**EBTJV-Related Science and Data Projects\_2013**

**Catchment Scale Brook Trout Status Assessment** (Mark Hudy/Amanda Colton/Jason Coombs)

In 2011, the EBTJV began updating its range wide brook trout status assessment at the catchment scale. The mid-Atlantic and southern states are in the process of verifying the analysis of their data sets and the northern states have either provided their data sets, or are in the process of providing their data sets (VT and RI), for analysis.

* 132,321,688 catchments in the historic eastern range of brook trout; average size = 237 ha

**Brook Trout Habitat Patch Layer** (Mark Hudy/Jason Coombs)

The end products of this work will be NHD+ layer with brook trout occurrence and brook trout patch layer at the catchment scale. This tool will enable retrospective analysis by producing patch layers through time and quantifying patch loss. A framework for future analysis using occupancy models that result in the capability to assign catchments with the probability of having brook trout present.

* “Patch” = a group of contiguous catchments occupied by wild brook trout. Patches are not connected physically either due to fish passage barriers, warm water habitat, or downstream invasive species. Patches are assumed to be genetically isolated populations.
* “Patch Populations” - number of patches = 2,698; average size = 1,541 ha; median size = 855 ha.
* Patch Metrics (based on occupancy sampling of catchments) - number of patches; number of patches with increasing size/connectivity (additional upstream and downstream catchments with brook trout); number of patches decreasing in size/connectivity (loss of catchments); average patch size of the entire resource; and, number of patches with allopatric or sympatric (with brown or rainbow) populations.

Need: to have a system that utilizes the catchment scale brook trout assessment data to identify priority areas for brook trout conservation actions (protection, enhancement, and restoration).

* The Chesapeake Bay Program is considering using allopatric brook trout catchments, Audubon priority forest blocks, and state identified healthy watersheds to identify priority areas as well as using oil and gas well locations and climate change vulnerability maps associated with the subwatershed brook trout status assessment.
* At the subwatershed scale, EBTJV uses a model that consists of the following six core metrics to predict brook trout distribution and status at this scale: percentage of forested land, combined sulfate and nitrate deposition, percentage of mixed forest in the water corridor (riparian habitat), percentage of agriculture, road density, and latitude. Threshold levels of concern for these metrics include forested landed that is less than 68%, combined NO3 and SO4 deposition value greater than 24 kg/ha; agricultural lands is 12-19% or higher; and, road density is greater than 1.8-2.0 km/km2.

**Climate Change Vulnerability** (Mark Hudy/Jason Coombs/JMU)

Climate change vulnerability classification model for brook trout populations; brook trout populations are classified into one of four quadrants based on direct measurements or model predictions of sensitivity and exposure. Low exposure, low sensitivity populations are most likely to persist under various climate change scenarios.

* Cluster metrics: elevation, maximum air temperature, % ground water, % forest, solar gain.
* Predictive metrics – Exposure (81.1 % concordance): elevation (m), % forest corridor, watershed area (km2); Sensitivity (75.2% concordance): maximum air (°C), watershed area (km2), solar\_mean\_corridor.
* Solar gain (30 meter pixel): topography, aspect, elevation, latitude, longitude, riparian cover.
* Solar radiation (upper quartile) – canopy cover (<70%)

**Riparian Planting Tool** (AppLCC/Jason Coombs)

The purpose of this tool is to locate and prioritize locations where tree plantings would be most beneficial range wide. The data being used to develop this tool includes canopy cover, solar radiation, NHD+ stream layer with 100 meter buffer (30 meter Raster). The end product is a web-based GIS tool with features that allows the user to specify threshold values for % canopy cover, % rank solar radiation, and spatial extent for various geographic and hydrologic layers. This tool will be housed by the AppLCC and made available through all partner portals including the EBTJV website; however output of data sets can be exported by user. Additional suggested functions of this tool are to include delineation of the 100-year floodplain and to provide the ability to change the buffer size.

