Policy Implications of Aging and Manipulated River Systems
A Case Study of the Black Warrior River

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A case study of Alabama's Black Warrior River provides a strategic environmental assessment of lateral connectivity issues on aging and manipulated river systems. The assessment focuses on associated ecosystem health and human impact issues. The Black Warrior River, located in the Eastern Gulf Coast Region of the United States, is categorized as an inland waterway and considered representative of other manipulated river systems in North America and perhaps throughout the world.

Background

Inland waterways are created by the construction of a series of locks and dams that convert a river into a series of impoundments. Within each impoundment, the primary management focus is to maintain adequate width and depth for commercial navigation, however, after lock and dam construction, a river's upstream aquatic surface area expands and the water stage level rises, creating aquatic pools and reservoirs allowing for uses beyond commercial navigation, such as fishing (Schramm Jr. et al. 2008; Pinter et al. 2010). There are 25,000 miles of inland, intracoastal and coastal waterways and channels in the U.S. The U.S. Army Corps of Engineers (USACE) maintain 12,000 miles of commercially active waterways that consists of 275 lock stations at 230 lock sites (USACE Institute for Water Resources 2009; USACE 2005).

Lateral connectivity is a dimension of an inland waterway's hydrological connectivity, representing the surface water exchange between the main river channel and off-channel areas, such as backwaters. It is an important inland waterway attribute due to its effect on the environmental (e.g., fishery health) and human dimensions (e.g., sport fish anglers) and is directly and indirectly impacted by the system's management. Lateral connectivity creates off-channel areas such as side-arms, backwaters, cut-off braided channels, oxbow lakes, floodplain ponds and marshes (Amoros and Bornette 2002). A river's lateral connectivity and interactions with the floodplain and backwaters often dominate a river's longitudinal characteristics (Junk, Bayley, and Sparks 1989). Sedell, Richey, and Swanson (1989) state that lateral connectivity is "an integral part of carbon and biochemical cycling systems and of the fisheries ecology of rivers of all sizes."

Lateral connectivity's significance, as indicated above, spans the environmental and human dimensions. Movement among habitats along a river system is an important aspect of fish population, recruitment and sustainability. River connectivity to off-channel areas provides important spawning and nursery habitats that larval, juvenile, and adult fish populations depend on for survival (Sparks 1995; Bayley 1995). Laterally connected areas may also serve as a refuge during natural and human induced disturbances (Amoros and Bornette 2002).

With regards to the human dimension, lateral connections between a river system's main channel and off-channel areas provide numerous recreation opportunities to people, including access to productive fisheries (USACE Mobile District 1971). Lateral connectivity is often described in terms of small boat access channels when discussing its connections with the human dimension (Nielsen 1999). A river's lateral connectivity and the recreation activities that stem from its presence provide social, cultural, and economic benefits to the human dimension (Marmulla 2001).

Two main user groups of USACE managed inland waterways are waterborne shippers and carriers and recreationists. Waterborne shippers own and move cargo (e.g., coal), and carriers represent the transporters of cargo (e.g., the barge lines) (Hanson Professional Services, Inc. 2007; Waterways Council Inc. 2009; USACE Institute for Water Resources 2009). Recreationists on USACE managed inland waterways and lakes include picnickers, campers, swimmers, water skiers, boaters, sightseers, fisherman, hunters, and others. The recreationists utilize resources at 419 USACE lakes in the U.S. In 2006, over 372 million visits (person-trips) occurred at USACE managed areas (USACE 2006a). The 372 million visits to USACE lakes created $8.1 billion in visitor spending within a 30 mile radius of these lakes. Sixty-two percent of the spending was captured by the local economy. With a multiplier effect, visitor trip spending accounted for an additional $7.8 billion and $3.9 billion in value added. Additionally, 104,811 jobs in local communities were supported by USACE lakes (USACE 2006a).

Case Study

The Black Warrior River contains four locks and dams that form lentic or lake-like environments creating a multi-use system (USACE Mobile District 2007; USACE Mobile District 1971; USACE Operations Division Mobile District n.d.). Lateral connectivity and off-channel entrances are declining along the Black Warrior River, specifically between river miles 213 and 292. This 80 mile stretch of the Black Warrior River, the focus of this case study, encompasses portions of the Demopolis and Warrior lakes which are utilized by an array of stakeholders that are impacted by declining lateral connectivity. The Warrior and Demopolis lakes encompass approximately 7,800 and 10,000 surface acres respectively.

