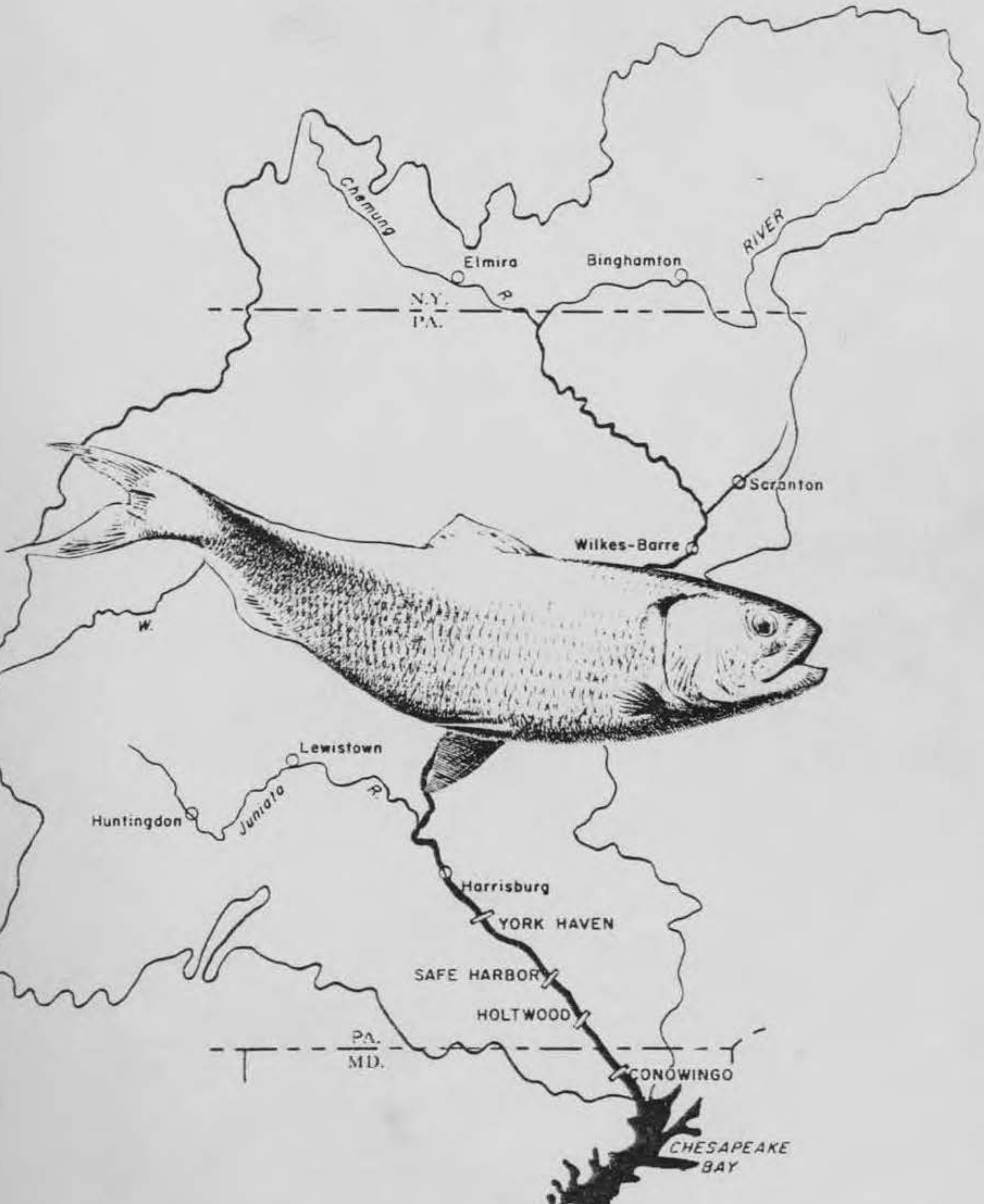
Restoration of American Shad to the Susquehanna River

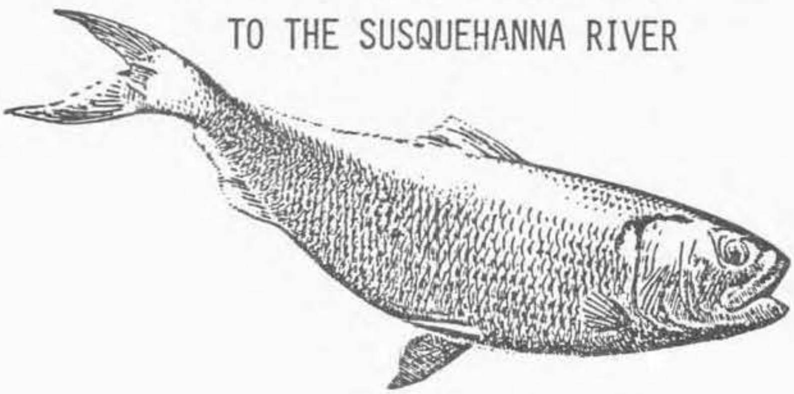
ANNUAL PROGRESS REPORT
— 1984 —



SUSQUEHANNA RIVER
ANADROMOUS FISH RESTORATION COMMITTEE

JANUARY 1985

RESTORATION OF AMERICAN SHAD TO THE SUSQUEHANNA RIVER



ANNUAL PROGRESS REPORT

1984

SUSQUEHANNA RIVER
ANADROMOUS FISH RESTORATION COMMITTEE

MARYLAND DEPARTMENT OF NATURAL RESOURCES
UNITED STATES FISH AND WILDLIFE SERVICE
NEW YORK DIVISION OF FISH AND WILDLIFE
PENNSYLVANIA POWER AND LIGHT COMPANY
SAFE HARBOR WATER POWER CORPORATION
SUSQUEHANNA RIVER BASIN COMMISSION
NATIONAL MARINE FISHERIES SERVICE
PHILADELPHIA ELECTRIC COMPANY
PENNSYLVANIA FISH COMMISSION
YORK HAVEN POWER COMPANY

JANUARY 1985

INTRODUCTION

This Annual Report discusses the numerous activities undertaken by member agencies and contractors for the Susquehanna River Anadromous Fish Restoration Committee during 1984. These efforts represent a continued commitment on the part of interested state and federal agencies and private utility companies to rebuild stocks of American shad to the Susquehanna River system. The program is based on the premise that a population of shad can be developed through natural reproduction of stocked adults and production of hatchery reared fry and fingerlings. Young shad resulting from these stockings should be imprinted to the Susquehanna River and will hopefully migrate to sea and return as spawning adults in future years.

The 1984 restoration program was similar to that of past years and is separated into seven major work elements. Collection and transplantation of prespawned adult shad from out-of-basin sources, collection of shad eggs and delivery to the hatchery, shad culture, cultural research and stocking, and juvenile outmigration evaluation studies were financially supported by the Pennsylvania Power & Light Company and Safe Harbor Water Power Corporation as part of a settlement agreement reached in April, 1981 with the Pennsylvania Fish Commission and the Susquehanna River Basin Commission.

Operation of the fish collection facility at Conowingo Dam, transport of prespawned adult shad and herring upstream from that site, and juvenile shad assessment in Conowingo Pool and tailwaters is funded by the Philadelphia Electric Company and conducted by contractors to PECO. Assessment of population size and characterization of the American shad stock returning to the upper Chesapeake Bay-lower Susquehanna River is conducted by the Tidal Fisheries Division of the Maryland Department of Natural Resources as a cost-shared Federal Aid project.

The Conowingo trap had to compete with high river flows and turbine discharges throughout the spring migration season. These higher than normal flows adversely affected shad catch and also hindered population assessment activities in the lower river.

Compared to prior years, more emphasis was placed on juvenile assessment in an effort to develop baseline indices of abundance in the North Branch, Juniata River, and at hydroproject forebays. Maryland DNR intensified their juvenile recovery effort below Conowingo and drew funds from the settlement agreement for this activity. The adult transfer program was cut back from 1983 levels to accommodate this shift in funds and major emphasis was placed on taking Hudson River shad and improving survival during transport.

Shad eggs were collected from the Pamunkey, James, Delaware, and Columbia Rivers and were delivered to the PFC Van Dyke Hatchery. A record number of shad fry were produced and stocked into the Juniata River in 1984.

This is the final year of effort funded by the 1981 settlement agreement. A new 10-year agreement was reached in December, 1984 between upstream utilities and intervenor agencies which were involved in relicensing proceedings. All four utilities and the Susquehanna River Basin Commission are provided voting representation on SRAFRC as part of the new agreement.

SUMMARY OF ACCOMPLISHMENTS

During May, 1984 a total of 4,671 adult American shad were transferred to the Susquehanna River from the Hudson (4,372) and Connecticut (299) Rivers. All fish were stocked at Tunkhannock, PA and average survival to the release site was measured at 82%. Three transport units were used for hauling and an improved aeration system on one unit outperformed the others in terms of survival. A single stocking of a flow-through pond at Pleasant Mount Hatchery (PFC) resulted in 98% survival after 5 days. Improved handling and hauling conditions and a healthy Hudson River stock contributed to this success. Over 15,000 adult shad have been stocked into the upper Susquehanna River during 1982-1984.

A total of 41.11 million shad eggs were collected from the Pamunkey (9.83M), James (0.74M), Delaware (2.64M), and Columbia Rivers (27.88M) in 1984. This is the largest number of eggs delivered to Van Dyke Hatchery since its inception in 1977. Pamunkey River totals were the greatest in the 11 years of egg taking from that stream and the Columbia take was the second highest in 8 years. Approximately 45% of the eggs hatched at Van Dyke and a record 73% of those survived to stocking. Greatest viability was recorded for Virginia eggs, lowest for the Delaware.

Just over 13½ million fry were produced of which 12 million were stocked into the Juniata River. This is equivalent to the total fry production for the three previous years combined. About 30,000 fingerlings were produced in the Thompsontown Canal and an additional 4,000 were provided to RMC for tagging studies. Over half the fry stocked in the Juniata were less than 18 days of age due to crowding at the hatchery during June.

Catch of American shad at the Conowingo lift was the lowest since 1980 (167 fish). Low catch of shad in 1983 and 1984 is related to high river flow rates and concomitant increased generation at the project during the migration season. Shad apparently cannot find the trap when large turbine releases compete for their attention. In 1984, flow at Conowingo did not drop below 50,000 cfs until June 5. By contrast, in 1982 over 2,000 shad were collected at the trap during the month of May, and river flows never exceeded 50,000 cfs. No shad or herring were transported upstream in 1984.

Maryland DNR continued their adult shad population assessment in the upper Chesapeake Bay. Anchored gill nets and hook and line (Conowingo tailrace) were used to collect 221 shad for tagging. Of 13 recaptures, 10 were used in the population estimate and 7 of those recaptures came from the lift. The estimated shad population size in 1984 was 3,500-3,800, considerably smaller than estimates for 1981 through 1983. Maryland shad fisheries remained closed.

No young shad were collected in the main Susquehanna River above Clarks Ferry during seining efforts in August and September. Unusual flow conditions during late spring and summer, failed reproduction of adults, or inadequate sampling may be responsible for lack of shad in collections. Almost 1,300 juvenile shad were taken by seine at Amity Hall near the mouth of the Juniata River during six sample dates in August through October. Cast net samples at York Haven, Safe Harbor and Holtwood produced erratic results during weekly collections (September-November) and baseline abundance indices were not developed. Strainers at Safe Harbor produced 112 shad and Peach Bottom intake screens took 38. Only one shad was collected below Conowingo Dam in 1984 despite increased sampling intensity which included midwater trawling. Size of juveniles in the lower river was larger than past years with many fish in the 150-175mm fork length range. This may be related to a poor year-class of gizzard shad in the lower river impoundments.

Research conducted by the Pennsylvania Fish Commission in 1984 emphasized feed and feeding regimes in early shad larvae in an effort to improve growth and survival, and use of oxytetracycline to mark daily otolith rings in shad fry for future identification. It appears that shad larvae do not feed at night and that growth and survival are enhanced with a feeding rate of 12 Artemia nauplii per fish per day supplemented with Larval AP-100 dry diet. Two production lots of shad fry (age 15 days) were treated with 50 mg/l oxytetracycline hydrochloride for 12 hours per day for 4 consecutive days. Water was buffered and pure oxygen added to reduce stress. At 57 days of age, 39 of 40 fish examined displayed the fluorescent mark on otoliths, and at 152 days of age 14 of 17 (82%) showed the mark. Future marking of all fry released from Van Dyke may be extremely useful in determining the efficacy of the hatchery versus adult transfer programs.

Additional information on activities discussed in this Annual Progress Report can be obtained from the authors or by contacting the Susquehanna River Coordinator, U.S. Fish and Wildlife Service, P.O. Box 1673, Harrisburg, Pennsylvania 17105.

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JOB I. TRANSFER ADULT AMERICAN SHAD TO THE SUSQUEHANNA RIVER FROM OUT-OF-BASIN SOURCES

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1.1 INTRODUCTION

From 1981 through 1983 over 9,800 pre-spawned shad were transported from the Connecticut (1981-83) and Hudson Rivers (1982-83) and released to the Susquehanna. The purpose of this activity is to establish a run of American shad to the Susquehanna River based upon fish which are spawned in the river.

The 1984 SRAFRC work program was basically a continuation of the activities conducted during 1981-1983. Due to funding limitations the program was streamlined and the target numbers reduced from the previous year. A minimum of 4,000 adult shad were to be collected from the Hudson and Connecticut Rivers and transported to the Susquehanna River. Handling and transport mortality was to be limited to 25% or less. The Delaware was not used in 1984 to provide adult shad for hauling.

The Hudson River was expected to provide 3,000 fish, taken by haul seining near Hudson, N.Y. The remaining 1,000 adults were to be taken from the fishlift at Holyoke Dam on the Connecticut River. Provisions were made to increase the target numbers and days on the Hudson River if sufficient quantity of shad were available. Consequently, this would reduce the number of days at the Holyoke Fish Lift.

1.1 Continued

The Connecticut River operational procedures differed little from previous years (see previous SRAFRC reports). This operation was conducted by the PFC, using Pleasant Mount Fish Cultural Station as a center of operations. A series of changes were employed on the PFC transfer trucks and will be discussed in more detail later in the report.

The Hudson River out-of-basin transfer program, in its third year, utilized methods developed in past years. This program was conducted by NES, utilizing local commercial fishermen for this operation.

1.2 HUDSON RIVER SHAD TRANSFER PROGRAM

In 1982 and 1983 NES successfully captured pre-spawned adult shad from the Hudson River and transferred them to a release site on the upper Susquehanna River, in New York. A total of 992 in 1982 and 3,123 in 1983 fish were presumed alive at release, resulting in a survival rate of 84% for both years. Past experience by NES on the Hudson River indicated that a substantial adult shad population was available for the transfer program. However, unlike the Connecticut River, there was no means for capture of adult shad other than by netting. In 1982, NES began operations utilizing gill-nets as the primary gear, however, shad capture was shifted to haul seine when low survival resulted. The overall success of the haul seine and the operation in general led to its expansion in 1983.

1.2.1 Schedule and Collecting Methods

The Hudson River program was conducted from 30 April - 22 May on a seven day per week basis. Operational timetables were contingent on tidal conditions; i.e., when the tide was running full haul seines could not be used effectively. Generally, fishing activities took place between 0600 and 2000 hours. Sampling days were utilized to the fullest in order to reach the proposed goal.

American shad were collected from the Hudson River in the vicinity of Greenport, NY. Crews ranging from 10-12 technicians worked cooperatively with commercial fishermen contracted to collect shad. Crews worked to capture shad, transport them to a shore-based site and load the tank truck.

A 500 x 12 ft haul seine with 2 inch square mesh wings and 1 inch square mesh bag was utilized to collect shad. The seine operation was directed through mutual agreement with commercial fishermen and NES to ensure that the operation was carried out in the most effective manner. Site selection was based on an area of river that was found to have large numbers of shad in the 1982 and 1983 operations. The seine was hauled along the shoreline as soon as the tide changed from ebb to flood. This tidal condition was used to minimize manpower needs in hauling the seine.

Two people were needed to lay out the net from a boat captained by a fisherman, while an additional 5-6 individuals pulled the opposite end of the net along the shoreline. An entire area was encircled and the net ultimately pulled to the shore. The shad were concentrated in the bag section.

Shad collected in the seine were immediately hand brailed from the bag to one of two tanks mounted in 16 ft boats. One system consisted of a 400-gallon oval fiberglass tank, while the other boat supported a 300-gallon round galvinized stocktank. Both systems were circulated by 3 HP trash pumps which drew water from the bottom center of the tank to an intake valve on the top inside tank wall. Oxygen levels were maintained by large cylinders of oxygen mounted in each boat.

Tests by NES determined that the 400-gallon oval tank could safely support 125-130 shad for a 30 minute period, while the 300-gallon round tank could hold a maximum of 60-65 shad before overly stressed fish were observed. However, the number of fish loaded each day was determined by several factors including water temperature, size of fish and river conditions. The boats and tanks, after loading, were driven by two NES personnel to a shore-based loading site, approximately a five minute ride. The addition of the second shuttle boat in 1984 enabled the crew to increase efficiency and to reduce the time the fish were held in the seine.

At the shoreline 3-5 shad were dip-netted from the stock tank into a 15-gallon round galvanized metal wash tub filled with water. Two individuals carried each tub a distance of about 100 yards. The shad were lifted by hand to the opening of the transfer tank and deposited into the tank. The process was continued until all shad had been loaded.

The minimum load to be transferred to the Susquehanna River was 50 shad. They were accumulated in the transport tank until that number was reached. The maximum capacity of the tank was about 150 shad. Most shipments averaged between 120-130 fish.

1.2.2 Description of Transfer Equipment Utilized by NES

The transport tank has a 1,100-gallon capacity and is about 4-ft high and 8-ft in diameter. The top is removable and shad are loaded through a 2-ft square hatch on the top. Unloading is accomplished by removing the outside circular cap by a gate release located on the back of the tank. A portable cylindrical shoot, fitted with a flexible discharge tube to avoid forcing fish to the river bottom during release, is attached below the unloading hatch and directs both water and shad into the Susquehanna River.

The fiberglass tank is mounted onto a wooden platform with rubber cushions on both sides of the structure to provide shock absorption and reduce stress on the legs of the tank. This structure is mounted to the bed of the truck. In addition, cable guide lines are attached from the tank top to the truck bed to supply additional support. The mounting system was employed as a result of stress fractures in the legs of the tank in the 1983 operation.

Water circulation is created by two 3 HP gasoline driven centrifugal pumps. Each pump has an individual pressure discharge to the tank, located tangential to the inner tank wall. Pressure discharges are located at different heights to create equal current throughout the water column in the tank. A common return suction to the pumps is located at the bottom center of the tank. Each pump is equipped with a bleeder valve which introduces air into the system during pumping.

Aeration of the system is controlled by air intake valves on the suction side of each pump. An inverse relationship exists between the amount of aeration and strength of the current. Opening air valves and increasing the amount of air in the lines causes a reduction in the current and increases the rate of aeration. Approximately 70% water and 30% air were continually delivered to the tanks by the pumps. Air valves were opened to the maximum position.

1.2.3 Description of the PFC Transfer Equipment

The transport tank used by the PFC is of the same dimensions and specifications as that employed by NES. The basic differences are the mounting structure (NES utilized the platform and guide lines) and the life support system (aerators and oxygen injection). The following description of the system was supplied by the PFC:

The two Fresh-Flow (model #TT, 12 VDC) aerators are mounted through the lip of the tank. Power is supplied by the trucks existing electrical system. Water current speed in the tank is adjusted by directing the aerator discharge against the tank wall or into the desired flow direction. A 12-inch section of Porex tubing is mounted under the aerators so that the oxygen flows directly into the aerators intake screens. A flow meter as well as an oxygen injection cylinder are utilized in order that a constant amount of oxygen can be maintained.

1.2.4 Water Conditioning

On suggestions from the PFC, prior to loading shad in the transport tank, the water was treated with 80 pounds of Agway Solar Salt (0.9% solution) and 100 ml of Argent Silicone Based Antifoam Solution (diluted to 500 ml with distilled water.) These suggestions were based on transportation studies conducted by the PFC during the 1983 program. (See 1983 Annual Progress Report - Appendix I-A Adult American Shad Transportation Studies - 1983). The report stated that the addition of salt to the transportation tank seems to reduce mortalities in long duration stocking trips. The antifoam is necessary to reduce foaming which results from the addition of salt.

1.2.5 Temperature/Oxygen Monitoring and Release of Fish

Cooling of the transport tank was not necessary. Cooling is necessary when water temperature is more than 70°F, a situation which did not occur. Water temperature differential between the Hudson River and the Susquehanna River was measured and every effort was made to minimize increases in temperature during transport. Dissolved oxygen (DO) was maintained by an aeration system which is an integral part of the transport tank. Dissolved oxygen (DO) and temperature were monitored with a YSI Model 57 oxygen meter. A small opening at the top edge of the tank provided access to the release hatch cover. The probe was inserted prior to securing the tank for transport. Readings were monitored throughout the course of the trip and recorded at two hour intervals. A final water temperature and dissolved oxygen reading was made in the tank prior to stocking.

Tunkhannock, PA., was used as the primary release site. At the release site, the truck was backed down the access ramp to the shoreline and circulation pumps shut down. The hatch cover was removed and the flexible shoot attached. Before the release cover was raised, visually dead shad were removed. Some mortality was unavoidable during transfer. After release, divers dip-netted around the release site for approximately 15-30 minutes to retrieve any fish which died in transit or release. It is probable that all dead fish are not recovered in this manner.

1.2.6 Results - Numbers of Shad Transplanted and Survival

Shad were collected from the Hudson River from 30 April through 24 May. The abundance and condition of fish began to decline by end of the program. Some 4372 prespawned American shad were transferred by

NES and the PFC from the Hudson River and released at Tunkhannock, PA. Of these fish, a total of 3592 were alive at release. The PFC trucked 2,418 fish while NES trucked 1,954. Mean survival was 87.5% (range 70% to 98%)* and 75.3% (range 30% to 99%) respectively. The average survival for Hudson River fish was 82%.

The primary release site on the Susquehanna River was at Tunkhannock, PA. This location was utilized for all but one load, which was examined for delayed mortality by the PFC. Some 107 shad were delivered to a 1/2 acre earthen pond at Pleasant Mount Fish Cultural Station. A total of 93 shad survived the transfer (87%) and 91 shad were found alive after 5 days in the pond (98% survival). These fish were trucked to the Susquehanna River and released at Tunkhannock, PA., after the five day study.

The average time for loading the tank depended on the number of fish taken in the haul and the number of trucks to be loaded. If sufficient numbers of fish were taken to fill the tank, the entire operation would take approximately 2-4 hours. The typical travel time from the Hudson River collection site to Tunkhannock was less than five hours.

The condition of fishes taken by haul seine appeared to be extremely good. The haul seine, though labor intensive, is an excellent device for shad capture. It is a practical means of capturing large

*excludes transport data for 17 May when pump system was utilized by PFC.

quantities of fish with a minimal amount of handling. The addition of the second boat mounted shuttle system greatly increased the efficiency of the operation and reduced the time shad were held in the net. In addition, the Hudson River seining site has provided the transport operation with a consistant supply of shad since its inclusion in the program. These factors, lower fish survival, and greater travel time for the Holyoke Operation prompted the SRAFRC technical committee to expand the Hudson River transfer project for an additional five days, consequently reducing the number of hauls scheduled for the Connecticut River.

1.2.7 Water Temperature and Dissolved Oxygen

Water temperature during the time of the shad capture ranged from 54-57°F (Table 3). The increase in temperature during transit varied between the NES and PFC systems. The increase in temperature in transit for NES was approximately 5°F, while the PFC transport system had less than a 2°F rise during the 4-5 hour trip. Water temperature in the Susquehanna and Hudson Rivers were within 3-5°F of each other.

Dissolved oxygen was usually about 8 ppm (6.4 - 9.5 ppm) on the Hudson River during the transfer operation. The average DO for the NES system was approximately 5.0 ppm (4.5 - 6.8 ppm) at trips end and 8.5 ppm (6.9 - 9.9 ppm) for the PFC. The difference in these parameters may have contributed to the higher survival of shad trucked by the PFC.

1.2.7 Continued

It is important to note the results of 17 May when the PFC compared the two systems. (One truck employed the gasoline trash pumps while the other system supported the new aerator and oxygen injection). Every effort was made to minimize differences in loading and trucking procedures. The PFC indicated that DO for the gasoline powered system declined by 5.3 ppm while temperature rose some 7°F. In comparison the Free Flo System had approximately a one ppm decline in DO (9.6 start - 8.5 finish) and water temperature was up only 2°F. Survival was 49.5% and 98.0% respectively.

1.2.8 Interagency Cooperation

The Hudson River adult transfer program was a cooperative effort between various agencies. The NYDEC, PFC and USFWS were available for technical consultation, as necessary, during the course of carrying out the operation. The PFC was also involved in the fish transport and delayed mortality studies of shad. In addition, PFC Waterways Patrolman were helpful in disposal of dead shad, as well as the retrieval of fish that had washed to the shoreline in the various days after release. Some 100 fish were collected in this manner.

1.3 CONNECTICUT RIVER SHAD TRANSFER PROGRAM

1.3.1 Introduction and Schedule

Adult transplant operations from the Connecticut River to the Susquehanna River were first conducted on an experimental basis in 1980.

1.3.1 Continued

Since its inclusion in the program the Connecticut River has supplied some 6,200 fish for the restoration effort. The 1984 work plan called for a minimum of 1,000 fish to be captured and trucked to the Susquehanna River. The program was later streamlined to one day, in order that the Hudson River operation could be expanded.

1.3.2 Results

The PFC utilized the same transport system that had proved effective on the Hudson River. A total of 299 shad were handled from Holyoke to Tunkhannock, PA., in two truck loads on 29 May. Only 185 of these shad (62%) were alive following stocking (Table 2). Due to the reduced schedule, no shad were taken to the Pleasant Mount Pond for mortality studies.

