Summary

The Navigation Study being performed by the U.S. Army Corps of Engineers (USACE) is assessing the potential environmental impacts associated with anticipated increases in commercial navigation traffic on the Upper Mississippi River-Illinois Waterway (UMR-IWW) System. The assessment addresses a period beginning with the present condition (defined as 1992) and continuing through the year 2050. Upon completion, the assessment will fulfill a requirement of the National Environmental Policy Act (NEPA) of 1969, and an Environmental Impact Statement (EIS) will be prepared. This report describes the overall approach adopted for assessing the potential impacts on and risks posed by commercial vessels to larval fishes in the UMR-IWW System and presents initial results for hypothetical percentage increases in traffic over the 1992 baseline data. Specific larval entrainment assessment results for more realistic traffic scenarios will be presented as future reports in the Navigation Study series of technical publications.

The larval fish entrainment component of the Navigation Study was organized according to the framework recommended in the Guidelines for Ecological Risk Assessment developed by the U.S. Environmental Protection Agency (USEPA). An ecological risk is defined as the probability of an adverse impact on an ecological resource. The Guidelines provide guidance for comprehensive, consistent, and coherent ecological risk assessments. The ecological risk assessment process consists of three steps: problem formulation, analysis (characterization of exposure and of ecological effects), and risk characterization. Completing each step may require the collection of new data and information.

The problem formulation component of the Navigation Study Fish Ecological Risk Assessment consists of developing a conceptual model of the entire assessment process. The conceptual model outlines the nature and source of stress to ecological resources, identifies ecological resources potentially at risk, specifies the ecological impacts of concern regarding these resources, identifies relevant data and information, and suggests models and methods of analysis that can be used to estimate risks. The need for discussion and participation among risk managers, risk assessors, and stakeholders in developing the overall design for risk assessment is emphasized in the problem formulation step. The conceptual model outlining the larval fish entrainment risk assessment evolved

through a series of meetings and workshops and continues to be evaluated, modified, and refined by members of the Navigation Study Model Integration and Simulation Team (MIST). Regular meetings with the Navigation Environmental Coordinating Committee (NECC) provide opportunities for review and comments from representatives of state governments, other governmental agencies, environmental organizations, and the concerned public. As a result of these activities, 30 species of fish were identified for inclusion in the assessment.

In this risk assessment, the ecological stressors take the form of the water entrained through the propellers of commercial vessels (i.e., "tows") navigating the UMR-IWW System. To characterize commercial traffic intensity, a baseline number of vessels passing through each pool for each month was developed using 1992 lockage data. For this initial larval fish risk assessment, four future traffic scenarios were constructed assuming 25, 50, 75, and 100 percent increases over the 1992 baseline data. Existing fleet data were also analyzed to construct a data set that describes, by pool and by month, the relative distribution of vessels across categories of vessel direction, size, speed, and load, and whether or not the vessel had a Kort nozzle (a type of propeller). This classification scheme produced 108 possible configurations for commercial vessels operating on the UMR-IWW System. In developing and assessing future traffic scenarios, it was assumed that the current fleet configuration will apply through the year 2050.

The existing data were used to estimate the water entrainment rates associated with each of the 108 possible vessel configurations. These estimates were based on existing models. Model inputs included propeller diameter, applied horsepower, vessel speed, and presence of Kort nozzle technology. Results of calculations for individual vessels were used to estimate the mean (± standard deviation) entrainment rate of water characteristic of each pool for each month on the UMR-IWW System. These values, combined with the corresponding statistics for vessel speed and the projected increase in vessels per day, characterized larval fish exposure to the risk of entrainment. Estimates for individual vessels ranged from 15.4 to 53.7 m^3/sec.

The characterization of ecological effects component in this risk assessment identified commercial traffic-induced increases in larval fish mortality as the principal focus of the assessment. To successfully realize the objective of the Navigation Study Fish Ecological Risk Assessment, methods and tools were developed to translate the baseline traffic and future traffic scenarios into estimates of associated ecological impacts on larval fish entrainment. Potential impacts or risks posed by commercial vessels on fish larvae are being assessed using the Conditional Entrainment Mortality (CEM) model, which is a standard modeling approach for evaluating fish entrainment by power plant water intakes. The results of the entrainment mortality calculations are extrapolated to estimates of future lost adults, recruitment forgone, and production forgone, using published models. The CEM model estimates the mortality rate of newly hatched fish larvae drawn through and subsequently killed by the propeller jet of

commercial vessels traversing each pool on the UMR-IWW System during the spawning season of that particular fish species.

