The Hudson River Environmental Conditions Observing System (HRECOS)

An Observational Network On the Hudson River Estuary

HRECOS Consortium (Alphabetical):

Cary Institute of Ecosystem Studies
Lamont Doherty Earth Observatory
Hudson River Foundation
New York State Department of Environmental Conservation
Stevens Institute of Technology
U.S. Geological Survey

www.hrecos.org

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Background:

In 2008, an environmental observing program was established on the Hudson River Estuary from Troy south to the New York/New Jersey Harbor to provide geographically distributed high frequency real-time data. The Hudson River Environmental Conditions Observing System (HRECOS) is operated by a consortium of many partners from government and the research community who together are operating and maintaining several observing stations along the estuary and are providing these data real-time. HRECOS has been designed to achieve the following objectives:

- Identify and address the needs of multiple users of the Hudson River Estuary ecosystem;
- Build upon existing monitoring and observing activities and capacities on the Hudson River estuary already established through the U.S. Geological Survey, National Oceanic and Atmospheric Administration, New York State Department of Environmental Conservation, Institute of Ecosystem Studies, Lamont Doherty Earth Observatory (Columbia University), Stevens Institute, and others;
- Improve the capacity of governmental and research entities to manage river and estuarine resources and to understand the ecosystem; these entities include the state's Hudson River Estuary Program, the Hudson River National Estuarine Research Reserve, and the NY-NJ Harbor Estuary Program;
- Provide a backbone of basic monitoring datasets and products necessary for applied research, modeling, and future technological innovation;
- Provide government, policy makers, and the public with timely datasets and data products to guide decision making; and
- Support the use of scientific data and real time information in educational settings.

Rationale:

Technological advances and pressing management problems have coalesced to foster a new mode of observing our environment. Many human benefits derived from the earth's ecosystems are contingent on knowing the current condition of those ecosystems, understanding the controls on those systems and identifying stressors that might lead to deterioration in the future. Continuous, real-time information on multiple variables is essential and increasingly feasible through new instrumentation and communication. This information is essential for measuring the environmental response to episodic events in the natural and anthropogenic system. Residents of New York and New Jersey and specifically the Hudson Valley would benefit from an integrated system for observing key characteristics of the Hudson River and local environmental conditions such as meteorology.

Information Needs:

Fundamental knowledge of the Hudson River Estuary, its resources and management has progressed dramatically over the past 25 years. Our understanding of the river system, however, has been hampered by manual approaches to data collection that cannot adequately capture rare events or describe rapid fluctuations and episodic pulses in environmental conditions. HRECOS will make available continuous information and real-time data on water quality and weather conditions to provide an understanding of some basic questions about important processes and their controlling factors, contribute to assessment of management needs and effectiveness and aid in direct human benefits from the Hudson River and its tributaries.

The major contributions of HRECOS include:

Enhanced Scientific Understanding

- Understanding the importance of extreme events (increased sediment loading and transport, increases in pathogen contamination);
- Collecting data to support development of new models;
- Determining the importance of short-term changes (low O_2 pulses and conditions);
- Understanding connections among processes occurring at high frequencies;
- Understanding the processing of materials from the watershed to the ocean;
- Understanding the processing of materials from the aquatic to atmospheric system; and
- Providing a backbone for innovative scientific capabilities.

Better Management Decisions and Emergency Response

- Establishing baselines to detect change caused by human-influenced and natural events, and management actions (for example changes associated with sea level rise, regulatory action, and management policies);
- Measuring trends in water quality conditions in relation to natural and human influences, using enforceable criteria as benchmarks;
- Describing habitat suitability (for example clarity and salinity) for existing resource species management and guiding future restoration;
- Detecting spills to aid rapid response; and
- Adding synoptic data to an accumulating historic database that can be used in the future by management agencies in project reviews and modeling.

Recreational Resource Use

- Providing real-time conditions for recreational users (wind, water temperature, water quality);
- Providing water and weather conditions for improved safety and efficiency of waterborne commerce; and
- Creating opportunities for education and stewardship.

Signature Elements of the Hudson River Environmental Conditions Observing System:

The Hudson River Environmental Conditions Observing System (HRECOS) is being developed, operated and managed as a consortium of government, private, and academic institutions. Effective collaboration and close coordination are core principles of HRECOS, and viewed by all partners as essential to program success. Through a shared commitment to operating the observing system, partner organizations maximize the expertise supporting the system.