1.4 SUMMARY

1.4.1 Comparison with Efforts of 1980 through 1984

The number of shad transferred from out-of-basin sources to the Susquehanna River ranged from a low of 193 in 1980 to 5,637 in 1983. The 1984 program added 4,372 shad for a 5-year total of 15,450 (Table 2). Survival to stocking during this period averaged 77% (range 59% to 84%), while the number released alive increased from 114 in 1980 to 4,310 in 1983. Transfer procedures over the years have also been modified and improved to best meet the SRAFRC goals.

1.4.2 Hudson River

In 1982 the Hudson River was added to the adult shad transfer program on an experimental basis. A total of 1,176 prespawned American shad were collected by haul seine and transferred to the Susquehanna River with a survival rate of 82%. The success of this effort and the effectiveness of seining encouraged SRAFRC to expand the efforts in 1983 and 1984. In 1984 a goal of 3,000 pre-spawn adult shad were to be taken by haul seine and trucked to Tunkhannock, PA., with at least 75% survival. The target number and operation was eventually expanded by the technical committee.

In 1984, adult shad were collected by haul seine near Greenport, NY by NES and transferred to the Susquehanna River by NES and the PFC. All fish were taken directly to Tunkhannock, PA., except for one shipment used for mortality tests. During the period of 30 April through 24 May a grand total of 4,372 shad were transferred, of which 3,592 were presumed alive at release. The average survival rate during transfer was 82%.

In 1984 the PFC utilized a Fresh-Flo aerator and oxygen injection system in their transport units. The system worked effectively and survival to stocking was significantly higher (87% PFC - 75% NES) than the conventional small engine system used by NES. Dissolved oxygen averaged 8.5 ppm while the NES unit was only 5.0 ppm. Temperature increase was less than 2°F for the PFC and 5°F for NES. The difference in these parameters may have contributed to the higher survival of shad trucked by the PFC.

1.4.3 Connecticut River

The Connecticut River operation was streamlined to one day, as a result of the Hudson River expansion. On 29 May a total of 299 shad of which 185 survived (62%) were trucked to Tuckhannock, PA in two loads.

Table 1.1 Data on Prespawned Adult Shad Transferred from the Hudson River to the Susquehanna River at Tuckhannock, PA. by NES and the PFC, 1984.

DATE	TRIP # AND AGENCY	NUMBER TRANSPORTED	NUMBER DEAD	NUMBER ALIVE	TOTAL TANK TIME (HRS: MIN)
4/30	1 NES	152	44	108	5:45
5/1	2 NES	148	35	113	4:35
5/2	3 NES	152	61	91	4:35
5/3	4 NES	156	109	47	5:30
5/4	5 NES	168	61	107	4:40
5/5	6 NES	107	6	101	5:00
5/5	1 PFC	107	10	97	5:00
5/6	2 PFC	125	16	109	5:20
5/7	7 NES	125	15	110	3:30
5/7	3 PFC	125	20	105	5:30
5/8	8 NES	135	22	113	4:15
5/8	4 PFC	125	37	82	4:00
5/9	9 NES	135	63	72	4:00
5/9	5 PFC	109	13	96	4:12
5/10*	10 NES	107	9	93	----
5/11	11 NES	125	5	120	4:00
5/11	6 PFC	102	3	99	4:55
5/12	12 NES	90	1	89	4:40
5/12	7 PFC	101	16	85	4:35
5/13	13 NES	123	6	117	4:00
5/13	8 PFC	102	6	96	4:35
5/14	14 NES	125	2	123	4:00

Continued

Table 1.1 Continued

DATE	TRIP # AND AGENCY	NUMBER TRANSPORTED	NUMBER DEAD	NUMBER ALIVE	TOTAL TANK TIME (HRS: MIN)
5/14	9 PFC	112	8	104	3:55
5/15	10 PFC	120	7	113	5:00
5/16	11 PFC	47	0	47	4:35
5/17 **	12 PFC	101	51	50	4:55
5/17	A12 PFC	108	5	103	4:10
5/18	13 PFC	107	4	103	7:05
5/18	A13 PFC	85	5	80	5:00
5/19 ***	14 PFC	0	0	0	----
5/21	15 PFC	125	6	119	4:10
5/21	A15 PFC	127	3	124	4:00
5/22	15 NES	106	42	64	5:45
5/22	16 PFC	106	11	95	5:15
5/22	A16 PFC	125	13	112	4:00
5/23	17 PFC	119	17	102	4:05
5/23	A17 PFC	117	13	104	5:00
5/24	18 PFC	123	24	99	5:10

* Transported to Pleasant Mount for delayed mortality studies.

** Trip #12 PFC (5/17) - Utilized small engine life support system.

*** Equipment failure, no fish transported.

TABLE 1.2
Comparison of pre-spawned adult American shad transferred from Connecticut River (1980-84) and Hudson River (1982-84) to Susquehanna River.

Year	Number Transported	Number Alive	Percent Survival
	CONNECTICUT RIVER		
1980	193	114	59%
1981	1,486	1,165	78%
1982	2,287	1,573	69%
1983	1,946	1,187	61%
1984	299	185	62%
Total	6,211	4,224	68%
	HUDSON RIVER		
1982	1,176	992	84%
1983	3,691	3,123	84%
1984	4,372	3,592	82%
Total	9,239	7,707	83%
GRAND TOTAL	15,450	11,931	77%

TABLE 1.3

Record of Dissolved Oxygen and Temperature During Transport of Adult American Shad by NES and the PFC from the Hudson River to the Susquehanna River, 1984.

		DISSOLVED OXYGEN (PPM)						TEMPERATURE (°C)					
DATE	TRIP # AND AGENCY	HUDSON RIVER	START TANK	TWO HRS.	FOUR HRS.	FINISH	SUSQUEHANNA RIVER	HUDSON RIVER	START TANK	TWO HRS.	FOUR HRS.	FINISH	SUSQUEHANNA RIVER
April 30	1 NES	6.4	7.8	7.5	5.1	5.1	8.2	13.0	13.0	15.0	16.0	16.0	13.0
May 1	2 NES	8.0	8.4	7.7	5.4	5.4	8.4	12.0	13.0	14.0	15.0	15.0	11.5
2	3 NES	8.0	9.0	7.9	5.5	5.5	8.0	13.0	13.0	15.0	15.0	15.0	13.0
3	4 NES	8.0	8.4	7.8	5.4	5.4	8.1	14.0	14.0	14.0	14.0	14.0	13.0
4	5 NES	8.0	6.8	5.5	4.8	4.8	8.2	12.0	12.0	14.0	14.0	14.0	12.0
5	6 NES	8.0	4.5	4.5	4.5	4.5	8.2	13.0	13.0	13.0	13.0	13.0	12.0
5	1 PFC	--	9.0	8.6	7.7	8.9	--	13.2	13.2	13.2	13.5	13.5	12.0
6	2 PFC	8.0	9.0	7.8	7.9	8.3	--	13.0	13.0	14.0	14.5	15.0	11.5
7	7 NES	--	--	--	--	--	METER MALFUNCTIONING		--	--	--	--	--
7	3 FPC	7.9	10.2	7.9	8.0	8.2	--	13.0	13.0	14.5	14.5	14.5	11.5
8	8 NES	9.5	4.2	4.8	4.5	4.5	8.0	12.0	11.0	13.0	13.0	13.0	11.5
8	4 PFC	9.5	9.5	8.0	8.2	8.4	--	12.0	12.0	11.5	12.0	12.0	11.5
9	9 NES	7.5	4.5	4.7	4.7	4.7	8.0	12.0	12.0	12.0	13.0	13.0	12.0
9	5 PFC	7.5	7.5	9.0	9.3	9.3	--	12.0	12.0	12.0	12.0	12.0	12.0
10	10 NES	8.4	5.0	4.8	4.8	4.8	8.0	11.0	11.0	11.0	12.0	12.0	12.0
11	11 NES	8.6	5.5	5.5	4.8	4.8	8.0	11.0	11.0	13.0	14.0	14.0	11.5
11	6 PFC	8.6	8.6	9.3	8.7	8.6	--	11.0	11.0	11.5	13.0	13.0	11.5
12	12 NES	8.6	6.4	5.0	5.0	5.0	8.5	13.0	13.0	14.0	15.0	15.0	12.0

		DISSOLVED OXYGEN (PPM)						TEMPERATURE (°C)					
DATE	TRIP # AND AGENCY	HUDSON RIVER	START TANK	TWO HRS.	FOUR HRS.	FINISH	SUSQUEHANNA RIVER.	HUDSON RIVER	START TANK	TWO HRS.	FOUR HRS.	FINISH	SUSQUEHANNA RIVER
May 12	7 PFC	8.6	8.6	7.6	8.9	8.9	--	13.0	13.0	13.0	13.5	13.5	12.0
13	13 NES	8.7	7.0	5.0	4.5	4.5	8.0	12.0	12.0	13.0	14.0	14.0	----
13	8 PFC	8.7	8.7	8.9	9.2	9.2	--	12.0	12.0	13.0	13.5	13.5	14.0
14	14 NES	9.0	6.0	6.8	6.8	6.8	8.0	12.0	12.0	13.0	14.0	14.0	11.5
14	9 PFC	9.0	8.7	8.5	9.2	9.2	--	12.0	12.5	12.5	12.5	12.5	11.5
15	10 PFC	9.5	9.5	7.8	9.9	9.9	--	12.0	12.0	11.5	11.5	11.5	12.0
16	11 PFC	10.0	9.0	9.2	9.8	9.5	--	11.0	11.0	12.0	11.5	11.5	11.5
17*	12 PFC	10.6	9.6	4.7	4.3	4.3	--	11.5	13.5	14.0	15.0	15.0	11.0
17	A12 PFC	10.6	9.6	8.5	8.5	8.5	--	11.5	12.0	13.0	13.0	13.0	11.0
18	13 PFC	9.0	5.5	8.9	8.5	6.8	--	12.0	12.5	13.0	13.0	13.5	12.0
18	A13 PFC	--	--	--	--	--	--	--	--	--	--	--	--
19	14 PFC	--	--	--	--	--	--	--	--	--	--	--	--
21	15 PFC	8.7	8.9	7.6	8.5	8.5	8.1	14.0	16.0	17.0	17.5	17.5	14.0
21	A15 PFC	8.7	5.5	7.4	8.4	8.4	8.1	14.0	16.0	17.0	17.5	17.5	14.0
22	15 NES	8.0	4.8	4.8	5.1	5.1	7.8	12.0	16.0	18.0	19.0	19.0	14.0
22	16 PFC	6.1	5.9	6.5	7.0	7.0	--	15.0	16.0	17.5	17.5	17.5	--
22	A16 PFC	6.0	6.0	6.8	7.2	7.2	--	16.0	16.0	17.0	17.5	17.5	15.0
23	17 PFC	8.3	9.3	8.7	7.4	7.4	7.9	16.5	16.5	15.5	15.5	15.5	16.0
23	A17 PFC	8.3	7.8	8.4	9.6	9.6	7.9	16.5	16.5	15.5	15.5	15.5	16.0
24	18 PFC	7.3	6.9	8.4	7.4	6.9	--	17.0	17.0	17.0	17.0	17.0	--

*Trip #12 PFC (5-17) - Utilized small engine life support system.

Table 1.4 1984 ADULT AMERICAN SHAD TRANSPORTATION -

IMMEDIATE MORTALITY ASSESSMENT BY SEX

(PENNSYLVANIA FISH COMMISSION)

				Males				Females			
Date	# Fish Hauled	# Dead	% Dead	# Dead	% of Total # Dead	Mean Length (inches)	Mean Weight (pounds)	# Dead	% of Total # Dead	Mean Length (inches)	Mean Weight (pounds)
5/8	135	24	17.8	17	70.8	21.2	3.8	7	29.2	23.3	5.4
5/8	125	35	28.0	26	74.3	20.4	3.3	9	25.7	23.6	5.3
5/9	136	64	47.1	49	76.6	20.2	3.6	15	23.4	22.4	5.1
5/9	109	13	11.9	10	76.9	19.1	3.1	3	23.1	22.1	5.3
5/10*	107	11	10.3	8	72.7	20.2	3.5	3	27.3	21.9	5.2
5/15	120	7	5.8	6	85.7	19.4	3.2	1	14.3	22.4	6.0
5/16	46	0	0	0	0	0	0	0	0	0	0
5/17	108	5	4.6	4	80.0	19.7	3.1	1	20.0	22.2	3.9
5/17	101	51	50.5	36	70.6	19.5	2.8	15	29.4	22.8	4.5
Overall	987	210	21.3	156	74.3	20.1	3.3	54	25.7	22.8	5.0

*Released in Pleasant Mount " Lagoon;" 5-day delayed mortality after stocking = 2 fish (2%). Subsequent harvest from "lagoon," and transport to the river resulted in the loss of 1 fish and the release of 93 live American shad.

JOB II. AMERICAN SHAD EGG COLLECTION PROGRAM

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2.1 INTRODUCTION

Egg Collection in 1984 was to be conducted on the James and Pamunkey Rivers in Virginia; the Delaware River; and the Columbia River, Oregon-Washington. The SRAFRC goal for 1984 was to obtain 25-40 million viable eggs, to reach a minimum production rate of 4 million fry and 100,000 advanced fry and fingerlings. The Hudson River was to be sampled only as an alternate if large numbers of ripe fish were encountered during routine adult collection. Eggs were to be delivered to the Van Dyke Hatchery. The fish released from the hatchery will supplement the development of the shad population below the Conowingo Dam with the urge to migrate upstream past dams to spawn.

In 1983 East and West Coast egg collection activities resulted in the incubation of a record 34.5 million American shad eggs. Of these a total of 4.1 million juvenile American shad, 4 million fry and 98,000 fingerlings were released into the Juniata River.

2.2 METHODS

2.2.1 Egg Collection

Eggs were collected from shad in spawning condition taken in gill-nets by commercial fishermen. Eggs were artificially fertilized in essentially the same manner established by Kilcer (1973), although minor revisions were employed. Modifications were made as a result of consultation with the PFC and fish culture experts on the West Coast. A brief description of the procedure follows.

Eggs were stripped from three or four spawning females into a dry collecting pan and fertilized with sperm from one or more males. After dry mixing eggs and sperm for several minutes, the eggs were allowed to set for 2-3 minutes to allow for optimum fertilization. A small amount of water was then added to the mixing pan and the gametes stirred, again. After the eggs settled, the water was drained and clean water added. This rinsing process was repeated 3-4 times to remove dead sperm, unfertilized and broken eggs, and debris. Fertilized eggs were then poured into large plastic buckets filled with clean river water and allowed to soak for several hours to become hardened. During this period, water was periodically drained, clean water added and agitated to provide aeration. Once the eggs were hardened, the water was drained and debris, such as scales and stickes, removed. Then, five liters each of eggs and clean water was placed in a plastic bag which had an outer plastic bag for protection in shipping.

Pure oxygen was put into the bag containing eggs and the bag securely

2.2.1 Continued

tied with two castrator rings. The package was then placed into styrofoam containers, sealed with tape and placed in cardboard boxes for shipment. Each box was labelled to show river name, date, number of liters of eggs, water temperature and ratio of females to males.

2.2.2 Collection Areas

2.2.2.1 Pamunkey River, Virginia

NES biologists began egg collection efforts on the Virginia rivers on 9 April, upon confirming reports that shad had been taken by fishermen in spawning condition. Biologists/technicians worked with commercial fishermen at Thompson's Landing, New Kent, Virginia, located approximately 4-6 miles upstream of Lester Manor. Previous years efforts have proven that this area is a viable location for catching adult spawning shad. Netting was usually conducted between 1530 and 2200 hours on a seven day per week schedule. NES biologists/technicians operated from the shoreline at Thompson's Landing. As fish were captured, a small shuttle system was utilized to bring the spawning fish to the shoreline as quickly as possible. This shuttle was new for 1984. Fish in spawning condition were processed at the shoreline.

2.2.2.2 James River, Virginia

Experience in past years has proven that shad migrate up the James River to spawn approximately two weeks later than on the Pamunkey River.

2.2.2.2 Continued

An overlap period of one to two weeks is not uncommon. Throughout the Pamunkey River egg collection program communication between commercial fishermen on the James and NES biologists was maintained, to determine when collection efforts on the James River should begin.

Egg collection efforts on the James River began on 20 April at Berkley Plantation Landing. Berkley Plantation is in the Charles City-Hopewell section of Virginia, directly below the Benjamin Harrison Bridge.

Commercial fishermen using gill-nets and biologists/technicians worked together out of small row boats during egg collection operations. Eggs were stripped from spawning females and fertilized on the boat, rather than on the shoreline, as was the case on the Pamunkey River. Gill-netting was conducted from 1530 to 2200 hours.

2.2.2.3 Hudson River

Although a total of 1,172,400 eggs were collected from the Hudson River in 1983, the Hudson River was not utilized as an egg source during 1984 SRAFRC activities. The Hudson River was considered as an additional source if large numbers of ripe fish were encountered during routine adult collection—a situation which did not occur.

2.2.2.4 Columbia River

The egg collection program on the Columbia River, Oregon-Washington was initiated on 11 June. This decision was determined only after NES

2.2.2.4 Continued

biologists had monitored routine fishing activities of Columbia River commercial fishermen and agreed that spawning shad were available in sufficient numbers.

Netting for shad was conducted on the north shoreline approximately two miles upstream at the Camas-Washougal Reef (Troutdale area). The reef is characterized by 10-30 foot water depths with rocky substrate and scattered logs and trees underlying the netting area. Shad were captured by gill-nets, as in previous years. The nets utilized during the 1984 operation were 150 fathoms in length and tapered in depth from a maximum of 1-2 fathoms with 5 3/4 inch monofilament mesh. Typically, three 45-60 minute drifts were made nightly.

2.2.2.5 Delaware River

In 1983 an experimental effort was conducted on the Delaware River at the Smithfield Beach by personnel of the U.S. Fish and Wildlife Service, PA Fish Commission and a local volunteer group to collect American shad eggs. Smithfield Beach is located about 8 miles upstream NE from East Stroudsburg, PA.

The success of last years program led to its continuation in the 1984 Work Plan. The PFC had the lead on this project.

The sampling program was initiated on 22 May and terminated on 7 June. By this time, the majority of shad taken were no longer in spawning condition. Shad were captured utilizing anchored gill-nets (200 ft long x

2.2.2.5 Continued

6 ft deep, with 4 3/4 - 6 in mesh) set parallel to the current. Nets were generally set between dusk and midnight. Fish were removed from nets and shuttled by boat to shore to be processed.

2.3 TRANSPORTATION

2.3.1 Virginia Rivers

Shad eggs collected from the Pamunkey and James Rivers were transported by automobile, as was the case in 1983. Eggs collected at the rivers were driven to Sandston, Virginia. Arrangements were made to deliver the shipments from Sandston to the Van Dyke Hatchery. NES personnel in Virginia notified the hatchery nightly to verify the estimated number of liters and the ETA of the shipment. The average delivery time from Virginia to Van Dyke was six hours.

2.3.2 Columbia River

After packaging the eggs from the Columbia River, the boxes were transported by van to the United Airlines Freight Terminal at Portland International Airport. Eggs were delivered to the airport between 2215 and 2230 hours, five days per week (Monday through Friday).

Unfortunately 1983 flight arrangements were no longer in service and alternate connections had to be made. In 1983 freight shipped to Washington, D.C. did not result in a plane change. However, no direct flights to the East Coast were available on any carrier in 1984.

Consequently the egg shipments were flown to Chicago and redirected to Harrisburg International Airport. This change in aircraft is believed to have reduced viability and is discussed in more detail later in the report.

Upon arrival of egg shipments into Harrisburg, PA., eggs were transported by van to the hatchery. Approximate shipping time was 11-13 hours.

2.3.3 Delaware River

Egg shipments from the Delaware Rivers were transported in the same manner as in Virginia. Eggs were delivered by automobile from the collection site to the Van Dyke Hatchery. Eggs were received usually within a few hours of processing. The driving distance to the hatchery was approximately 3 hours.

2.4 COLLECTION SCHEDULE

The shad egg collection schedule was based on experience gained over a ten year period. Initiation of collection activities on any river was determined through communications with commecial fishermen and/or participation in fishing activities which documented that spawning shad were available in sufficient numbers. Collection activities usually began when water temperature reached 55-60°F.

East Coast egg collection operations were terminated when less than 5 liters of eggs were taken on a number of consecutive nights or it was apparent that shad had concluded spawning activities. The West Coast operation was based on the number of fishing days that the budget could support and/or the quantity and quality of eggs available.

2.5 RESULTS

In 1983 a cooperative effort was made to improve procedures of collection, artificial fertilization and shipment of American shad eggs. The result was improved viability and egg quality for the entire program. These techniques which proved effective in 1983 were followed as closely as possible in this years program. Regardless, viability of eggs for 1984 was down on both East and West Coast Rivers. Decreased viability is attributed to:

(1) Abnormal weather conditions on the East Coast in 1984. High amounts of precipitation and unusually cold weather may have affected the number and quality of eggs available. For instance, in Virginia, the number of eggs stripped per fish was significantly lower than that of the previous year. An average of 12.7 thousand eggs per fish was taken in 1984, down about 35% from 17.2 thousand in 1983.

(2) The ratio of buck to roe. Viability on the West Coast declined by 9% from last years average of 48%. On several occasions this year, the buck - roe ratio exceeded the desired 1:3 ratio.

(3) Change in the flight schedule for egg shipments. In 1983, shipments air freighted to Washington, D.C. did not result in a carrier

2.5 Continued

change. However, in 1984, no flights to the East Coast were available without a plane change in Chicago. Consequently, the shipments were exposed to increased handling, some missed flight connections and delayed time of arrival. This situation was also a problem in 1981 and 1982.

2.5.1 Pamunkey River

Shad egg collection efforts began on 11 April on the Pamunkey River, Virginia and continued throughout the duration of the annual adult spawning runs. Water temperature ranged from 54 to 64°F. Egg collection efforts were halted on 1 May when commercial fishermen no longer caught shad in gill-nets. A total of 9.8 million eggs, of which 6.3 million were viable, were collected from the Pamunkey River.

Heavy rains and abnormally low temperatures in late March and early April resulted in a late shad run in Virginia. In addition, fishermen were forced to fish 1-2 miles below Thompson's Landing this year, due to reduced numbers of shad at the landing. Fishermen attributed the poor catch to the high rains in March and April which lowered the salinity of the river.

2.5.2 James River

While the Pamunkey River was producing the highest number of eggs in the history of the collection program, the James River had a disappointing season (Tables 2 and 5). A late shad run and high winds reduced the number of days in which fishermen were able to set their nets.

A total of only four fishing days were spent on the James River in 1984 as compared to 10 days in 1983. A sum of only 0.74 million eggs were collected between 20 April and 2 May. This figure was down significantly from 5.91 million eggs in 1983. In 1984, 63.9% of James River eggs were viable.

2.5.3 Columbia River

Egg collection on the Columbia River began on 11 June and continued through 29 June. Water temperature ranged from 52-62°F. A total of 27.8 million eggs, of which some 10.9 million were viable, were sent to the Van Dyke Hatchery in 14 seperate shipments. Although viability for 1984 was down about 9% from last year, a superior shad run resulted in an increase of 1.5 million more viable eggs than in 1983. The 27.80 million eggs taken on the Columbia River this year represents the second highest total number of eggs since the 54.80 million collected in 1976.

2.5.4 Delaware River

Over 2.60 million eggs were collected in efforts on the Delaware River (Table 7). Approximately 0.82 million (31.2%) were viable. This is down approximately 7% from last years 48% average. All eggs were delivered to the Van Dyke Hatchery nightly, in six separate shipments. Viability in these shipments ranged from a low of zero percent to a high

2.5.4 Continued

of 75.5%. The shipment of 24 May when no viable eggs were received was a result of not using oxygen in the shipment bags. The PFC also suggested that the low viabilities in shipments 23-25 (Table 7) may be weather related, as was the case in Virginia.

2.5.5 All Rivers Combined

The shad egg collection operation was conducted between 11 April and 7 June on three East Coast rivers and the Columbia River (Oregon-Washington). Combined, the total number of eggs collected was some 41.1 million. Of these, over 18.5 million were viable. Most eggs (67%) were obtained from the Columbia River. Although viability of eggs was lower for the entire program, a greater volume of eggs were collected in 1984.

2.6 COMPARISON WITH 1971 TO 1984 RESULTS

The total number of eggs collected in 1984 has increased steadily over the last three years. Much of this increase can be attributed to the Columbia River and the recent strength of the Pamunkey River. The Pamunkey in the last two years has made a significant contribution to the program (5.49 million - 1983 and 9.8 million - 1984). The 9.8 million eggs taken from the Pamunkey River this year marks the highest total since its inclusion in the program. Although the Pamunkey has been strong in 1983 and 1984, the East Coast rivers in general, remain an inconsistant

2.6 Continued

source of eggs. The Columbia River once again produced the highest number of eggs (67%) and remains the most reliable source of artificially fertilized shad eggs.

2.7 REFERENCE

Kilcer, T. F. 1973. Report on the 1973 American shad egg transplant program in the Susquehanna River. Ichth. Asso., Inc., Drumore, PA. Shad Egg Report No. 3 for Susquehanna River Shad Advisory Committee: 26p.

TABLE 1. Sampling period for East and West Coast rivers for collection of American shad eggs, 1984.

RIVER	SAMPLING SCHEDULE DATES	TOTAL FISHING DAYS
Pamunkey	11 April - 2 May	19
James	20 April - 2 May	3
Columbia	11 June - 29 June	15
Delaware	22 May - 7 June	6

TABLE 2. Collection data of the total volume and number of American shad eggs on the Pamunkey, James, Columbia and Delaware rivers, 1984.

RIVER	VOLUME OF EGGS SHIPPED (L)	TOTAL NUMBER OF EGGS (Millions)
Pamunkey	299.00	9.83
James	25.20	0.74
Columbia	779.40	27.88
Delaware	53.70	2.64
Totals	1,157.30	41.11

TABLE 3
Total number (millions) of American shad eggs collected from the Pamunkey, Mattaponi, James, Potomac, Susquehanna, Delaware, Connecticut, Hudson and Columbia Rivers, 1971-1984.

