Original: Fish Division ✓
cc: Education - Game
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March 14, 1951

Report No. 1280

EXPERIMENTAL OPERATION OF BLACK RIVER SEA LAMPREY BARRIER DAM 1950

By
Thomas M. Stauffer

ABSTRACT

The Black River barrier dam is located on the Black River, 3/4 mile from the mouth, in Mackinac County. It was constructed of wood, with the exception of the lip of the dam, which was of 1/4 inch steel.

The purpose of this dam was to experiment in attempting to prevent sea lampreys from reaching their spawning grounds, and at the same time, not block the rainbow run. The lip of the dam was constructed especially to achieve this purpose. This steel lip consisted of a 9 inch radius half circle hanging over downstream. The overhanging lip presumably would block the sea lamprey, which are not noted for their jumping ability, yet permit the high jumping rainbow trout to surmount it.

During the spring of 1950, the success of this structure in fulfilling its purpose was investigated. This was done by direct observations of sea lampreys and rainbow trout at the dam. In addition a checking weir was constructed a short distance upstream from the dam. This checking weir would conceivably catch all lampreys and fish which succeeded in getting over the dam.

The large numbers of sea lampreys taken in the upstream weir trap indicate that the sea lampreys were successful in penetrating the barrier dam. The method of penetration is believed to lie by way of cracks in the dam itself and channels cut around and under the structure. Channels were obviously present, as witness the continual cave ins and washouts. Three sea lampreys were found in cave ins behind the bulkheads which show that at least some sea lampreys were using these channels to escape upstream. That cracks as small as 1/2 to 3/4 inch can be used as a route of escape is shown by the discovery of 4 adult sea lampreys wedged in a crack a little over 1/2 inch. The belief that cracks and channels were the route of escapement is further supported by the observation period of 64 hours. During this time only one sea lamprey was noted to escape over the steel lip. This was during abnormal conditions. Since the steel lip is eliminated as a route of escapement, it leaves channels and structural failures as the only avenues of passage.

The small number of rainbow trout observed at the barrier dam indicate that, although they may have some difficulty, the majority of adult rainbow trout can surmount the dam. The limiting factor appears to be the swift current at the top of the lip. If the smaller fish observed could be definitely identified as rainbow trout, it would appear that smaller trout might have great difficulty.

Smelt were present in large numbers below the dam, but none were observed above. At this time the by-pass was open. Because of their observed poor jumping ability, it is quite apparent that smelt will be blocked by this type of dam.

Sturgeon (black) suckers were not observed to jump more than 1 1/2 feet clear of the water. The lip apparently constituted a barrier to them.

Although white (common) suckers were getting through the dam, it is thought that they followed the same route as did the sea lampreys. None were seen even attempting to ascend the lip. Those observed jumping in the trap showed no aptitude.

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Introduction

The experimental sea lamprey barrier dam is located in T. 43 N., R. 8 W., S. 29, Mackinac County. It is situated about 3/4 mile upstream from the mouth of the Black River in a location that has 5- to 10-foot partially wooded banks. The bottom material at this point is sand. The Black River was selected for this experiment because of the known heavy upstream migration of sea lampreys and rainbow trout.

The barrier dam was first put into operation on May 15, but continual operation was not initiated until May 24. The experimental operation was terminated abruptly on the 26th of June by a period of exceedingly high water which rendered the dam unserviceable. During the period of 32 days when the barrier dam was not in operation, sea lampreys and suckers were very actively migrating upstream and rainbow trout activity was limited.

Purpose of Barrier Dam

The purpose of this dam is, and I quote a letter of April 25, 1950, from Dr. Hazzard to me; "First to ascertain if a dam such as the Black River structure with a curved steel lip will effectively block sea lampreys

from migrating upstream. Second, how high must such a dam be to constitute a barrier? We wish to find out what is the lowest possible dam of this type which will block the sea lampreys. Third, does this barrier dam, at any given height, partially or entirely block the upstream migration of food and game fish? Briefly then, we wish to establish the characteristics of a dam which will be high enough and of a nature which will block spawning run sea lampreys, yet will permit lake-run rainbow trout to clear it and reach their spawning grounds."

Construction of Dam

The Black River barrier dam was designed with the previously mentioned purposes in mind. It was constructed entirely of wood, with the exception of the curved steel lip. The cost of the structure was $3,460.48. Exceedingly high water made the construction very difficult. That a better understanding of the structure might be had, a plan view and cross-sectional view are presented.

The east and west bank walls (bulkheads) were constructed with tongue and groove 1 1/4 inch sheet piling driven 4 feet into the river bottom. These walls were braced by 6 x 6 inch planks nailed horizontally to the inside top of the sheet piling. Both the east and west wall, at their extreme upstream and downstream ends, turn and extend into the bank. The open space behind these walls, was filled with sand and clay to the level of the top of the sheet piling.

The face of the dam was built of a double row of tongue and groove 1 1/4 inch sheet piling. A box-like platform was constructed on top of the double row of sheet piling for added strength, and to which the steel plates were bolted. The plates were bolted to the downstream side. These plates constituted the lip of the dam. They were 1/4-inch steel and the curved lip consisted of a 9 inch radius half circle. These plates were adjustable as to height over a 1-foot range.

