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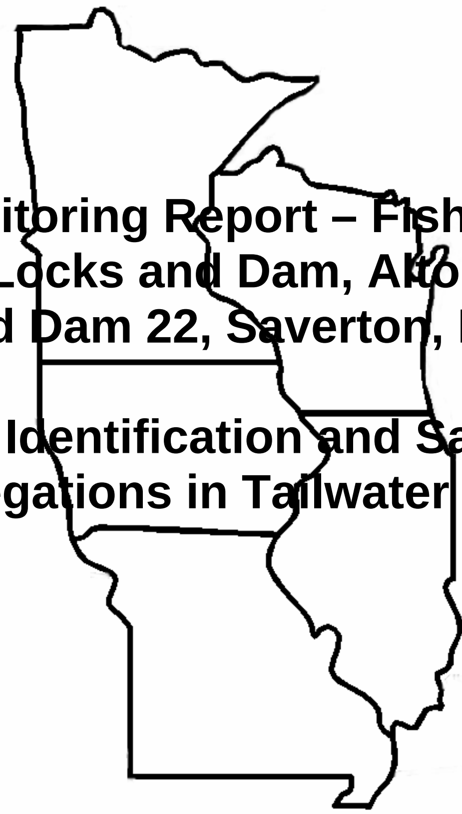
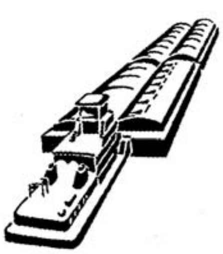
TECHNICAL REPORT FOR THE UPPER MISSISSIPPI RIVER – ILLINOIS WATERWAY NAVIGATION AND ECOSYSTEM RESTORATION PROGRAM



2005 Monitoring Report – Fish Passage Melvin Price Locks and Dam, Alton, Illinois and Lock and Dam 22, Saverton, Missouri

Hydroacoustic Identification and Sampling of Fish Aggregations in Tailwater Areas



June 2006

US Army Corps of Engineers®

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TECHNICAL REPORT FOR THE UPPER MISSISSIPPI RIVER – ILLINOIS WATERWAY NAVIGATION AND ECOSYSTEM RESTORATION PROGRAM

2005 Monitoring Report – Fish Passage Melvin Price Locks and Dam, Alton, Illinois and Lock and Dam 22, Saverton, Missouri

Hydroacoustic Identification and Sampling of Fish Aggregations in Tailwater Areas

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June 2006

PREFACE

The work reported herein was conducted as part of the Navigation and Ecosystem Sustainability Program. The information in this report will be considered in the plan formulation process for the fish passage projects at Melvin Price Locks and Dam and Lock and Dam 22.

The Upper Mississippi River-Illinois Waterway System Navigation Study was completed in Sept 2004 to address the navigation improvement and ecological restoration needs for the UMR-IWW system for the years 2000-2050. The final recommendation includes a program of incremental implementation and adaptive management to achieve the dual purposes of ensuring a sustainable natural ecosystem and navigation system. With congressional appropriations for Preconstruction, Engineering and Design (PED) beginning in February 2005, the study team adopted a working title of UMRS Navigation and Ecosystem Sustainability Program (NESP) to distinguish PED efforts from the Feasibility Study. This report, the 2005 Monitoring Report was produced for the NESP Fish Passage Projects. This report specifically documents the findings of the first year of monitoring activity relating to the installation of a fish passage structure at two operational Mississippi River Dams.

This report was written by Mr. Mark A. Cornish of the Economic and Environmental Analysis Branch, U.S. Army Corps of Engineer (USACE) Rock Island, IL District; Ms. Teri C. Allen and Mr. Brian L. Johnson of the Environmental Analysis Branch, USACE St. Louis District; and Mr. Nathan M. Caswell and Mr. Robert L. Simmonds, Jr. of the Carterville Fishery Resources Office, U.S. Fish and Wildlife Service, Marion, IL.

The authors wish to acknowledge and thank the many others who assisted in the production of this report including Mr. Travis Moore, Missouri Department of Conservation, Hannibal Field Office and Mr. Elmer “Butch” Atwood, Illinois Department of Natural Resources, Greenville for providing advice, sharing information, and technical support; Mr. Cory Hilliard, Mr. Shane Hilliard, and Mr. Derek Sims., U.S. Fish and Wildlife Service, Carterville Fishery Resources Office for field data collection of fishes; and Mr. James L. Keim, William “Randy” Trout and Joe Burnett, USACE St. Louis District for collecting hydroacoustic data; and Mr. Donald J. Degan, Aquacoustics, Sterling, Alaska for the analysis of hydroacoustic data.

An early draft of this paper was reviewed by Mr. Daniel B. Wilcox, USACE St. Paul, MN District. Administrative direction and funding for this effort were provided by Mr. Charles P. Spitzack, Mr. Scott D. Whitney, Project Managers, and Mr. Kenneth A. Barr, Environmental Technical Manager, USACE, Rock Island; Ms. Tamara L. Atchley, Melvin Price Locks and Dam Fish Passage Project Delivery Team Leader; and Mr. Richard F. Astrack, Project Manager, USACE St. Louis.

Members of the Melvin Price Locks and Dam and Lock and Dam 22 Project Delivery Team reviewed the draft report. This study was funded by the USACE Rock Island and St. Louis Districts through the Navigation and Ecosystem Sustainability Program.

ABSTRACT

The study areas of the 2005 Monitoring Report – Fish Passage Program include the tailwater sections of Melvin Price Locks and Dam (RM 200.8) and Lock and Dam 22 (RM 301.2) on the Upper Mississippi River. The U.S. Army Corps of Engineers is in the planning stage for construction of fish passage structures at these dams. Preconstruction monitoring activities in 2005 involved the hydroacoustic identification of fish aggregations in tailwater areas and the sampling of these aggregations to identify fish species and size structure. Information about species identification and the locations in tailwaters where fish aggregate is important in locating fishway entrances and establishing feasible alternatives. Hydroacoustic and fish capture surveys were conducted in late May, June, and early July 2005. The bathymetry, fish, and hydraulic conditions surveys were all conducted using hydroacoustic systems, including using a multibeam echo sounder, a split beam echosounder, and an acoustic Doppler current profiler (ADCP). Fish capture, identification, length measurement, and enumeration were performed by the U.S. Fish and Wildlife Service, Carterville Fisheries Resources Office, using multifilament gill nets and trammel nets. Deepwater electrofishing was unsuccessfully attempted.

In the Melvin Price Locks and Dam tailwaters, hydroacoustic surveys revealed several concentrations of large (>40 inches) fish between the lock chambers; below the 600-foot lock on the Illinois side of the channel; and at the head of Maple Island on the Missouri side of the channel. Hydroacoustic survey of the Melvin Price Locks and Dam tailwater aggregation size estimate was 241,267 fish (95 percent confidence integral 192,255 - 298,321). The overall catch at Melvin Price Locks and Dam was 83 fish representing 13 species, with the most abundant species being shovelnose sturgeon (N=44) and blue catfish (N=10).

In the Lock and Dam 22 tailwaters, hydroacoustic data showed clustering of fish on the east side of the river in the main channel border and below the spillway. A variety of fish sizes was observed. The fish aggregation size estimate from hydroacoustic survey of the Lock and Dam 22 tailwater was 27,779 fish (95 percent CI 20,946 - 37,080), whereas the overall catch at Lock and Dam 22 was 248 fish representing 10 species, with the most abundant species being shovelnose sturgeon (N=230).

Hydroacoustic data indicated that the fish identified at Melvin Price Locks and Dam in May were generally larger and more abundant than those at Lock and Dam 22 in June. Changes in dam operating and temporal conditions may have contributed to the differences in fish aggregations between the two sites. Open river conditions (all dam gates raised out of the water) occurred for 8 days at Melvin Price Locks and Dam in January and February 2005, whereas at Lock and Dam 22 open river conditions occurred for 8 days in mid April.

A radio-tagged lake sturgeon moving through Lock and Dam 22 during this period was documented by the Missouri Department of Conservation. Several species of Asian carp (bighead, silver, and grass) were captured during sampling. In order to limit size bias and to increase catch, it is recommended that future tailwater fish aggregation surveys use deep-water electrofishing equipment during times of the year when the water temperature is below 20^{o}C in combination with a limited number of bottom-set nets to continue monitoring benthic species that may not be caught by electrofishing.

