Jug Bay Research and Monitoring Needs

Jug Bay, a Component of the Chesapeake Bay National Estuarine Research Reserve in Maryland

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Workshop Participants

The information presented in this document was compiled through email requests and a workshop conducted at the Jug Bay Wetlands Sanctuary on April 27th, 2012. A total of thirty researchers from state resource agencies and research organizations participated and/or contributed in the development of the content of this document. A list of participants to the workshop is presented below.

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BACKGROUND

This document was developed to offer guidance on research and monitoring needs to scientists and students from different disciplines who are interested in conducting scientific investigations at the Jug Bay estuarine system. Based on the input of scientists familiar with the Jug Bay ecosystem, a list of research priority questions and topics was developed and organized under main management issues currently facing Jug Bay. The purpose of this report is to stimulate researchers to consider initiating studies that will provide new knowledge about the Jug Bay ecosystem. We especially encourage research projects that will examine key resource management questions, and that address environmental changes that may impact how this ecosystem functions now and in the future.

Jug Bay is a broad, shallow embayment on the upper Patuxent River estuary, about 64 river-kilometers (45 river-miles) from the mouth where the river enters the Chesapeake Bay. Even though it is some distance from the Bay, this region is still under the influence of tides. The diurnal tides result in two high and two low tides every 25 hours and the tidal amplitude is about 0.75 m. However, in spite of the tide cycle, the waters are fresh and they normally lack the salinity that is a universal feature of the lower estuary. Therefore, as a result of its location along the upper end of the estuary where freshwater predominates, this area contains a characteristic type of wetland known as tidal freshwater wetlands. The Jug Bay marshes, swamps and scrub shrub wetlands support more than 130 species of aquatic, vascular plants. Emergent, long-lived perennial species are much more numerous and extensive than annuals, but late in the growing season the biomass of annual plants becomes a dominant feature of the wetland landscape. Vertebrate animal diversity is very high, particularly that of teleost fish, birds, reptiles (especially turtles) and amphibians. Many species, for example most waterfowl, are migratory and do not breed at Jug Bay, whereas other animals (especially anadromous and estuarine fish) use the marshes and mudflats seasonally for reproduction. Many other animals are year round residents. No animal species are endemic to this area and many move regularly between aquatic and terrestrial habitats.

Jug Bay is located about 20 miles east from Washington D.C. and 18 miles south of Annapolis. This is a large, publicly-owned natural area that is cooperatively managed by several government entities working in partnership. The west side of Jug Bay in Prince George's County is managed by staff at the Patuxent River Park, within the Maryland National Capital Park and Planning Commission. Located on the east side in Anne Arundel County, the Jug Bay Wetlands Sanctuary protects about 1,500 acres and is operated by the Anne Arundel County Department of Recreation and Parks.

In 1990, Jug Bay was designated as one of three components of the National Estuarine Research Reserve in Maryland (CBNERR-MD). The National Estuarine Research Reserve System (NERRS) is a federal/state/local government partnership and consists of a network of 28 areas representing different biogeographic regions of the United States that are protected for long-term research, monitoring, education and coastal stewardship. CBNERR-MD partners with the two adjacent county governments to promote research, education and stewardship in the Jug Bay area. The Jug Bay component of CBNERR-MD consists of two entities: Jug Bay Wetlands Sanctuary and Patuxent River Park.

The Jug Bay Wetlands Sanctuary (JBWS) was established in 1985 and is operated as a research field station and environmental education center. Studies have been carried out in the Sanctuary and in the Jug Bay area for more than 40 years. Today, researchers from universities, research institutions and governmental agencies conduct a wide variety of scientific studies aimed at understanding nutrient

cycling, microbial and biogeochemical processes, impacts from global climate change, fundamental wetland functions, linkages between terrestrial and aquatic ecosystems, population dynamics and many other topics. Over the past two decades Jug Bay has become one of the best-studied wetland ecosystems in the mid-Atlantic region.