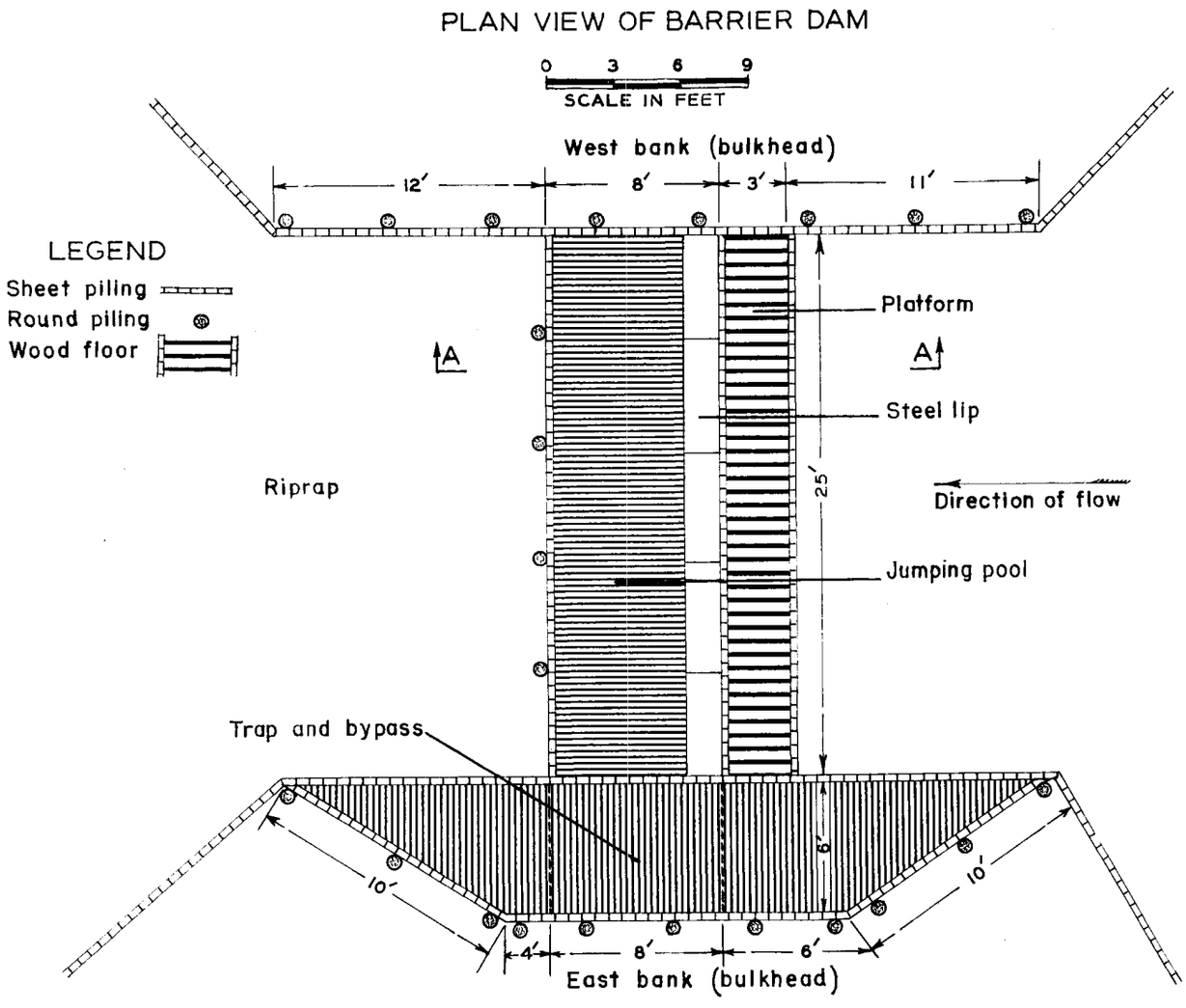

PLAN VIEW OF BARRIER DAM
0 3 6 9
SCALE IN FEET
West bank (bulkhead)
12′
8′
3′
11′
LEGEND
Sheet piling
Round piling
Wood floor
A
A
Platform
Steel lip
Riprap
25′
Direction of flow
Jumping pool
Trap and bypass
10′
6′
10′
4′
8′
6′
East bank (bulkhead)

Figure 1

SECTION VIEW OF BARRIER DAM
SECTION A-A

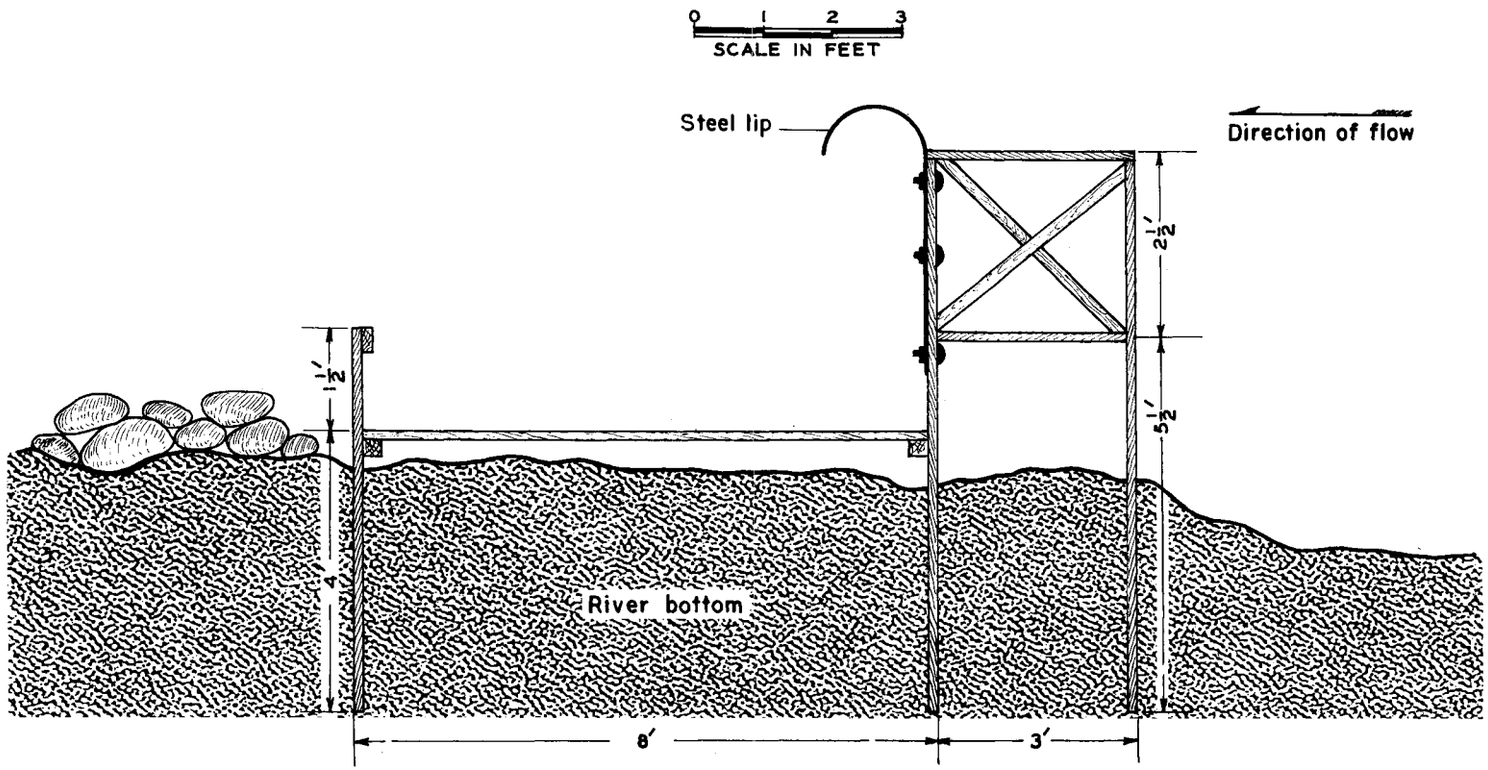


Figure 2

Immediately downstream and under the curved steel lip was the jumping pool. This was designed to insure an adequate depth of water for the rainbow trout to jump from. This pool has a wooden floor. The depth of water in this pool varied from 19 to 34 inches, depending on the level of the river. In the period May 18 to June 7 the jumping pool water depth was 20 to 24 inches. June 7 a 6-inch plank was added to the downstream wall and consequently the depth increased 6 inches. After this date the water depth in the jumping pool hovered around 27 inches.

