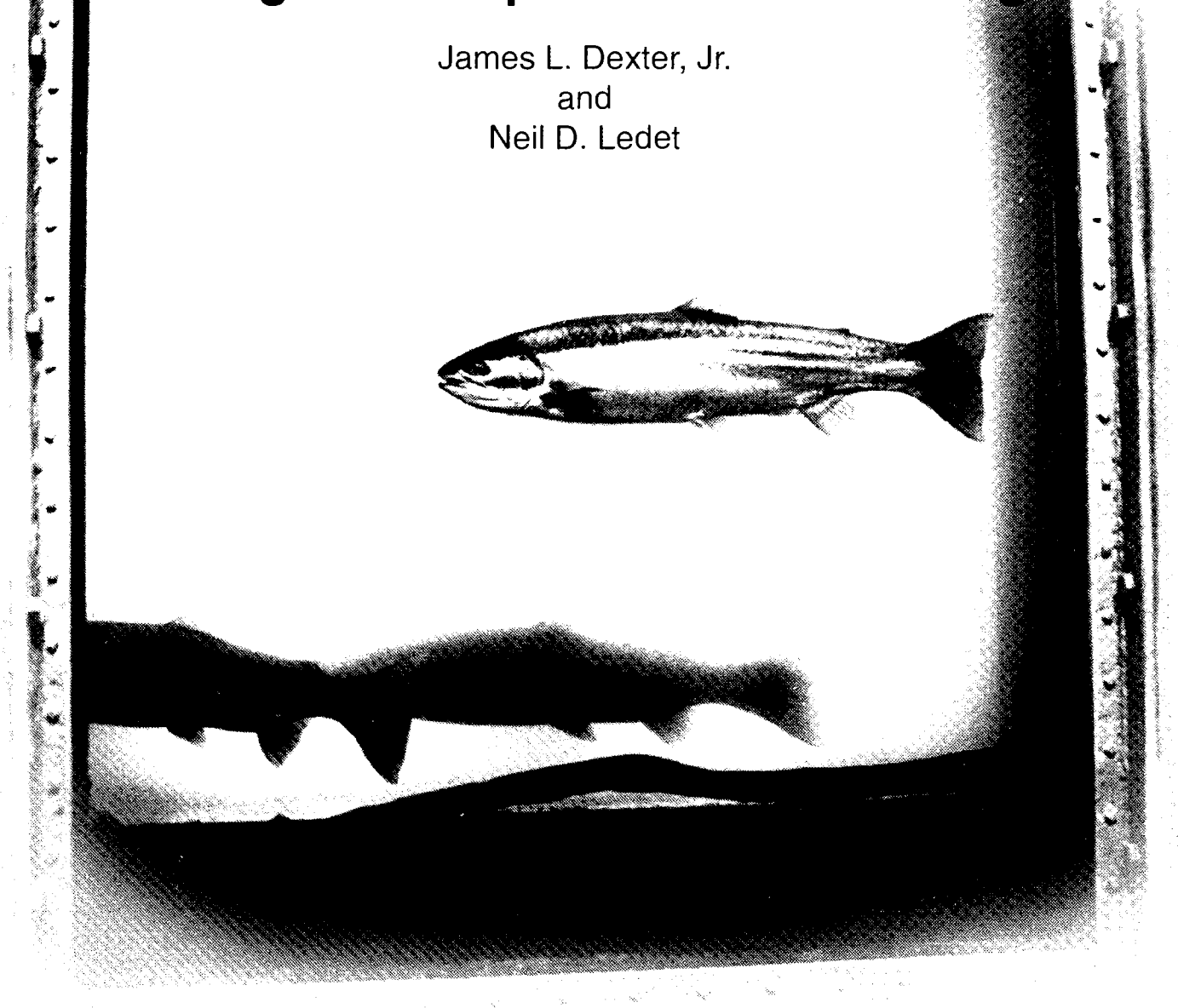
FISHERIES DIVISION
TECHNICAL REPORT

Number 94-5 July 27, 1994

Estimates of Fish Passage at St. Joseph River Dams in Fall 1992 Using Time-Lapse Video Recording

James L. Dexter, Jr.
and
Neil D. Ledet



DNR
STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
FISHERIES DIVISION

Fisheries Technical Report No. 94-5
July 27, 1994

ESTIMATES OF FISH PASSAGE AT ST. JOSEPH RIVER DAMS IN FALL 1992 USING TIME-LAPSE VIDEO RECORDING

James L. Dexter, Jr.
and
Neil D. Ledet

PRINTED BY AUTHORITY OF:Michigan Department of Natural Resources
TOTAL NUMBER OF COPIES PRINTED: 300 TOTAL COST: $337.00 COST PER COPY: $ 1.12
Michigan Department of Natural Resources DNR

COVER: Steelhead moving past the counting window at the Berrien Springs fish ladder.

Michigan Department of Natural Resources
Fisheries Technical Report No. 94-5, 1994.

Estimates of Fish Passage at St. Joseph River Dams in Fall 1992 Using Time-Lapse Video Recording

James L. Dexter, Jr.

Michigan Department of Natural Resources
621 North 10th Street
P.O. Box 355
Plainwell, MI 49080

Neil D. Ledet

Indiana Department of Natural Resources
Fish Management Headquarters
6889 North State Road 327
Orland, IN 46776

Abstract.—In fall of 1992, final modification of the Berrien Springs fish ladder in the St. Joseph River completed a 17-year project to construct fish passage facilities at the first 5 dams in the lower river. Monitoring of total fish passage at the Berrien Springs, Niles, and South Bend dams was accomplished between 11 September and 30 November 1992 using time-lapse video recording. Total passage of fish varied from 5,081 at the Berrien Springs dam to 3,403 at the South Bend dam. Various warm and coolwater species utilized the passage facilities, however, potamodromous salmonines comprised 99.6% of all fish passed at the three ladders. Approximately 25% of the total movements occurred at night (2000 to 0800 EST). The South Bend ladder showed the highest night usage. Numbers of fish passed at the Berrien Springs ladder were within the range of passage determined by manual counting in previous years. Steelhead and chinook salmon were the most prevalent species passed. The use of video time-lapse photography proved to be a good method for estimating returns of salmonines. With video, filming can take place continuously, improving fish identification and counting in order to evaluate ladder success. Continuous filming also allows better fish passage, since ladders can remain open throughout the 24-h period.

The St. Joseph River, located in southwest Michigan and northwest Indiana, is the third largest river basin in Michigan. It drains a watershed of approximately 2,600 square miles in Michigan and 1,685 square miles in Indiana. The average discharge (measured at the river mouth in St. Joseph, Michigan) is 4,598 cubic feet per second. The river is 306 miles long and has an additional 1,641 miles of tributary streams (Brown 1944). The St. Joseph River is designated as a top quality warmwater system in Michigan. The river has hosted runs of

introduced salmonines from Lake Michigan since the inception of the salmonine stocking program in the late 1960s. Even though it is classified as a warmwater system, the river does support a high quality population of coolwater species. Prior to the first dam being constructed in Niles in 1868, the St. Joseph River hosted a variety of potamodromous species that had free access to the entire river length. Species included: lake sturgeon *Acipenser fulvescens*, lake whitefish *Coregonus clupeaformis*, muskellunge *Esox masquinongy*, and lake trout *Salvelinus namaycush*.

In 1975, Michigan constructed a fish ladder at the Berrien Springs dam which expanded fishing opportunities for potamodromous trout and salmon 33 miles upstream from Lake Michigan to the Buchanan dam (Figure 1). Based on the success of this project, the Michigan Department of Natural Resources (MDNR), the Indiana Department of Natural Resources (IDNR), and the U.S. Fish and Wildlife Service (USFWS) began discussions to further develop and manage this fishery. An environmental impact statement (James et al. 1980) was developed and presented to the public in 1980. This $15 million dollar interstate project called for the construction of fish passage facilities at the Buchanan, Niles, South Bend and Mishawaka dams enabling spawning runs of trout and salmon to migrate from Lake Michigan 63 miles upstream to the Twin Branch dam in Mishawaka, Indiana. This plan also called for the construction of a cold-water fish hatchery in Indiana (Richard Clay Bodine State Fish Hatchery) to provide fish for Indiana's river stocking commitment. To date, all four ladders and the hatchery have been completed and modifications to the original Berrien Springs ladder continue to be made to improve its efficiency. Migrating salmonines had unimpeded access to the lower 63 miles of the St. Joseph River for the first time in 1992.

