L&D 22 Fish Passage Quantification Workshop
Meeting Notes
EL Conference Room, ERDC,
Vicksburg, Mississippi
11 January 2007

Purpose: The purpose of this meeting was to identify an acceptable methodology for quantifying habitat benefits of fish passage at Mel Price and Lock & Dam 22.

Attendees:

Jan Hoover	Jack Killgore	Rob Simmonds
Nate Caswell	Tamara Atchley	Teri Allen
Butch Atwood	Eric Gittinger	Barry Payne
Mark Cornish	Dan Wilcox	Dave Smith
Jon Duyvejonck		

Action Items:

- Update Pitlo et al. (1995), *Distribution and Relative Abundance of the Upper Mississippi River Fishes* Tables (Cornish, Moore, Atwood, Caswell and Simmonds)
- Modify the P_i value calculation of the Fish Passage Efficiency index (Wilcox)
- Update the swimming ability and habitat preference chart to include Hoover's recommendations (Cornish)

Decisions:

- Use the following formula for the Fish Passage Efficiency index to calculate environmental differences between the alternatives:

$$Є = \frac{\Sigma_{i..n} P_i \times D_i}{n*5}$$

  And calculate the P_i value as:

$$P_i = \frac{(A_i + E_i + U_i)}{3}$$

  With A_i, E_i and U_i identified through a combination of available data and professional judgment.
- The systemic benefits of cultural services, provisioning services, and supporting functions and structures should not be considered in the incremental analysis.
- Fish stocking alternative costs should not be calculated using fish replacement costs.

Notes:

Introductions/Project overview

Cornish welcomed the group and provided a brief review of the fish passage project development and monitoring activities. He explained that this meeting was second and final meeting to complete the process of fish passage environmental benefits quantification at Lock and Dam 22 and Mel Price Locks and Dam. The first meeting was help in St. Louis on 11 July 2006. The goal of this meeting was to review the fish passage effectiveness index sensitivity analysis and

modify the index as appropriate. This meeting also involved a broader group of stakeholders, including experts from the ERDC staff, to tightening up the analysis and identifying areas which need additional description to aid in the ECO-PCX review process. The Lock and Dam 22 Project Delivery Team (PDT) has reached a stage where these measures will be arranged into alternatives and evaluated using incremental analysis by the end of the February.

Alternatives Review for Lock and Dam 22

The group was provided a *Ready Reference Guide* that contained a list of viable alternatives for Lock and Dam 22 with a short description of each alternative (Table 1). Attached to this list was a series of design drawings for each alterative.

Table 1. Fish Passage Alternatives for Lock and dam 22

Name	Description
Alternative 1 - Rock ramp	Rock ramp adjacent to storage yard through spillway - near center of the channel (5 options)
Option 1 - 1D50	50 feet wide – downstream of dam
Option 2 - 1D100	100 feet wide – downstream of dam
Option 3 - 1D200	200 feet wide – downstream of dam
Option 4 - 1D300	300 feet wide - downstream of dam
Option 5 - 1U50	50 feet wide – upstream of dam
Alternative 2 – Rock ramp	Rock ramp adjacent to Illinois shore through spillway - near left descending bank upstream of the dam
Alternative 3 - Nature-like bypass channel	Illinois shore extending through the Sny Levee
Alternative 4 - Gate manipulation	Manipulation of pool, pulling the gates 2 ft earlier to extend open river (non-structural)
Alternative 5 - Assisted fish lockage	Use of existing 600' lock to move fish past the dam (non-structural)
Alternative 6 - Dual slot fishway	Technical fishway adjacent to storage yard through spillway - near center of the channel
Alternative 7 - Gate 13 rock ramp	60 ft wide rock ramp structure in tainter gate 13 – upstream of dam – near center of the channel
Alternative 8 - Modified gate fish passage	Manipulation of all dam gates to extend open river in tainter gate 13 (non-structural)
Alternative 9 – Fish stocking	Fish replacement through propagation and stocking in Pool 22 (non-structural)
Alternative 10 – Siphons	Use of siphon tubes over the spillway to allow fish to swim upstream over dam through the tubes
Alternative 11 – No project	Maintain dam operation without modifications for fish passage (non-structural)
Performance testing and experimental design options	Project performance and enhancement testing options
Pre-construction monitoring findings	Hydroacoustic identification of fish concentrations of the tailwaters

*Packet does not contain a drawing of this alternative

Background

Dan Wilcox explained that the biological objectives of the projects at Lock and Dam 22 and Mel Price were to increase the size and distribution of native migratory fish populations and provide increased upriver fish passage opportunity.

