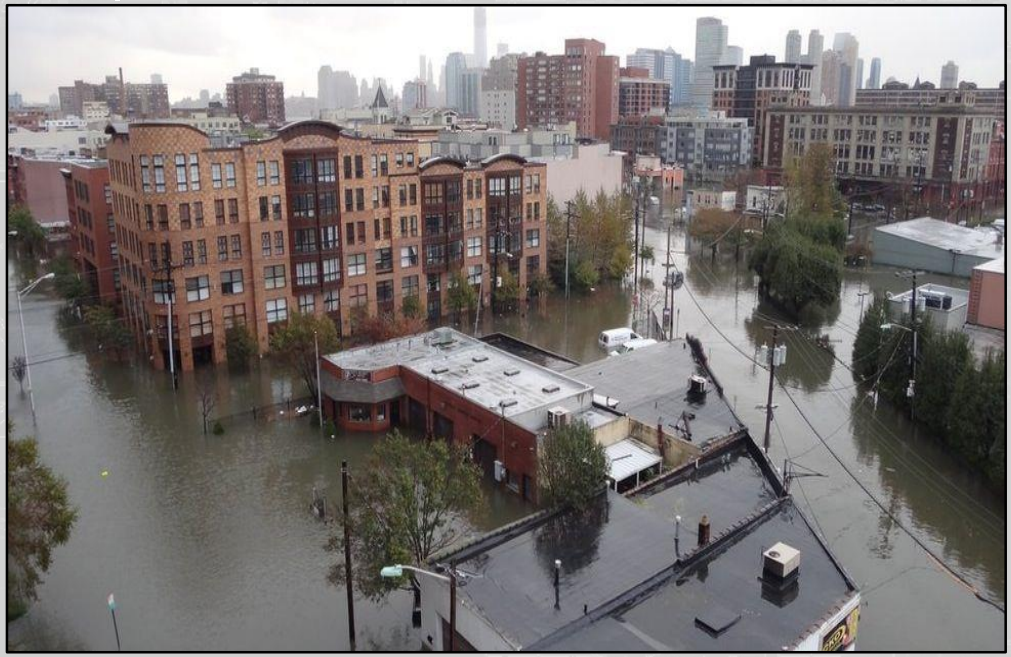
NEW YORK – NEW JERSEY HARBOR AND TRIBUTARIES STUDY (HATS):

EVALUATION OF ENVIRONMENTAL EFFECTS OF GATED SURGE BARRIERS

H. L. Carey Tunnel between Manhattan and Brooklyn flooded during Hurricane Sandy, October 2012

S. Kyle McKay, Ph.D., P.E.

Workshop on “Assessing the Effects of Storm Surge Barriers on the Hudson River Estuary”
28 Jan 2020



Flooding in Hoboken, NJ October 2012

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REGIONAL FLOOD RISK MANAGEMENT STUDIES

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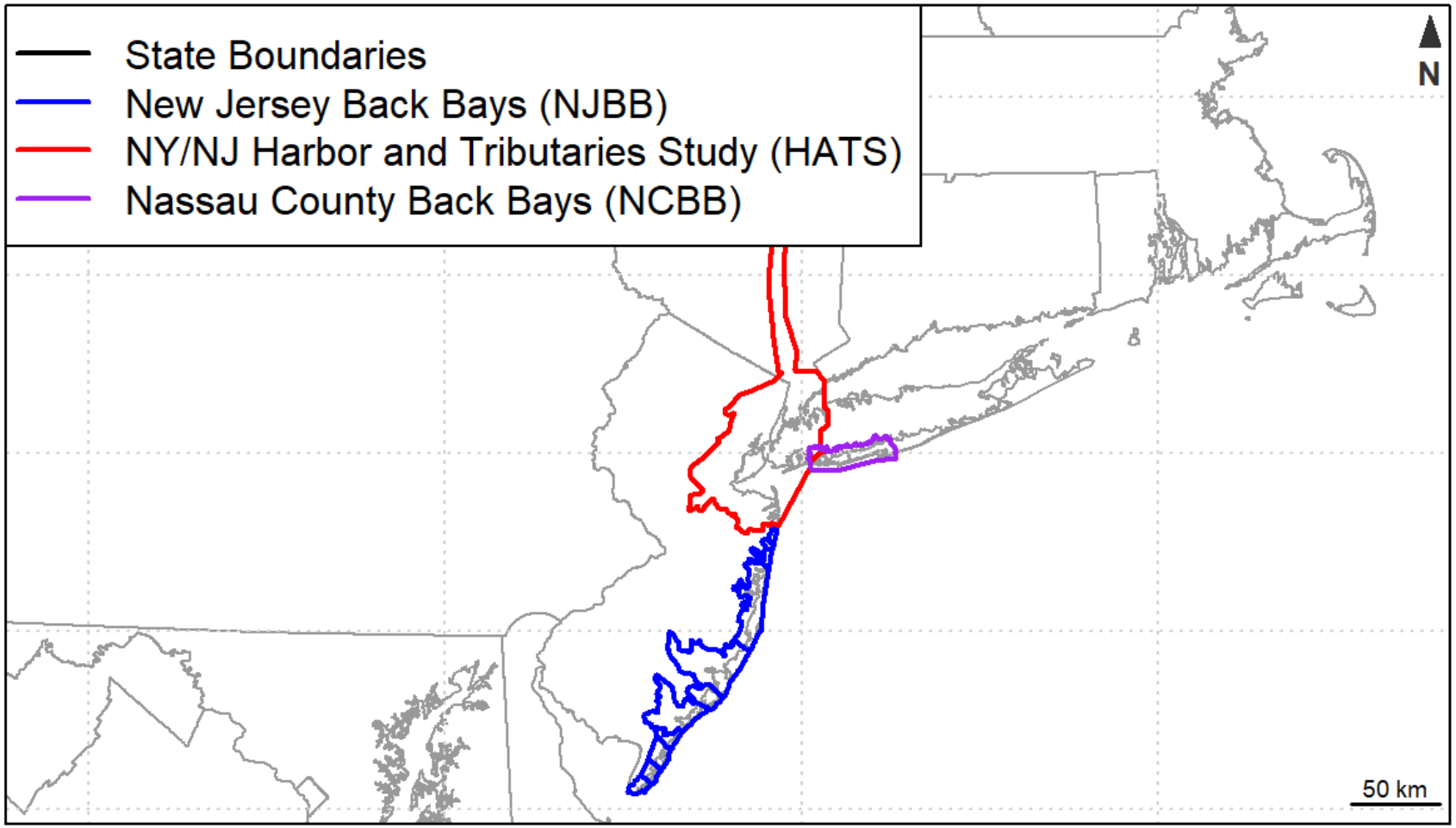

