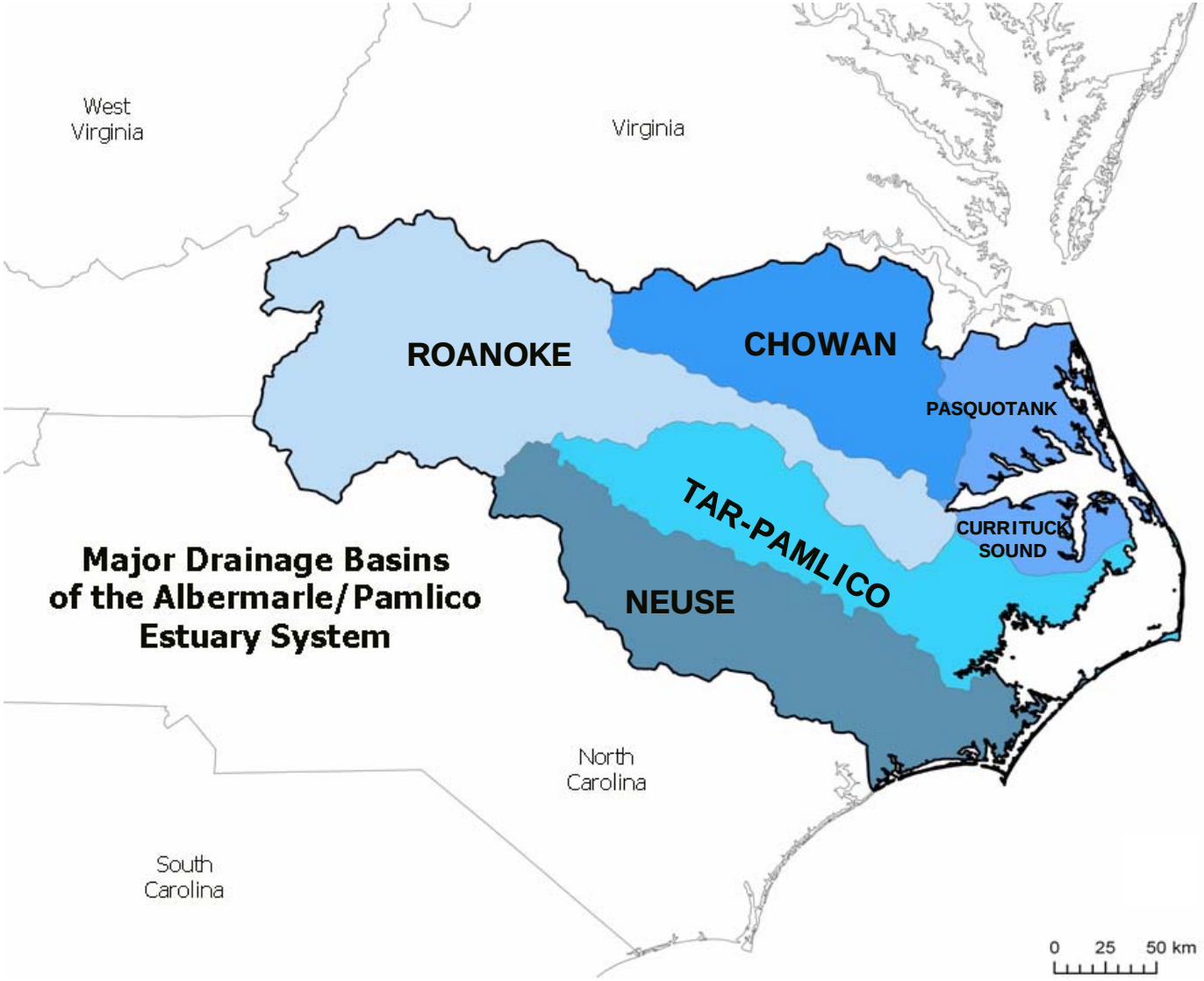
APES 2008 Modeling Goal

Prepare and make operational the APES modeling system


West Virginia
Virginia
ROANOKE
CHOWAN
PASQUOTANK
TAR-PAMLICO
CURRITUCK SOUND
NEUSE
Major Drainage Basins of the Albermarle/Pamlico Estuary System
North Carolina
South Carolina
0 25 50 km

APES Conceptual Problem Statement

How will aquatic ecosystems and services related to fresh water fisheries across a sub-regional to regional landscape be affected by changes in nitrogen, mercury, and pesticide loading patterns under various land-use and climate change scenarios?

APES Detailed Problem Statements

- **Type I.** What percent of APES HUC 12 streams are expected to demonstrate at least an X percent reduction in their provisioning of ecosystem service ***S*** in conjunction with stressor scenario ***A*** over the next 5, 10, and 20 years?

- **Type II.** What percent of APES HUC 12 streams are expected to have their provisioning of ecosystem service ***S*** below the threshold value of σ in conjunction with stressor scenario ***A*** over the next 5, 10, and 20 years?

  - Ecosystem services ***S*** are: (1) water quantity, (2) water quality, (3) habitat suitability for valued aquatic wildlife, (4) fishery production, and (5) contaminant-free fisheries.

  - Stressors of concern include: (1) regional climate change, (2) land cover conversion/build-out, (3) nitrogen source loadings, (4) mercury source loadings, and (5) pesticides source loadings.

  - Explicit uncertainty estimates required

APES Water Provisioning Assessment Questions

- What percent of APES HUC-12 streams are expected to decrease their mean annual streamflow by at least 30% in conjunction with stressors A > α, B > β, and C > γ over the next 5, 10, and 20 years? **(water quantity-Type I)**

- What percent of APES HUC-12 streams are expected to decrease their mean annual streamflow to *X* m^3/yr in conjunction with stressors A > α, B > β, and C > γ over the next 5, 10, and 20 years? **(water quantity-Type II)**

- What percent of APES HUC-12 streams are expected to increase their mean annual nitrate-nitrite concentrations by at least 30% in conjunction with stressors A > α, B > β, and C > γ over the next 5, 10, and 20 years? **(water quality-Type I)**

- What percent of APES HUC-12 streams are expected to have mean annual nitrate-nitrite concentrations greater than the current drinking water standard in conjunction with stressors A > α, B > β, and C > γ over the next 5, 10, and 20? **(water quality-Type II)**

APES Fishery Provisioning Assessment Questions

- What percent of APES HUC-12 streams are expected to have habitat suitability scores for largemouth bass (or other sport species) decrease by at least 30% in conjunction with stressors A > α, B > β, and C > γ over the next 5, 10, and 20 years? **(fish or wildlife habitat-Type I)**

- What percent of APES HUC-12 streams are expected to have habitat suitability scores for largemouth bass (or other sport species) less than 0.5 in conjunction with stressors A > α, B > β, and C > γ over the next 5, 10, and 20 years? **(fish or wildlife habitat-Type II)**

- What percent of APES HUC-12 largemouth bass fisheries (or other sport fishery) are expected to reduce their annual secondary production by at least 30% in conjunction with stressors A > α, B > β, and C > γ over the next 5, 10, and 20 years? **("fishery" production-Type I)**

- What percent of APES HUC-12 largemouth bass fisheries (or other sport fishery) are expected to have an annual secondary production of less than *X* kg/ha/yr in conjunction with stressors A > α, B > β, and C > γ over the next 5, 10, and 20 years? **("fishery" production-Type II)**

