Warmwater Fish in the Era of Climate Change

by Mike S. Allen, Mark W. Rogers and Christopher M. Horton, BASS/ESPN Outdoors

Although one might expect a warming climate to benefit warmwater fish, some effects of climate change will likely be counterintuitive, influencing warmwater fish populations in many negative ways. This chapter provides an overview of the problems that climate change poses to warmwater fish and possible solutions.

Warmwater fish may be particularly susceptible to the following consequences of climate change:

Climate change will shift precipitation patterns

Shifts in rain and snowfall that intensify the severity and duration of both droughts and floods will be the most profound effect of climate change on warmwater fish in freshwater aquatic systems.

Several key studies predict that long and severe summer droughts will be followed by pulses of extreme high-water events. A strong sport fish year-class (individuals spawned in the same season) often follows a year of high water levels. However, extended periods of low water diminish habitat quality and reduce juvenile fish survival, with low numbers of young fish entering the population.

Climate change will alter aquatic plant growth

The effects of global climate change on aquatic plants could be contradictory: Longer growing seasons and improved growth rates would bolster the abundance of aquatic plants in freshwater systems, but variable water levels could impede growth. High water levels could shade out plants but droughts will expose them to drying. Additionally, threats from exotic plants, most of which are tropical in origin, would increase as the thermal environment becomes more favorable to their establishment and range expansion.

Climate change will accelerate sea-level rise

By forcing salt water into freshwater portions of rivers, rising sea levels will cause a contraction of suitable habitat for freshwater species.

Habitats most susceptible to sea-level rise would be in coastal areas of low elevations, wetlands and dammed rivers where fish have no escape from saline conditions. The counter to saltwater intrusion into estuarine fisheries is inflows of fresh water. If, during years of drought, freshwater flows are not available, the effects of rising seas could be exacerbated.

Climate change will aggravate existing stresses

Humans have altered watersheds with dams, water control structures and development in flood plains and riparian zones. Increasingly frequent droughts and severe floods could magnify the effects of these alterations on aquatic systems and the warmwater fish that they support.

How Warmwater Fish Will Respond to Climate Change

As water temperatures rise and rainfall patterns change, increased floods and droughts will compromise fish habitat and reduce its complexity in lakes, reservoirs and rivers. Changes in habitat quality will influence the abundance of warmwater sport fish and ultimately threaten the quality and sustainability of the fisheries. In response to sea-level rise increasing salinity levels in rivers and estuaries, warmwater fish could shift to upstream habitats. Warming temperatures in the southern reach of their range could force warmwater fish to withdraw and move northward. In regions such as the Great Lakes and the Rocky Mountain states, warmwater fish could replace coldwater fish as dominant species.

Yesterday's Programs Can't Solve Today's Problems

Presently the federal dollars spent to improve warmwater fisheries come from the Dingell-Johnson Sport Fish Restoration Funds. Taxes on fishing tackle, supplies and fuel furnish the funds, from which money is allocated to states based, in part, on fishing license sales. The Dingell-

Johnson Funds, however, are inadequate to finance effective responses to climate change. Maintaining warmwater fisheries under conditions of climate change will require new, broad-scale renovation and restoration programs.

States, particularly if helped by local government and private partners, can conduct projects on smaller lakes and rivers, but cannot undertake new issues such as aquatic plant management or fish habitat loss in large reservoir and lake systems. Furthermore, large rivers and impounded systems often cross state boundaries and have regional water-use implications that are currently beyond the scope of states to address. As a consequence, large, system-wide projects to assist warmwater fish adapting to climate change would require substantial new funding.

What Can be Done: Project Types

Fish and wildlife professionals recognize that they can't rely on yesterday's programs to address the consequences of global climate change. The first step toward innovation is to see clearly the broad categories within which new ideas can take shape. The following survey of project types offers that perspective.

Nutrient reduction projects

Excess nutrients in a water body stimulate inordinate plant growth and algal blooms and cause poor oxygen conditions. In response, fish assemblages shift away from sport fish species toward rough fish (carps). Occurrences of this phenomenon could multiply as a longer growing season — a consequence of global warming — combines with increased nutrient loads produced by an expanding human population.