Adjoining the jumping pool on the east side was the trap and by-pass. These, too are floored. The upstream and downstream walls of the trap are indicated by a broken line in the plan view. The planks (splash boards) making up the walls can be removed, thus converting the trap into a by-pass. When these splash boards are removed, the impoundment empties rapidly, and soon all the flow is through the by-pass. That is, if there is not too much water in the river. The by-pass is completely floored to the points of the east bulkhead. In the middle wall of the dam, which is the west wall of the trap, is the entrance to the trap. On May 29 a wire funnel was attached to the inside of the hole. This would prevent escapement of upstream migrants, when they found themselves in the trap. In operation, a small amount of water was let into the trap over the upstream wall. This water flowed out of the entrance of the trap, where presumably it would attract upstream migrants.

Advantages of Dam

At this point I might mention the possible advantages a structure such as the Black River barrier dam would have over a V-type sea lamprey weir as a barrier to spawning sea lampreys. Number one advantage would be the man hours saved in maintenance. A barrier dam would not require any more than

casual care once it was installed. While a sea lamprey weir requires continual care when it is in operation. Secondly, the barrier dam would be relatively permanent, which would eliminate difficult spring installation. A disadvantage of the barrier dam might be the prevention of valuable food and game fish from reaching their spawning grounds. However, these fish could be trapped below the dam and released upstream with a small fraction of the time required to care for a weir.

Checking Weir

In addition to the barrier dam, another structure was constructed on the Black River. This was a checking weir located 200 to 300 yards above the barrier dam. This structure was in operation from the night of May 27 to November 24. It was constructed as a check on the effectiveness of the barrier dam. Any upstream migrant which was not blocked by the barrier dam would conceivably be taken in this weir. However, there are two factors which precluded a 100 percent capture of escapees. The most obvious was the frequent undercutting of the screens and sill. This was twice present during the operation of the barrier dam. There was a large hole under the center of the weir from May 31 to June 12 and on June 26. Through these holes it is estimated that there was 50 ± 10 percent escapement. Secondly, there was a small tributary entering the Black River between the barrier dam and the checking weir. Undoubtedly some fish went up this stream. I believe that this escapement was small since the tributary was not more than 3 feet wide at the mouth and within 1/2 mile narrowed down to about 1 foot. There was probably not much, if any, spawning area in this stream.

The checking weir was constructed by the U. S. Fish and Wildlife Service. The details of construction are similar to those of a V-type sea lamprey weir. That is, with a sill laid directly on the bottom and the screens placed on

the sill and braced with steel fence posts. The checking weir was not the V-type but was strung diagonally across the river with a trap at either bank. Thus it could take both upstream and downstream migrants.

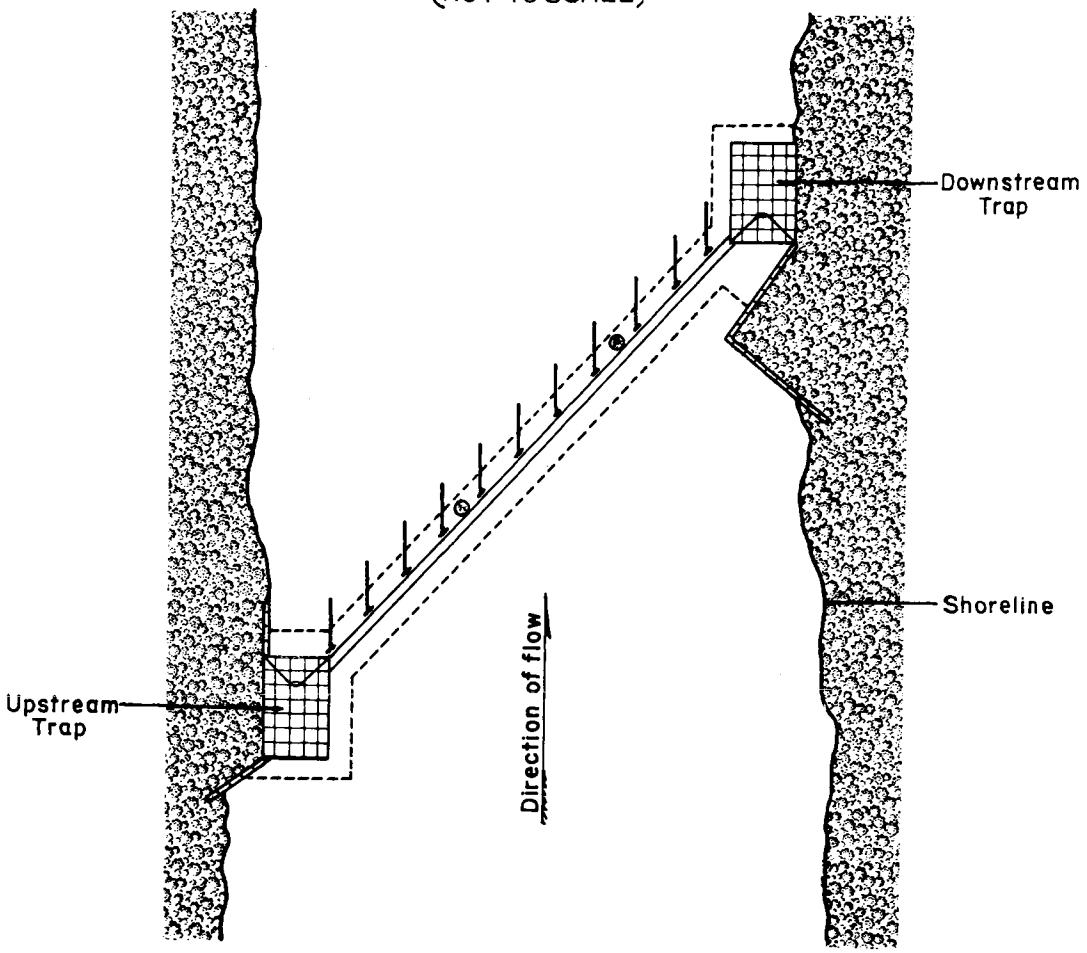
Observation Period - With Special Reference to the Sea Lamprey

The night observation period was initiated on May 9, when the by-pass was still open and one steel plate was not yet in place. This was the condition of the dam until May 13 when the dam was put into operation. The position of the observer was on the lower east bulkhead. From this place a clear view of the falls was obtained, with the exception of the plate next to the trap. Two Coleman single mouth lanterns provided illumination for all night observation. These were hung to the walls about 5 feet downstream on either side of the falls. The position mentioned was held until May 13, when my attention was called to the portion of the lip where the plate was missing (extreme west side). Here fishermen had noticed rainbow trout going up, so the point of observation was changed to a position directly above the point where the plate was missing. This remained the observation post until May 30. Then, in order to observe activity in the trap, the observation point was changed back to the lower east bulkhead. Also, at this time the lantern on the middle wall (east side of falls) was hung in the trap. This position was held until the dam was partly washed out on June 26, whereupon formal observation ceased.