Fish passage at the Berrien Springs dam has been counted each year since 1977. The facility at that time consisted of a resting pool at the top of the ladder, with several boards (stop logs) to control flow and escapement ability of fish. The ladder operator would remove boards in the morning and evening, visually count each passed fish and identify the species as accurately as possible.

At present, the Berrien Springs, Niles, South Bend, and Mishawaka fish ladders have underground fish viewing (counting) rooms with windows located along the ladder wall. Fish migrating through these ladders are directed within 16 to 20 in of the window by an angled aluminum crowder grate. A fish-viewing room was built above ground in the Buchanan fish ladder. At this facility, an angled steel grate forces fish within 12 in of the water surface for viewing. Fish counts are not immediately planned for the Buchanan and Mishawaka dams.

In 1988, a formal written agreement between the states of Michigan and Indiana was developed to serve as a management framework for the program (Anonymous 1988). This agreement, signed by the directors of the MDNR and IDNR, included monitoring the returns of adult salmonines from Lake Michigan. The Berrien Springs, Niles, and South Bend fish ladders are primary counting locations at this time. The Berrien Springs dam, 23 river miles upstream from the mouth, is the first dam encountered by returning adult salmonines. The Niles dam is located 19 river miles upstream of Berrien Springs. It is the last dam salmonines encounter before entering Indiana's portion of the St. Joseph River. The South Bend dam is an additional 14 river miles above Niles and is the first dam salmonines encounter in Indiana (Figure 1). The objectives of this project were to determine the number, times of movement, and species of resident and potamodromous salmonines that utilize the Berrien Springs, Niles, and South Bend fish ladders.

Methods

We monitored fish passage through the Berrien Springs, Niles, and South Bend fish ladders using identical Super VHS time-lapse video recording equipment (Table 1). This equipment provides recording speeds ranging from 2 to 480 h per standard 2-h tape. Recording modes recommended by Hatch (1990) included the 24-h mode at 5 frames per second, the 48-h mode at 2.5 frames per second, and the

72-h mode at 1.7 frames per second. Normal speed recording (2 h mode) provides 60 frames per second. In 1992, the IDNR used the 48-h mode almost exclusively, while the MDNR used the 48-h mode on weekdays and the 72-h mode on weekends. The dimensions of the Berrien Springs and Niles viewing windows are 5 ft high x 4 ft wide. The South Bend viewing room has two windows that are 5 ft high by 3 ft wide and 5 ft high by 2 ft wide. These windows are separated by a 1.5 ft-wide column of concrete. The larger of the two windows at South Bend was used for recording fish movements.

Lights mounted in the viewing rooms illuminate fish as they pass the window. At the Berrien Springs window, 2 portable 500-W quartz lights were used at a distance of about 2 ft from the window. At Niles a bank of 8 (150 W) flood lights permanently attached to the wall opposite the window (distance of 10 ft) were used. A single 150-W portable flood light was mounted within 12 in of the South Bend window.

Backlighting is also available at each viewing chamber but is used intermittently depending on water clarity. At Berrien Springs and Niles, back lighting is provided by 8 high-output fluorescent bulbs with a diffuser panel. The back lighting is approximately 16 in across from the viewing window. Backlighting at South Bend is provided by 4 high-output fluorescent bulbs with no diffuser panel.

Tapes were reviewed by fisheries personnel experienced in identification of fishes. The equipment used for viewing allowed the tape reader to control playback speed and tape direction. Tapes could be played one frame at a time in either direction to permit fish identification as needed. Fish passage was tabulated hourly on a daily basis, from which 4-h passage periods (i.e., 0400 to 0800) and weekly totals were derived. These were then entered into a database for analysis.

For periods where recordings were missed, estimates were made by averaging passage by species for the same time period 2 d before and 2 d after the missed time period. However, estimation for the first period missed in Michigan included only 1 d before and after because a power outage occurred on the second day of recording (Table 2).

Recording started on 12 September 1992 at Niles and South Bend. Recording at Berrien Springs did not start until 7 October due to continued construction work inside the viewing chamber. However, limited manual counting of passage was conducted at Berrien Springs from 11 September to 6 October. Counts during this period varied from 15 min to 8 h on most days. Because of the limited counts made at Berrien Springs through 6 October, very few results will be presented for these dates. At Niles and South Bend, recording was conducted 24 h per day, 7 d per week. Table 2 lists the days and time periods that recording was not conducted at each ladder, and the reasons recording was not done. Fish counts were terminated at all three ladders by 30 November 1992.

The IDNR has stocked Chinook salmon *Oncorhynchus tshawytscha* in the St. Joseph River since 1984, and Skamania-strain steelhead *Oncorhynchus mykiss* since 1985. The majority of these stockings occur in Indiana waters of the St. Joseph River, five dams upstream of Lake Michigan. The MDNR has stocked fall- and spring-run (Little Manistee River strain) steelhead, chinook salmon, some coho salmon *Oncorhynchus kisutch*, and brown trout *Salmo trutta* in the river since the early 1970s. These are all stocked between the Berrien Springs dam and Lake Michigan. Stocking targets for the river (both states combined) are 175,000 spring yearling Skamania steelhead; 50,000 fall fingerling Skamania; 50,000 spring yearling Michigan-strain steelhead 580,000 spring fingerling chinook salmon; and 15,000 spring yearling brown trout.

Results

Fish passage

Total fish passage at all three ladders between 11 September and 30 November 1992 varied from 5,081 at Berrien Springs (including manual counts) to 3,403 at South Bend (Table 3). The Berrien Springs ladder was open a total of 78 d, and the South Bend ladder 80 d. Fish counts at Berrien Springs were lower than those in 1991, but similar to historic levels (Figure 2).

Undoubtedly, additional fish were passed at Berrien Springs that were not counted due to manual counting methods. Daily tabulated fish passage at each dam can be found in Tables 4, 5, and 6. Due to failure of video recorders and manpower limitations, a total of 1.6%, 1.8% and 5.5% of the passage at the Berrien Springs, Niles, and South Bend ladders were estimated, respectively.

Potamodromous salmonines comprised 99.6% of all fish passage at the three ladders. Steelhead were the most numerous species passed at Berrien Springs, while chinook salmon were the most common at both Niles and South Bend. Suckers (Catostomidae), walleye *Stizostedion vitreum*, smallmouth bass *Micropterus dolomieu*, channel catfish *Ictalurus punctatus*, largemouth bass *Micropterus salmoides*, common carp *Cyprinus carpio*, and brook trout *Salvelinus fontinalis* accounted for only 48 observations at the Berrien Springs and Niles ladders. Warmwater and coolwater species were not tabulated for the South Bend ladder due to personnel time limitations. Total counts of warmwater and coolwater species for 1992 are shown in Tables 4-6.

Steelhead

A minimum of 2,371 steelhead passed through the Berrien Springs ladder during the fall of 1992 (Table 4). We manually counted 1,468 steelhead from 11-30 September, with 1,252 of these passing during the first five days. This was a partial count. Steelhead passage during October and November was 598 and 305, respectively. Once complete counts began, steelhead passed this ladder each day with the exception of 21 October, and averaged 18 fish per day.

The first steelhead moved through the Niles ladder on 12 September, approximately 24 h after the Berrien Springs ladder was opened (Table 5). Of the 1,540 steelhead that passed the Niles ladder, 1,121 moved through in September and 341 in October. The highest daily movement was on 16 September (114 fish). Only 78 steelhead moved through the Niles ladder during November. During the sampling period there were 12 d when no steelhead passed, while an average of 18 steelhead passed per day.