Some important resources that summarize information about the Jug Bay estuarine system include:

- A Jug Bay Site Profile (http://www.dnr.state.md.us/bay/cbnerr/)
- A Volunteer's Guide to the Jug Bay Ecosystem (Friebele, Swarth and Stafford)
- A reference book: Tidal Freshwater Wetlands (Barenderegt, Whigham and Baldwin, eds.)
- An Estuarine and Coasts special journal feature (Barendregt and Swarth, eds.), to be published in 2013
- A list of publications and reports , which can be found in the Jug Bay Wetlands Sanctuary website: http://www.jugbay.org/research/reports
- An Abiotic Data Warehouse (http://www.jugbay.org/research)
- A GIS Layer Library

In addition, the following is a list of some of the research and monitoring projects currently underway at Jug Bay, which are led by CBNERR-MD and Jug Bay staff and volunteers:

- Monitoring of marsh and submerged aquatic vegetation
- Studies on marsh surface elevation dynamics
- Monitoring of weather and water quality
- Monitoring of groundwater levels and salinity
- Monitoring of secretive marsh birds
- Monitoring osprey and wood duck reproductive productivity
- Monitoring of larval yellow perch
- Stream monitoring
- Vernal pool monitoring
- Winter waterbird surveys
- Phytoplankton characterization
- Population ecology, diet and movements of turtles
- White-tailed Deer population control
- Monitoring Aviation Productivity and Survivorship (MAPS) study
- Maryland Herp Atlas surveys

The Reserve and its partners from the Patuxent River Park in Prince George's County and the Jug Bay Wetlands Sanctuary in Anne Arundel County, provide many resources to students and scientists to support research at Jug Bay. Some of these resources include meeting spaces, laboratory space and some laboratory equipment, storage areas, water access facilities such as piers and ramps, and the use of boats and motors depending on availability. Additionally, at JBWS there are many large datasets and a number of technical reports that are available.

RESEARCH AND MONITORING NEEDS

The following research and monitoring needs have been identified and organized under main management issues facing the Jug Bay estuarine system. This is not a comprehensive list, but is an initial effort to recognize some of the main information gaps at Jug Bay.

CLIMATE CHANGE

- **Sedimentation Dynamics:**
  - Study sediment dynamics to understand marsh and submerged aquatic vegetation (SAV) sustainability to sea level rise.
  - Study marsh, SAV, and coastline erosion and the relationship of erosion to sea-level rise and increased storm events.
  - Conduct an historical mapping analysis of the shorelines of the Patuxent River and creeks to better understand impacts as a result of erosion/deposition with projected sea level rise and other climate-related impacts.
  - Study sediment availability and transport, and rates of sediment deposition/erosion in creeks to determine impacts from predicted increased storm events.
  - Study SAV physiology in relationship to eroding peat/marsh sediments.

- **Carbon Sequestration:**
  - Link soil carbon and soil density measurements with marsh surface elevation data (SET data-surface elevation table) above and below the feldspar marker horizons to better understand relationships between the depth of carbon inputs (i.e. surface vs. subsurface) and marsh elevation trajectories.
  - Study marsh carbon sequestration (which may translate into biomass production and organic matter buildup) and greenhouse gas balance and their role in keeping the marshes in equilibrium with sea level rise.
  - Study the role of submerged aquatic vegetation communities in sediment retention, nutrient cycling, carbon sequestration, nitrogen and phosphorus sequestration, use as nursery habitat, and as a food source.
    - Emphasize interactions of key factors regarding carbon sequestration using data and modeling.
  - Study the role of upland vegetation community in carbon sequestration by monitoring tree growth.
  - What is the impact, in terms of carbon and nutrient cycling, of benthic algal productivity in the marsh flats and the shallow subtidal habitats in Jug Bay?