NEW JERSEY BACK BAYS (NJBB)

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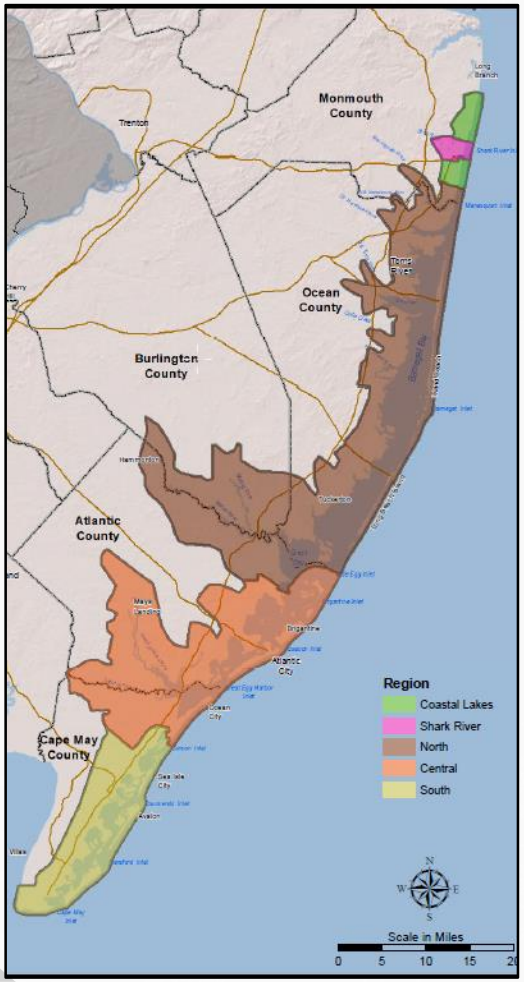

- Coastal New Jersey is big!
  - 936 square miles, 3,398 miles shoreline, 247,692 structures
- Subdivided into five regions based on problems, opportunities, and hydrologic connectivity
- Multiple families of alternatives considered in each region
  - Non-structural actions, Storm surge barriers, Perimeter plans, Natural and nature-based features
- Multiple “cycles of planning”
  - Cycle 0 qualitatively "screened out" perimeter measures that had zero damageable structures. No cost, no benefits.
  - Cycle 1 quantitatively analyzed all perimeter measures (0% design).
  - Cycle 2 (Dec 2018) quantitative analysis of economically viability.
    - Alternatives reduced from 50 to 20
    - Level of design = 5% (with cost update)
    - Screening out 7 storm surge barriers and 3 perimeter plans
  - Cycle 3 (Jan 2020) quantitative incremental justification of sites.
    - Alternatives: 20 to ~8 (and soon a “Tentatively Selected Plan”)
    - Level of design = 15% (with cost update)
    - Screening out additional surge barriers and perimeter plans