HRECOS will provide the necessary datasets and interpretive products to address many science and management questions, especially those dealing with water and sediment quality, fisheries management, aquatic habitat, and human use of the estuary. These are discussed in greater detail below.

HRECOS sites will combine high-frequency measurement of water quality and atmospheric variables co-located with a pumping system for collection of water samples. These water samples may be analyzed for key contaminants on a regular basis should the need arise. As of May 2008, six permanent stations have been established with the intent of developing a multi-variable, long-term, time series data set for the Hudson River. The six sites span the length of the estuary from Schodack Island (RM 131) to Castle Point (RM 3) with intermediate sites at Tivoli Bays (2 sites at RM 98), Norrie Point (RM 85), and Piermont Pier (RM 25). Here RM refers to the distance in miles along the river from the Battery in New York City. At a later date, additional sites may be established to include the Mohawk, the upper Hudson River and the upper part of New York Harbor, as resources permit and need dictates.

The HRECOS is patterned after and nested within larger efforts to observe the global oceans and coastal waters. The U.S. Integrated Ocean Observing System (IOOS) and the National Science Foundation Ocean Observing Initiative (OOI) will routinely and continuously provide quality controlled data and information on the current states of oceans, estuaries, and the Great Lakes, from the global scale of ocean basins to local scales of coastal ecosystems. HRECOS is a multidisciplinary system designed to provide data in forms and at rates required by a wide range of organizations and programs to address local and regional natural resource, heath, safety and research issues. Recently, the Mid-Atlantic Coastal Ocean Observing Regional Association received a three-year grant to establish the Mid-Atlantic Regional Coastal Ocean Observing System (MARCOOS). MARCOOS is focused on the coastal ocean, and does not extend into either the NY/NJ Harbor Estuary or the Hudson River Estuary. HRECOS fills this gap in MARCOOS.

Broad Scale Utility of HRECOS Data and Information

The National Oceanic and Atmospheric Administration (NOAA) with other federal partners have established seven societal goals for regional observing systems (http://www.ocean.us). These goals are in concert with those of HRECOS. They are:

- Improve predictions of climate change and weather and their effects on coastal communities and the nation;

- Improve the safety and efficiency of maritime operations;
- Mitigate the effects of natural hazards more effectively;
- Improve national and homeland security;
- Reduce public health risks;
- Protect and restore healthy coastal ecosystems more effectively; and
- Enable the sustained use of ocean and coastal resources.

To realize these goals, the HRECOS integrated observing system will:

- Efficiently link observations, data communication and management, and data analysis and modeling (to form an "end-to-end" system);
- Provide rapid access to multi-disciplinary data from many sources;
- Serve data and information required to achieve multiple goals that historically have been the domain of separate agencies, offices or programs;
- Efficiently link advances in science and technology to the development of operational capabilities; and
- Establish and maintain cross-cutting partnerships among federal and state agencies, the private sector, and academic institutions.

Several organizations will find the data and information collected and disseminated under HRECOS valuable, including the Port Authority of New York/New Jersey, the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, state and federal fisheries and natural resource managers, marina owners, public water supply agencies, emergency managers, emergency responders, shoreline property owners, municipalities on the Hudson River waterfront, recreational boaters, recreational tour boats and ferry operators, and state and local public health agencies. An early goal for HRECOS is to survey potential users to get a solid understanding of the types of information they want and how best to get this information to them.

Regional Management Issues Served by HRECOS

Because the Hudson River Estuary is facing many challenges, several management programs guiding its future protection and restoration have been created. A missing component in these programs is a dedicated long-term observational system that extends from the watershed to the coastal ocean. Data are required to evaluate how well these management efforts, and others, are working and to facilitate a framework from which new strategies may be employed to adaptively react to unforeseen changes.

Several efforts to control the inputs of harmful substances, like TMDLs for nutrients, pathogens and toxics, are underway and all require the establishment of baselines and the use of models to predict future conditions in light of potential actions to curb pollution. Model development and verification has been hindered, in large part, because of the lack of historic ambient data that can be used to set current conditions and verify model estimates. This situation is particularly severe in the Hudson River north of Poughkeepsie. An observational network, coupled with modeling, is essential to understand the long-term effects of major actions to curb pollution, such as the planned dredging of PCB “hot spots” in the upper river.

Comprehensive ecosystem restoration planning for the Hudson River has begun and requires more observations to better describe existing water quality conditions for detailed feasibility planning and performance monitoring. The planned observational system will significantly augment existing knowledge.