Wilcox presented nine factors affecting the potential effectiveness of fish passage improvement alternatives:

- Presence of migratory fishes at Lock and Dam 22 and Mel Price
- Relative abundance of these migratory fishes
- Seasonal timing of upriver fish movements
- Swimming performance of migratory fishes
- Migration behavior, potential for species to use fishway type
- Size of fishway
- Potential for fish to find fishway entrance
- Duration of availability to pass fish during fish movement period
- Future without-project opportunity for upriver fish passage

Wilcox said that much of the information used to evaluate alternatives was found summarized in ENV Report 54, *Improving Fish Passage through Navigations Dams on the Upper Mississippi River system* (Wilcox et al. 2004). Key components of this report that were used in the Lock and Dam 22 fish passage analysis include the approximate upriver movement and spawning periods of UMR migratory fishes that may occur at Lock and Dam 22 (Figure 1) and the aquatic habitat types and areas associated with Pool 22 and 26 (Table 5).

Wilcox provided the updated formula for the fish passage effectiveness index that he used to perform a sensitivity analysis to compare Lock and Dam 22 alternatives as follows:

$$Є = \frac{\Sigma_{i..n} P_i \text{ x } D_i}{n*5}$$

Where,

P_i = Potential that fish passage alternative will pass will pass a significant number of individuals of the species i population when the passage pathway is available (1 = low, 5 = high).

D_i = Duration of availability (fraction of weeks available during fish movement period)

And,

$$P_i = \frac{(A_i + S_i + B_i + W + F + U)}{6}$$

Where,

A_i = Abundance rating from Pitlo et al. (1995) (1 = rare, 5 = abundant)

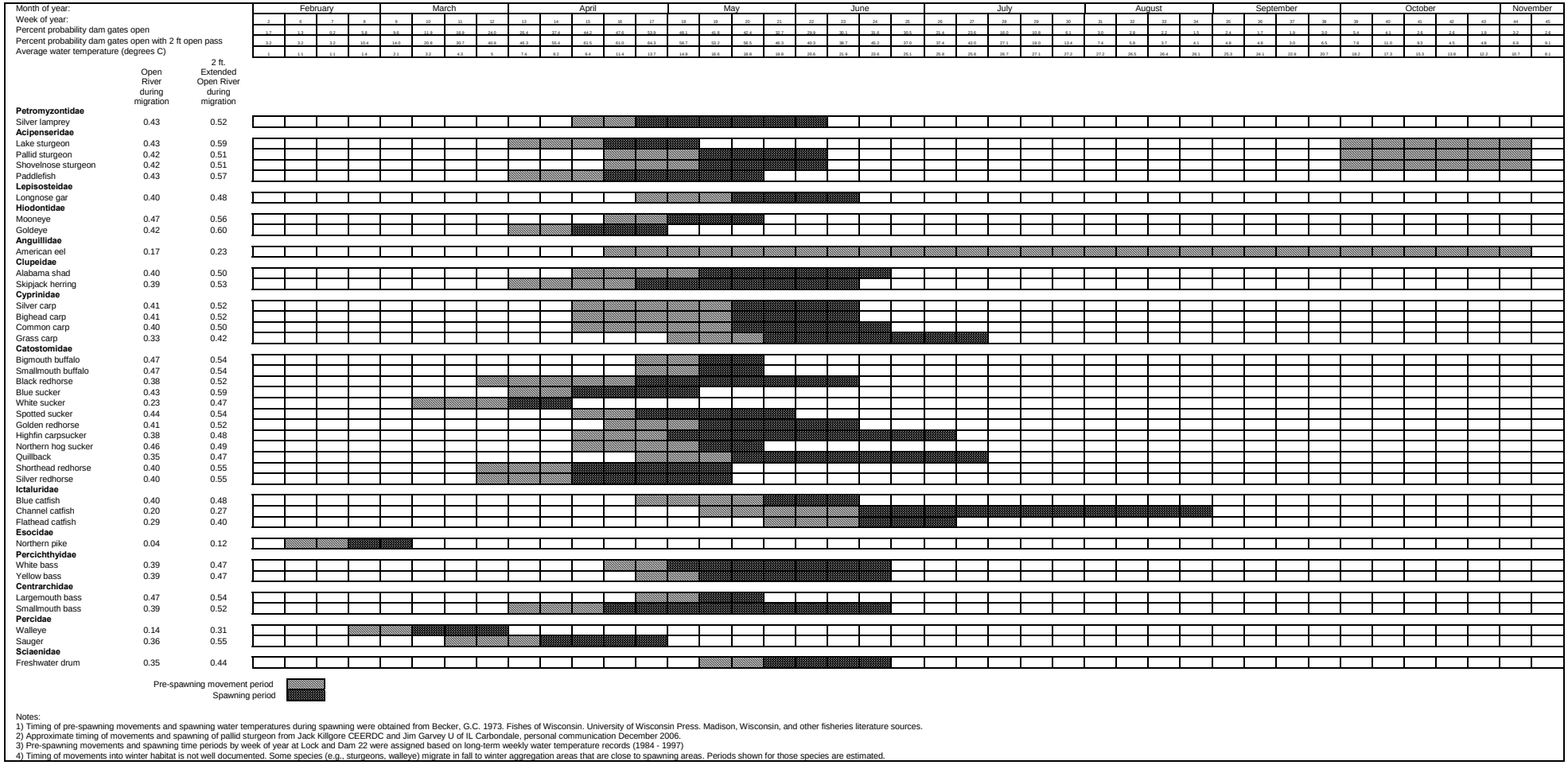
S_i = Swimming performance based on estimated critical velocity for adults (1 = weak 5 = strong)