Future monitoring activities are tied to the project goals and objectives and monitoring activities identified by the Project Delivery Team with the assistance of the Science Panel. Near-term studies include repeating hydroacoustic and fisheries sampling during the fall, early spring, and late spring; monitoring fish movements through the dam gates with hydroacoustic equipment; and using telemetry to monitor movements of silver carp, shovelnose sturgeon, paddlefish, skipjack herring, and white bass. In order to provide potential design information for fishway entrance areas, concurrently-obtained fish location and hydraulic data from the tailwater fish surveys will be analyzed in an attempt to model the hydraulic environment selected by fish aggregating in the tailwater areas.

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1. INTRODUCTION

This report describes the results of preconstruction monitoring performed in fiscal year 2005, the first year of study, at Melvin Price Locks and Dam and at Lock and Dam 22. The purpose of this collection effort was the evaluation of fisheries below Melvin Price Locks and Lock 22 prior to construction of the fish passageway. Monitoring of the effects of fish passage improvements allows for the evaluation of the degree to which ecosystem restoration objectives are attained.

The general goal of the fish passage project at each lock and dam is to increase opportunity for fish passage through, thereby increasing access to upstream habitats which should result in an increase in the size and distribution of native migratory fish populations. Migratory species are defined as a fish species that have major annual movements to spawning, foraging, or wintering habitats within the river system. Because the Melvin Price Locks and Dam and the Lock and Dam 22 fish passage projects will be the first of this kind on the UMR, another general goal is to monitor, evaluate, learn, and adapt future fish passage projects using lessons learned from these initial projects. These goals and objectives are identified below.

Goals for Fish Passage

- Obtain information needed for project planning and design
- Monitor fish passage through Melvin Price Locks and Dam and Lock and Dam 22 and fish passage projects
- Monitor ecological response by migratory fishes
- Monitor physical performance of the fish passage improvement features
- Monitor effects of the fish passage project on structural integrity, navigation operations at Melvin Price Locks and Dam and Lock and Dam 22

The evaluation of monitoring results will provide lessons learned to inform future fish passage improvements on the Upper Mississippi River System (UMRS).

Objectives for Biota

- Increase populations of native migratory fishes upriver from Melvin Price Locks and Dam and Lock and Dam 22 as demonstrated by range extensions and increases in relative abundance from those described in Pitlo (1995)
- Increase the numbers of skipjack herring passing upriver through Melvin Price Locks and Dam and Lock and Dam 22 within 5 years post construction.
- Provide increased upriver fish passage opportunity at Melvin Price Locks and Dam and at Lock and Dam 22 that allows adult individuals of fish species occurring in the tailwaters to pass upriver through the dams.
- Provide increased upriver fish passage opportunity at Melvin Price Locks and Dam and at Lock and Dam 22 that allows 95 percent of the adult individual migratory fishes occurring in the tailwaters to pass upriver through the dams during their upriver migration periods.
- Increase the time that fish can pass upriver through Melvin Price Locks and Dam and Lock and Dam 22 to 90 percent of the time or more.

Objectives for Habitat

- Create rock rapids and riffles in a fishway at Melvin Price Locks and Dam and Lock and Dam 22 that provides year-round habitat for fish and macroinvertebrates

Objectives for Physical Performance of a Fishway

- Maintain current velocities less than 0.3 m/sec in at least 1 meter of the fishway cross section
- Prevent annual erosion and loss of material of more than 1 meter from the fishway cross section
- Limit maintenance requirements for removal of woody debris, repair to rock riffles, replacement of bed material

Realities and Constraints of Monitoring. The problem of fish passage is systemic. The projects at Mel Price Locks and Dam and Lock and Dam 22 will contribute to the alleviation of serial disconnectivity, but by themselves will not fix the problem and eliminate the need for systemic fish passage. This was recognized in the Feasibility study for the navigation study where it was recommended that fish passage be implemented at 14 dams before systemic benefits could be realized. Systemic monitoring of fish populations goes beyond the scope of the monitoring effort in 2005.

Northcote (1998) identified several realities for fish passage projects that were considered in monitoring planning. These include 1) we cannot define the biological enormity of the problem, 2) for these projects, we aren't developing fish passage facilities to accommodate the multidirectional (lateral, upstream and downstream – only upstream) movement of migratory fishes, 3) we still lack information on migratory behavior and swimming performance of many species, 4) a fish passage facility can be an important contribution in the life cycle of migratory fish, but it addresses only one aspect of that cycle. These fish passage projects are one component of a comprehensive ecosystem restoration program that when completed will benefit all aspects of the life cycle for migratory fishes.

We acknowledge that the assignment of numerical objectives for measuring success of the fish passageway is arbitrary. For example, the objective "that allows 95 percent of the adult individual migratory fishes occurring in the tailwaters to pass upriver through the dams" has no specific biological connection. These numerical estimates were identified through informed discussion between river resource managers and fisheries biologists and will be used until better information is identified. The strongest bioresponse indicator will likely be identified through monitoring. Pre-construction monitoring utilizing both mobile and stationary hydroacoustic sampling methods can show the abundance and distribution of aggregations of fish in the tailwaters. Changes in these aggregations will be quantified as these dams go into open river condition at various times of the year. This change in abundance will be used to establish the baseline condition for change by which the fish passage alternative's effectiveness will be measured. A value of 100 percent will be assigned to the number of fish that moved from the tailwater during open river condition during a specified period of time, as measured by hydroacoustic equipment. We acknowledge that by setting and measuring these numerical objectives for these first fish passage projects that we will have more information to set relevant performance standards for other Upper Mississippi River System (UMRS) fish passage projects.

Fiscal Year 2005 Scope of Work. Preconstruction monitoring activities in 2005 involved hydroacoustic monitoring and sampling of fish aggregations in tailwater areas in support of Objective 1. Determining the locations in tailwaters where fish aggregate is important in situating fishway entrances and in identifying feasible alternatives. The locations, numbers, and relative size structure of fish aggregations in the tailwater areas were surveyed using mobile hydroacoustic equipment. The species composition and size structure of the fish aggregations were sampled using nets and deep-water electrofishing. Hydraulic conditions were sampled concurrently with the hydroacoustic fish surveys using an acoustic Doppler current profiler (ADCP) system. Mobile hydroacoustic fish surveys, coupled with ADCP, provide spatially explicit information about where fish aggregate in the tailwaters for use in designing fishway entrances. Information about the species and length frequency of fish aggregations in the tailwater is needed to supplement the hydroacoustic survey information that provides only numbers and relative size of fish.

2. MATERIALS, METHODS, AND RESULTS

Preconstruction surveys of bathymetry and fisheries were conducted by the St. Louis District for the Rock Island District in late May and June 2005. All hydroacoustic data were collected from the *Motor Vessel Boyer (M/V Boyer).* All capture and quantification of fish was performed by the U.S. Fish and Wildlife Service (USFWS), Carterville Fisheries Resources Office.

A. Melvin Price Locks and Dam

1. Hydroacoustic Monitoring of Fish Aggregations in Tailwater Areas

a. Description of Survey. Two areas were sampled—the tailwater area 2,000 feet downstream of the dam and the main channel borders. Bathymetry data was collected on May 24. ADCP hydraulic data and fish surveys were completed on May 25. Sampling lines (transects) for data collected on May 25 were generally oriented perpendicular to flow. Transects were run 100 feet apart in both areas surveyed. Weather was sunny and warm during the week.

b. Horizontal Control. The horizontal control datum for this project is North American Datum of 1927 (NAD 27). The state plane coordinate system is Missouri East using U.S. survey feet. The precise location of each hydrographic survey point was determined using a high accuracy Differential Global Positioning System (DGPS)-aided Inertial Navigation System.

c. Vertical Control. The vertical datum slope of the river was calculated using the nearest accessible river gage immediately upstream and downstream of the survey site. Datum for the gages used is National Geodetic Vertical Datum (NGVD) 1929.

d. Accuracy Standards. U.S. Army Corps of Engineers (USACE) hydrographic survey accuracy performance standards as outlined in U.S. Army Corps of Engineers Engineering Manual 1110-2-1003 (2002) were adhered to. 100 percent bottom coverage was requested, but not required for this underwater investigation survey.

e. Data Equipment and Acquisition. As stated previously, all bathymetric and hydroacoustic information was collected from the *M/V Boyer*. Surveying hardware and software on the *M/V Boyer* form an integrated system. A DGPS-aided Inertial Navigation System was used for obtaining horizontal positioning.