On 14 September, approximately 60 h after the Berrien Springs ladder was opened, the first steelhead moved through the South Bend fish ladder (Table 6). A total of 1,245 steelhead passed through that ladder during the sampling period. A total of 801, 309, and 135 steelhead were counted in September, October and November, respectively. Skamania steelhead were identified based on fin clips and body shape. This strain of steelhead represented 92.6% of the total steelhead moving through the South Bend ladder. The first Michigan steelhead was observed on 15 October at this ladder. Of the 135 steelhead that passed through the South Bend ladder in November, 92 were Michigan steelhead. Eighty of these Michigan steelhead moved through between 17 and 29 November. The largest steelhead passage occurred on 15 September (70 fish). During the sampling period, steelhead were observed on all but 12 d in the South Bend ladder, while an average of 16 steelhead passed through the ladder each day.

Peak time periods for movement occurred between 0800 and 2000 for all three ladders (Table 7). The South Bend ladder exhibited the highest tendency for night movement (26.9%), while the Berrien Springs ladder exhibited the lowest amount of night movement (17.8%). Based on video counts, 30% of the total steelhead passage from Berrien Springs passed the Niles ladder (Figure 3).

Chinook salmon

A minimum of 2,049 chinook salmon passed through the Berrien Springs fish ladder during fall 1992 (Table 4). A total of 395 (partial count), 1,639, and 15 fish were counted in September, October and November, respectively. Chinook salmon were observed each day the ladder was opened (except for two) through 4 November. The largest passage of chinook salmon through this ladder (640 fish) occurred on 16 October. An average of 33 chinook salmon passed the Berrien Springs ladder each day of video taping.

Chinook salmon were observed using the Niles ladder from 12 September through 6 November. Of the 1,771 that moved through this ladder, 980 were observed in September, 785 in October, and 6 in November. The highest chinook salmon passages occurred on 24, 25, and 26 September (119, 117 and 148 fish, respectively). A smaller secondary peak in chinook salmon movement occurred at Niles on 17 and 18 October, approximately 24 h after the October peak movement at Berrien Springs. An average of 23 chinook salmon passed through the ladder each day.

A total of 1,995 chinook salmon utilized the South Bend ladder (Table 6). A total of 835, 1,122 and 38 fish passed through the South Bend ladder in September, October and November, respectively. The highest passages at South Bend occurred on 26, 27 and 28 September (107, 129 and 94 fish, respectively). A smaller secondary peak in chinook salmon movement was observed at South Bend on 19 and 20 October. There were eight days when no chinook salmon passed, all in November. Both the primary and secondary peak movements of chinook salmon at South Bend occurred approximately 24 and 48 h after similar peak observations at Niles and Berrien Springs, respectively. An average of 26 chinook salmon passed through the ladder each day.

Peak time periods for movement occurred between 0800 and 2000 for all three ladders (Table 7). The South Bend ladder had the highest frequency of fish passage at night (34.2%), while the Niles ladder had the lowest (15.0%). Based on video counts, only 34.3% of the total chinook salmon passage at Berrien Springs passed the Niles ladder (Figure 4). Of the total number of chinook salmon known to pass Niles and South Bend, a total of 228 additional chinook salmon (11.2%) passed South Bend that were not recorded at Niles.

Coho salmon

Coho salmon were observed passing through the Berrien Springs ladder from the first day of operation through 12 November, with the exception of 23 d (primarily late October and early November, Table 4). A minimum of 149 coho salmon were passed at Berrien Springs. September passage of coho salmon was 55 fish (partial count), followed by 92 in October and 2 in November. The largest coho salmon movement occurred on 16 October (32 fish). An average of 2 coho salmon passed through the ladder each day during video taping.

Coho salmon first used the Niles ladder on 13 September, approximately 45 h after the first coho salmon passed through Berrien Springs ladder (Table 5). A total of 193 coho salmon moved through Niles ladder. A total of 159 and 34 fish were counted in September and October, respectively. The largest passage of coho salmon at this ladder occurred on 15 September when 25 were observed. Peak coho salmon movements occurred between 13 through 19 September (96). Only one coho salmon was observed between 19 and 31 October. An average of 2.5 coho salmon passed through the ladder each day.

A total of 146 coho salmon moved through the South Bend ladder (Table 6). The first coho salmon were observed at South Bend on 15 September, the same day they were first observed at Niles. The last coho salmon was observed at South Bend on 19 October. A total of 111 and 35 coho salmon were counted during September and October, respectively. Peak movements occurred between 26 and 30 September, when all 111 coho salmon moved through for the month (Table 4). An average of 1.9 coho salmon passed through the ladder each day.

Peak time periods for movement of coho salmon occurred between 0800 and 2000 for all three ladders (Table 7). Once again the South Bend ladder exhibited the highest tendency for night passage (29.4%), while the Niles ladder exhibited the lowest amount of night movement (11.0%). Based on video counts, 17.9% of the total passage at Berrien Springs passed the Niles ladder (Figure 5).

Brown trout

Brown trout were observed moving through the Berrien Springs ladder between 11 September and 19 November (Table 4). The largest movement occurred on 11 September (71 fish)

followed by 59 fish on 16 October. Total brown trout movement through the Berrien Springs ladder was 481 fish, with 227 (partial count) in September, 238 in October and 16 in November. An average of 5.1 brown trout passed through the ladder each day during video taping.

Brown trout were first observed at Niles on 15 September, 4 d after first observation at Berrien Springs (Table 5). A total of 127 brown trout migrated through the Niles fish ladder. A total of 62, 49, and 16 brown trout were counted during September, October, and November, respectively. The largest passage of brown trout at this ladder occurred on 26 and 27 September, with 10 and 11 fish, respectively. An average of 1.6 brown trout passed through this ladder each day.

Only 17 brown trout passed through the South Bend fish ladder (Table 6). Three moved through in September and 14 in October. Browns were first observed at South Bend on 24 September and were periodically seen through 28 October (Figure 6).

Peak time periods for movement of brown trout occurred between 0800 and 2000 at all three ladders (Table 7). Berrien Springs ladder exhibited the highest tendency for night movement (30.8%), while the South Bend ladder exhibited the lowest amount of night movement (17.7%). Based on video counts, 18.2% of the total passage at Berrien Springs passed the Niles ladder.

Ladder usage by daily time period

Daily movement of salmonines through the fish ladders occurred mainly during the daytime hours (0800 to 2000 Eastern Standard Time). Approximately 25% of total ladder movements occurred at nighttime (2000 to 0800). The highest nighttime salmonine movement occurred at South Bend; 29.9% for steelhead, 34.2% for chinook salmon, and 29.4% for coho salmon.

Each ladder exhibited different time periods when movements of a certain species peaked. Passage by steelhead peaked at Berrien Springs and Niles in the early afternoon period (1200 to 1600), and at South Bend in the late morning period (0800 to 1200). Passage by chinook salmon peaked at Berrien Springs in the late afternoon period (1600 to 2000), and at Niles and South Bend in the late morning period. Passage by coho salmon peaked at Berrien Springs in the late afternoon period, the late morning period at Niles, and the early afternoon period at South Bend. Brown trout passage peaked at Berrien Springs in the late afternoon period, at Niles in the early afternoon period, and at South Bend in the late morning period .

Use of attraction water

A specific study of the efficiency of each ladder at passing fish was not conducted in 1992. However, fish passage through the South Bend fish ladder was compared against the daily maintenance log. Manpower limitations and accumulation of debris during leaf fall periodically prevented the use of auxiliary water supplied to the lower end of the fish ladder. This water (known as attraction water) helps to attract fish to the ladder entrance. Although not conclusive, the number of salmonines moving through the South Bend ladder was higher when auxiliary water was used. When attraction water was shut off for short periods of time (1 to 2 d), salmoninemovement through the South Bend ladder declined 50-88% Additional testing will be conducted in 1993 at both Niles and South Bend. Berrien Springs does not have capabilities for attraction water.