Bi = Swimming behavior of species (1 = littoral, 3 = pelagic, 5 = benthic)

W = Fishway size (1 = small 5 = large, relative to the alternatives being considered)

F = Potential for fish to find fishway entrance (5 = immediate tailwater, 3 = dam gates, 1 = other locations)

U = Potential for fish to use fishway type (5 = nature-like, 3 = technical, 1 = forced)



Notes:
1) Timing of pre-spawning movements and spawning water temperatures during spawning were obtained from Becker, G.C. 1973. Fishes of Wisconsin. University of Wisconsin Press. Madison, Wisconsin, and other fisheries literature sources.
2) Approximate timing of movements and spawning of pallid sturgeon from Jack Killgore CEERDC and Jim Garvey U of IL Carbondale, personal communication December 2006.
3) Pre-spawning movements and spawning time periods by week of year at Lock and Dam 22 were assigned based on long-term weekly water temperature records (1984 - 1997)
4) Timing of movements into winter habitat is not well documented. Some species (e.g., sturgeons, walleye) migrate in fall to winter aggregation areas that are close to spawning areas. Periods shown for those species are estimated.

Figure 1. Approximate upriver movement and spawning periods of UMR migratory fishes that may occur at Lock and Dam 22.

Table 2. Summary - Potential Effectiveness of Fish Passage Alternatives

Alternatives	Є = Fish Passage Effectiveness Є = Σ Pi x Di / 5	Increase over future without project	Effectiveness Rank
1D50: Rock Ramp Adjacent to Storage Yard - 50 ft wide	0.73	0.73	3
1D100: Rock Ramp Adjacent to Storage Yard - 100 ft wide	0.76	0.76	2
1D300: Rock Ramp Adjacent to Storage Yard - 300 ft wide	0.83	0.83	1
1U100: Rock Ramp Adjacent to Storage Yard - 100 ft wide	0.76	0.76	2
2: Rock Ramp Adjacent to Illinois Shoreline	0.71	0.71	4
3: Nature Like Fish Bypass Channel	0.64	0.64	5
4: Gate Manipulation to Extend Open River (Non-structural)	0.34	0.18	6
5: Assisted Fish Lockage (Non-structural)	0.07	0.07	8
6: Technical Fishway (Dual Slot)	0.63	0.63	5
7: Gate 13 Fish Passage	0.73	0.73	3
10: Future Without Project	0.16	0.00	7

Wilcox provided the results of a sensitivity analysis each fishway alternative at Lock and Dam 22 using the revised effectiveness index (Table 2). The sensitivity analysis showed that the effectiveness index is suitable for comparing fish passage alternatives at Lock and Dam 22 but the group had some concerns on how the P_i value was calculated. They recommended that this calculation be revised to lessen the significance of some of the factors. See the later discussion of the P_i factor for details.