HYDRODYNAMIC MODELING OF STORM SURGE BARRIER INDIRECT IMPACTS

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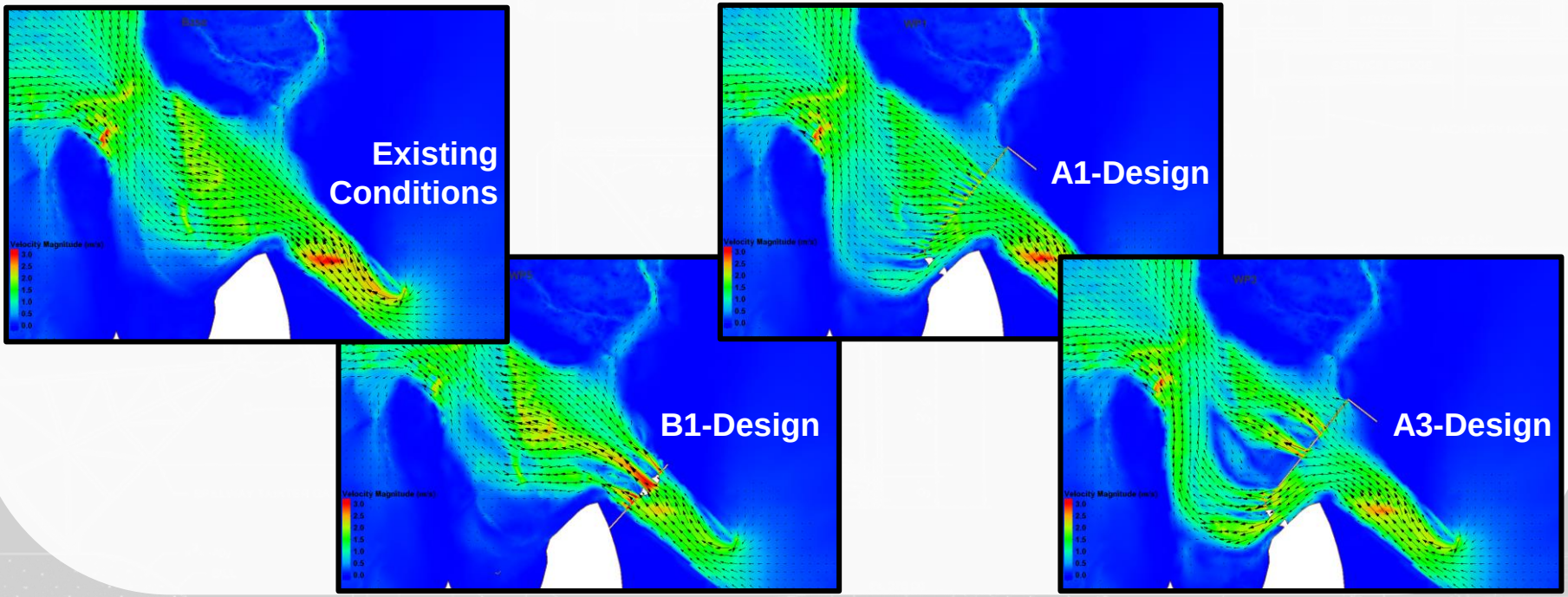
- ERDC-CHL developed Adaptive Hydraulics (AdH) model to inform evaluation of indirect impacts of storm surge barriers
  - Present analyses: tides, velocities, salinity, and residence time
  - Future analyses: navigation, sediment transport, water quality
- Calibrated to 2019 ADCP field data at 3 inlets and long-term tide/salinity stations
- Investigate sensitivity to storm surge barrier design:
  - Alignment, sill elevation, sector gate size, number of vertical lift gates,…



Figures: Preliminary AdH Velocities at Barnegat Inlet

NJBB STUDY MILESTONES

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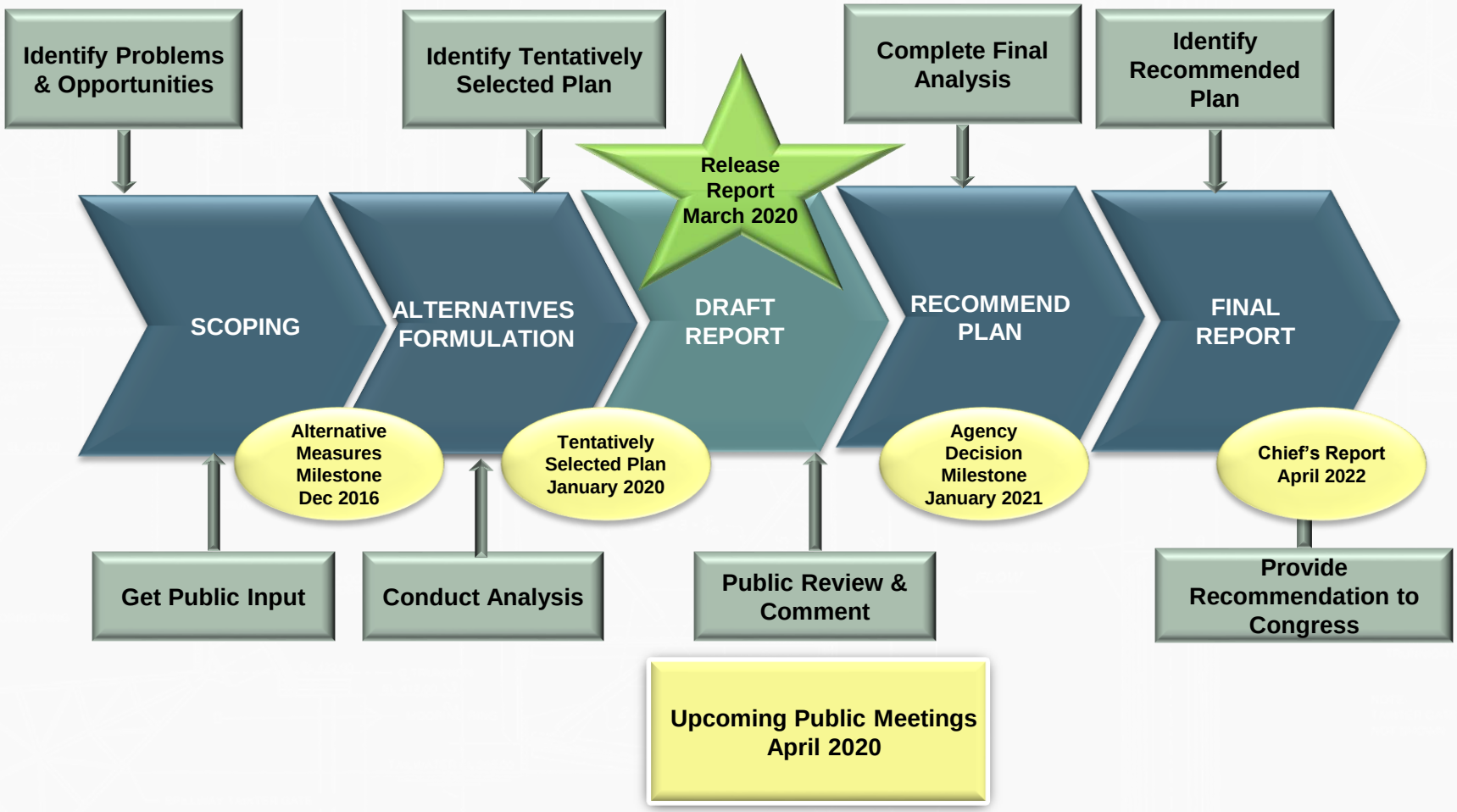

