SUMMARY OF THE OPERATION OF THE CONOWINGO DAM FISH COLLECTION FACILITY DURING THE SPRING OF 1972

by

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FISH FACILITY OPERATION REPORT 1

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INTRODUCTION

The Conowingo Dam Fish Collection Facility was constructed for the Philadelphia Electric Company by Arundel Corporation using conceptual plans supplied by the United States Department of Interior Fish and Wildlife Service through the Susquehanna Shad Advisory Committee. The facility was designed to attract and collect adult American shad (Alosa sapidissima) when available immediately below Conowingo Dam.

The collection facility was operated according to stipulations outlined in the document "Operation of the Conowingo Dam Fish Facility" which was originally drafted by Dr. Timothy W. Robbins and which was approved by the Operations Subcommittee (Ralph W. Abele, Robert J. Rubelmann and Paul R. Nichols) of the Susquehanna Shad Advisory Committee.

The present report summarizes the 1972 operations. The items covered include: (1) measurement of attraction water velocity, (2) schedule of operation, (3) tests of velocities suitable for attracting shad, (4) disposition of fishes collected and (5) results of the operation which extended from 5 April to 21 June 1972.

METHODS AND MATERIALS

Attraction Velocity

Water velocity was determined at the entrance of the facility at various weir gate depths and under various conditions of discharge from station service units prior to taking fish. According to the proposed schedule of operation, specific velocities for attracting shad were to be obtained by adjusting the volume of water supplied through the two Conowingo Station service units in 10% increments. The latter method was not satisfactory because of time considerations and the possibility of damage to the structure.

Controlling velocities by changing the depth of the weir gates was preferred since it resulted in more flexibility. Ten to 15 min were required for plant personnel to change a service unit to a different gate setting. A change in velocity from approximately 1.0 to 9.0 ft sec was quickly and easily accomplished at either entrance by changing weir gate depth. Weir gates could be raised or lowered at about 1 ft min, and a significant velocity change could be produced in 5 min. Time was important when a velocity change was desired while fishing for short periods (5 to 10 min) or while running a series of tests on preferred velocities. Weir gate adjustment was also preferred because a high velocity could be achieved with the use of less water. Early in the testing period it was found that a large volume of water passing through the facility could cause damage. For example, on 6 April, debris from the service unit draft tubes blocked the picketed barrier and caused the facility to overflow at a time when the service units were set at 35% and 90% gate (the maximum volume used up to that time).

The original plans proposed using water from both service units to vary water supply. However, plant operators preferred not to adjust Service Unit 1 for this purpose because it provides house current and is standardly set at 30% to 40% gate, depending upon plant load. Service Unit 2 could be operated at any gate setting. Thus, the maximum water available was approximately 350 cfs. This volume of water was sufficient for the proper operation of the collection facility and was less than that which the engineers considered potentially damaging to the facility. An adequate range of attraction velocities was achieved at 350 cfs and less.

A Gurley Current Meter (Model 665) was initially used to measure water velocity. Shortly after the study began it was replaced by a Digital Flowmeter with readout (General Oceanics Model 2031). Velocities were determined when weir gates were operated, either separately or concurrently, at depths ranging from 1 to 13 ft below the elevation of the tailrace. Readings were taken in the center of the attraction current at a point 2 to 3 ft in front of the weir entrance. The difference between the holding channel elevation and the tailrace elevation (net head) was recorded with each velocity measurement in order to duplicate fishing conditions. Velocities were determined empirically over a wide range of conditions, and specific conditions were duplicated to achieve desired attraction velocities.

During the sampling period an effort was made to maintain a continuous attraction flow in the tailrace via the facility when the Conowingo Station was not operating. This flow was provided by maintaining a 30% to 40% gate on one service unit. Main generating Unit 2 was operated through the night between 6 April and 20 June as part of an agreement with the State of Maryland, Department of Natural Resources, to prevent fish mortalities when anadromous fishes were in the tailrace. The use of Unit 2 was partially determined by the need for maintaining an attraction flow along the west side of the tailrace. Any unit (3 to 6) could also have been used to fulfill the agreement with the State of Maryland.

The same effort regarding an attraction flow on the west side of the tailrace was made when the Conowingo Station was in operation. When full generation was not required, plant engineers were asked to operate only those main generators closest to the collection facility, excluding main generating Unit 1. Turbulence from the latter prevented the development of a smooth

attraction flow near the collection facility. However, due to exceptionally high river flow, full generation was required for 24 hours a day prior to 25 May.

The importance of maintaining an attraction flow along the west side of the tailrace is based on observations in past years which suggest that when the four large units on the east side of the plant were operating, American shad were attracted to the east side of the tailrace. In 1972 behavior of the shad fishermen fishing from boats suggested the same pattern. When the four large units began generating, boats were moved from the west side of the tailrace towards the east side and occupied positions to the east of the swiftest currents from these units. These fishermen indicated in interviews that fishing success was often good, while success of bank fishermen on the west shore was observed to be poor. Boats with an average of three fishermen have reportedly taken as many as 50 shad in 3 or 4 hours below the large generating units. The maximum number of shad taken by a single fisherman on the west shore was five.

Schedule of Operation of the Collection Facility

The collection facility was operated primarily during daylight from 5 April to 21 June. It was inoperable from 17 to 24 April and 11 to 13 May due to high water. The daily time schedule of operation was 8 A. M. to 5 P. M. EST between 25 April and 30 April, from 7 A. M. to 4 P. M. EST between 1 May and 10 May, and from 5 A. M. to 8 P. M. between 11 May and 21 June. The total time of operation on any one day may have varied due to routine maintenance and repairs. The installation of a 1-inch-mesh screen on the picketed barrier to prevent entry and entrapment of small fish behind the barrier also delayed operations.

Overnight operations were not attempted. However, sets were made during darkness on several days in May. Operation of the facility prior to 5 A. M. EST was considered when many American shad were taken in an early morning list on 21 June. However, flooding halted operations on 22 June. [Agree]

The original schedule of operation called for 1/2-hour or longer fishing periods (sets) at the beginning of each day to obtain an indication of the numbers of fish present in the vicinity of the collection facility. By mid-May it became evident that this procedure was not satisfactory. It was assumed initially that fishes would not enter the collection facility overnight when the crowder gates were closed. However, when large numbers of fish were present in the tailrace, small specimens passed through the closed crowder gates and accumulated in the holding channel. The following species passed through easily in large numbers: blueback herring (Alosa aestivalis), alewife (Alosa pseudoharengus), white perch (Morone americana), channel catfish (Ictalurus punctatus), and white crappie (Pomoxis annularis). Three or four lifts were required in the morning to clear the holding channel before the crowder gates could be opened and normal fishing begun. Generally, the first catch after the crowder gates were opened was large because many fishes had gathered in front of the closed gates at night. The first set with the gates open was usually less than 10 min, and the duration of the next set was determined by the number of fish caught in the first lift. This procedure was followed every day. Normally, fishing times ranged from 15 to 30 min, but 5 min sets were not uncommon. For example, at the peak of the blueback herring run, 5 min sets were made to reduce the number of fish taken per lift to prevent stress or mortality due to crowding in the hopper and/or holding tank.