The study area's historic management was largely one-dimensional and main channel-oriented. This one-dimensional approach caused a significant deterioration of lateral connectivity. Identifying the study area's change regarding lateral connectivity is completed by analyzing and comparing United States Department of Agriculture (USDA) aerial photos from 1965 and 2006. Two aspects of lateral connectivity are analyzed: 1) the status of entrances to off-channel areas and 2) the status and size of each entrance's associated off-channel area. The status of the entrances and off-channel areas is a measure of human accessibility (i.e., does the entrance and off-channel area provide small boat access). The status levels include: open, marginally open, and closed.

Between 1965 and 2006, the number of open or marginally open entrances to off-channel areas declined from 251 to 119. Open and marginally open off-channel areas decreased 1,125 acres between 1965 and 2006, representing a 26 percent decline. Overall, 643 off-channel acres, regardless of status (i.e., open, marginally open, or closed), were lost during this timeframe, representing a 15 percent decline, and the average and median size of off-channel areas also declined 30 and 53 percent respectively.

The study area's stakeholder groups involved in the lateral connectivity policy debate were initially determined by using secondary data. Field observations and informal interviews supplemented the secondary data, identified additional stakeholders and allowed for the development of stakeholder profiles specifically focused on their association with the study area and lateral connectivity. Field observations took place over numerous trips to the study area and included multiple study area boating trips with river experts and others. Field observations also included monitoring river activity and stakeholder behavior at various locations, such as boat ramps, recreational facilities, and marinas. Field observations also took place near dwellings and residential areas adjacent to the study area. Informal stakeholder interviews were conducted at boat ramps, recreational facilities, river dwellings, marinas, the USACE's local management office, and during river trips with river experts. The stakeholder groups and subgroups (in parenthesis) identified were:

- Recreationist (fisherman; boater; hunter)
- Main Channel Resident (primary residence; secondary residence)
- Off-Channel Resident (primary residence; secondary residence)
- Private Landowner (substantial acreage in off-channel areas; minimal acreage in off-channel areas)
- Land Leaser (substantial acreage in off-channel areas; minimal acreage in off-channel areas)
- Main Channel Cabin/Trailer Renter
- Off-Channel Cabin/Trailer Renter
- Environmental Interests Group/Organization
- Waterborne Shipper and Carrier
- Government
- Local Business

The impacts of declining lateral connectivity on the environmental dimension were assessed through analyzing the study area's fishery health. Mixed results were observed. Maceina and Spike (2005) found higher species richness and largemouth bass catch rates in open off-channel areas compared to closed or nearly closed off-channel areas. Haffner, Moss, and Piper (2010) concluded that historic largemouth bass sampling within the study area indicated quality spawning and recruitment. Haffner (pers. comm.) suspects, that even though lateral connectivity has declined, an adequate amount of off-channel areas remain accessible providing the habitat needed to maintain quality largemouth bass spawning and recruitment. Several reasons may explain Haffner, Moss, and Piper's (2010) conflicting findings. Sampling data from Haffner, Moss, and Piper (2010) only dates to 1987 and does not encompass the entire timeframe of the lateral connectivity analysis (i.e., 1965 to 2006), creating an incomplete comparison. Additionally, Haffner, Moss, and Piper (2010) do not analyze the study area's total size and total fish population, and they do not compare open, marginally open and closed off-channel areas. Although not analyzed by Haffner, Moss, and Piper (2010), this research showed a decline in the study area's accessible aquatic area which reduced the overall size of the fishery. Subsequently, the system's overall capacity for fish and stakeholders declined.