APES Fishery Provisioning Assessment Questions

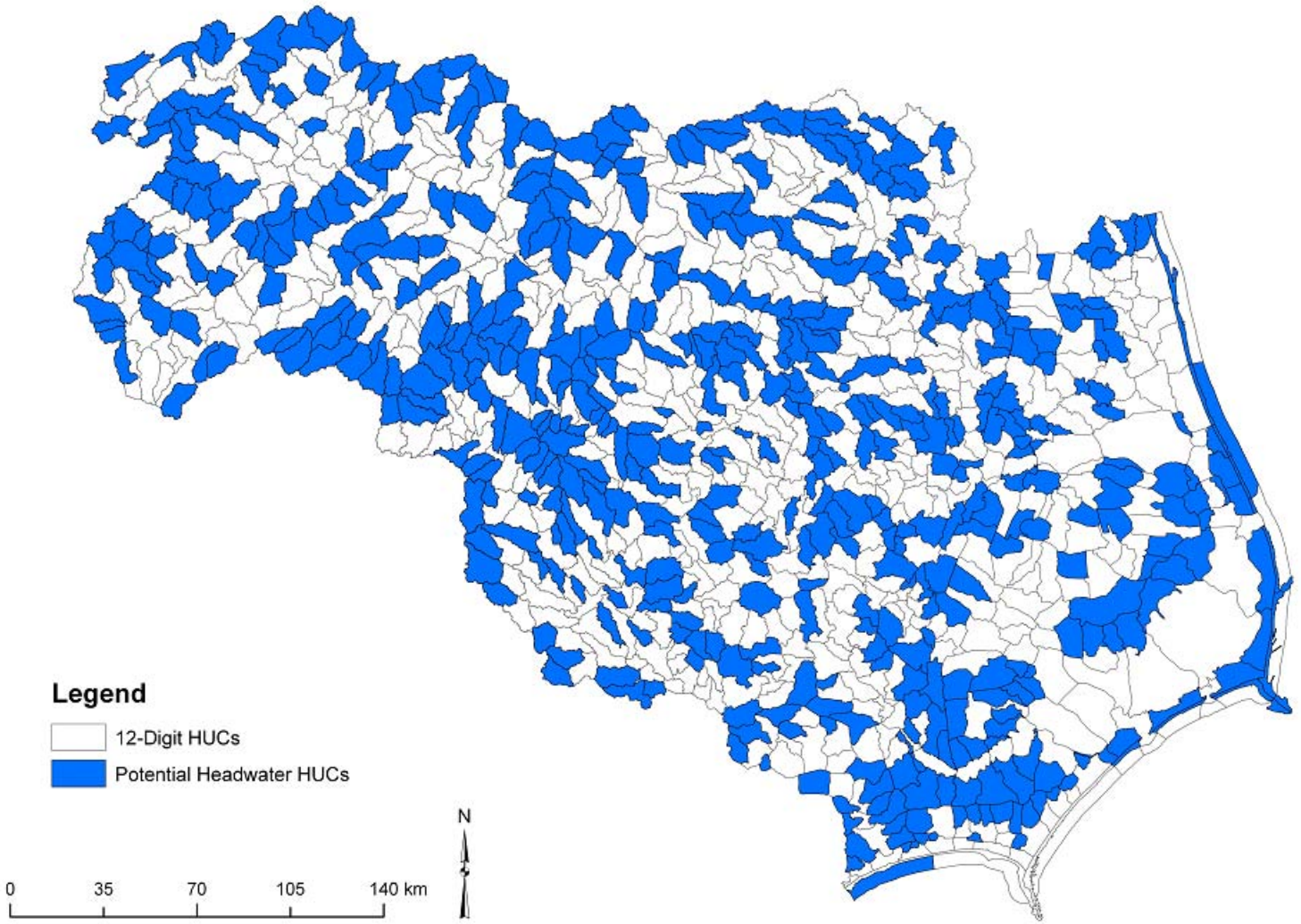
- What percent of APES HUC-12 fish communities are expected to decrease their annual secondary production by at least 30% in conjunction with stressors A > α, B > β, and C > γ over the next 5, 10, and 20 years? **(fishery production/aquatic ecosystem health-Type I)**

- What percent of APES HUC-12 fish communities are expected to have an annual secondary production of less than *X* kg/ha/yr in conjunction with stressors A > α, B > β, and C > γ over the next 5, 10, and 20 years? **(fishery production/aquatic ecosystem health-Type II)**

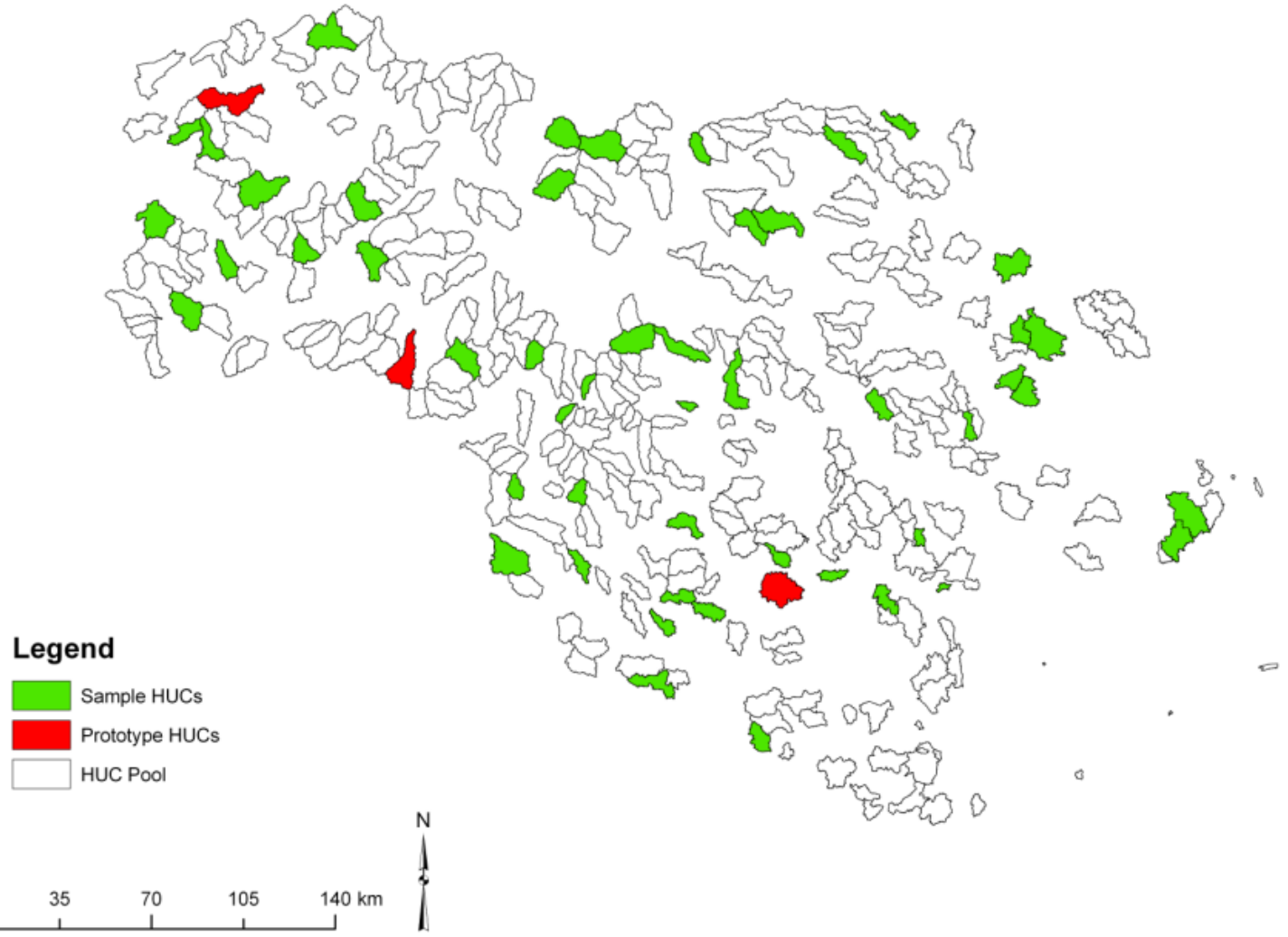
- What percent of APES HUC-12 largemouth bass fisheries are expected to increase their whole-body mercury concentration by at least 30% in conjunction with stressors A > α, B > β, and C > γ over the next 5, 10, and 20 years? **(contaminant-free fisheries-Type I)**