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ENVIRONMENTAL IMPACT ASSESSMENT

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

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Multiple laws, executive orders and regulations are considered as part of the NEPA process.

- National Historic Preservation Act, as amended
  - *Preserves historic and archaeological sites*
- Clean Water Act
  - *Prevents water pollution*
- Endangered Species Act
  - *Protects plants and animals from extinction*
- Clean Air Act
  - *Prevents air pollution*
- Environmental Justice
  - *Addressing equity in adverse and beneficial environmental effects*
- State laws

Piping Plover.

Atlantic Sturgeon.

TYPES OF NEPA ANALYSIS

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- Categorical Exclusion
- Environmental Assessment (EA)
- Environmental Impact Statement (EIS)
- Tiered Environmental Impact Statement (EIS)

ENVIRONMENTAL CONSIDERATIONS

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COMPARING DISSIMILAR OUTCOMES ON A CONSISTENT SCALE

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Impact Rating	Description
5 - High	Impacts to the resource would have substantial consequences, locally and/or regionally, to the resource. Impacts would exceed regulatory standards. Mitigation measures to offset the adverse effects would not be enough to reduce impacts and therefore, impacts to the resource would not be environmentally acceptable.
4 - Moderate to High	Impacts to the resource would be locally and/or regionally significant. Impacts would be within regulatory standards; however, existing resource conditions are expected to be affected in the near-term, but not necessarily in the long term. Mitigation measures to reduce any potential adverse impacts would be necessary.
3 - Moderate	Impacts to the resource are expected to be moderate in the near-term and localized. Impacts would be within or below regulatory standards, as applicable, and the use of mitigation measures would reduce potential adverse impacts, if applicable.
2 - Low	Impacts to the resource would either be negligible or, if detectable, have minor temporary impacts locally to the resource. The impacts would be well below regulatory standards, as applicable, and mitigation measures may be implemented to sustain low to no impact to the resource.
1 - No Impact	The resource would have no impacts because the resource would not be affected.

DRAFT CONCEPTUAL EXERCISE

WHAT WOULD THIS LOOK LIKE IN PRACTICE?

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RESOURCE CATEGORIES	Alternatives					
	1: No Action	2: Sandy Hook to Breezy Point Barrier	3A: Regional barriers	3B: Mid-size barriers	4: Small barriers	5: Perimeter only solutions
Physical Resources	1	1	4	2	3	3
Hydrological Processes	1	4	1	3	4	1
Water Quality	1	4	1	2	4	4
Air Quality	1	4	5	5	2	1
Regional Climate	1	2	5	4	4	2
Regional Ecosystems	1	5	3	4	3	3
Regional Ecological Resources	1	1	4	1	5	4
Special Status Species	1	5	3	3	5	2
Protected Areas	1	1	4	4	5	5
Cultural Resources	1	1	5	1	1	5
Hazardous, Toxic and Radioactive Waste	1	1	4	3	3	1
Infrastructure	1	4	1	5	3	3
Navigation	1	4	1	4	5	4
Communities	1	1	3	4	2	4
Occupational Safety and Health	1	3	4	2	1	3

All values are random numbers for demonstration purposes.

Hydrodynamic Models (AdH)

RESOURCE CATEGORIES	Alternatives					
	1: No Action	2: Sandy Hook to Breezy Point Barrier	3A: Regional barriers	3B: Mid-size barriers	4: Small barriers	5: Perimeter only solutions
Hydrological Processes	1	3	4	5	1	5
Hydrology (inland)	1	4	1	2	4	4
Hydrology (coastal)	1	3	4	1	1	3
Currents and velocities	1	2	4	2	3	5
Circulation	1	1	5	4	1	3
Tidal range	1	1	1	4	3	4
Tidal exchange	1	5	5	4	1	3

All values are random numbers for demonstration purposes.