Discussion

Anadromous fish passage at Berrien Springs in the fall of 1992 was well within the range of passage in previous years (Figure 2). From 1977-1982, fall passage at Berrien Springs was composed mainly of chinook and coho salmon. Fall passage totals during that time averaged 2,900 fish. Stocking of coho salmon into the St. Joseph River was discontinued in 1979, but chinook salmon stockings remained constant through 1988. Chinook salmon experienced much greater survival in 1983-1987, as is evident by the strong passage figures at Berrien Springs in those years. In 1988, chinook salmon survival

rates plummeted, and have continued to be poor. Bacterial kidney disease and a changing forage base in Lake Michigan are considered major factors influencing chinook salmon survival (Johnson and Hnath 1991; Stewart and Ibarra 1991). Michigan stocking rates for chinook salmon in the St. Joseph River have doubled since 1987, in response to the additional river miles available because of ladders. Additional stocking may be compensating for lower survival in recent years. Higher fish passage totals at Berrien Springs are mainly due to increased steelhead passage in the fall. This is due to MDNR stocking larger spring yearlings (both Skamania and winter-run strain) than past years, and IDNR stockings of Skamania-strain yearlings.

Skamania steelhead showed a tendency to migrate as soon as the ladders were open. Movements were quick, as steelhead reached the South Bend dam in about 60 h. The steelhead run occurred in two distinct peaks (Figure 3). The first peak at Berrien Springs was made up primarily of Skamania steelhead, while the second peak consisted of winter-run fish (MDNR stocked). All winter-run steel-head were stocked below Berrien Springs, and their fall movements showed a definite tendency to stay in Michigan waters and not pass into Indiana. The Dowagiac River, a high quality trout stream and the second largest tributary to the St. Joseph River, may attract many of these fish. The Dowagiac River has its confluence with the St. Joseph just down-stream from the Niles dam.

Chinook and coho salmon tended to be more distributed in their run periods over the fall, but did exhibit definite peaks (Figures 4 and 5). It is not known what percentage of the chinook salmon that passed Niles into Indiana were actually stocked in Indiana. Most chinook salmon returning in 1992 from Indiana stockings were from one of the few year classes that were not fin clipped. These fish could not be differentiated from chinook salmon stocked in Michigan. All other Indiana chinook salmon stockings in the St. Joseph River have identifying fin clips so that return rates of each year class can be determined. All coho salmon returns were presumably from a 1990 fall net-pen project at St. Joseph (rearing of 291,000 fall fingerlings), or were stray fish. While the number passed at each ladder was low, coho salmon did exhibit a definite tendency to continue into Indiana (188 passed at Niles and 146 at South Bend). The 1992 return of coho salmon was much below expectations. Anglers may have accounted for the low return, as the 1992 fishery for coho salmon was so good in Lake Michigan that numbers of adults may have been reduced to the point of providing low returns to tributaries. Coho salmon reared to the fall fingerling stage in net pens showed no positive benefit to the river fishery in 1992, as compared to the previous returns of coho at the Berrien Springs ladder. Proposed future in-creases in coho salmon stockings into the lower St. Joseph River may contribute to the Indiana river fishery, since yearling smolts will be stocked.

The run of brown trout in the St. Joseph River was very good in 1992. Only 15,000 yearling brown trout are stocked annually at the port of St. Joseph; roughly 500 were counted ascending the Berrien Springs ladder. These large Lake Michigan dwellers always attract anglers and create excitement when they are caught. It is not uncommon to have several brown trout captured by anglers below Berrien Springs that exceed 15 pounds. Once these fish pass Berrien Springs, they have a strong tendency to remain in Michigan waters of the river, and not pass into Indiana (Table 3). Differences in passage totals between dams for a given species are not necessarily due to ladder inefficiencies, because some fish may locate suitable spawning grounds below a dam, or become attracted to a tributary.

While the 1992 fall data show that the majority of passage occurred between 0800 and 2000, a significant proportion of the 1992 fall run did take place during the night. This information indicates that it would be beneficial to operate the ladders on a 24-h basis in order to assure good passage.

Use of video time-lapse photography proved to be a good method for estimating returns of salmonines. In past years, fish were passed only when the ladder operator was on site to conduct manual counts. Now, time-lapse filming can take place continuously, improving fish passage counts and counting capabilities. owever, reading

tapes can be time consuming, depending on how many fish are on a tape and the recording mode. In 1992, tape reading ranged from 1 - 7.5 h per tape. An image processing system (Hatch et al. 1993) that compresses tapes to remove blank frames and yield only frames that have fish may reduce tape-reading time significantly.

It is very unfortunate that video recording of fish passage at Berrien Springs could not take place until 7 October. This prevented us from making many comparisons between ladder usage for the full fall season. Only a small amount of time was spent making manual counts from 11 September to 6 October due to construction activities. Undoubtedly some portion of the September and early October run was missed.

The only major problem encountered with using video taping to evaluate run strength was the discrepancy between chinook salmon totals at Niles and South Bend. There are four possible explanations for this. One possible reason is that by using the 72-h mode at Niles, some fish may have been missed. Fish passing the Niles viewing window had a tendency to move through much quicker than at Berrien Springs. Generally, fish that were seen and counted using the 72-h mode gave the viewer a minimum of only 2 frames of tape to view the fish. A second explanation may be that some fish were misidentified during turbid water conditions. Thirdly, there is about a 7-in gap between the bottom of the viewing window and bottom of each ladder, and many times fish passed along the bottom and only half or less of a fish could be seen on tape. Smaller fish could escape video detection along the bottom, especially in turbid conditions. This potential problem will be overcome in 1993 as metal ramps have been placed on the ladder floor in front of the window at each ladder to force fish into the camera's view. Finally, some chinook salmon at South Bend may return over the dam after passing through the ladder or through the East Race (a kayak course) and may ascend the ladder a second time, although this seems unlikely. Chinook salmon were unable to pass the Niles dam without going through the ladder.

One final problem encountered at the Berrien Springs ladder had to do with hydraulic conditions directly upstream of the viewing window. The hydraulics at the window are quite laminar, but directly upstream of the window flow becomes very turbulent and confusing to the fish. Many fish hesitated for hours before passing through the turbulence. This caused the tape reviewers significant problems as fish would drift back and forth across the window. The cement baffles, located just above the viewing window (designed to break up the flow), have been removed and replaced with wooden baffles that can be adjusted to different heights. This may alleviate future problems with fish hesitating in front of the window, and will be tested in 1993.

Distribution of salmonines throughout the 63-mile stretch indicates that the majority of fish passing into Indiana originated from Indiana stockings (based on fin clip observations from the creel census). The majority of brown trout and steelhead that passed the Berrien Springs ladder did not pass the Niles ladder. With chinook salmon, it is unclear what proportion of the fish returning to Indiana were of Indiana or Michigan origin. These fish, along with coho salmon, are readily available to anglers, but in 1992 little fishing effort was expended between Berrien Springs and Niles.

Passage of warmwater and coolwater species was very low, and was not tabulated before 1992. Objectives for 1993 include comparison of the accuracy of the 48- and 72-h modes at the three ladders, testing of attraction water and its effect on passage at Niles and South Bend, and testing the new baffle system at Berrien Springs.

