Modeling Climate Change and Sturgeon Populations in the Missouri River

The U.S. Geological Survey (USGS) Columbia Environmental Research Center (CERC), in collaboration with researchers from the University of Missouri and Iowa State University, is conducting research to address effects of climate change on sturgeon populations (*Scaphirhynchus* spp.) in the Missouri River.

The CERC is conducting laboratory, field, and modeling research to identify causative factors for the responses of fish populations to natural and human-induced environmental changes and using this information to understand sensitivity of sturgeon populations to potential climate change in the Missouri River drainage basin. Sturgeon response information is being used to parameterize models predicting future population trends. These models will provide a set of tools for natural resource managers to assess management strategies in the context of global climate change.

This research complements and builds on the ongoing Comprehensive Sturgeon Research Program (CSRP) at the CERC. The CSRP is designed to provide information critical to restoration of the Missouri River ecosystem and the endangered pallid sturgeon (*S. albus*). Current research is being funded by USGS through the National Climate Change Wildlife Science Center (NCCWSC) and the Science Support Partnership (SSP) Program that is held by the USGS and the U.S. Fish and Wildlife Service. The national mission of the NCCWSC is to improve the capacity of fish and wildlife agencies to respond to climate change and to address high-priority climate change effects on fish and wildlife. Within the national context, the NCCWSC research on the Missouri River focuses on temporal and spatial downscaling and associated uncertainty in modeling climate change effects on sturgeon species in the Missouri River. The SSP research focuses on improving survival and population estimates for pallid sturgeon population models.

Climate Change

Climate change operates over a broad range of spatial and temporal scales. Understanding climate change effects on ecosystems therefore requires implementation of models at multiple scales. For understanding effects on fish populations, climate projections made by course-resolution global climate models must be downscaled by regional climate models to obtain regional projections to link with watershed models, river hydraulics models, and population responses (fig. 1). An additional challenge is to quantify sources of uncertainty given that interactions between climate variables and community-level processes are expected to be highly nonlinear. Our modeling approach is designed to quantify uncertainty by applying the multiscale climate models in a hierarchical Bayesian framework

