1 Introduction

Background

The Mississippi River is an integral part of American heritage, both as a unique resource and as the best example of a multipurpose river in the United States. The Mississippi River drainage basin is nearly 4 million square kilometers, one of the largest and most productive ecosystems in the world (Holland-Bartels et al. 1990b). The river above the confluence of the Ohio River is commonly called the Upper Mississippi River (UMR) (Figure 1) and includes nearly 500,000 km^2 of watershed (Holland-Bartels et al. 1990b). The UMR, including the Illinois Waterway (IWW) (Figure 1), is designated both a nationally significant ecosystem and a nationally significant navigation system, the only inland river in the United States to have such a designation. Many national wildlife refuges exist along the river corridor. The Mississippi Flyway is the migration corridor for 40 percent of North America's waterfowl and shorebirds, as well as an important flyway for raptors and neotropical songbirds. A total of 50 species of freshwater mussels have been recorded in the river system. In addition, the Mississippi River System is noteworthy among the world's large temperate rivers because it supports an unusually large number of fish species; historically, at least 150 species of fish have been reported in the UMR (Gutreuter 1997).

The history of navigation on the UMR-IWW System goes back to the 1820s, when Congress authorized navigation improvement measures by the U.S. Army Corps of Engineers such as the removal of snags and other obstructions in several locations of the Mississippi River and construction of a canal connecting Lake Michigan to the IWW (Fremling and Claflin 1984). Several navigation improvement projects, including the excavation of rocks, closing off of sloughs, construction of the 4.5-foot navigation channel, and construction of the 6-foot navigation channel, continued throughout the early 1900s (Fremling and Claflin 1984). Projects creating the current 9-foot navigation channel were authorized in the 1930s, and most were completed by 1940 by the Corps (Fremling and Claflin 1984). Twenty-nine locks and dams on the Mississippi and eight on the Illinois replaced rapids and falls with a stairway of water or a series of terraced pools for commercial and recreational traffic (Figure 1). Habitats in a typical pool include