Water-level management projects

Restoring water volumes and depths to healthy levels in rivers and reservoirs shows the greatest potential for improving warmwater fisheries on a large, watershed scale. This type of project can be accomplished by renegotiating water use permits and allocations, but requires fisheries managers to work as teams, across jurisdictions, and

with competitors using water for other purposes, such as hydropower generation and agriculture.

Riparian management projects

Improved management of soil and vegetation along the banks of waterways — the riparian zones — bolster fish populations in lakes and reservoirs. Projects that reduce sediment and nutrient loads from agricultural and urban areas can increase water clarity, foster beneficial aquatic plant growth and improve fish habitat throughout lakes and watersheds. Examples in Iowa provide excellent case studies of the costs of watershed-scale riparian improvements and their benefits to lake water chemistry and fisheries.

Projects mitigating effects of human development

Urban encroachment and development along shorelines can reduce fish habitat in lakes and throughout watersheds. Extensively developed lake shorelines support less sport fish biomass and slower fish growth rates than do natural shorelines. Due to concerns about flooding, urban development constrains management of water levels in reservoirs and rivers. Droughts and floods that alter water flows will only exacerbate pressures of an expanding human presence on water resources. To mitigate the negative consequences of hydrological manipulations, projects involving homeowners and land planners can restore habitat, reduce further habitat loss and benefit warmwater fisheries.

Aquatic plant control projects

High vegetative coverage — greater than 80 percent of surface area — reduces angler access and fish growth rates. Control of native and exotic plants will be important as growing seasons lengthen and increase the number of locations requiring aquatic plant management.

Aquatic plant establishment projects

Establishing aquatic plants could mitigate fish habitat losses that result from increased droughts and floods. Establishing aquatic plants has succeeded in improving fish habitat in reservoirs and lakes such as Lake Conroe, Texas and Lake Monroe, Florida.

Artificial habitat projects

Inserting woody debris and brush piles, adding rock and stone, and dredging to improve the substrate are common methods of restoring lake and stream habitat. Typically these projects focus on developing fish attractors for anglers and are conducted on a relatively small scale, but such projects may be viable for improving fish abundance on the large scale of entire lakes or rivers.

Angler access projects

Low water levels, whether caused by severe droughts or resource management actions, can have disastrous effects on local economies reliant on warmwater fisheries. An example comes from Cumberland Lake, Kentucky: The U.S. Army Corps of Engineers estimated that lowering the lake level by 40 feet to repair the Wolf Creek Dam would cause local economic losses of up to $75 million, with the fishing and boating industries bearing the brunt of the losses.

Such extreme water-level fluctuations will become more common under global climate change. Existing boat ramp construction and maintenance are not suited for such drastic fluctuations in water levels, and sustaining fisheries-based economies will require new lake and river access projects. Large investments in infrastructure — boat ramps, lake and river access and parks — will be needed.

Solutions for Warmwater Fish: Three Case Studies

Editor's note: Fish and wildlife professionals contending with the effects of climate change need a framework to consider the essential factors of a successful field project. The following case studies demonstrate the approach of BASS/ESPN Outdoors to common project components such as goal identification, implementation barriers and costs.

Warmwater fish management agencies should consider three types of projects for countering the effects of climate change. Presumably some states would implement all three types, others only one or two, but all

states except Alaska would need at least one type to address the effects of climate change on warmwater fisheries.

A case study: Small water bodies

Project location

Water bodies and riparian areas ranging from 50 to 10,000 acres across nearly all of the United States

Background

This project would improve fish populations in a small reservoir system within a single watershed that is affected by the combination of land-use practices and climate change. The project is typical of those undertaken on smaller lakes (100-3,000 acres) and streams throughout the United States. These waterways are characterized by

- high sedimentation, a result of riparian habitat loss
- increased levels of nutrients, caused by agricultural runoff
- undesirable fish communities, including high biomass of invasive species like gizzard shad and nonnative species like common carp

These problems would be exacerbated by further urban development along shorelines and by the effects of climate change. For example, erosion will wash more sediment into streams and rivers as buildings and roads replace trees and shrubs, droughts expose shorelines and then floods scour the exposed shorelines. Increased nutrient loads and longer growing seasons will intensify algal blooms and multiply fish deaths caused by a lack of oxygen.