The effects of the study area's management policy and declining lateral connectivity were also determined for the study area's stakeholder groups. The effects are based on the stakeholder group profiles developed from knowledge acquired through the study area's stakeholder analysis. The vast majority of the identified stakeholder groups were negatively affected by the decline in lateral connectivity. The only stakeholder groups receiving positive effects from the historic decline were private landowners with substantial acreage in off-channel areas, land leasers with substantial acreage in off-channel areas, and waterborne shippers and carriers. The decline in lateral connectivity allowed these private landowners and land leasers to exclude other stakeholder groups from using the water resources on their private or leased property, and the historic neglect of lateral connectivity management allowed the waterborne shippers and carriers' waterway management needs to maintain priority. As a consequence, this group did not have to relinquish federal monetary allocations for lateral connectivity management. These three stakeholder groups were better organized and aware of the effects of lateral connectivity management compared to other stakeholder groups. This organization and awareness allowed these groups to effectively engage the lateral connectivity policy debate.

Management policy alternatives were developed and their social impacts assessed to provide decision-makers with options to address lateral connectivity issues. The management policy alternatives were influenced by information acquired throughout this case study including the study area's historic management policy and associated stakeholder group effects, societal values, managing institutions and frameworks, management challenges, and lessons learned from management policies on similar inland waterways. The low management alternative is a business-as-usual approach to lateral connectivity management and represents an infrequent and inconsistent management regime for lateral connectivity. The moderate management alternative places greater emphasis on lateral connectivity management than the low management alternative. The moderate management alternative resolves numerous issues in the low management alternative that hinder lateral connectivity such as: eliminating budgetary confusion**;** providing a federal and/or local revenue stream to fund lateral connectivity management; eliminating progressively more expensive and uneconomic external dredging contracts and providing access to internal expertise and dredging equipment; leveraging management costs across multiple inland waterway projects; and expediting dredging permits. The aggressive management alternative includes all aspects of the moderate management alternative in addition to: increasing the dredging depth and width standards for off-channel entrances to decrease the dredging frequency of the entrances; creating revetments on the upstream banks of off-channel entrances to decrease the dredging frequency of the entrances; dredging within the off-channel areas to increase aquatic surface acreage, create diverse habitat, and quickly return off-channel areas to historic dimensions; and obtaining federal monetary allocations to take aerial photos of off-channel entrances and areas at similar dates and river conditions to provide data for future analyses.

The majority of the stakeholder groups were negatively affected by the low management alternative and positively affected by the moderate and aggressive management alternatives. The moderate and aggressive management alternatives provide the majority of the stakeholders with improved access to higher quality recreation experiences. The three stakeholder groups that went against the majority in each management alternative were private landowners with substantial acreage in off-channel areas, land leasers with substantial acreage in off-channel areas, and waterborne shippers and carriers. The low management alternative benefited these groups by excluding other stakeholder groups from accessing off-channel areas, located on private or leased lands, that were previously accessible and allowing the waterborne shippers and carriers' waterway management needs to maintain priority. In contrast, the moderate and aggressive management alternatives improves access to off-channel areas on private or leased lands and increases the awareness of lateral connectivity management potentially infringing upon the management priorities of waterborne shippers and carriers.

Conclusion

The construction of two federally owned locks and dams within the study area created a multi-use inland waterway due to the formation of lentic environments upstream of the regulating structures. The inland waterway's historic management was largely one-dimensional and main channel-oriented. This approach caused a significant deterioration of lateral connectivity, resulting in environmental impacts to the area's fishery and differential effects on a range of stakeholder groups. The vast majority was negatively affected by the decline in lateral connectivity. The only stakeholders positively affected were private landowners with substantial acreage in off-channel areas, land leasers with substantial acreage in off-channel areas, and waterborne shippers and carriers. The decline in lateral connectivity allowed these groups to exclude other stakeholder groups from getting support for or using certain water resources and/or allowed their waterway management needs to maintain priority.

Low, moderate, and aggressive management alternatives were developed and their social impacts assessed to provide decision-makers with options to address lateral connectivity issues. The majority of the stakeholder groups were negatively affected by the low management alternative and positively affected by the moderate and aggressive management alternatives. The moderate and aggressive management alternatives provide the majority of the stakeholders with improved access to higher quality recreation experiences. The low management alternative benefited private landowners with substantial acreage in off-channel areas, land leasers with substantial acreage in off-channel areas, and waterborne shippers and carriers. In contrast, these three stakeholder groups were negatively impacted by the moderate and aggressive management alternatives.

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