Managers face mounting pressure from development interests to modify existing Hudson River shorelines. HRECOS data and information about habitat conditions will be helpful in determining the ecological value of shorelines, and will illuminate ecosystem services and habitat tradeoffs for resource managers and regulators.

Science Issues Served by HRECOS

HRECOS serves a wide array of science, management and public information needs. Within the basic and applied science domain, there are several classes of questions and unknowns that will benefit from HRECOS data and information. Many of these have been identified in workshops sponsored by the Hudson River Foundation (nutrients and lower food webs in particular) and in The Hudson River Estuary (2006) [Levinton, J.S., and Waldman, J. (eds.), Cambridge University Press, New York].

Episodic Large Scale Events: Many events are difficult to observe either due to their unpredictable occurrence, inhospitable conditions, and their influence on the entire estuarine system. Storms are the best example and are known to cause major changes in suspended sediment loads, physical and biogeochemical conditions, and contaminant transport. However, performing fast-response sampling over the whole estuarine system is often difficult, dangerous and very expensive unless there is a system such as HRECOS in place.

Episodic and Small Spatial and Temporal Scale Events: Particular environmental circumstances may have large and persistent effects although the actual occurrence may be quite transient. Examples of these kinds of events include sewage treatment plant failure, salinity intrusion and low dissolved oxygen events. These conditions may have detrimental effects although the actual spatial and temporal extent of the event is small and difficult to document. HRECOS data can be used to predict the convergence of physical conditions conducive to development of small harmful algal blooms that would otherwise be difficult to target for sampling.

Large Noise to Signal Variables: Some variables such as dissolved oxygen saturation will vary with currents, water levels and time of day. The detection of long-term trends and even knowledge of the present conditions in the estuary requires a large number of observations to quantify the variability. Also, relationships among variables may be strongly non-linear or contain thresholds. A large number of observations across a large range of conditions is needed to establish process-oriented relationships. For instance, suspended-sediment concentration is often related to freshwater discharge by a power law function. Quantifying these relations requires a large set of observations.

Filling Gaps: Research and monitoring in the Hudson River Estuary have been spatially uneven and disjointed due to differences in research goals and geography. A spatially distributed set of observing points will ensure common scientific information on the whole system at the same time. Locations where a good suite of background variables are measured

will attract more focused, intensive, and sophisticated sampling efforts such as for pathogens or contaminants. Real-time reporting of conditions will also allow researchers to target certain conditions for manual or automated sampling. Additionally, model calibration and validation require large multi-variant sets of observations that are expensive to collect manually.

Legacy Science Information: A major asset of HRECOS is the long-term and persistent measurements of the whole estuary. The health, dynamics, and constituents of the estuary will vary with weather, land-use, and climate changes. A utility of HRECOS is to understand how the system changes over time. In order to understand how changes occur across the whole Hudson River Estuary system, a method to provide a legacy of observations needs to be in place to provide both a baseline and continuous information for comparison. HRECOS is spread across a range of diverse physical and ecological systems. Observations across the whole system will reveal how both different parts of the estuarine system respond to external forcings and how they respond and are connected to each other.

Watershed and Ocean Integration

HRECOS is an important component of the continuum of observing programs and systems ranging from the watershed of the Hudson River Estuary to the coastal ocean. In order to glean the most information from the data collected through HRECOS, these data can only be fully interpreted by accurately integrating watershed and coastal ocean processes and understanding. Land use, water quality, meteorological events, management activities, and biodiversity in the watersheds all have a direct influence on the health and ecosystem processes of the Hudson River Estuary. This first phase of HRECOS is the beginning upon which to build in the future.

Data Management and Communications

HRECOS will provide data that are high quality, reliably available, accurate, easy to find, and relevant to users' needs. Over the next two years, one partner organization will assume responsibility for all aspects of data acquisition, quality control and assurance, storage and distribution. This organization will provide internet access to the real-time data, review and archive all historical data, and assure the system is operational at all times. Three organizations currently provide this service for water quality monitoring data on the Hudson River, including:

(1) Stevens Institute of Technology
(http://hudson.dl.stevens-tech.edu/maritimeforecast/info/)
(2) USGS
(http://ny.water.usgs.gov/projects/dialer_plots/saltfront.html),
(http://ny.water.usgs.gov/projects/poused/index.html)
(3) Central Data Management Office of the National Estuarine Research Reserve System (http://cdmo.baruch.sc.edu/)

In the interim, Stevens Institute of Technology has developed and is maintaining a pilot website for HRECOS to capture data and provide them in near real-time.