Determining Optimum Attraction Velocity

Two phases of operation were considered in determining the optimum attraction velocity for the American shad and other anadromous species. The first was from approximately 1 April to 1 May when it was anticipated that American shad would be absent and the most common fishes would be the alewife and blueback herring. The second was from approximately 1 May to 1 June, when it was thought that American shad would be present. Tests for determining the optimum attraction velocity were to be run at least once during each of the above time periods. The test procedure involved operating the collection facility with the weirs located 3 ft below tailrace elevation and using test velocities over a range of 4 to 6 ft sec at 0.5 ft sec intervals. The three possible combinations of entrance openings to be used were: (1) both open, (2) only Entrance 1 open, and (3) only Entrance 2 open. The facility was to be fished for four consecutive 1/2-hour intervals for each increment of velocity. These tests would have taken nine days. It was impractical to use a nine consecutive day schedule because of variations in species composition and numbers in the tailrace. Also, there were interruptions due to high water and maintenance.

An alternate procedure was planned which reduced the number of velocities used to two (4 and 8 ft sec). These were to be tested with three combinations of weir openings. Six sets would produce these combinations of velocities and weir openings. This experimental design was not used during the alewife and blueback herring runs in the first phase of operation, but a wide range of velocities was tested. The alternate procedure was first followed during the second phase of operation on 1 and 2 June when the American shad was present in the tailrace. On 1 June velocity combinations of 4 and 8 ft sec were used.

A flow of 35% and 75% was used on the station service units. Fishing time was 15 min. The schedule was run twice, once in the morning and once in the afternoon. On 2 June the same procedure was followed using velocities of 5 and 6 ft sec. The original plan called for following this procedure once a day for three consecutive days, but the actual schedule was twice a day for two consecutive days.

Disposition of Catch

Fishes collected in the facility were handled in one of two ways. Before the appearance of the American shad, all fishes were released into a 4 x 6 x 12 ft holding tank and counted by species. Length, weight, sex and scales were taken from subsamples. Emphasis was placed on the collection of detailed data for anadromous species.

When the American shad appeared in collections the contents of the hopper (all species) were transferred to a tank truck provided by the Pennsylvania Fish Commission and were released above Conowingo Dam. Before the American shad run, the efficiency of the truck was tested with hickory shad, blueback herring and alewife. Only visual estimates of the number of American shad were made. Specimens from lifts which did not contain American shad were released into the river from the holding tank.

Some change in procedure was made when only one or two American shad were in the hopper. They were often temporarily overlooked among the large numbers in the catch and were emptied into the holding tank. Unless more than five specimens of American shad were observed, all lifts were discharged into the holding tank. The American shad were counted and hand-dipped into the truck where those from several lifts sometimes accumulated before a load was released above the dam.

American shad were sometimes collected while the truck was transporting fish. A method of holding American shad was developed for this situation. A 300 gal stock tank supplied with fresh water from the tailrace was satisfactory for holding specimens for several hours. The truck was used until 11 June and all specimens of American shad taken through 10 June were transported above the dam. Those taken later were returned to the tailrace. 116 Am. Shad.

The number of other fishes was determined. With small catches all fish were counted. In large catches subsamples were taken. An estimated percentage of the total fish in the tank was crowded into one end of the tank with a 1/4-inch, wire mesh divider. Those in this subsample were counted after the remainder of the catch was released, and an estimate of the total catch was calculated. Fish were released through a sliding door on the side of the holding tank and passed down a release pipe to the tailrace.

Care was taken to avoid mortality in the hopper or holding tank. Some lifts contained large numbers of fish. They were immediately returned to the tailrace after a visual estimate was made of the species composition and the number of fish.

RESULTS AND DISCUSSION

Water velocity in the holding channel averaged 2 ft sec. The maximum velocity attainable was 3 ft sec. Conowingo plant engineers preferred to keep the velocity below 3 ft sec to prevent excessive pressure on the picketed barrier. Velocities of 3 ft sec or more also restricted movement of the crowder.

In the early phases of operation, an area of turbulence was observed at the entrance to the holding channel near the diffusion valve openings which was caused by up-welling from diffusion Valve 1. This turbulence appeared to disorient fish as they swam toward the facility. Schools of alewife congregated in front of this turbulence and avoided swimming the full length of the holding channel area above the hopper. Closing the opening of Valve 1 to 50% gate reduced this turbulence and resulted in a smoother flow from the holding channel, through the diffusion area and through the two weir entrances. Fish were not disoriented when this turbulence was reduced.

It had been anticipated that the operation of Conowingo Station main generating Unit 1 would have some effect on the characteristics of the attraction flow from the collection facility. The area of maximum turbulence created by its discharge is close to the entrances to the facility. Entrance 1, which faces east, was not greatly affected by this turbulence. However, because of this turbulence a linear flow was not attained in front of Entrance 2, which faces south. After the river flow decreased so that generation at full capacity was not required (25 May), the main generating Unit 1 was shut down or run at a reduced level. At this time a smooth attraction flow was produced from each weir entrance.

A total of 346,113 fish comprising 39 species was taken during the operation. The most common species taken was the channel catfish (123,413 specimens). The second most abundant species was the blueback herring and the third was the white perch (57,221 specimens).

The anadromous species other than American shad taken were as follows: hickory shad (Alosa mediocris), 369 (6 over dam); blueback herring, 76,867 (1,500 over dam); and alewife, 12,218 (1,000 over dam). The alewife and hickory shad reached peaks in abundance from 27 April to 3 May. The blueback herring reached a peak during the week of 11 to 17 May, and the American shad and gizzard shad (Dorosoma cepedianum) were most abundant from 8 to 21 June.

A total of 292 adult American shad was collected. One juvenile shad was taken. A total of 125 American shad was transported by truck and released in Conowingo Reservoir above the west corner of the dam. With the exception of one lift on 21 June, exact counts were made for all American shad. The largest single catch was made at 0650 hours on 21 June. Approximately 65 American shad were collected along with a large number of gizzard shad. After 16 American shad had been removed from the holding tank, the catch was released to prevent mortality due to oxygen depletion. The truck was not present to transfer this catch above the dam.

Specimens of the American shad were taken in the collection facility for the first time on 15 May at 1600 hours. The last catch was made on 21 June at 0650 hours. It was taken every day between 24 May and 21 June with the exception of 7 and 20 June. Data taken with all lifts containing American shad are included in Table 1.

Differences existed in the time of day that American shad were most frequently taken (Table 2). A total of 253 (86%) were taken prior to 0900 hours; the peak occurred from 0600 to 0900 hours (Figure 1).

