Introduction

Little has been published about the effects of sand and gravel mining on fisheries resources in Wisconsin. To develop insight into possible effects, we conducted a literature review that focused on physical and biological results of sand and gravel mining both in and adjacent to streams. Additionally, we compared fisheries and habitat characteristics in areas with and without mining in the Big Rib River, Marathon County, Wisconsin. The area around the Big Rib River has been mined for the past 40 years (Zmuda 1982). The goals of both the literature review and the field sampling were to develop management recommendations for dealing with possible conflicts between stream fisheries and mining activities. For purposes of this report, sand and gravel mining is defined as excavations of sand, gravel, and larger substrates such as rubble, cobble, and boulders.

As of 1977, there were approximately 34,800 ha in Wisconsin that had been disturbed by surface sand and gravel mining operations (U.S. Dep. Agric. 1977). By 1987, over 4,860 ha in Marathon County alone had been disturbed by sand and gravel operations (Mitch Zmuda, Wis. Dep. Nat. Resour., pers. comm.). In the area near the Big Rib River between Marathon City and Rib Falls, Wisconsin, there are 49 different mining sites that encompass over 170 ha (Mitch Zmuda, pers. comm.). Types of mining in the Big Rib River area include inactive and active riparian (upland) excavations, inactive and active floodplain excavations, which can include unconnected and connected ponds with outlets to a river, and actual in-stream mining (dredging) excavations. For the purpose of this report, we limit our discussion to active floodplain excavations (connected ponds only) and old in-stream dredging.

Wisconsin regulations that require state permits for gravel excavations in or adjacent to navigable water were first enacted in 1961 under Chapter 30, Wisconsin Statutes. Under Chapter 30, permits were required if excavations resulted in removal of material from a streambed, relocation of a stream, creation of an artificial waterway within 150 m of a stream, and/or grading on the bank in excess of 930 m² (Zmuda 1982). No provisions were included for the reclamation of gravel excavations under Chapter 30. Many of the gravel operations during the late 1960s and early 1970s did not have Chapter 30 permits (Zmuda 1982). With increases in permit applications during the mid-1970s, it became apparent that added regulations were needed.

Therefore, in 1979, new regulations were formulated under Chapter NR 340, Wisconsin Administrative Codes, that gave specific guidelines for gravel excavations in or near navigable waterways. The main purpose of NR 340, rewritten in September 1991, is to minimize adverse effects, provide for reclamation of excavated areas, restrict excavations where adverse effects cannot be minimized or avoided, and define certain terms, including some used in Chapter 30, Wisconsin Statutes (Zmuda 1982, Wis. Dep. Nat. Resour. 1991). After an application is submitted under Sections 30.19, 30.195, or 30.20, the Wisconsin Department of Natural Resources (DNR) reviews the project and compiles an Environmental Assessment (EA) to determine if an Environmental Impact Statement is needed (Zmuda 1982). The EA data are assembled by the fish, wildlife, water resources, and water regulation and zoning programs. The formulation of these laws, regulations, and guidelines have deterred many permit applications to dredge in and around the Big Rib River since 1980.

Sand and gravel mining operation.
This report describes the results of surveys conducted on the Big Rib River in 1986 and 1987. In 1986, DNR Fisheries Management and Research personnel conducted a brief fishery survey on 2 sections of the Big Rib River in an area that had experienced in-stream mining almost 10 years before sampling. In 1987, DNR Fish Research personnel conducted a more detailed 2-week survey of the habitat and fish communities at 6 stations on the Big Rib River between Marathon City and Rib Falls. The objective of these surveys was to evaluate and document impacts from active, connected floodplain excavations and from old, abandoned, unclaimed in-stream-mined areas.

**Methods**

To determine what is currently known about in-stream and floodplain sand and gravel mining, we conducted a literature review and contacted DNR water regulations personnel. This evaluation included studies and articles published as of summer 1990. A database search was conducted by the U.S. Fish and Wildlife Reference Service, Bethesda, Maryland, on the key words of gravel mining and streams. Additional reports and articles were provided by Mitch Zmuda (DNR Bur. Water Regul. and Zoning). The articles and reports that we reviewed contained information on additional studies and articles that we attempted to obtain from various agencies.

Our review primarily focused on the physical and biological effects of in-stream sand and gravel mining and secondarily on floodplain (connected ponds only) sand and gravel mining. For the purpose of this report, we excluded such topics as effects on recreation, aesthetics, terrestrial biota, and geotechnical engineering aspects. However, due to the dearth of actual studies conducted on in-stream and floodplain sand and gravel mining, we researched other in-stream modifications and effects, such as channelization, silt deposition, and channel clearing. We also provide short summaries of 6 specific case studies conducted on in-stream and floodplain excavations in other states. These summaries include stream and location, references, types of mining operations, physical and biological effects, and recommendations.

Methods for the Big Rib River surveys conducted in 1986-87 by DNR personnel are discussed in the section of this report titled “Big Rib River: A Wisconsin Case Study of Gravel Mining Impacts.”


**Literature Review**

**Physical Effects**

Gravel mining operations (both in-stream and floodplain excavations) can affect the physical nature of a stream. The stream channel may be modified, flow patterns and bedload transport may be altered, headcutting can increase, and the water quality of a stream may be altered.

**Stream Channel Modifications**

The actual dredging or scraping of sand and gravel during mining operations can alter stream channels and banks. Dredging or scraping usually involves enlargement or widening of the stream channel (Etnier 1972, Woodward Clyde Consult. 1976b, Yorke 1978), which creates uniform conditions of either deep or shallow reaches throughout the channel (Yorke 1978). These physical effects can change the stream length, gradient, width, and depth of the channel (Woodward Clyde Consult. 1976b). Channel deepening can also cause stream banks to become unstable and eroded (Bull and Scott 1974). In the Crooked River, Idaho, where placer mining (a type of gold mining that involves dredging of sand and gravel) occurred, the stream was channelized and straightened; all trees, boulders, and other cover were removed, and pool habitat was eliminated, thus creating a channel devoid of habitat suitable for salmonids (Hair et al. 1986). Widening of the channel also increases the surface area of the stream (Yorke 1978). If dredging occurs, deep pools are often created because the amount of material being removed is greater than the amount of material that the river can redeposit (Bull and Scott 1974, Crunkilton 1982, Rivier and Seguier 1985). However, once the mining operation ceases, these pools often fill with sand or silt in a relatively short period of time, depending upon the rate of sediment renewal (Yorke 1978, Rivier and Seguier 1985). Thus, these pools created by dredging may serve temporarily as sediment traps, which may be beneficial to downstream habitats and organisms (Martin and Hess 1986). This condition is, however, a short-term response, because the sediment basins will eventually fill in.

**Channel Flow Modifications**

The physical effects of deepening and widening the stream channel can alter the flow patterns and velocities of the stream (Crunkilton 1982). As in channelization (the creation of a uniform channel), peak flows will be higher, resulting in a shorter duration of flooding (Yorke 1978). Velocities will be