Effects of Coalbed Natural Gas Development on Fish Assemblages in the Powder River Basin, 2005

Introduction

The Powder River Basin in Wyoming and Montana is currently undergoing one of the world's largest coalbed natural gas (CBNG) developments with about 12,000 wells in place in 2003, 14,200 in 2005, and up to 70,000 projected over the next 20 to 30 years. Because CBNG development involves production and disposal of large quantities of coalbed ground water that differs from surface waters, potential exists for substantial effects on aquatic ecosystems. Coalbed natural gas product water is dominated by sodium and bicarbonate ions and may have a higher salinity than associated surface waters. However, information on effects of CBNG product water on warmwater fishes of the Powder River Basin is lacking, presenting a substantial gap in predicting the potential effects of these discharges in the Great Plains ecosystem. This study, funded by the U.S. Bureau of Land Management, is designed to provide scientifically sound information to aid agency, tribal, and industry resource managers in making land and water use decisions in Montana and Wyoming. Additionally, it creates a framework for the evaluation of potential effects of CBNG development to aquatic life worldwide. Our objectives are to:

Objective 1: Identify the potential effects of CBNG development on fish assemblages by comprehensively reviewing the literature.
Objective 2: Determine if CBNG development within the drainage area of a stream affects the fish assemblage present.
Objective 3: Determine if CBNG development in the middle or lower reaches of a stream affects expected longitudinal distribution patterns of fish assemblages.
Objective 4: Determine if fish assemblages change immediately after CBNG development in a drainage area.
Objective 5: Determine if fish assemblages at specific locations in the Powder River Basin are the same now as they were prior to CBNG development.

Figure 1. Shorthead redhorse (*Moxostoma macrolepidotum*).

Literature Review

Few studies have been conducted to specifically address the effects of CBNG development on fish assemblages in the Powder River Basin, but studies conducted elsewhere have addressed changes in water quality and water quantity and surface environment alterations similar to those created by CBNG development. We reviewed the literature pertaining to these potential effects and considered the applicability of these studies to CBNG development. However, CBNG development in the Powder River Basin is unique because product water in other basins is not typically discharged to surface waters. An exception is the Black Warrior Basin, Alabama, where no significant decline in fish species diversity or total fish biomass occurred after discharge of CBNG product water began. However, the abundance of Gulf darters (*Etheostoma swaini*) decreased with the presence of product water, and reproduction of the rough shiner (*Notropis baileyi*) was significantly greater downstream of discharge. These subtle patterns of fish species variation suggested that the aquatic system was changing and that long periods of CBNG product water discharge may result in changes in assemblage composition.

The inferences that can be made among geologic basins with CBNG development are limited because the major ion composition of product water varies among them. Fathead minnow eggs exposed to sodium bicarbonate ($NaHCO_3$), the major salt associated with CBNG product water in the Powder River Basin, had lower hatch and survival rates than controls in both acute and chronic exposures. The effects that other water quality parameters may have on fish assemblages in the Powder River Basin are uncertain. Continuous input of constant-temperature CBNG product water may disrupt natural environmental cues and result in changes in fish behavior and reproduction. Additionally, road construction and stream crossings associated with CBNG development may lead to stream sedimentation, fragmentation of fish populations, and decreased fish assemblage diversity.

Based on our review of the literature, it is apparent that limited knowledge and therefore uncertainty exists pertaining to the potential effects of CBNG development on fish in the Powder River Basin. The severity and direction of effects that are known are ambiguous because of differing environmental conditions and spatial and temporal differences in product water chemistry among geologic

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basins and within the Powder River Basin. This ambiguity highlights the need for further field and laboratory research. The literature review is available on-line at *http://www.wy.blm.gov/bfo/prbgroup/monitoring.htm*.