Governance of HRECOS

A governance system has been established by a consortium of data users, most of whom are participants, experts on the Hudson River and funding providers. Quarterly meetings will be held to assess products and advise HRECOS managers. This governance group will ensure HRECOS projects are relevant to the multiple needs of the community, and that outreach products are linked to users and audiences. The group will work to heighten awareness of HRECOS among Hudson River Estuary researchers, river stakeholders and interest groups. HRECOS activities will be integrated and coordinated with MARCOOS and MACOORA activities. Figure 1 provides a conceptual view of the governance structure.

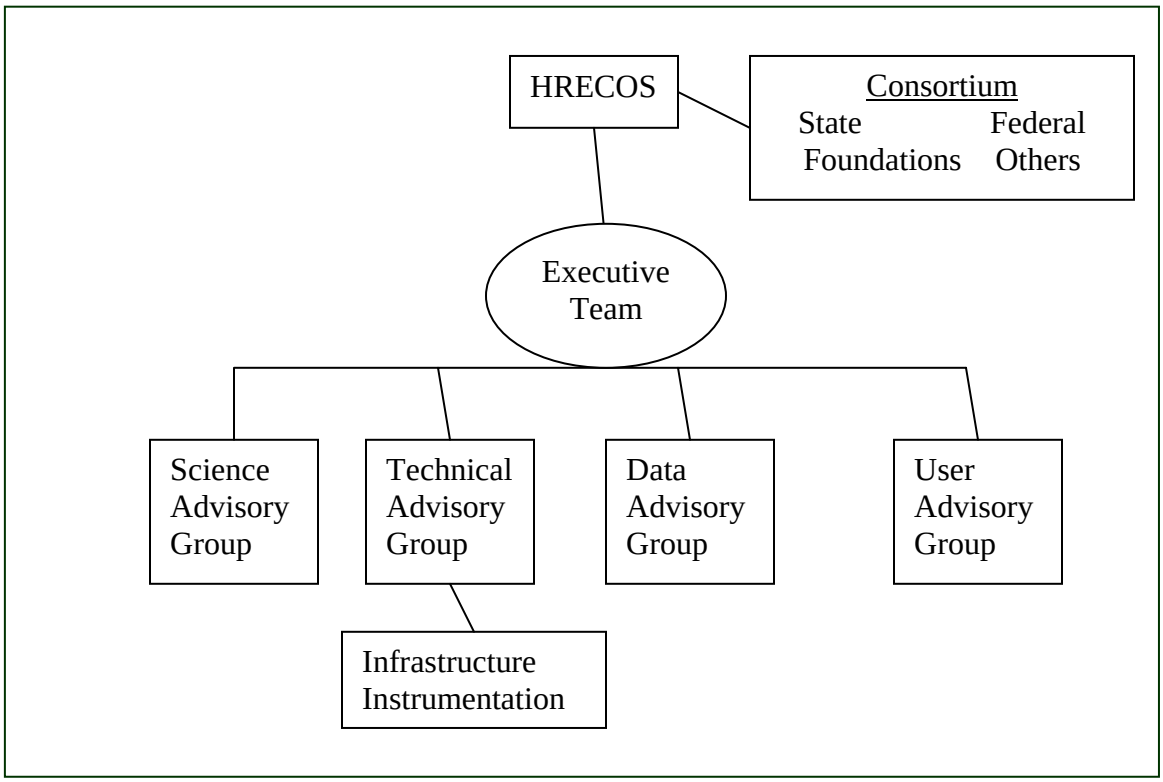

Figure 1: Conceptual layout of the governance structure of the Hudson River Environmental Conditions Observing System (HRECOS)

Core Components of HRECOS

Evaluation and Innovative Exploration

Once fully operational, the HRECOS station platforms will be available for the testing and development of in-situ monitoring sensors and can provide supportive data and information for higher intensity research studies on the Hudson River. HRECOS would provide for the opportunity for independent research results to be interpreted in a broader spatial and temporal context than is currently possible. HRECOS will encourage partners to make funds available on an open competitive basis to enable researchers to carry out studies for evaluating the data from each of the six permanent sites. This might include actual field data and/or synthesis of existing or historical and discreet water, meteorological, or real-time in water measurements. Investigators could supplement HRECOS data with additional field

work by conducting finer spatial scale sampling, and through analysis contrasting the data from the permanent sites with other locations. Analysis of historical data to help put the sites in the broader context of the Hudson River ecosystem should be encouraged. A pool of perhaps $250K to engage investigators in maximizing the information gain from HRECOS is recommended.