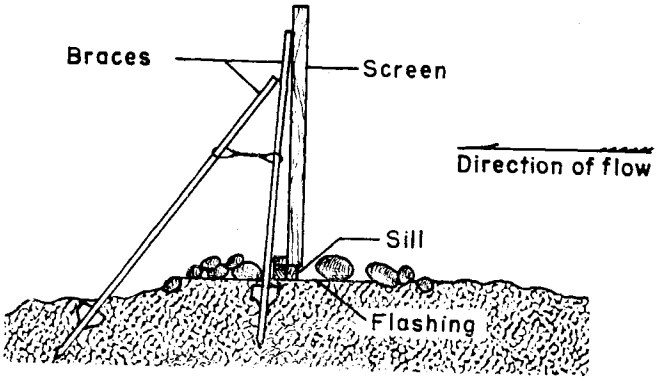
At first, the observation procedure was as follows: the falls, jumping pool, and the steel lip were observed carefully from the observation post and every half hour an inspection tour was conducted of vital points. Vital points included: (1) the walls where the plates meet it, (2) the platform, (3) the lower east and west bulkhead, (4) the trap and (5) the steel lips. The preceding procedure was followed until June 14 when it was modified slightly. Vital points were checked every 15 minutes. Several observable leaks had developed and these and an area a short distance above the dam were added to the points checked.

CHECKING WEIR

DIAGRAMMATIC PLAN VIEW
(NOT TO SCALE)



SECTIONAL VIEW



LEGEND

Sheet piling
Round piling
Edge of flashing ----

Figure 3

The areas of concentration of sea lampreys observed during 65.4 hours of observation time are quite well defined. These areas are listed in order of decreasing concentration: (1) the floor of the by-pass below the trap, (2) the trap itself and (3) the west bulkhead where the lower jumping pool wall meets it. Sea lampreys were seen at other points but not in large numbers. Several were seen to ascend the downstream wall of the jumping pool, and many more must have done so since the entrance to the trap opens on the jumping pool. Those seen in the jumping pool were observed clinging to the west bulkhead and to the middle wall (east wall of jumping pool).

The behavior of the sea lampreys below the dam was somewhat standardized. The first habit of the sea lamprey noted was that of seeking out leaks in the dam from which small currents were issuing. This was especially noted on the night of May 21 when an attempt was made to capture a few lampreys with a spear. It was interesting to note how the lampreys would seek out the places where the dam was leaking and attempt to get upstream. On this particular night the by-pass was open and there were small leaks between the west bulkheads and the floor of the trap and a small current issuing from between the floor boards of the jumping pool. Also there was a strong current coming from the entrance to the trap which extended half way across the jumping pool. The sea lampreys tended to concentrate around those currents, most being observed close to the entrance to the trap. It is of interest to note that the immediate area around these leaks was alive with American brook lampreys.

Another indication of the attraction of small currents is seen by the heavy concentration of sea lampreys on the by-pass floor downstream from the trap. During most of the observation period water was flowing from between and under the downstream splash boards and from between the east bulkhead wall and the floor. Many sea lampreys were observed trying to penetrate the dam at this point. On one occasion a sea lamprey was seen to dive into one of the leaks. It was not seen to come out.

The observations made indicate that the jumping ability of the sea lamprey is about nil. One procedure of "jumping" is as follows: a sea lamprey would be attached to a vertical surface with the point of attachment 2 to 4 inches out of water. Suddenly it would release its hold and attempt to swim or jump straight up. Seldom could they clear the water by this method. Although no sea lampreys were observed in the proximity of the steel lip early in the season, some sea lampreys were observed attempting to jump the lip on June 26. When migration hit its peak, behavior was more active even including the daylight hours. The only date upon which this was observed was June 26. The by-pass was open and water was still going over the steel plates. There was a large boil of water in the jumping pool next to the west bulkhead where two floor boards were missing. One sea lamprey was observed to jump from the top of the boil to the lip and thus escaped upstream. It is estimated that the distance between the boil and the lip was not more than 1nfoot. The sea lampreys were very active on this date and many jumped clear of the water. It is not known whether this was a vertical or horizontal movement. Details are not available since I was not present on the 26th and Mr. Hanson's notes are brief. As mentioned previously others attempted to jump the falls on the 26th but as before further details are not available.

Almost half of the sea lampreys observed were fastened to some object, most of those seen were attached to the vertical walls composing the dam. They were usually attached some 2 to 4 inches above the water line. The highest point of attachment observed was 2/3 of this particular lampreys length out of water. This would be anywhere from 6 to 16 inches. It is thought that this sea lamprey arrived at this position by the jumping procedure described previously. Nine sea lampreys were observed to jump up a vertical wall and attach themselves 2 to 4 inches above the water line.

The observation period indicates that the steel lip was successful in preventing the sea lampreys from going over the face of the dam. The one sea lamprey which was observed escaping over the plates did so during abnormal conditions. However, I wonder if the steel lip would prove to be a barrier if there were no other avenues of escape upstream. It would seem that the longer the sea lampreys were held below the dam, the more powerful would become the spawning urge and consequently their desire to surmount the dam. It was noticed that the sea lampreys were much more active late in the season than during the early part.

Escapement Through By-pass

At one time it was thought that many sea lampreys escaped upstream through the by-pass when it was open during the day for repairs. It was believed that the sudden release of water might stimulate the lampreys into active movement. This theory has little substantiation other than the observations of June 16 when the sea lamprey were active when the by-pass was open. Two were seen in the trap 1/2 hour after the by-pass was closed and 1 was seen immediately upstream from the by-pass during repairs. However, there is no apparent correlation between the open by-pass and the upstream weir catch of lampreys except with a rise in temperature. It appears that the open by-pass was not an important avenue of escape during daylight hours. Probably some numbers of suckers and rainbows escaped through the open by-pass, since on occasion they were active in the late afternoon.