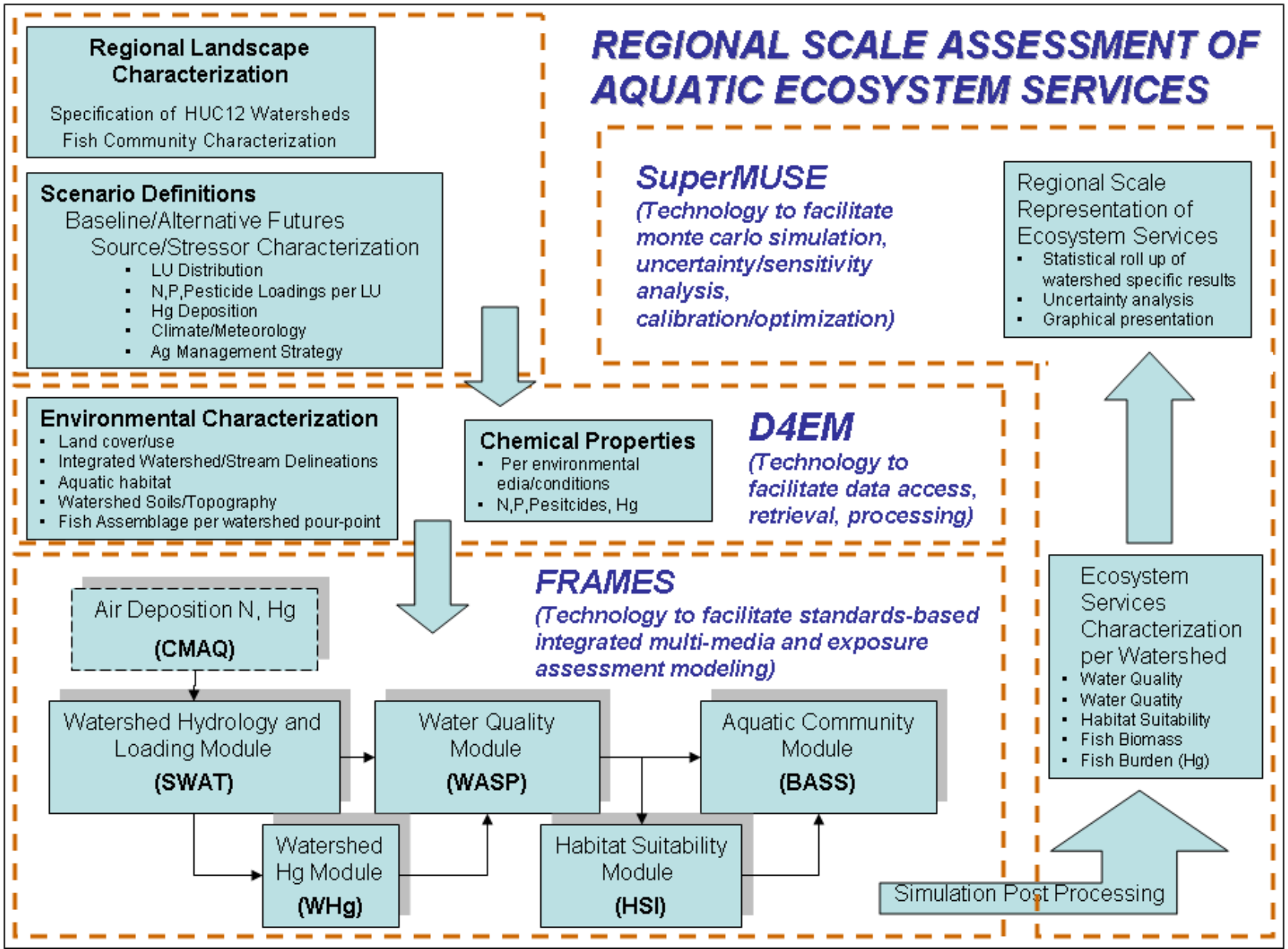
- What percent of APES HUC-12 fish communities are expected to have whole-body mercury concentration greater than 0.35 ppm in conjunction with stressors A > α, B > β, and C > γ over the next 5, 10, and 20 years? **(contaminant-free fisheries-Type II)**

Potential 12-Digit Headwater HUCs in the APES Region

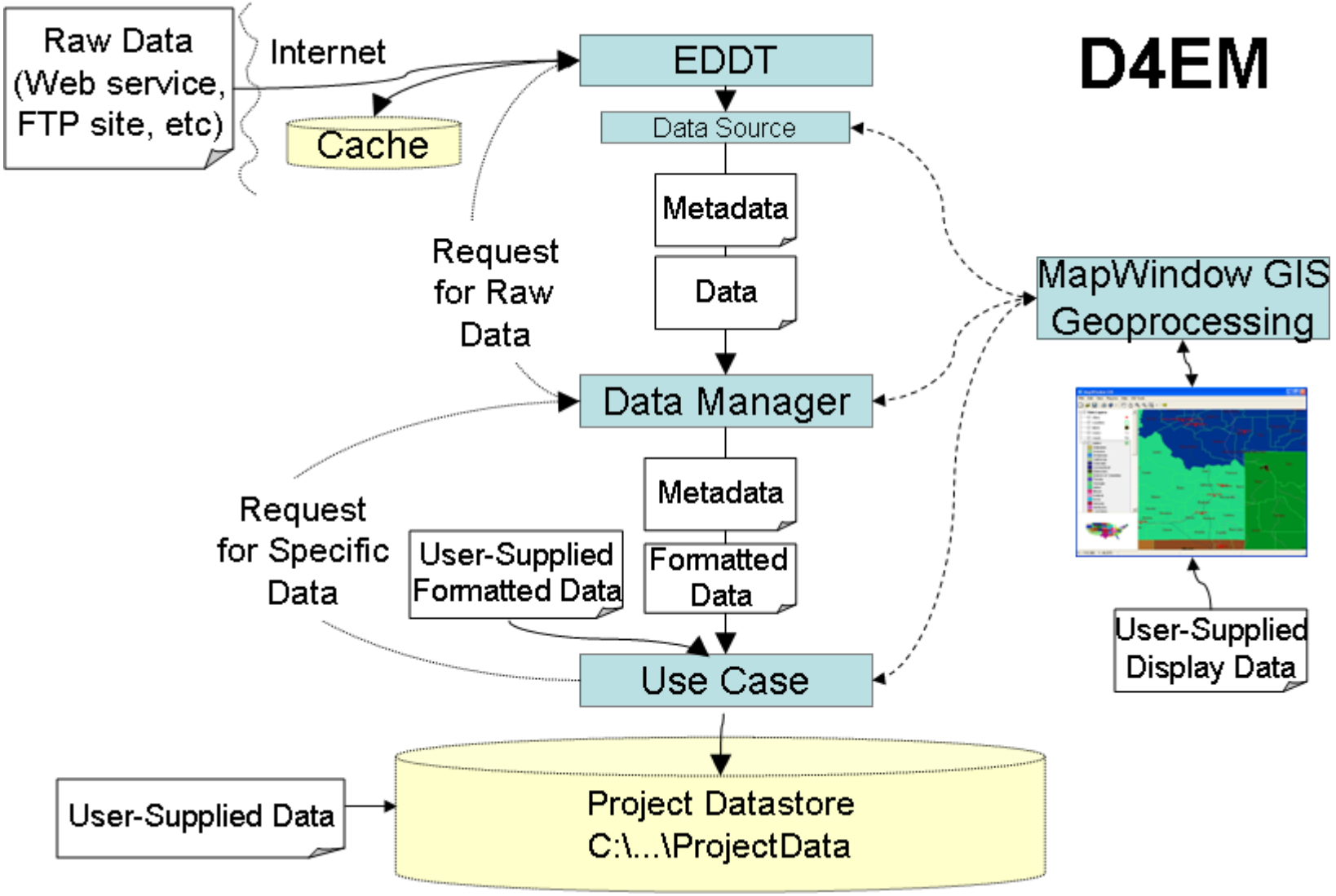


Sample and Prototype Headwater HUCs




REGIONAL SCALE ASSESSMENT OF AQUATIC ECOSYSTEM SERVICES
Regional Landscape Characterization
Specification of HUC12 Watersheds
Fish Community Characterization
Scenario Definitions
Baseline/Alternative Futures
Source/Stressor Characterization
LU Distribution
N,P,Pesticide Loadings per LU
Hg Deposition
Climate/Meteorology
Ag Management Strategy
SuperMUSE
(Technology to facilitate monte carlo simulation, uncertainty/sensitivity analysis, calibration/optimization)
Regional Scale Representation of Ecosystem Services
Statistical roll up of watershed specific results
Uncertainty analysis
Graphical presentation
Environmental Characterization
Land cover/use
Integrated Watershed/Stream Delineations
Aquatic habitat
Watershed Soils/Topography
Fish Assemblage per watershed pour-point
Chemical Properties
Per environmental edia/conditions
N,P,Pesitcides, Hg
D4EM
(Technology to facilitate data access, retrieval, processing)
FRAMES
(Technology to facilitate standards-based integrated multi-media and exposure assessment modeling)
Air Deposition N, Hg
(CMAQ)
Watershed Hydrology and Loading Module
(SWAT)
Water Quality Module
(WASP)
Aquatic Community Module
(BASS)
Watershed Hg Module
(WHg)
Habitat Suitability Module
(HSI)
Ecosystem Services Characterization per Watershed
Water Quality
Water Quatity
Habitat Suitability
Fish Biomass
Fish Burden (Hg)
Simulation Post Processing