**Optimal Stream Survey Design for Detection of Fish Population Trends: Insights Gained from Long-Term Monitoring** (Coombs et al)

Use of surveys to detect trends in population abundance over time can be difficult due to high natural variability. Salmonid populations are no exception, with reported coefficients of variation (CV) ranging fro 15%-108%. Givene the finite amount of resources available to managers, knowledge of how survey design affects the ability of monitoring to detect population trends would be highly beneficial. To assess the affects this research applied varying spatial and temporal survey designs to a brook trout population dataset that contained nineteen years of fine-scale survey data, and had a positive linear trend over that interval. Spatial designs revealed that annual sampling of four 50 meter sections (10% of available habitat) that were initially randomly selected but remain fixed over the monitoring period resulted in CV (51.4%) and statistical power (0.88) values comparable to those obtained from sampling the entire stream (46.7%, 0.99). Temporally, sampling the entire stream at a fixed annual frequency ranging from 2 to 5 years resulted in significant trend detection in only 29% (4/14) of all monitoring possibilities. The low detection rate was caused by high abundance variability, evidenced by the fact that complete stream annually monitoring required a minimum of seventeen years before reaching adequate statistical power (0.81).

**Proposed Monitoring Design and Methods**:

Cluster analysis to subsample existing 331 patches:

* Sentinel samples - (yearly trends)
* Panel samples - every 5 years (long-term trends)

Example: 125 sites from cluster analysis; 25 are designated “sentinel” to be sampled yearly; additional 20 sites sampled yearly on a rotating panel (each site visited every 5 years); equals 45 sites monitored statewide per year.

**Genetic Monitoring Metrics**

1. Nb = number of individual brook trout (regardless of age) contributing to year class; not the data requirements of Ne (Whiteley et al. 2012)

2. Amount of genetic diversity within a patch can evaluate changes in relative abundance

* Increasing Nb trends: positive response from improved habitat or increasing population.
* Decreasing Nb trends: suggest habitat loss and decreasing population.

For genetic monitoring of headwater brook trout populations, it’s recommended that the sample size be at least 75 fish; there be three (3) starting locations for sampling; and to focus on Nb of age-0 cohort. This works across brook trout populations with varying family structure and should be the general outcome for monitoring Nb of headwater trout populations.

**Fragmentation and Patch Size Shape Genetic Structure of Brook Trout Populations** (Whitely et al)

This research tested the relative influence of habitat patch size and connectivity on brook trout genetic structure and effective population size. Above-barrier patch size had a strong positive relationship with genetic diversity, effective number of breeders (Nb), and genetic differentiation. This analysis is consistent with greater extinction risk in smaller above-barrier patches. Larger above-barrier patches contained greater genetic diversity but reduced Nb relative to adjacent below-barrier patches. The primary effect of barriers may be to reduce available above-barrier spawning habitat, even for larger above-barrier patches.

The results of this study suggest that a simple measure of habitat area (patch size), the combination of patch area and stream length, may be useful for the prediction of genetic diversity maintenance across amuch larger number of eastern brook trout populations and perhaps those of other headwater fishes. However, differences in patch quality could confound the relationship between patch size and genetic variation; that is, larger patches with poor habitat quality might be predicted to have lower genetic variation than small patches with high habitat quality.

Patches should not be assumed to be safe from extinction risk simply because they occur below a barrier as below-barrier patches may be isolated due to high stream temperature, poor stream conditions, and/or the presence of invasive species.

**Habitat Assessment Model & Decision Support Tools** (NALCC/WVU/Downstream Strategies) <http://applcc.org/resources/video-gallery-and-webinars/webinars/neighboring-lccs/habitat-assessment-models-and-decision-support-tools-for-aquatic-habitats>; <http://www.northatlanticlcc.org/projects/downstream-strategies-project/decision-support-tool-to-assess-aquatic-habitats-and-threats-in-north-atlantic-watersheds>

This project is being funded by the NALCC and the work is being completed by WVU and Downstream Strategies. The geographic scope of the project is the NALCC boundary. The project objectives are to 1) quantify fish population and habitat conditions at a spatial scale relevant for conservation; 2) identify and quantify the effect of dominant stressors on the landscape; 3) prioritize spatially explicit conservation actions; 4) predict the conservation benefits within the context of climate change; and, 5) link inland, estuarine, and coastal assessments.

**EBTJV Project Tracking Data Fields** (AppLCC/EBTJV)

This is a basic spreadsheet used to track what kind of monitoring is going on and where.