Experimental Operation - With Special Reference to Sea Lampreys

The first sea lamprey seen this spring in the Black River was observed the night of April 27 about 100 feet upstream from the mouth, although one was reported on April 19. Apparently the run began during the first two

Table 1.--Dates and time of observation period

Date	Time From	Time To	Total hours
5- 9-50	10:30 PM	11:30 PM	1.0
5-10-50	8:00 PM	11:00 PM	3.0
5-11-50	8:00 PM	10:30 PM	2.5
5-12-50	9:30 PM	10:30 PM	1.0
5-13-50	8:00 PM	10:30 PM	1.5
5-14-50	12:30 PM	1:00 PM	0.5
5-15-50[1]	7:00 AM	8:00 AM	1.0
5-22-50	9:00 PM	10:30 PM	1.5
5-24-50	9:00 PM	11:00 PM	2.0
5-25-50	8:00 PM	12:00 PM	4.0
5-26-50	12:00 PM	8:00 AM	8.0
5-26-50	9:00 PM	12:00 PM	3.0
5-27-50	12:00 PM	2:00 AM	2.0
5-29-50	10:30 PM	12:00 PM	1.5
5-30-50	12:00 PM	12:30 AM	0.5
5-30-50	8:00 PM	12:00 PM	4.0
6- 2-50	8:30 PM	12:00 PM	3.5
6- 4-50	8:00 PM	11:00 PM	3.0
6- 5-50	8:30 PM	10:00 PM	1.5
6- 6-50	7:30 PM	11:00 PM	3.5
6- 7-50	8:00 PM	11:00 PM	3.0
6- 9-50	9:00 PM	11:00 PM	2.0
6-10-50	9:00 PM	11:00 PM	2.0
6-13-50	9:00 PM	11:00 PM	2.0
6-14-50	9:00 PM	11:00 PM	2.0
6-15-50	9:00 PM	11:00 PM	2.0
6-17-50	9:00 PM	11:00 PM	2.0
6-24-50	9:00 PM	11:00 PM	2.0
Total			65.5

[1] From the 15th on, all observations were made with the barrier dam in complete operation.

weeks in May when a few were taken by smelt dippers. The 18th and 21st of May were periods of active movement.

During the period May 24 to June 26, when the barrier dam was in relatively continuous operation, there were 4 separate periods of active sea lamprey movement. To determine the effectiveness of the barrier dam it is necessary to analyze these periods closely and correlate them with the upstream weir catch and related conditions. As a general rule these 4 periods were accompanied by a rise in mean water temperature and/or water level. The 4 periods of active movement are: (1) May 28 to June 3, (2) June 6 to June 10, (3) June 13 to June 17 and (4) June 24 to June 30. These periods can be verified by the observation period and the dam trap catch. Additional evidence is supplied by the upstream weir catch and by the mean water temperature records.

The first period to be considered will be (1) May 28 to June 3. The dam had been in operation May 24, 25, 26, but the by-pass was opened at 9:00 AM May 27 and remained open until 5:00 PM of the following day. During the time that the by-pass was open it is thought that the sea lampreys were moderately active since 9 were taken in the upstream weir trap on the night of May 27. A slight increase in temperature also suggests activity.

From the very beginning of operation there was a stream of water issuing from the corner of the lower east bulkhead and between the floor of the by-pass and lower east bulkhead. On May 29 the trap was discovered to have about a 1/2-inch crack under the bottom splash board. Four sea lampreys were discovered wedged in this crack and doubtless some had escaped upstream. This was repaired. On the 31st a heavy rain raised the level of the river some 20 inches. The fill behind the upstream east bulkhead began to cave, probably as a result of the high water. The following day (June 1) the fill and sand continued to wash badly. The upstream east bulkhead corner was especially bad. The cave-ins were filled as soon as possible, but they were

not all filled on this date. On the 2nd of June a crack was discovered in the floor of the trap and more sand was being washed from behind the upper east bulkhead. The by-pass was open from 10:00 AM to 1:00 PM on the 3rd for purposes of checking for possible avenues of escape. A crack was found in the jumping pool floor and a hole was discovered in the east bank about 10 feet upstream from the east bulkhead. The hole in the bank was filled.

During this period (May 28 - June 3) 338 adult sea lampreys were taken in the upstream weir trap. Undoubtedly some of these sea lampreys were in the river between the barrier dam and the checking weir when the barrier was put into operation. Also some probably went up the by-pass when it was open on the night of May 27. It is likely that some escaped upstream from the trap through the previously mentioned crack under the splash boards. The cave-ins behind the east bulkhead suggest the presence of one or more underground channels which probably were avenues of escape. In this period it can be seen that the barrier dam was not at all effective in blocking the sea lampreys from reaching their spawning grounds.

The period of June 4-5 was one of little activity as shown by the barrier dam catch and the observation period. The mean water temperature and water level also indicate little movement.

The next active period of movement was from June 6-10. It is evident that sea lampreys were moderately active during this 4-day period since 40 were seen during the observation period, 16 were taken in the barrier dam trap and 84 were taken in the upstream weir trap.

In addition to the permanent leaks, i.e., between floor and east bulkhead and from corner of lower east bulkhead, there was a stream of water issuing from between the lower east bulkhead wall and the bank. These remained throughout the entire operation. On June 7 a large hole formed under the face of the dam but was repaired on the same date. The by-pass was open 9:00 AM - 4:30 PM for this repair.

On the same date a cave-in occurred behind the upper east bulkhead. In water of the cave-in was an adult sea lamprey. The following day the sand and fill was still washing out. On the 9th two large cave-ins were present behind the east bulkhead. An adult sea lamprey was discovered in one. The cave-ins were filled but another one formed the next day and it, too, was repaired (filled).

During this period evidence that sea lampreys were going through the dam was obtained. Two adult sea lampreys were observed in cave-ins, one of which was next to the upstream east bulkhead. This lamprey must have traveled some distance underground to arrive at such a position. The continued difficulty with the east bulkhead indicates that channels are still present, and the presence of lampreys in the cave-ins caused by the channel show that at least some sea lampreys are using the channels for escapement.

The 11th and 12th of June were periods of little active movement. The limited activity is thought to have been due to the relatively low mean water temperature and stable water level. It has been noted that the upstream migration of white suckers coincides with that of the sea lamprey. Since the white suckers have free access (via the dam trap) to the weir they might be used as an index. Since neither species were taken in any number at the checking weir trap, it can be assumed that the lampreys were not prevented from reaching the checking weir but merely were not active.

Following this quiesent period was a period of moderate to heavy activity of sea lampreys and white suckers extending from June 13-17. In this time 13 sea lampreys were taken at the upstream trap of the checking weir, 3 at the barrier dam and 52 sea lampreys were seen during 6 hours observation time.

Four cave-in holes were discovered on the 16th, two behind each bulkhead. A sea lamprey was discovered in one of the cave-ins behind the east bulkhead. Also on the 16th a large hole was formed under the face of the dam. The by-pass was open 2:00 to 4:00 PM for purposes of repair. During this time I have no doubt that many suckers and a few lampreys went up since both species were quite active that afternoon. Two lampreys were seen in the trap shortly after the by-pass was closed. The following day (17th) the four cave-ins were still present and were somewhat enlarged.

The weir catch during this period indicates that the dam was blocking the majority of sea lampreys. It is known that sea lampreys were concentrating below the dam. Hundreds were seen clinging to the rip rap on the 13th when the impoundment was being filled and the rocks were exposed below. This concentration may be normal, as Applegate (1950) mentions concentrations of sea lampreys below natural obstructions on the Ocqueoc River. As he uses it an obstruction is not a barrier. The upstream weir catch of white suckers was high and that of the sea lamprey low in spite of the activity of the sea lamprey as shown by the observation period. The sea lampreys taken in the weir are believed to have penetrated the dam through cracks and channels as the discovery of an adult sea lamprey in a cave-in substantiates.