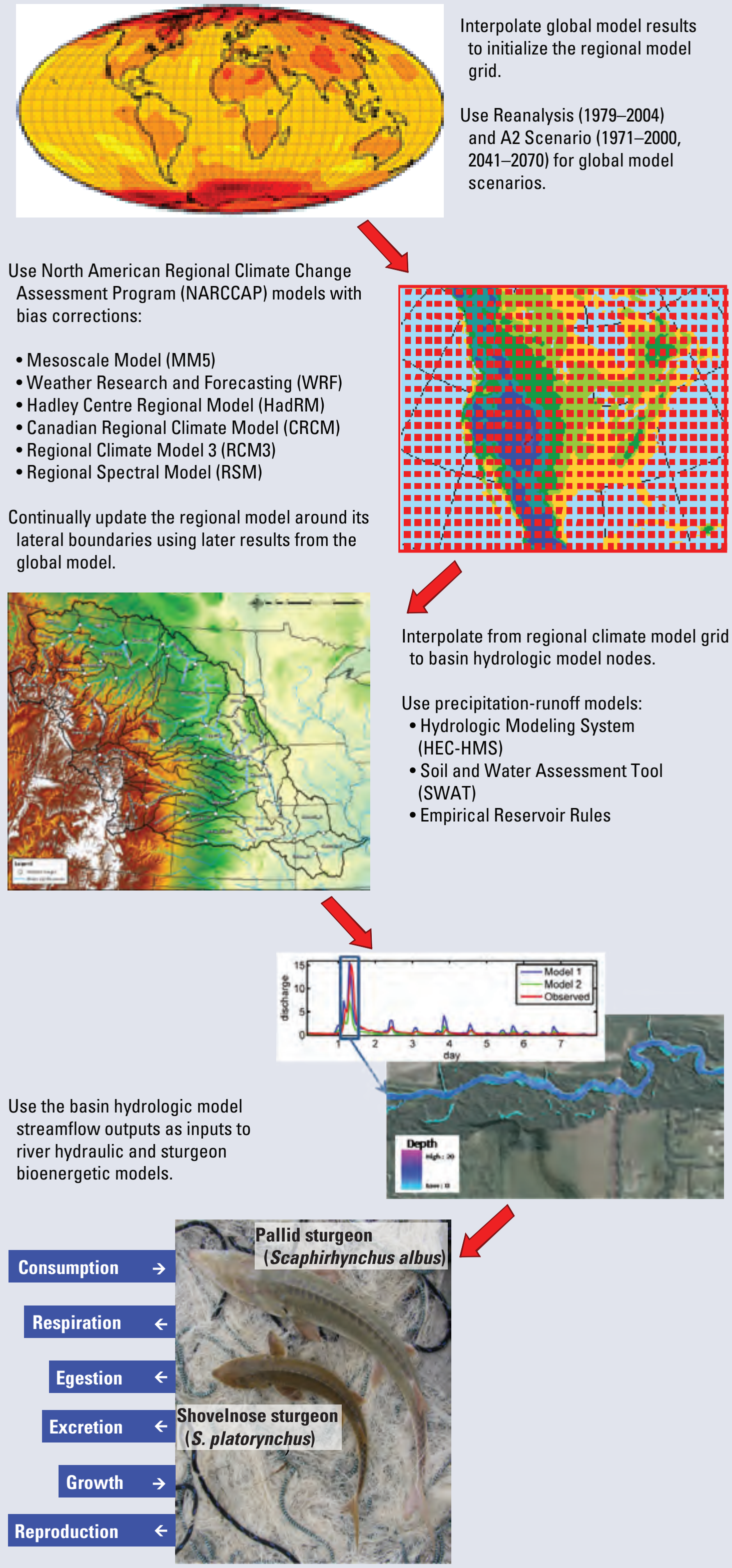

Figure 1. Understanding climate change effects on aquatic ecosystems requires implementation of a hierarchy of models at multiple scales.

to link model components together by formal rules of probability. This hierarchical modeling approach will account for sources of uncertainty in estimates of community or population response. The goal is to evaluate the potential distributional changes in an ecological system, given distributional changes predicted by a series of linked climate and system models under various emissions scenarios. This understanding is intended to help resource managers evaluate options for coping generally with the prospect of global climate change and specifically with how climate change may affect water management options to support sturgeon populations.

Sturgeons in the Missouri River

The pallid sturgeon is rare throughout the Missouri River basin and was Federally listed as endangered in 1990 (Dryer and Sandvol, 1993). The shovelnose sturgeon (*S. platorynchus*) was historically more common and widespread (Becker, 1983). Persistence and resiliency of shovelnose sturgeon in comparison to pallid sturgeon may be due to earlier maturity, lower trophic status, and adaptability to environmental conditions (Keenlyne and Jenkins, 1993). Understanding how climate change may differentially affect these two species may be useful for species management.

Wildhaber and others (2007) introduced a conceptual life-history model or pallid and shovelnose sturgeon. The model was developed to delineate how *Scaphirhynchus* sturgeon ecology relates to river management actions, but it also provides a framework to illustrate how climate may interact with management actions to affect species recovery. The model will be used as the foundation for expanding an existing population model (Bajer and Wildhaber, 2007) to include environmental variables for predicting future population sizes and distributions.

In collaboration with the University of Missouri and Iowa State University, this project will advance efforts to understand climate change and accommodate uncertainty by applying multiscale climate models and hierarchical Bayesian modeling frameworks to understand Missouri River sturgeon population dynamics. The hierarchical framework allows model components to be tied together by formal rules of probability. For shovelnose and pallid sturgeon, extant data and models will be used for each scale for the Missouri River. We will relate spatial and temporal patterns of Missouri River benthic fishes to physical and chemical factors (for example, Arab and others, 2008), sturgeon population models (Bajer and Wildhaber, 2007), and sturgeon life-history models (Wildhaber and others, 2007) to better understand factors affecting Missouri River sturgeon spawning physiology, behavior, habitat choice, and success (for example, Delonay and others, 2007; Holan and others, 2009).

Applications to River and Species Management

The ultimate objectives of this research are to provide resource managers with a quantitative understanding of how climate change may propagate through the Missouri River system to affect sturgeon populations and to identify the dominant sources of uncertainty in those predictions. This understanding is expected to provide a foundation of science to inform policy decisions about how to mitigate adverse effects to sturgeon populations. Strategies for mitigating climate change potentially include long-term planning for water resources management, investment in propagation infrastructure, acquisition of lands and habitat, development of water-resources infrastructure, and investments in science to optimize adaptive management.

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