**NFHP Science and Data Committee**

2013 Work Plan Outcomes

* Develop mechanisms and document procedures to guide Fish Habitat Partnerships and partners in data management practices to improve data and information exchange that will facilitate collaborative science and data efforts across the National Fish Habitat Partnership: A draft standard operating procedures document has been completed and will be finalized by the next Board meeting.
* Update and improve the NFHP data system to improve usability by a broad range of partners: An updated data system has been completed by USGS staff and is currently in use with additional refinements to be completed over the winter.

Draft Science and Data Priorities for 2014

* Refine mechanisms and document procedures to guide Fish Habitat Partnerships and partners in data management practices to improve data and information exchange that will facilitate collaborative science and data efforts across the National Fish Habitat Partnership.

**Resources**: $197,000 to support applications developer, metadata specialist, infrastructure maintenance and support – in-kind from USGS, Core Science Analytics & Synthesis for FY2014

* Continue to catalog data products developed by Fish Habitat Partnerships via the NFHP Data System. Refine developed workflow strategies to allow implementation of best practices in data management including data curation and preservation tasks to ensure data access and re-use in the future.

**Resources**: $63,200 to provide dedicated data management support to catalog FHP data – in-kind from USGS, Core Science Analytics & Synthesis for FY2014

* Complete development of standard effectiveness measures for conservation actions used to address nationwide fish habitat focus areas.

 **Resources:** Needed resources being determined at this time.

**Brook Trout Strategic Science Plan for the Chesapeake Bay Watershed** (USGS)

Research Priority 1: Refine and develop patch-prioritization tools based on brook trout occupancy and abundance.

Research approach

* Refine and develop patch-prioritization tools (PPTs) based on patterns of abundance which precede changes in occupancy and should generate a more sensitive indicator compared to occupancy

Products and benefits

* Help managers assess metrics of brook trout abundance and identify areas for brook trout conservation and restoration

(a) maps of potential brook trout habitat distributions within the Bay

(b) probabilities of brook trout occupancy and abundance in response to simulated future scenarios of climate change, land use, and invasive species

Additional Research Priority A: Conduct new sampling to assess brook trout habitat suitability and resilience across spatial scales.

Research approach

* Nested sampling design for air/stream temperature and fish
* Fine-scale sampling nested within coarse-scale sampling among watersheds
* Geologic evaluation, groundwater contribution to stream flow using hydrograph separation techniques

Products and benefits

* Refine the PPTs described above by enabling estimates of brook trout habitat availability, occupancy, and abundance across spatial scales from reaches to catchments
* Provide important new information on the role of groundwater for brook trout habitat and sensitivity to climate change
* Provide a framework to evaluate the optimal spatial and temporal sampling designs for brook trout monitoring programs

Additional Research Priority B: Assess adaptive potential (evolvability) for brook trout populations.

Research approach

* Sequence brook trout genome using a combination of state-of-the-art "next generation" technologies,
* Generate comparative gene expression profiles from deep sequencing (RNA-Seq) to identify genes exhibiting baseline (control) differential expression in brook trout representing the three major life history forms (salter, coaster, and riverine) across the latitudinal and elevational distributions within the Chesapeake Bay Watershed

Products and benefits

* New assessment tools of population vulnerability based on adaptive potential (evolvability)
* Incorporate evolutionary changes in physiological/metabolic and immunological systems into mechanistic models of species distributions
* Incorporate heritable variation, selection intensity and demographic effects on genetic variance into mechanistic models
* Assembled and annotated genome sequences, the entire mitochondrial genome sequence, single nucleotide polymorphisms (SNPs), and new microsatellite markers for brook trout will be made available
* Improved understanding of the functional differences among ecophenotypic variants for the brook trout

Additional Research Priority C: Assess effects of unconventional oil and gas development on brook trout populations.