The hydrographic survey was collected using a RESON SeaBat 8101 multibeam echo sounder. This sounder transmits 101 sonar beams spaced one and a half degrees apart in a fan pattern to provide a total swath angle of 150 degrees. With this projection angle, the swath width is approximately 7.4 times the measured water depth. Approximately 1,010 depth soundings per second were taken. The SeaBat 8101 operates at a frequency of 240 kHz.

An RDI workhorse ADCP was used to measure hydraulic conditions throughout the water column. The ADCP system measures current velocity, direction and other hydraulic parameters using the transmission of high frequency acoustic signals in the water. Time gating circuitry is employed which uses differences in acoustic travel time to divide the water column into range intervals, called bins. The bin determinations allow development of a profile of current speed and direction over the entire water column. Bin sizes of 30 cm (15 inches) were used. The ADCP on the *M/V Boyer* transmits sonar pulses from a transducer assembly along four beams at a frequency of 600 kHz. The transducers receive back-scattered sound from suspended sediments floating in the water. The ADCP converts the back-scattered sound into components of water current velocity and measures a profile of the currents throughout the water column.

Hydroacoustic fish and bottom type surveys were conducted using a BioSonics model DT 5000 digital transducer with a 200 kHz dual beam system. The hydroacoustic system was calibrated to US Navy standards at the BioSonics, Inc. laboratory in Seattle, Washington. An *in situ* calibration was performed at the conclusion of the sample. Data collection parameters for the DT 5000 system were set to sample to -70dB from 1.0 meters below the transducer to near the river bottom. Depth of the transducer during sampling was 0.5 meters below the surface. Data was collected at a pulse width of 0.3 millisecond at seven pings per second. An XY coordinate position was provided by Global Positioning System (GPS)—via a serial cable—to the DT5000 system and stored with the fish data.

f. Multi beam Bathymetric Survey System Calibration. Prior to beginning this project, a patch test was run. The angular mounting components (roll, pitch and yaw) of a multibeam system must be accurately measured. Errors in these measurements can lead to inaccuracies within a survey. The patch test is a data collection and processing procedure used to calibrate these angles. An initial patch test was done when the system was first installed on the boat. Any offsets that were detected were input into the software as known mounting offset parameters. All patch tests that are performed subsequent to the initial patch test are used to verify that the known mounting offsets have not changed due to deterioration, fatigue or damage to the mounting bracket.

Position system latency is another measurement that must be checked. Latency is the delay between the time a device makes a measurement and the time it begins transmission to the data collection computer. Position latency was also established during the initial patch test. It is checked to determine if programs running simultaneously with the data collection program are hampering the computer's processing speed and therefore slowing the transmission of position data to the computer. Current device offsets are:

- yaw (degrees) -3.05
- pitch (degrees) -4.10
- roll (degrees) -0.10

After the patch test calculations were processed, no changes in these offsets were necessary.

g. Data Processing. The hydrographic survey data was acquired and stored using HYPACK Inc's HYSWEEP software. Additional software from HYPACK was utilized to plan the survey and display real-time vessel navigation (figure 1). HYPACK software was also used to sort, edit and apply water level corrections to the hydrographic survey data. The data sets were edited to correct for spikes or false bottom returns within the water column. The edited XYZ ASCII data were loaded onto an office-based computer equipped with Bentley Systems, Inc. Microstation software. These data were reviewed and a three-dimensional model of the river bottom surface was developed using InRoads software from Intergraph, Inc. This surface was then triangulated forming a Topological Triangulated Network (TTN) file, a three-dimensional model of the river bottom. The TTN is then imported into Intergraph's Terrain Analyst software package and converted to a grid model. The models are color shaded and displayed with colors assigned by elevation ranges.

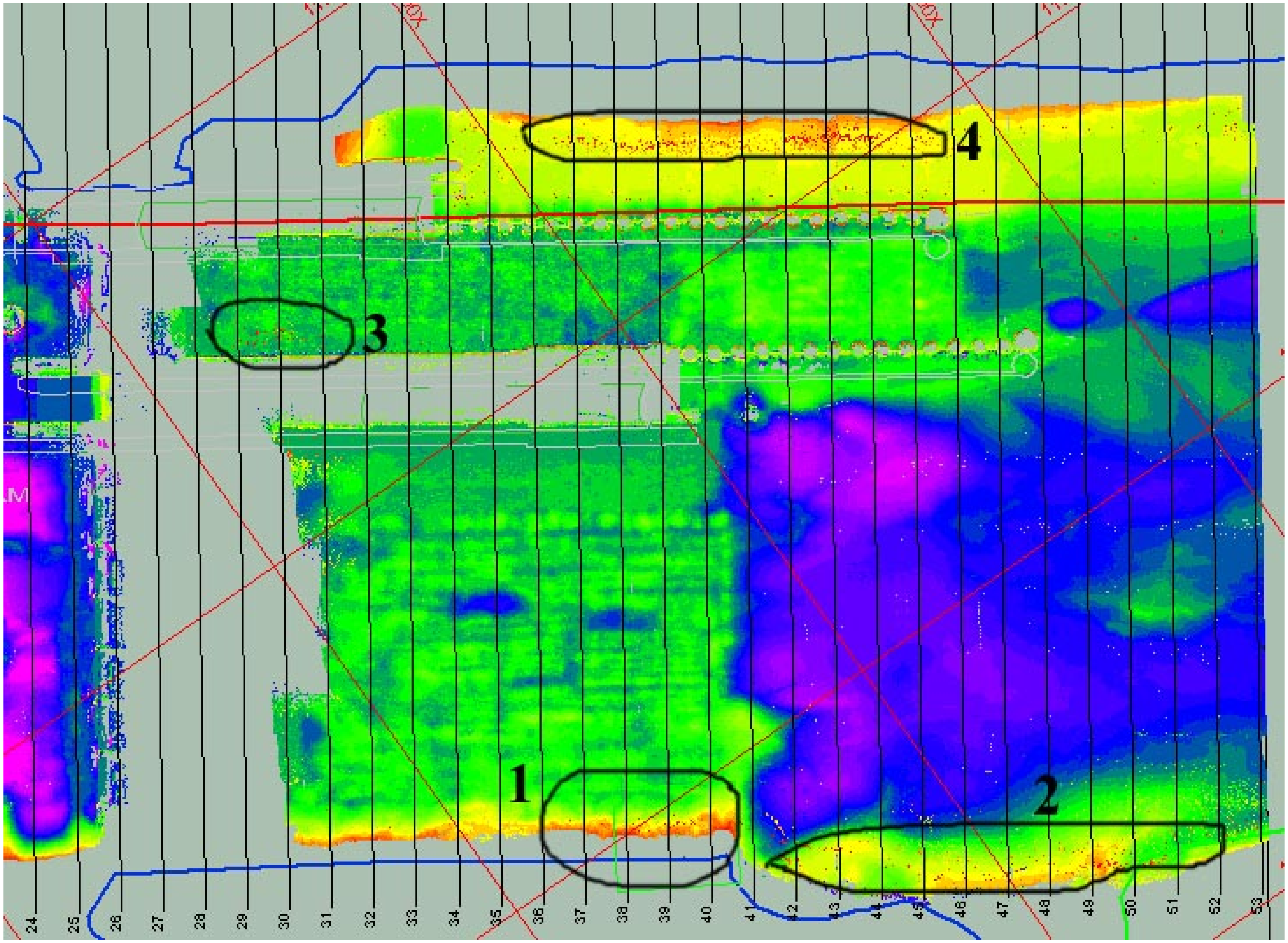

Figure 1. Bathymetric Survey Map of the Tailwater Area of Melvin Price Locks and Dam – May 25, 2005
Circled areas represent fish aggregations identified by the *M/V Boyer* and sampled by USFWS Carterville Fishery Resources Office. Small dots on the map represent fish located with hydroacoustic equipment.

h. River Parameters. A Marimatech sound velocity probe was used at each job site. Water temperature was 18.9 C (66.2F). Salinity was 0.0 parts per thousand. The speed of sound in the water was hard coded into the SeaBat processor prior to beginning the survey.

i.. Hydroacoustic Analysis - Fish Summary. Personnel aboard the *M/V Boyer* collected the hydroacoustic fish survey data. Fish survey data were only collected downstream of the dam. These data were analyzed by Aquacoustics, Inc. of Kenai, Alaska. The hydroacoustic survey detected 2,471 fish. Estimated size ranged from 3 inches to over 40 inches. The acoustic signal size was translated to estimated fish length with Love's (1977) any aspect equation: (TS =20*logLength,,,,- 69.23). This equation works well up to fish lengths of 40 inches. Estimated lengths above 40 inches were all designated *>40-inch fish*. Fish aggregation size estimates were determined by breaking the areas below the Lock and Dam into seven strata (outlined in blue in figure 2). Fish aggregations in the different strata ranged from 1,795 fish in the area below the coffer cells near the right bankline, to 146,648 fish in the area just downstream of the 600-fot lock on the left bankline. The overall aggregation size estimate in the Melvin Price Locks and Dam tailwater area surveyed was 241,267 fish, with a 95 percent confidence interval (CI) between 192,255 and 298,321 fish.