Habitat Models (NYBEM)

RESOURCE CATEGORIES	Alternatives					
	1: No Action	2: Sandy Hook to Breezy Point Barrier	3A: Regional barriers	3B: Mid-size barriers	4: Small barriers	5: Perimeter only solutions
Regional Ecosystems	1	5	1	1	1	4
Marine, deepwater	1	1	1	2	4	2
Marine, subtidal	1	3	3	3	5	4
Marine, intertidal	1	3	5	3	4	3
Estuarine, subtidal	1	2	5	5	4	3
Estuarine, intertidal	1	2	1	4	3	3
Tidal fresh	1	5	1	2	3	5
Systemwide connectivity	1	4	1	5	5	1

All values are random numbers for demonstration purposes.

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DEVELOPING A NEW YORK BIGHT ECOLOGICAL MODEL (NYBEM)

WHAT WE'RE WORKING TOWARD

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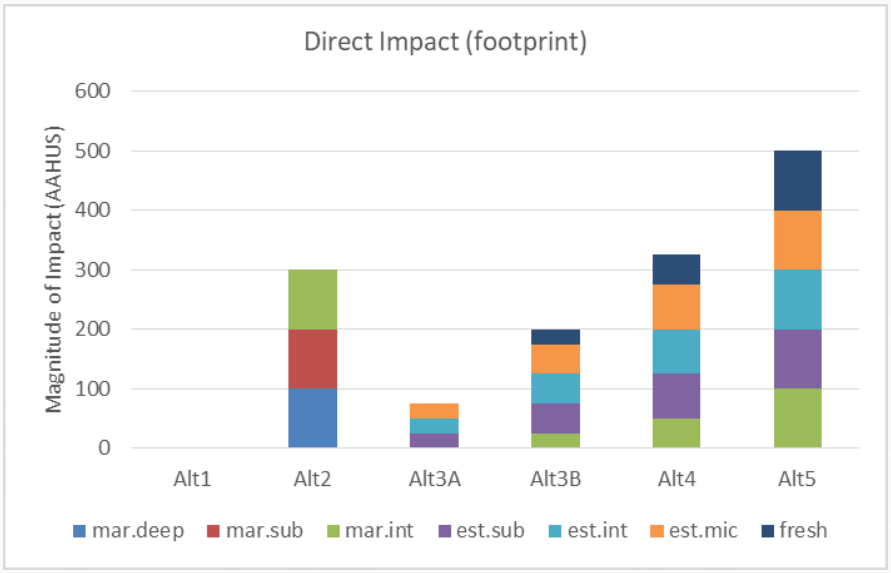