Systemic Benefits of Fish Passage Improvements on the Upper Mississippi River

Wilcox explained that it was possible to calculate systemic benefits from each of the alternatives in addition to the site-specific benefits. There were two approaches to calculating systemic benefits. The first was an ecosystem goods and services approach that factored in the systemic biological contribution of fish passage as well as the social services to estimate the biological "bottom line" (Table 3).

Table 3. Systemic benefits of fish passage

Supporting Functions and Structures
Nutrient Cycling
Habitat
Biodiversity
Genetic Resources
Biological Regulation
Provisioning Services
Food
Medicinal Resources
Cultural Services
Sport Fishing
Ecotourism/Science/Education
Aesthetic
Spiritual and Historical

Systemic benefits could be calculated as:

$$\Delta S = P \times V \times E$$

Where,

ΔS = Relative change in service value from future without-project condition
P = Potential for fish passage improvements to affect service (-3 = low, +3 = high)
V = Relative value of service (0 = low, 3 = high)
E = Fish passage effectiveness index for alternative

Wilcox said the second approach to systemic benefits quantification was to simulate the population-level response in geographic range and abundance of migratory fishes to fish passage improvements through a Leslie matrix (a discrete and age-structured model of population growth). This approach would factor the biological contribution of each fish passed through the dam in terms of increased distribution, recruitment and abundance in the next pool and even within the system (Figure 2).

The group understood the merits of calculate systemic benefits but believed that these analyses went beyond the immediate need for evaluating the site-specific effects of this project. The group encouraged the PDT to work other NESP groups like the science panel in creating these tools in the future, but not to use it in incremental analysis for Lock and Dam 22 and Mel Price.

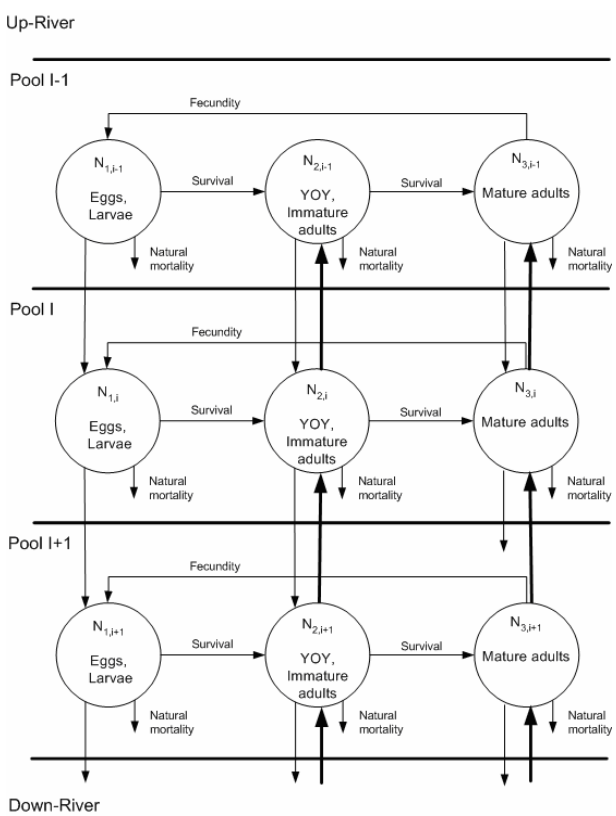


Figure 2. A hierarchical concept for modeling the systemic effects of fish passage (Bartell 2006).

The P_i value

There was agreement that the sensitivity analysis showed that the fish passage effectiveness formula was effective at selecting between alternatives, but P_i value should be modified to combine the values of S_i, B_i, W, F and U into two values E_i (chance of encounter) and U_i (use) to mathematically emphasize the significance of these factors in the assessment of the alternatives. This change is represented in the following formula:

$$P_i = \frac{(A_i + E_i + U_i)}{3}$$

Where,

Ai = Abundance (1-5)

From Pitlo et al. (1995) and updated with professional judgment from Travis Moore, Butch Atwood, and Nate Caswell.

