---|---|---|---|
| Surge barrier closure frequency analysis codes | Tool – computer codes | Open-source journal supplementary materials; project webpage | Journal publication is pending | Journal (pending) Project webpage | Uploaded |
| Surge barrier closure duration analysis codes | Tool – computer codes | Open-source journal supplementary materials; project webpage | Journal publication is pending | Journal (pending) Project webpage | Uploaded |
| Surge barrier closure frequency analysis results | Dataset | Open-source journal supplementary materials; project webpage | Journal publication is pending | Journal (pending) Project webpage | Uploaded |
| Surge barrier closure duration analysis results | Dataset | Open-source journal supplementary materials; project webpage | Journal publication is pending | Journal (pending) Project webpage | Uploaded |

# 3b) Data Sharing Plan Summary

**Project title:** Assessing the Effects of Storm Surge Barriers on the Hudson River Estuary
**Project lead:** Philip Orton

## 1. General Description of Data to be Managed

- This project produced derived data from statistical analyses from preexisting NOAA and USGS observational data.
- This project did not collect any new environmental observation data.

## 2. Data Quality Control / Quality Assurance Procedures

- No new environmental data is being created, so no new data quality control is required
- The data created by statistical analysis has been quality-controlled following normal scientific practices required for publication in a peer-reviewed journal.

## 3. Data Documentation / Metadata

- Datasets are accompanied by an ASCII file with metadata, and the peer-review article summary of the methods and results (the publication; Chen et al. submitted).
- Similarly, statistical analysis codes are accompanied by the peer-review article summary of the methods and results (the publication; Chen et al. submitted).

## 4. Data Access and Sharing

- Results of statistical analyses are available via project webpage and submitted peer-review article Supplemental Materials with summaries of the variables and a text summary of the methods and results (the publication; Chen et al. submitted).
- Similarly, statistical analysis codes are available on the project webpage and with the submitted peer-review article Supplementary Materials.

## 5. Data Archival

- Data will be archived for at least five years. Data are always backed up at least three-fold, on the computing system which was used to create the data, and also on two backup storage drives kept in two different locations. Data in the Project Lead's present archives contain data back to the 1990s.