Technologies of the FRAMES-based APES Modeling System


Raw Data
(Web service,
FTP site, etc)
Internet
Cache
EDDT
Data Source
Metadata
Data
Request
for Raw
Data
D4EM
MapWindow GIS
Geoprocessing
Data Manager
Metadata
Formatted
Data
Request
for Specific
Data
User-Supplied
Formatted Data
User-Supplied
Display Data
Use Case
User-Supplied Data
Project Datastore
C:\...\ProjectData

Data Needs for APES

- Data accessed from National data sources
  - –Meteorological data timeseries
  - –Watershed characterization
  - –Stream network
  - –Land cover
  - –Soils data

Data Needs for APES (cont'd)

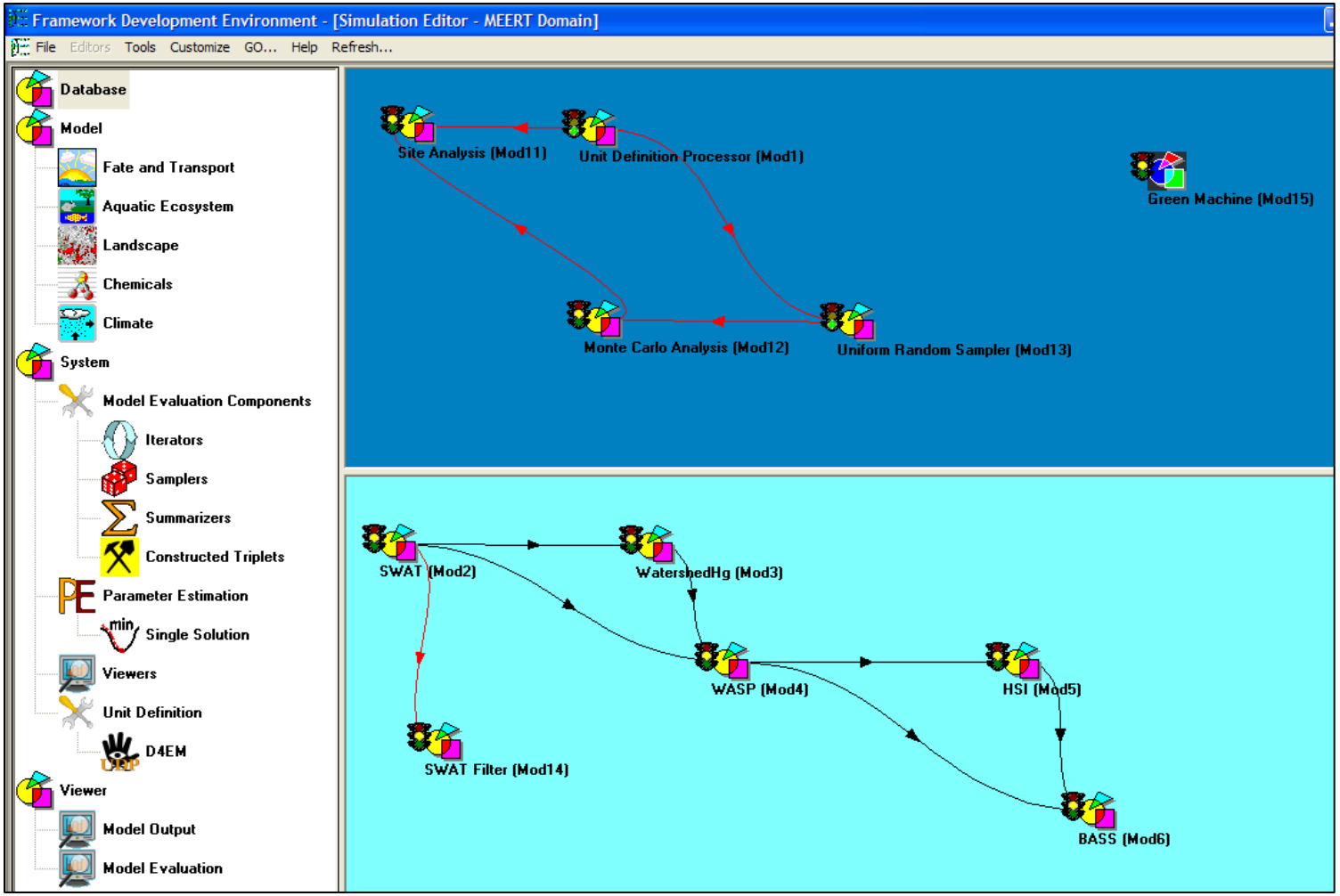
- Modeler supplied data (i.e., not available from national source)
  - –Mercury properties
  - –Fish communities and densities (1 community/HUC)
  - –Fish properties (78 species, 4 properties each)
  - –Background concentration load fluxes (66)
  - –Wet/dry Hg Deposition data (/HUC)
  - –Stochastic variable distribution parameters (89)

Note : These are data set up by the modeler for a stressor/region and become data sources processed by D4EM just like national databases such as NHD+, STATSGO, NLCD, etc.

Volume of Data processed by D4EM for APES

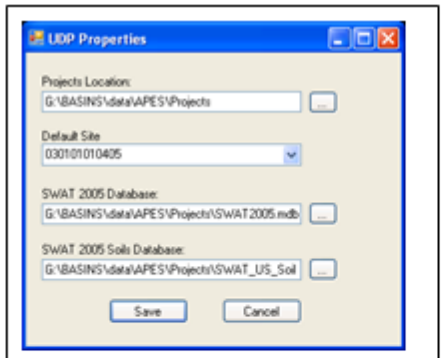
- For 50 sample HUCs
  - > 1.2 GB of data
  - > 25,000 data files
- Each HUC
  - ~ 20MB of data
  - ~ 500 data files