5 = Abundant
4 = Common
3 = Occasional
2 = Uncommon
1 = Rare, historic, or stray from tributary or inland stocking

And,

E_i = Chance of encounter

5 = Likely to encounter the structure
3 = Moderately likely to encounter the structure
1 = Unlikely to encounter the structure

Based upon:

Habitat use during migration with regard to location of the structure

Littoral, pelagic, or benthic (Table 4)

Size of structure

Larger structures are more likely to be encountered

U_i = Use

5 = Species has a swimming ability capable of using the structure (Table 4), structure is large enough to pass populations of this species, and abundant preferred habitat is available in the pool above the dam.
3 = Species has a swimming ability capable of using the structure, structure is large enough to pass populations of this species, and preferred habitat is moderately available in the pool above the dam.
1 = Species has a swimming ability capable of using the structure, structure is large enough to pass individuals or sub-populations of this species, and preferred habitat is rare in the pool above the dam.
0 = Species is incapable of swimming though the structure (Rule: if $U_i = 0$ then $P_i = 0$)

Species analysis

The group discussed the alternatives analysis in the context of guilds or grouping species into categories. One of the outputs of the St. Louis meeting was a table that grouped the migratory fish species into categories based upon general habitat preference and swimming ability. This table had not been updated to include the recommended changes made by Jan Hoover. This table was subsequently revised to include these comments and is provided as Table 4.

Table 4. Upper Mississippi River Migratory Fish Swimming Ability and General Habitat Preference

Swimming Ability	Benthic	Littoral	Pelagic
Strong	lake sturgeon, blue sucker, silver redhorse, shovelnose sturgeon	walleye, sauger	silver carp, bighead carp, paddlefish, skipjack herring, white bass, yellow bass
Medium	channel catfish, flathead catfish, freshwater drum, shorthead redhorse, blue catfish, smallmouth buffalo, bigmouth buffalo	largemouth bass, smallmouth bass, spotted bass	mooneye, goldeye, Alabama shad
Weak	quillback carpsucker, highfin carpsucker, white sucker, spotted sucker, black redhorse, golden redhorse	bluegill, emerald shiner, northern pike, American eel	longnose gar, silver lamprey

The group agreed that this new table should be used as reference in the re-calculation of P_i.

Habitat quantification options

The group decided that due to the lack of time at the meeting that Cornish, Gittinger, and Allen should continue to work in quantifying habitat within Pools 26 and 22. The source of habitat information would be the UMRS-EMP Long Term Resources Monitoring Program database as reported in ENV Report 54 (Wilcox et al 2004) (Table 5). Habitat desirability would be considered on a species-by-species basis for each migratory fish to identify habitat units (acres) for each alternative.

Table 5. Aquatic Habitat Types and Areas Associated with Upper Mississippi River Navigation Dam at Lock and Dam 22 and Mel Price Locks and Dam (adapted from Wilcox et al. 2004)

	Pool 22 acres (hectares)	Pool 26 acres (hectares)
Contiguous Floodplain Lake-Abandoned Channel Lake	415 (168)	2,300 (931)
Contiguous Floodplain Lake – Floodplain Depression Lake	-	-
Contiguous Floodplain Shallow Aquatic Area	-	-
Contiguous Impounded Area	-	1,492 (605)
Main Channel-Channel Border	10,344 (4,186)	19,353 (7,832)
Main Channel-Navigation Channel	4,856 (1,965)	10,040 (4,063)
Sandbar	-	-
Secondary Channel	3,121 (1,275)	9,051 (3,663)
Tertiary Channel	10 (4)	84 (34)
Excavated Channel	-	309 (125)
Contiguous Floodplain Lake-Manmade Lake	-	-
Contiguous Floodplain Lake-Borrow Pit	-	-
Contiguous Floodplain Lake-Lateral Levee Lake	-	17 (7)
Secondary Channel	-	-
		-
Channel	18,360 (7,430)	-
Backwater	415 (168)	38,842 (15,719)
Lake	-	10,747 (4,349)
		-
Contiguous Floodplain Lake-Tributary Delta	-	-
Water Total	37,550 (15,196)	99,175 (40,135)

Subsequent to the meeting, Gittinger provided new information for habitat quantification that being developed by the Great Rivers LTRMP Field Station. The field station is breaking down habitat types for the entire aquatic area of Pool 26 into 50-m^2 sampling grids (Table 6). The Pool 26 data will be completed in 2007 and will be available for use in quantifying habitat benefits for fish passage at Mel Price.