American shad were first taken (15 May) when the water temperature was 59 F. However, most were collected after the temperature reached 67 F (24 May).

They were taken most frequently at 70 F. Some 73% of the total catch was taken at water temperatures between 68 and 71 F (Figure 2). The water temperature was 74 F when the largest single catch of 65± American shad was made on 21 June.

The activities of anglers and their catch of American shad indicate that the distribution of American shad may be affected by the amount and nature of generating at Conowingo Station. Analysis of the catch in the collection facility (Table 3) tends to confirm this; 79% were taken in the facility when none of the large (new) units were operating. The operation of any combination of large units, regardless of the number of smaller units which were also in operation, resulted in small catches of American shad in the facility. Some 86% of the total shad catch was taken when four or fewer small units were generating. A total of 279 American shad (95%) was taken when Unit 1 was not generating. Generally, the catch was poor when large volumes of water were being released during generating.

The results of tests for optimum attraction velocity were generally inconclusive. Those made prior to the presence of American shad in the tailrace gave little indication of the optimum attraction velocity for blueback herring, alewife, or hickory shad. Generally, when fish were near the facility, they were captured. For example, on 3 May, 96 hickory shad were taken when entrance velocities ranged from 5 to 7 ft sec. These velocities were repeated the next day, and no hickory shad were taken.

A velocity of 7 to 8 ft sec or greater discouraged some species from entering the facility. On 16 May, approximately 2,000 blueback herring were taken in each of a series of 5 min sets until the entrance velocity reached

8 ft sec. The catch then dropped to less than 100 fish per lift.

A total of 24 sets was made on 1 and 2 June to determine the optimum attraction velocity for American shad. Only four shad were collected, and all were taken at an attraction velocity of 6 ft sec. It is obvious that the number taken is too small to clearly indicate a preferred velocity. Also, examination of the relationships between the time of day, water temperature and generating level of the Conowingo Station suggests that the catch is related to a combination of variables. Shad were taken at velocities between 1.4 and 9.5 ft sec. An attraction velocity of 5.5 to 6.5 ft sec was used most often during the sampling period.

Peter S. Foote and Charles A. Anjard were involved in the daily supervision and operation of the biological aspects of the facility. Rosielea Gash and Emily C. Weller assisted with this manuscript.

EXPLANATION OF ABBREVIATIONS AND CODES FOR TABLE 1

Total Fish: 1) 3,200± - Estimate of total fish taken in lift
2) a - Catch released without count or estimate due to O_2 depletion in tank

Rel. Loc.: Location shad were released - 1) 0 - Preserved
2) 1 - Placed in PFC truck
3) 2 - Returned to tailrace

Lift No.: Daily lift number; b - Clean out of lift

Rain: 1) + - Yes
2) blank - No

At. Pressure: Atmospheric Pressure; blank - data not available

Small Gen. on: Number of small generating units in operation
Large Gen. on: Number of large generating units in operation
} c - condition of generation varying

Unit 1 on:
Unit 2 on:
} Small generating units 1) + - Yes
2) blank - Not in operation

% Gate S. U. 1:
% Gate S. U. 2:
} Percent gate opening of station service units

% Valve 1 open:
% Valve 2 open:
} Percent gate opening of diffusion valves 1 & 2

Vel. Weir 1:
Vel. Weir 2:
} Water velocity (ft./sec.) at Entrances 1 & 2; d - velocities varying

Vel. Hld. Chan.: Water velocity (ft./sec.) in holding channel;
d - velocity varying

Ft. Below TR: Setting of each weir gate (ft. below tailrace elevation)
Weir 1 d - elevations varying
Weir 2

Tailrace Elev.: Tailrace elevation; d - elevation varying

Hld. Chan. El.: Holding channel elevation; d - elevation varying

Crowder Position: Fishing position: 1) 1 - Full
2) 2 - Reduced

Crowder Gate Position: 1) 1 - Full open
2) 2 - Intermediate open

Spill Gates op.: Number of spill gates open

Table 1. Numbers of American shad (Alosa sapidissima) taken in the Conowingo Fish Collection Facility from 15 May to 21 June 1972 and data describing conditions for each lift.

DATE	15 May		16 May		17 May		20 May
PARAMETERS							
Shad Taken	1	1	1	1	1	1	1
Total Fish	312	391	3,200±	2,750±	163	125	145
Rel. Loc.	0	0	1	1	1	1	1
Lift Time	1600	1715	1305	1850	1725	1805	1410
Min Fished	15	15	5	15	30	30	10
Lift No.	20	22	22	33	15	16	9
Water Temp.	59	59	60	60	62	62	64
Air Temp.	69	68	71	68	72	72	62
% Cloud Cover	50	75	50	75	50	25	100
Rain							
At. Pressure	29.95	29.95	29.96	29.94	29.97	29.97	30.00
River Flow	81.4	81.4	74.2	74.2	76.9	76.9	72.5
Small Gen. on	7	7	7	7	7	7	7
Large Gen. on	4	4	4	4	4	4	4
Unit 1 on	+	+	+	+	+	+	+
Unit 2 on	+	+	+	+	+	+	+
% Gate S. U. 1	35	35	35	35	35	35	35
% Gate S. U. 2	100	100	100	100	100	100	100
% Valve 1 open	50	50	50	50	50	50	50
% Valve 2 open	100	100	100	100	100	100	100
Vel. Weir 1	5.0	5.0	5.5	6.5	6.5	6.5	0.0
Vel. Weir 2	4.0	4.0	4.0	6.0	5.5	5.5	6.5
Vel. Hld. Chan.	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ft. Below TR							
Weir 1	7.5	7.5	7.5	6.0	6.0	6.0	0.0
Weir 2	7.5	7.5	7.5	6.0	6.0	6.0	12.0
Tailrace Elev.	21.5	21.5	20.4	20.3	20.5	20.5	20.1
Hld. Chan. El.	22.8	22.8	21.8	22.0	22.2	22.2	21.8
Crowder							
Position	1	1	1	1	1	1	1
Crowder Gate							
Position	2	2	1	1	1	1	1
Spill Gates op.	1	1	0	0	0	0	0

Table 1. (Continued)