Year	Pamunkey	Mattaponi	James	Potomac	Susquehanna	Delaware	Connecticut	Columbia	Hudson	Total
1971	--	--	--	--	8.42	--	--	--	--	8.4
1972	--	--	--	--	7.00	--	--	--	--	7.1
1973	8.45	6.48	--	34.64	4.74	--	4.30	--	--	58.6
1974	9.75	6.80	19.20	5.56	--	--	0.53	8.18	--	50.0
1975	1.88	--	7.15	5.70	--	--	--	18.42	--	33.2
1976	--	--	--	--	--	4.10	--	54.80	--	58.9
1977	4.40	0.57	3.42	--	--	--	0.35	8.90	--	17.6
1978	6.90	--	10.11	--	--	--	--	--	--	17.0
1979	3.17	--	4.99	--	--	--	--	--	--	8.2
1980	6.73	--	6.83	--	--	--	--	--	--	13.6
1981	4.58	--	1.26	--	--	--	--	5.78	--	11.6
1982	2.03	--	1.25	--	--	--	--	22.57	--	25.8
1983	5.49	--	5.91	--	--	2.40	--	19.51	1.17	34.48
1984	9.83	--	0.74	--	--	2.64	--	27.88	--	41.11
TOTALS	63.21	13.85	60.86	45.90	20.16	9.14	5.18	166.04	1.17	385.59

TABLE 4

Collection data for American shad eggs taken on the Pamunkey River, 1984.

Collection Date	Water Temperature (°F)	Number of Adult Shad	Volume of Eggs (Received at Hatchery) (In Liters)	Weather Conditions Air Temperature (°F)	Number of Commercial Fisherman	& Boats
April 11	55	21	8.0	60 - Clear	3	2
12	57	66	16.7	60 - Clear	5	3
13	56	66	21.2	59 - Rain	3	2
14	59	84	23.7	63 - Rain	5	3
15	60	67	14.6	55 - Cloudy	3	2
16	60	97	26.4	55 - Clear	3	2
17	60	49	20.5	55 - Clear	1	1
18	59	44	12.8	52 - Clear	3	2
19	58	73	25.2	52 - Rain	5	4
20	58	94	24.6	55 - Clear	4	3
21	59	86	29.3	58 - Clear	7	4
23	54	33	8.5	52 - Cloudy	4	3

TABLE 4 Continued

Collection Date	Water Temperature (°F)	Number of Adult Shad	Volume of Eggs (Received at Hatchery) (In Liters)	Weather Conditions Air Temperature (°F)	Number of Commercial Fisherman	& Boats
April 26	56	24	4.7	60 - Clear	2	2
27	60	21	8.4	65 - Cloudy	1	1
28	61	30	10.5	65 - Cloudy	4	3
29	63	50	12.0	70 - Clear	4	3
30	63	37	10.5	73 - Clear	4	3
May 1	64	34	9.8	72 - Clear	3	2
2	64	55	11.6	70 - Cloudy	3	2

TABLE 5
Collection data from American shad eggs taken on the James River, 1984.

Collection Date	Water Temperature (°F)	Number of Adult Shad	Volume of Eggs (Received at Hatchery) (In Liters)	Weather Conditions Air Temperature (°F)	Number of Commercial Fisherman	& Boats
April 20	59	38	10.6	55 - Clear	4	2
23	54	19	7.5	52 - Cloudy	2	1
26	56	20	7.1	60 - Clear	2	1

TABLE 6
Collection data for American shad eggs taken on the Columbia River, 1984.

Collection Date	Water Temperature (°F)	Number of Adult Shad		Volume of Eggs (Received at Hatchery) (In Liters)	Weather Conditions Air Temperature (°F)
		Male	Female		
June 11	59	38	114	58.8	65 - Clear
12	54	40	120	62.1	65 - Cloudy
13	54	33	100	51.3	62 - Cloudy
14	58	33	100	55.2	70 - Clear
15	55	36	110	56.4	67 - Clear
18	56	26	140	72.3	70 - Clear
19	60	40	120	68.7	70 - Clear
20	58	15	80	52.4	50 - Rain
21	52	23	70	41.6	60 - Rain
22	56	29	87	55.9	75 - Clear
25	62	44	132	71.9	85 - Clear
26	60	23	70	38.1	68 - Rain
27	60	20	60	37.8	70 - Clear
29	60	20	90	56.9	55 - Cloudy

TABLE 7
Collection data for American shad eggs taken on the Delaware River, 1984.

Collection Date	Date Received By Hatchery	Volume of Eggs Received at Hatchery
April 22	April 23	4.6 - Liters
23	24	12.2 - Liters
24	25	4.7 - Liters
May 5	May 6	6.0 - Liters
6	7	11.9 - Liters
7	8	14.3 - Liters

Σ 53.7

JOB III. AMERICAN SHAD HATCHERY OPERATIONS

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The Pennsylvania Fish Commission has operated the Van Dyke Research Station for Anadromous Fishes since 1976 as part of an effort to restore diadromous fishes to the Susquehanna River system. The objectives of the Van Dyke Station are to research culture techniques (Job V) for American shad and to rear juveniles, both fry and fingerlings, for release into the Juniata River. The program goal is to develop a stock of shad imprinted to the Susquehanna drainage, which will subsequently return to the river as spawning adults. During 1984, the Van Dyke Station incubated 41.1 million eggs with a 45.2 percent hatch. A 73 percent survival of fry resulted in the production of 13.6 million juvenile American shad from which a record 12 million were released into the Juniata River. All fish stocked were exposed to phenethyl alcohol, an imprinting agent to be used as a chemical attractant at the Conowingo Dam fish collection facility.

This year's effort was supported by funds provided from the settlement agreement between Pennsylvania Power and Light Company, Safe Harbor Water Power Corporation, the Pennsylvania Fish Commission, and the Susquehanna River Basin Commission.

Egg Collection, Shipment and Incubation Data

The Van Dyke Research Station received 39 egg shipments in 1984 with a total of 41.1 million eggs, the largest number of eggs ever received at the facility (Table 3-1). National Environmental Services, Incorporated, primarily responsible for egg collection, provided eggs from three sources: the Pamunkey and James Rivers in Virginia, and the Columbia River, Oregon. The Pennsylvania Fish Commission was responsible for the egg collection effort on the Delaware River.

Nineteen egg shipments were received from Virginia river sources with a total of 10.6 million eggs (346 liters), 65 percent viable. The Pamunkey River shipments provided the majority of eggs, 9.8 million (299.0 liters) of which 64.5 percent were viable. This was the largest annual collection of eggs from the Pamunkey River. In contrast, the James River collection effort provided only 0.7 million eggs (25.2 liters), 63.9 percent viable which is the lowest annual collection of eggs from the James River. Egg collection efforts on the James River were suspended, however, due to funding rather than the availability of eggs.

The Delaware River egg collection effort provided 2.6 million eggs (53.7 liters) with an average viability of 31.2 percent. Egg viability was initially high (70-76 percent) until one shipment was delayed resulting in a 0 percent hatch. Shortly thereafter, the high river flow temporarily suspended the egg collection effort. When this operation resumed, egg quality was poor (17.0 percent viable) and resulted in the termination of this collection effort.

Table 3.1 American Shad egg totals from Van Dyke, 1984.

Total # of shipments (all rivers)	39
Number of eggs received	41,112,900
Volume of eggs received	1,157.3L
Average percent viability	45.2
Total number of viable eggs	18,593,600
Number of fry (at hatch)	18,007,000
Number of fry stocked	11,995,690

Totals (broken down by river)

<u>Pamunkey River</u>

Number of eggs received	9,839,800
Volume of eggs received	299.0L
Percent viability	64.5
Total number of viable eggs	6,369,500
Number of fry (at hatch)	6,242,000

<u>James River</u>

Number of eggs received	749,700
Volume of eggs received	25.2L
Percent viability	63.9
Total number of viable eggs	479,200
Number of fry (at hatch)	446,300

<u>Delaware River</u>

Number of eggs received	2,641,200
Volume of eggs received	53.7L
Percent viability	31.2
Total number of viable eggs	823,600*
Number of fry (at hatch)	785,800*

<u>Columbia River</u>

Number of eggs received	27,882,200
Volume of eggs received	779.4L
Average percent viability	39.2
Total number of viable eggs	10,921,300
Number of fry (at hatch)	10,532,900

*Estimate

The Columbia River has, as in the past, remained an excellent source for a large number of eggs. A total of 27.9 million eggs were collected, 39.2 percent viable.

A breakdown by river system and shipment can be found in Table 3-2.

The egg collection effort had an excellent year in 1984 with a record number of eggs delivered to the hatchery over an extended period of time (April 12 to June 29). There were some problems; however, egg viability, 45.2 percent, was 10 percent lower than in 1983. In 1983, 6.6 million fewer eggs resulted in over half a million more fish at hatch. The egg viability problem was partially due to the use of greater than a 3 to 1 ratio (eggs from 3 females fertilized by 1 male) when fertilizing eggs. This situation occurs because the mesh size used is designed to catch fish that typically approach the size of female American shad; the males tend to be smaller and are often missed. A 48.3 percent hatch occurred when a standard 3 to 1 ratio was used, as compared to a 34.9 percent hatch when greater ratios (8 to 1 or 10 to 1) were used for eggs collected on the same day. In addition,shipment of eggs (delays in shipment or breakage of bags) and quality control of spawning techniques (maintaining clean, dry basins between lots of eggs, limiting number of eggs collected before fertilization, etc.) contributed to poor egg quality. It has been demonstrated that a large number of eggs can be collected over an extended period of time and successfully handled at Van Dyke. Effort should now be directed towards making all eggs, "quality" eggs, without reducing the total number of eggs collected.

Table 3-2. American Shad egg data (listed by shipment) from Van Dyke, 1984.

Shipment Number	River	Date Taken	Date Received	Vol. (1) Received (VD)	Eggs	Percent Viability	Viable Eggs	Sac Fry
1	Pamunkey	4/11	4/12	8.0	300,700	69.2	208,000	207,600
2	Pamunkey	4/12	4/13	16.7	692,200	62.2	430,600	421,800
3	Pamunkey	4/13	4/13	21.2	877,700	54.8	480,600	468,300
4	Pamunkey	4/14	4/15	23.7	889,100	76.6	681,300	667,700
5	Pamunkey	4/15	4/16	14.6	455,100	60.8	276,500	272.400
6	Pamunkey	4/16	4/17	26.4	805,400	74.7	601,500	592,900
7	Pamunkey	4/17	4/18	20.5	582,900	81.8	476,800	448,800
8	Pamunkey	4/18	4/19	12.8	416,800	55.7	232,000	229,900
9	Pamunkey	4/19	4/20	25.2	816,900	51.9	423,600	421,300
10	Pamunkey	4/20	4/21	24.6	766,000	73.7	564,900	553,000
	James	4/20	4/21	10.6	329,600	66.4	218,700	211,600
11	Pamunkey	4/21	4/22	29.3	851,600	55.0	468,600	466,300

Table 3-2. American Shad egg data (listed by shipment) from Van Dyke, 1984.

Shipment Number	River	Date Taken	Date Received	Vol. (1) Received (VD)	Eggs	Percent Viability	Viable Eggs	Sac Fry
12	Pamunkey	4/23	4/24	8.5	248,400	50.8	126,100	121,200
	James	4/23	4/24	7.5	204,300	61.6	125,800	102,000
13	Pamunkey	4/26	4/27	4.7	189,800	63.4	120,400	119,000
	James	4/26	4/27	7.1	215,800	62.4	134,700	132,700
14	Pamunkey	4/27	4/28	8.4	255,400	59.7	152,400	150,400
15	Pamunkey	4/28	4/29	10.5	319,100	80.6	257,300	249,300
16	Pamunkey	4/29	4/30	12.0	348,300	61.1	212,700	205,500
17	Pamunkey	4/30	5/1	10.5	309,900	68.2	211,200	206,800
18	Pamunkey	5/1	5/2	9.8	297,900	64.3	191,500	190,400
19	Pamunkey	5/2	5/3	11.6	416,600	60.8	253,500	249,500
20	Delaware	5/22	5/23	4.6	196,100	75.5	148,100	145,500
21	Delaware	5/23	5/24	12.2	480,400	69.8	335,500	300,300
22	Delaware	5/24	5/25	4.7	245,700	0	0	0
23	Delaware	6/5	6/6	6.0	236,200	46.6	110,000*	110,000*
24	Delaware	6/6	6/7	11.9	756,500	7.9*	60,000*	60,000*
25	Delaware	6/7	6/8	14,3	726,300	23,4*	170,000*	170,000*

Table 3-2. American Shad egg data (listed by shipment) from Van Dyke, 1984.

Shipment Number	River	Date Taken	Date Received	Vol. (1) Received (VD)	Eggs	Percent Viability	Viable Eggs	Sac Fry
26	Columbia	6/11	6/12	58.8	2,052.400	47.8	980,600	953,100
27	Columbia	6/12	6/13	62.1	2,123,100	41.1	872,500	831,400
28	Columbia	6/13	6/14	51.3	1,993,500	40.5	808,300	786,600
29	Columbia	6/14	6/15	55.2	1,947,100	32.1	624,400	610,300
30	Columbia	6/15	6/17	56.4	1,813,400	34.7	628,500	616,200
31	Columbia	6/18	6/19	72.3	2,624,000	50.6	1,327,200	1,255,700
32	Columbia	6/19	6/20	68.7	2,518,800	40.7	1,025,600	921,900
33	Columbia	6/20	6/21	52.4	1,874,900	31.8	595,800	582,700
34	Columbia	6/21	6/22	41.6	1,808,800	26.0	469,700	459,600
35	Columbia	6/22	6/23	55.9	1,925,000	41.1	791,000	777,100
36	Columbia	6/25	6/26	71.9	2,628,500	43.2	1,135,800	1,123,400
37	Columbia	6/26	6/27	38.1	1,388,300	38.1	473,900	456,700
38	Columbia	6/27	6/28	37.8	1,418,300	35.2	499,200	479,100
39	Columbia	6/29	6/30	56.9	1,766,100	39.0	688,800	679,100

Production: Shad Culture and Stocking Data

A 72.8 percent fry survival resulted in the production of 13.6 million juvenile American shad (Table 3-3). A record 12 million shad were released into the Juniata River toward the realization of production goals (Table 3-4) and 847,000 fry were utilized in studies conducted at the facility and for stocking ponds. Additionally, in cooperation with other Sections and Agencies, Van Dyke provided over 700,000 fry and 4,300 fingerlings for various research programs.

Forty-two stockings in 1984 resulted in the release of 12,026,160 juvenile American shad; 11,995,690 fry 7 to 59 days of age and 30,500 fingerlings (1 inch or greater in length). Shad stocked were exposed to the chemical attractant phenethyl alcohol, which was administered 12 hours each day during the period the fish were cultured in tanks. The fish were stocked in good condition at the Pennsylvania Fish Commission's Thompsontown Access Area.

The majority of fingerlings stocked in 1984 were reared in the canal-pond at the Thompsontown Access Area. The pond failed to produce fingerlings from the first fry planting but was successfully restocked. The second crop resulted in the release of an estimated 25,000 fingerlings directly into Delaware Creek at the confluence with the Juniata River. The Van Dyke Station (including tanks and ponds) produced an additional 9,875 fingerlings.

Table 3-3. Production and utilization of juvenile American shad at the Van Dyke Research Station in 1984.

Fry released into the Juniata River	11,995,690
released into ponds at Van Dyke and ancillary facilities	416,900
provided to Benner Spring Research Station	601,700
provided to Delmarva Ecological Laboratory	100,000
(18 days of age) retained for studies at the Van Dyke Facility	430,140
Total Production	13,544,430
Total Number of Viable Eggs	18,593,600
Survival (%) (all fry)	72.8
Survival (%) (of all fry greater than 18 days of age from the Pamunkey, James and Columbia Rivers)	63.3

Fingerlings released into the Juniata River:	
from the Van Dyke Facility	5,500
from ancillary facilities (canal-pond)	25,000
fingerlings provided to Radiation Management Corp.	4,000
provided to Wellsboro National Fishery Research and Development Laboratory	375
Total production	34,875

Table 3.4 Summary of stocking activities from the Van Dyke Hatchery in 1984.

Date	Number	River of Origin	Age (days)	Size
4/30*	142,000	Pamunkey	11	Fry
	209,100	Pamunkey	8	Fry
5/3*	230,200	Pamunkey	10	Fry
	202,700	Pamunkey	11	Fry
5/4	230,500	Pamunkey	11	Fry
5/5	223,200	Pamunkey	11	Fry
5/6	133,200	Pamunkey	12	Fry
5/7	200,300	Pamunkey	13	Fry
5/9	200,300	Pamunkey	15	Fry
5/13	165,400	Pamunkey	19	Fry
5/14	122,600	Pamunkey	18	Fry
5/15*	331,790	Pamunkey	18	Fry
5/17*	695,300	Pamunkey	18	Fry
5/20*	602,500	Pamunkey	19	Fry
	174,100	James	19	Fry
5/21*	55,100	Pamunkey	19	Fry
	30,900	James	19	Fry
5/23*	115,650	Pamunkey	18	Fry
	115,450	James	18	Fry
5/24	125,800	Pamunkey	18	Fry
5/25	193,300	Pamunkey	18	Fry
5/29*	109,100	Pamunkey	18	Fry
	189,000	James	19	Fry
6/25	38,100	Delaware	11	Fry

(Table Continued)

Table 3.4 (Continued). Summary of stocking activities from the Van Dyke Hatchery in 1984.

Date	Number	River of Origin	Age (days)	Size
6/26*	946,200	Columbia	8	Fry
6/27*	470,400	Columbia	7	Fry
6/28*	294,900	Columbia	8	Fry
	489,900	Columbia	7	Fry
6/30	286,900	Columbia	9	Fry
7/1*	594,700	Columbia	9	Fry
7/2*	363,800	Columbia	9	Fry
7/3*	248,800	Columbia	10	Fry
	328,600	Columbia	8	Fry
7/5*	726,800	Columbia	9	Fry
7/13*	93,700	Columbia	18	Fry
7/15*	489,400	Columbia	18	Fry
7/16	67,700	Columbia	18	Fry
7/17	71,600	Columbia	18	Fry
7/18	56,500	Columbia	18	Fry
7/19*	290,100	Columbia	18	Fry
7/20	141,300	Columbia	19	Fry
7/21	112,800	Columbia	18	Fry

(Table Continued)

Table 3.4 (Continued). Summary of stocking activities from the Van Dyke Hatchery in 1984.

Date	Number	River of Origin	Age (days)	Size
7/22*	305,700	Columbia	18	Fry
7/23*	304,700	Columbia	18	Fry
7/31*	65,300	Columbia	22	Fry
	145,800	Columbia	27	Fry
	64,500	Columbia	30	Fry
8/22	50,000	Columbia	45	Fry
8/24	50,000	Columbia	47	Fry
8/28*	50,000	Columbia	59	Fry
	50,000	Columbia	56	Fry
9/18	4,500	Columbia	77-87	Fingerling (1")
9/20**	25,000	Columbia	112	Fingerling (2")
10/4	1,000	Pamunkey	151	Fingerling (1")

*More than one tank stocked.

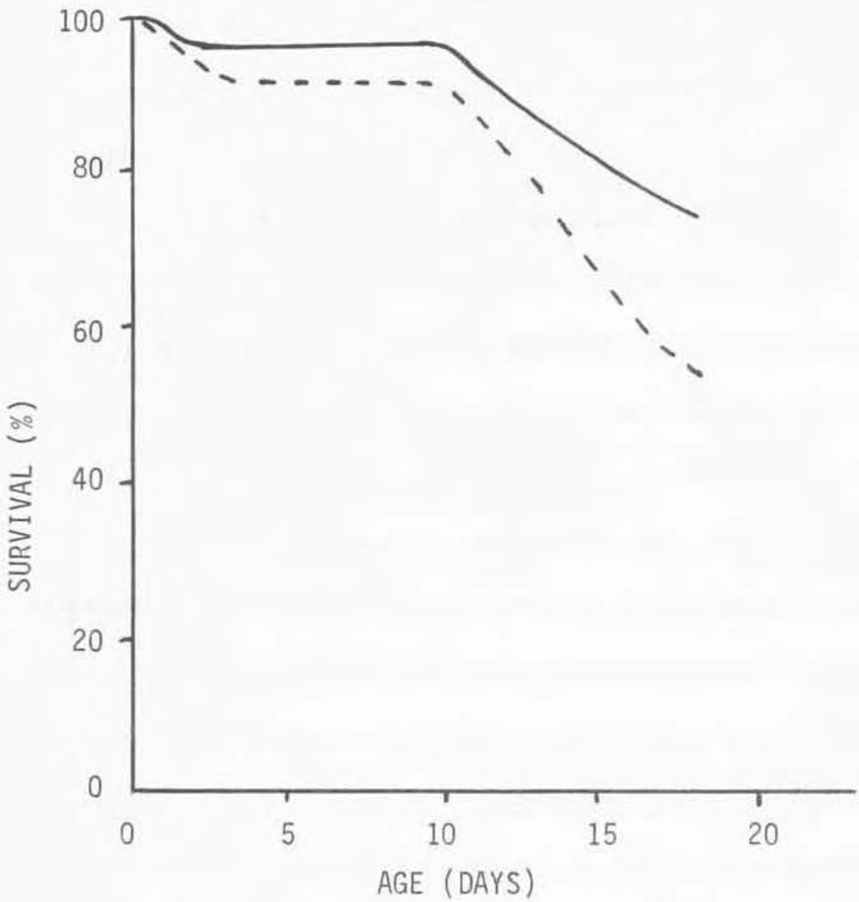
**Fingerlings from the canal-pond.

The 1984 hatchery program was quite successful with a record 72.8 percent fry survival. The survival of fry from Virginia River sources was the highest yet obtained at the facility with 78 percent of the viable eggs resulting in stocked fish. Survival for fry to 18 days of age was 75 percent. The Columbia River had an overall fry survival of 70 percent, with 57.4 percent survival of all fry (including test fish) to 18 days of age. Fry used strictly for production had a slightly lower survival of 53.1 percent (Figure 3-1). There were instances of low fry survival in some of the early Columbia River shipments; however, the exact cause, whether water quality (Van Dyke's spring source had a pH of 5.7 in July) or some other problem, was not determined.

The record high survival of fry appears to be the result of several things: constant regulation of the water supply appeared to reduce, but not eliminate, the mortality due to gas supersaturation; significant changes were made in the feeding regime (including scheme and rate) as a result of studies conducted in 1983.

Early in the spring when the change in water temperatures is greatest, it appears that flows of approximately 35 gallons per minute and above exceed the ability of the degassing devices to reduce total dissolved gases. Close regulation of the water supply was maintained; however, at the high production levels experienced in 1984 this is an extremely difficult task. In order to maintain survival rates similar to those in 1984, gas supersaturation must be controlled.

Figure 3-1. Percent survival to 18 days of age for hatchery reared American shad from Virginia Rivers (James and Pamunkey) and the Columbia River, Oregon.



———Survival of fry from Virginia River Sources

-------Survival of fry from the Columbia River, Oregon

First-feeding larval shad demonstrated diel variations in feeding intensity (Wiggins et al. 1985) and consequently, the introduction of food should coincide with the appetite peak - i.e., with the period when fish have the greatest stimulation to feed (Corazza and Nickum, 1983). The highest level of feeding intensity occurred during the evening hours (1800-2100 hours) and the lowest level at night. As a result the feeding scheme was adjusted to reflect this pattern and feed was presented for 8 to 14 hours each day while feeding at night was discontinued. This allowed the Artemia nauplii to be presented at a higher density, during a period when feed would be more likely utilized.

Studies also indicated that there was a difficult period of transition from endogenous to exogenous nutrition. The early larvae were not as efficient at feeding, and there was selection for smaller Artemia nauplii, possibly because the larger Artemia nauplii could not be utilized. From 9 to 14 days of age, there was a high age specific mortality rate which parralleled periods when growth and feeding intensity did not increase. It was assumed the fish were starving and the high mortality could be reduced by increasing the quantity of feed. The feeding rate was changed from an average of 12 to 18 Artemia nauplii per fish per day. It appears that the change in feeding scheme and rate resulted in the record survival attained in 1984.

The early release of fry became a problem in 1984 when 6.6 million or 55 percent of the fry were released at less than 18 days of age. The facility has 24 rearing units which, in the past, have often been under-utilized. Now, with the recent expansion of the egg collection effort and the short duration of spawning activity on each river system, the hatchery receives large numbers of eggs over a relatively short time frame. This results in large numbers of hatching fry, rapidly utilizing the existing rearing units, and a cycle emerges where fry, less than 18 days of age, must be released in order to provide a sufficient number of rearing units to accommodate the continued daily hatch of fry.

Nineteen egg shipments from Virginia River sources were received during a 21 day period (April 12 to May 3) and required 31 tanks for hatching fry (mean fish density of 198,000 fry per tank or 165 fry per liter). This necessitated the early release of 8 tanks of fish, 8 to 13 days of age. As a result 37 percent or, 1.8 million fry, were released early from Virginia sources in 1984. The annual problem is magnified when looking at the large numbers of eggs collected from the Columbia River. Fifteen shipments of eggs in 19 days utilized 41 rearing units (mean fish density of 266,000 fry per tank or 220 fry per liter) at hatch. As a result 18 tanks of fry (4.8 million), 66 percent of the Columbia River's production, were released at less than 18 days of age (7 to 10 days of age).

Facility Improvements

Research conducted during 1983 demonstrated the need to rear significantly larger quantities of *Artemia*. To meet this demand, two 50 gallon (200 liter) units were set up and tested. The units proved successful in hatching large quantities of brine shrimp and were also less time consuming to set up and operate. In addition, 10 vibrator type feeders (model AFG, Sweeney Enterprises, Inc.) were purchased for the specific purpose of dispensing finely ground and/or oily larval diets. The feeders worked quite well and the purchase of additional feeders is anticipated.

A new, electric, submersible pump was installed at the canal-pond at the Thompsontown Access Area following several acts of vandalism. The new pump provides an estimated 40 gallons per minute and is easily maintained.