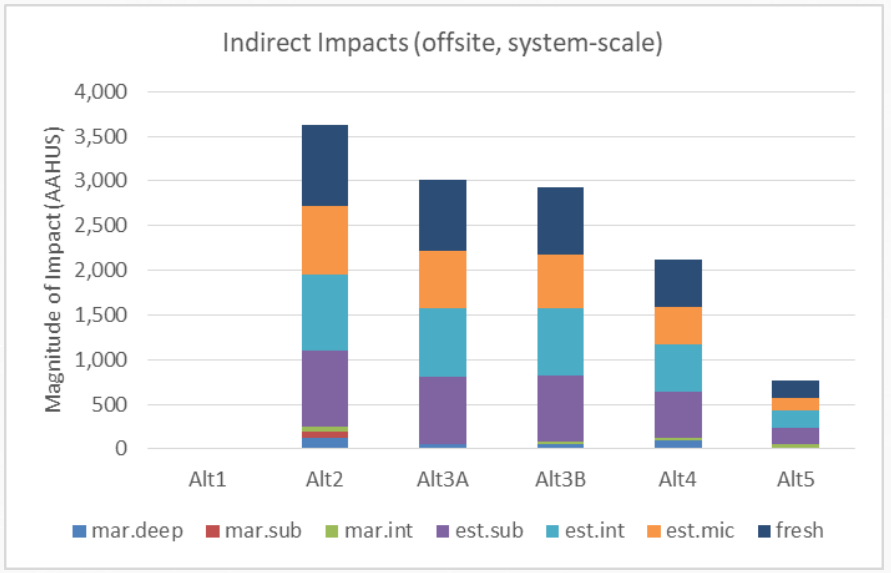

ALL VALUES ARE FICTIONAL AND PURELY REPRESENTATIVE OF THE TYPES OF POTENTIAL ANALYTICAL OUTCOMES

NEW YORK BIGHT ECOSYSTEM

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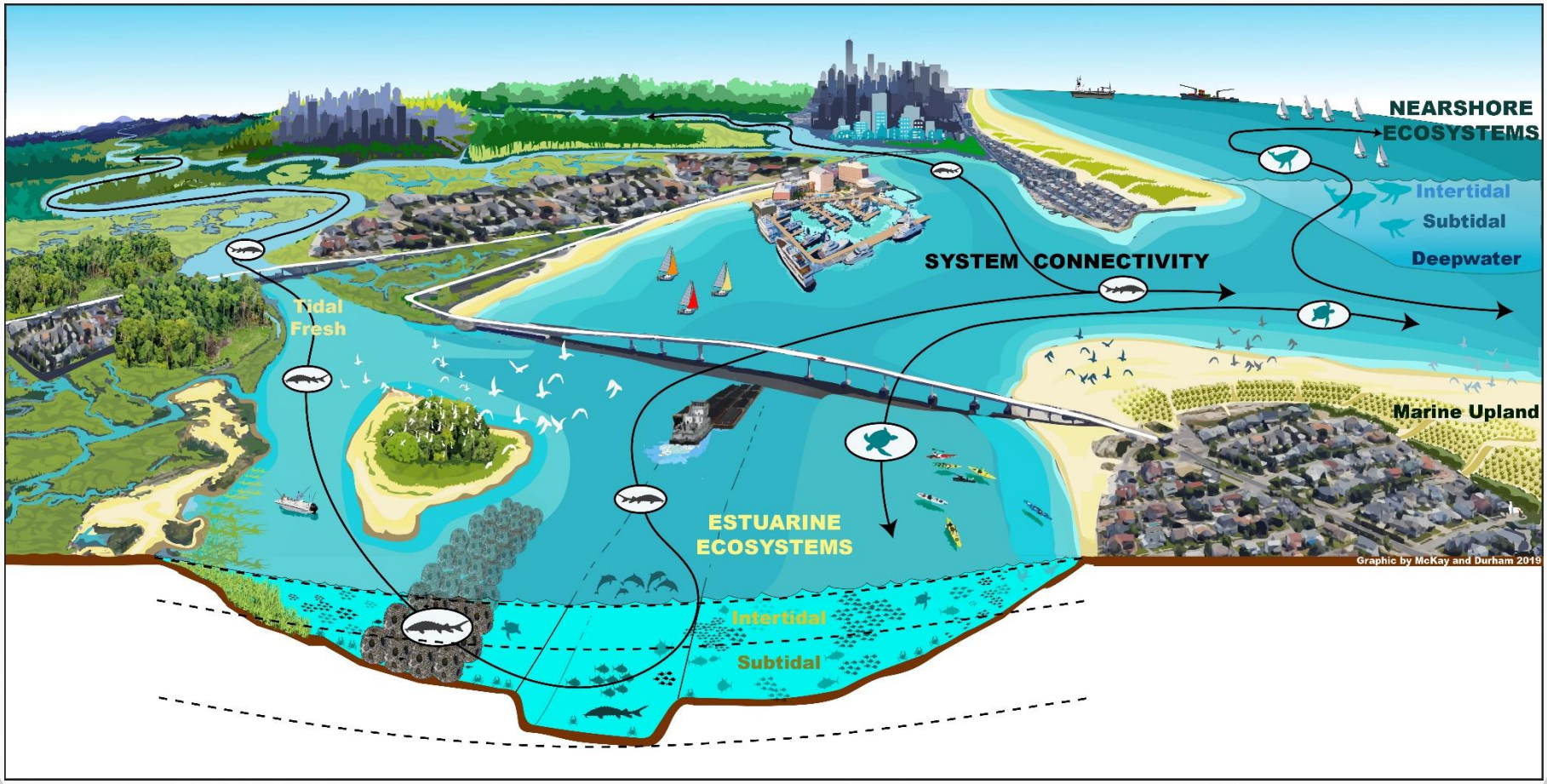

EXAMPLE OF PATCH-SCALE MODELS: MARINE, DEEPWATER ECOSYSTEM

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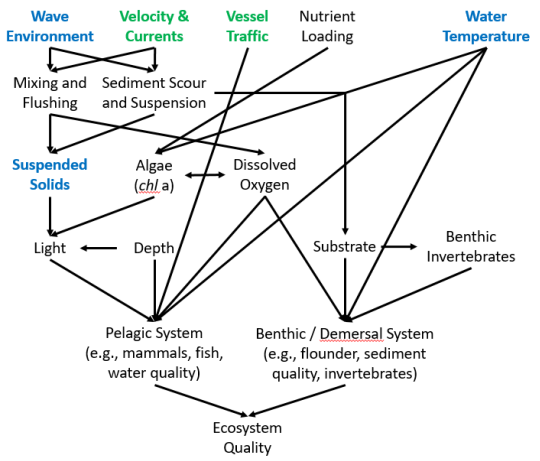
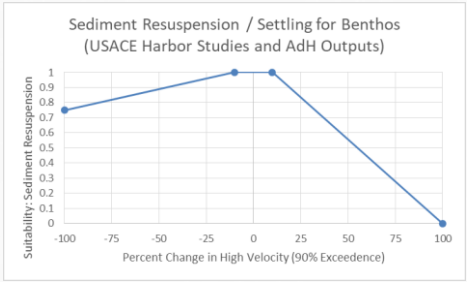
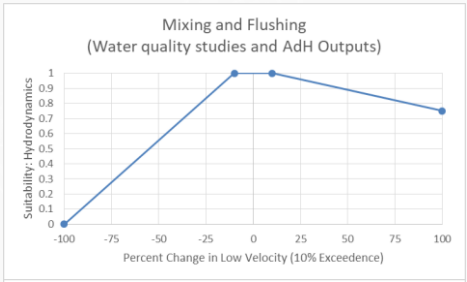
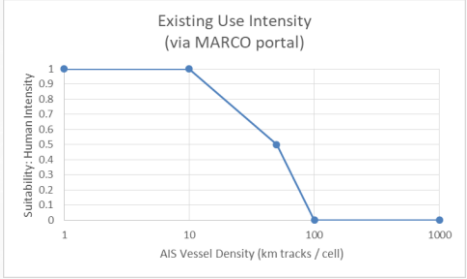
Conceptual Model
"How the system works"