Field Research

We are using four different approaches to assess the local and large scale effects of CBNG on fish assemblages of the Powder River Basin. First, to determine if CBNG development within the drainage area of a stream affects the fish assemblage present, fish surveys are being conducted on streams with CBNG development (treatments) and streams without development (controls). Second, to determine if CBNG development in the middle or lower reach of a stream affects expected longitudinal distribution patterns of fish assemblages, fish surveys are being conducted at multiple points along streams to determine if differences are found in fish assemblages above and below CBNG development. Third, to determine if fish assemblages change immediately after CBNG development in a drainage area, fish surveys are being conducted immediately before and after the initial development of CBNG. Finally, to determine if fish assemblages at specific locations in the Powder River Basin are the same now as they were prior to CBNG development, fish surveys conducted in the mid 1990s in areas with (historical treatment) and without (historical control) CBNG development are being repeated. Using a variety of approaches is necessary because of limited availability of baseline information and study sites, and high levels of variability among study streams.

Methods

All treatment, control, and longitudinal sites are being sampled once each summer in 2005 and 2006. Surveys of historical sites are being conducted once during the summer of 2005 or 2006. Water quality sampling for major ions is being conducted within a 1-week period in August 2005 and 2006. Sampling at each site includes the following:

Seining a 300-m reach of stream

Counting, measuring, and identifying fish to species

Collecting and preserving fish voucher specimens for laboratory verification and museum curation

Measurement of physical stream characteristics—wetted width, depth profile, and substrate composition

Measurement of habitat characteristics—instream fish cover, riparian cover

Measurement of field water quality—pH, dissolved oxygen, specific conductance, temperature, and turbidity

Measurement of major ions—dissolved calcium, magnesium, potassium, sodium, chloride, sulfate, bicarbonate, ammonia as nitrogen, pH, total dissolved solids, and conductivity

Study Sites

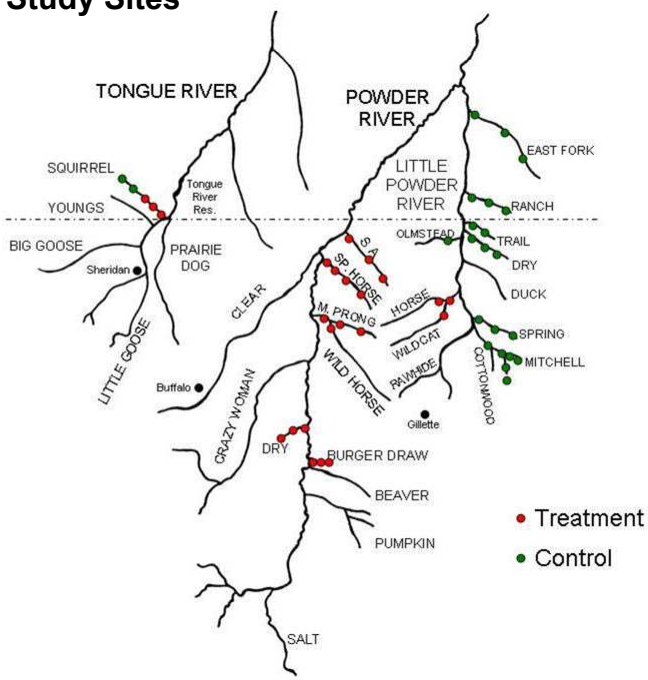

Figure 2. Treatment and control sites sampled for fish, water quality, and habitat in 2005.

Figure 3. Coalbed natural gas product-water discharge point into Burger Draw, Wyoming.

