2 Problem Formulation

The disturbance or stressor in the Navigation Study Fish Ecological Risk Assessment is the incremental increase in commercial navigation traffic, specifically a tow passing through the river system. Traffic projections are being developed by economists for the future (2000, 2010, 2020, 2030, 2040, and 2050) for the conditions that would occur without any major improvements to the system, referred to as the without-project conditions. Future traffic projections also are being developed for the National Economic Development (NED) Plan for the years 2000-2050 (every 10 years). Traffic that actually occurred on the river system in 1992 is being used as the baseline for comparison. As of this report, traffic projections are still under development. Therefore, for the purposes of presenting the methodology used here, traffic increases were based on the 1992 traffic level and increased in each pool by 25, 50, 75, and 100 percent. For use in the ecological models, traffic projections were broken down into the average number of tows per day by month for each pool.

Since the focus of this risk assessment is on larval fish mortality resulting from entrainment in the propeller zone of a passing tow, knowing the volume of water entrained by a tow is critical. Entrainment volumes have been calculated using a model developed by Maynord (1999). Entrainment volumes were calculated for 108 different tow configurations (e.g., empty/full, going upstream/downstream, Kort nozzle/open wheel propeller type). The volume of water in a particular pool was calculated from bathymetry cross-section data using a geographic information system (GIS) at the U.S. Army Engineer Research and Development Center, Vicksburg, MS.

In order to assess the ecological risks to fish associated with the incremental increase in commercial navigation traffic 25, 50, 75, and 100 percent above 1992 baseline numbers, 30 fish species that inhabit the UMR-IWW System were selected (Table 1). This list of 30 species was assembled as a result of numerous meetings and workshops held throughout the Navigation Study. The fish species selected for this ecological risk assessment include species that have different life history strategies as well as species important to both the commercial and recreational fishery, important forage species, and species listed as threatened or endangered or other similar category. The status of Federal and State listed fish species included in this risk assessment is detailed in Table 2.

Table 1
Fish Species Selected to Assess the Ecological Risks Associated With the Incremental Increase in Commercial Navigation Traffic

Scientific Name	Common Name	Category[1]
Family Acipenseridae - Sturgeons		
Scaphirhynchus platorynchus	Shovelnose sturgeon	Commercial
Scaphirhynchus albus	Pallid sturgeon	Listed
Acipenser fulvescens	Lake sturgeon	Listed
Family Polyodontidae - Paddlefishes		
Polyodon spathula	Paddlefish	Commercial, Listed
Family Lepisosteidae - Gars		
Lepisosteus platostomus	Shortnose gar	Commercial
Family Amiidae - Bowfins		
Amia calva	Bowfin	Commercial
Family Clupeidae - Herrings		
Dorosoma cepedianum	Gizzard shad	Forage
Family Hiodontidae - Mooneyes		
Hiodon alosoides	Goldeye	Listed
Hiodon tergisus	Mooneye	Commercial
Family Esocidae - Pikes		
Esox lucius	Northern pike	Recreational, Listed
Family Cyprinidae - Minnows		
Cyprinus carpio	Common carp	Commercial
Notropis atherinoides	Emerald shiner	Forage
Family Catostomidae - Suckers		
Carpiodes carpio	River carpsucker	Commercial
Cycleptus elongatus	Blue sucker	Listed
Ictiobus bubalus	Smallmouth buffalo	Commercial
Ictiobus cyprinellus	Bigmouth buffalo	Commercial
Minytrema melanops	Spotted sucker	Commercial
Moxostoma macrolepidotum	Shorthead redhorse	Commercial
		(Continued)

[1] Commercial = Of commercial importance
Recreational = Of recreational importance
Listed = State or Federal listed as threatened, endangered, candidate for listing, need of management, etc.