FRAMES

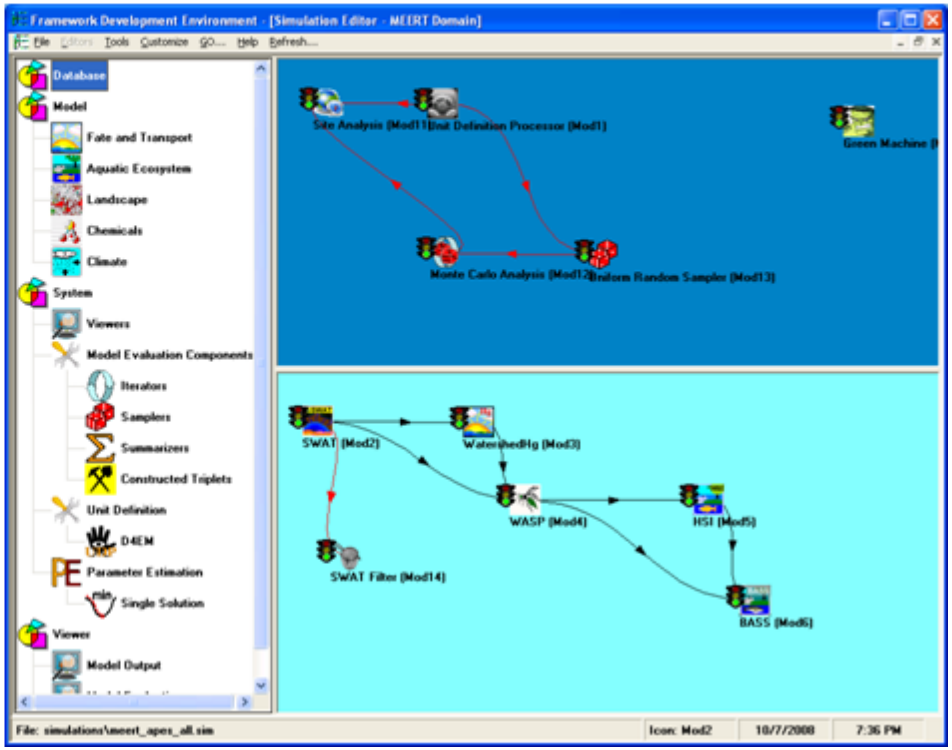

Framework Development Environment - [Simulation Editor - MEERT Domain]
File
Editors
Tools
Customize
GO...
Help
Refresh...
Database
Model
Fate and Transport
Aquatic Ecosystem
Landscape
Chemicals
Climate
System
Model Evaluation Components
Iterators
Samplers
Summarizers
Constructed Triplets
Parameter Estimation
Single Solution
Viewers
Unit Definition
D4EM
Viewer
Model Output
Model Evaluation
Site Analysis (Mod11)
Unit Definition Processor (Mod1)
Green Machine (Mod15)
Monte Carlo Analysis (Mod12)
Uniform Random Sampler (Mod13)
SWAT (Mod2)
WatershedHg (Mod3)
WASP (Mod4)
HSI (Mod5)
SWAT Filter (Mod14)
BASS (Mod6)