Project goals

This project seeks to restore lake habitat by addressing watershed issues such as land-use practices and runoff and in-lake issues such as shoreline degradation and the presence of exotic fish species. The project's goals include

- improving fish habitat in lakes and streams
- improving warmwater fish spawning habitat
- boosting sport fish abundance
- reducing interactions between sport fish and invasive or exotic species

- reducing algal blooms that can result in fish kills and consequent dominance of undesirable fish species

Implementation barriers

Implementing these programs takes a strong commitment from public and private stakeholders. State agencies cannot accomplish these projects alone; doing the work and garnering state and federal aid require effort and support from local communities.

Project tasks, timeline and costs

Based on existing programs in Iowa, the tasks, timeline and estimated costs for renovating a 500-acre water body within a 5,000-acre watershed comprising both agricultural and urban components are outlined below. An effective state program would initiate two or three renovation projects of this type every year, with each project taking two to three years and costing close to $8 million.

Tasks	Narrative	Cost
	Years One-Three	
Dredge lakes and streams, construct fish barriers, stabilize shorelines, construct settling ponds	$11,00 per lake-acre X 500 acres	$5,500,000
Acquire land or easements	$4,500 per land-acre X 5,000 acres	$2,250,000
	Total project costs over three years	$7,750,000

A case study: Large water bodies and river systems

Project location

Watersheds ranging from 3,000 to 150,000 acres with multiple impoundments, including reservoirs operated for hydroelectric, flood control or navigation purposes, occurring in most states

Background

Systems of large, impounded lakes (e.g., Kissimmee Chain of Lakes in Florida) and rivers (e.g., Missouri River in the Midwest) include many of the most valuable warmwater fisheries in the U.S. As global climate change causes droughts and consequent low water levels, large-scale losses in warmwater fish habitat throughout the lower 48 states could occur. Recent, persistent droughts in the West, upper Midwest and Southeast demonstrate the threat of uncontrolled lower and more variable water levels in large, impounded river systems.

Nearly all large reservoirs were built for purposes such as navigation, flood control, power generation and water supply. Recreational fisheries are usually a secondary objective of dam operations in large river basins. Although a decade of managing varied water levels in Missouri River reservoirs has demonstrated the advantages this approach could deliver to fish, designing flow and stage regimes solely to benefit warmwater fisheries is unlikely.

Project goals

This project would improve fish habitat and promote fish abundance while maintaining other community benefits of reservoirs such as flood control, hydropower and navigation. The project goals include

- **establishing native aquatic vegetation:** Pilot projects will plant small, founder colonies of native aquatic plants within protected enclosures. This approach promises to improve habitat at the whole-lake scale.
- **maintaining adequate oxygen levels for open water fish such as striped bass:** Rising water temperatures can limit suitable zones of both oxygen and temperature within the water column for sport fish and particularly for striped bass. Oxygen diffuser systems can alleviate this "thermal squeeze," which is expected to become more common as temperatures rise under climate change.
- **improving fish habitat by managing water levels in a chain of reservoirs:** In staggered years, water levels in designated reservoirs would be kept elevated during spring fish-spawning season to produce strong year-classes among their fisheries. Managing for fish would alternate among reservoirs, with each reservoir prioritizing fisheries at three-

to six-year intervals while other reservoirs in the chain are managed for hydropower generation or other basin objectives. This schedule would allow strong year-classes to occur with sufficient frequency to preserve fishing quality in the basin even under long-term drought conditions. Potentially improving fisheries across large areas while ensuring that human use of water resources is sustainable, this concept would be developed by multidisciplinary teams that include engineers, economists, civic planners and natural resource managers.