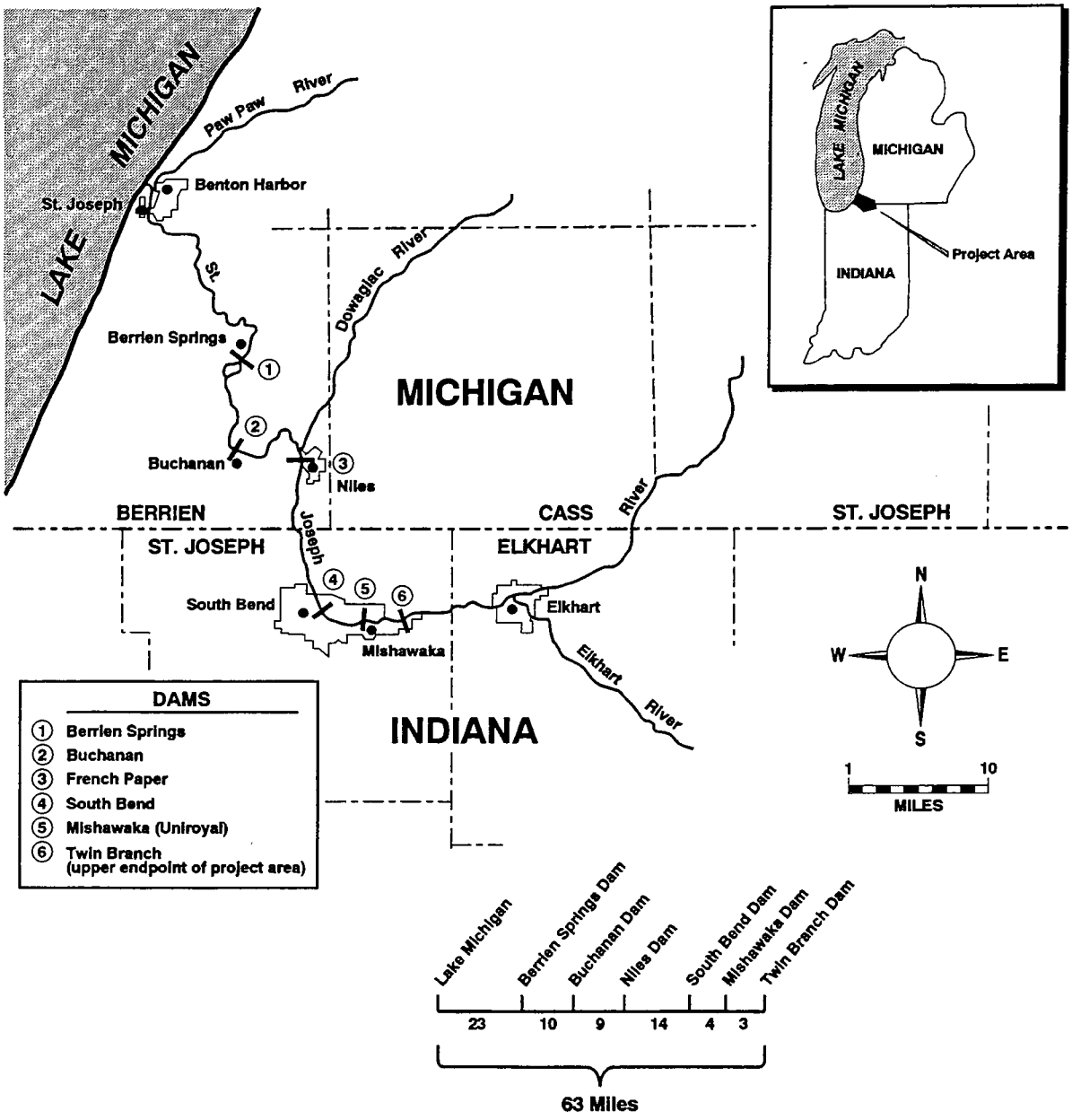


Figure 1.—Project vicinity map.

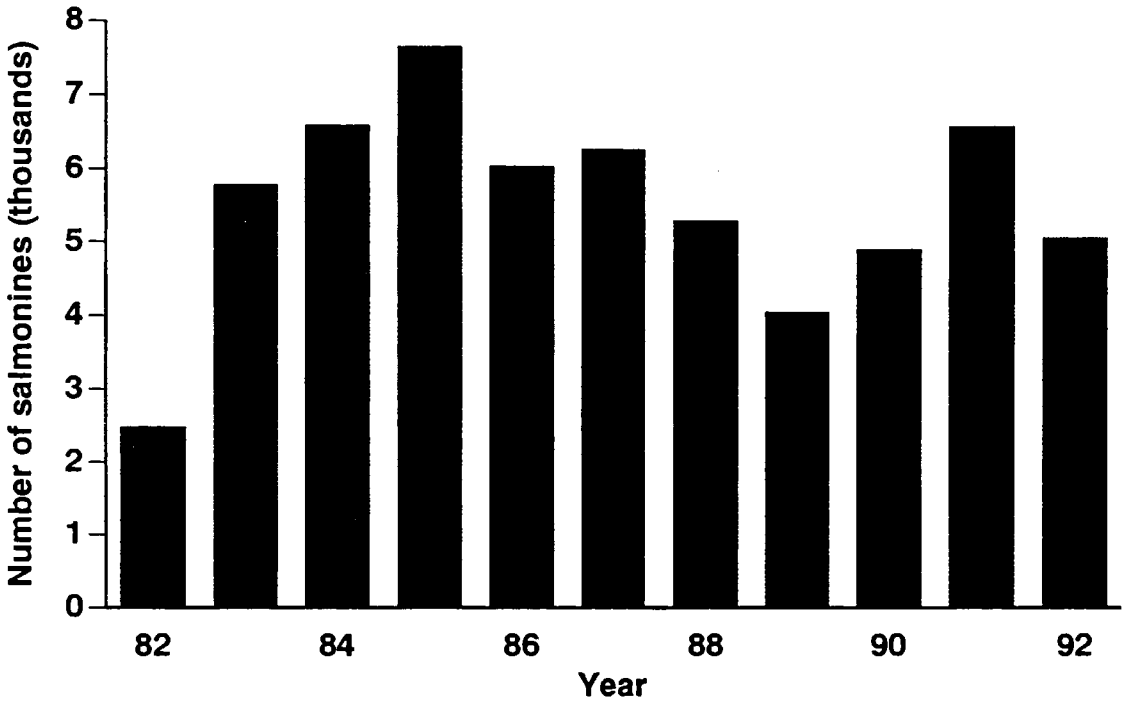


Figure 2.—Total fall passage of all salmonines at the Berrien Springs fish ladder, 1982-1992. Results were tabulated from part time manual passage and counts during 1982-1991, as well as 24-hour passage and time lapse video recorded counts in 1992, although fish passage from 12 September through 6 October was only partially counted.