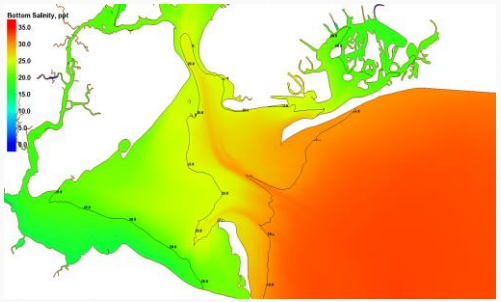
Quantitative Model
("Suitability Index")







Model Application
(parameterized with hydro models and available data)



SYSTEMS-SCALE MODEL FOR ORGANISMAL CONNECTIVITY

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Adopt a network-based approach from a long history of ecological applications

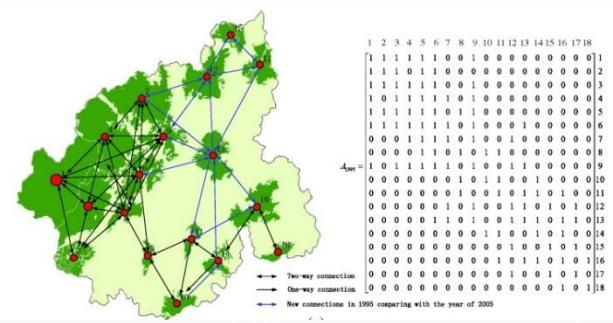
- Network topology
- Habitat patches & home range
- “Passage” rate between patches

Passage Rate Assessment

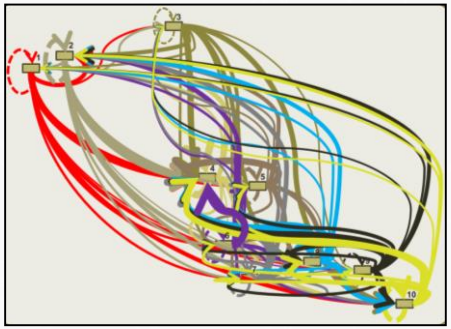
- Professional judgment
- “Rules” (e.g., velocity < 2 ft/s)
- Statistical models
- Agent-based models

Guilding focal taxa

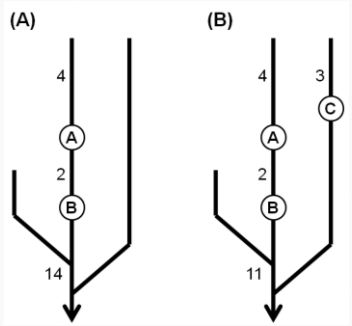
- Marine mammals (e.g., whales)
- Andromous, pelagic fish (e.g., herring)
- Anadromous, benthic fish (e.g., sturgeon)
- Drifting organisms (e.g., larvae)
- Others?



Ecological Reserve Design
(Liu et al. 2015, Ecological Modeling)



Oyster Larval Transport
(Kjelland et al. 2015, Ecological Modeling)



Fish Passage Prioritization
(McKay et al. 2017, Ecological Modeling)

PHASED MODEL DEVELOPMENT: SHARPENING THE PENCIL OVER TIME

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	Interim Report (to date)	Winter 2020 Draft Report (Phase 1 Model)	Winter 2021 Final Report (Phase 2 Model)
Scope of environmental impacts	Direct / footprint	Direct / footprint Indirect / offsite Change / switching	Direct / footprint (refined) Indirect / offsite (refined) Change / switching (refined) Cumulative impact across studies
Extent of environmental effects	Project footprint	Footprint for alternatives + Range of offsite impacts (by ecosystem type)	Footprint for alternatives + Range of offsite impacts (by ecosystem type and quality) + Actual mitigation requirements
Potential Inputs	Footprint	Footprint + Tidal Range + Salinity + Hydro + Habitat Maps	Footprint + Tidal Range + Salinity + Hydro + Habitat Maps + Sediment+ Temperature + Waves + Water Quality + Other
Time window	Snapshot	One-year of tidal forcing Multiple sea levels 50 year planning horizon	Multiple years of tidal forcing Multiple sea level rise scenarios 50+ year planning horizon

NYBEM DEVELOPMENT PROCESS

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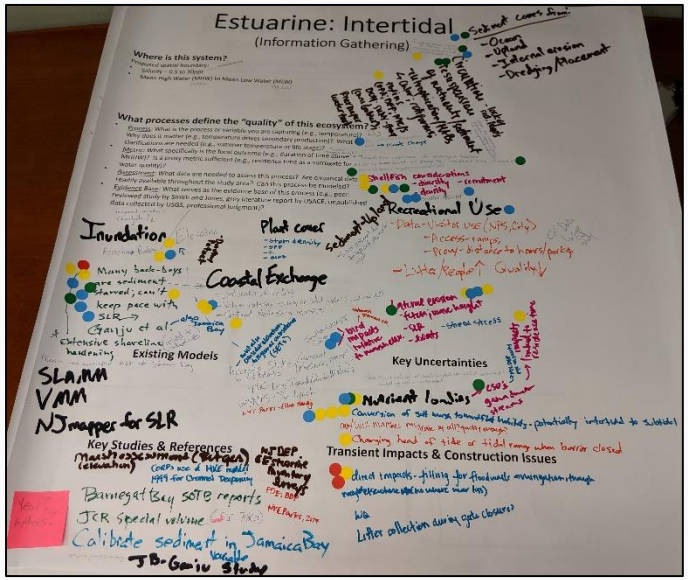
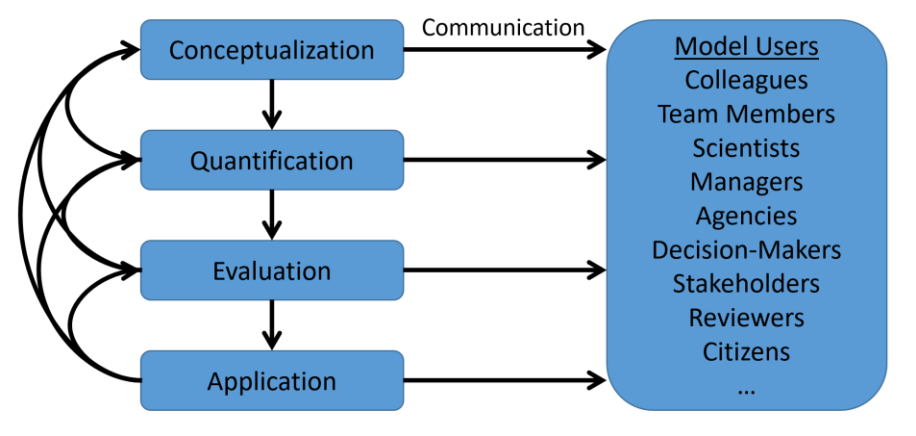
A series of workshops to iteratively develop models with research and synthesis between meetings.