Summary

The Van Dyke Research Station continued to rear and release American shad as a part of the diadromous fish restoration effort on the Susquehanna River drainage. The station received 41.1 million eggs, the largest number of eggs incubated at the facility; however, egg viability (45.2 percent) was less than the viability for 1983 (55.6 percent). Fry survival was a record 73 percent, which resulted in the rearing of 13.6 million fry and the release of 12 million juvenile American shad into the Juniata River. Research demonstrated more effective feeding regimes (Job V) and verified the ability to intensively culture shad and attain high survival rates. All fish were exposed to a chemical imprinting agent, phenethyl alcohol, to be used as an attractant at the Conowingo Dam fish collection facility. Including fish released in 1984, a total of 31.4 million juvenile American shad have been released into the Susquehanna drainage since 1976 (Table 3-5).

TABLE 3-5. Annual Summary of Van Dyke Production from 1976-1984.

	1976	1977	1978	1979	1980	1981	1982	1983	1984
Volume of Eggs Received (liters)	120.3	145.8	381.2	164.8	347.6	286.0	624.3	938.6	1,157.3
Number of Eggs Received (millions)	4.0	6.4	14.5	6.4	12.6	11.6	25.9	34.5	41.1
Egg Viability (percent hatch)	52.0	46.7	44.0	41.4	65.6	44.9	35.7	55.6	45.2
Number of Viable Eggs (millions)	2.1	2.9	6.4	2.6	8.2	5.2	9.2	19.2	18.6
Shad Stocked									
Fry (up to 1")	518,000	968,901	2,124,000	629,500	3,526,275	2,029,650	5,018,800	4,047,610	11,995,690
Fingerling (1" and larger)	266,000	34,509	6,379	34,087	5,050	23,620	40,700	98,300	30,500
TOTAL	784,250	1,003,410	2,130,379	663,587	3,531,325	2,053,270	5,059,500	4,145,910	12,026,190
Percent of Eggs Received which were eventually stocked	19.4	15.9	14.0	10.4	28.3	17.7	19.6	12.0	29.3
Percent of Viable Eggs which were eventually stocked	37.3	34.2	33.0	25.1	43.1	39.3	54.8	21.6	72.8*

Total Shad Stocked from 1976 to 1984 - 31,397,500

*Eggs and fish that were not used for stocking purposes were not included.

Recommendations for 1985

1. Culture of 10 million 18-day old American shad followed by direct planting into the Juniata River as river conditions become suitable. To attain this goal, 30 million viable eggs should be provided. The Van Dyke Station can handle 8 million eggs per week.
2. Culture of 100,000 fingerlings (1 inch or larger) using the canal-pond at Thompsontown Access Area and the Benner Spring Complex.
3. To facilitate high larval production such as that of 1984 and to reduce the recurrence of the high larval mortality experienced in 1983, the following facility improvements are necessary:
   a) Vacuum degasser which can reduce total dissolved gases to 100 percent for a flow of 80 gal/min. The present degassing system can only reduce total dissolved gases below 102 percent at a flow of approximately 35 gal/min when heating water (generally April and May). To maintain the entire facility early in the season, a minimum flow of 50 gal/min should be available at 100 percent saturation.
   b) Supplemental water supply of 30 to 40 gal/min filtered river water (2 swimming pool sand filters are available) pumped to the warming pond and/or building. The quantity of water available is adequate for the present facility, but offers no flexability for increased number of rearing tanks. Moreover, the water quality is suspect, and

supplemental flow with higher pH and alkalinity would be advantageous. Another additional benefit might be realized, viz., the river water may provide for a warmer water supply and result in cost savings to our heating bill (we heat water during the springtime).

c) Ultraviolet light treatment unit that can handle 80 gal/min with easy maintenance (removable cover for cleaning). The present units restrict total hatchery flow to 50 gal/min and require a great deal of maintenance. The production effort during the receipt of Columbia River eggs requires more water and therefore the use of ultraviolet treatment is necessarily discontinued. A new unit should be designed to handle the higher flow and require less time to maintain.

d) Installation of 18 tanks and appropriate shelter, wiring, plumbing and platform. The early release of fry was a major problem in 1984 when more than half (55 percent) of the fry had to be released at less than 18 days of age because of inadequate tank space. The existing Van Dyke building could accommodate six additional tanks which would reduce, but not eliminate the problem.

e) Brine shrimp incubation room with heat, water and electric (possibly an extension to the furnace room). In 1984, it was possible to meet the demand for feed only through the use of two experimental units, each with a 200 liter (50 gallon) capacity. A more permanent situation is needed.

f) Twenty larval feeders. Studies in 1984 showed a definite increase in survival (85 percent survival for test units) when the feeding regime was supplemented with a dry, larval diet. The dry, larval feed should be presented at a production level.

4. Continue testing procedures for the administration of oxytetracycline to mark fish; attempt to mark all production fish; determine the extent of tagged fish in samples collected during the evaluation of American shad stockings. Tagged hatchery stocks would permit an evaluation of the contribution of hatchery shad to the out-migration on the lower Susquehanna River and possibly the eventual return of adults.

5. Continue research into larval and fingerling culture techniques. Research in culture techniques, larval development, feeding techniques and feeding regime have resulted in the continual increase in larval survival to a high of 73 percent in 1984. In addition, research in 1984 indicated that an increase

in survival of 10 to 15 percent could be achieved through the addition of a dry, larval diet.

6. A piped or pumped water supply to the effluent head of the canal-pond. A "warm" water (river) supply is generally needed during stocking of the canal-pond. Use of river water from the discharge at the influent end of the pond results in muddy water and the upstream movement of fish back into the pond. Therefore, a new line and discharge pipe are required at the effluent end.
7. Continue imprinting efforts at Van Dyke using phenethyl alcohol, and coordinate the dispensing of this chemical attractant at the Conowingo fish collection facility (provide pump, chemical, expertise).

JOB IV. JUVENILE SHAD OUTMIGRATION ASSESSMENT

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INTRODUCTION

In prior years, juvenile shad assessment was largely qualitative and involved determining if shad were present at various locations during the outmigration season. In 1984, the SRAFRC work plan required that the assessment be designed to provide an index of abundance of young shad for future year comparisons. Leroy Young of the PFC reviewed past experience on the Susquehanna and evaluation programs on other northeast shad rivers in preparation of the study plan which was approved by the Technical Committee. The study was broken into several river segments with the following stated objectives:

- Confirm natural reproduction of transplanted adult shad
- Develop relative abundance index for the mainstem Susquehanna above Clarks Ferry
- Develop relative abundance index for the hatchery produced stock component in the Juniata River
- Track downstream movement of juvenile shad through hydroprojects
- Determine relative abundance of shad from dam to dam in lower river
- Experiment with means to enhance downstream survival of shad

Information being sought in this evaluation is essential for monitoring success of the restoration effort. In past years juveniles were collected at numerous locations from Conowingo Pool to Tunkhannock, PA. Yet very few shad have been taken below Conowingo Dam. To improve the lower river assessment the Maryland DNR increased netting activity below Conowingo in 1984 and was partially supported by SRAFRC funds.

EVALUATION OF SPAWNING SUCCESS OF ADULT SHAD AND UPSTREAM INDEX

NES and PFC biologists worked together in this netting activity in the mainstem Susquehanna above Clarks Ferry. Penn State Coop Unit personnel also assisted on one sampling day. Biologists from Ichthyological Associates in Berwick examined intake screens at Susquehanna SES (PP&L) and plant staff from UGI monitored the screens at Hunlock Creek SES for impinged shad.

The juvenile assessment plan called for sampling the Falls to Wilkes-Barre area up to 4 times between mid-August and mid-September in an effort to document reproduction of shad. Reconnaissance sampling in the river reach from Sunbury to Millersburg was scheduled for mid-August, followed by weekly sampling at two or more select sites until fish left the area. This area was to be used for development of the relative abundance index.

Sampling Schedule and Methods

The principal gear used for sampling the river above Clarks Ferry was a haul seine measuring 300-ft. x 8-ft. with ½-in. mesh. A smaller net measuring 150-ft. x 6-ft. was employed at select sites as needed. PSU personnel attempted electroshocking for shad at two North Branch locations.

Sampling in the Falls to Wilkes-Barre area began on August 22 and continued biweekly through September 19. Seine sites were those which had produced shad in prior years. At Falls, three sites upstream from the PFC West Falls Access Area were netted during late afternoon hours on 2 occasions. Two sites at Coxton Yards were sampled during late afternoon and evening on 3 dates. Sampling was conducted at 9 different sites at Wilkes-Barre during morning hours on 3 dates. Electrofishing was attempted at Falls and Coxton Yards on September 4.

An initial attempt at reconnaissance sampling below Sunbury on August 16 was abandoned due to very high river flows. Relative abundance sampling was shifted to above Sunbury to increase gear effectiveness in the narrower stretch of river. Seining was conducted at Danville on August 28-29 and September 11 and 25; Bloomsburg on August 29; and, Berwick on September 11. Further attempts to collect shad downstream from the confluence of the West Branch occurred on September 10 and 25. Twenty-five sites were sampled with seines between the PFC Mahantango Access and Berwick on 5 netting days. Both day and night sampling was conducted.

Intake screens at Susquehanna SES were surveyed daily between September 4 and October 12, and those at Hunlock were checked daily from August 24 to October 12. Routine plant maintenance at both projects conflicted with the survey during the sampling period.

Results of North Branch and Mainstem Sampling

Between August 16 and September 25, 75 seine hauls were made at 39 separate sites over a 95 mile stretch of river (Table 4.1, Figure 4.1).

No American shad were collected with nets, electrofishing gear or on power plant intake screens. Numerous other species were collected at all sites including smallmouth and rock bass, bluegill and redbreast sunfish, crappie, perch, walleye, musky, pickeral, carp, shiners, quillback, white suckers, catfish and gizzard shad. With no American shad in collections, day versus night sampling effectiveness could not be analyzed.

In reconnaissance efforts below Berwick most areas were uniformly shallow and very rocky, and therefore extremely difficult or impossible to seine effectively. However, at least 2 sites appeared to be suitable for future index sampling. These were located downstream of Danville Boat Club and below Sunbury. In addition, 2 sites at Coxton Yards and 1 or 2 sites at Wilkes-Barre should also be useful as future index sites.

River flows during the summer of 1984 were considerably higher than normal. This could have adversely affected larval survival or prematurely pushed juveniles downstream below the sampling areas. Similar conditions in 1982 were suggested as the reason for failing to take any juvenile shad in the North Branch that year.

EVALUATION OF HATCHERY STOCKED SHAD IN THE JUNIATA RIVER

As in the mainstem, this was a cooperative effort between NES and PFC. On occasion, personnel from the PSU Coop Fish and Wildlife Research Unit and USFWS assisted. Past year efforts in the Juniata indicated that a single site at Amity Hall near the river mouth was best suited to collection of shad during late summer. The Job IV study plan called for biweekly seine sampling at this site from mid-August until shad were no longer available for capture. The goal in 1984 was to establish a baseline index of abundance. As noted in Job III, a record 12 million shad fry were stocked in the Juniata River in 1984.

Sampling Schedule and Methods

Gear used on the lower Juniata was a beach seine measuring 150-ft. x 6-ft. with ½-in. mesh bag. To standardize effort, only one site was sampled, beginning 30 minutes after sunrise with successive hauls at 30 minute intervals. Three to 5 hauls were made each sample day beginning August 17 and continuing through November 7.

Subsamples of 20 shad from each haul were measured for total and fork length and were examined for physical deformities. Any remaining fish were counted and either released alive below the seine site or preserved for experimental purposes. The Penn State Coop Unit and Maryland DNR both requested shad samples for studies.

Results of Juniata Sampling

SRAFRC biologists collected almost 1,300 shad on 6 sample days between August 17 and October 23. Shad were taken in every seine haul during this period. A final collection was made on November 7, but with water temperature declining by 17°F during the previous 2 weeks, no shad were taken and the effort was terminated (Table 4.2). Penn State personnel collected an additional 250 shad at Amity Hall on October 22 for use in meristic count studies.

Many shad were available for capture during this survey particularly between mid-September and mid-October. Individual hauls of over 100 shad were made on all 3 sample dates during this period. Many hauls were comprised exclusively of American shad. Other fish in collections at Amity Hall included rock bass and smallmouth bass, several sunfish species, carp and shiners, crappie, suckers and gizzard shad. Three deformed American shad were recorded, one each with a short gill cover, deformed lower jaw, and crooked back. Shad ranged in length from 25mm to 133mm (FL).

Figure 4.2 shows daily river flow on the Juniata River as measured at the USGS gauge at Newport and catch per unit effort of shad at Amity Hall. Largest collections were made when river flows were relatively low (<1,300 cfs) and water temperatures high (57-72°F).

EVALUATION OF DOWNSTREAM MIGRATION THROUGH HYDROELECTRIC PROJECTS

This phase of the assessment program is important to determine if shad from upstream sources are successfully passing through hydroelectric projects on their way to the Chesapeake Bay. Hatchery and naturally produced shad cannot be differentiated and fish collected in the lower Susquehanna are attributed to both sources.

NES and PFC worked together to sample forebays at York Haven, Safe Harbor and Holtwood dams during September - November using several nets.

Ecological Analysts, Inc. sampled the river near Three Mile Island using seines and electrofishing gear; RMC surveyed the intake screens at Peach Bottom Atomic Power Station and the Conowingo Dam strainers; and Safe Harbor personnel sampled the cooling water strainers at that project. Maryland DNR biologists further intensified their efforts to collect shad below Conowingo and drew funding assistance from the agreement with upstream licensees.

Sampling Schedule and Methods in the Lower Susquehanna

Three Mile Island

EA biologists sampled for shad in the vicinity of TMI as part of their routine studies for the nuclear plant. Efforts included electrofishing at 6 sites on September 4, 20, and 27, October 11 and November 8. Beach seines were used at 6 stations (10 hauls/station) on September 12 and 26, October 11, and November 8.

York Haven

NES and PFC sampled here on August 22 with cast nets in response to reports that shad were dimpling in the vicinity. Weekly assessment began on September 26 and continued through November 14. Various areas in front of trash racks were sampled with 20-ft. diameter cast nets fished off the deck of a boat during early morning hours.

Efforts were standardized by starting collections at approximately ½-hour before sunrise and by establishing fixed intervals between casts of the net with the gear being allowed to descend the full length of the hand rope. An experimental lift net measuring 8-ft x 8-ft with ½-in. mesh was fished from a portable boom off the forebay walkway on 5 different days (October 10 - November 8). Various sites were tried and length of set ranged from 5-30 minutes.

Safe Harbor

Net sampling began here on October 5 and continued weekly through November 28. Cast nets were the primary gear and they were fished in the trash gatewell inside the forebay and on both side of the forebay skimmer wall within 100-ft. of the dam. The lift net was used experimentally on 2 occasions in the same locations. An experimental push net measuring 30-ft long by 14-ft wide with ½-in mesh was deployed on one occasion inside the trash gatewell. Sampling began in early morning hours on most days since this practice proved effective in past years. However, some sampling was attempted in mid-morning and on one occasion, during evening hours.

RMC sampled outside the skimmer wall with a 200-ft x 35-ft x 3/4-in mesh seine on November 15. Sets were made in late afternoon and at night in an attempt to collect live shad for radiotelemetry experiments. Safe Harbor personnel checked cooling water intake strainers daily from August 28 through December 12.

Holtwood

Sampling here began on October 11 and continued weekly through November 28. Cast nets were the primary gear used and they were fished from a platform in the forebay. The lift net was used on 2 occasions and the push net once. All sampling was conducted here during mid- to late morning, depending on when collections were concluded at Safe Harbor. On 2 occasions RMC personnel set floating trap nets in the forebay at Holtwood to collect live shad for experimental work.

Peach Bottom and Conowingo

As in past years, RMC sampled the cooling water intake screens at PBAPS three days each week from October 15 through December 14. They also routinely examined strainers at Conowingo Dam during autumn through mid-December. No netting trials were made at Conowingo in 1984.

Lower River and Flats

Maryland DNR continued their regular upper Bay tidal fish juvenile sampling program during July - October. Starting the first week in November, DNR initiated efforts in the lower river and Susquehanna Flats to catch outmigrant American shad. This survey occurred weekly through the second week of December and involved multiple gears at 14 stations. Purpose of this work is to document outmigration of juvenile shad from the river and to establish a baseline index of abundance.

Gear used by the DNR in 1984 included a 16-ft otter trawl with ½-in mesh cod; a 5-ft x 5-ft midwater trawl with ½-in mesh; and a haul seine measuring 200-ft x 10-ft with ½-in mesh. Gill nets as used in previous years were not deployed. Single samples were taken at each site weekly using the gear most applicable. Collecting locations and gears are shown in Figure 4.3.

Results of Lower River and Hydro Forebay Collections

TMI and York Haven

Ecological Analysts collected 2 American shad near TMI using electrofishing gear. Surface dimpling usually indicative of the presence of shad was noted in this area between October 17 and November 14.

Reports were received in late July that shad were seen at Wrightsville (Route 30 bridge). Ten cast net throws on August 22 at York Haven project failed to verify early outmigration, but RMC biologists did collect 2 shad at Wrightsville on August 1 (78-83mm). The York Haven forebay was sampled unsuccessfully on three more occasions before shad were first taken there on October 17. From that date through November 14, a total of 76 American shad were collected on five dates. The lift net caught only 2 shad in 15 sets and it was not possible to fish this gear in front of trash racks where shad were most abundant. The push net was ineffective. Shad collected at York Haven ranged in size from 85 - 165mm and average fork length increased progressively each sampling date (Table 4.3).

Safe Harbor

Only 24 shad were collected by PFC/NES at Safe Harbor on 9 sampling dates between October 5 and November 28. In 1983, 283 shad were taken in 8 trips. All 24 fish were taken with cast nets in early November (Table 4.4), and fish ranged in length from 92mm to 173mm. By contrast, shad collections on strainers at Safe Harbor were considerably greater than past years with 112 fish being taken between September 22 and November 28. These fish ranged in length from 88-178mm with the majority of fish being large.

Units 2 and 3 accounted for most of the shad at Safe Harbor, and just as in 1983, most fish were collected between November 10-18 at water temperatures of 42-51°F (Table 4.5).

RMC took 48 shad at Safe Harbor with their 200-ft seine on November 15 during late afternoon and late night hours. Dimpling was first noticed at this project on November 1 with none observed after November 9. River flows were lower than normal during October and November (Figure 4.4).

Holtwood

A total of 203 American shad were collected at Holtwood forebay on 5 sampling occasions between October 11 and November 28. All but 31 of the fish were taken with cast nets and 92% of the total were collected on one day - November 15 (Table 4.6). Shad ranged in size from 80-170mm (FL).

RMC captured 3 shad with their floating trap net on November 21 and 2 shad on November 28. Very few gizzard shad were observed compared to prior years, indicating a poor hatch for the species in the lower river. Other species taken in net collections at Holtwood included channel catfish, striper hybrids, and shiners.

Peach Bottom, Conowingo Dam and Lower River

No shad were collected at PBAPS between October 15 and November 12. From November 14th to the 26th, 38 shad ranging in length from 111 to 175mm were taken from the screen wash samples and none were taken after that period. This is very similar to the 1983 collection at Peach Bottom when 22 of 31 shad were taken during the same dates. Three shad were collected from the Conowingo Dam strainers during the week of December 5, the only American shad collected here in 1984.

In the lower river and Susquehanna Flats, the Maryland DNR made a total of 25 seine pulls, 12 otter trawl runs, and 39 midwater trawl runs during the 5 weeks of effort (Tables 4.7 and 4.8). This sampling accounted for 2,670 fish representing 28 species. Gizzard shad (1077), spottail shiner (699), bay anchovy (350), silvery minnow (129), yellow perch (107), and white perch (96) made up 92% of the total catch. A single juvenile American shad (FL=150mm) was captured at the Happy Valley Branch seine site on November 28.

DISCUSSION

Since no shad were collected in the North Branch or mainstem Susquehanna above Clarks Ferry in 1984, the objectives of confirming natural reproduction and developing a baseline abundance index were not met. A similar situation occurred in 1982 when young shad were not captured following stocking of 3,463 adults at Owego, NY and Tunkhannock, PA. River flows were unusually high during May through August in the Susquehanna and it is possible that reproduction occurred but that progeny were pushed downstream earlier than normal. High flows and cooler water temperature in late spring may have resulted in excessive egg and larval mortality. Abiotic factors have been cited as the major cause of prerecruit mortality of American shad in the Connecticut River (Crecco and Savoy, 1984). Finally, the lack of shad in collections may reflect minimal reproduction due to excessive female mortality during transportation, or the paucity of females transferred. Table 1.4 showed that females comprised only 26% of observed mortalities. If this reflects their relative abundance in Hudson River collections, and with 20% overall trucking mortality, then less than 1,000 of the total adults transferred in 1984 would be surviving females. If female mortality rate is higher than that of males as indicated in past analysis with Connecticut River fish, then total reproduction from survivors may have been too small to document with the level of effort expended.

Personnel in charge of field operations in the upper river believe that the 300-ft seine is an effective collecting gear and they have identified four sites for future index sampling. These are located at Coxton Yards, Wilkes-Barre, Danville, and Sunbury. Efforts will be concentrated at these sites in future years.

As in past years the Amity Hall site on the lower Juniata River was productive in collecting outmigrant fingerlings of hatchery origin. With 1,295 shad collected here on 6 sample dates in 1984, we may have sufficient data to make comparisons in future years. However, high variability in numbers of shad collected between hauls on the same day may pose problems in statistical interpretation. More frequent sampling at this site may be desirable.

In the lower river forebays, the cast net proved far superior to experimental lift and push nets. This was especially evident at Holtwood where the largest numbers of shad were collected. A good comparison could be made here between the cast net and lift net because shad were present in large numbers and both nets could be fished in the same location. On November 15, 157 shad were collected in three samples with the cast net, while just 31 shad were taken on the same day in six samples with the lift net. The push net proved too unwielding at all three sites and was virtually impossible to use with even minimal current.

One way to standardize the cast net sampling would be to restrict the index to only those samples in which the cast net had opened to at least 70% of its maximum diameter. This determination would be somewhat subjective, but variability between samples would probably be about the same as with other active sampling devices such as seines and trawls. Other major hindrances to development of abundance indices at lower river hydroprojects include variations in flow conditions and subsequent operating regimes at each power facility, and perhaps weather conditions. At York Haven for example, the number of turbines generating and their location had a profound effect on the location of shad in the forebay. Abundance of shad would be similarly affected as greater flow through the turbines would result in fewer fish available as compared to minimum flow conditions. Spilling at the trash gate would also affect the number of fish available, further biasing estimates of abundance.

Weather conditions may also affect sampling efficiency, especially at Safe Harbor Dam. Shad were taken there on only 2 sampling dates in 1984 using cast nets, but many more shad were collected in the project cooling water strainers. On several days when no shad were taken with nets, strainer catch was at a peak. On these days high wind and turbulence on both sides of the skimmer wall was noted. It is not known if these conditions served to drive the fish deeper out of the reach of the cast net, but this is a possibility. These sources of variability should be addressed in planning future year sampling activities.

Early morning sampling seems a necessity at York Haven Dam. Catch success decreases here as more generation comes on line. Time of day does not appear to be critical in sampling at Safe Harbor or Holtwood. Fish were easily collected in 1983 during mid-morning at Safe Harbor. On the one day this year when appreciable numbers were taken, the early morning (predawn) sampling did not show any clear superiority to samples taken later that morning. Collecting shad at Holtwood has always been successful regardless of the time of day.

Although the lift net was not a good device for index sampling it did show some merit for the live capture of outmigrant juvenile shad, particularly at Holtwood. Almost no abrasion of fish on the net was observed and fish could be water-brailed to further reduce stress. This method should be considered for use where live shad are needed for experimental purposes.

The 415 shad collected with nets and on strainers at York Haven, Safe Harbor and Holtwood in 1984 is considerably fewer than were taken in 1983 (701). This may be partially explained by unusual weather conditions resulting in very mild water temperatures through October followed by rapid decreases into mid-November. Water temperature fell from 64°F on November 2 to 38°F on the 25th. It is likely that the entire lower river migration occurred over a very short period of time and the weekly sampling schedule was insufficient to adequately quantify the movement.

Researchers working on the lower river in 1984 were impressed with the size of American shad in collections. In past years shad ranged in length from 90-150mm and averaged about 125mm in late October and early November.

This year, numerous fish were measured in the 150-180mm size range and the mean length of shad in Safe Harbor strainer collections was 142mm (n=111). This average increase in size noted may be directly related to the poor gizzard shad year class and associated lack of competition for food from this species.

As in past years, collections of juvenile shad below Holtwood were disappointing. The 38 shad taken on the intake screens at Peach Bottom compare favorably to 1983 results but remain considerably below what was taken there in 1982. However, one of the two Peach Bottom reactors was shut down during this year's migration season. With a total of only 4 shad taken at Conowingo Dam and in the lower river below Conowingo in 1984, we must once again speculate that few shad are reaching the Chesapeake on their seaward migration. The major emphasis in the Susquehanna program during the next several years should be to increase survival of young shad emigrating from the river.

REFERENCE

Crecco, V.A. and T.F. Savoy. 1984. Effect of fluctuations in hydrographic conditions on year-class strength of American shad (*Alosa sapidissima*) in the Connecticut River. Can. J. Fish. Aquat. Sci. 41: 1216-1223.

Table 4.1 Juvenile American shad collections in the mainstem Susquehanna River above Clarks Ferry, August 22 - Sept. 25.

Date	Location	# Am. shad	Effort*	Time of Day	Water T.
8/22	Coxton/Pittston	0	4 hauls	1900-2045	71 F
	Falls	0	1 haul	1600	72 F
8/23	Wilkes-Barre	0	5 hauls	0800-1220	-
8/28	Danville	0	6 hauls	1400-1730	76 F
8/29	Danville	0	5 hauls	0845-1200	74 F
	Bloomsburg	0	2 hauls	1410-1600	74 F
9/4	Falls	0	3 hauls 1 hr. electrofish	1600-1700	72 F
	Coxton Yards	0	4 hauls 1 hr. electrofish	1900-2030	69 F
9/5	Wilkes-Barre	0	6 hauls	0800-1100	-
9/10	Mahantango	0	4 hauls	1130-1330	70 F
	Sunbury	0	5 hauls	1545-1800	73 F
9/11	Danville	0	2 hauls	0745-0820	71 F
	Berwick	0	2 hauls	1145-1300	-
9/18	Coxton Yards	0	8 hauls	1720-2045	66 F
9/19	Wilkes-Barre	0	6 hauls	0830-1045	62 F
9/25	Sunbury	0	4 hauls	1720-1900	72 F
	Danville	0	2 hauls	2115-2145	72 F

* Gear used was 300'x8'x3/8" mesh haul seine except for 8 hauls with the 150'x6'x½' mesh bag seine

Table 4.2 Juvenile American shad collections in the Juniata River at Amity Hall, August-November, 1984.