System Details: ***Year One Accomplishments***

Seven permanent continuous-monitoring stations have been established (Table 1). Each of these stations is or will soon be equipped with:

- An array of water quality instruments allowing for the measurements of dissolved oxygen, turbidity, stage, temperature, salinity, pH, Chlorophyll, colored dissolved organic matter, and blue-green pigments;
- A meteorological station for wind, rain, barometric pressure, relative humidity, air temperature, and photosynthetically active radiation;
- Real-time telemetry via cell phone or satellite; and
- Stations are able to accommodate web camera accessible via the internet to assess river conditions.

Site Name	**Location (RM)**	**Operator**	**CTD**	**WQ**	**Met**
Schodack	131	Cary IES/USGS	✓	✓	✓
Tivoli Bays North	98	NYSDEC	✓	✓	✓
Tivoli Bays South	98	NYSDEC	✓	✓	✓
Norrie Point	85	NYSDEC	✓	✓	✓
Piermont Pier	25	LDEO/NYSDEC	✓	✓	✓
George Washington Bridge	4	Stevens Institute/LDEO	✓	✓	✓
Castle Point	3	Stevens Institute	✓	✓	✓

Table 1: The seven HRECOS observing sites established in 2008. Operators include the Cary Institute of Ecosystem Studies (Cary IES), Lamont Doherty Earth Observatory (LDEO), New York State Department of Environmental Conservation (NYSDEC), Stevens Institute of Technology, and U.S. Geological Survey (USGS). CTD may include water temperature, salinity, and conductivity. WQ may include pH, dissolved oxygen, water level, chlorophyll, turbidity. Meteorological may include air speed & direction, rainfall, barometric pressure, air temperature, and solar radiation.

These initial seven sites include (from north to south): Schodack Island (RM 131), Tivoli Bays (2 sites) (RM 98), Norrie Point (RM 85), Piermont Pier (RM 25), George Washington Bridge (RM 4) Castle Point (RM 3) (see Figure 2). To take full advantage of the system, it is contemplated that sampling with subsequent laboratory analyses, and other augmentations, will take place in the future. It is likely that additional measurements for nutrients, carbon, sediment and contaminants will be collected at the fixed stations for use in models and data interpretations. In addition, augmentation of the system to include physical measurements, such as current flow and water level tied to vertical datum, would also be of great benefit.

These could be readily integrated with activities of MACOORA and the New York Harbor Observation and Prediction System (NYHOPS) developed and maintained by Stevens Institute of Technology and with the Hudson River National Estuarine Research Reserve, which operates several of this stations.

HRECOS data are available real-time through Stevens Institute of Technology at:
http://hudson.dl.stevens-tech.edu/hrecos/

System Details: Year 2-5

Long-term Goals for Fully Implemented HRECOS Program

Research focusing on the loading, transport, dynamics and processes of particles and contaminants in the Hudson River Estuary is a significant, relevant and important science focus for HRECOS. The pilot phase of HRECOS cannot accomplish everything and other worthwhile issues such as tracking organisms or continuous monitoring of nutrients will require additional planning. Sediments have an integral role in lower food webs and water quality, higher-trophic levels and recreational fishing, contaminant transport, commerce and economics, and net metabolism of the Hudson River Estuary. NYSDEC, through the Hudson River Estuary Program and the Hudson River Research Reserve, will provide financial and governance support for the HRECOS backbone to ensure the long-term operation of the system.

Build-out Scenario

In addition to the continuous monitoring of water quality and atmospheric conditions, HRECOS must allow for the regular measurements of significant contaminants and other chemical parameters. To accomplish this, the permanent HRECOS stations would be outfitted with a pumping system to allow for periodic water sample collection. These samples would be analyzed for concentrations of PCBs, suspended sediments, and other contaminants including: pathogens, PCBs, dioxins, Hg, DDT, chlordane, dissolved inorganic and organic carbon, and particulate organic and inorganic carbon. Additional sensors would also be required for continuous monitoring of colored dissolved organic matter, methane, CO_2, and blue-green pigments.