2. Sampling of Fish Aggregations in Tailwater Areas. Hydroacoustic surveys revealed four main fish aggregations in the tailwaters of Melvin Price Locks and Dam (figure 1). Capture sampling of these aggregations took place on May 25, 2005. A deep-water boat electrofishing rig was used to try to capture fish suspended between two and ten meters below the surface. Several of the identified fish aggregation areas were electrofished over a period of approximately 6 hours. A variety of depths was sampled with a variety of anode configurations (diameter and length of anodes varied). A chase boat was used to retrieve fish that surfaced downstream of the electrofishing boat.

Deep-water electrofishing was unsuccessful. Only one freshwater drum and seven gizzard shad were raised during the six-hour period. The lack if success is believed to be a result of high water temperature, which increases the conductivity of fish but decreases their susceptibility to electrofishing. Deep-water electrofishing is not reputed to be effective in water temperatures over 20^{o}C (Garvey, 2005). Water temperature at Melvin Price on May 25 was approximately 22^{o} C.

The second fish capture sampling at Melvin Price Locks and Dam took place from May 31 through June 2, 2005. Sampling methods included standard electrofishing; deep electrofishing; floating and bottom set monofilament gill nets; suspended experimental multifilament gill nets; and drifting trammel net. A variety of gill and trammel nets were used to capture fish at the four sites shown in figure 1. Although a range of species and sizes were captured, sampling the majority of fish identified by the *M/V Boyer* and on sonar was difficult. Most of the fish at the four aggregation areas were suspended 2 to 10 meters deep. Sites 1, 2, and 3 tended to be more than 10 meters deep, and the nets were designed to fish at either the surface or on the bottom. Attempts were made at each site to suspend nets; results of these attempts are discussed as follows and are summarized in table 1.

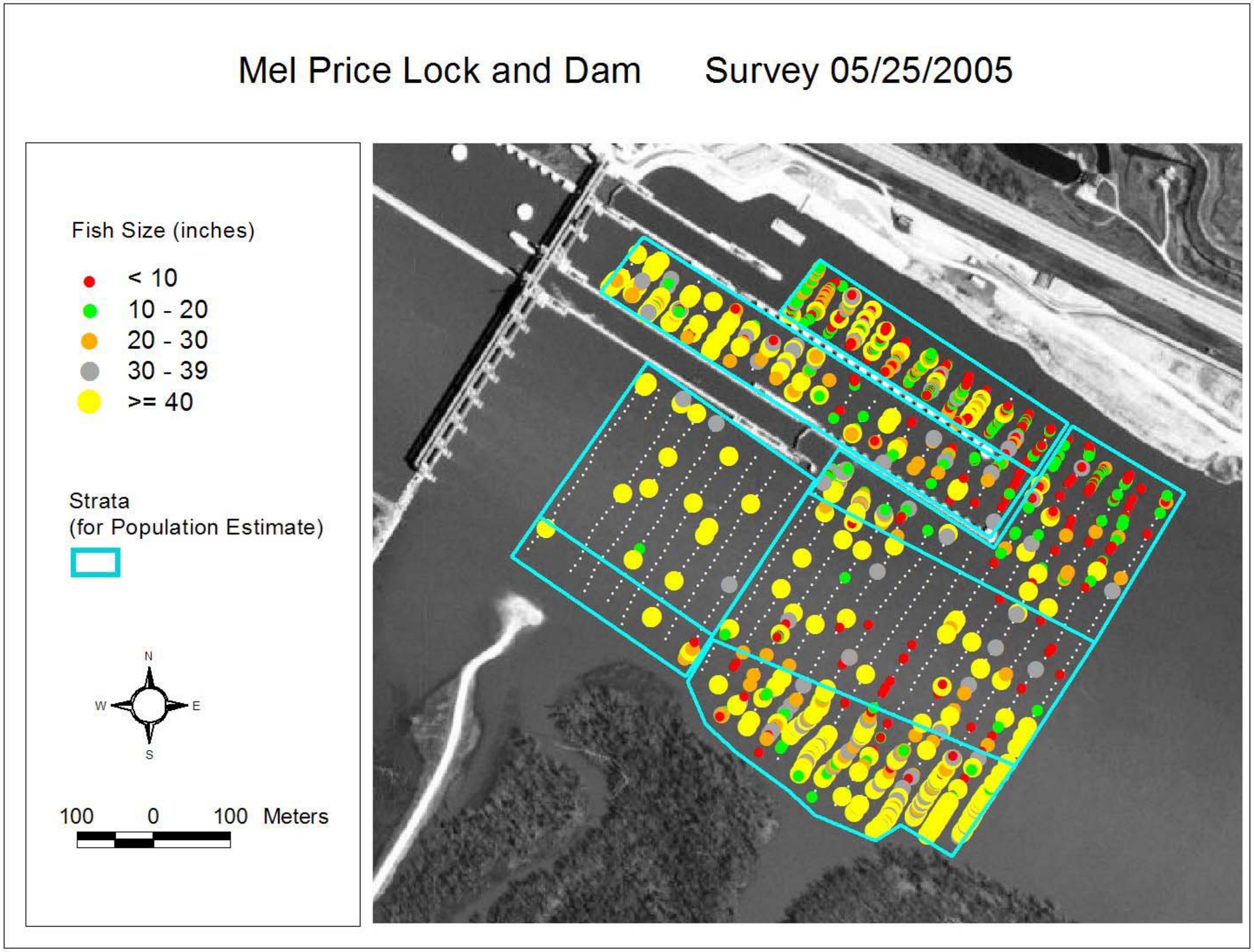

Figure 2. Location and Size of Fish in Tailwaters of Melvin Price Locks and Dam – May 25, 2005

Table 1. Fish Species and Numbers Captured in Areas Identified at Fish Aggregations by the *M/V Boyer* Below Melvin Price Locks and Dam on the Upper Mississippi River in May 2005

	Catch (N)			
Species	**Site 1**	**Site 2**	**Site 3**	**Site 4**
common carp, *Cyprinus carpio*	1	-	-	-
blue catfish, *Ictalurus furcatus*	2	-	7	1
freshwater drum, *Aplodinotus grunniens*	3	2	-	1
gizzard shad, *Dorosoma cepedianum*	1	-	-	2
shovelnose sturgeon, *Scaphirhynchus platorynchus*	2	40	2	-
flathead catfish, *Pylodictis olivaris*	-	1	-	-
river carpsucker *Carpoides carpio*	-	1	-	1
skipjack herring, *Alosa chrysochloris*	-	1	-	4
goldeye, *Hiodon alosoides*	-	-	1	-
smallmouth buffalo, *Ictiobus bubalus*	-	-	1	-
silver carp, *Hypophthalmichthys molitrix*	-	-	-	4
bighead carp, *H. nobilis*	-	-	-	1
shorthead redhorse, *Moxostoma macrolepidotum*	-	-	-	5
Total	**9**	**45**	**11**	**19**

Site 1. Site 1 could not be fished effectively with nets due to the presence of a commercial trotline and a large, powerful eddy directly below the site. One 5.1-centimeter bar mesh monofilament net (45 m X 2.4 m) was set near the eddy for one night. This net was drawn into the eddy, tangled, and subsequently had to be cut. One experimental multifilament gill net (45 m X 1.8 m) was placed in the slack water next to the eddy for two nights. Nine fish from five species were captured at this site.