The Equivalent Adults Lost (EAL) model extrapolates the calculated larval entrainment mortalities to the number of adult individuals lost from the future population as a result of larval entrainment. The EAL model essentially compares the incremental entrainment mortalities to natural mortalities suffered by fish larvae and juvenile life stages.

The Recruitment Forgone (RF) model represents a more complex extrapolation of entrainment mortalities to lost future recruits. The RF model addresses fish growth, in addition to simply adding to natural mortality. The RF model is important in evaluating the implications of larval entrainment of individual fish that fail to recruit to commercial and recreational fisheries in the UMR-IWW System.

The Production Forgone (PF) model is analogous to the RF model, except that lost future biomass is estimated instead of individual recruits or adults. This model is important for assessing risks posed by commercial vessels to the biomass of important forage species (e.g., gizzard shad (*Dorosoma cepedianum*)), which may indirectly determine the population sizes of future commercial or recreational fisheries in the UMR-IWW System.

Using a combination of published data and information, workshops, unpublished reports, and professional judgment, the necessary data sets were developed for each of the 30 species of fish selected for the ecological risk assessment. These data served as input to the CEM, EAL, RF, and PF models. These input parameters will be the focus of future numerical sensitivity and uncertainty analyses aimed at revising and refining the initial estimates of larval fish entrainment and its extrapolation using the ecological models.

Characterization of potential ecological risks posed by commercial traffic on the UMR-IWW System, the third step in the larval fish risk assessment process, is developed from the integration of the entrainment calculations with the ecological models. The 1992 baseline traffic estimates of larval fish entrainment mortality and subsequent extrapolations to lost adults, lost recruits, and lost biomass are presented for the channel catfish (*Ictalurus punctatus*) for Pools 4, 8, 13, and 26 in the UMR and the La Grange Pool in the IWW. The results suggest that for baseline traffic, on average, from 0.4 to 7 percent of the total larval channel catfish fish standing crop might be killed by entrainment. The higher percentage impacts occurred for more southerly UMR pools with higher traffic intensities (and potentially longer spawning seasons). The impacts of the 25, 50, 75, and 100 percent increase in traffic scenarios resulted in the same percentage increases in larval fish mortality, as demonstrated for channel catfish using July results for Pool 8. The incremental impacts of commercial traffic in UMR Pool 13 were summarized for six selected species during the peak spawning months (June or July). The selected species included emerald shiner (*Notropis atherinoides*), freshwater drum (*Aplodinotus grunniens*), mooneye (*Hiodon tergisus*), gizzard shad, channel catfish, and walleye (*Stizostedion*

vitreum). Depending on the species, the larval entrainment calculations suggest increased mortality ranging from ~100,000 (e.g., walleye) to 100,000,000 (e.g., emerald shiner, gizzard shad) individual larvae for Pool 13 in the peak spawning months. In addition, the numbers of lost future recruits were summed over all pools in the UMR-IWW System for the six species to demonstrate the relative risk ranking for these species associated with a 25 percent increase in traffic intensity. Based on these initial results, the emerald shiner suffered the highest potential losses in future recruits, followed in order by freshwater drum, mooneye, channel catfish, gizzard shad, and walleye. The results of these kinds of analyses can be used to assess the relative impacts of traffic increases on different species and for different pools. The relative impacts can be used to design and evaluate possible plans to avoid or minimize actual impacts or to develop mitigation measures.

One key aspect of ecological risk assessment that distinguishes this process from more historical environmental assessments performed under the NEPA is the explicit identification and quantification of uncertainties that enter into the analysis. Once quantified, these uncertainties are included in the assessment calculations to produce probabilistic estimates of ecological impacts (i.e., risks). In the Navigation Study Fish Ecological Risk Assessment, uncertainties enter the analysis in the form of bias and imprecision in the estimates of future traffic intensity, in the characterization of entrainment volumes for specific vessel configurations, and in the ecological responses to entrainment produced by the ecological models. Uncertainties also take the form of the simplifications and assumptions that are inherent in the modeling process. Numerical analyses of these preliminary results will be used to identify and rank-order the contributions of specific sources of uncertainty to the Navigation Study Fish Ecological Risk Assessment results. Such analyses can be used to design additional studies or to identify additional data collection that will provide the greatest return in reducing bias and imprecision per unit investment of future Navigation Study resources.