Date	No. Shad	Mean Length	Length Range	Effort	CPUE	Flow (cfs)	Water Temp
8/17	31	66	25-104	5	6.2	5,790	73
8/28	26	68	33-107	4	6.5	1,510	72
9/10	576	61	44-82	3	192.0	1,110	68
9/25	299	83	60-133	3	99.7	830	72
10/9	296	91	54-119	3	98.7	830	57
10/23	67	93	63-130	4	16.8	1,190	63
11/7	0	-	-	3	0.0	-	46

Gear used was 150' x 6' x ½" mesh bag seine
All collections were made between 0620-0845 hrs.

Table 4.3 Summary of juvenile American shad collections at York Haven Dam during autumn, 1984.

Date	No. Shad	Mean Length	Length Range	Effort	Time	Water Temp.
8/22	0	-	-	10 CN	0745-0845	68
9/26	0	-	-	8 CN 1 PN	0715-0815	73
10/3	0	-	-	2 CN	0645-0715	65
10/10	0	-	-	6 CN 1 LN	0730-1000	58
10/17	10	112	96-141	6 CN 2 LN	0705-0830	60
10/25	21	115	85-132	7 CN 4 LN	0705-0840	59
10/31	34	122	94-153	7 CN 4 LN	0605-0745	63
11/8	9	146	132-164	13 CN 4 LN	0605-0740	47
11/14	2	150	150	11 CN	0630-0720	40

Table 4.4 Summary of juvenile American shad collections at Safe Harbor Dam with nets during autumn, 1984
Note: Headings are the same as in Table 4.3.

10/5	0	-	-	8 CN 2 PN 3 LN	0715-1030	61
10/11	0	-	-	8 CN	0640-0745	63
10/18	0	-	-	7 CN	0720-0820	63
10/26	0	-	-	8 CN	0645-0755	65
11/1	2	145	140-149	9 CN	0555-0700	63
11/9	22	131	92-173	12 CN 7 LN	0600-0910	53
11/14	0	-	-	13 CN	1630-1740	48
11/20	0	-	-	9 CN	0830-0915	42
11/28	0	-	-	10 CN	0850-0925	40

CN = cast net; LN = lift net; PN = push net

Table 4.5 Summary of American shad collections on cooling water strainers at Safe Harbor Dam, 1984.

Date	No. Shad	Mean Length	Length Range	Collecting Unit	Water Temp.	Flow
9/22	1	122	122	-	69	7600
9/23-11/2	0	-	-	-	-	-
11/3	4	142	88-165	2,4	59	7800
11/4	2	107	105-110	2	62	8100
11/5	0	-	-	-	61	9700
11/6	2	142	130-155	5	58	9700
11/7	1	122	122	2	56	9400
11/8	1	158	158	2	54	9600
11/9	4	133	112-155	2,3	53	12600
11/10	13	130	105-178	1,2,3	51	13500
11/11	0	-	-	-	51	13600
11/12	22	139	103-170	1 thru 7	50	12700
11/13	10	151	136-170	2,3,5,7	48	13300
11/14	1	171	171	3	48	18000
11/15	10	140	104-168	2,5,7	47	17600
11/16	22	147	105-164	3	46	16800
11/17	5	165	145-176	3	42	15300
11/18	6	149	138-167	2	43	14600
11/19	2	150	140-160	2	44	13700
11/20	2	157	157-158	2	42	13300
11/21	2	164	156-173	2	41	11800
11/22-25	0	-	-	-	-	-
11/26	1	140	140	5	38	10100
11/28	1	-	-	-	40	10200
11/29-12/14	0	-	-	-	-	-
total	112					

Table 4.6 Summary of American shad collections at Holtwood Dam during autumn 1984.

Date	No. Shad	Mean Length	Length Range	Effort	Time	Water Temp.
10/11	0	-	-	4 CN 2 LN 1 PN	0915-1100	63
11/9	6	123	86-167	7 CN	1115-1155	56
11/15	188 *	118	85-170	3 CN 6 LN	0850-1050	46
11/20	9	109	80-146	3 CN	1130-1150	41
11/28	0	-	-	6 CN	1100-1120	40

CN = cast net; LN = lift net; PN = push net

* 157 shad with CN and 31 with LN

Table 4.7 Locations sampled and effort by gear during the 1984 Maryland DNR juvenile shad outmigration study.

Gear Type	Station No.	Effort	Station Name
Haul Seine	1	4	Wild Duck Cove
	5	5	Spoil Island
	6	5	Tydings Park
	7	4	Quarry
	LAP	4	Lapidum
	HVB	3	Happy Valley Branch
Otter Trawl	1	4	Wild Duck Cove
	5	4	Battery Island
	6	4	Tydings Park
Midwater Trawl	1	2	Tydings Park
	2	3	Concord Lt-Perry Pt.
	3	3	Penn Central RR Bridge
	4	4	Garret Is.-Cecil West
	5	4	Garret Is.-Cecil East
	6	4	" -Harford East
	7	4	" -Harford West
	8	4	I-95 Bridge
	9	4	Port Deposit
	10	3	Port Deposit-Lapidum
	11	4	Lapidum

Table 4.8 Sample dates by gear type and water temperatures during the Maryland DNR juvenile shad outmigration study - 1984.

Date	Seine	MW Trawl	Otter Trawl	Temperature Range (F)
November 5			X	55-61
November 6		X		56-62
November 9	X			54-57
November 15		X	X	50-53
November 16		X		50
November 19	X			45-48
November 20		X		45-48
November 21			X	42-45
November 26	X			39-43
November 28	X			44-48
November 29		X		44-45
November 30		X	X	44-45
December 5	X			42-43

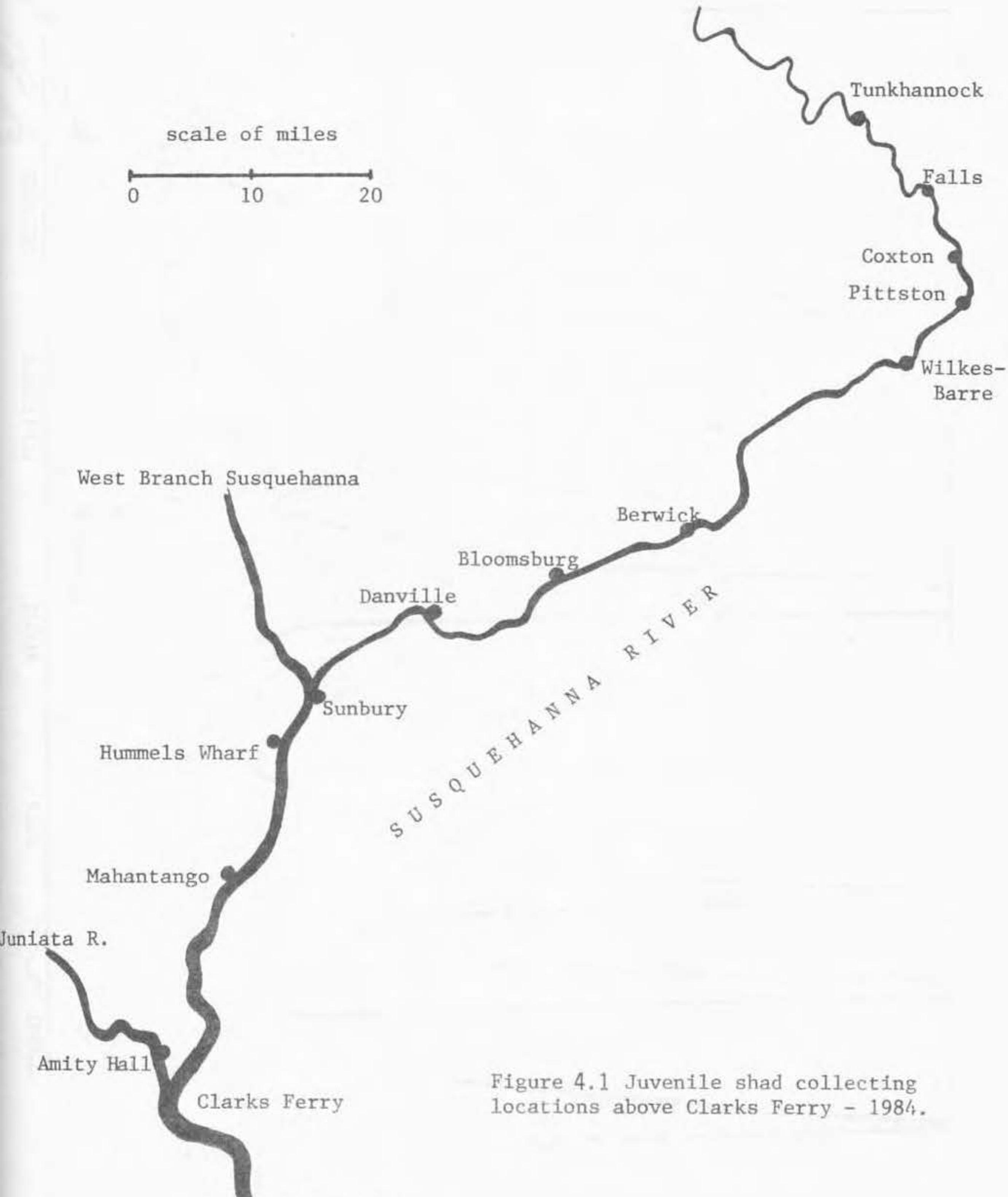


Figure 4.1 Juvenile shad collecting locations above Clarks Ferry - 1984.

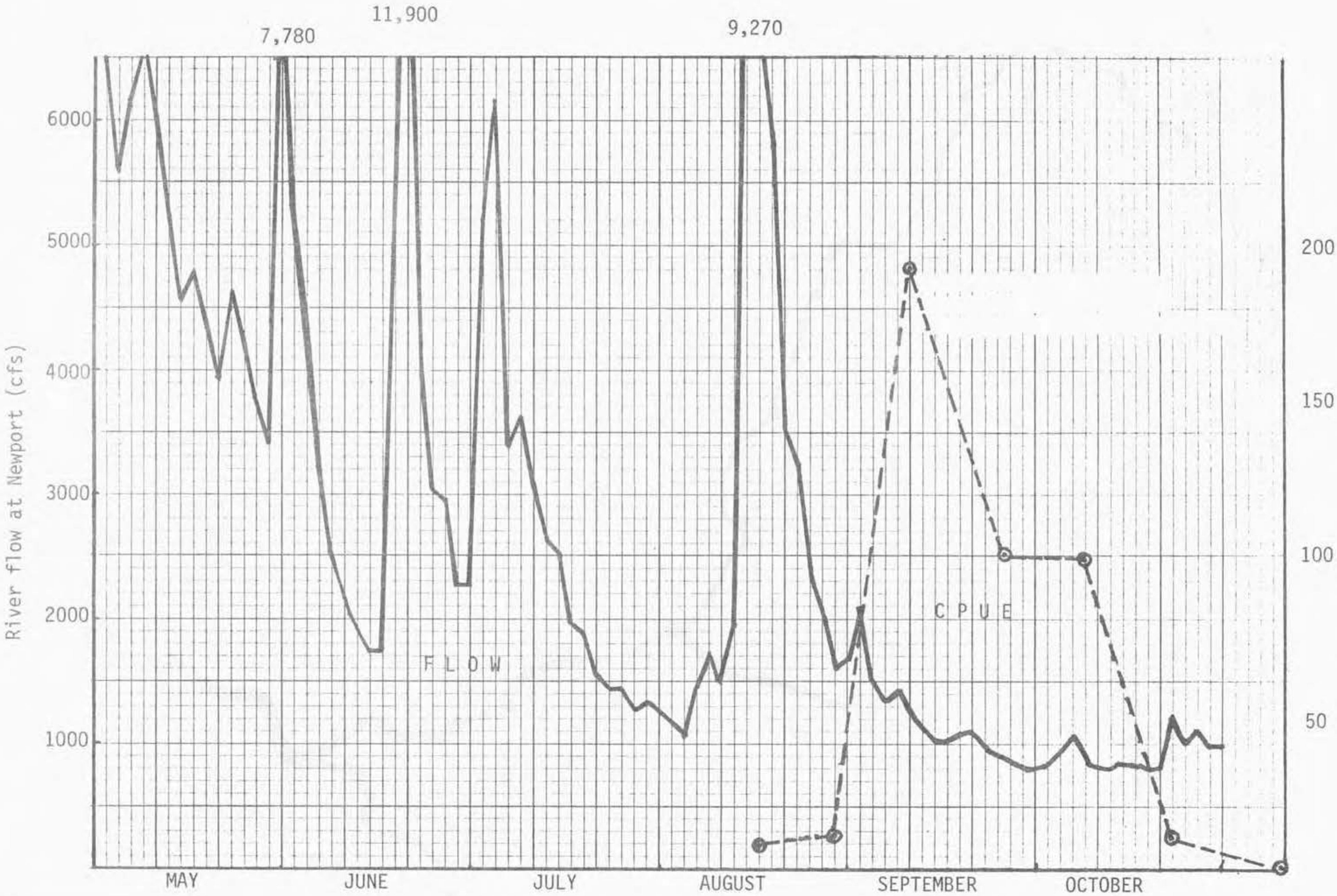
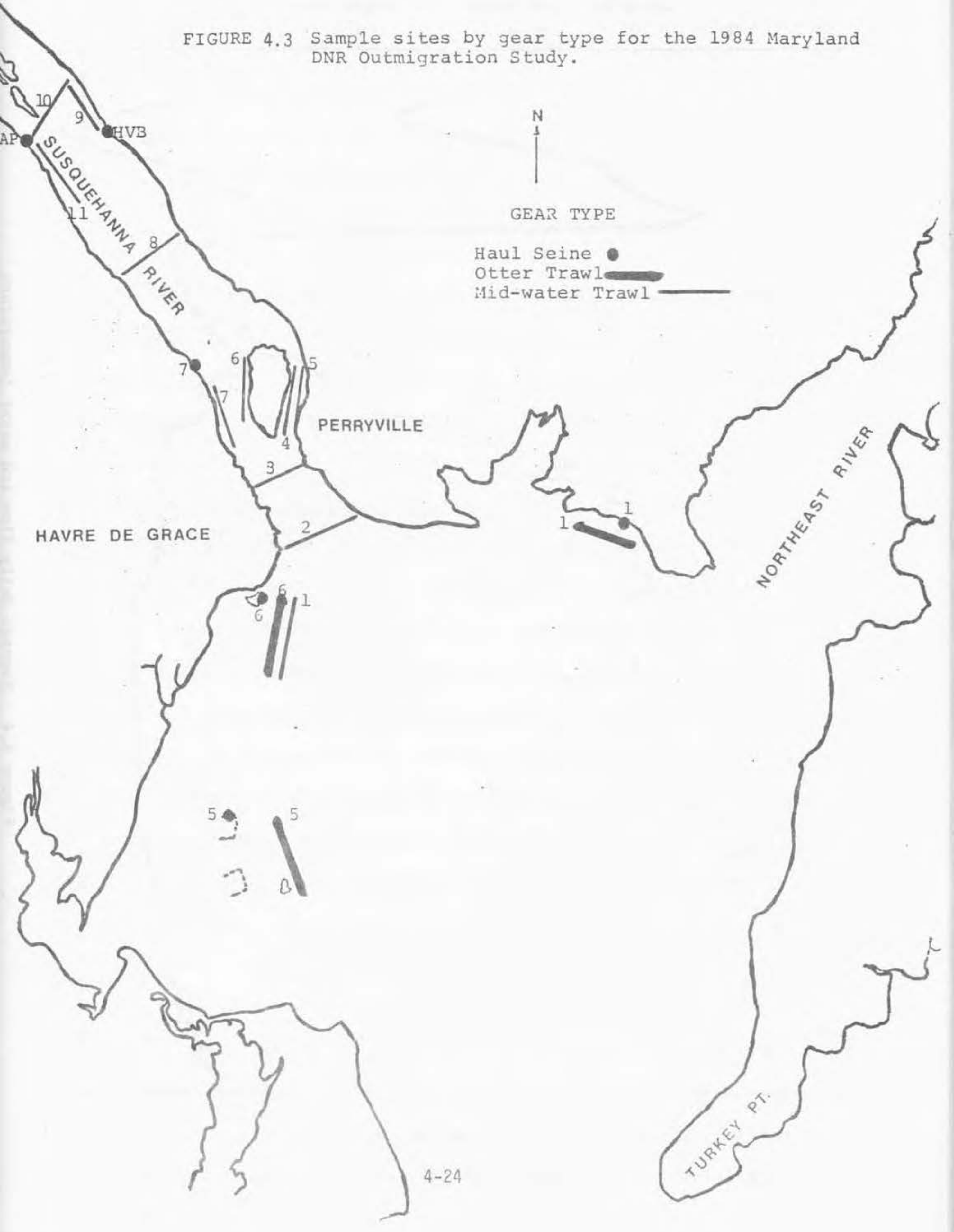


Figure 4.2 River flow on the Juniata River at Newport and

FIGURE 4.3 Sample sites by gear type for the 1984 Maryland DNR Outmigration Study.



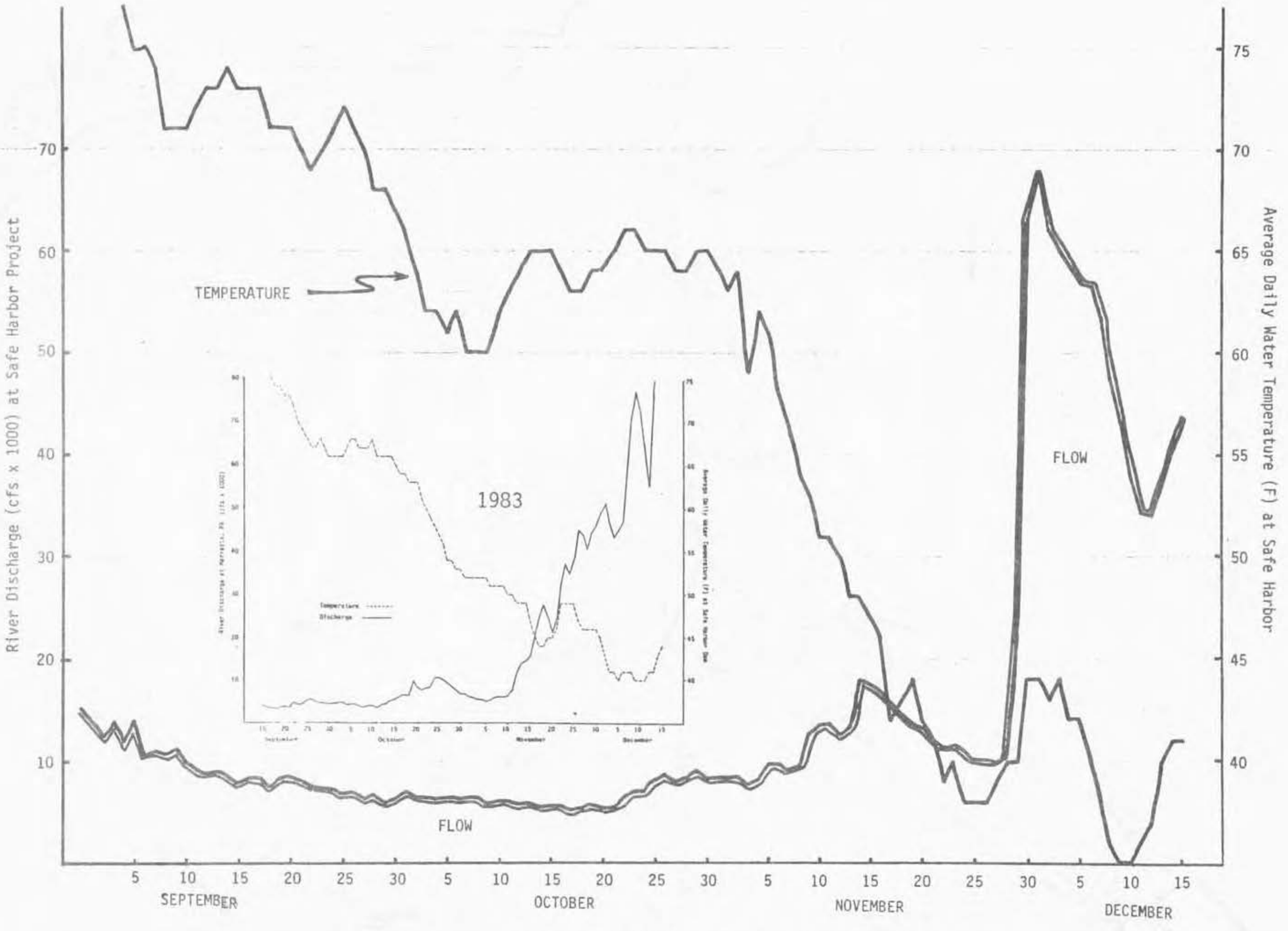


Figure 4.4 Average daily flow and water temperature

JOB V. AMERICAN SHAD CULTURAL RESEARCH

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Introduction

Food Deprivation of Larval American Shad

The Van Dyke Research Station continued studies in 1984 which emphasized feeding and feeding regimes in early larvae. Wiggins et al. (1985) demonstrated it was characteristic of cultured American shad larvae during the transition from endogenous to exogenous nutrition, to experience a period of low feeding incidence paralleled by periods of slow growth and high mortality. First-feeding herring larvae are particularly sensitive to food deprivation (O'Connell and Raymond, 1970; Houde 1977, 1978; Werner and Blaxter, 1980) and reach a point where effects of starvation rapidly become irreversible (Blaxter and Ehrlich 1974). A test was conducted, utilizing larval shad, to determine the pattern of growth to be expected solely as a result of endogenous nutrition, and to identify the age where food deprival, after the absorption of yolk, results in complete mortality.

Night Feeding of Cultured American Shad Larvae

Diel variations in larval shad feeding intensity were also found in 1983 studies. Since it is important that the introduction of feed coincide with peaks in feeding intensity, a test was conducted to determine the extent of feeding that occurred at night.

Effects of Different Initial Feeding Rates of *Artemia* Nauplii on the Growth and Survival of American Shad Larvae

As a greater understanding of feeding behavior in shad larvae is gained, feeding regimes must be established. At the present time, *Artemia* nauplii are an essential component of the diet of larval shad in an intensive culture situation. High mortality in early larvae was apparently the result of unsuccessful feeding on *Artemia* nauplii. A test was conducted to determine if larval mortality was the result of insufficient quantities of nauplii fed; and if so, to determine an optimum feeding rate of nauplii for survival and growth of larval shad.

The Effects of Dry Diet on Growth and Survival When Offered as a Feed Supplement to Larval Shad

Although feeding regimes which incorporated dry feeds were unsuccessful in the past, two different *larval* diets were tested in combination with *Artemia* nauplii to determine if alternative feeding regimes could be developed which would improve survival and growth.

Use of Oxytetracycline to Mark Daily Otolith Rings of American Shad Fry

A need exists to be able to differentiate between out-migrant juvenile shad resulting from the Van Dyke hatchery effort and those resulting from the natural spawning of translocated adults. This capability would make it possible to determine the relative contribution of both methods to the overall restoration effort. To that end, a project was undertaken to determine if a distinguishable mark could be applied to the daily otolith rings of American shad fry, using oxytetracycline bath treatments, before they are stocked at 18-19 days of age.

Survival of Fry During Transport

Data will be presented which deal with the survival of fry during transport (these were not collected for test purposes). Presently, the only data available, relative to mortality of shad larvae resulting from fish transfer, are those collected when fish were brailed in small numbers for experimental purposes. The work to be presented gives a more accurate impression of larval mortality using typical production procedures (handling large numbers of fish).

Materials and Methods

The tests were conducted in 1200 liter circular fiberglass rearing units with a diameter of 1.52 m (60 in.) at the top, 1.37 m (54 in.) at the bottom and a depth of .76 m (30 in.).

Estimates of the number of larvae hatched into each rearing unit were obtained using a modification of von Bayer's (1910) method of egg enumeration to determine the total number of eggs (E), and the number of dead eggs (E_d). The number of larvae (LV) hatched was then determined:

$$LV = E - E_d$$

Larval shad were initially stocked at a mean density of 208 fish/L (250,000 fish/tank) with fish densities ranging from 158-270 fish/L.

Age specific survival rates through 18 days of age were determined for each test unit as described by Wiggins et al. (1985).

Since hatch occurred over a 3 to 4 day period, a single hatch date was assigned to each lot on the day the majority of fry hatched (generally the 7th day of incubation at 15.6^{o} C). Feed was first presented to larvae at 4 days of age.

Sampling of 25 fish for incidence of feeding and growth (total length 0.1 mm) was conducted from 4 to 18 days of age at 2 day intervals. The samples were taken at 1400 hours to allow feed to be present in the rearing unit for a period of 4 to 6 hours prior to sampling.

Incidence of feeding (IF, %) was determined by:

$$IF = \frac{L_i}{N_i} (100);$$

N_i = Total number of larvae sampled on day (i);

L_i = Number of larvae with feed in the gut.

In addition, the number of nauplii in the gut of feeding larvae was recorded.

Studies on initial feeding rates of *Artemia* nauplii and the effects of dry diet as a feed supplement were run in triplicate. Analysis of variance (Snedecor 1957) was computed for growth.

Food Deprivation of Larval American Shad

The successful culture of American shad larvae is dependent on the successful transition from endogenous to exogenous nutrition. Food deprival of larvae would demonstrate patterns of growth to be expected solely due to endogenous nutrition, and identify the point where food deprival, after the absorption of yolk, results in complete mortality.

A rearing unit was set up with approximately 2700 fish in a manner typical of other rearing units except that no food was presented to the fish. Mortalities were syphoned from the rearing unit each day and hand counted. Complete mortality of food deprived larval shad occurred in 16 days (post-hatch); however, less than 1 percent of the fish survived through 14 days of age.