DATE	24 May		25 May		26 May	
PARAMETERS						
Shad Taken	1	1	1	1	1	1
Total Fish	200+	182	216	34	178	38
Rel. Loc.	1	1	1	1	1	1
Lift Time	0605	0900	0835	1008	1230	1700
Min Fished	15	15	15	15	20	15
Lift No.	b	5	4	5	16	24
Water Temp.	67	67	68	68	67	67
Air Temp.	59	64	62	64	65	66
% Cloud Cover	0	0	85	90	0	0
Rain						
At. Pressure	29.75	29.75	29.80	29.80	30.08	30.07
River Flow	54.4	54.4	47.6	47.6	44.2	44.2
Small Gen. on	4	7	7	7	7	3
Large Gen. on	4	4	4	4	4	0
Unit 1 on		+	+	+	+	
Unit 2 on	+	+	+	+	+	+
% Gate S. U. 1	35	35	35	35	35	35
% Gate S. U. 2	100	100	100	100	50	50
% Valve 1 open	50	50	50	50	50	50
% Valve 2 open	100	100	100	100	100	100
Vel. Weir 1	0.0	0.0	0.0	0.0	0.0	0.0
Vel. Weir 2	6.5	7.5	8.5	8.5	6.0	9.5
Vel. Hld. Chan.	2.0	2.5	2.5	2.5	2.0	3.0
Ft. Below TR						
Weir 1	0.0	0.0	0.0	0.0	0.0	0.0
Weir 2	10.0	12.0	8.0	8.0	10.0	5.0
Tailrace Elev.	18.2	20.0	20.0	20.0	20.1	16.5
Hld. Chan. El.	20.0	21.9	22.5	22.5	21.6	19.3
Crowder						
Position	1	1	2	2	2	2
Crowder Gate						
Position	1	2	2	2	2	2
Spill Gates op.	0	0	0	0	0	0

Table 1. (Continued)

DATE	27 May		28 May				
PARAMETERS							
Shad Taken	2	1	1	2	3	3	3 (15)
Total Fish	1,500±	245	1,000±	300±	300±	200±	200±
Rel. Loc.	1	1	1	1	1	1	1
Lift Time	0750	1645	0650	0705	0725	0745	0835
Min Fished	10	30	5	5	5	10	10
Lift No.	5	17	3	.4	5	6	8
Water Temp.	68	68	68	68	68	68	68
Air Temp.	58	68	51	51	51	52	62
% Cloud Cover	0	0	100	100	100	50	0
Rain							
At. Pressure	30.10	30.10	30.06	30.06	30.06	30.06	30.06
River Flow	37.9	37.9	34.6	34.6	34.6	34.6	34.6
Small Gen. on	c	4	1	1	1	1	1
Large Gen. on	c	1	0	0	0	0	0
Unit 1 on							
Unit 2 on	+	+	+	+	+	+	+
% Gate S. U. 1	35	35	35	35	35	35	35
% Gate S. U. 2	50	75	0	50	50	50	50
% Valve 1 open	50	50	50	50	50	50	50
% Valve 2 open	100	100	100	100	100	100	100
Vel. Weir 1	d	6.0	1.4	5.5	5.5	5.5	5.5
Vel. Weir 2	d	6.0	1.4	4.0	4.0	4.0	4.0
Vel. Hld. Chan.	d	2.0	1.0	2.0	2.0	2.0	2.0
Ft. Below TR							
Weir 1	d	5.0	3.7	3.7	3.7	3.7	3.7
Weir 2	d	5.0	3.7	3.7	3.7	3.7	3.7
Tailrace Elev.	d	16.8	13.7	13.7	13.7	13.7	13.7
Hld. Chan. El.	d	18.3	14.0	14.9	14.9	14.9	14.9
Crowder							
Position	2	2	1	1	1	1	1
Crowder Gate							
Position	2	2	1	1	1	1	1
Spill Gates op.	0	0	0	0	0	0	0

Table 1. (Continued)

DATE	29 May			30 May			
PARAMETERS							
Shad Taken	1	3	1	1	2	2	1
Total Fish	1,237±	132	140	2,184±	48	245±	151
Rel. Loc.	1	1	1	1	1	1	1
Lift Time	0825	1320	1715	0615	0730	0810	1435
Min Fished	15	30	30	10	30	30	15
Lift No.	7	14	19	3	5	6	17
Water Temp.	69	70	70	70	70	70	70
Air Temp.	65	74	74	66	67	67	72
% Cloud Cover	5	0	0	100	100	100	50
Rain						+	
At. Pressure	29.86	29.85	29.83	29.76	29.75	29.74	29.72
River Flow	30.6	30.6	30.6	27.2	27.2	27.2	27.2
Small Gen. on	3	5	6	2	2	5	6
Large Gen. on	0	0	0	0	0	2	4
Unit 1 on			+				+
Unit 2 on	+	+	+	+	+	+	+
% Gate S. U. 1	35	35	35	35	35	35	35
% Gate S. U. 2	50	75	75	75	75	75	75
% Valve 1 open	20	50	50	50	50	50	50
% Valve 2 open	100	100	100	100	100	100	100
Vel. Weir 1	d	8.5	0.0	d	0.0	0.0	7.0
Vel. Weir 2	d	8.5	6.0	d	6.0	2.5	7.0
Vel. Hld. Chan.	d	3.0	2.0	d	2.0	1.8	3.0
Ft. Below TR							
Weir 1	d	2.3	0.0	d	0.0	0.0	3.0
Weir 2	d	2.3	6.2	d	7.4	12.7	3.0
Tailrace Elev.	d	17.3	17.2	d	14.5	19.0	19.6
Hld. Chan. El.	d	20.2	18.6	d	16.1	19.3	21.8
Crowder							
Position	2	2	2	2	2	2	2
Crowder Gate							
Position	1	2	2	2	2	2	2
Spill Gates op.	0	0	0	0	0	0	0

Table 1. (Continued)

DATE	30 May		31 May				
PARAMETERS							
Shad Taken	1	1	1	2	5	1	1
Total Fish	135	112	a	a	a	410+	a
Rel. Loc.	1	1	0	0	1	1	1
Lift Time	1815	1850	0630	0715	0800	1030	1315
Min Fished	30	20	15	30	30	30	30
Lift No.	23	24	1	.2	3	6	10
Water Temp.	70	70	70	70	70	70	70
Air Temp.	76	75	70	70	73	73	75
% Cloud Cover	30	80	100	100	100	100	95
Rain							
At. Pressure	29.70	29.69	29.63	29.62	29.62	29.61	29.61
River Flow	27.2	27.2	30.5	30.5	30.5	30.5	30.5
Small Gen. on	c	1	5	5	4	7	6
Large Gen. on	0	0	0	1	1	4	4
Unit 1 on						+	
Unit 2 on	+	+	+	+	+	+	+
% Gate S. U. 1	35	35	35	35	35	35	35
% Gate S. U. 2	75	75	75	75	75	75	75
% Valve 1 open	50	50	50	50	50	50	50
% Valve 2 open	100	100	100	100	100	100	100
Vel. Weir 1	d	5.5	d	4.5	d	0.0	0.0
Vel. Weir 2	d	5.5	d	4.5	d	7.5	7.5
Vel. Hld. Chan.	d	2.0	d	1.8	d	3.0	3.0
Ft. Below TR							
Weir 1	d	4.0	d	6.5	d	0.0	0.0
Weir 2	d	4.0	d	6.5	d	5.0	6.0
Tailrace Elev.	d	14.3	d	16.6	d	19.6	19.6
Hld. Chan. El.	d	15.7	d	17.4	d	22.0	22.0
Crowder							
Position	1	1	2	2	2	2	1
Crowder Gate							
Position	2	1	2	2	2	2	2
Spill Gates op.	0	0	0	0	0	0	0