Site 2. Site 2 was fished with two 5.1-centimer bar mesh monofilament nets (45 m X 2.4 m) for two nights. Forty-five fish from five species were caught. Nearly 89 percent of the fish captured at this site were shovelnose sturgeon, *Scaphirhynchus platorynchus* (N=40). In addition to and directly downriver from the bottom-set gill nets, on June 1 and June 2, a 91.4-meter x 2.4-meter trammel net with 8.9-centimerter bar mesh was drifted. The net was suspended 2.4-3.0 meters deep. The net was drifted for approximately 200 meters on June 1, and approximately 400 meters on June 2. No fish were caught with this net. Although the fish thought to be suspended in the water column were not captured, many adult silver carp, *Hypophthalmichthys molitrix*, were observed jumping in this area. In addition, several paddlefish, *Polydon spathula*, surfaced. Many of the suspended fish were believed to be silver carp, a difficult fish to catch.

Site 3. Site 3 was located between the main lock and the auxiliary lock at Melvin Price. One 5.1-centimeter bar mesh monofilament net (45 m x 2.4 m) and one experimental multifilament gill net (45 m X 1.8 m) were each set for two nights. Eleven fish from four species were captured at this site. In addition, a number of silver carp were seen jumping at the dam gates just upstream from the site.

Site 4. No nets were set overnight at this site. The majority of the fish we located with our sonar were small and relatively shallow. On June 1, two experimental multifilament gill nets (45 m X 1.8 m) were set at or near the surface for several hours. On June 2, the same nets were set for approximately the same time period, but suspended approximately 1.5 meters below the surface.

Only 19 fish from 8 species were captured with these nets, including 2 gizzard shad and 3 juvenile silver carp. Additionally, many juvenile silver carp were seen jumping in this area (photograph 1). Many of the fish viewed on the sonar unit were believed to have been juvenile silver carp.

The overall catch at Melvin Price Locks and Dam was 83 fish representing 13 species. The most abundant species were shovelnose sturgeon (N=44) and blue catfish (N=10). Length-frequency distributions for these two species are illustrated in figures 3 and 4.

Photograph 1. Juvenile Silver Carp Jumping Near Fish Aggregation Site 4 During May and June 2005

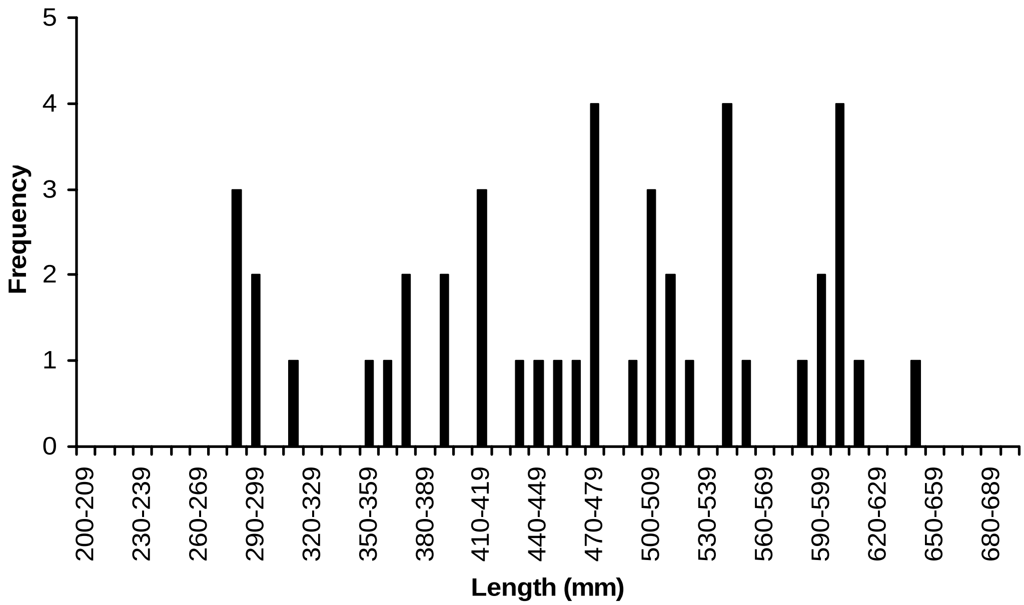

Figure 3. Length-frequency Distribution (N=44) for Shovelnose Sturgeon (*Scaphirhynchus platorynchus*) Captured Using Gill Nets at Melvin Price Locks and Dam May 31- June 2, 2005

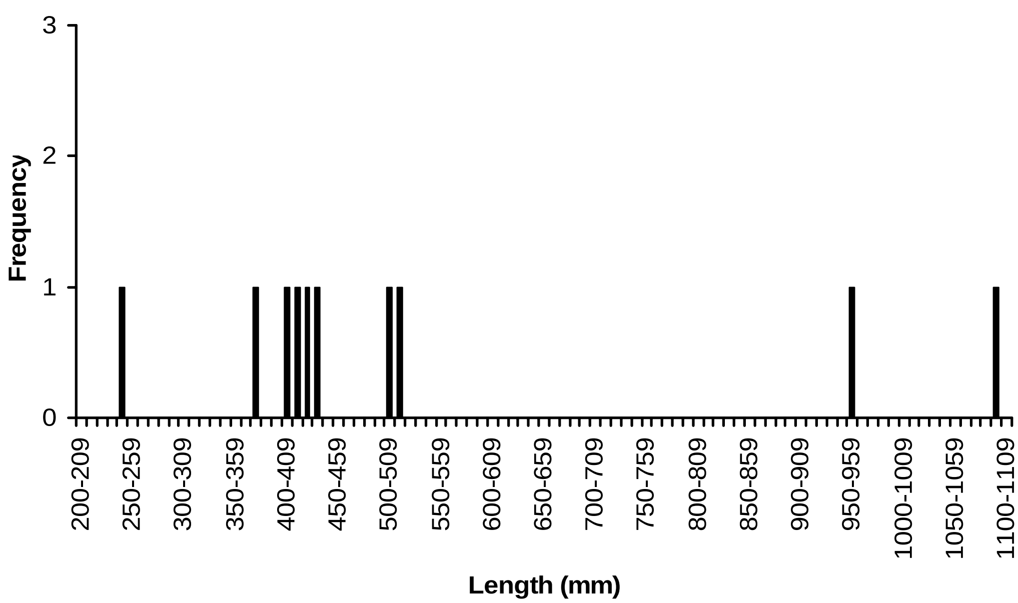

Figure 4. Length-frequency Distribution (N=10) for Blue Catfish (*Ictalurus furcatus*) Captured Using Gill Nets at Melvin Price Locks and Dam May 31- June 2, 2005

B. Lock and Dam 22

1. Hydroacoustic Monitoring of Fish Aggregations in Tailwater Areas

a. Description of Survey. Three areas were sampled; the tailwater area 2000 feet downstream of the dam in the main channel, the main channel border and the area below the spillway. Bathymetry data was collected on June 28 and June 30. ADCP hydraulic data and hydroacoustic fish surveys were conducted on June 29 and June 30 (fish were collected only on 30 June). Sampling lines (transects) for data collected on June 29 and June 30 were generally oriented perpendicular to flow. Transects were run 100 feet apart at each of the two sites. Weather was sunny and warm during the week.

The methods for horizontal control, vertical control, accuracy standards, data equipment and acquisition, multi beam system calibration, current device offsets, and data processing were the same as Melvin Price. See Section 2.A.1 for a complete description. Hydrographic survey bathymetry data was displayed using HYPACK software (figure 5).

b. River Parameters. A Marimatech sound velocity probe is used at each job site. Water temperature was 27.9 C (82.3 F). Salinity was 0.0 parts per thousand. The speed of sound in the water was hard coded into the SeaBat processor prior to beginning the survey.

c. Hydroacoustic Analysis - Fish Summary. Personnel aboard the *M/V Boyer* collected hydroacoustic fish survey data. Fish data were collected downstream of the dam only. The data were analyzed by Aquacoustics, Inc. of Kenai, Alaska. The survey detected 458 fish. Estimated fish size ranged from 3 inches to over 40 inches. Acoustic signal size was translated to estimated fish length with Love's (1977) any aspect equation: (TS =20*logLength,,,,- 69.23). This equation works well up to fish lengths of 40 inches. Fish lengths above 40 inches were designated *>40 inch fish.* Fish aggregation size estimates were calculated by breaking the areas below the Lock and Dam into three strata (outlined in blue in figure 6). Aggregation size estimates ranged from 3,116 fish in Area 3 (below the overflow dam), to 18,406 fish in Area 2 (downstream of the dam along the left bankline). The overall aggregation size estimate in the Lock and Dam tailwater area surveyed was 27,779 fish, with a 95 percent confidence interval between 20,946 and 37,080 fish.