- **Salinity Intrusion and Temperature Changes:**
  - Determine salinity impacts on tidal freshwater plants, biogeochemistry, decomposition, and the processing of phosphorus and other nutrients.
  - Determine how the reproductive cycle and development of fish (particularly those of economic and high ecological value) as well as their migration and feeding patterns would be impacted by changes in salinity and water temperature. Specifically, regarding temperature changes: would earlier spawning seasons have an impact on bioenergetics and fecundity?

- **Jug Bay Flora and Fauna and Climate Change:**

- Develop vulnerability assessments for key emergent wetland plant species (e.g., wild rice, spatterdock, cattail) to climate change, particularly sea level rise.
- Study and understand SAV and marsh migration processes to uplands, potential barriers, as well as spatial and temporal plant and sediment changes by establishing long-term limited-monitoring sites across a range of expected sea-level rise response predictions and habitats/elevations (SLAMM or MEMIII could be used to establish predicted sea-level rise sites).
- Study herbivory or secondary production on emergent vegetation in relation to climate change.
- Determine species shifts due to invasive species and evaluate responses to potential climate and land use changes.
- Determine how temporal and spatial environmental changes (including climate change) influence larval production, forage base and juvenile fish species (specifically, anchovy, menhaden, gizzard shad, and snakehead).
- Study the responses of different species of turtles to climate change and other environmental pressures.
- Study population structure and dynamics of the benthic macroinvertebrate communities in non-tidal waters, specifically monitor key species shifts as a response to climate change.
- Determine how changes in precipitation patterns, intense drought conditions, and changes in salinity may impact microbial communities in the water and sediments of tidal freshwater systems.
- Survey the waterbirds that breed and migrate through the Jug Bay wetlands
- Summarize the existing data on waterbirds occurrences and the existing data on Osprey reproduction

- **Groundwater**:
  - Understand the regional groundwater flow and the affects of pumping on groundwater heads and subsidence.
  - Study and monitor groundwater resources (marshes and upland forests within the watershed), including groundwater contamination, potential for salinization, and the potential compounding impacts of human uses and climate change on groundwater levels.

DEVELOPMENT AND LAND USE CHANGE

- **Tidal Freshwater Marshes:**
  - Study nutrient sinks in the Jug Bay estuarine system, particularly regarding nitrogen and phosphorus retention (SAV, benthic algae, etc.).
  - Determine how tidal channels function in delivering sediments, nitrogen and phosphorus to the Patuxent River.
    - What proportion of nitrogen retention occurs via plant assimilation (eg. Hydrilla and macrophytes?
    - Quantify sediment and particulate organic matter deposition within SAV canopies?
    - What effect will climate change have on nitrate transformation pathways?
  - Assess/quantify ecosystem services and value provided by the tidal freshwater marshes of the Patuxent River.
  - Use historical data to create models for freshwater wetlands of the entire Chesapeake Bay.
  - Use GIS tools, particularly habitat mapping and change analyses, to study the impact of development and land use changes on aquatic and upland resources.

- **Water Quality and Other Environmental Issues:**
  - Assess the short and long-term effects of untreated sewage overflows from the various wastewater treatment plants located around the Jug Bay estuary on water quality, nutrient dynamics, and overall contamination (eutrophication, fecal coliform, trace metals) of the aquatic environment by using antibiotics or caffeine as trackers or by learning where the sewage goes.
  - Assess the response on Jug Bay's water quality from inorganic nutrient loads from the Western Branch Wastewater Treatment Plant.
  - Quantify the impact of sewage, septic systems (with/without enhanced N processes), existing private sewage treatment plants at/near/over capacity, and future sewage from development on bacterial communities and water quality in the Patuxent River.
  - Study the response of the Jug Bay estuarine system to Total Maximum Daily Loads (TMDLs) and/or Best Management Practices (BMPs):
    - Investigate septic systems upgrade and the success of cover crops (which practice started approximately 10-15 years ago) regarding water quality.
    - Quantify positive effects of BMPs such as rain gardens and rain barrels on TMDLs to promote their use within the region as a practice to improve water quality.
    - Determine the correlation of the EPA's Watershed Implementation Plans to long-term Patuxent River water health.
    - Explore the potential of using soil tests from local farms (if made public) to supplement nutrient information and management plans already available to the public.
  - Study marsh seasonal nutrient cycling. Considering plant dieback during the fall and winter it would be important to study nutrient translocation belowground during the fall and the export of organic matter to the system.
  - Determine the interrelationships between plankton components and water quality, physical and chemical environmental factors, and the estuarine food web.
  - Monitor potentially harmful phytoplankton species, specifically *Microsystis*.
  - Study the role of upland vegetation community in primary productivity, nutrient cycling, and natural regeneration under natural and stressed conditions.
  - Assess the impacts of black plastic leaf bag litter from the Prince George's county leaf compost facility on the aquatic and terrestrial ecosystems