Relationship between D4EM & FRAMES

D4EM Data Store



Unit Definition Processor

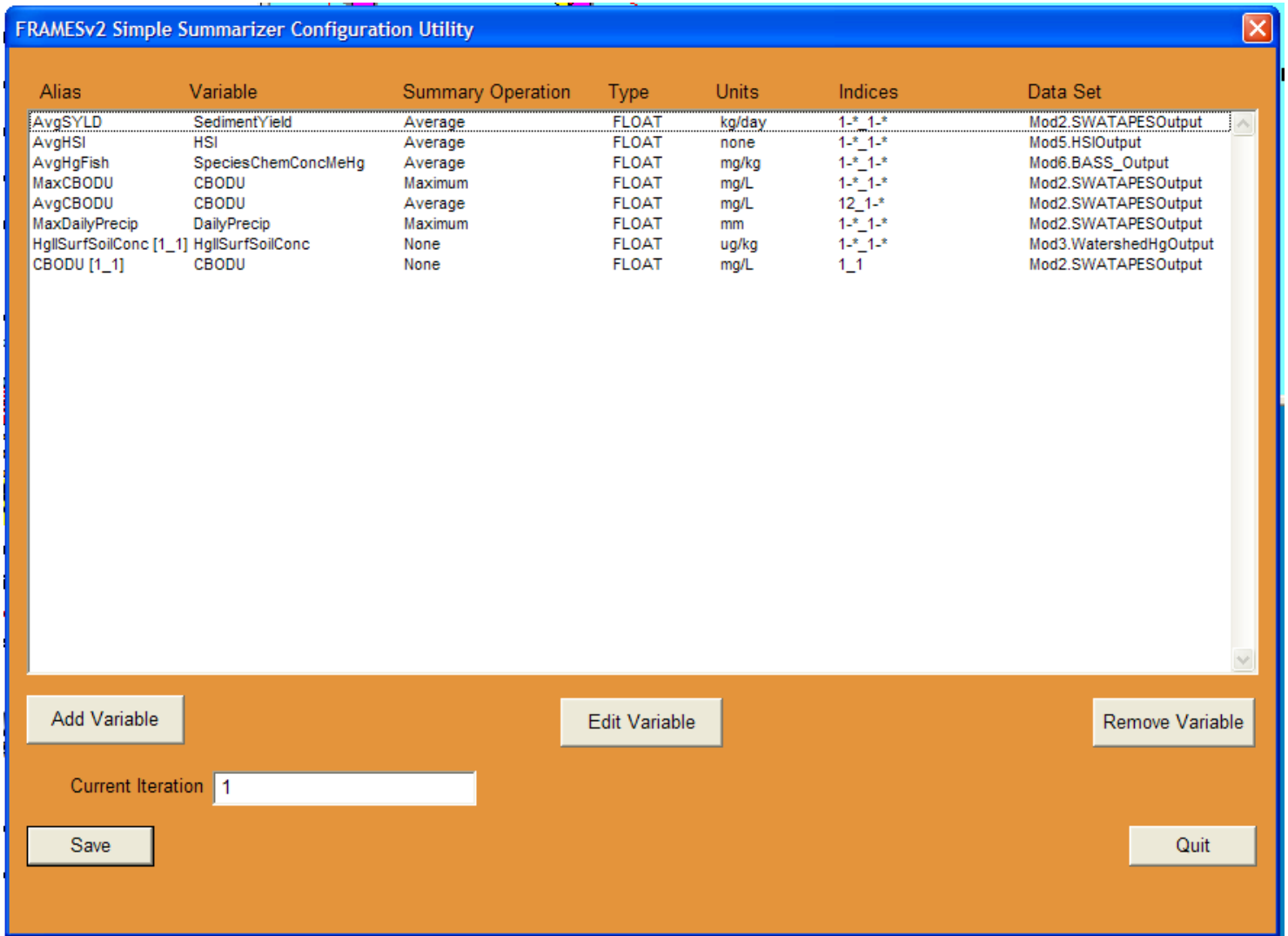


SuperMUSE Parallel Computing Cluster

3MRA Version 1.x

SuperMUSE – Supercomputer for Model Uncertainty and Sensitivity Evaluation

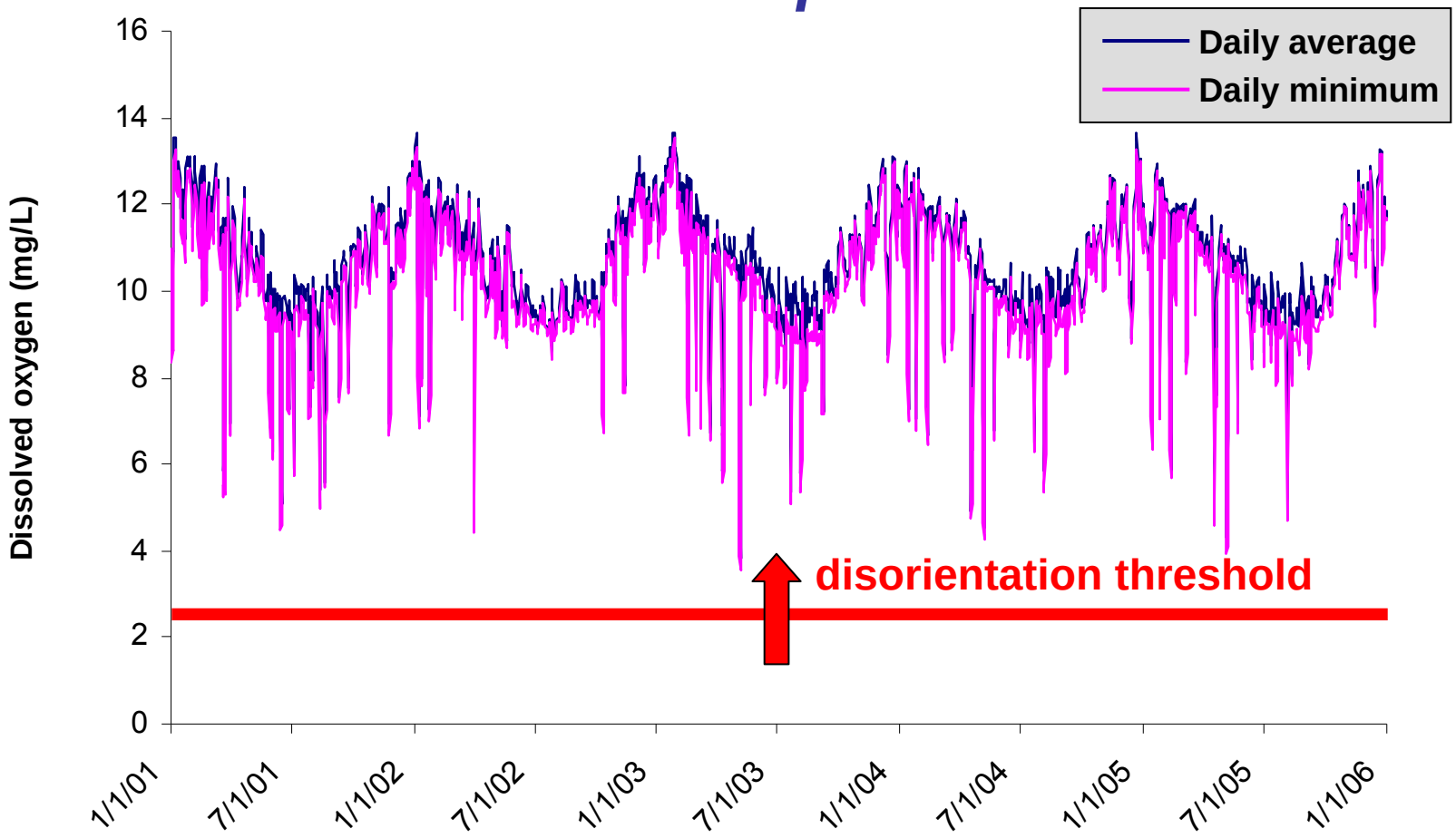
SuperMUSE based Data Post-Processing



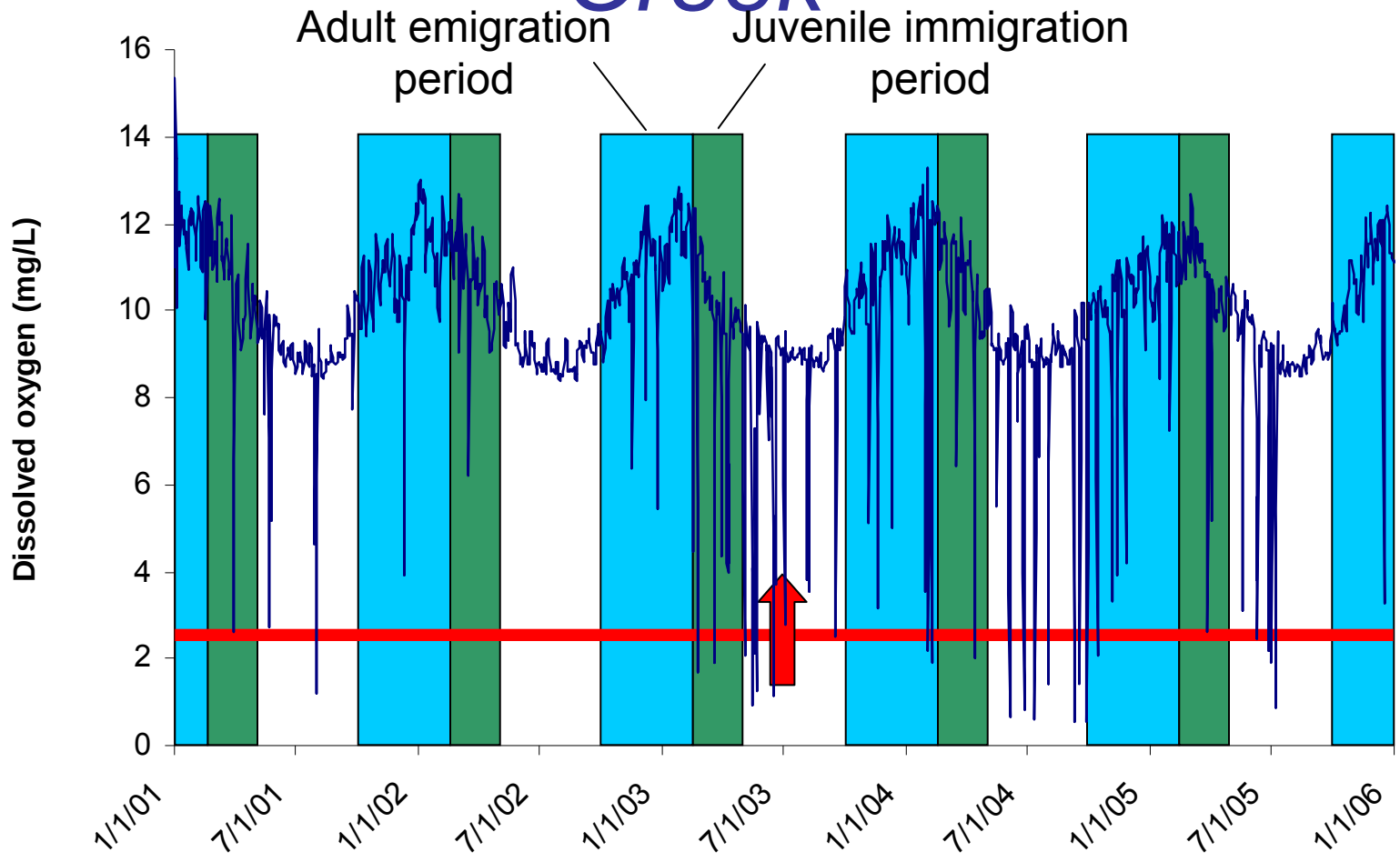
Example APES Modeling outputs

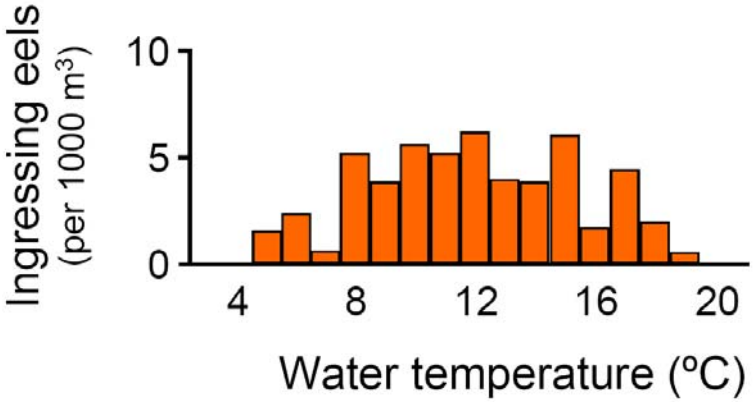
(Detailed time series analysis per simulated headwater stream)