Evaluation and Innovative Exploration

Funds should be made available on a competitive basis to enable researchers to carry out studies to evaluate the representative characteristics of the six permanent sites. One scenario is 1-2 year projects to use the infrastructure to explore new and innovative explorations. This might include actual field data and/or synthesis of existing or historical and discreet water, meteorological, or real-time in water measurements. Investigators may wish to add analyses, conduct finer spatial scale sampling, contrast the permanent sites with other locations or otherwise help put historical sites in broader context of the Hudson River ecosystem. We envision a pool of perhaps $250K to engage other investigators in maximizing the information gain from the pilot phase of HRECOS.

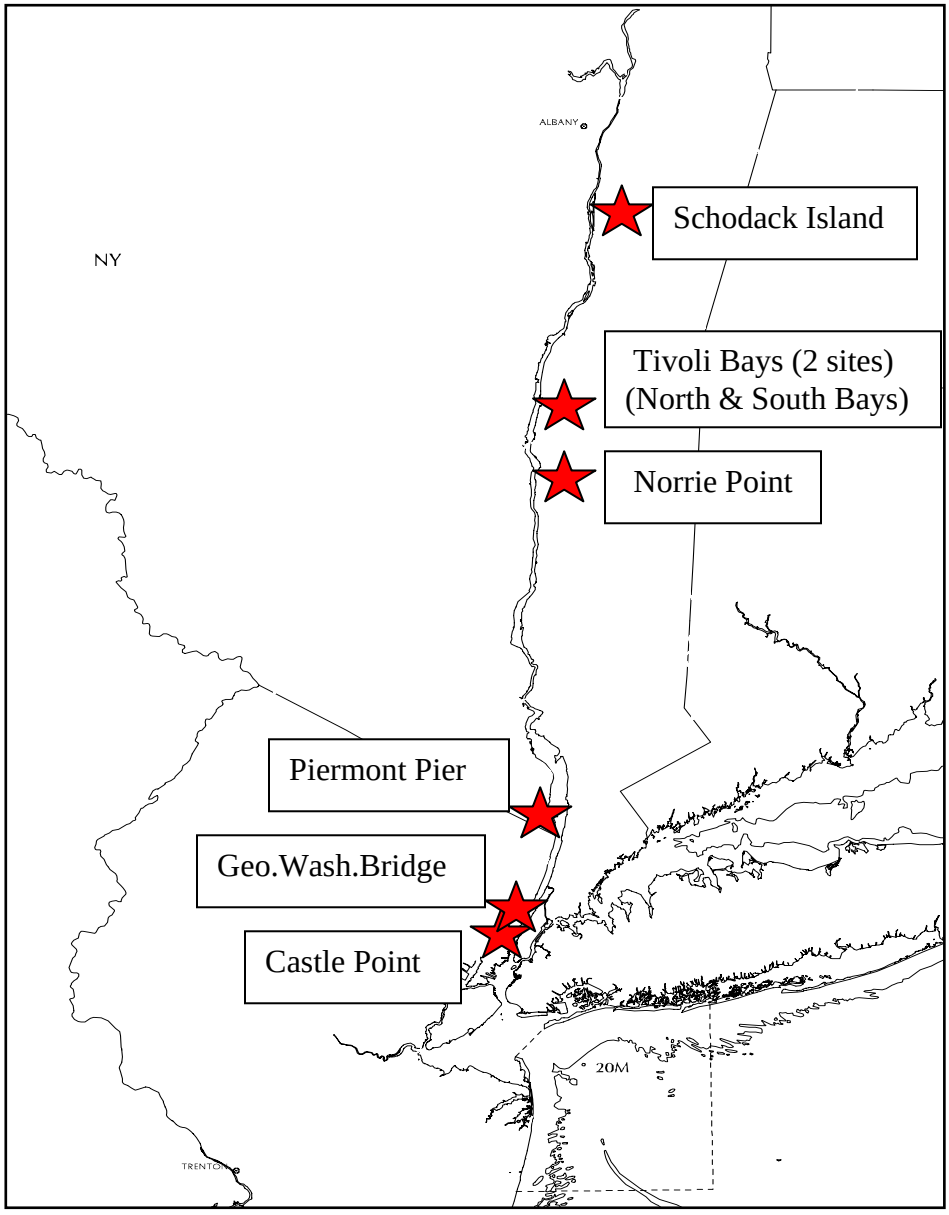

Figure 2: Location map of the initial seven Hudson River Environmental Conditions Observing System (HRECOS).

Appendix: Participants in HRECOS Meetings

Last Name	First Name	Program	Organization	Email
Blair	Betsy	Hudson River NERR	NYSDEC/NOAA	bablair@gw.dec.state.ny.us
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