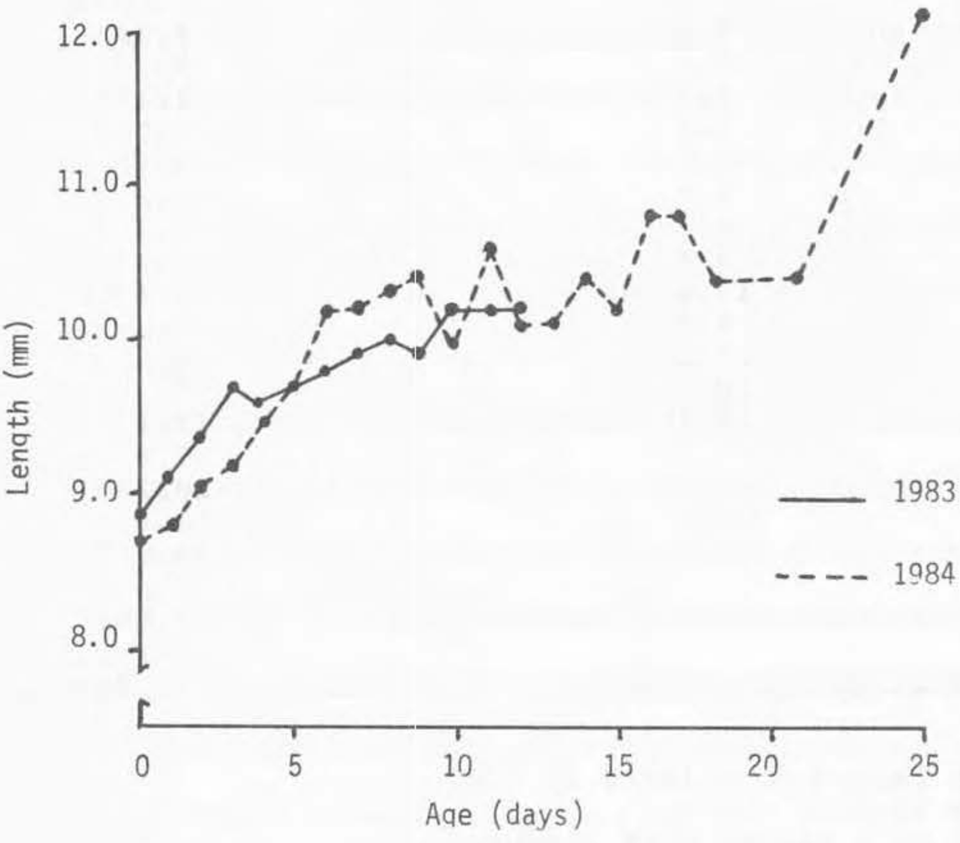
Samples of 14 to 25 fish were collected daily and measured for total length until 12 days of age when there was no longer a sufficient number of fish to continue sampling (Table 5-1). Larvae were 8.9 mm at hatch and increased in length to 10.2 mm at 12 days of age. Both growth and time of survival were similar to results obtained by Wiggins et al. (1985). There was a period of rapid growth, apparently due to endogenous nutrition, followed by a period of slowing growth as the necessity for exogenous nutrition increased (Figure 5.1). Initial mortality was high inasmuch as 54 percent of the test larvae died within 4 to 5 days following hatch. Time of survival, less than 1 percent of the larvae survived through 14 days of age, corresponds to the age where mean age specific survival reported by Wiggins et al. (1985) changed from a mortality rate averaging 5.5 percent per day to less than 0.4 percent per day. The similarity of results makes it apparent that there was a difficult transition to exogenous nutrition which resulted in the starvation of many larvae.

Table 5.1. Mean total length of American shad larvae deprived of food compared to values reported by Wiggins et al. (1985) for larvae receiving 12 Artemia nauplii per fish daily (based on initial tank density).

	Total Length (mm))	
Age (days)	Food Deprived Larvae[a]	Fed Larvae[b]
0	8.9	8.7
1	9.1	8.8
2	9.4	9.1
3	9.7	9.2
4	9.6	9.5
5	9.7	9.7
6	9.8	10.2
7	9.9	10.2
8	9.8	10.3
9	10.0	10.4
10	9.9	10.0
11	10.2	10.6
12	10.2	10.1
13	10.2[c]	10.1
14		10.4
15		10.2
16		10.8
17		10.8
18		10.8
21		10.5
25		12.1

[a]Sample size ranged from 14 to 25 fish
[b]Sample size 50 fish
[c]Measurement of a single fish captured

Figure 5.1. Mean total length of American shad larvae totally deprived of food (1984) compared to mean total length of fish fed 12 Artemia nauplii per fish each day (the number of nauplii based only on initial fish density) presented by Wiggins et al. (1985).



Night Feeding of Cultured American Shad Larvae

Feeding at night as well as during the day has often been recommended for larval fishes as it was assumed the fish had little or no energy reserve (McHugh and Heidinger 1977). It is, however, imperative that patterns of feeding be defined so that the introduction of feed coincides with peaks in feeding intensity (Corazza and Nickum 1983). Diel variations in feeding intensity exist in early larvae (Rosenthal and Hempel, 1970; Levesque and Reed 1972; Wiggins et al. 1985). Feed was found in the gastrointestinal tract of shad larvae during the night; however, the incidence of feeding, the percentage of fish with feed in the gastrointestinal tract, declined through the night. This test was designed to determine if feeding occurs at night in 16 day old American shad larvae (16 days of age was chosen to ensure that all fish were receiving exogenous nutrition).

Fish used in the test were reared in a 1200 liter (317 gallon) circular unit at a density of 105 fish/liter. No feed was presented to the fish 24 hours prior to the test. The test was conducted at night, and a cover was placed over the rearing unit to prevent the infiltration of light from outside sources. Feeding was initated at 2200 hours when 2 liters of *Artemia* suspension (270,000 *Artemia*/liter) were placed into the rearing unit. Feed was then presented for 5 seconds every 5 minutes from two live food dispensers located on the rearing unit. The total volume of Artemia suspension fed during the test period was 6.7 liters. A sample of 50 fish was collected at 0100 hours; measured for total length and examined for incidence of feeding. Mean total length of the larval shad was 10.9 mm (0.4 inches). There was a 0 percent incidence of feeding on Artemia nauplii but 16 percent (8 fish) had Artemia cysts in the gastrointestinal tract.

It appears that larval shad do not actively feed at night. It is probable that cysts found in the gastrointestinal tract were remnants of previous feedings, consumed during the daylight hours prior to the test.

A new feeding regime utilized in 1984 reduced the hours of feeding by discontinuing feeding at night. Artemia nauplii are now presented at a higher density during the daylight hours when utilization by larvae is more likely. The new feeding regime reduced waste and it increased the amount of feed available to the larvae.

Effects of Different Initial Feeding Rates of *Artemia* Nauplii on the Growth and Survival of American Shad Larvae

The presence of adequate densities of suitable prey organisms is of crucial importance to the survival of larval fishes (Werner and Blaxter 1980). It has been shown that the number of striped bass which survive to stockable size is directly related to the quantity of *Artemia* cysts incubated to feed larvae (Lewis and Heidinger, 1981). Although evidence has been presented that, at least to some extent, cultured American shad larvae are starving, the optimum quantities of *Artemia* nauplii to feed were not known. The quantities of *Artemia* nauplii necessary for other larval fish species vary considerably. Using rate of digestion, Rosenthal and Hempel (1970) estimated that early postlarval herring could digest 35-40 *Artemia* nauplii per day. Experimentally, Werner and Blaxter (1980) determined threshold prey densities for larval herring to be near 0.17 *Artemia* per ml, above which changes in prey densities have little effect on survival or growth. In contrast to this low prey density, it has been estimated that early striped bass larvae must be initially fed at a rate of 50 to 60 nauplii per ml of rearing tank volume per day to 15 days of age. After 15 days of age, the density of nauplii is increased to 100-120 per ml per day (Lewis and Heidinger 1981).

This study was initiated to determine threshold feeding rates for American shad larvae, using *Artemia* nauplii, below which deleterious effects would occur, and above which would result in little effect on survival and growth. Three feeding rates were compared; 12, 18 and 24 *Artemia* nauplii per fish, based on the initial stocked densities of fish in a tank. Feeding rates for the study were chosen to bracket the feeding rate used in 1984, 18 *Artemia* nauplii per fish, and include the feeding rate used in 1983, 12 *Artemia* nauplii per fish. Two live food dispensers, a modified version of a dispenser developed by Theis and Howey (1981), released a suspension of newly hatched Sanders *Artemia salina* nauplii (after nauplii were seperated from unhatched cysts) to each rearing unit for 5 seconds every 5 minutes, 8 to 12 hours each day. The volume of the suspension fed daily was based on the initial stocked density of a rearing unit; the feeding rate that unit was to receive, and the density of the newly hatched nauplii.

Performance based on growth and survival was lowest for larvae receiving 12 *Artemia* per fish. There was no significant difference ($P < 0.05$) in growth; however, percent survival for this test group was also lowest with a mean of 65.9 percent (Table 5.2). Larvae receiving feed at a rate of 18 *Artemia* per fish had a mean length of 11.2 mm compared to

Table 5-2. Summary of mean growth and survival of American shad larvae to 18 days of age at initial daily feeding rates of 12, 18 and 24 *Artemia* nauplii per fish (Van Dyke 1984).

	Feeding Rates		
	12 *Artemia*/ Fish	18 *Artemia*/ Fish	24 *Artemia*/ Fish
Length (mm)	11.1	11.2	11.6
Survival (%)	65.9	77.8	74.5

11.6 mm for larvae fed at a rate of 24 *Artemia* nauplii per fish.

The mean number of *Artemia* nauplii found in the gastrointestinal tract of feeding fish was determined for the test period at each feeding rate (Table 5-3) and appeared to directly correlate with growth.

Survival, on the other hand, was highest at a feeding rate of 18 *Artemia* nauplii per fish, 77.8 percent, as compared to 74.5 percent for the feeding rate of 24 *Artemia* nauplii per fish. Detailed growth and survival data was provided in Appendix A.

Feeding intensity, measured as the incidence of feeding (Table 5-4), reflected the results obtained for survival with the highest incidence of feeding generally occurring in fish receiving 18 *Artemia* nauplii per fish and lowest where fish received 12 *Artemia* nauplii per fish.

The study demonstrated that a feeding rate of 12 *Artemia* nauplii per fish did not perform as well as higher feeding rates. The results of the two higher feeding rates were mixed. The difference in growth was considered insignificant; therefore, the data suggests the feeding rate of 18 *Artemia* per fish (highest survival), the feeding rate used for production in 1984, was the optimum rate tested.

Table 5-3. Mean number of *Artemia* nauplii found in the gastrointestinal tract of feeding larvae through 18 days of age for initial feeding rates of 12, 18 or 24 *Artemia* nauplii per fish per 24 hour period (Van Dyke Station, 1984).

	Mean Number of Artemia Nauplii		
Age (days)	12 *Artemia*/Fish	18 *Artemia*/Fish	24 *Artemia*/Fish
4	2	2	3
6	3	3	3
8	3	3	3
10	3	2	4
12	2	3	2
14	3	3	4
16	2	3	3
18	4	4	4
Mean number of *Artemia* found in the gastrointestinal tract per day from 4-18 days	2.8	2.9	3.3

Table 5-4. The mean incidence of feeding for three trials through 18 days of age for larvae initially fed at a rate of 12, 18 or 24 *Artemia* nauplii per fish per 24 hour period (Van Dyke Research Station, 1984).

	Incidence of Feeding (%)		
Age (days)	12 *Artemia*/Fish	18 *Artemia*/Fish	24 *Artemia*/Fish
4	31	53	48
6	51	60	60
8	57	80	75
10	77	88	93
12	84	91	89
14	92	98	96
16	90	94	94
18	94	92	92

The Effects of Dry Diets, on Growth and Survival When Offered as a Feed Supplement to Larval American Shad

At the present time, Artemia nauplii are an essential component of the diet for larval American shad. Past attempts failed to sustain larvae solely on dry feeds or a slurry made from the mash (1978 Annual Report). The major problem when using dry diets to feed many larval species is little acceptance of the diet (Nickum 1978, Lewis and Heidinger 1981).

This study had several objectives: 1) to determine if, and possibly when, early postlarval American shad (to 18 days of age) would accept a dry larval feed; 2) if accepted, were the dry diets, when fed in combination with Artemia nauplii, beneficial to survival and/or growth through the transition from endogenous to exogenous nutrition; and 3) to compare two larval diets. Three daily feeding regimes compared were 12 Artemia nauplii per fish fed in combination with milled Artemia flakes (12A + AF); 12 Artemia nauplii per fish fed in combination with Larval AP-100 diet (12 A & AP-100); and a typical production diet of 18 Artemia nauplii per fish (18A).

The milled Artemia flakes were supplied by Bio-Marine, Inc. Aquafauna (Hawthorne, California), the larval diet AP-100 manufactured by Ziegler Brothers, Inc. (Gardners, Pennsylvania) and the Artemia cysts purchased from Sanders Brine Shrimp Company (Ogden, Utah). The quantity of the dry larval diets fed was a mass equal to twice that of an equivalent mass of 6 live Artemia nauplii per fish (the manufacturer of the AP-100 recommended the mass of larval diet be equivalent to twice the live mass of Artemia nauplii supplemented). Larval diet was dispensed from a single vibrator type feeder (model AF6, Sweeney Enterprises, Inc.) while the Artemia suspension was released from two live food dispensers for 5 seconds, every 5 minutes, 8 to 12 hours each day. The volume or mass of feed was based on the initial stocked density of a rearing unit, the feeding rate that unit was to receive; and the density of the newly hatched nauplii.

The milled Artemia flakes were provided in four sizes: 150 micron; <220 micron; <400 micron; and <800 micron. The larval diet AP-100 was provided in five sizes; however, only the three smallest sizes of AP-100; 150 micron, 200 micron and 250 micron, were used during the study. The different sizes of each diet were distributed as evenly and comparably as possible during the study.

The dry diets were first presented to larvae 4 days of age. First feeding larval shad, mean total length of 10.4 mm (0.4 in.), would accept a dry larval diet (150 micron). Incidence of feeding on the dry diet was 5 percent for the fish in rearing units receiving Artemia flakes and 19 percent for fish receiving the AP-100 (Table 5-5). The highest incidence of feeding on Artemia flakes was noted for larvae 8 days of age when 33 percent of the sampled fish had fed. For AP-100, the incidence of feeding continued to increase until

Table 5-5. Mean incidence of feeding for larvae with dry diet in the gastrointestinal tract through 16 days of age offered 12 *Artemia* nauplii per fish supplemented with either *Artemia* flakes or larval diet AP-100.

	Mean Incidence of Feeding (%)	
Age (days)	Artemia Flakes	AP-100
4	5	19
6	24	52
8	33	65
10	27	80
12	15	80
14	24	51
16	12	45

10 days of age when 80 percent of the larvae had fed on the dry diet. There was an apparent decline in the incidence of feeding on AP-100 following day 12, which coincided with a change to the largest particle size (250 micron) offered during the study.

There were no apparent differences in the initial incidence of feeding when comparing the average of the two feeding regimes supplemented with dry diet, 12 A + AF and 12 A + AP-100 (22 percent) to the control diet of 18A (25 percent). Subsequent increases in the incidence of feeding through 12 days of age were similar for the 12A + AP-100 and the 18A. Throughout the study, the incidence of feeding was lowest for the 12A + AF diet (Table 5-6).

There were no significant differences in growth among diets; however, the greatest growth was demonstrated in the 12A + AP-100 feeding regime (Table 5-7).

Hatchery survivals throughout the study were low (53 percent) and were reflected in the 47 percent mean survival obtained in controls receiving the 18A feeding regime. The feeding regimes 12A + AF and 12A + AP-100 had much higher mean survival rates, (66 and 84 percent respectively) than the controls (Table 5-7 and Figure 5-2). Detailed growth and survival data are presented in Appendix B.

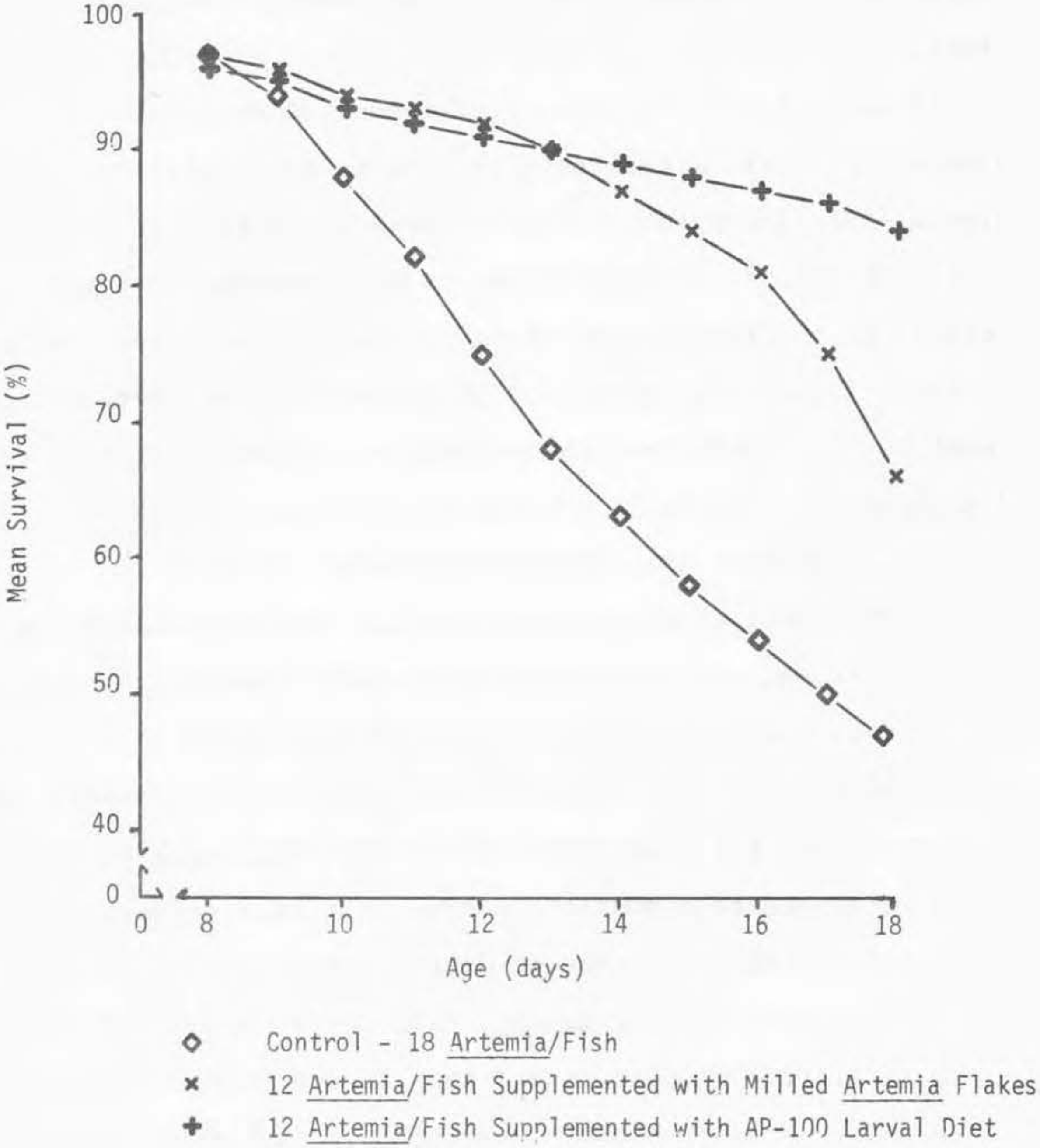
Table 5-6. Mean incidence of feeding for larvae offered 18 *Artemia* nauplii per fish, 12 *Artemia* nauplii per fish supplemented with *Artemia* flakes, and 12 *Artemia* nauplii per fish supplemented with larval diet AP-100.

	Mean Incidence of Feeding (%)		
Age (days)	18 *Artemia*	12 *Artemia* and *Artemia* Flakes	12 *Artemia* and AP-100
4	25	11	31
6	63	47	91
8	75	60	75
10	76	69	71
12	93	65	96
14	95	61	81
16	89	45	69

Table 5-7. Summary of mean growth and survival of American shad larvae at the Van Dyke Research Station (1984) to 18 days of age for the feeding regimes of 18 *Artemia*, 12 *Artemia* + *Atrtemia* Flakes, and 12 *Artemia* + AP-100.

	Feeding Rates		
	18 *Artemia*/ Fish	12 *Artemia* + *Artemia* Flakes	12 *Artemia*+ AP-100
Length (mm)	11.5	11.4	12.0
Survival (%)	46.5	66.0	84.1

Figure 5-2. Larval survival from 8 to 18 days of age at the Van Dyke Research Station (1984) comparing the feeding regimes of 18 *Artemia* nauplii; 12 *Artemia* nauplii fed in combination with a dry diet of milled *Artemia* flakes; and 12 *Artemia* nauplii fed in combination with a dry diet of larval AP-100; presented per fish per day.



Artemia nauplii continue to be an essential component of the diet for larval shad, however the study demonstrated that: dry larval feeds were accepted by first-feeding shad larvae; larval feeds remained a major portion of the diet; and prepared diets greatly reduced and almost eliminated the high larval mortality experienced in other studies (Wiggins et al. 1985).

It was apparent that prepared feeds, offered in combination with *Artemia* nauplii, and in particular the larval diet AP-100, enhanced survival; however, the reasons prepared diets enhanced survival were not clear. Several aspects related to the feed and feeding; 1) quantity and presentation of feed, 2) particle size, and 3) nutrition, may have, at least in part, affected the survival rates and will be discussed.

1) Quantity and Presentation of Feeds

The feeding regimes supplemented with prepared diets received a larger quantity of feed than the control. Twelve *Artemia* nauplii in combination with an equivalent mass (live) of the appropriate prepared diet was fed per fish daily (a mass of 24 *Artemia* nauplii) compared to a control receiving 18 *Artemia* nauplii. The moisture content of prepared feeds would also be less than that of *Artemia* nauplii which, in addition to affecting quantity would also affect the amount of feed that was nutritionally available. It was demonstrated, however, in the previous test on feeding rate of *Artemia* nauplii that there were no apparent differences in larval survival obtained for feeding rates of 18 and 24 nauplii per fish fed daily (based on the initial density of the rearing unit). Although *Artemia* nauplii are presently an essential component of the diet for larval shad, simply increasing the quantity of nauplii does not yield the increases in survival which was obtained when using prepared diets in conjunction with *Artemia* nauplii.

Larval feeding efficiency is low, initially limited by the larvae's ability to feed, mobility, competition within the tank, size of feed, etc. As a result, presentation of feed is critical in making feed available to the larvae. *Artemia* nauplii were released into a rearing unit from two locations and immediately began to sink through the water column. Dispersal of the nauplii is vertically concentric at the perimeter of the rearing unit. The nauplii are weak swimmers and do little to expand the distribution. The dry larval diet drops onto the water surface within a rearing unit from one location. Some of the diet sinks immediately; however, a portion disperses over the water's surface, sinking at various time intervals, while some remains on the surface. The dispersal of the dry larval diets, particularly in rearing units with such high fish densities, should positively affect availability of the diet to larvae. Increasing the availability of the feed can directly and positively affect survival (1981 Annual Report). Incidence of feeding, however, did not support the inference that the dry larval feed would be more available to larvae. The incidence of feeding for the feeding regimes 18A and 12A + AP-100 were similar. The feeding regime 12A + AF had the lowest incidence of feeding throughout the study, although feed dispersal was similar to that of 12A + AP-100.

2) Particle Size

Initially, the size of the prepared diets fed was much smaller than _Artemia_ nauplii. Mean width of _Artemia_ nauplii without appendages was 0.19 mm (0.007 in.) (Wiggins et al. 1985), very similar to the 200 micron particle size of the larval diet. The horizontal mouth width of larval shad 6 days of age is 0.76 mm (0.03 in.), apparently large enough to accept larger diets; however, it was demonstrated that larvae selected for _Artemia_ nauplii less than the mean width (Wiggins et al. 1985). In comparison, the initial particle size for both prepared diets was 150 micron. The largest size offered during the test was 250 micron for AP-100 and 800 micron for _Artemia_ flakes. There was a sharp decline (from 80 to 51 percent) in feeding incidence for the larval diet AP-100 after day 12, which coincided with a change in particle size from 200 to 250 micron. It appears that particle size may have influenced the incidence of feeding.

) Nutrition

The nutritional composition of any diet is important; however, the ability of an organism to utilize nutritional components must also be considered. It is assumed that the nutritional value of the Artemia flake diet (almost a pure Artemia composition) is no more than equal to and likely of less nutritional value than the diet of Artemia nauplii. If only a small percentage of the nutritional value is lost in processing then you would expect a gram of dry Artemia flakes to yield more growth than a gram of wet nauplii (similar to dry feed vs. live fish!). Although quantities for the two feeding regimes cannot be equally compared, the incidence of feeding was lowest for the feeding regime using the Artemia flake diet, and yet higher larval survival was obtained. In comparison, it was demonstrated that larger quantities of Artemia nauplii did not increase survival. Digestion of Artemia nauplii is very incomplete in larval shad and therefore the nutritional value received from the prey organism must be limited. It is possible that the larvae realize a greater nutritional value from even the partial digestion of prepared feeds because of the more homogenous distribution of nutritional components within the particle.

Comparing the feeding regimes which utilized prepared diets, the quantity, presentation, and initial particle size were equivalent. Through 8 days of age, feed particle size for both diets was 150 micron, and there was little difference in diet particle size through 10 days of age (200 micron for the AP-100 and 220 micron for *Artemia* flakes). The following diet sizes, offered after 10 days of age, were not comparable: 400 and 800 micron for flaked *Artemia* and 250 micron for AP-100. The incidence of feeding for the AP-100 was much higher than for *Artemia* flakes throughout the study. Survivals did not begin to differentiate until 14 days of age, after which larval mortality remained exceptionally low for the AP-100 diet. A higher mortality rate occurred from 14 to 18 days of age (18 percent) for larvae receiving *Artemia* flakes. The delayed mortality experienced by larvae on the 12A + AP diet was not typical of the mortality pattern reported by Wiggins et al. (1985) for larvae shad. Differences between the feeding regimes utilizing prepared diets may have been, in part, the result of the difference in particle sizes offered later in the test. This would explain the high initial survival of both supplemental diets as well as the delayed mortality which occurred in units receiving *Artemia* flakes.