- Preliminary workshop with Philadelphia District (Jan 2019)
- USACE workshop with two Districts (Mar 2019)
- Interagency conceptual modeling workshop (Jun 2019)
- Interagency numerical modeling update (Nov 2019)
- Phase-1 Model application to NJBB (Jan/Feb 2019)
- Phase-1 Model application to HATS (Mar/Apr 2020)
- Phase-1 Ecological model documentation (Mar 2019)
  - USACE model certification (i.e., external review)
- Phase-2 development and application (TBD)





Ecological Model Development Process
(Herman, McKay, et al. 2019)

EXECUTING NUMERICAL MODELS

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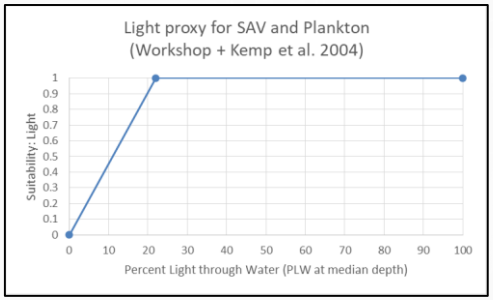
Model Structure:

Workshop-based synthesis
Literature review
Analysis of existing data

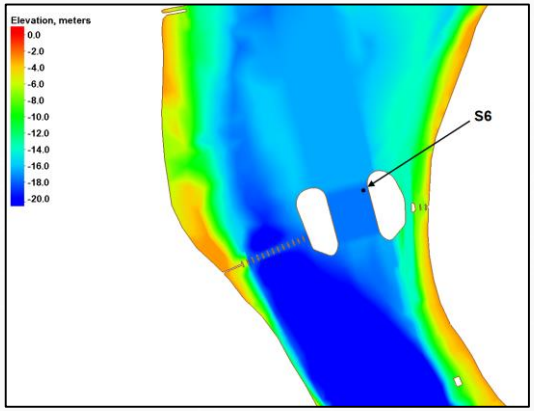


R Statistical Software:

EcoRest Package (beta)
Geospatial functionality
Watershed connectivity tools

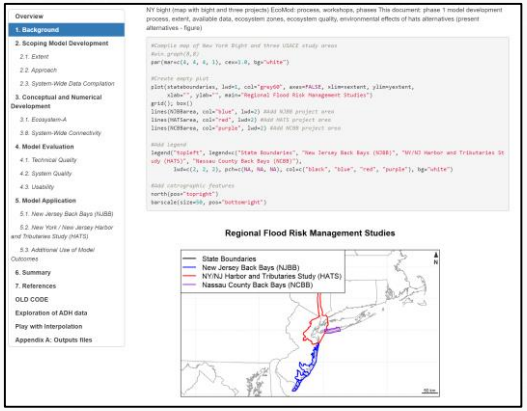
Model Parameterization:

Adaptive Hydraulics (AdH)
MARCO Data Portal
Other GIS Data



Rmarkdown Documentation:

Real-time report assembly
NJBB / HATS outputs
USACE model certification



ADDITIONAL STUDY NEEDS

(KYLE'S THOUGHTS ONLY)

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Near-term

Connectivity-related

- What is the seasonal pattern of taxa presence / absence?
- How does ***each*** taxa respond to alternative infrastructure design parameters (e.g., cross-sectional area, width, velocity)?
- How would operational duration and timing alter movement rates?

Habitat-related

- What drives critical thresholds in regional habitat switching?
- How well does NYBEM perform at predicting habitat distributions?
- How do tidal ecosystems respond to different rates of sea level rise?

Long-term

Connectivity-related

- How do changes in habitat or connectivity lead to population decline or increase (e.g., thresholds in processes)?
- What is the rate-of-change of population recovery times? How do recovery rates relate to potential barrier operational patterns?
- What is the relationship between migration patterns and the influence of storms (e.g., avoidance vs. attraction)?

Habitat-related

- Is existing habitat degradation a limiting factor with or without the influence of HATS?
- How do sequential events influence trajectories of ecosystem outcomes?