Table 6. An example of 50-m^2 sampling grids from each of the five strata defined for stratified random sampling of fishes in Pool 26.

Strata	Number of 50-m^2 sampling grids
main channel border unstructured (MCB-U)	3,199
main channel border structured (i.e., wing dams) (MCB-S)	7
contiguous backwater shoreline (BWC-S)	764
impounded shoreline (IMP-S)	172
side channel border (SCB)	5671

Tributary Habitat Quantification

Wilcox mentioned that tributary habitat was quantified previously using the Longitudinal Connectivity Index (Wilcox et al. 2004). This index was developed to aid in identifying the

priority of fish passage improvements throughout the system. It was recommended at the St. Louis meeting that the group consider using stream specific information (i.e. IBIs) to quantify the habitat benefits of tributaries rather than the Longitudinal Connectivity Index. Gittinger provided Index of Biotic Integrity (IBI) and Biological Stream Characterization (BSC) stream classification system for the Illinois tributaries from the Great Rivers Field Station database (Table 6).

Table 6. Biological quality ratings for Illinois tributaries of Pools 26 and 22.

Illinois Watersheds	Acres	RIBI scores	BSC scores (based on old IBI not new RIBI)
Watersheds in Pool 26		**Sampled in 2005**	
Piasa Creek Basin	77,967	37 Piasa Branch	B (1984)
		49 Mill Creek branch	
Illinois River Basin	18,500,000	per Tributary	A - 93.2 miles (1993)
			B - 851.2 miles (1993)
			C - 321 miles (1993)
			D & E - 0 miles (1993)
Watersheds in Pool 22		**Sampled in 2004**	
Mill / Burton Creek Basin	65,420	52 Mill Creek	B (1980)
		51 Burton Creek	
Pigeon / Fall Creek Basin	72,807	37 Pigeon Creek	
		score is high for Fall creek	

RIBI = Revised Index of Biotic Integrity, (Smogor 2000)
BSC = Biological Stream Characterization, (Doppelt et al 1993)
A = Unique Aquatic Resource (IBI 51-60)
B = Highly Valued Aquatic Resource (IBI 41-50)
C = Moderate Aquatic Resource (IBI 31-40)
D = Limited Aquatic Resource (IBI 21-30)
E = Restricted Aquatic Resource (IBI <21)

Cornish could not provide equivalent information for the Missouri tributaries (Pool 26 - Bobs Creek, Cuiver River, Peruque Creek, Dardenne Creek; Pool 22 - Fabius River, North River, Mill Creek). The Missouri Department of Conservation had incomplete IBI data for these tributaries.

Without equivalent information from both sides of the river (Illinois and Missouri) and given that the tributary sizes were so different (from 8th order to 4th order) it was decided that the best available information on these tributaries was not consistent enough for an adequate habitat comparison analysis. The analysis should either fall back to the LCI analysis or perform no analysis of tributaries for habitat quantities.

Fish stocking alternative example

The group briefly discussed how the fish stocking alternative could be evaluated. Wilcox recommended that the team should no longer consider this a viable alternative based upon three factors:

1) Sustainability – Fish stocking as a long term measure is contrary to the goals and objectives for the Navigation and Ecosystem Sustainability Program. Stocking is an

artificial means for managing an ecosystem and is highly susceptible to the human influence of political change and reductions in agency funding. Cornish estimated that a warmwater multi-species fish hatchery costs approximately $20.7 million dollars to construct with an average annual Operation and Maintenance cost estimated between 400-500 thousand dollars annually. This estimate was based upon the recently constructed Ft. Peck warmwater fish hatchery in Montana (Ted Streckfuss, USACE Omaha District, pers com.). These costs would need to be factored into the cost of this alternative and based upon past trends, the likelihood of federal hatcheries receiving adequate funding for the duration of the project is low.