Table 1. (Continued)

DATE	1 June		2 June			
PARAMETERS						
Shad Taken	2	4	3	1	1	2
Total Fish	200±	126	197	205	205	124
Rel. Loc.	1	1	1	1	1	1
Lift Time	0530	0615	0615	1345	1415	1715
Min Fished	15	15	15	15	15	15
Lift No.		1	1	16	17	23
Water Temp.	70	70	70	70	70	70
Air Temp.	53	53	60	76	76	77
% Cloud Cover	100	100	0	90	50	60
Rain						
At. Pressure	29.62	29.62	29.63	29.67	29.67	29.68
River Flow	47.5	47.5	53.2	53.2	53.2	53.2
Small Gen. on	1	1	4	6	6	6
Large Gen. on	0	0	3	4	4	4
Unit 1 on						
Unit 2 on	+	+	+	+	+	+
% Gate S. U. 1	35	35	35	35	35	35
% Gate S. U. 2	75	75	75	75	75	75
% Valve 1 open	50	50	50	50	50	50
% Valve 2 open	100	100	100	100	100	100
Vel. Weir 1	5.1	5.1	5.0	6.0	6.0	6.2
Vel. Weir 2	0.0	0.0	0.0	0.0	5.8	6.0
Vel. Hld. Chan.	2.0	2.0	1.8	1.8	1.8	1.8
Ft. Below TR						
Weir 1	8.5	8.5	11.0	9.0	5.0	5.0
Weir 2	0.0	0.0	0.0	0.0	4.0	4.0
Tailrace Elev.	15.7	15.7	18.6	20.0	20.0	20.1
Hld. Chan. El.	17.3	17.3	19.6	21.5	21.5	21.5
Crowder						
Position	1	1	1	1	1	1
Crowder Gate						
Position	2	2	2	2	2	2
Spill Gates op.	0	0	0	0	0	0

Table 1. (Continued)

DATE	3 June					4 June	
PARAMETERS							
Shad Taken	2	2	4	1	1	3	2
Total Fish	2,000±	588±	800±	95	102	a	a
Rel. Loc.	1	1	1	1	1	1	1
Lift Time	0555	0615	0645	0715	0910	0545	0615
Min Fished	6	15	15	15	30	10	15
Lift No.	1	2	3	4	7	1	2
Water Temp.	71	71	71	71	71	71	71
Air Temp.	69	69	69	69	74	63	69
% Cloud Cover	60	60	60	40	20	0	0
Rain							
At. Pressure	29.75	29.75	29.75	29.75	29.75		
River Flow	53.5	53.5	53.5	53.5	53.5	52.4	52.4
Small Gen. on	4	4	4	4	4	1	1
Large Gen. on	0	0	0	3	4	0	0
Unit 1 on							
Unit 2 on	+	+	+	+	+	+	+
% Gate S. U. 1	35	35	35	35	35	35	35
% Gate S. U. 2	75	75	75	75	75	75	75
% Valve 1 open	50	50	50	50	50	50	50
% Valve 2 open	100	100	100	100	100	100	100
Vel. Weir 1	5.0	5.5	5.0	d	0.0	6.5	6.5
Vel. Weir 2	5.0	5.5	5.0	d	6.0	6.5	6.5
Vel. Hld. Chan.	2.0	2.0	2.0	d	2.0	2.0	2.0
Ft. Below TR							
Weir 1	6.0	6.0	6.0	d	0.0	3.0	3.0
Weir 2	6.0	6.0	6.0	d	9.3	3.0	3.0
Tailrace Elev.	16.0	16.0	16.0	d	19.2	13.0	13.0
Hld. Chan. El.	17.1	17.1	17.1	d	20.8	15.0	15.0
Crowder Position	1	1	1	1	2	1	1
Crowder Gate Position	2	2	2	2	2	2	2
Spill Gates op.	0	0	0	0	0	0	0

Table 1. (Continued)

DATE	4 June				5 June	6 June	8 June
PARAMETERS							
Shad Taken	4	1	4	1	1	1	4 (12)
Total Fish	a	530+	a	614+	123	700+	469+
Rel. Loc.	1	1	1	0	0	0	0
Lift Time	0640	0735	0755	0950	1200	0615	0700
Min Fished	10	15	15	30	30	15	30
Lift No.	3	5	6	10	9	1	2.
Water Temp.	71	71	71	71	71	70	70
Air Temp.	69	69	69	80	81	65	74
% Cloud Cover	0	0	0	50	20	100	0
Rain							
At. Pressure							29.70
River Flow	52.4	52.4	52.4	52.4	50.7	43.3	41.8
Small Gen. on	1	3	4	6	6	4	c
Large Gen. on	0	0	0	4	4	2	c
Unit 1 on							
Unit 2 on	+	+	+	+	+	+	+
% Gate S. U. 1	35	35	35	35	35	35	35
% Gate S. U. 2	75	75	75	75	75	75	75
% Valve 1 open	50	50	50	50	50	50	50
% Valve 2 open	100	100	100	100	100	100	100
Vel. Weir 1	6.5	6.5	6.5	0.0	6.0	d	d
Vel. Weir 2	6.5	0.0	6.5	6.0	6.0	d	d
Vel. Hld. Chan.	2.0	2.0	3.0	2.0	2.0	d	d
Ft. Below TR							
Weir 1	4.0	8.0	8.0	0.0	5.3	d	d
Weir 2	4.0	0.0	8.0	9.3	5.3	d	d
Tailrace Elev.	13.0	15.0	15.0	20.0	20.0	d	d
Hld. Chan. El.	15.0	16.9	17.0	21.4	21.4	d	d
Crowder							
Position	2	2	2	2	1	1	1
Crowder Gate							
Position	2	2	2	2	2	2	2
Spill Gates op.	0	0	0	0	0	0	0

Table 1. (Continued)