From June 18 to 23 there was little activity of sea lampreys or suckers. Over this 6-day period the weir catch of lampreys was 2, that of the dam trap 0 and none were seen during 1.5 hours of observation. The mean water temperature was relatively low (49°-52°).

The period June 24 to 30 was a period of great activity of sea lampreys. Nine hundred and thirty-three sea lampreys were taken in the upstream weir trap, 0 in the barrier dam trap, and many were seen during a 2-hour observation period on the 24th.

The checking weir's efficiency was reduced tremendously June 26 when the water was so high that it was running around the ends of both the upstream and downstream trap as well as over them. The water was so high that the weir could not be cleaned and consequently a large hole was worked under the middle of it.

The dam fared little better in this period. On the 24th two large cave-ins were observed behind the west bulkhead and one behind the east. These cave-ins were partially filled on the same day and repair work continued through the next day. There was a heavy rain on the morning of the 26th which raised the water level some 18 inches in a 24-hour period. As a result of the heavy rain there were 3 very large cave-ins behind the east bulkhead and 2 behind the west. As was subsequently discovered, there was a large hole under the face of the dam. Incidentally, the upper east bulkhead had settled preceptibly. The by-pass was opened at 10:30 AM, June 26. The condition of the dam prevented further operation.

Judging from the weir catch during this period the lampreys were very successful in their attempts to reach their spawning grounds. Of the 933 taken in this period 289 were caught when the dam was in operation. Over this period it was noted that there were cave-ins present behind both east and west bulkheads continually, indicating the presence of underground channels. These channels along with cracks and leaks in the dam, it is believed, are responsible for the 289 sea lampreys taken in the upstream weir trap.

Rainbow trout

During the time (May 24 to June 26) that the barrier dam was in continuous operation, relatively few rainbow trout were taken migrating upstream. A total of 26 rainbows were caught in the barrier dam trap. Of these, 11 were parr (young with parr marks), 1 was a smolt (immature silvery fish), 9 were adult ripe females, 1 was a spent female, there were 2 ripe

miles and 2 rainbows, sex unknown. It is thought that the barrier dam weir trap hindered the experiment since 13 adult ripe rainbow trout were taken in this trap. Presumably some were captured before they could attempt to jump the dam. In the same period 34 rainbows were taken in the upstream trap of the checking weir. These consisted of 20 parr, 2 smolt, 4 adult females, 3 adult males, and 5 adults whose sex was undetermined. The additional fish taken in the checking weir may be presumed to have jumped over the barrier dam.

The downstream migration was very much heavier over this period as shown by the checking weir catch. A total of 492 rainbow trout were taken in the downstream trap. This figure was composed of 422 rainbow parr, 22 smolts, 11 adult spent females, 21 adult spent males, and 15 adults, sex unknown.

The catches of the barrier dam trap, the upstream weir trap and the downstream weir suggests that the upstream spawning migration of rainbow trout was nearing its end when the barrier dam and checking weir were put into operation. Few (24) ripe spawners were taken in this period, and after the period only one ripe adult was taken until the beginning of the fall run. Additional evidence is the fact that of the 18 fish whose sex was determined 13 were females, or 72 percent. Also, during this period 47 spent adults were taken in the downstream weir trap. As a consequence of the nearness of the end of the spring run, the number of rainbow trout observed jumping at the dam was small.

The catch of the upstream trap of the checking weir indicates that rainbow trout were having some success in surmounting the dam. Twelve ripe adults were taken which presumably must have surmounted the dam to arrive at the weir. Some of these may have been seen jumping over the dam, but there is no apparent correlation, except in one instance. Undoubtedly others passed through the weir by means of a large hole under the weir. The remaining rainbow trout taken were mostly parr with a few smolt. It is

believed that they just wandered into the trap after release downstream from the downstream trap. At the time there was a heavy downstream migration of parrs.

More direct evidence that some rainbow trout can successfully jump the dam is supplied by direct observation of rainbows jumping the falls. During the 65.5 hours of direct observation at least 13 rainbow trout were observed jumping or attempting to jump the falls caused by the barrier dam.

Since there were so few rainbow trout seen jumping, perhaps an individual discussion of the activities of each rainbow trout observed would prove to be of interest. First, however, a consideration of the conditions under which these fish were jumping. These trout were jumping from a pool 8 by 25 feet. In depth the pool varied from 20 to 28 inches with 21 inches being the usual. A 6-inch board was added to the downstream wall of the jumping pool June 7 and consequently the depth was increased 6 inches. The head of water varied from 30 to 38 inches and the depth of water going over the lip varied from 4 to 7.5 inches (see following data sheet).

Individual discussion of rainbow trout seen jumping at dam

No. 1 This trout made the jump over the lip on the first attempt within the observation period. It jumped and swam up the stream of water coming over the lip. It was not noted at what time this fish made the attempt so it is not known whether this was the first attempt.

No. 2 On the first attempt within the observation period this trout swam or jumped up the flow over the lip with such velocity that it broke water on the upstream side of the lip. Again the exact time was not recorded so it is not known if this was the first attempt.

Table 2.--Various Water Measurements at Dam

Date	Water level	Jumping pool depth	Depth over lip [1]	Head of water [2]
May 18	+2	24	5	37
19	+1	--	-	--
20	0	--	-	--
21	-1	--	-	--
22	-2	24	5	36
23	0	--	-	--
24	-4	--	-	--
25	-4	21	5	37
26	-6	20	5	38
27	-7	--	-	--
28 [3]	-8	16	-	--
29	-8	20	5	37
30	-7	20	4	38
31	+13	--	-	--
June 1	+5	28	7	34
2	0	24	6	36
3	-1	24	5	36
4	-3	23	5	36
5	-4	22	5	36
6	-5	21	5	35
7	-5	21	4	35
8	-6	27	5	31
9	-6	26	5	30
10	-5	27	5	30
11	-6	27	4	29
12	-7	27	4	30
13	-6	28	4	29
14	-7	29	4	31
15	-6	27	4	31
16	-6	27	4	29
17	-5	26	5	30
18	-7	27	4	31
19	-7	27	4	31
20 [3]	-7	--	-	--
21 [3]	-6	--	-	--
22	-7	27	4	30
23	-7	27	4	30
24	-3	28	6	30
25	-6	26	4	30
26 [3]	+12	34	8	26

[1] Measured from top portion.
[2] Measured from water surface of jumping pool to surface of water in impoundment.
[3] By-pass open or partly open.

All measurements in inches.