Research approach

* Combine baseline distributional data with occupancy models developed in RP1 to develop region-wide assessments of pre-shale gas development conditions
* Develop stressor-response relationships and metrics to predict responses to disturbances associated with shale-gas development
* Gradient or paired designs (e.g., BACI studies) to determine the changes in water availability, water quality, brook trout populations, macro-invertebrate communities and periphyton communities for headwater streams that can be attributed to shale-gas development

Products and benefits

* Provide improved understanding of brook trout threshold responses to shale gas development
* Help industry and resource managers identify areas of greatest conservation value and provide a tool to estimate the cumulative impact of proposed shale-gas development on brook trout headwater ecosystems
* Improve precision of PPTs developed in Research Priority 1

Additional Research Priority D: Comprehensive assessment of brook trout health, sub-lethal effects, and biological endpoints.

Research approach

* A battery of biomarkers, ranging from necropsy-based organism level to molecular, have been developed for use on a number of fish species in the Chesapeake Bay watershed
* Histopathology, in combination with expression of genes for immune function, endocrine disruption, oxidative damage and various contaminant-induced enzymes, can be very powerful for assessing overall health
* Comprehensive assessments for general and reproductive brook trout health will be conducted using these tools in collaboration with other brook trout studies, especially those related to changes in land use (e.g., unconventional oil and gas) and climate

Products and benefits

* Detect sub-lethal effects of endocrine disruptors, emerging and legacy contaminants on brook trout health and reproduction.
* Identify potential pathogens/parasites that may affect brook trout abundance
* Provide information on the current health of brook trout populations and science-based approaches for monitoring programs

**Brook Trout Climate Change Resiliency (USGS Northeast Climate Change Science Center)**

**EBTJV Web Portal Development (AppLCC)**

**GIS & Web Map Viewer (AppLCC/Jason Coombs)**

**Climate Change/Land Use Brook Trout Study (PSU)**

**EBTJV Monitoring Strategies**

1. Monitor brook trout habitat and water quality trends. Focus on remotely-sensed data when possible to minimize manpower needs.
2. Monitor long-term brook trout population trends at selected sites throughout the EBTJV geographic area. Develop statistically designed site selection procedures and standard protocols for data collection.
3. Summarize monitoring data into summary reports, integrate with web-based GIS applications, and make information available via EBTJV web site.

**EBTJV Data Management Strategies**

1. Work with brook trout management agencies to develop minimum data standards to facilitate data sharing and reporting;
2. Assess current data gaps;
3. Create a centralized, web-based, data access system to query brook trout data owned and maintained by the management agency;
4. Develop a web-based map server application to view brook trout distribution, abundance and habitat information; and
5. Establish a web-based system for the efficient dissemination of EBTJV related data, maps, reports, and outreach material.

**Eastern Brook Trout Joint Venture Science and Research Focus List** (2012)

Fish-habitat relationships, including human impacts and their variation at different scales (focus on trout biology)

* Factors that influence brook trout spawning survival
* Brook trout response to changes in the annual flow cycle in streams and rivers
* Interactions between brook trout and exotic salmonids fish species
* Determination of persistent population size
* Movements of brook trout in large lakes and rivers
* Interactions between brook trout and exotic non-salmonid fish species
* Limiting factors on large-river brook trout populations
* Determination of effective population size from a genetic perspective

Identifying baselines and their current range, trajectories and gaps in knowledge (focus on baseline / existing data)

* Ground truth assessment (i.e. test models)
* Update baseline assessment of populations in HUCs
* Evaluate baseline assessment approach

Appropriate standardization of sample design, methodology, and monitoring for data analysis

* Scale of assessment vs. sample scale vs. project scale
* Identification of suitable accountability measures, robust measures of success
* Pure strain vs. mixed strain (base level genetics – what is the management unit?)

Identifying and predicting impacts and their cumulative effects, and determining thresholds above which fish populations recover

* Identification of factor and elements of successful and unsuccessful restoration techniques
* Impacts of projected changes in land use / water use on restoration potential (e.g. Marcellus Shale development)
* Incorporation of climate change into restoration potential at small scales

Evaluation of management activities and socioeconomic values

* Effectiveness of regulations for brook trout management
* Relationship between brook trout and socioeconomic benefits
* Restoration potential for brook trout fisheries
* Cost-effectiveness of restoration techniques
* How do we improve the management of fishable populations
* Relationship between brook trout and production of ecosystem services
* Biological control of bass and other invasive fish species

Range-wide genetic inventories

Brook trout intrinsic value and value of brook trout fisheries

Economic impact assessment of brook trout throughout their historic range