2) Biological concerns – There are numerous biological concerns such as spreading of diseases from hatchery fish to wild stocks (whirling disease), genetic homogenization, and the extinction of homing instincts from stocked fish that make fish stocking undesirable as an alternative.

3) Capability – There are no fish hatcheries that raise all the UMR migratory species. Some of these large river fish because they require unique and very specialized spawning conditions that cannot be duplicated in a hatchery. It was estimated that approximately 13 of these species have been raised successfully in captivity, leaving at least 15 species that would either be raised experimentally or could not be raised at all.

Cornish mentioned that other Corps projects had been halted at the HQ level because fish stocking had not been adequately considered in the alternatives analysis. He proposed a method for calculating fish stocking costs based upon the best available data with was; hydroacoustic tailwater population estimates, and; abundance estimates from Pitlo et al. (1995). This method subtracted the population estimate of fish in the tailwater after open river to the population of fish prior to open river to come up with a number of fish that moved through the dam. Abundance of each migratory fish species was calculated by applying Pitlo et al. (1995) estimated abundances to the difference value. Monetary values were then calculated using American Fisheries Society replacement values (Southwick and Loftus 2003) for fish 11 inches in length (Table 7).

Table 7. Example Fish Replacement Costs at Lock and Dam 22.

Species	# of fish	AFS Cost (assuming an 11 in. fish)	Species	# of fish	AFS Cost (assuming an 11 in. fish)
silver lamprey	450	853.20	golden redhorse	9000	17,064,00
lake sturgeon	2250	46,998.00	quillback	5400	1,166.40
shovelnose sturgeon	6100	126,894.60	shorthead redhorse	9000	17,064,00
paddlefish	3400	51,246.00	spotted sucker	45	85.32
longnose gar	9000	17,064.00	white sucker	45	85.32
goldeye	9000	6,552.00	blue catfish	9000	6,336.00
mooneye	9000	6,552.00	channel catfish	9000	6,336.00
American eel	4740	8,958.60	flathead catfish	9000	6,336.00
skipjack herring	9000	864.00	northern pike	450	2,430.00
silver carp*	9000	0.00	white bass	7200	14,112.00
bighead carp*	9000	0.00	yellow bass	6100	9,525.60
common carp*	9000	0.00	smallmouth bass	900	3,074.40
grass carp*	6100	0.00	largemouth bass	9000	34,200.00
bigmouth buffalo	9000	4,104.00	sauger	9000	34,776.00
smallmouth buffalo	9000	4,104.00	walleye	5400	20,865.60
blue sucker	5400	10,238.40	freshwater drum	9000	3,816.00
*Nuisance species - not stocked			**Total**	**210,000**	**$ 427,573.44**

The group did not support this method of evaluation for the following reasons:

1. The two sampling periods for hydroacoustic data (pre and post open river) were insufficient to assess the movements of fish through the dam. Continuously collected stationary hydroacoustic data should have been collected to assess the actual numbers of moving through the dam and the direction they headed.
2. Hydroacoustic data does not adequately capture small fish, fish close to the bottom, and fish high in the water column, resulting in an underestimate of the fish present within the tailwater.
3. Using an 11 inch fish to base costs is flawed. Most migratory fish are much larger; therefore their replacement costs would be much larger.

The group decided that fish stocking was not a viable alternative and the explanation for why it was removed from further analysis in the Project Implementation Report should be based on the factors of sustainability, biology, and capability.

Wrap-up Round Table

Cornish went around the room asking each of the meeting attendees if they had anything else that the team needed to be discussed. All attendees declined the opportunity. Cornish then reviewed the action items and the meeting dismissed.

References

Pitlo, J., Jr., A. VanVooren, J. Rasmussen. 1995. Distribution and relative abundance of Upper Mississippi River fishes. Upper Mississippi River Conservation Committee, Rock Island, Illinois.

Southwick, R. I. and A.J. Loftus, editors. 2003. Investigation and monetary values of fish and freshwater mussel kills. American Fisheries Society, Special Publication 30. Bethesda, Maryland.

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