Table 3.--Summary of Rainbow Trout Seen Jumping at Dam

Date	Numbers	Success	Number of attempts	Estimated size	Point where attempt made	Total time required
May 22	1	yes	1	20-25"	steel lip	1 sec.
22	2	yes	1	15-20"	steel lip	1 sec.
22	3	yes	1	20-25"	steel lip	1 sec.
25V	4	no	3	10-12"	steel lip	1 hour, 40 min.
25	5	no	2	20-25"	steel lip	15 min.
26	6	yes	1	20"	steel lip	1 sec.
26	7	yes	8	18-20"	steel lip	20 min.
29	8	yes	5	20"	steel lip	30 min.
30	9	yes	1	15-17"	wall of trap	1 sec.
30	10	yes	2	12-15"	wall of trap	22 min.
30	11	no	2	15-20"	wall of trap	15 min.
June 6	12	no	5	15"	steel lip	1 hour, 10 min.
7V	13	no	1	6-8 "	wall of trap	1 sec.

V Questionable as to species.

No. 3 This fish broke from the water some distance downstream from the lip and lit on top of the lip. It lay there for a split second and swam over. Again it is not known whether the fish jumped at the beginning of the observation period and so may have made more than one attempt.

No. 4 No information available except that which is shown on the summary.

No. 5 On the first attempt within the observation period this fish jumped 2 feet from the water in a vertical direction 6 to 12 inches downstream from the falls. This first attempt was made 2.5 hours after the observation period was initiated. Fifteen minutes later the second attempt was made. The fish broke water about 1 foot below the falls. In the air it traveled vertically and slightly forward and lit on top of the lip. Here it attempted to swim upstream but was swept downstream. No more attempts were made by this rainbow for at least 6 hours, which was the duration of the observation period.

No. 6 This trout went over on the first attempt within the observation period. There are no notes as to method. Since this successful attempt was made at the very beginning of the observation period, it is not known whether this was the first attempt.

No. 7. On the first attempt, 1 hour and 45 minutes after the beginning of the observation period, this fish jumped halfway (1.5 feet) to the lip. Three minutes later in the second attempt it jumped 2/3 of the way to the lip. One minute later it made a third attempt, upon which no details are available. The fourth attempt, 6 minutes later, resulted in the fish landing on top of the lip, but it was swept back downstream. Five minutes later the fish just broke water immediately downstream from the lip. On the sixth attempt, 2 minutes later, it again landed on the lip and fell back. One minute later the fish jumped halfway to

the lip but fell back. The eighth attempt, 2 minutes later resulted in success. Details, unfortunately, are not available on this.

No. 8 One hour and 15 minutes after the beginning of the observation period this trout made its first attempt. It jumped higher than falls but lacked forward momentum to carry it over. On the second attempt, 10 minutes later, the trout broke water 6 to 12 inches below falls and lit on top of the lip, but fell back. The third attempt, 10 minutes later, was exactly like the second. The fourth attempt, also 10 minutes later, resulted in success. The fish broke water 2 feet below the falls, travelling upward diagonally toward the lip. It landed on top of the lip and swam on over.

No. 9 This fish jumped from the trap over the upstream splash boards. It was observed to go over at the beginning of the observation period so it may have made more than one attempt.

No. 10 This trout made an attempt to jump over the upstream splash boards 1 hour and 10 minutes after the beginning of the observation period. On this first attempt it made it to top of splash boards, but fell back. Twenty-two minutes later the trout cleared the splash boards and swam on upstream.

No. 11 This fish was also jumping from the trap. It made the first attempt 3 hours and 10 minutes after the start of the observation period. On this first attempt it jumped to the top upstream splash boards but fell back. Fifteen minutes later in another attempt it reached the second top splash board. At this point the observation period was terminated, so it is not known whether this trout succeeded in getting upstream from the trap. However, the following morning an adult female was taken from the barrier dam trap. It is quite possible that this was the same one seen jumping in the trap.

No. 12 The first attempt made by this fish was reported to the observer as he arrived on the dam site. The second attempt, 15 minutes later, was just glimpsed by the observer. The third jump, 10 minutes later, was 2 feet directly up the fall of water over the lip. Ten minutes later the fourth attempt was made. The fish broke from the water 6 to 12 inches below the lip and lit on top of the lip, but fell back. The final attempt was 40 minutes later. The fish jumped from a point 1 foot below the falls in a vertical direction (about 2 feet). Because of lack of forward momentum this attempt resulted in failure.

No. 13 The last rainbow observed was a 6 to 8 inch fish jumping 4 to 6 inches up the trap wall. It is questionable whether such a small fish could be positively identified as a rainbow in such light and distance. However, several parrs were taken from the trap the next morning. If this fish was a parr it is probable that it was trying to get out of the trap rather than move upstream.

A total of 3 or 33 1/3 percent of the 9 rainbows attempting to scale the steel lip were unsuccessful. These fish are numbers 4, 5 and 12. Although there is little information on number 4, numbers 5 and 12 were able to jump the required vertical distance, but were unable to cope with the swift water rushing over the lip. Number 7 and 8 attained the lip but were swept downstream before they were successful in their attempts to surmount the dam. The few fish observed suggests that the vertical height of the dam is not a preventive factor but that the nature of the steel lip may prove to be a limiting factor.

Of the 3 trout observed attempting to move upstream from the trap only 1 was unsuccessful or 33 1/3 percent. On the date that these trout made their attempt a block of wood 1 to 4 inches was inserted between the top and next lower splash board. The block was inserted at the extreme ends of the boards.

Thus the flow into the trap was provided by a triangular crack 1 to 4 inches wide at one end and 0 inches at the other. These trout were jumping from an enclosure 6 by 8 feet, with a depth of about 2 feet. The distance jumped was about 3 feet.

Before the dam was in complete operation several other observations of trout were made at the dam. When these observations were made the by-pass was open and water was still going over the steel plates. One steel plate was missing. Three trout were seen on the 13th of May. Two, which looked to be about 14 inches were observed to go up over the dam where the plate was missing. At this point there was a large volume of water coming over. This fall was not vertical. The fish swam up the falls. Another fish 8 to 10 inches made two attempts to swim up the falls in the same place, but could only get two-thirds of the way up the falls. Another fish was observed on May 14, but was not positively identified as a rainbow trout. However, it looked like a trout and the behavior pattern seemed to be the same as positively identified fish. At 12:30 AM, this fish attempted to jump the plated portion of the falls. It got halfway up and fell back. At 12:50 the second attempt was made, the fish jumping a little higher. At 12:55 the fish broke water 6 inches downstream from the falls and lit on top of the lip and fell back. The length of this fish was estimated at 9 inches. If the smaller fish observed jumping could be positively identified as rainbow trout, it would appear that smaller rainbows might have difficulty in scaling the lip of the dam.

Smelt

The first smelt taken in the Black River were taken at the mouth on the night of May 1. They were first observed below the dam on May 10, and were present there in unbelievably large numbers until the 14th, when their numbers started falling off. During this period a single pass with a long-

handled net would take 10 pounds of smelt. By the 15th they had largely disappeared from the vicinity of the dam.