The feeding regime test using larval diet AP-100 in combination with 12 *Artemia* nauplii per fish was run in triplicate at production levels. The high mean survival obtained in the study, 84 percent, occurred concurrently with the lowest production survival obtained in 1984 (53 percent). It appears that this feeding regime significantly increased hatchery survival and should be incorporated on a production basis.

Use of Oxytetracycline to Mark Daily Otolith Rings of American Shad Fry

This project was undertaken to determine if a distinguishable mark could be applied to daily otolith rings of American shad fry before they are stocked at 18-19 days of age. This mark could potentially be applied by a tank bath treatment using the antibiotic oxytetracycline (OTC). The otolith is an ossified tissue and begins growth even before hatch in some species (Marshall and Parker, 1982; Tanaka et al., 1981), and therefore the tetracycline property of being incorporated into calcified tissue (Trojnar, 1973; Weber and Ridgeway, 1962) might provide for a means of differentiating between fish that did or did not receive contact with OTC.

Two production tanks of American shad fry were treated at the Van Dyke facility, with a third serving as a control. One treated tank was inside the hatchery building and the other was outside, since direct light is known to negatively effect the fluorescent properties of tetracycline (Choate, 1964; Trojnar, 1973). Each treatment consisted of 50 mg/l oxytetracycline hydrochloride (88.5% active ingredient); 32 mg/l potassium phosphate and 67 mg/l sodium phosphate as buffers; and a supply of pure oxygen added to each tank. The treatment duration was 12 hours per day for four consecutive days (days 15-18). Temperature, pH, and dissolved oxygen were monitored during treatment to be certain safe levels for each remained throughout the treatment period. After treatment, the fish were transported to Benner Spring Fish Research Station and stocked in concrete raceways for the duration of the study.

Upon completion of this test and microscopic perusal using an ultraviolet light source, a distinguishable fluorescent mark was discernible on the daily otolith rings of treated fish and persisted for at least 152 days (Table 5-8). Data on the number marked were first gathered when the fish were 57 days old. The mark was found on 39 of 40 fish and yielded a success rate of 97^{+}% for both tanks combined at 57 days-of-age. Otoliths from the untreated 57 day-old control sample displayed no evidence of a fluorescent mark.

Table 5-8. Results of tetracycline tagging of daily otolith rings of American shad fry when treated at 15-18 days-of-age. (Benner Spring Fish Research Station, 1984).

	Number of Fish Marked	
Treatment Group	At 57 days-old	At 152 days-old
Fish treated inside and held in raceway (Sample Size)	20 (20)	8 (9)
Fish treated outside and held in raceway (Sample Size)	19 (20)	6 (8)
Percent Marked Tanks Combined	97.5%	82.4%
Untreated Controls (Sample Size)	0 (5)	0 (5)

Fish were again checked for the number marked when they reached 152 days of age; the overall percent marked was 82.4% (14 of 17 fish). Otoliths from a 5-fish sample of 152-day-old untreated control fish did not manifest a fluorescent mark.

There was no appreciable difference in marking between those fish treated inside and those treated outside; however, post-treatment survivals were quite different. At 21 days of age (3 days post-treatment), 28 percent of the inside test fish survived, compared to 87 percent of the outside test fish and 73 percent of the inside control fish (Table 5-9). No definite statement can be made regarding potential tetracycline effects but the discrepancies in survival warrant further investigation. Refinement of this technique will be the primary objective for 1985 studies to reach our goal of successfully producing adequate numbers of marked juvenile shad.

In summary, a discernable mark can be applied to the daily otolith rings of American shad fry, and will persist for at least 152 days. After some refinements and further research, this method should prove useful in determining the origin of outmigrating American shad in the Susquehanna River.

Table 5-9. Percent survival for shad fry utilized in the oxytetracycline tagging study (Van Dyke, 1984).

Treatment	Initial Tank Density	Percent Survival		
		Days of Age		
		14	18	21
50 ppm OTC (Inside)	86,800	82	56	28
50 ppm OTC (Outside)	125,900	97	93	87
Untreated Control (Inside)	211,200	85	78	73

Survival of Fry During Transport*

It has been assumed from experimental data within the facility, that a high larval mortality during transport may occur. Mean mortality for transfer of larvae in experimental situations within the hatchery was extremely high, 63 percent (1982 Annual Report); however, it was also assumed that the experimental situation was more stressful than a production effort, and direct extrapolation was not possible.

Testing of larval survival during transport has not been conducted because of the inability to establish a proper control for the study (a sufficient number of larvae with the same hatch date and source) when time and tank space were available. However, data collected in 1984 yielded encouraging results relative to larval survival following transport.

On June 14, a tank of 274,300 larvae, 14 days of age, was transferred from Van Dyke to Benner Spring. Fry were water brailed into 8 to 10 plastic bags with 5 to 10 liters of water. The bags were inflated with oxygen and sealed. Bags were then placed inside a styrofoam box and shipped to the Benner Spring Fish Research Station. Total time in transport was 3 to 5 hours. The bags of fry were removed from the boxes and placed into outside tanks similar to those at Van Dyke. When suddenly exposed to light, the larvae crowded near the bottom of the bags. Upon shading, the larvae dispersed more uniformly. The bags of larvae were tempered for a very short period (5 to 10 minutes, since temperatures were nearly identical) and were released into the tanks. Mortalities were collected for 3 days in the same manner as described for the Van Dyke Station (Table 5-10). Total larval mortality for 66 hours (approximately 3 days) following transport was 11.3 percent. Approximately 1 percent mortality would be expected in a hatchery control tank (no transport). A large part of the initial mortality (6.4 percent) was apparently caused by entrapment of larvae in the folds of the bag. It appears that handling and transport mortality for larval shad, in a production situation, is less than 10 percent.

*Note: This was not a test, but a qualatative and quantitative description of a larval transfer so that an assumption can be made relative to handling and transport mortality for larval American shad in a production situation.

Table 5-10. Larval survival following 3 to 5 hours of transport.

Time following transport (hours)	Collected Mortality	Mortality (%)
18	17,600	6.4
25	7,200	2.6
42	2,900	1.1
66	3,400	1.2
Total	31,100	11.3

Summary

1) The slow growth and high mortality characteristic of the transition period from endogenous to exogenous nutrition is the result of starvation.
2) Larval shad do not actively feed at night. Reducing the number of hours of feeding (as done in 1984) permits the introduction of a higher density of *Artemia* nauplii to coincide with peaks in feeding intensity.
3) A feeding rate of 12 *Artemia* per fish, as fed in past years, did not perform as well as higher feeding rates.
4) A feeding rate of 18 *Artemia* per fish (the feeding rated used for production in 1984) was the optimum rate tested, considering growth, survival and economy of operations.
5) Prepared diets fed in combination with *Artemia* nauplii increased survival.
6) The supplemental larval AP-100 almost eliminated the suggested starvation mortality experienced during the transition from endogenous to exogenous nutrition.
7) Particle size of prepared diets being fed is critically important. The suggested initial particle size would be 150-200 micron.
8) A discernible mark can be applied to the daily otolith rings of American shad fry using an oxytetracycline bath treatment, and will persist for at least 152 days.
9) Transportation of larvae should result in less than 10 percent mortality.

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Appendix A-1. Temporal patterns in growth of American shad larvae to 18 days of age at an initial feed rate of 12 *Artemia* nauplii per fish per 24 hour period (Van Dyke Station, 1984).

Age (days)	Trial Mean Length (mm)			
	#1	#2	#3	$\bar{x}$
4	10.4	10.1	10.6	10.3
6	10.4	10.3	10.7	10.5
8	10.2	10.1	11.1	10.5
10	10.2	10.2	10.9	10.4
12	10.4	10.6	11.1	10.7
14	10.4	--	11.6	11.0
16	--	10.8	11.0	10.9
18	10.9	10.9	11.4	11.1

Appendix A-2. Temporal patterns in growth of American shad larvae to 18 days of age when the feeding rate was initially 18 *Artemia* nauplii per fish per 24 hour period (Van Dyke Station, 1984).

Age (days)	Trial Mean Length (mm)			
	#1	#2	#3	$\bar{x}$
4	10.5	10.2	10.6	10.4
6	10.6	10.1	10.5	10.4
8	10.7	10.5	11.0	10.7
10	11.0	10.6	10.7	10.8
12	11.1	10.6	11.0	10.9
14	11.0	--	11.5	11.3
16	--	11.3	11.1	11.2
18	11.6	11.0	11.0	11.2

Appendix A-3. Temporal patterns in growth of American shad larvae to 18 days of age when the feeding rate was initially 24 *Artemia* nauplii per fish per 24 hour period (Van Dyke Station, 1984).

Age (days)	Trial Mean Length (mm) #1	#2	#3	$\bar{x}$
4	10.3	10.3	10.5	10.4
6	10.3	10.7	10.7	10.6
8	10.4	10.6	11.1	10.7
10	10.7	10.6	10.9	10.7
12	10.7	10.8	11.2	10.9
14	10.9	--	11.5	11.2
16	--	11.4	11.2	11.3
18	11.8	11.6	11.3	11.6

Appendix A-4. Larval survival for 18 days at the Van Dyke Research Station (1984) with an initial feeding rate of 12 *Artemia* nauplii per fish.

Age (days)	Trial Survival (%)			
	#1	#2	#3	$\overline{x}$[a]
1	99.3	97.6	-	99.0
2	99.1	97.2	97.3	97.8
3	98.9	97.1	96.7	97.4
4	98.9	97.1	96.5	97.3
5	98.8	97.1	96.4	97.3
6	98.7	97.1	95.9	97.1
7	98.6	97.0	95.8	97.0
8	98.5	97.0	95.7	96.9
9	98.4	96.9	95.5	96.8
10	98.3	94.8	94.1	95.4
11	97.8	89.7	91.5	92.4
12	96.0	82.4	87.1	87.6
13	92.6	80.6	81.7	84.0
14	90.5	77.2	75.3	79.8
15	88.6	76.7	62.3	74.0
16	84.6	75.9	55.8	70.2
17	83.2	74.9	50.8	67.5
18	80.6	74.0	49.1	65.9

[a]Mean survival was determined by the ΣN_{x+i} divided by the ΣN_x for 3 trial tanks multiplied by 100.

Appendix A-5. Larval survival for 18 days at the Van Dyke Research Station (1984) with an initial feeding rate of 18 *Artemia* nauplii per fish.

Age (days)	Trial Survival (%)			
	#1	#2	#3	$\bar{x}$[a]
1	99.2	98.1	-	99.2
2	99.0	97.5	98.5	98.4
3	98.8	97.4	98.1	98.2
4	98.8	97.4	97.7	98.1
5	98.7	97.3	97.6	98.0
6	98.7	97.2	97.6	98.0
7	98.6	97.2	97.5	97.9
8	98.6	97.2	97.4	97.8
9	98.4	96.8	97.0	97.5
10	98.4	93.8	95.4	95.8
11	97.9	87.8	92.2	92.4
12	97.1	85.6	87.7	89.9
13	96.0	84.2	83.6	87.8
14	95.5	82.6	81.2	86.3
15	95.1	82.4	75.8	84.3
16	94.6	80.3	72.5	82.4
17	94.4	78.8	67.3	80.1
18	93.8	77.9	61.6	77.8

[a]Mean survival was determined by the ΣN_{x+i} divided by the ΣN_x for 3 trial tanks multiplied by 100.

Appendix A-6. Larval survival for 18 days at the Van Dyke Research Station (1984) with an initial feeding rate of 24 *Artemia* nauplii per fish.

Age (days)	Trial Survival (%) #1	#2	#3	$\bar{x}$[a]
1	99.0	96.7	-	98.7
2	98.8	95.9	99.0	98.0
3	98.8	95.8	98.3	97.7
4	98.7	95.8	98.1	97.6
5	98.6	95.6	98.1	97.5
6	98.5	95.6	98.0	97.5
7	98.4	95.3	97.9	97.3
8	98.4	95.3	97.9	97.3
9	98.3	93.9	95.6	97.1
10	98.3	93.9	95.6	96.0
11	97.5	89.2	90.9	92.6
12	95.6	85.4	87.3	89.7
13	90.6	85.0	82.7	86.1
14	89.1	84.3	79.7	84.3
15	88.5	83.9	74.9	82.3
16	87.1	83.3	66.7	78.8
17	87.0	82.0	61.2	76.4
18	86.1	80.9	57.6	74.5

[a]Mean survival was determined by ΣN_{x+i} divided by ΣN_x for the 3 trial tanks multiplied by 100.

Appendix B-1. Temporal patterns in growth of American shad larvae to 18 days of age utilizing a feeding regime of 18 *Artemia* nauplii per fish per 24 hour period (Van Dyke Research Station, 1984).

Age (days)	Trial Mean Length (mm) #1	#2	#3	$\overline{x}$
4	-	10.5	10.3	10.4
6	10.7	11.3	10.5	10.8
8	10.8	10.8	11.0	10.9
10	11.4	11.3	10.5	11.1
12	11.2	11.2	10.8	11.1
14	11.2	11.0	11.1	11.1
16	11.5	11.7	11.3	11.5
18	11.8	11.0	11.6	11.5

Appendix B-2. Temporal patterns in growth of American shad larvae to 18 days of age utilizing a feeding regime of 12 *Artemia* nauplii per fish supplemented with a dry diet of Larval AP-100.

Age (days)	Trial Mean Length (mm)			
	#1	#2	#3	$\bar{x}$
4	-	10.5	10.2	10.4
6	11.5	11.0	10.4	11.0
8	11.6	10.9	10.4	11.0
10	12.1	11.0	10.5	11.2
12	11.9	11.6	10.6	11.4
14	12.0	11.6	11.2	11.6
16	12.8	11.5	10.9	11.7
18	12.8	12.0	11.1	12.0

Appendix B-3. Temporal patterns in growth of American shad larvae to 18 days of age utilizing a feeding regime of 12 *Artemia* nauplii per fish supplemented with a dry diet of milled *Artemia* flakes (Van Dyke Research Station, 1984).

Age (days)	Trial Mean Length (mm)			
	#1	#2	#3	$\bar{x}$
4	-	10.7	10.3	10.5
6	10.7	11.0	10.3	10.7
8	11.4	11.3	11.1	11.3
10	11.5	10.9	10.6	11.0
12	11.1	11.5	11.0	11.2
14	11.1	11.2	11.7	11.3
16	11.9	11.8	11.3	11.7
18	12.0	11.0	11.3	11.4

Appendix B-4. Larval survival to 18 days of age at the Van Dyke Research Station (1984) with an initial feeding regime of 18 *Artemia* nauplii per fish.

Age (days)	Trial Survival (%)			
	#1	#2	#3	$\bar{x}$[a]
1	-	-	99.2	99.7
2	97.5	98.6	98.5	98.3
3	96.8	-	98.3	98.0
4	96.5	98.4	98.1	97.8
5	96.1	98.3	98.0	97.6
6	96.0	98.3	97.8	97.5
7	95.9	98.2	97.5	97.3
8	95.1	98.2	96.0	96.6
9	91.6	98.1	91.2	94.1
10	85.5	97.8	77.5	88.0
11	76.9	96.1	68.5	82.0
12	69.4	93.4	56.1	75.0
13	62.0	91.7	43.3	68.2
14	61.0	86.8	32.7	62.6
15	52.6	83.6	30.7	58.3
16	44.8	79.9	29.0	54.0
17	38.7	77.0	25.2	50.0
18	33.3	74.2	22.3	46.5

[a]Mean survival was determined by ΣN_{x+i} divided by the ΣN_x for the 3 trial tanks multiplied by 100.

Appendix B-5. Larval survival to 18 days of age at the Van Dyke Research Station (1984) utilizing an initial feeding regime of 12 *Artemia* nauplii per fish supplemented with a dry diet of milled *Artemia* flakes.

Age (days)	Trial Survival (%)			
	#1	#2	#3	$\bar{x}$[a]
1	-	-	98.3	99.7
2	97.4	99.5	98.1	98.4
3	97.0	98.1	97.9	97.7
4	96.5	98.1	97.4	97.7
5	96.3	98.0	97.4	97.3
6	96.3	97.9	97.1	97.2
7	96.1	97.9	97.1	97.0
8	95.7	97.8	96.6	96.8
9	94.3	97.3	95.0	95.7
10	93.2	96.2	93.0	94.4
11	91.2	94.4	91.6	92.6
12	90.1	93.6	90.8	91.7
13	87.2	91.8	89.1	89.5
14	83.8	89.5	86.8	86.9
15	80.8	86.9	85.0	84.4
16	76.8	83.4	82.3	80.9
17	71.6	79.5	73.6	75.3
18	60.0	74.6	60.3	66.0

[a]Mean survival was determined by ΣN_{x+i} divided by the ΣN_x for the 3 trial tanks multiplied by 100.

Appendix B-6. Larval survival to 18 days of age at the Van Dyke Research Station (1984) utilizing an initial feeding regime of 12 *Artemia* nauplii per fish supplemented with a dry diet of Larval AP-100.

Age (days)	Trial Survival (%) #1	#2	#3	$\overline{x}$[a]
1	-	-	97.6	99.2
2	98.4	98.7	96.9	98.0
3	98.3	97.5	96.8	97.5
4	98.1	97.3	96.5	97.3
5	97.9	97.2	96.4	97.2
6	97.8	97.1	96.0	97.0
7	97.7	97.1	95.6	96.8
8	97.6	97.0	94.6	96.4
9	97.5	96.7	91.7	95.3
10	97.2	95.8	87.1	93.3
11	96.6	94.4	84.6	91.8
12	96.0	93.4	83.2	90.8
13	95.5	92.9	81.9	90.1
14	94.8	92.3	80.9	89.3
15	94.1	91.1	79.2	88.1
16	93.3	90.4	78.0	87.2
17	91.9	89.9	75.2	85.6
18	90.5	89.2	72.6	84.1

[a]Mean survival was determined by ΣN_{x+i} divided by the ΣN_x for the 3 trial tanks multiplied by 100.

JOB VI. SUMMARY OF OPERATION OF THE CONOWINGO DAM FISH PASSAGE FACILITY IN SPRING OF 1984

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INTRODUCTION

The Conowingo Dam Fish Passage Facility (hereafter Fish Lift) has been in operation since 1972. It is part of a cooperative private, state, and federal effort to restore American shad to the upper Susquehanna River. The operational goal of the Fish Lift has been to monitor fish populations below Conowingo Dam and transport as many migratory fishes (American shad, herrings, hickory shad, striped bass, and American eel) upriver as possible. This is in accordance with the restoration plan for the Susquehanna River. Operation of the Fish Lift is one of many long term commitments by the Philadelphia Electric and Susquehanna Electric companies to aid in the restoration of migratory fishes to the Susquehanna River.

The Conowingo Hydroelectric Station is operated as a run of the river peaking power station. The maximum rated peak discharge from all eleven units at Conowingo Dam is 85,000 cfs. The natural river flows in excess of 85,000 cfs are released over the spillway. Generally, under efficient operating conditions discharge from the seven small units (1-7) is 5,000 cfs each and from the four large units (8-11) is 10,000 cfs each for a total of 75,000 cfs. However, in 1984 unit 10 was out of service limiting peak discharge to 65,000 cfs.

Objectives of the 1984 operation were to (1) monitor relative abundance of Alosa species in the tailrace, (2) monitor species composition of fishes in tailrace, (3) obtain life history information from selected migratory and resident species, (4) contribute to restoration efforts by the trap and transfer of prespawned American shad and other migratory fishes to upstream localities, and (5) assist Maryland Tidewater Administration in assessing the population of American shad in the upper bay.

Methods

Prior to the operation of the Fish Lift several surveys were conducted in the spring to detect the arrival of alosids into the lower river area. Personnel at Owen's Fish House (Perryville, Maryland) were contacted on alternate weekdays starting on 12 March to determine if commercial fishermen were catching these species in the river or Susquehanna Flats. A visual survey of Deer Creek was conducted daily from 19 March to 15 May to determine if river herrings were present in the lower river. Herrings were first observed in Deer Creek at Stafford Bridge on 11 April.

Mechanical preparation of the Fish Lift (Figure 6.1) was initiated during the week of 19 March 1984. All mechanical preparations were completed with a successful test run of the Fish Lift on the afternoon of 2 April. Fish Lift operation commenced on 3 April. However, the operation scheduled for 5 April was cancelled due to high spring flows which necessitated the removal of weir gate and crowder motors. Lift operation resumed on 13 April and was scheduled to operate on a alternate half day basis according to the 1984 Susquehanna River Anadromous Fish Restoration Committee (SRAFRC) work plan (SRAFRC 1984). Operation was limited on 17 April and cancelled on 19 April due to high river flows. Operation resumed on an alternate half day basis on 21 April and continued on that schedule until 24 May. Starting on 25 May the Lift operated daily with an extended schedule to include afternoon and early evening hours. This operation was terminated on 30 May due to increasing river flows which necessitated removal of the Lift motors. Operation resumed on 6 June on an alternate half day basis and continued until termination of the 1984 spring trapping season on 14 June.

The mechanical aspect of Fish Lift operation was similar to that described in the 1982 Summary Report (RMC 1983). Fishing time and/or lift frequency was determined by abundance of fishes and the time required to process the catch.

Attraction velocity and flow at the Fish Lift in 1984 were generally similar to those maintained in 1982 (RMC

1983). Based on the 1982 experience hydrologic conditions were maintained in the area of the Lift between the crowder gate and weir gate entrances similar to that reported in the latter part of the 1982 trapping season (RMC 1983).

A minimum spring flow of 5,000 cfs from Conowingo Dam has been released from approximately 15 April to 15 June from 1972 to 1984. Due to high natural river flows in 1984 dam discharges were above 5,000 cfs until 2 May. Unit No. 5 was used to discharge the continuous minimum flow from 2 May to 11 June when station discharge did not exceed 5,000 cfs. The release of 5,000 cfs from Unit No. 5 was based on the 1982 experience which showed the Lift's efficiency increased when the competition between the attraction flow from the Lift and continuous release was reduced.

Release of the chemical attractant, phenethyl alcohol, was to follow the schedule outlined in SRAFRC's 1984 work plan (SRAFRC 1984). The attractant was to be released on every other scheduled day of Fish Lift operation until water temperatures reached 68 F. However, as in past years, equipment malfunction prevented release of the attractant on a regular basis.

Fishes were processed as reported earlier (RMC 1983). Fishes were enumerated by counting and/or estimation based on their abundance and released back to the tailrace. When large numbers of fish were present, the number was estimated and fishes released to minimize handling. Length, weight, sex and scale samples were taken from blueback herring, alewife, hickory shad, striped bass, and striped bass x white bass hybrid as in 1983. Common names of fishes (Bailey et al. 1970) are used throughout the text and tables. A list of common and scientific names is given in Table 6.1.

American shad were sorted and held for transport in one of three circular tanks continually supplied with river water. Transport was scheduled to occur whenever fifty or more green or gravid shad were collected in a day. All healthy, active shad not transported were tagged with floy anchor tags and released back to the tailrace. Prior to their release to the tailrace length, weight, sex, and spawning condition were determined as conditions permitted. Scale samples were taken when possible.

Shad scales were cleaned, mounted and aged following procedures of Cating (1953). Results of age analysis in this report are considered preliminary until scale samples are exchanged with Maryland DNR for independent validation. Scale samples collected from 1972 to 1983 have been aged, These data along with other life history information (length, weight and sex) are in the process of being collated and will be available at a later date.

Results and Discussion

In 34 days of Fish Lift operation (2 April to 14 June) 957,821 fish representing 35 taxa were caught in 519 lifts with a total fishing time of 192 hours (Table 6.2). Predominate species in order of abundance were gizzard shad, channel catfish, carp, and white perch. Alosids (alewife, American shad, blueback herring, and hickory shad) comprised a small portion of the catch.

The relative abundance of fishes in 1984 was similar to 1983 (Table 6.2). In recent years the catch has generally been dominated by gizzard shad and carp whereas in the early years of Lift operation the catches were dominated by alosids (primarily blueback herring) and white perch.

The total catch of 510 alosids in 1984 was the lowest on record since operation began in 1972 (Table 6.2). However, the catch of American shad (167) ranked fourth by year. The low number of alosids collected in 1984 was generally a result of few river herrings being captured. The catch of alewife, blueback herring and hickory shad was 26, 311, and 6 individuals, respectively.

The first American shad was captured on 3 May at a water temperature of 59 F (Table 6.3). Most American shad (138) were captured between 23 and 29 May when water temperatures ranged from 61.7 to 69.9 F and natural river flows ranged from 48,500 to 60,900 cfs. Over 40% of the American shad were collected on 27 May at a water temperature of 68 F.

Some 150 American shad were floy tagged in 1984; six shad were recaptured. Three were recaptured at the Fish Lift. One fish was taken by a sport angler in the tidal portion of the Susquehanna River off Wiley's Ship Yard in Port Deposit, MD. Two shad were captured by commercial netters, one was collected in Delaware Bay and the other was collected in the Atlantic Ocean off the coast of Maine. Seven American shad tagged by the Maryland DNR in the tailrace were recaptured at the Fish Lift.

Data on sex, mean fork length, and age structure of American shad collected in 1984 are presented in Table 6.4. Eighteen shad were returned to the tailrace prior to obtaining any data in an effort to prevent mortalities that might have occurred due to weakened condition of the specimens. The sex ratio of the remaining 149 specimens was 2.17:1, male to female. Males ranged in age from III to V years and were dominated by IV year olds. Females ranged in age from IV to VII years and were dominated by VI year olds. One IV year old male was a repeat spawner while the other shad examined were virgins.

The relative efficiency (number of American shad caught) of the Fish Lift was highest at lower river flows. The operation of the Fish Lift had been modified in 1982 in an effort to increase the relative efficiency of the Lift (SRAFRC 1983). Figures 6.3 to 6.5 show the catch of American shad at the Lift by day, river flow (cfs) and water temperture (F) for 1982 to 1984, respectively. American shad have been collected at river flows that ranged from

15,400 cfs to 80,500 cfs and at water temperatures that ranged from 59.0 F to 74.8 F during those years. Generally, as flows decreased the catch of American shad increased.