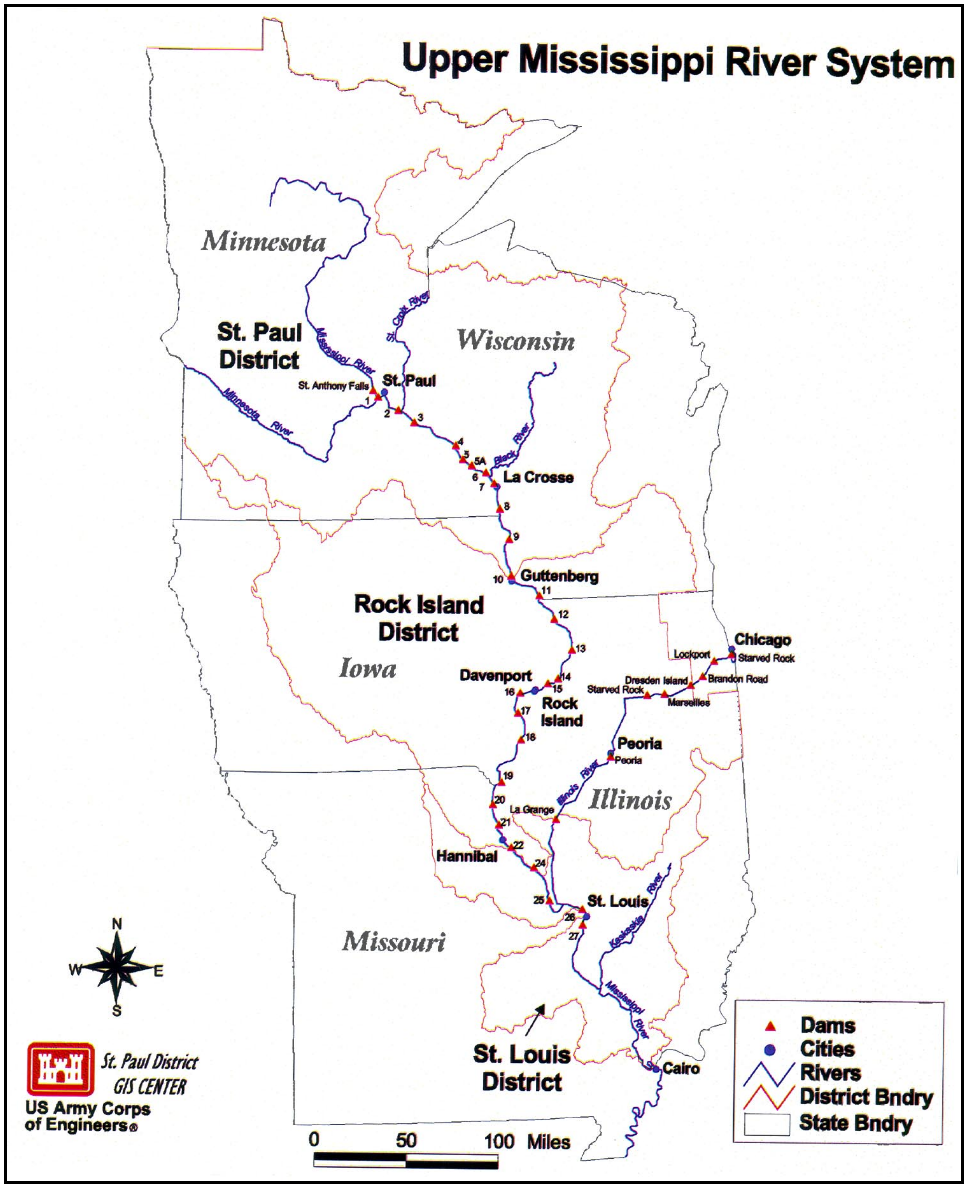

Figure 1. The Upper Mississippi River-Illinois Waterway System (the pool upstream from the dam has the same number or name as the dam)

a braided channel, a lotic area at the head of the pool, and a lentic environment above the impounding lock and dam (Van Vooren 1983). More barge traffic than ever before transports a wide variety of essential goods on the UMR-IWW System; agricultural commodities, petroleum products, and coal are the leading cargoes, with various farm products accounting for approximately half of the total tonnage shipped.

In the UMR-IWW System, a typical commercial "tow" consists of a towboat and 15 barges with the configuration of 3 barges wide by 5 barges long (Holland 1986b). Effects of increased navigation traffic on fish that inhabit the main navigation channel during any stage of their life, including how any navigation-related mortality could affect recruitment, are of the greatest concern (Holland 1986b; Holland-Bartels et al. 1990a). Potential sources of direct navigation-related mortality include turbulence, waves, shear, pressure, entrainment through the towboat propeller, and short-term dewatering of backwater nursery areas (Morgan et al. 1976; Holland 1987; Holland-Bartels et al. 1995; Killgore et al. in preparation; Keevin, Adams, and Killgore in preparation; Keevin et al. in preparation; Adams et al. in preparation). Lentic or backwater areas have usually been considered the primary fishery habitat in the river system, and it was formerly believed that the main navigation channel contributed little to the spawning or nursery needs of fish. However, many studies have shown that the main navigation channel is used extensively by early life stages, as well as by juvenile and adult stages, of several fish species and that the main channel may be critical to the maintenance of certain valuable fisheries (Holland et al. 1984; Holland 1986b; Holland-Bartels et al. 1990a; Gutreuter, Dettmers, and Wahl 1998).

The purpose of the Navigation Study Fish Ecological Risk Assessment is to assess the incremental impact of increased commercial navigation traffic from 2000 to 2050 (in 10-year increments) on fish in the UMR-IWW System. For the writing of this report, future traffic projections were not yet available; therefore, traffic projections increased 25, 50, 75, and 100 percent above the 1992 baseline numbers were used. The estimated incremental navigation impact on the larval stages of 30 fish species due to mortality resulting from entrainment in the propeller zone of a passing tow has been calculated using the Conditional Entrainment Mortality (CEM) model (Boreman et al. 1981). Impacts on early life stages have been extrapolated to estimate the numbers of future equivalent adults lost, using the Equivalent Adults Lost (EAL) model (Horst 1975; Goodyear 1978) and the Recruitment Forgone (RF) model (Jensen 1990), and the fish biomass lost using the Production Forgone (PF) model (Jensen et al. 1988). These models were initially developed to assess the consequences of fish entrainment and impingement at water intakes for power plants.

The U.S. Environmental Protection Agency Framework for Ecological Risk Assessment

This report is written in the framework recommended in the U.S. Environmental Protection Agency (USEPA) Guidelines for Ecological Risk Assessment (USEPA 1998). The USEPA framework was developed to promote consistent approaches to ecological risk assessment, identify key issues, and define the terminology (Bartell 1996). The USEPA framework includes three components: problem formulation, analysis (characterization of exposure and of ecological effects), and risk characterization (USEPA 1998).

In the problem formulation component, the disturbance or stressor is identified, the subject or endpoints of the risk assessment are delineated or defined, and the scope and scale of the ecological risk assessment are presented (Bartell 1996). In the characterization of exposure, the disturbance is described

(USEPA 1998). The ecological effects consistent with the objectives of the assessment are defined and the exposure-response relationships used to translate the exposure profile into risk estimates are presented in the characterization of ecological effects section of the assessment process (USEPA 1998). In the risk characterization section, the available information and data are integrated, the risks are estimated, and the uncertainties and their assessment implications are characterized (Bartell 1996).