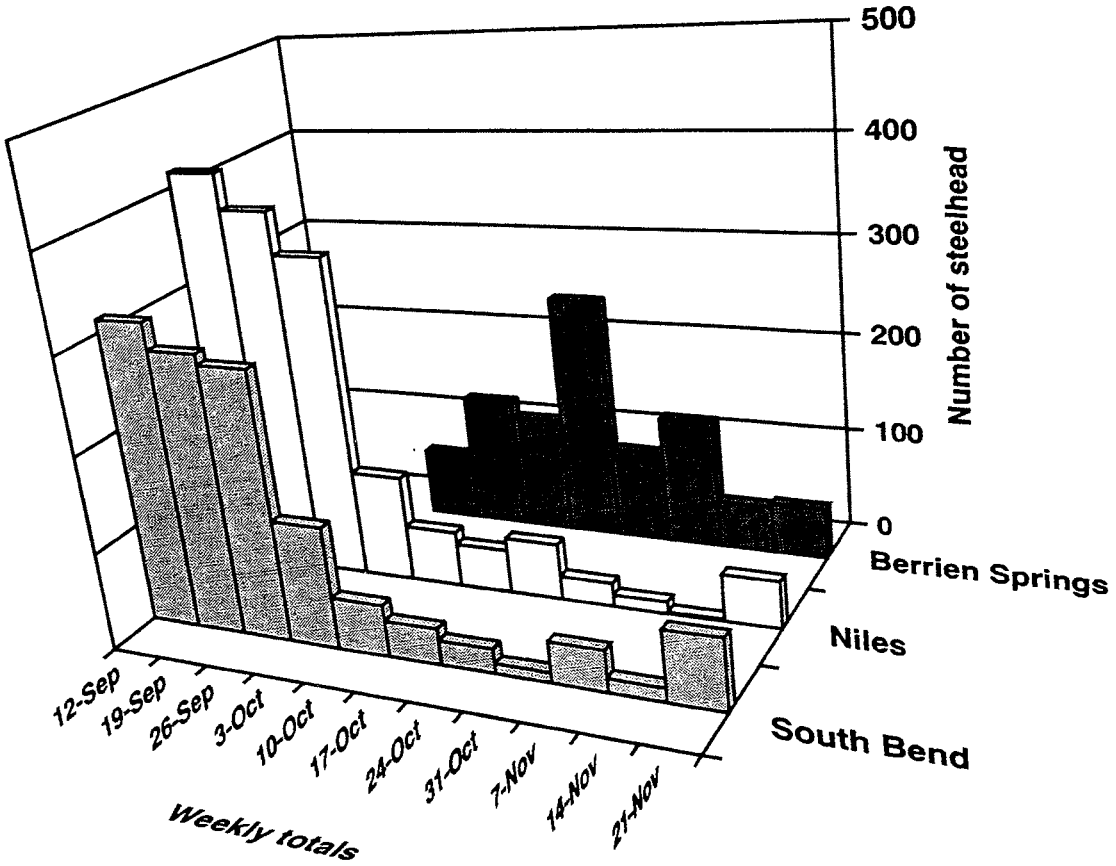


Figure 3.—Weekly movements (total passage) of steelhead through the Berrien Springs, Niles, and South Bend fish ladders, fall 1992, as estimated using video recordings.

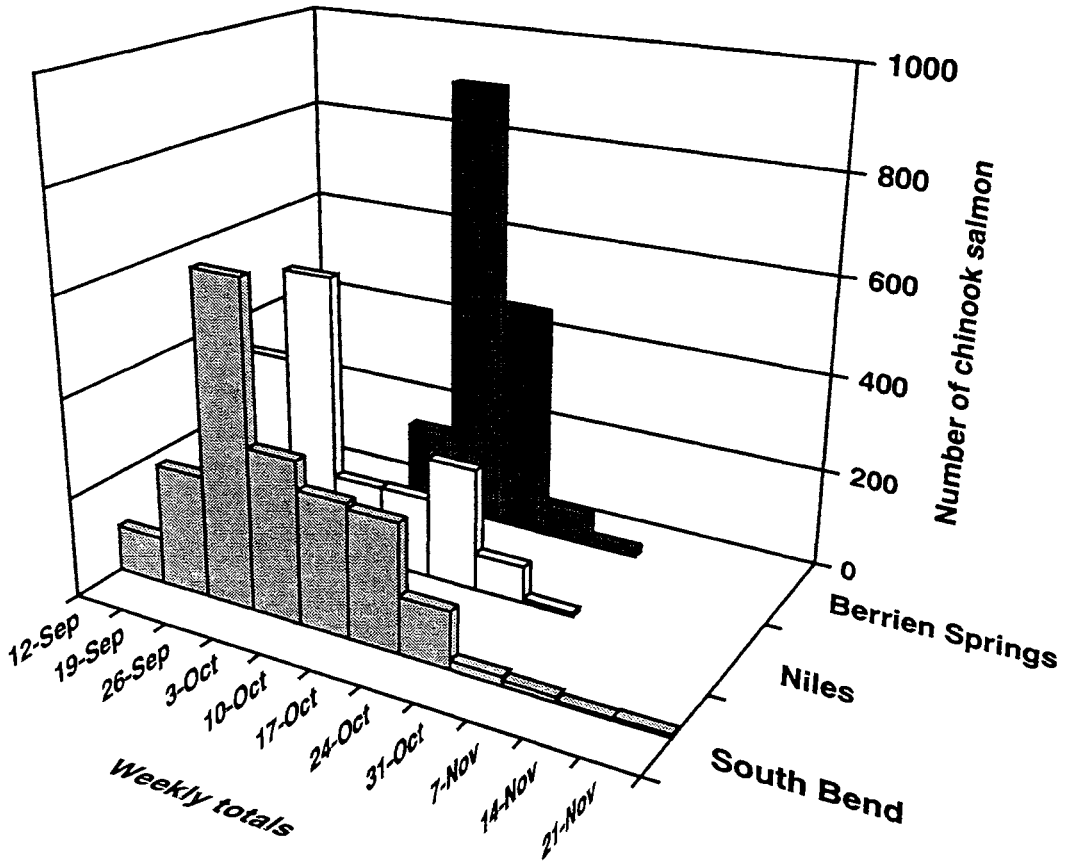


Figure 4.—Weekly movements (total passage) of chinook salmon through the Berrien Springs, Niles, and South Bend fish ladders, fall 1992, as estimated using video recordings.

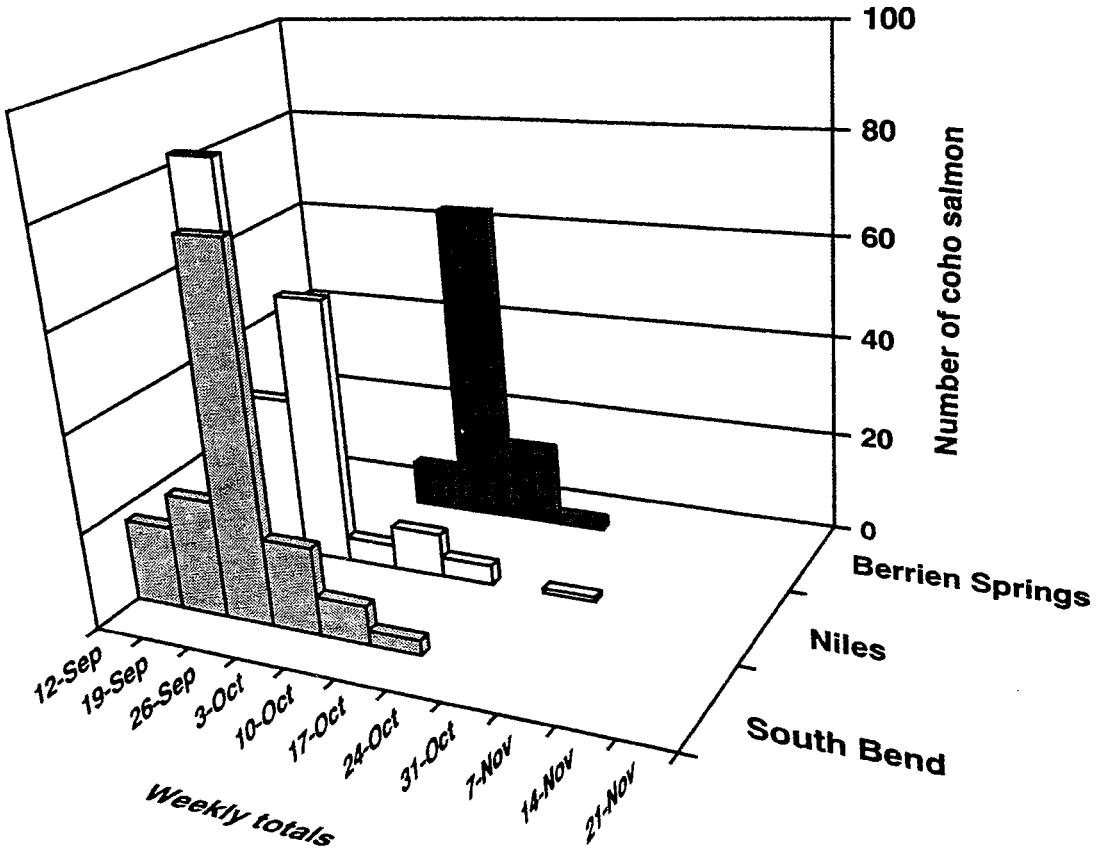


Figure 5.—Weekly movements (total passage) of coho salmon through the Berrien Springs, Niles, and South Bend fish ladders, fall 1992, as estimated using video recordings.

