Mapping refugia in Atlantic salmon Habitat Recovery Units for the Gulf of Maine Distinct Population Segment

## *Concept proposal —USGS New England Water Science Center in cooperation with NOAA*

# Problem Statement

Wild populations of Atlantic salmon are listed as endangered under the Endangered Species Act and are designated as the Gulf of Maine (GOM) Distinct Population Segment (DPS). Restoring and maintaining access to high quality freshwater and estuarine habitats in Maine are the primary focus of efforts to aid in the recovery of Atlantic salmon. Data-driven methods for identification of refugia in salmon Habitat Recovery Units (SHRU) in Maine (fig. 1) can help identify high quality freshwater habitat and optimize limited conservation and restoration resources. Consideration of how climate related changes may affect habitats and species survival also are of great concern to fisheries managers.



**Figure 1**. The three Salmon Habitat Recovery Units (SHRU) for the Gulf of Maine Distinct Population Segment (GOM DPS).

# Objective

The objective of this proposed work plan is to provide statistical methods that could be applied to the stream network throughout the GOM DPS SHRU to identify refugia as a function of both base flow and in-stream temperature. To meet this objective, we propose the following tasks:

1. Develop base flow regression model(s)
2. Develop in-stream temperature regression model(s)
3. Map base flow and stream temperature in the GOM DPS SHRU
4. Estimate future climate-related changes to base flow and temperature-related refugia

***The focus of this concept proposal is task I.*** *Outlining of tasks II-IV provide context for eventual use of the product of task I and potential future work.*

# Work Plan: Approach & Methods

## Task I: Develop base flow regression model(s)

Work on Task I will begin with some exploratory regression-model analysis of stream temperature data from the SHEDS Stream Temperature Database (<http://db.ecosheds.org/>) and USGS National Water Information System (NWIS; https://maps.waterdata.usgs.gov/) gages in anticipation that results from this task could be used to support subsequent in-stream temperature modeling (task II). The exploratory analysis will help identify the most appropriate base flow variable (dependent variable) to estimate (i.e. the metric with greatest explanatory power for stream temperature) as there are multiple methods for computing baseflow from streamflow records, for example: HYSEP, (Sloto and Crouse, 1996); PART (Rutledge, 1993); and RORA (Rutledge, 1998). We also will consider baseflow normalized to total seasonal flow (base-flow index, or BFI) and baseflow normalized to drainage area (seasonal baseflow per unit of drainage area). NOAA and USGS also will decide on the most appropriate seasonal period on which to estimate the chosen base flow variable (e.g. July-September, or August only, etc.). The exploratory analysis will not only help identify the most appropriate base flow variable to use by its ability to describe spatial variability in stream temperatures, but will provide insight into the amount and quality of in-stream temperature data available (SHEDS and NWIS) to help scope the approach, time, and cost of task II should it be pursued.

With the base flow metric defined, we will derive regression equations that estimate seasonal base flow at a point of interest on a stream as a function of upstream basin characteristics (explanatory variables). Candidate explanatory variables will include basin characteristics such as surficial geology, hydrologic soil types, topography, land cover, and climatology. This work will necessarily be constrained to gage locations. Once derived, the regression equations can be applied at ungaged locations and could be used to support in-stream temperature modeling work of task II.

The baseflow regression equation(s) resulting from task I will be incorporated into the [USGS StreamStats application](https://pubs.usgs.gov/fs/2017/3046/fs20173046.pdf) to provide a publicly available and convenient means of estimating the base flow metric at any location of interest in the SHRU.

## Task I: Products

Data release ([example](https://www.sciencebase.gov/catalog/item/58b58dbfe4b01ccd54fde06d)). Incorporate baseflow equations into [StreamStats](https://streamstats.usgs.gov/ss/). USGS Scientific Investigations Report ([example](https://pubs.er.usgs.gov/publication/sir20155151)).

## Task I: Schedule and Budget

|  |  |  |
| --- | --- | --- |
| **Tasks** | **FY19** | **FY20** |
| Assemble data sets for explanatory variables |  | X |  |  |  |  |
| Select study basins in the DPS watersheds |  | X |  |  |  |  |
| Choose target baseflow season and derive baseflows from gage records |  | X | X |  |  |  |
| GIS Analysis: Derive basin characteristics for study gages |  |  | X |  |  |  |
| Assemble available temperature records for study gages |  |  | X |  |  |  |
| Exploratory analysis: Temperature and baseflow metrics vs explanatory variable |  |  | X | X |  |  |
| Derive regression equations for estimating baseflow metric |  |  |  | X | X |  |
| Data release & Scientific Investigations Report draft |  |  |  |  | X | X |
| Add approved regressions to StreamStats |  |  |  |  |  | X |

# Work Plan: Future Tasks

## Task II: Develop in-stream temperature regression model(s)

We propose to develop spatial regression models that estimate summer water temperatures as a function of explanatory variables such as baseflow (from task I), air temperatures, and other basin characteristics that may have explanatory power such as river corridor vegetation or slope (for example, see Table 1 in: Isaak et al., 2017, [https://doi.org/10.1002/2017WR020969](https://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST/downloads/publications/NorWeST-stream-temperature-model-scenarios_crowd-sourced-database-geospatial-tools.pdf).) NOAA and USGS will decide on a seasonal period and statistic on which to compute the dependent variable, stream temperature (for example, Isaak et al. (2017) chose August mean, though we may consider other variables such as, August 7-day high temperature, July 15- August 15 mean, etc.).

## Task III: Map base flow and stream temperature in the GOM DPS SHRU

This task will involve GIS application of the statistical models from tasks I & II throughout the SHRU to create maps of base flow (water quantity) and seasonal stream temperatures (water quality). The GIS map products will serve as important geospatial information layers in addition to existing habitat information to support range-wide habitat mapping.

## Task IV: Estimate future climate-related changes to base flow and temperature-related refugia

This task will specifically address concerns about the effects of climate change on habitat quality. A sensitivity analysis of the derived models from tasks I & II will provide insight into the future of baseflow and stream temperatures in the context of climate change. For example, assuming derived models for estimating stream temperature have air temperature as an explanatory variable, sensitivity of stream temperature changes to changes in air temperature could be estimated by perturbing the air temperature inputs of the model. An alternate approach would be to model specific climate-change scenarios (e.g. Isaak et al., 2017).

Schedule and costs of Tasks II-IV TBD.