116 A. Shad Transported into Canal via Pool 17 PFC.

DATE	9 June			10 June		11 June	
PARAMETERS							
Shad Taken	2	4	3	1	1	5	17
Total Fish	600±	590±	370±	148	704±	180	373±
Rel. Loc.	1	1	1	(2)	(2)	1	1
Lift Time	0555	0630	0700	1430	1805	0715	0800
Min Fished	15	10	20	30	35	30	30
Lift No.	b	1	2	12	16	2	3
Water Temp.	70	70	70	72	72	70	70
Air Temp.	79	79	79	64	62	53	54
% Cloud Cover	50	50	75	10	90	0	0
Rain							
At. Pressure	29.61	29.61	29.61	29.60	29.73	29.91	29.92
River Flow	39.7	39.7	39.7	39.7	33.4	31.5	31.5
Small Gen. on	1	1	4	6	4	1	1
Large Gen. on	0	0	2	4	1	0	0
Unit 1 on							
Unit 2 on	+	+	+	+	+	+	+
% Gate S. U. 1	35	35	35	35	35	35	35
% Gate S. U. 2	75	75	75	75	75	75	75
% Valve 1 open	50	50	50	50	50	50	50
% Valve 2 open	100	100	100	100	100	100	100
Vel. Weir 1	6.0	6.0	d	6.0	0.0	6.0	6.0
Vel. Weir 2	6.0	6.0	d	6.0	6.0	6.0	6.0
Vel. Hld. Chan.	2.0	2.0	d	2.0	2.0	2.0	2.0
Ft. Below TR							
Weir 1	5.0	5.0	d	4.5	0.0	4.5	4.5
Weir 2	5.0	5.0	d	4.5	9.3	4.5	4.5
Tailrace Elev.	15.0	15.0	d	20.0	16.9	13.5	13.5
Hld. Chan. El.	16.4	16.4	d	21.6	18.5	15.0	15.0
Crowder Position	1	1	1	1	1	1	1
Crowder Gate Position	2	2	2	2	2	2	2
Spill Gates op.	0	0	0	0	0	0	0

Table 1. (Continued)

DATE	11 June			12 June			
PARAMETERS							
Shad Taken	13	1	2	8	2	1	1
Total Fish	a	345+	223	300+	496	175	27
Rel. Loc.	1	②	②	②	②	②	②
Lift Time	0855	1355	0715	0800	0845	0930	1630
Min Fished	30	30	30	30	30	30	35
Lift No.	4	10	3	4	5	6	15
Water Temp.	70	71	70	70	70	70	70
Air Temp.	56	65	72	72	73	75	77
% Cloud Cover	0	5	0	0	10	0	80
Rain							
At. Pressure	29.92	29.92	29.85	29.84	29.84	29.83	29.81
River Flow	31.5	31.5	28.7	28.7	28.7	28.7	28.7
Small Gen. on	1	4	1	1	c	6	4
Large Gen. on	0	1	0	0	c	4	2
Unit 1 on							
Unit 2 on	+	+	+	+	+	+	+
% Gate S. U. 1	35	35	35	35	35	35	35
% Gate S. U. 2	75	75	75	75	75	75	75
% Valve 1 open	50	50	50	50	50	50	50
% Valve 2 open	100	100	100	100	100	100	100
Vel. Weir 1	6.0	0.0	5.5	5.5	d	6.0	6.0
Vel. Weir 2	6.0	6.0	5.5	5.5	d	6.0	6.0
Vel. Hld. Chan.	2.0	2.0	2.0	2.0	d	2.0	2.0
Ft. Below TR							
Weir 1	4.5	0.0	6.4	6.4	d	4.5	4.5
Weir 2	4.5	9.1	6.4	6.4	d	4.5	4.5
Tailrace Elev.	13.5	17.1	13.6	13.6	d	19.9	18.3
Hld. Chan. El.	15.0	18.5	14.9	14.9	d	21.5	19.7
Crowder Position	1	1	1	1	1	1	1
Crowder Gate Position	2	2	2	2	2	2	2
Spill Gates op.	0	0	0	0	0	0	0

Table 1. (Continued)

DATE	13 June					14 June	
PARAMETERS							
Shad Taken	2	2	1	2	1	1	1
Total Fish	235	560+	83	95	160	911+	329+
Rel. Loc.	②	②	②	②	②	②	②
Lift Time	0715	0800	1230	1700	1800	0645	1810
Min Fished	35	30	30	30	45	15	30
Lift No.	2	3	9	15	16	1	16
Water Temp.	70	70	70	70	70	70	70
Air Temp.	64	64	70	73	72	68	75
% Cloud Cover	100	100	100	100	100	100	100
Rain	+	+					
At. Pressure	29.80	29.80	29.79	29.76	29.76	29.76	29.76
River Flow	28.6	28.6	28.6	28.6	28.6	29.2	29.2
Small Gen. on	1	1	6	4	4	6	2
Large Gen. on	0	0	4	2	0	4	0
Unit 1 on							
Unit 2 on	+	+	+	+	+	+	+
% Gate S. U. 1	35	35	35	35	35	35	35
% Gate S. U. 2	75	75	75	75	75	75	75
% Valve 1 open	50	50	50	50	50	50	50
% Valve 2 open	100	100	100	100	100	100	100
Vel. Weir 1	6.0	6.0	6.0	6.0	6.0	d	6.0
Vel. Weir 2	6.0	6.0	6.0	6.0	6.0	d	6.0
Vel. Hld. Chan.	2.0	2.0	2.0	2.0	2.0	d	2.0
Ft. Below TR							
Weir 1	6.4	6.4	4.5	4.5	4.5	d	4.0
Weir 2	6.4	6.4	4.5	4.5	4.5	d	4.0
Tailrace Elev.	13.6	13.6	20.0	18.3	16.4	d	15.1
Hld. Chan. El.	15.2	15.2	21.5	19.7	17.9	d	16.7
Crowder							
Position	1	1	1	1	1	1	1
Crowder Gate							
Position	2	2	2	2	2	2	2
Spill Gates op.	0	0	0	0	0	0	0

Table 1. (Continued)

DATE	15 June						
PARAMETERS							
Shad Taken	3	4	5	8	1	1	1
Total Fish	1,000±	1,034±	595±	368±	333±	358±	1,321±
Rel. Loc.	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Lift Time	0600	0630	0700	0730	0800	0845	0930
Min Fished	15	15	15	15	15	30	30
Lift No.	1	2	3	4	5	6	7
Water Temp.	69	69	69	69	69	69	69
Air Temp.	72	72	72	72	72	72	74
% Cloud Cover	90	90	100	100	100	100	100
Rain							
At. Pressure	29.76	29.76	29.76	29.76	29.76	29.76	29.76
River Flow	25.2	25.2	25.2	25.2	25.2	25.2	25.2
Small Gen. on	1	1	1	1	1	4	6
Large Gen. on	0	0	0	0	0	0	4
Unit 1 on							
Unit 2 on	+	+	+	+	+	+	+
% Gate S. U. 1	35	35	35	35	35	35	35
% Gate S. U. 2	75	75	75	75	75	75	75
% Valve 1 open	50	50	50	50	50	50	50
% Valve 2 open	100	100	100	100	100	100	100
Vel. Weir 1	6.5	6.0	6.0	6.0	6.0	5.5	4.0
Vel. Weir 2	6.5	6.0	6.0	6.0	6.0	5.5	4.0
Vel. Hld. Chan.	2.0	2.0	2.0	2.0	2.0	2.0	1.8
Ft. Below TR							
Weir 1	3.5	4.5	4.5	4.5	4.5	4.5	8.5
Weir 2	3.5	4.5	4.5	4.5	4.5	4.5	8.5
Tailrace Elev.	13.5	13.6	13.6	13.6	13.6	15.8	20.0
Hld. Chan. El.	15.4	15.2	15.2	15.2	15.2	17.2	20.8
Crowder							
Position	1	1	1	1	1	1	1
Crowder Gate							
Position	2	2	2	2	2	2	2
Spill Gates op.	0	0	0	0	0	0	0