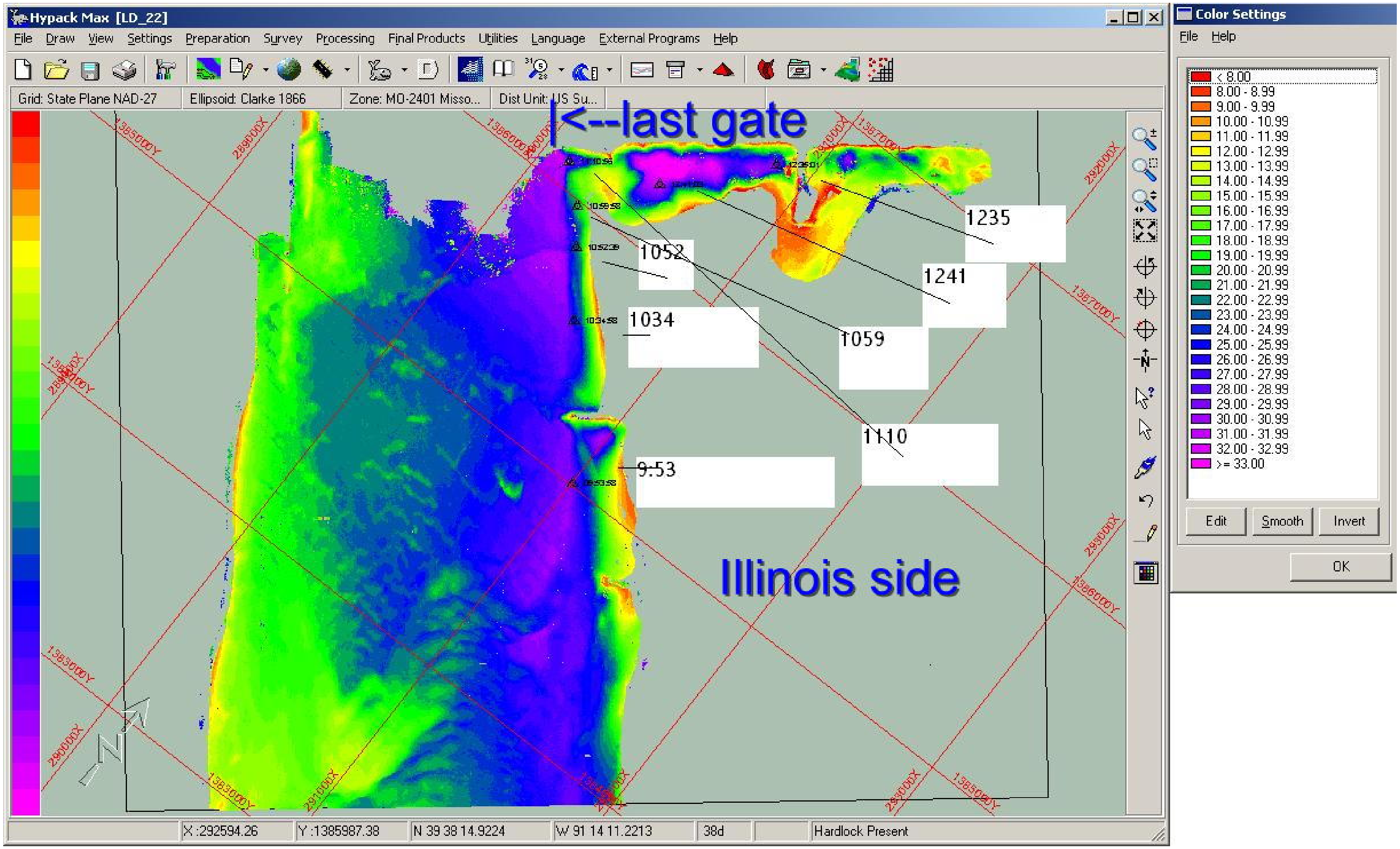

Figure 5. Bathymetric Survey Map of the Tailwater Area of Melvin Price Locks and Dam -June 30, 2005. Numbers in white boxes represent fish aggregations detected by hydroacoustic survey and sampled by USFWS Carterville Fishery Resources Office. Small dots on the map represent fish located with hydroacoustic equipment.

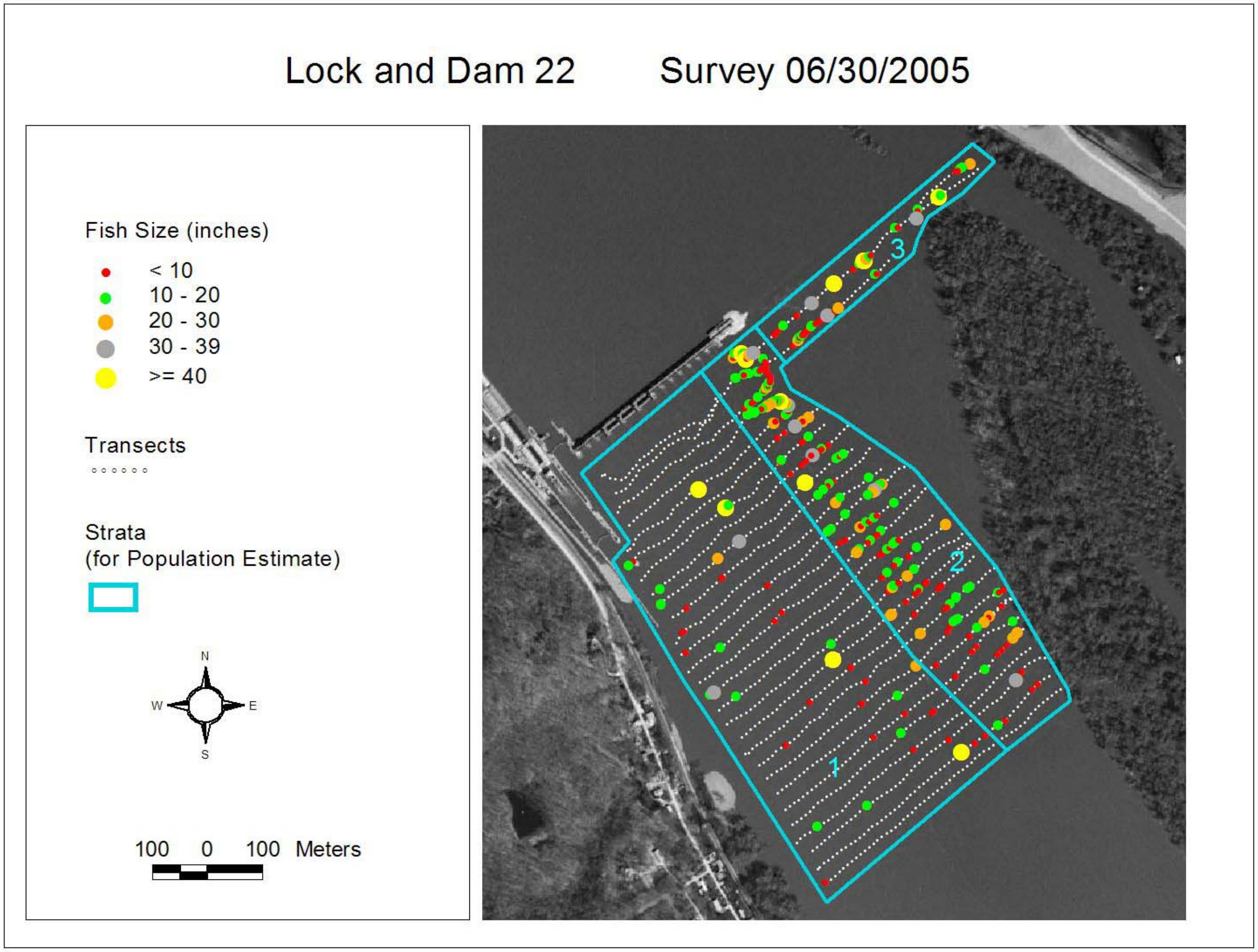

Figure 6. Location and Relative Size of Fish in Tailwaters of Lock and Dam 22 – June 30, 2005