Table 1 (Concluded)		
Scientific Name	**Common Name**	**Category**[1]
	Family Ictaluridae - Catfishes	
Ictalurus punctatus	Channel catfish	Commercial, recreational
Ictalurus furcatus	Blue catfish	Commercial, recreational
Pylodictis olivaris	Flathead catfish	Commercial, recreational
	Family Moronidae - Temperate Basses	
Morone chrysops	White bass	Recreational
	Family Centrarchidae - Sunfishes	
Lepomis macrochirus	Bluegill	Forage, recreational
Micropterus dolomieu	Smallmouth bass	Recreational
Micropterus salmoides	Largemouth bass	Recreational
Pomoxis annularis	White crappie	Recreational
Pomoxis nigromaculatus	Black crappie	Recreational
	Family Percidae - Perches	
Stizostedion canadense	Sauger	Recreational
Stizostedion vitreum	Walleye	Recreational
	Family Sciaenidae - Drums	
Aplodinotus grunniens	Freshwater drum	Commercial, recreational

Using the CEM model (Boreman et al. 1981), larval fish mortality was calculated by month for each pool; calculations were also combined to give a systemwide mortality value for a particular scenario. The larval mortality of a particular fish species was used to extrapolate the future equivalent adults lost (both numbers of fish and biomass) using the EAL model (Horst 1975; Goodyear 1978), the RF model (Jensen 1990), and the PF model (Jensen et al. 1988). Where assumptions were made regarding the selection of model parameters, the approach was consistently biased toward overestimating impacts and risk.

In evaluating the significance of entrainment mortality, it must be recognized that the basic life history strategy of fishes is to produce large numbers of eggs and larvae, most of which will fail to reach mature adulthood (i.e., recruit stage). In addition, there appear to be density-dependent processes that serve to increase the survivorship of remaining individuals during conditions of increased mortality. This density-dependent or “compensatory” effect has received much attention in relation to the exploitation of fish populations by commercial fishing, as well as to the potential impacts of entrainment by power plants (Van Winkle 1977). The significance of larval entrainment by commercial traffic should be realistically evaluated in terms of how this additional mortality impacts the compensatory reserve of the local population.

Table 2

Threatened and Endangered Fish Species of the Upper Mississippi River and Illinois Waterway Selected for the Modeling Effort to Assess the Ecological Risks Associated with Increased Navigation Traffic

		Status				
Species	**Federal Status**	**Wisconsin**	**Minnesota**	**Iowa**	**Illinois**	**Missouri**
Pallid sturgeon	Endangered					Endangered
Lake sturgeon			Special concern	Endangered	Endangered	Endangered
Paddlefish		Threatened	Threatened			On watch list
Blue sucker		Threatened	Special concern			On watch list
Goldeye		Endangered				
Mooneye						Rare
Northern pike						Rare

Large numbers of fish eggs and larvae can be entrained by power plants and commercial navigation traffic. For example, Jensen (1990) estimated that approximately 128,000,000 yellow perch (*Perca flavescens*) larvae were entrained on an annual basis from the western basin of Lake Erie by the Monroe Power Plant, Monroe, Michigan. While this number appears large, Jensen (1990) further emphasized that natural mortality was high for these larvae and that this additional mortality translated into approximately 9,000 fish that were ultimately lost from the yellow perch population as a result of this magnitude of larval entrainment. However, Jensen's study (1990) is not offered as support for condoning the entrainment of large numbers of fish larvae. The main point is that the population-level implications of entrainment are difficult to interpret from the absolute number (often large) of larvae lost to entrainment.

Finally, for a fish population to remain in a steady-state equilibrium, each mature female needs to produce only one adult female and one adult male during her life span (Goodyear 1978). In other words, a population in equilibrium has a net reproductive rate equal to 1.0. Jensen (1990) speculated that, on average, the net reproductive rates for fish populations do not vary from 1.0 for considerable lengths of time. Otherwise, populations would face either local extinction or reach some upper limit defined by the environmental carrying capacity of the system. In general, fish populations appear to undergo considerable variation in size from year to year. This often reflects the relative success of strong year classes, and these dynamics remain poorly understood for specific populations and ecosystems. Importantly, in spite of these fluctuations, the populations seem rarely to become extinct or excessively abundant.