Table 1. (Continued)

DATE	15 June	16 June				17 June	
PARAMETERS							
Shad Taken	1	2	6	3	1	1	6
Total Fish	589+	250	322+	346+	460+	1,457+	710+
Rel. Loc.	②	②	②	②	②	②	②
Lift Time	1745	0630	0715	0800	0845	0600	0645
Min Fished	30	15	30	30	30	15	30
Lift No.	18	2	3	4	5	2	3
Water Temp.	70	71	71	71	71	70	70
Air Temp.	82	70	70	70	71	69	69
% Cloud Cover	0	0	50	90	100	100	100
Rain							
At. Pressure	29.75	29.73	29.73	29.73	29.73	29.73	29.73
River Flow	25.2	27.3	27.3	27.3	27.3	30.0	30.0
Small Gen. on	4	1	1	1	4	1	1
Large Gen. on	0	0	0	0	0	0	0
Unit 1 on							
Unit 2 on	+	+	+	+	+	+	+
% Gate S. U. 1	35	35	35	35	35	35	35
% Gate S. U. 2	75	75	75	75	75	75	75
% Valve 1 open	50	100	100	100	100	50	50
% Valve 2 open	100	100	100	100	100	100	100
Vel. Weir 1	6.0	6.5	6.0	6.0	6.0	5.5	6.0
Vel. Weir 2	6.5	6.0	6.0	6.0	5.5	6.0	6.0
Vel. Hld. Chan.	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ft. Below TR							
Weir 1	4.1	3.8	4.5	4.5	4.5	5.2	4.5
Weir 2	4.1	3.8	4.5	4.5	4.5	5.2	4.5
Tailrace Elev.	16.5	13.8	13.8	13.8	15.8	13.6	13.6
Hld. Chan. El.	18.2	15.5	15.3	15.3	17.3	14.9	15.1
Crowder							
Position	1	1	1	1	1	1	1
Crowder Gate							
Position	2	2	2	2	2	2	2
Spill Gates op.	0	0	0	0	0	0	0

Table 1. (Continued)

DATE	17 June		18 June			19 June	21 June
PARAMETERS							
Shad Taken	10	1	1	4	2	1	65+
Total Fish	710+	721+	3,000+	416+	606+	79	3,000+
Rel. Loc.	②	②	②	②	②	②	②
Lift Time	0730	0815	0555	0730	0815	1115	0650
Min Fished	30	30	10	30	30	30	30
Lift No.	4	5	1	3	4	7	1
Water Temp.	71	71	71	71	71	72	74
Air Temp.	69	70	69	70	70	80	69
% Cloud Cover	75	100	100	100	100	50	100
Rain				+	+		
At. Pressure	29.74	29.75	29.82	29.82	29.82	29.84	29.53
River Flow	30.0	30.0	36.2	36.2	36.2	40.2	47.3
Small Gen. on	1	2	1	2	3	6	0
Large Gen. on	0	0	0	0	0	4	0
Unit 1 on							
Unit 2 on	+	+	+	+	+	+	
% Gate S. U. 1	35	35	35	35	35	35	35
% Gate S. U. 2	75	75	75	75	75	75	75
% Valve 1 open	50	50	50	50	50	50	50
% Valve 2 open	100	100	100	100	100	100	100
Vel. Weir 1	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vel. Weir 2	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vel. Hld. Chan.	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ft. Below TR							
Weir 1	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Weir 2	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Tailrace Elev.	13.6	14.4	13.6	14.0	15.2	20.1	12.0
Hld. Chan. El.	15.1	15.9	15.1	15.5	16.8	21.7	13.5
Crowder							
Position	1	1	1	1	1	2	1
Crowder Gate							
Position	2	2	2	2	2	2	2
Spill Gates op.	0	0	0	0	0	0	0

Table 2. Number of American shad (Alosa sapidissima) taken in the Conowingo Dam Fish Collection Facility from 11 May to 21 June 1972, with respect to time of day.

DATE	May 11-17	May 18-24	May 25-31	June 1-7	June 8-14	June 15-21	Totals
Time of Day Taken (EST)							
0500-0559				7	2	1	10
0600-0659		1	3	20	8	16 + (65±)	48 + (65±)
0700-0759			14	6	13	33	66
0800-0859			12		43	9	64
0900-0959		1		2	1	1	5
1000-1059			2				2
1100-1159						1	1
1200-1259			1	1	1		3
1300-1359	1		4	1	1		7
1400-1459		1	1	1	1		4
1500-1559							
1600-1659	1		1		1		3
1700-1759	2		2	2	2	1	9
1800-1859	2		2		2		6
Totals	6	3	42	40	75	127	293

Table 3. The conditions of generation and the respective numbers of American shad (Alosa sapidissima) taken at the Conowingo Dam Fish Collection Facility from 15 May to 21 June 1972.

KNOWN NO. OF UNITS GENERATING	NO. AMERICAN SHAD TAKEN	% OF TOTAL CATCH
Small (old) Units (1-7)		
None	65±	22
One to Four	187	64
Five to Seven	33	11
Large (new) Units (8-11)		
None	234	79
One	10	3
Two	9	3
Three	4	1
Four	28	10