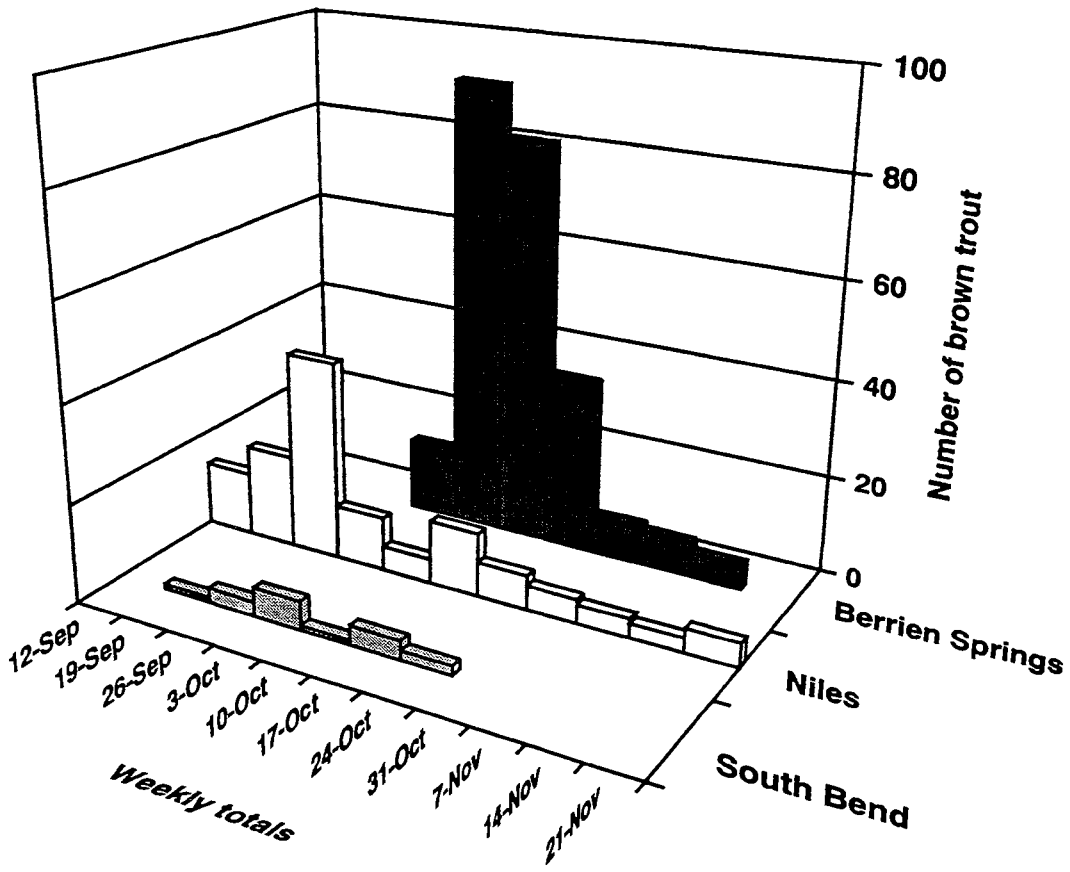


Figure 6.—Weekly movements (total passage) of brown trout through the Berrien Springs, Niles, and South Bend fish ladders, fall 1992, as estimated using video recordings.

Table 1.—Equipment used in the evaluation of fish passage at the Berrien, Niles, and South Bend fish ladders.

Item	Make	Model
Color camera with 8mm lens	Panasonic	WV-CL700
Time-lapse VCR	Panasonic	AG-6720
Viewing VCR	Panasonic	AG-1960
Monitor for camera	Panasonic	CT-1382Y
Monitor for tape viewing	Panasonic	CT-2082Y
VHS Video tape	Panasonic	NVT120PSD
Tripod	Bilora	6135
Viewing window lighting (a,b)		(8) 150 watt flood
Viewing window lighting (c)		(1) 150 watt flood
Backlighting (a,b) (with diffuser panel)		(8) High Output 4 foot fluorescent
Backlighting (c) (without diffuser panel)		(4) High Output 4 foot fluorescent

a,b = Berrien Springs and Niles dams
c = South Bend dam

Table 2.—Time periods and dates where no recording took place at each ladder.

Ladder and date	Down Time (h)	Reason
Berrien Springs		
27-28 Oct	19	Recorder malfunction (fish passage blocked for 18 of 19 hours)
Niles		
13-14 Sep	25	Programming error
25 Oct	7.5	Power outage
South Bend		
16 Sep	8	Manpower shortage
17 Sep	24	Manpower shortage
18 Sep	12	Manpower shortage
21 Sep	12	Manpower shortage
27 Sep	7	Manpower shortage
28 Sep	13	Manpower shortage
4 Oct	8	Manpower shortage
5 Oct	10	Manpower shortage
16 Oct	4	Manpower shortage
2 Nov	8	Manpower shortage

Table 3.—Fish passage at Berrien Springs, Niles, and South Bend dams as determined by video time-lapse recording, Fall 1992. Numbers in parenthesis below Berrien Springs counts are total counts that include manual estimates made between 11 September and 6 October 1992.

Species	Berrien Springs	Niles	South Bend
Rainbow trout	891 (2,371)	1,540	1,245
Chinook salmon	1,633 (2,049)	1,771	1,995
Coho salmon	84 (149)	193	146
Brown trout	253 (481)	127	17
Walleye	0 (12)	1	0
Smallmouth bass	3 (5)	4	0
Channel catfish	0 (1)	0	0
Carp	2 (3)	2	0
Suckers	4 (9)	9	0
Largemouth bass	0	1	0
Brook trout	1	0	0

Table 4.—Daily counts of fish passage and water temperature (0800) at the Berrien Springs ladder, Fall 1992, using video recording. Manual counts done 11 September through 6 October were not complete counts of a 24-h period.

Date	Rainbow trout	Chinook salmon	Coho salmon	Brown trout	Walleye	Small-mouth bass	Channel catfish	Carp	Suckers	Other species	Temp
11 Sep	440	61	6	71	2						
12 Sep	559	45	11	24	4	1	1		1		66
13 Sep	167	6	1	3	1						66
14 Sep	46	4		13		1					67
15 Sep	27	1	3	9	2						68
16 Sep	13	2	1	2							68
17 Sep											69
18 Sep	82	20	11	3							70
19 Sep	23	22	10	21							68
20 Sep											67
21 Sep											66
22 Sep	47	61	4	47							66
23 Sep	21	16	1	13	2						63
24 Sep	23	106		4					4		63
25 Sep	5	22	1	8							61
26 Sep		3		1							62
27 Sep		6		1							61
28 Sep											60
29 Sep											59
30 Sep	15	20	6	7	1						58
1 Oct											57
2 Oct	2	2	1								58
3 Oct											
4 Oct											
5 Oct	3	3	1								60
6 Oct	7	16	8	1							59
7 Oct	33	49	3	3		1					59
8 Oct	12	59	4	5							60
9 Oct	25	63	2	7							58
10 Oct	5	16	3	8							57
11 Oct	17	90	16	12							58
12 Oct	4	73	2	7							56
13 Oct	13	65		10					1		55
14 Oct	2	13	2			1					55
15 Oct	20	14		6							57
16 Oct	73	640	32	59					1		56
17 Oct	53	239	7	37							55
18 Oct	22	80	5	12							53
19 Oct	12	66	4	26					1		52
20 Oct	12	48		4							50

Table 4.—Continued:

Date	Rainbow trout	Chinook salmon	Coho salmon	Brown trout	Walleye	Small-mouth bass	Channel catfish	Carp	Suckers	Other species	Temp
21 Oct		9		1							50
22 Oct	12	16		2							49
23 Oct	7	19		0							51
24 Oct	37	13		6							53
25 Oct	24	11	1	6							53
26 Oct	36	11	1	1					1		52
27 Oct	27	7									50
28 Oct	52	8		11							50
29 Oct	25	4		7							52
30 Oct	48	5		5							52
31 Oct	15			2							50
1 Nov	6										48
2 Nov	6	1		1							50
3 Nov	34	13		3							50
4 Nov	21	1		1							48
5 Nov	7			1							46
6 Nov	3										45
7 Nov	7										45
8 Nov	6										44
9 Nov	23			1							44
10 Nov	12			1		1					45
11 Nov	17			2							46
12 Nov	26		2								48
13 Nov	39			1				1		1	46
14 Nov	4			1							43
15 Nov	8										42
16 Nov	2			1							42
17 Nov	5			1							42
18 Nov	7			1							41
19 Nov	1			1							40
20 Nov	20										41
21 Nov	9										44
22 Nov	16										44
23 Nov	15										44
24 Nov	5										45
25 Nov	6										45
26 Nov											
27 Nov											
Total	2371	2049	149	481	12	5	1	3	9	1	

Table 5.—Daily counts of fish passage at the Niles fish ladder, Fall 1992, using video recorder.