- Assess the potential impacts of the establishment of a trash transfer station at Western Branch on the Jug Bay estuarine system.

- **Jug Bay Flora and Fauna - Development and Land Use Change:**
  - Determine the potential impacts of commercial and recreational fishing on Jug Bay fish stocks and their potential collateral damage to other aquatic species (potentially through tagging or fyke and pound nets). Priority fish species to study: yellow perch, white perch, mummichogs, rockfish, and snakeheads.
  - Monitor and analyze fish catch data of commercial fishermen in the Patuxent River.
  - Study specific interactions between key fish species and various estuarine habitats, their role within the food web, and population responses to natural and anthropogenic impacts including poor water quality, heavy metal contamination, and climate change.
    - Study and understand if larval fish dynamics tied to the Estuarine Turbidity Maximum (ETM) are being altered by development (specifically, yellow perch, white perch, rockfish, and snakeheads). Is there evidence that detritus loading or salinity distribution have been altered by development?
  - Determine shifts of native plankton species due to plankton invasive species and evaluate responses to potential climate and land use changes.
  - Determine how phytoplankton community structure (plankton size) and distribution changes as a result of varying levels of nutrient concentrations (pollution).
  - Determine spatial and temporal changes of macroinvertebrate populations in both marsh and open water and evaluate potential responses to anthropogenic and natural stressors (e.g., eutrophication).
  - Study how different species of birds and mammals make use of the wetlands and other habitats, which are their food sources, habits, population sizes, and their responses to a changing environment.
  - Continue the Monitoring Aviation and Productivity Study (MAPS) to provide the data necessary to correlate bird population health with Jug Bay forest trajectories.
  - Are the forests at Jug Bay recovering or progressing towards collapse owing to the deer population at Jug Bay?
  - Determine the success of deer control, specifically deer exclusion devices on deer management at Jug Bay, particularly the effects on the recovery of the forest understory.
  - Conduct an evaluation of management options such as fire, mowing, tree removal, and the application of herbicides to maintain and augment current vulnerable sandy areas (sand barrens).

- **Stream Hydrology and Fluvial Geomorphology:**
  - Expand on the ongoing three-stream study of Galloway, Two Run, and Pindell Creeks to include yearly or bi-yearly geomorphological assessments of stream sections where water chemistry, macroinvertebrates, and fish are monitored. As possible, expand to monitor the branch of Galloway Creek on the newly acquired parcel east of Route 4.
    - Conduct a biological assessment of Two Run Branch and other Sanctuary streams to determine their potential for gaining Tier II High Quality Waters status from MDE.
    - Determine a restoration strategy for Two Run Branch where threats of water quality (point source pollution) and bank erosion persist.
  - Assess the impacts of potential large-scale developments (e.g., Riverdale Baptist Church) on local watersheds.
  - Quantify current changes in substrate, cross-section, and longitudinal section of streams, ponds, and banks. Determine sediment load and transport along with stream erosion and deposition areas over time, especially with increasing development.