2. Sampling of Fish Aggregations in Tailwater Area. Hydroacoustic surveys did not identify large aggregations of fish at Lock and Dam 22, as it did at Melvin Price Locks and Dam. However there were several areas where fish were located (figure 6). Fish capture sampling at Lock and Dam 22 took place on from July 5 through July 7, 2005. On July 5, a series of tandem nets (one experimental, 45 m x 1.8 m, multifilament gill net tied to a 5.1-centimeter bar mesh, 45 m x 2.4 m, monofilament net) was set to sample nearly all of the sites shown in figure 5. Nets were set at site 953, 1034, 1052/1059, 1241, and 1235. The only site that was not sampled was site 1110 due to dangerous currents near the last dam gate. All of the nets except for the one at site 1235 were in water between 6.4 and 9.4 m deep. The net at site 1235 ran from 7.6 m into a shallow area approximately 1.5 m deep. Nets at sites 953, 1034, 1052/1059 were set perpendicular to the dam, while the remaining nets were set parallel to the dam.

With the exception of a single shortnose gar (*Lepisosteus platostomus*) at site 1034, the catch in the first four nets was composed of shovelnose sturgeon and lake sturgeon (*Acipenser fulvescens*). A length-frequency distribution for shovelnose sturgeon captured at Lock and Dam 22 is given in figure 7. The net at site 1235 caught a wider variety of species, possibly due to being partially set in shallow water. Overall, the bottom-set gill nets captured 244 fish, 94 percent of which were shovelnose sturgeon (table 2 and figure 7). In addition, nets at sites 953, 1034, and 1052/1059 were clogged with massive quantities of debris. Because of the abundance of sturgeons, low diversity in the catch, and the high levels of debris, bottom-set gill nets were used for only one night.

Table 2. Fish Species and Numbers Captured in Bottom-set Gill Nets at Sites Identified by the *M/V Boyer* Below Lock and Dam 22 on the Upper Mississippi River in July 2005

Species	N
freshwater drum, *Aplodinotus grunniens*	3
goldeye, *Hiodon alosoides*	1
lake sturgeon, *Acipenser fulvescens*	6
quillback, *Carpoides cyprinus*	1
shorthead redhorse, *Moxostoma macrolepidotum*	1
shortnose gar, *Lepisosteus platostomus*	1
shovelnose sturgeon, *Scaphirhynchus platorynchus*	230
striped bass, *Morone saxatilis*	1
Total Catch	**244**

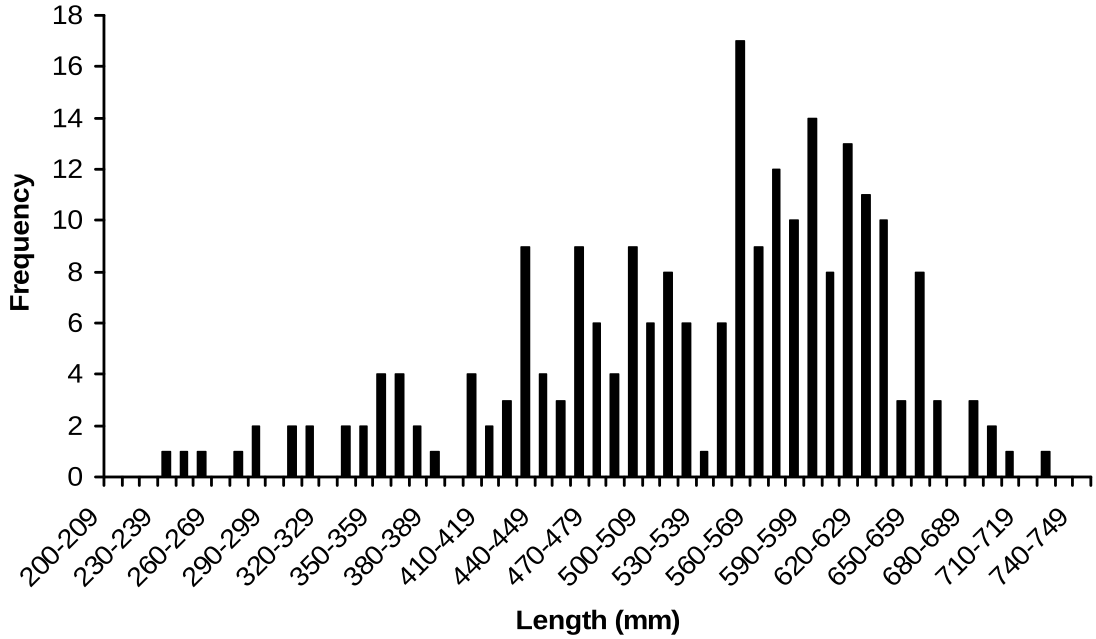

Figure 7. Length-frequency Distribution (N=230) for Shovelnose Sturgeon (*Scaphirhynchus platorynchus*) Captured at Lock and Dam 22 in July 2005.

On July 7, 2005, a single 7.6-centimer bar mesh floating gill net (1.8 m x 45.7 m) was set at site 1241 for approximately 3 hours. No fish were captured in this net. An 8.9-centimeter bar mesh trammel net (3.0 m x 91.4 m) was set through and within the area occupied by sites 953, 1034, 1052, and 1059. Four drifts of 30 minutes each were made. Only four fish were captured with this method, indicating that large fish at less than 3.0 meters deep were able to avoid the net almost entirely (table 3); in addition, most small fish would likely have been able to pass through the rather large mesh net. Due to the lack of success with deep-water electrofishing at Melvin Price Locks and Dam, and considering the water temperature of approximately 27^{o} C at Lock and Dam 22, the deep-water electrofishing method was not used at Lock and Dam 22.

Table 3. Fish Species and Numbers Captured in Floating/Drifting Trammel Nets at Sites Where Fish Were Detected by Hydroacoustic Survey Below Lock and Dam 22 on the Upper Mississippi River in July 2005

Species	N
bighead carp, *Hypophthalmichthys nobilis*	1
freshwater drum, *Aplodinotus grunniens*	1
goldeye, *Hiodon alosoides*	1
grass carp, *Ctenopharyngodon idella*	1
Total Catch	**4**

As illustrated in table 2 and table 3, the overall catch at Lock and Dam 22 was 248 fish representing 10 species. The most abundant species was shovelnose sturgeon (N=230).

3. DISCUSSION

The hydroacoustic surveys and fish capture sampling revealed that the fish aggregation in the tailwater at Melvin Price Locks and Dam in May was larger in number with generally larger fish than the fish aggregation sampled in the Lock and Dam 22 tailwater in June. Use of the tailwaters by fishes is dynamic. Johnson et al. (2005) observed dramatic seasonal variability in the lock chamber at Lock and Dam 25. Fish aggregations in the tailwater may occur when many fish species and individuals are staging prior to migration, attempting to migrate, or making use of the tailwater as a foraging area. Most migratory fishes in the Upper Mississippi River system spawn in the spring and summer. At the time of sampling, the water temperature was approximately 22^{o}C at Melvin Price Locks and Dam and 27^{o}C at Lock and Dam 22, which was after and during spawning season for most of the 34 migratory fish species identified by Wilcox et al (2004). Lake sturgeon spawn when water temperature is between 11.7 and 15.0^{o}C (Priegel and Wirth, 1971), and shovelnose sturgeon spawn between 19.5 and 21.1^{o}C (Christenson 1975; and Hurley et al 1983), whereas flathead catfish spawn later in the season when temperatures reach 23.9^{o}C (Becker 1983). Dam operating conditions and sampling times may have contributed to the differences in fish aggregations between the two sites.