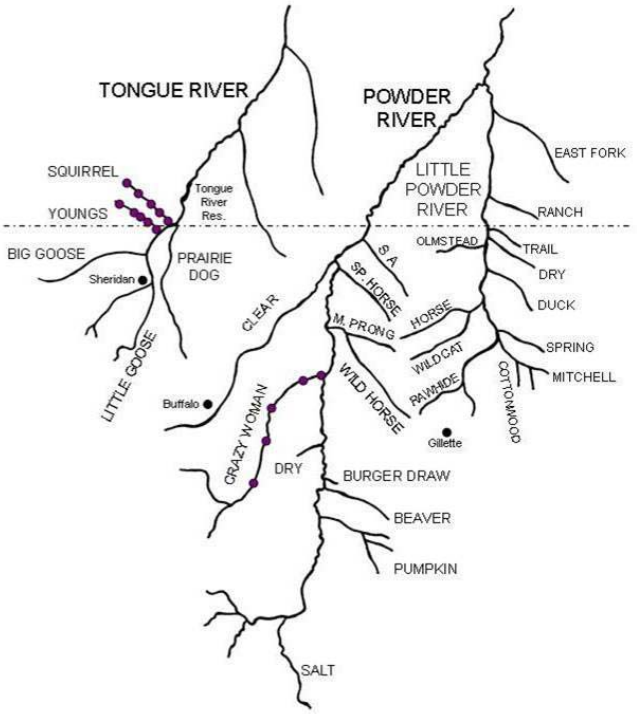

Figure 4. Longitudinal sites sampled for fish, water quality, and habitat in 2005.

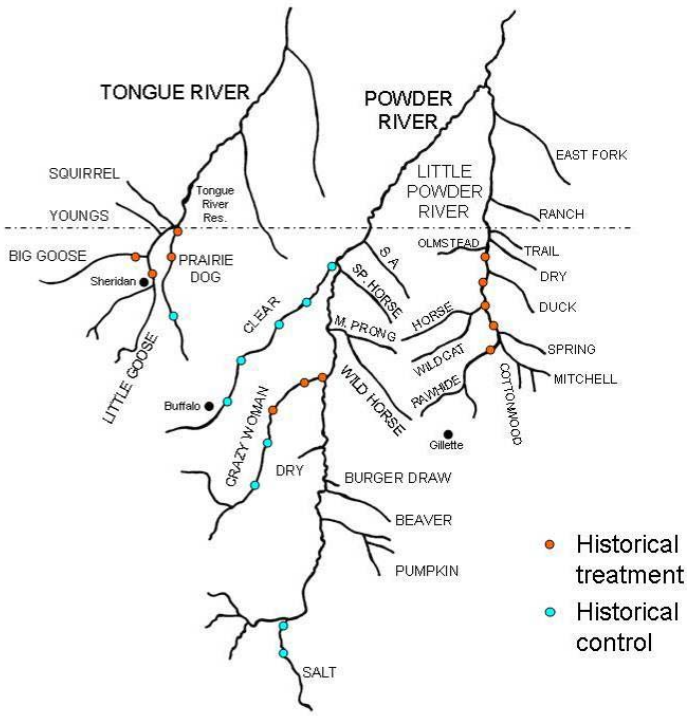

Figure 5. Fish surveys conducted in the 1990s being repeated in our 2005-2006 field study.

Progress to Date

We sampled 57 sites in 2005, including all treatment, control, and longitudinal sites. Crazy Woman and Salt creeks were sampled for historical comparisons. Water quality samples were collected from all streams and sent to

Figure 6. Seining in Dry Creek, Wyoming.

Energy Labs, Inc., in Billings, Montana, for ion analysis. Twenty-four fish species were collected. Treatment streams had a range of 0 to 8 fish species whereas control streams had a range of 1-12 fish species. Plains killifish (*Fundulus zebrinus*) and river carpsucker (*Carpoides carpio*) were found exclusively in treatment streams whereas channel catfish (*Ictalurus punctatus*), stonecats (*Noturus flavus*), shorthead redhorse, and plains minnows (*Hybognathus placitus*) were found exclusively in control streams.

Future Work

We will repeat all of the fish surveys conducted in 2005 in 2006. Additionally, we will add at least one additional site on Youngs Creek and sample the remainder of the historical comparisons. Water quality samples will be collected at all sites.

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