- Expand the monitoring of the Two run Branch beaver pond(s) at Otter Point to include more physical monitoring (elevation of dam top, surface area, depth profiles, consolidated and unconsolidated sediment depths, sediment size characteristics and sediment grain size (related to sediment deposition on marshes, etc.).
  - Determine the impact of increased sediment, reduced pond depth, etc. on denitrification in the beaver pond(s) at Otter Point.
  - Determine if there are hypoxic zones in the beaver pond(s) at Otter Point. What is the impact of sediment on this?
- Quantify stream flow to compute nutrient (or other component) load from concentration measures.
  - Complete a synoptic study of streams in a larger region to determine the correct context for the local streams.
- Determine the hydrological characteristics of streams including groundwater fluxes and stream water discharge.
- Study estuarine hydrodynamics, including water residence time on a small scale.

INVASIVE SPECIES

- **Invasive Species in the Jug Bay Estuary:**
  - Determine the past, current status, and potential expansion of invasive species, particularly common reed and purple loosestrife.
  - Study the competitive interaction between native and non-native species for both marsh and submerged aquatic vegetation species.
  - Monitor the presence of snakeheads in the Patuxent River.

- **Invasive Species in Upland Communities:**
  - Monitor upland communities to detect new invasions from non-native species as well as the appearance of new species that may result from expanding distributional ranges resulting from climate change.
  - What is the trajectory, the *prognosis* for each area of the forest? How will the prognosis for each major part of 1,000+ upland acres impact other biota monitored at Jug Bay including invasive species?
  - Study and quantify the impacts of invasive species in upland communities. Are exotic invasive plants contained or spreading across uplands and wetlands? How long will their expansion and impacts be reversible? What are impacts of inadequately controlled invasives that limit growth of tree saplings and of native herbs that escape deer damage? Reversible if delayed five years, ten years?

GENERAL RESEARCH

- **Data Analyses**
  - Conduct analyses of long-term existing data (e.g., water quality, vegetation, and fauna surveys). Design data analyses to answer specific questions and include a plan for potential outreach and communication of findings to resource managers and stakeholders.

- **General Flora and Fauna Research:**
  - Conduct more detailed and quantitative studies of Jug Bay's vernal pools including a detailed spatial and temporal characterization of their hydrological cycle, physical-chemical properties, and associated plant community. Also, study their role as habitat and reproductive sites for various organisms.
  - Investigate the prey-predator relationship between fish and zooplankton on the Patuxent River.
  - Study population dynamics, habitat use, and feeding habits of reptiles and amphibians found in Jug Bay habitats, including the vernal pools.
  - Study beavers: their population density, feeding habits, and habitat use, and their influence in marsh hydrology.
  - Study muskrats and their role on marsh vegetation to better understand their potential impact in marsh dynamics.
  - Determine species composition, abundance, biomass, and productivity as well as seasonal and spatial patterns of the tidal freshwater phytoplankton and zooplankton communities. (Timing of zooplankton peaks directly relates to the Young of the Year (YOY) striped bass peaks).
  - Conduct an image analysis of zooplankton communities using open-source imaging software with either a flatbed scanner or camera with macro lens and extension tube. This can provide both images of the plankton community as well as size-frequency distributions and possibly some taxonomic information, depending on the resolution of the imaging system.
  - Conduct a comprehensive baseline characterization including species composition and abundance in different substrates and habitats within the estuary. Aquatic insects and benthic invertebrates constitute food supply for waterfowl and there is limited knowledge of what is there or their relative abundances.
  - Monitor native and non-native crayfish as well as freshwater mussels.
  - Monitor the relationships between SAV and macroinvertebrates.
  - Determine indicator macroinvertebrate species and track their populations as a relation to Patuxent River health.
  - Conduct an inventory of arthropod species at Jug Bay with a concentration on open sandy areas (sand barrens).

Regarding any questions about the information presented in this document please contact: Patricia Delgado, Research Coordinator of the Chesapeake Bay National Estuarine Research Reserve in Maryland at pdelgado@dnr.state.md.us or Christopher Swarth, Director of the Jug Bay Wetlands Sanctuary at rpswar96@aacounty.org.