Date	Rainbow trout	Chinook salmon	Coho salmon	Brown trout	Walleye	Small-mouth bass	Suckers	Carp
12 Sep	7	3						
13 Sep	75	10	3					
14 Sep	87	2	8					
15 Sep	63	4	25	4			1	
16 Sep	114	8	20	3		1		
17 Sep	80	42	20	3		1	2	
18 Sep	51	86	10	3		1	1	1
19 Sep	77	64	10	1		1		
20 Sep	47	29	4	3	1			
21 Sep	28	20	2					
22 Sep	40	21	3	1				
23 Sep	44	19	1	5				
24 Sep	86	119	9	8			3	
25 Sep	56	117	4	1				
26 Sep	46	148	0	10				
27 Sep	92	84	5	11			1	
28 Sep	60	49	20	3				
29 Sep	43	97	10	4				
30 Sep	25	58	5	2				
1 Oct	40	73	9	5				
2 Oct	28	66	6	6				
3 Oct	18	22		4				
4 Oct	39	27	2	4				
5 Oct	16	17	2				1	
6 Oct	10	26						
7 Oct	13	31		2				
8 Oct	6	23	1	1				
9 Oct	6	15						
10 Oct	7	40	1					
11 Oct	9	29		1				
12 Oct	3	17	5					
13 Oct	6	31	1	3				1
14 Oct	5	19						
15 Oct	10	13						
16 Oct	15	13	2	1				
17 Oct	11	79		4			1	
18 Oct	15	85	4	5				
19 Oct	9	38		1				
20 Oct	4	6						

Table 5.—Continued:

Date	Rainbow trout	Chinook salmon	Coho salmon	Brown trout	Walleye	Small-mouth bass	Suckers	Carp
21 Oct	1	14		1				
22 Oct	2	13		1				
23 Oct	2	12		1			1	
24 Oct	1	6						
25 Oct	2	11						
26 Oct	7	19						
27 Oct	4	10		2				
28 Oct	18	7		1				
29 Oct	11	7		3				
30 Oct	15	15		1				
31 Oct	8	1	1	2				
1 Nov	6							
2 Nov								
3 Nov	1			1				
4 Nov	1			2				
5 Nov	2	3						
6 Nov	6	3		1				
7 Nov	1							
8 Nov								
9 Nov	1			1				
10 Nov								
11 Nov	10			1				
12 Nov				2				
13 Nov								
14 Nov								
15 Nov				1				
16 Nov	1			1				
17 Nov				1				
18 Nov								
19 Nov	1							
20 Nov								
21 Nov								
22 Nov								
23 Nov	18			1				
24 Nov	13			3				
25 Nov	13			1			1	
26 Nov	3							
27 Nov	1							
Total	1540	1771	193	127	1	4	12	3

Table 6.—Daily counts of fish passage at the South Bend ladder, Fall 1992, using video recording.

Date	Rainbow trout	Chinook salmon	Coho salmon	Brown trout
12 Sep				
13 Sep				
14 Sep	67	13		
15 Sep	70	15	1	
16 Sep	54	12	7	
17 Sep	58	21	5	
18 Sep	64	31	4	
19 Sep	40	23	8	
20 Sep	42	49	2	
21 Sep	57	33	6	
22 Sep	24	29	2	
23 Sep	26	15	0	
24 Sep	44	42	2	1
25 Sep	52	53	4	
26 Sep	31	107	16	
27 Sep	36	129	16	
28 Sep	45	94	16	
29 Sep	42	81	12	1
30 Sep	49	88	10	1
1 Oct	48	75	2	
2 Oct	23	81	4	1
3 Oct	31	70	5	
4 Oct	27	53	2	1
5 Oct	16	49	4	
6 Oct	20	36	2	
7 Oct	13	49	4	1
8 Oct	2	25		2
9 Oct	14	44	1	2
10 Oct	15	62	3	1
11 Oct	5	51	1	
12 Oct	2	35	1	
13 Oct	4	54	3	
14 Oct	9	27		
15 Oct	10	16		
16 Oct	8	23		
17 Oct	1	20		
18 Oct	0	39		
19 Oct	21	84	3	2
20 Oct	5	53		1
21 Oct	5	31		1
22 Oct	2	7		

Table 6.—Continued:

Date	Rainbow Trout	Chinook Salmon	Coho Salmon	Brown Trout
23 Oct	3	23		
24 Oct	2	19		1
25 Oct	2	19		
26 Oct	5	17		
27 Oct	3	22		
28 Oct	5	18		1
29 Oct	6	17		
30 Oct	2	2		
31 Oct		1		
1 Nov	2	2		
2 Nov	2	6		
3 Nov		3		
4 Nov				
5 Nov		1		
6 Nov	6	5		
7 Nov	3	2		
8 Nov	3	3		
9 Nov	1	4		
10 Nov	8	1		
11 Nov	9			
12 Nov	17	1		
13 Nov				
14 Nov				
15 Nov				
16 Nov				
17 Nov	1	1		
18 Nov	3	1		
19 Nov	2	1		
20 Nov	8	1		
21 Nov	6			
22 Nov	7	1		
23 Nov	13	1		
24 Nov	7	1		
25 Nov	13			
26 Nov	14	3		
27 Nov	6			
28 Nov	3			
29 Nov	1			
30 Nov				
Total	1245	1995	146	17

Table 7.—Daytime passage (0800 to 2000) of salmonids (by percent) at each ladder by species.

Species	Berrien	Niles	South Bend
Steelhead	82.2	79.4	73.1
Chinook	71.1	85.0	65.8
Coho	78.7	89.0	70.6
Brown trout	69.2	75.4	82.3

References

Anonymous. 1988. St. Joe River Fishery Agreement between the State of Michigan and the State of Indiana. Michigan Department of Natural Resources, Lansing.

Brown, C.J.D. 1944. Michigan streams - their lengths, distribution and drainage areas. Miscellaneous Publication 1, Institute for Fisheries Research, Ann Arbor.

Hatch, D.R. 1990. Wenatchee River salmon escapement estimates using video tape technology in 1989. Columbia River Inter-tribal Fish Commission, Technical Report 90-4. Portland, Oregon.

Hatch, D.R., A. Wand, D. Pederson, and M. Schwartzberg. 1993. The feasibility of documenting and estimating adult fish passage at large hydroelectric facilities in the Snake River using video technology. Annual Report 1992. United States Department of Environment, Bonneville Power Administration, Department of Fish and Wildlife, Portland, Oregon.

James, W.D., D.E. Reynolds, and B. Fuchs. 1980. Environmental impact statement. A cooperative Indiana-Michigan anadromous fisheries program for the St. Joseph River, St. Joseph County, Indiana and Berrien County, Michigan. Indiana Department of Natural Resources, Indianapolis.

Johnson, D.C., and J.G. Hnath. 1991. Lake Michigan chinook salmon mortality-1988. Michigan Department of Natural Resources, Fisheries Technical Report 91-4, Ann Arbor.

Stewart, D.J., and M. Ibarra. 1991. Predation and production by salmonine fishes in Lake Michigan, 1978-1988. Canadian Journal of Fisheries and Aquatic Sciences 48:909-922.

Report approved by Paul W. Seelbach
James S. Diana, Editor
Paul W. Seelbach, Editorial Board Reviewer
Alan D. Sutton, Graphics
Kathryn L. Champagne, DTP