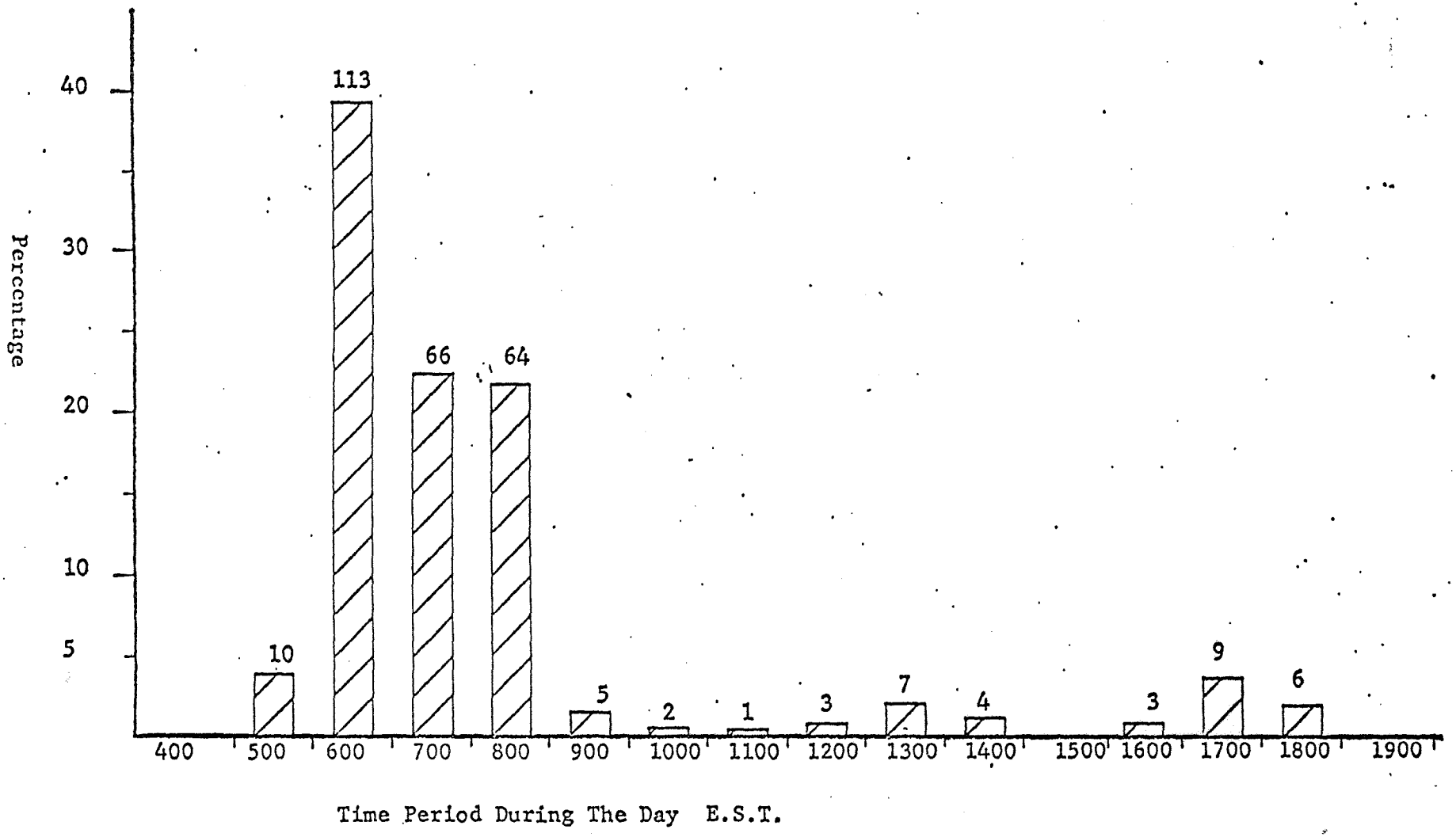

Figure 1. The percentage of American shad (Alosa sapidissima) taken in the Conowingo Dam Fish Collection Facility with respect to time of day. Numbers at the top of columns are the actual number of shad taken.

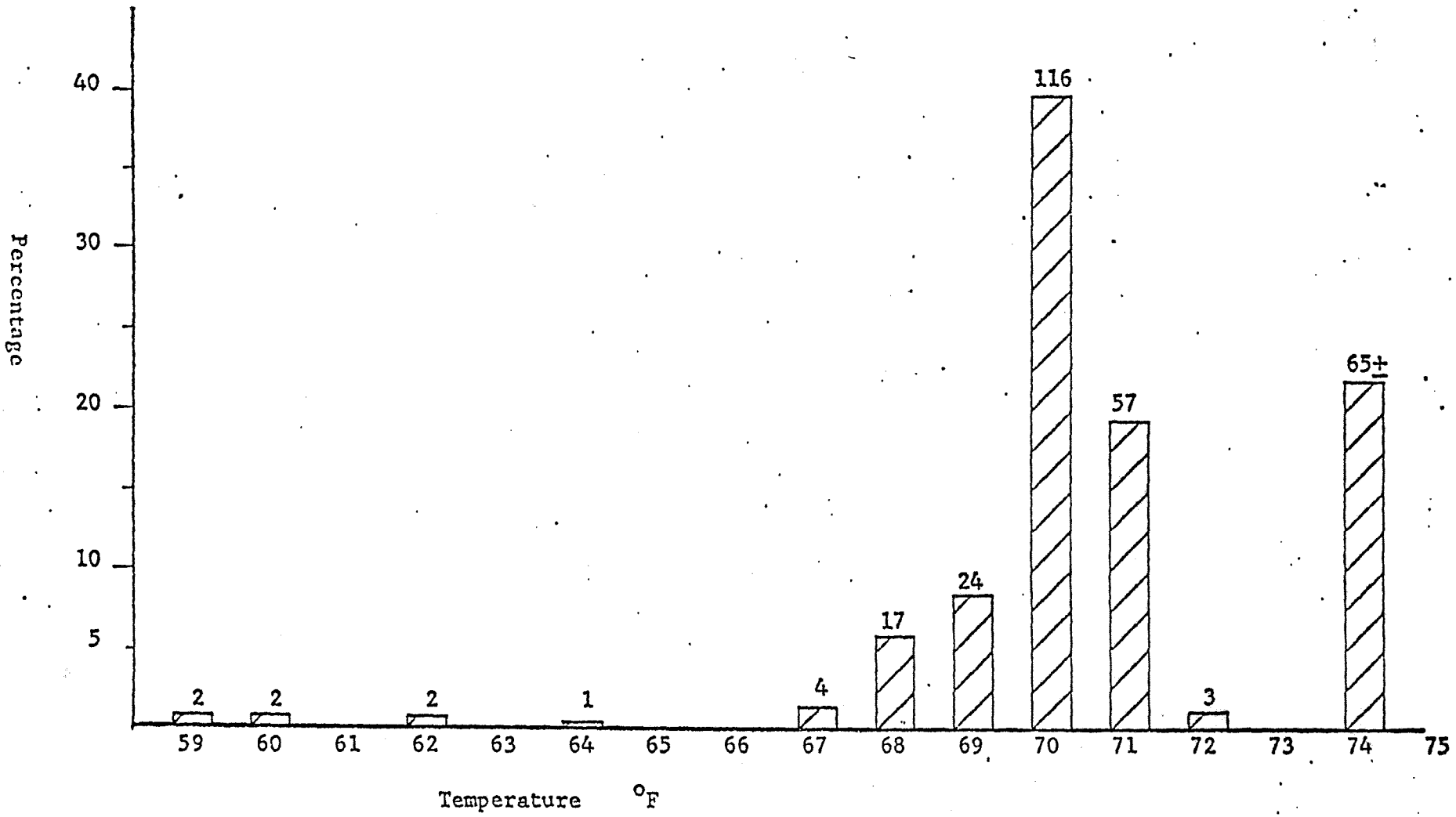

Figure 2. The percentage of total catch of American shad (Alosa sapidissima) taken in the Conowingo Dam Fish Collection Facility with respect to temperature. Numbers at the top of columns are the actual number of shad taken.