During the period that the smelt run was on, the by-pass was open and one steel plate was not on yet. Water was still going over the face of the dam in spite of the open by-pass. It was interesting to note that the smelt, in their desperate attempts to penetrate the dam had wedged themselves between the face of the dam and the steel plates. The slots for the bolts were clogged with them.

Only 3 smelt were observed to attempt to jump the dam. One leaped 6 inches clear of the water and the height to which the other 2 leaped was certainly not more than a foot. Even with the by-pass open, no smelt were observed above the barrier dam. Coupled with the observed poor jumping ability of the smelt, this observation indicates that the smelt were blocked by the dam. With the by-pass closed it seems certain that smelt will be blocked.

Sturgeon suckers

The first sturgeon sucker observed was netted below the dam May 14. Several were seen and small numbers were trapped in the barrier dam trap from May 15 to 27.

The observation period is one of the most reliable indexes of determining whether suckers can get over the lip of the dam. No suckers were seen attempting to jump the face of the dam although many were observed jumping in the trap. The actions in the trap were rather uniform. Most of the suckers would nose up to the upstream splash boards and attempt to jump. Seldom did they clear the water by more than 1 and 1/2 their length in a vertical jump. Judging from the weak jumping ability of suckers observed in the trap, it is rather doubtful if they could surmount the face of the dam.

All sturgeon suckers taken at the barrier dam May 29 to June 6 were marked with fin clips and released upstream to determine escapement. That is, all unmarked suckers taken in the upstream weir trap which were not marked would be those which penetrated the dam without help. The following table indicates the numbers and percent of these fish taken in the upstream weir.

Although the record was not kept for any length of time, a trend toward 100 percent marked fish appeared. Although not conclusive, this brief investigation substantiates the belief that sturgeon suckers could not pass the dam.

White suckers

White suckers were actively migrating during the whole period that the dam was operating. The time of upstream migration was coincident with that of the sea lamprey.

During the observation period these suckers could not be distinguished from the sturgeon suckers so the activities of the white suckers would be considered similar to that described for the sturgeon suckers. The escapement from the dam was somewhat different, however. The following table will illustrate. This investigation was conducted in the same manner as that for the sturgeon sucker.

The percent of clipped suckers taken in the weir varied over the period June 13 to 22. Thereafter it steadied and remained at 50 ± 1 percent for 4 days which gives a fair indication of escapement over or under the barrier dam. Since none of these suckers were observed to jump the dam, it is probable that some other method of escapement was employed. It is believed that these routes of escapement were the underground channels, which are mentioned in the discussion of the sea lamprey.

Table 4.--Number and percent of marked sturgeon suckers taken in upstream weir

Date	Dam catch	Upstream weir catch[1]	Number marked[2]	Percent marked
May 29	160	44	0	0
30	199	52	33	63
31	78	152	79	50
June 1	61	18	18	100
2	54	- - - - - - - - data missing - - - - - - - -		
3	7	10	7	70
4	9	0	0	0
5	25	3	3	100
6	26	1	1	100

[1] Total (included marked fish).

[2] Number taken at weir which were marked at barrier dam.

Table 5.--Number and percent of marked white suckers taken in upstream weir

Date	Dam catch	Upstream weir catch[1]	Number marked[2]	Percent marked
June 13	8	60	0	0
14	46	24	6	25
15	56	28	21	75
16	44	44	24	55
17	3	11	5	45
18	1	2	2	100
19	0	1	0	0
20	0	8	1	12.5
21	0	5	2	40
22	3	2	0	0
23	5	28	14	50
24	28	50	23	49
25	76	29	14	49
26	--[3]	29	15	51

[1] Total

[2] Number taken at weir which were marked.

[3] Dam trap out of operation

Suggested Improvements

The need for several imporvements in the Black River barrier dam became apparent during experimental operation. Number one is the addition of a sturdier foundation. That is, a structure more deeply imbedded in the river which would prevent undercutting. Undercutting and bankcutting were frequent during the experimental operation. In addition, the bank walls (bulkheads) will have to be heightened. The water nearly topped them this year. More rip-rap is necessary below the dam to prevent washing.

Although the trap and by-pass are not to be operated this year (1951), several short-comings were noticed. First, there should be a cover over the trap. Considerable difficulty was experienced with fishermen molesting the fish in the trap. Second, the entrance must be modified. Lampreys wandered in and out almost at will. Concerning the by-pass, some other method of opening and closing would prove to be of value. Often the splash boards would become swollen and it was very difficult to get them out. Also the by-pass should be wider to accommodate excess flood waters.

Most of these defects will be eliminated this year (1951) by the addition of a single row of steel sheet piling which is to be driven where the steel plates are now. The steel plates are to be bolted to the steel sheet piling. The piling is to extend through both east and west bulkheads and a considerable distance into the bank to prevent bankcutting. The by-pass and trap are to be eliminated.

Perhaps I should mention that the steel plates were set at the lowest possible setting. This provided a head of 30 to 36 inches. It is entirely possible that a setting of the plates which would hold a head of 24 inches would block the spawning lampreys. Of a certainty this lower setting would make it easier for a rainbow trout to surmount this structure. Once it is definitely proved that sea lampreys cannot negotiate the lip holding a 30-inch head, I believe it would be worthwhile to lower the head to 24 inches, sometime during

the operation of 1951. The observations made of sea lampreys jumping suggest that a 24-inch head will constitute a barrier to them.

Summary

1. The large numbers of sea lampreys taken in the upstream weir trap indicates that the sea lampreys were successful in penetrating the barrier dam. The method of penetration is believed to be by way of cracks in the dam itself and channels cut around and under the structure. Channels were obviously present, as witness the continual cave-ins and washouts. Three sea lampreys were found in the cave-ins which indicates that at least some sea lampreys were using these channels to escape upstream. That cracks as small as 1/2 to 3/4 inch can be used as a route of escape is shown by the discovery of 4 adult sea lampreys wedged in a crack a little over 1/2 inch. The belief that channels and cracks were the route of escapement is supported by the observation period of 64 hours. During this time only 1 sea lamprey was observed to escape over the lip. This was under abnormal conditions. Since the steel lip is eliminated as a route of escapement, it leaves channels and structural failures as the cause of escapement.

2. The small number of rainbow trout observed at the barrier dam indicates that although they may have a little difficulty, the majority of adult rainbow trout can surmount the dam. The limiting factor appears to be the swift current at the top of the lip. If the smaller fish observed could be definitely identified as rainbow trout it would appear that smaller trout might have great difficulty.

3. Smelt were present in large numbers below the dam, but none were observed above. At this time the by-pass was open. Because of their observed poor jumping ability, it is quite apparent that smelt will be blocked by a dam of this type and head.

4. Sturgeon suckers were not observed to jump more than 1 and 1/2 feet clear of the water. The lip apparently constituted a barrier to them.

5. Although white suckers were getting through the dam, it is thought that they followed the same route as did the sea lampreys. None were seen even attempting to ascend the lip. Those observed jumping in the trap showed no aptitude.

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