A. 2005 Open River Conditions. At Melvin Price Locks and Dam, open river conditions (when the gates are out of the water and the river is uncontrolled by the dam) occurred for 8 days in early 2005 over three separate periods; January 5 through 7; January 13 through 15; and February 16 through 17. (Asunskis, 2005). Any fish that migrated into the tailwaters after mid-February could not proceed upstream unless it locked through with boats. Open river conditions also occurred for 8 days at Lock and Dam 22, but later in the year and over consecutive days without interruption, April 12 through 19.l (Landwehr, 2005). There was strong evidence that fish were moving through the dam at this time. Personnel from the Missouri Department of Conservation (DOC) observed a radio-tagged lake sturgeon moving through several dams. Fisheries biologist Travis Moore, of the Missouri DOC, tracked and described the movement of the 23-pound male lake sturgeon, named “Goober,” in the spring of 2005.

This fish was radio tagged in late March at river mile 300.5 below Lock and Dam 22. Moore observed the fish moving downstream 18 miles, and then moving back upstream through several navigation dams to the Lock and Dam 19 tailwaters. This lake sturgeon traveled 80 miles in just 6 days, 13.3 miles per day and at times reached an upstream speed of ¾ mile per hour. The gates at the three navigation dams that the fish passed through were in open river condition during the period of upstream movement. Moore observed changes in this fish’s behavior as it encountered passing barges, jetties, and dams.

At Lock and Dam 20, near Quincy, Illinois, the fish approached from the main channel border on the Missouri side and continued to move across the tailwater of the dam looking for a way around it. The lake sturgeon checked all of the gates and, not finding a way around, it worked back toward the center of the dam, unleashed a burst of energy, and passed upstream through the gate. The whole process took about three hours, after which the fish returned to the Missouri shoreline to continue its migration. Future studies should test if this movement strategy to pass through dams during open river conditions is repeated by other species

A number of factors may have contributed to the differences in the sizes and composition of fish aggregations observed in the tailwaters of Melvin Price Locks and Dam and Lock and Dam 22. This underscores the need for repeated sampling at different times of the year, with an emphasis on the fish migration period, and attempting to sample both study areas at the same time. This would provide information to infer if fish aggregations in the tailwater are associated with migration, ability to pass upriver through dams, or other behaviors.

B. Species Identification Using Hydroacoustic Data. The hydroacoustic equipment used for this study cannot identify fish to the species level, but because so few fish species grow to large size, the fish species that grow to >40-inches long in the study areas can be estimated. Fishes longer than 40 inches are of particular interest because they are migratory and some are considered invasive species (bighead, silver, and grass carp). Table 4 is an inventory of fish species which may attain a length of >40 inches in the study areas. For comparison, the table also lists the relative abundance of those fish in the reach or pool immediately below the study areas as found in 1995 (Pitlo et al 1995).

Table 4. Fish Species Potentially Longer Than 40 Inches in the Study Areas and Their Relative Abundance

	1995 Relative Abundance [1]		**2005 Captures**	
Species	**Melvin Price**	**L&D 22**	**Melvin Price**	**L&D 22**
northern pike, *Esox lucius*		O	-	-
flathead catfish, *Pylodictis olivaris*	C	C	1	-
blue catfish, *Ictalurus furcatus*	R	O	10	-
channel catfish, *Ictalurus punctatus*	C	C	-	-
bigmouth buffalo, *Ictiobus cyprinellus*	U	C	-	-
black buffalo, *Ictiobus niger*	O	U	-	-
smallmouth buffalo, *Ictiobus bubalus*	O	C	1	-
bighead carp, *Hypophthalmichthys nobilis*			1	1
silver carp, *Hypophthalmichthys molitrix*			4	-
grass carp, *Ctenopharyngodon idella*	O	U	-	1
American eel, *Anguilla rostrata*	O	O	-	-
longnose gar, *Lepisosteus osseus*	U	C	-	-
shortnose gar, *Lepisosteus platostomus*	A	C	-	-
pallid sturgeon, *Scaphirhynchus albus*	R	R	-	-
lake sturgeon, *Acipenser fulvescens*		R	-	6
paddlefish, *Polyodon spathula*	O	O	-	-

[1]Key to distribution and relative abundance of UMR fish species in 1995 (Pitlo *et al*. 1995)

Blank	does not occur	C	commonly taken	R	considered rare
U	unknown	O	occasional	A	abundant

Although total captures in 2005 were low, it is interesting to note the changes in fish presence/absence within the last 10 years. The blue catfish, which was rare in 1995, was the most commonly caught large species in the 2005 tailwater sampling (photograph 2).

C. Tailwater Fish Capture Techniques. A total of 15 species of fish was captured during sampling. This represents a small fraction of the 84 fish species that have been historically observed in the study areas (Pitlo, et. al. 1995). Vastly fewer fish were captured by netting and electrofishing than aggregation size estimates from hydroacoustic surveys. Tailwaters are difficult to sample because many fish are suspended and congregated in areas near swift moving current, uneven bottoms, and massive quantities of debris (photograph 3).

Photograph 2. Blue Catfish Caught Below Melvin Price Locks and Dam During 2005 Field Sampling

Photograph 3. Net Filled With Debris from Lock and Dam 22 Sampling

Various methods were attempted to capture fish with varying degrees of success. The trammel and gill nets fished higher in the water column were ineffective because the nets were too small and fish simply swam under and around them to avoid capture. Monofilament gill nets fished on the bottom were effective at catching fish, but were biased toward capturing large benthic fishes such as blue catfish and shovelnose sturgeon. Additionally, the mesh sizes on the gill nets were too large to capture small fish.

D. Recommendations. It is recommended that future tailwater fish aggregation surveys use deep-water electrofishing equipment during times of the year when the water temperature is below 20^{o}C; in addition, to continue monitoring benthic species that may not be caught by electrofishing, it recommended that a limited number of bottom-set nets be utilized in order to limit size bias and to increase catch, The use of suspended seines deployed as purse nets should be tested to see if they are effective at capturing the many suspended fish observed in the hydroacoustic surveys in areas with low or moderate flow.

Future monitoring activities should be tied to the project goals and objectives and the monitoring activities identified in a comprehensive monitoring plan for fish passage. Near-term studies include repeating hydroacoustic and fisheries sampling during the fall, early spring, and late spring; monitoring fish movements through the dam gates with hydroacoustic equipment; and using telemetry to monitor movements of silver carp, shovelnose sturgeon, paddlefish, skipjack herring and white bass. In order to provide potential design information for fishway entrance areas, concurrently-obtained fish location and hydraulic data from the tailwater fish surveys would be analyzed in an attempt to model the hydraulic environment selected by fish aggregating in the tailwater areas.

4. PROPOSED FY06 MONITORING ACTIVITIES

Monitoring activities are tied to the ecosystem objectives for the fish passage projects. Actual monitoring work performed in fiscal year 2006 is contingent on funding received for the project. The following is a brief description of potential monitoring activities according to the project goals they are intended to address.

A. Goal 1. Obtain information needed for project planning and design

- Hydroacoustic monitoring of fish aggregations in tailwater areas and sampling of fish aggregations in tailwater areas. Repeat sampling performed in 2005 under different temporal and physical conditions—fall, early spring, and late spring. This will show if fish are concentrating at potential entrance locations during the time of year when they would be migrating.
- Analysis of Hydraulic Conditions at Fish Locations - The tailwater surveys have provided a wealth of data on fish locations and hydraulic conditions. Conduct an analysis of the ADCP hydraulic and fish location data to model the parameters and ranges of hydraulic conditions that best predict fish locations in the tailwater. Results of this analysis may provide design criteria for hydraulic conditions in the vicinity of fishway entrances.

B. Goal 2. Monitor fish passage through both Melvin Price Locks and Dam and Lock and 22 and a fish passage project

- Hydroacoustic monitoring of fish passage through dam gates and lock chambers. To define the “No Project” condition.
- Design a passive hydroacoustic system capable of monitoring dam gate openings and lock chamber, recording the number and relative size of fish passing upriver and downriver through the dam.
- Deploy hydroacoustic instruments in dam gate bay; operate the hydroacoustic system continuously during the April through June primary fish migration period to monitor the timing, numbers, and relative size of fish passing upriver and downriver through the dam gates; deploy acoustic Doppler current profiling equipment in the gate bay openings to characterize the velocity patterns in each of the monitored gate bays, under conditions when gates are first raised from the water, and at two higher levels of river discharge.

C. Goal 3. Monitor ecological response by migratory fishes

- Telemetry study of migratory species of interest to understand the behavior and response to future fish passage structures. Insert tags into silver carp, shovelnose sturgeon, paddlefish, skipjack herring, and white bass; deploy and test receivers, and collect data.

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