Dissolved Oxygen Profile – Middle Swamp



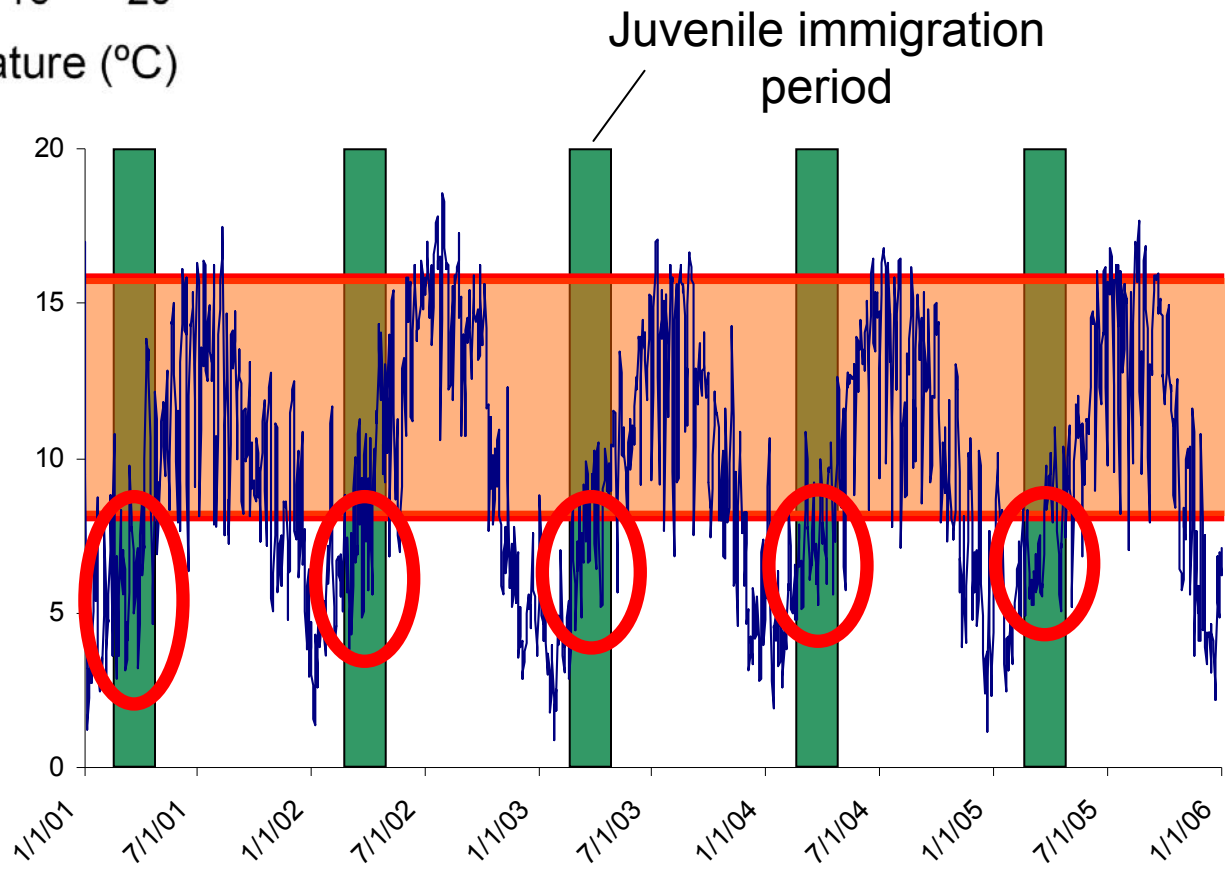
Dissolved Oxygen Profile – Back Creek





Glass eel ingress in Beaufort Inlet, NC (Sullivan *et al*. 2006)

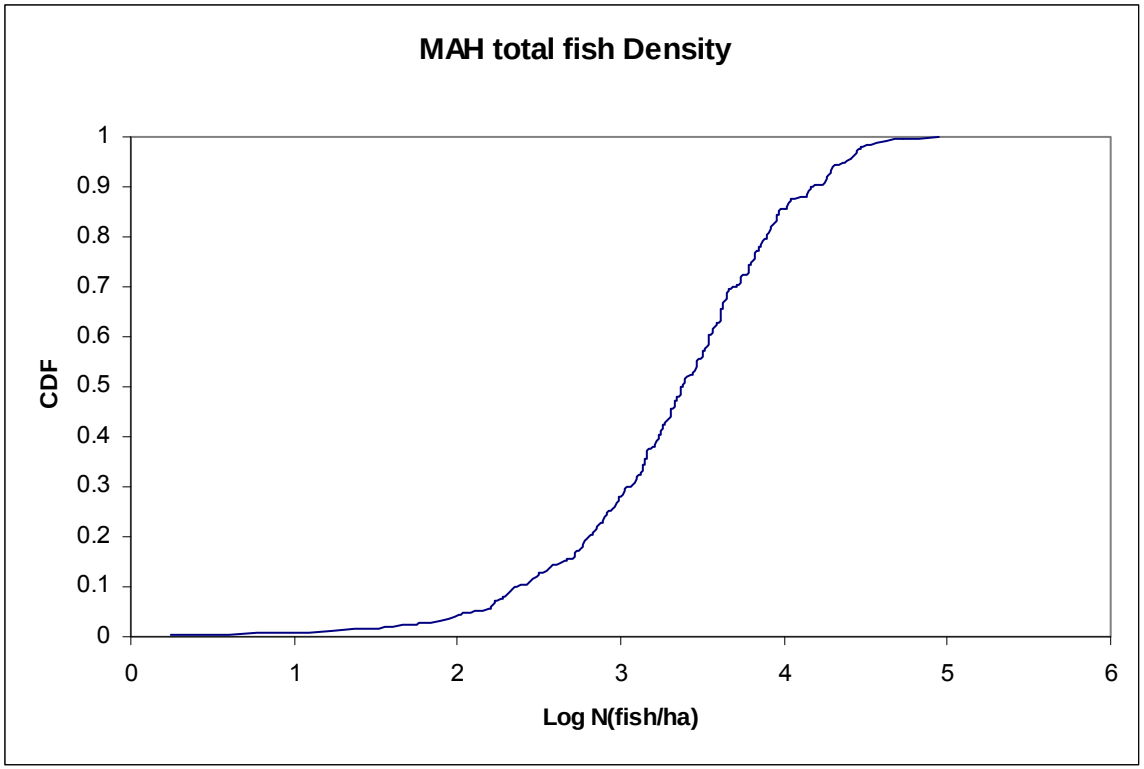
Water temperature (ºC) in Middle Swamp (WASP data)



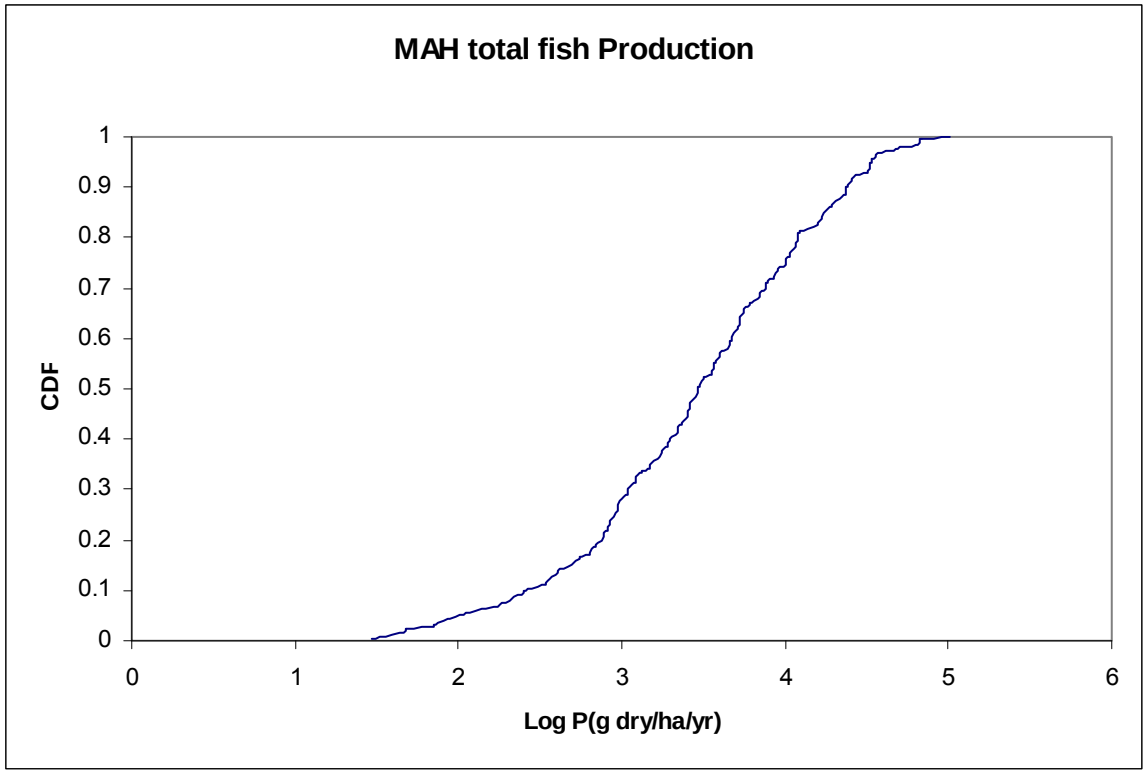
Example APES Modeling outputs

(Regional distribution of ecosystem services)