Implementation barriers

Installing and operating diffuser systems to maintain adequate oxygen levels for striped bass is expensive. Policy-makers would have to weigh the cost against the value, which exceeds $25 million annually for some striped bass fisheries.

Managing water levels in a chain of impoundments would require fisheries agencies to work with power companies and federal agencies to be certain that other basin objectives such as hydropower generation or flood control would not be compromised. This goal would be the most difficult to accomplish, as it would encounter barriers involving

- power generation
- multi-state jurisdictions
- conflicting stakeholder interests
- political commitment to reallocate water within basins to maximize benefits to all user groups
- a significant financial investment to identify viable schedules

Project tasks, timeline and costs

Three project tasks, used singly or in combination, could sustain and improve warmwater fisheries where decades of extended droughts or low levels of spring runoff are expected to cause harm. All tasks are important in reaching the desired outcome, but regulating water levels on an alternating schedule shows the most promise for improving fisheries on a basin-wide scale.

Tasks	Narrative	Cost
	Single-year projects	
Establish native aquatic vegetation	Pilot projects to evaluate founder colonies' potential to spread and improve fish habitat. Cost per pilot project:	$50,000 to $100,000
Install oxygen diffusers in lakes and impoundments	Although costly, diffuser systems could maintain popular striped bass fisheries.	Installation: $300,000 to $2,000,000 Annual operations: $75,000 to $800,000
Develop alternate water flow plan	Alternates spring high-water levels for a chain of reservoirs	Not available

A case study: Managing aquatic plants

Project location

Most states will need to manage increased aquatic plant growth in warmwater fisheries. Presently many states are not prepared to meet this challenge.

Background

Because climate change will raise water temperatures and extend growing seasons, aquatic plants are expected to expand into regions that have not previously conducted intensive plant management.

Goals and objectives

The project will provide moderate levels of aquatic plants for fish habitat while maintaining lake access for homeowners, boaters and anglers.

Implementation barriers

Barriers to implementing aquatic plant control in a lake usually involve conflicts among different user groups. State agencies will need to educate the public about today's safe aquatic herbicides and stress the negative result of using grass carp (i.e., elimination of aquatic plants).

Project tasks, timeline and costs

Outlined below are the tasks, timeline and estimated costs for managing *hydrilla* colonization in a 500-acre lake. Each management option results in a slightly different outcome.

Tasks	Narrative	Cost
	Single-year projects	
Introduce grass carp	Grass carp could eliminate *hydrilla* from the system, thereby reducing the quality of recreational fishing but satisfying the boaters and homeowners who object to plants.	$10,000
Use herbicides	Herbicides require expensive, regular treatments but could retain some aquatic plant presence and maintain quality fisheries while opening areas for boating, swimming and skiing. Depending on herbicide used, annual costs for treating 250 acres of a lake:	$75,000 to $250,000,
Use mechanical control measures	Use of mechanical controls such as plant harvesters, feasible around boat ramps and some docks, is not economically viable for areas larger than 50 acres. Annual costs for clearing a 50-acre area around boat ramps and docks:	$25,000

Conclusion

These projects address the stresses on warmwater fish that are most likely to demand management action, but there will be other costly consequences of global climate change that are difficult to forecast. For example, protecting warmwater fish populations could require eradicating or controlling the spread of exotic fish and invertebrates.

Mitigating the effects of global climate change on warmwater fisheries will require fish and wildlife agencies to use a multifaceted approach. Almost all states would engage in two or more project types at multiple locations. Thus, annual costs per state to sustain and improve warmwater fisheries could easily add $10-20 million to current resource management expenditures.

But project funding even at this level will be insufficient to eliminate all climate-change-induced threats to warmwater fish. Unfortunately, it will not be cost-effective to preserve or restore all fisheries. Agencies will have to make tough choices and prioritize systems based on the probability of success and the popularity of the water body among the angling public.

Many of the challenges that warmwater fish already face will intensify under the looming threat of global climate change. Management agencies must begin addressing those challenges now through monitoring and project planning to be able to counter their increasing severity under future conditions.