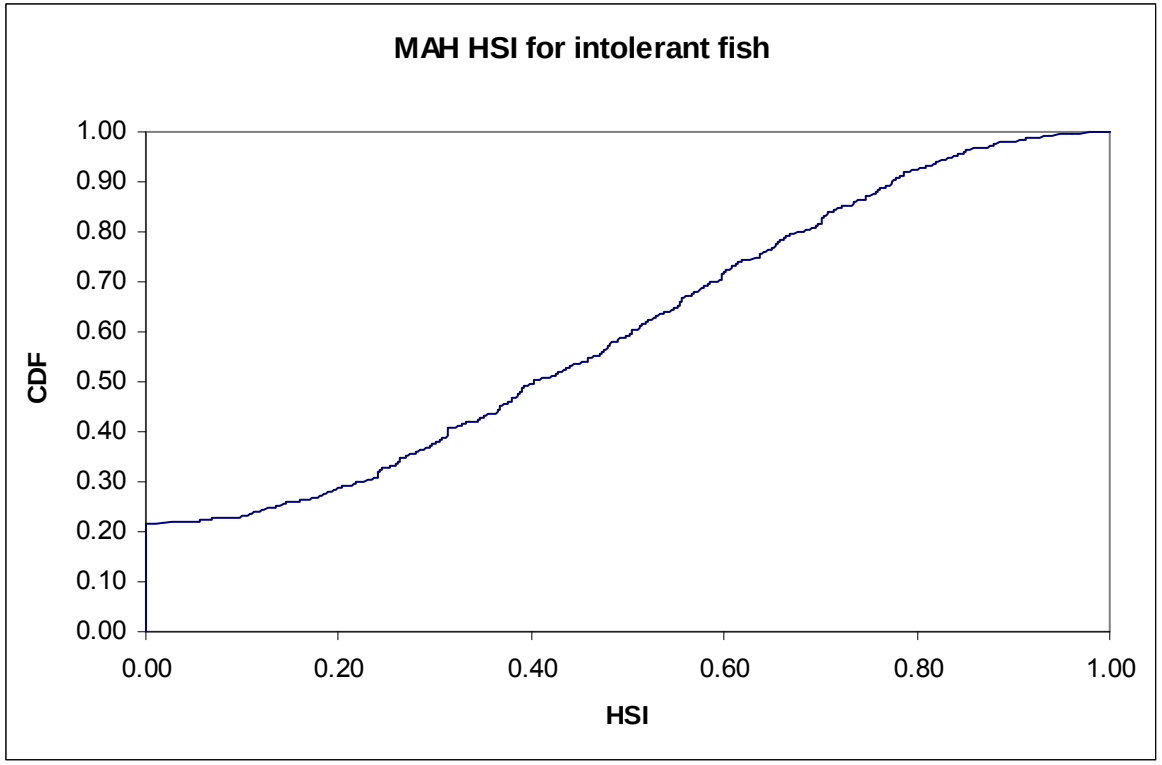
Example Annual Fisheries Roll-up: Mean annual abundances



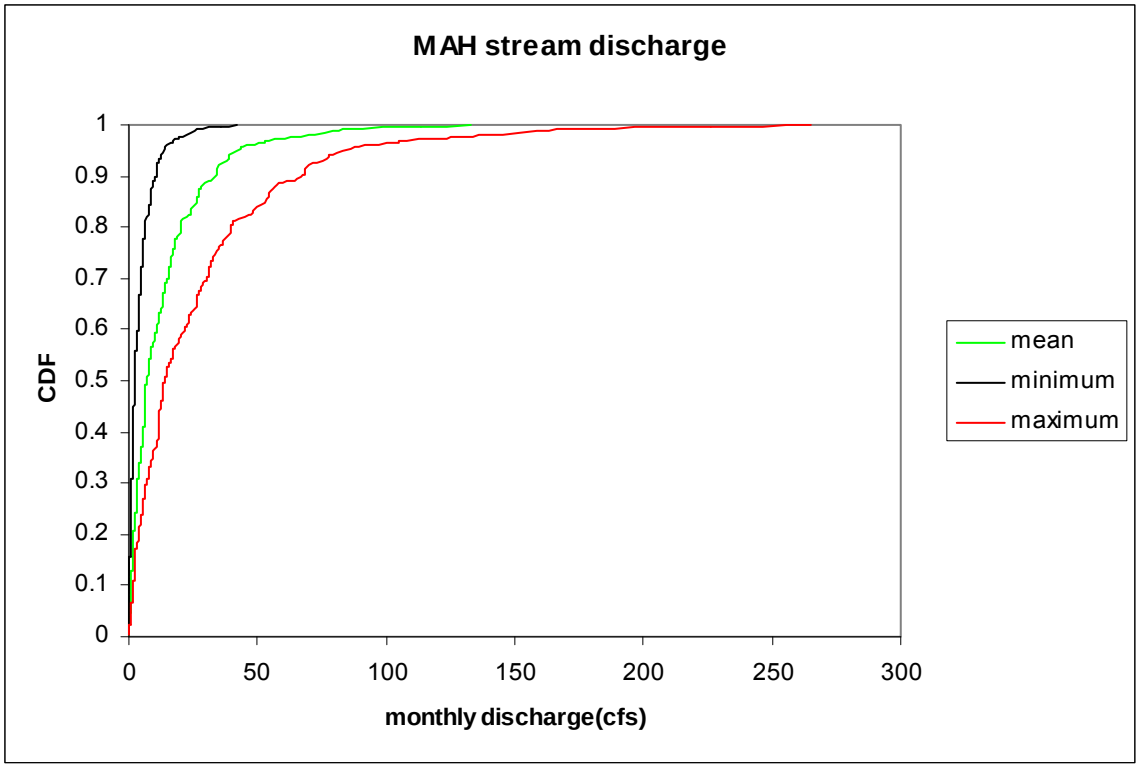
Example Annual Fisheries Roll-up: Annual fish production



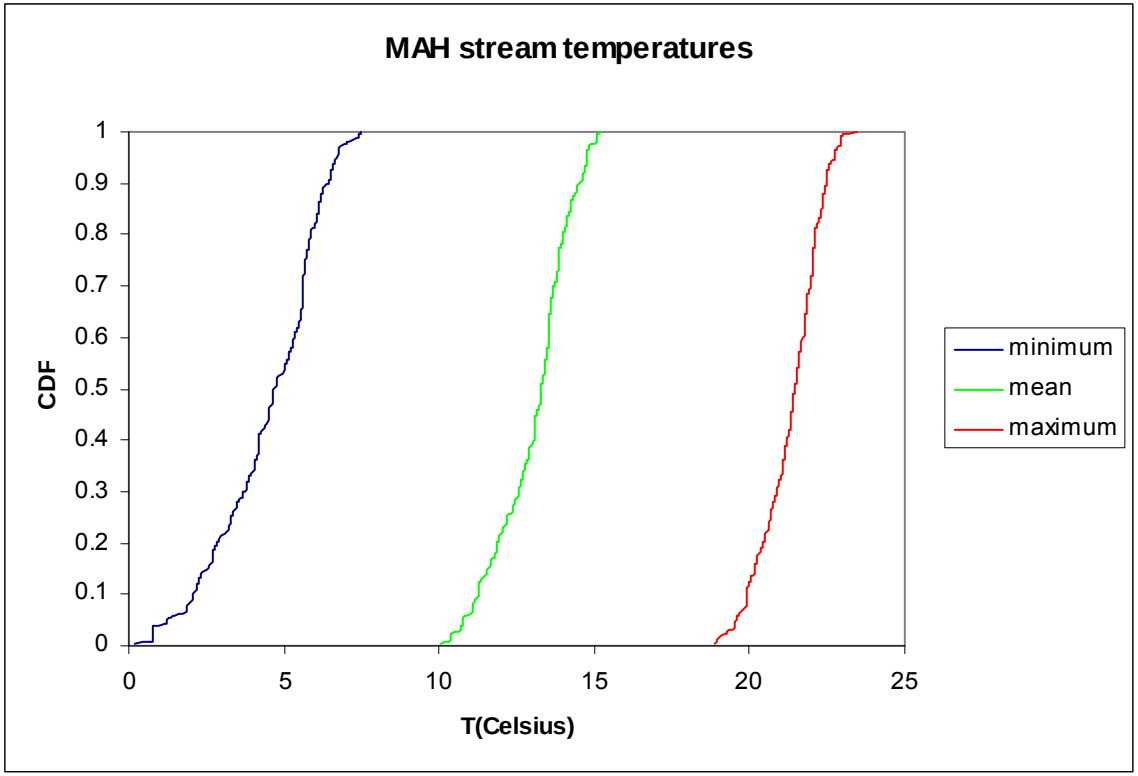
Example Annual Fisheries Roll-up: Fish habitat suitability



Example Water Quantity Roll-up: Monthly stream discharge



Example Water Quality Roll-up: Daily stream temperatures



Example Annual Fisheries Roll-up: Mean annual biomass