Station operation also appeared to influence the relative efficiency of the Fish Lift. At river flows below 85,000 cfs, the number of turbines in operation determines the volume of water discharged to the tailrace and thereby tailrace configuration. Figure 6.2 shows by time the volume of discharge (cfs) at Conowingo Dam on 27 May when average daily river flow was 55,100 cfs. Flows in the tailrace on 27 May varied from a low off-peak generation level of 10,000 cfs to a peak generation level of approximately 65,000 cfs. The catch of American shad decreased steadily as generation increased.

The pattern of increased catch with decreased generation is repeated throughout 1982 through 1984. The catch/hr of American shad at discharges $\leq$ 5,000 cfs, 10,000 cfs to 40,000 cfs, >40,000 cfs was 13.9, 5.9 and 1.0 shad, respectively (Table 6.5). The data were further examined to detect the effect of the operation of Units No. 1 and 2 (Units located closest to Fish Lift). The catch of American shad was generally highest at all the aforementioned levels of discharges when Units No. 1 and/or 2 were not in operation. Thus, the relative efficiency of the Lift is greatest at lower discharges and/or when Units 1 and/or 2 are off.

The lower number of American shad captured in 1983 and 1984 compared with 1982 was in part due to the high spring time natural river flows in 1983 and 1984. Because of the high spring flows in 1983 and 1984, most Lift operation occurred simultaneously with full peaking generation and/or at spills. The amount of time the lift operated in 1983 and 1984 at higher levels of generation was greater than in 1982 (Table 6.6). The lower overall Lift efficiency and limited Lift operation in 1983 and 1984 compared to 1982 contributed to the lower catches of American shad. In May 1982, when most American shad were captured, historic low natural river flows occurred.

The reduced efficiency of the Fish Lift at times of high generation may indicate either that American shad are not as susceptible to capture under these conditions or that they utilize other areas of the river. Boat anglers have collected American shad by hook and line in a restricted location (about 500 sq.ft.) along the east side of the tailrace. This is an area, about 100 ft downstream from the retaining wall, historically fished for shad by anglers, particularly at times of higher generation (RMC, 1979). Shad apparently utilize this restricted location during times of peak generation. However, the number of shad using this area appears to be small. Radiotagging studies have indicated that only a small percentage of shad utilize the tailrace; most utilize the tidal portion of the river.

No transportation of American shad or other migratory fishes occurred in 1984. On 27 May a sufficient number of shad (68) were collected, however, due to their advanced sexual condition they were floy tagged and released back to the tailrace.

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TABLE 6.1. List of scientific and common names of fishes collected at the Conowingo Fish Lift, Spring 1972-1982 (according to Bailey, et al., 1970).

Scientific Name	Common Name
Family - Petromyzontidae	Lampreys
Petromyzon marinus	Sea lamprey
Family - Anguillidae	Freshwater eels
Anguilla rostrata	American eel
Family - Clupeidae	Herrings
Alosa aestivalis	Blueback herring
Alosa mediocris	Hickory shad
Alosa pseudoharengus	Alewife
Alosa sapidissima	American shad
Brevoortia tyrannus	Atlantic menhaden
Dorosoma cepedianum	Gizzard shad
Family - Salmonidae	Trouts
Salmo gairdneri	Rainbow trout
Salmo trutta	Brown trout
Salvelinus fontinalis	Brook trout
S. fontinalis x S. namaycush	Splake
Family - Coregonidae	White Fishes
Coregonus artedii	Lake herring
Family - Esocidae	Pikes
Esox niger	Chain pickerel
Esox lucius	Northern pike
Esox masquinongy	Muskellunge
E. masquinongy x E. lucius	Tiger muskie
Family - Cyprinidae	Minnows and carps
Carassius auratus	Goldfish
Cyprinius carpio	Carp
Nocomis micropogon	River chub
Notemigonus crysoleucas	Golden shiner

TABLE 6.1 Continued.

Scientific Name	Common Name
Family - Cyprinidae (continued)	
Notropis sp.	Shiners
Notropis amoenus	Comely shiner
Nortopis hudsonius	Spottail shiner
Notropis procne	Swallowtail shiner
Notropis rubellus	Rosyface shiner
Notropis spilopterus	Spotfin shiner
Pimephales notatus	Bluntnose minnow
Rhinichthys atratulus	Blacknose dace
Rhinichthys cataracta	Longnose dace
Family - Catostomidae	Suckers
Carpiodes cyprinus	Quillback
Catostomus commersoni	White sucker
Erimyzon oblongus	Creek chubsucker
Hypentelium nigricans	Northern hogsucker
Moxostoma macrolepidotum	Shorthead redhorse
Family - Ictaluridae	Freshwater catfishes
Ictalurus catus	White catfish
Ictalurus natalis	Yellow bullhead
Ictalurus nebulosus	Brown bullhead
Ictalurus punctatus	Channel catfish
Noturus sp.	Madtoms
Noturus insignus	Margined madtom
Family - Belonidae	Needlefishes
Strongylura marina	Atlantic needlefish
Family - Cyprinodontidae	Killifishes
Fundulus heteroclitus	Mummichog
Family - Percichthyidae	Temperate basses
Morone americana	White perch
Morone saxatilis	Striped bass
M. saxatilis x M. chrysops	Striped bass x White bass

TABLE 6.1 Continued.

Scientific Name	Common Name
Family - Centrarchidae	Sunfishes
Ambloplites rupestris	Rock bass
Lepomis auritus	Redbreast sunfish
Lepomis cyanellus	Green sunfish
Lepomis gibbosus	Pumpkinseed
Lepomis macrochirus	Bluegill
Micropterus dolomieui	Smallmouth bass
Micropterus salmoides	Largemouth bass
Pomoxis annularis	White crappie
Pomoxis nigromaculatus	Black crappie
Family - Percidae	Perches
Etheostoma olmstedi	Tessellated darter
Etheostoma zonale	Banded darter
Perca flavescens	Yellow perch
Stizostedion vitreum	Walleye
Percina caprodes	Log perch
Percina peltata	Shield darter

TABLE 6.2 Comparison of annual catch of fishes in the Fish Lift, 1 April - 15 June, 1972-1984.

YEAR	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
NO. DAYS	54	62	58	55	63	61	35	27	30	37	44	29	34
LIFTS	817	1527	819	514	654	707	358	301	403	490	725	648	519
OPER. TIME(HR.)	607	981	500	307	375	413	212	187	222	275	502	288	250
FISHING TIME(HR)	313	623	222	189	252	245	136	123	117	178	336	224	192
# SPECIES	40	43	42	41	38	40	44	37	42	48	48	41	35
AMERICAN EEL	805	2050	91937	64375	60409	14601	5878	1602	377	11329	3961	1080	155
BLUEBACK HERRING	58198	330341	340084	69916	35519	24395	13098	2282	502	618	25249	517	311
HICKORY SHAD	429	739	219	20	-	1	-	-	1	1	15	5	6
ALEWIFE	10345	144727	16675	4311	235	188	5	9	9	129	3433	50	26
AMERICAN SHAD	182	65	121	87	82	165	54	50	139	328	2039	413	167
GIZZARD SHAD	24849	45668	119672	139222	382275	742056	55104	75553	275736	1156662	1225374	950252	912666
ATLANTIC MENHADEN	-	-	112	-	506	1596	-	-	16	42	-	1	-
TROUTS	1	-	-	-	-	-	-	-	-	-	-	-	-
RAINBOW TROUT	34	67	20	24	54	291	70	15	23	219	20	2	5
BROWN TROUT	172	286	483	219	427	700	261	324	259	207	219	225	141
BROOK TROUT	1	3	4	1	-	2	23	-	4	3	5	2	-
TROUT	-	-	-	-	-	-	-	-	-	2	-	-	-
CHAIN PICKEREL	-	1	10	-	-	1	-	-	-	1	-	-	-
NORTHERN PIKE	-	2	2	-	-	2	2	4	3	-	5	1	-
MUSKELLUNGE	20	104	9	7	12	44	14	5	27	1	4	-	-
MINNOWS	-	-	-	-	-	-	-	-	-	-	1	-	-
GOLDFISH	-	27	1	9	4	1	-	-	-	1	-	-	-
CARP	4370	16362	34393	15114	6755	16256	11842	14946	8879	18313	15362	16273	8012
RIVER CHUB	-	-	-	-	-	-	-	-	1	-	-	-	-
GOLDEN SHINER	165	430	437	751	1622	652	221	304	35	155	92	216	8
COMELY SHINER	5	252	3870	2079	740	769	1152	1737	761	281	14216	3176	371
SPOTTAIL SHINER	34	137	2036	268	1743	8107	8506	1533	849	31	315	2132	-
SWALLOWTAIL SHINER	-	-	-	-	-	-	-	-	-	3	-	-	-
ROSYFACE SHINER	1	-	-	1	-	-	-	-	-	-	8	-	-
SPOTFIN SHINER	103	40	3011	1231	45879	7950	3751	41	314	524	622	501	-
BLUNTNOSE MINNOW	-	-	-	-	-	-	4	-	-	-	-	-	-
BLACKNOSE DACE	-	-	-	-	-	-	-	-	-	-	2	-	-
LONGNOSE DACE	-	-	1	-	-	-	4	-	-	-	-	-	-
SHINERS	264	3	-	-	-	-	-	-	-	-	6	-	-
QUILLBACK	7119	27780	14565	8388	9882	6734	2361	5134	2929	3622	1617	4679	1942
WHITE SUCKER	363	1034	286	152	444	282	189	906	1145	1394	582	412	109
CREEK CHUBSUCKER	3	3	1	-	-	-	-	-	-	4	2	-	-
NORTHERN HOG SUCKER	-	2	-	1	5	-	3	6	13	1	-	-	-
SHORTHEAD REDHORSE	1097	4420	434	445	1276	1724	697	2163	1394	6533	6974	7558	3467
WHITE CATFISH	3070	6394	2200	6178	1451	3081	982	515	605	2199	565	224	77
YELLOW BULLHEAD	7	45	1	32	2	47	25	13	18	36	61	10	7
BROWN BULLHEAD	510	5328	1612	740	451	2416	125	284	675	531	339	179	69
CHANNEL CATFISH	61042	55084	75663	74042	41508	90442	48575	38251	38929	55528	40941	12559	20479
MARGINED MADTOM	-	-	-	-	-	-	-	-	-	-	6	-	-
MADTOMS	-	-	-	-	-	-	-	-	-	-	1	-	-
TADPOLE MADTOM	-	-	-	-	-	-	-	-	-	-	1	-	-
MUMMICHOG	-	-	-	-	1	-	-	-	-	-	1	-	-
WHITE PERCH	50971	647493	897113	511699	568018	224843	113154	43103	26971	83363	53527	23151	6402
STRIPED BASS	3142	495	1150	174	13	1196	934	260	904	3277	60	23	151
ROCK BASS	66	32	31	46	227	128	50	46	88	381	138	269	158
REDBREAST SUNFISH	707	2056	1398	3040	3772	8377	4187	3466	1524	1007	1335	401	465
GREEN SUNFISH	3	-	4	39	81	168	25	-	16	28	91	16	7
PUMPKINSEED	229	2578	2579	1000	878	1587	512	323	446	306	848	225	104
BLUEGILL	567	1423	927	3058	2712	5442	1361	913	942	1299	1184	587	284
SMALLMOUTH BASS	182	298	119	153	327	701	262	374	455	881	1095	1003	608
LARGEMOUTH BASS	82	80	23	19	33	14	22	22	41	13	20	17	8
WHITE CRAPPIE	4457	664	4371	9290	2987	1003	673	384	100	231	303	450	59
BLACK CRAPPIE	8	4	25	45	86	199	103	53	15	20	39	46	6
TESSELLATED DARTER	-	1	4	1	-	-	1	-	-	2	-	-	-
YELLOW PERCH	5955	1090	682	494	2904	735	526	379	373	1007	724	387	467
LOGPERCH	-	-	-	-	-	-	27	-	-	-	-	-	-
SHIELD DARTER	-	-	-	-	-	-	-	-	-	1	-	-	-
WALLEYE	1840	2734	1613	369	2267	2140	967	2491	4153	2645	504	663	236
BANDED DARTER	-	-	-	-	-	-	1	-	-	-	9	-	-
ATLANTIC NEEDLEFISH	1	-	-	1	-	-	-	-	-	2	-	-	-
LAMPREYS	-	-	-	-	-	-	-	-	-	-	-	2	-
SEA LAMPREY	-	2	-	2	29	11	1	3	1	55	56	8	4
LAKE HERRING	-	1	-	-	-	-	-	-	-	-	-	1	-
STRIPED BASS X WHITE BASS	-	-	-	-	-	-	270	273	2674	39	160	355	282
TIGER MUSKIE	-	-	-	-	-	-	13	132	34	53	56	16	10
BROOK TROUT X LAKE TROUT	-	-	-	-	-	-	-	-	-	-	-	-	2
	241419	1300345	1617888	917043	1175616	1169161	276045	197769	372379	1353308	1403175	1028090	957821

TABLE 6.3

Daily summary of the catch of fishes in the Fish Lift for the 1984 spring operation.

DATE	04/03/84	04/13/84	04/15/84	04/17/84	04/21/84	04/23/84	04/25/84	04/27/84
NO. LIFTS	11	10	10	7	12	9	11	11
FIRST LIFT	610	730	608	605	600	715	600	600
LAST LIFT	1159	1307	1204	930	1200	1200	1200	1200
OPERATING TIME	5.82	5.62	5.93	3.42	6.00	4.75	6.00	6.00
FISHING TIME(HR)	4.77	4.25	4.50	2.75	5.08	3.83	5.17	5.17
AVE RIVER FLOW	91800	87600	73700	95600	100000	89700	73800	82200
AVE WATER TEMP.	45.6	50.9	51.8	51.8	51.8	51.8	50.9	52.7
ATTRACTANT USED?	NO	NO	NO	NO	NO	NO	NO	YES
AMERICAN EEL	1	4	4	2	-	-	-	-
BLUEBACK HERRING	-	-	3	-	-	-	-	-
HICKORY SHAD	-	-	-	2	-	-	-	2
ALEWIFE	-	1	2	2	3	2	1	-
AMERICAN SHAD	-	-	-	-	-	-	-	-
GIZZARD SHAD	2	540	2182	238	1362	2095	3179	1888
RAINBOW TROUT	-	-	-	-	-	-	-	-
BROWN TROUT	-	-	1	-	-	1	1	1
CARP	-	-	-	-	-	-	3	1
GOLDEN SHINER	-	-	-	-	-	-	-	-
COMELY SHINER	-	-	-	-	-	-	-	-
QUILLBACK	1	-	-	-	-	-	-	1
WHITE SUCKER	1	2	7	1	5	1	1	1
SHORTHEAD REDHORSE	-	1	5	-	2	-	-	10
WHITE CATFISH	-	2	-	-	-	-	-	-
YELLOW BULLHEAD	-	-	-	-	-	-	-	-
BROWN BULLHEAD	-	4	1	3	-	-	-	-
CHANNEL CATFISH	389	11	2	1	1	1	-	1
WHITE PERCH	-	-	-	-	-	-	-	-
STRIPED BASS	-	-	-	-	-	-	-	-
ROCK BASS	-	-	1	-	-	-	-	-
REDBREAST SUNFISH	-	-	-	-	-	-	-	-
GREEN SUNFISH	-	-	-	-	-	-	-	-
PUMPKINSEED	-	-	-	-	-	-	-	-
BLUEGILL	-	-	-	-	-	-	1	-
SMALLMOUTH BASS	-	-	-	-	-	-	-	-
LARGEMOUTH BASS	-	-	-	-	-	-	-	-
WHITE CRAPPIE	-	-	-	-	-	-	-	-
BLACK CRAPPIE	-	-	1	-	-	-	-	-
YELLOW PERCH	-	-	10	-	-	-	-	1
WALLEYE	1	1	1	-	2	-	-	1
SEA LAMPREY	-	1	-	-	-	-	1	-
STRIPED BASS X WHITE BASS	-	1	25	4	6	3	2	5
TIGER MUSKIE	-	-	-	-	-	-	-	-
BROOK TROUT X LAKE TROUT	-	-	-	-	-	-	-	-
	395	568	2245	253	1381	2103	3189	1912

TABLE 6.3

Continued.

DATE	04/29/84	05/01/84	05/03/84	05/05/84	05/06/84	05/07/84	05/09/84	05/11/84
NO. LIFTS	11	15	14	24	23	12	12	12
FIRST LIFT	510	500	505	508	505	508	520	505
LAST LIFT	1100	1101	1055	1800	1601	1101	1052	1100
OPERATING TIME	5.83	6.02	5.83	12.87	10.93	5.88	5.53	5.92
FISHING TIME(HR)	5.00	4.17	4.67	10.83	8.78	5.18	3.50	4.33
AVE RIVER FLOW	69200	58900	52600	60600	61700	64100	66300	58700
AVE WATER TEMP.	55.4	56.3	59.0	59.0	59.0	59.0	58.1	57.2
ATTRACTANT USED?	NO	YES	NO	NO	NO	NO	NO	NO
AMERICAN EEL	2	1	3	3	5	1	5	2
BLUEBACK HERRING	-	-	-	1	1	-	-	-
HICKORY SHAD	1	1	-	-	-	-	-	-
ALEWIFE	1	1	1	-	-	-	-	-
AMERICAN SHAD	-	-	1	2	3	-	1	-
GIZZARD SHAD	6730	48810	43950	49500	60070	2975	41010	37300
RAINBOW TROUT	-	1	-	-	-	-	-	-
BROWN TROUT	-	4	3	1	2	-	2	3
CARP	5	18	9	29	17	2	10	8
GOLDEN SHINER	-	-	1	-	-	-	-	-
COMELY SHINER	-	-	-	1	-	-	-	-
QUILLBACK	-	5	19	1	-	3	-	-
WHITE SUCKER	2	5	10	7	9	-	1	-
SHORTHEAD REDHORSE	30	103	61	41	28	-	11	5
WHITE CATFISH	-	-	-	-	-	-	-	-
YELLOW BULLHEAD	-	-	1	-	-	-	-	-
BROWN BULLHEAD	-	1	-	25	5	-	-	-
CHANNEL CATFISH	15	329	49	484	222	474	90	63
WHITE PERCH	1	6	44	41	76	147	21	275
STRIPED BASS	-	4	5	3	2	2	4	1
ROCK BASS	-	2	10	15	12	1	-	1
REDBREAST SUNFISH	-	-	-	2	1	1	-	-
GREEN SUNFISH	-	-	-	1	1	-	-	-
PUMPKINSEED	-	-	1	1	-	-	-	-
BLUEGILL	-	1	3	2	-	1	3	1
SMALLMOUTH BASS	10	10	4	8	36	-	2	3
LARGEMOUTH BASS	-	-	1	-	1	-	-	-
WHITE CRAPPIE	-	-	-	1	-	-	-	-
BLACK CRAPPIE	-	-	-	-	1	-	-	1
YELLOW PERCH	2	9	9	20	20	3	1	-
WALLEYE	1	3	14	2	17	-	-	-
SEA LAMPREY	-	1	-	-	1	-	-	-
STRIPED BASS X WHITE BASS	11	23	35	11	41	-	3	2
TIGER MUSKIE	-	-	1	-	2	-	-	-
BROOK TROUT X LAKE TROUT	-	-	-	-	1	-	-	-
	======	======	======	======	======	======	======	======
	6811	49338	44235	50202	60574	3610	41164	37665

continued

TABLE 6.3

Continued.

DATE	05/13/84	05/15/84	05/17/84	05/19/84	05/20/84	05/21/84	05/23/84	05/24/84
NO. LIFTS	14	11	11	12	11	12	20	23
FIRST LIFT	503	500	520	510	507	458	505	505
LAST LIFT	1110	1103	1111	1105	1000	1100	140	1333
OPERATING TIME	6.12	6.05	5.85	5.92	4.88	6.03	20.58	8.55
FISHING TIME(HR)	3.50	2.58	4.75	5.00	3.68	5.08	6.60	6.42
AVE RIVER FLOW	57900	75400	82600	63400	55800	52300	59800	60900
AVE WATER TEMP.	58.1	60.8	59.0	58.1	58.1	60.0	61.7	64.4
ATTRACTANT USED?	NO	YES	NO	YES	NO	NO	YES	NO
AMERICAN EEL	1	7	3	2	3	4	2	-
BLUEBACK HERRING	-	-	-	-	-	2	-	2
HICKORY SHAD	-	-	-	-	-	-	-	-
ALEWIFE	-	-	-	-	-	-	-	-
AMERICAN SHAD	1	-	-	-	1	-	6	13
GIZZARD SHAD	59075	12350	18750	23685	37665	31825	27100	39060
RAINBOW TROUT	-	-	-	-	-	1	-	-
BROWN TROUT	4	6	2	2	4	3	4	4
CARP	11	170	9	12	7	77	997	882
GOLDEN SHINER	-	-	-	-	-	-	1	-
COMELY SHINER	-	-	-	-	-	-	-	-
QUILLBACK	-	31	-	-	-	13	281	270
WHITE SUCKER	3	3	-	1	1	1	4	3
SHORTHEAD REDHORSE	49	212	54	52	74	222	563	766
WHITE CATFISH	-	-	1	-	1	-	-	-
YELLOW BULLHEAD	-	1	-	-	-	-	-	-
BROWN BULLHEAD	1	2	-	-	-	1	-	1
CHANNEL CATFISH	61	265	515	138	105	283	189	217
WHITE PERCH	187	2132	55	8	88	212	1205	33
STRIPED BASS	-	1	-	1	-	4	6	6
ROCK BASS	7	13	4	-	2	3	4	4
REDBREAST SUNFISH	2	2	-	-	2	2	-	8
GREEN SUNFISH	-	1	-	-	1	-	-	-
PUMPKINSEED	-	1	-	-	1	1	1	4
BLUEGILL	5	5	1	1	5	1	1	5
SMALLMOUTH BASS	10	36	13	7	6	9	103	125
LARGEMOUTH BASS	-	-	-	-	-	-	-	1
WHITE CRAPPIE	-	1	-	-	1	1	2	1
BLACK CRAPPIE	-	-	-	-	-	-	-	-
YELLOW PERCH	4	7	4	3	3	15	13	5
WALLEYE	1	1	-	1	2	6	11	19
SEA LAMPREY	-	-	-	-	-	-	-	-
STRIPED BASS X WHITE BASS	4	3	1	1	2	-	3	3
TIGER MUSKIE	1	-	1	-	-	-	-	-
BROOK TROUT X LAKE TROUT	-	-	-	-	-	-	-	-
	======	======	======	======	======	======	======	======
	59427	15250	19413	23914	37974	32686	30496	41432

continued

TABLE 6.3

Continued.

DATE	05/25/84	05/26/84	05/27/84	05/28/84	05/29/84	06/06/84	06/08/84	06/10/84
NO. LIFTS	25	28	25	26	26	20	13	12
FIRST LIFT	503	455	505	505	504	500	505	505
LAST LIFT	605	1743	1752	1738	1554	1522	1100	1055
OPERATING TIME	1.03	12.80	12.78	12.55	10.83	10.37	5.92	5.83
FISHING TIME(HR)	10.72	7.67	9.67	10.08	7.50	7.52	4.62	4.92
AVE RIVER FLOW	56500	54300	55100	48500	55900	54000	40900	35400
AVE WATER TEMP.	66.2	67.0	68.0	68.0	69.9	65.3	68.0	69.9
ATTRACTANT USED?	NO	NO	YES	NO	NO	NO	NO	NO
AMERICAN EEL	3	2	3	10	6	1	15	7
BLUEBACK HERRING	36	2	172	18	13	2	2	49
HICKORY SHAD	-	-	-	-	-	-	-	-
ALEWIFE	3	-	9	-	-	-	-	-
AMERICAN SHAD	23	11	68	2	15	1	4	8
GIZZARD SHAD	25850	77600	31450	45270	31225	66050	29900	17700
RAINBOW TROUT	2	-	1	-	-	-	-	-
BROWN TROUT	8	4	5	4	6	18	9	14
CARP	605	637	542	206	2242	344	153	22
GOLDEN SHINER	1	1	1	-	1	-	-	2
COMELY SHINER	105	-	30	-	-	-	-	-
QUILLBACK	581	51	26	42	310	99	135	3
WHITE SUCKER	8	3	7	2	9	4	4	1
SHORTHEAD REDHORSE	466	226	190	53	128	53	61	1
WHITE CATFISH	12	2	4	3	18	6	5	3
YELLOW BULLHEAD	2	-	-	-	1	-	1	-
BROWN BULLHEAD	5	2	2	1	7	-	2	1
CHANNEL CATFISH	984	3580	3640	2680	1975	1095	505	205
WHITE PERCH	59	35	116	441	524	38	148	155
STRIPED BASS	8	6	3	10	6	19	10	3
ROCK BASS	27	7	7	19	3	1	4	5
REDBREAST SUNFISH	29	13	28	51	16	8	49	64
GREEN SUNFISH	-	1	-	-	-	1	-	-
PUMPKINSEED	6	-	1	16	3	2	18	21
BLUEGILL	13	-	17	35	3	5	15	42
SMALLMOUTH BASS	99	34	10	10	4	32	14	7
LARGEMOUTH BASS	-	-	1	-	1	-	-	2
WHITE CRAPPIE	2	-	4	3	1	-	2	7
BLACK CRAPPIE	-	-	-	-	-	-	1	2
YELLOW PERCH	17	22	36	122	24	5	12	29
WALLEYE	23	13	17	20	11	8	10	11
SEA LAMPREY	-	-	-	-	-	-	-	-
STRIPED BASS X WHITE BASS	4	1	7	3	1	3	5	4
TIGER MUSKIE	-	-	1	-	1	-	-	1
BROCK TROUT X LAKE TROUT	-	-	-	1.	-	-	-	-
	======	======	======	======	======	======	======	======
	28981	82253	36398	49022	36554	67795	31084	18369

continued

TABLE 6.3

Continued.

DATE	06/12/84	06/14/84	TOTALS
NO. LIFTS	15	11	519
FIRST LIFT	455	500	
LAST LIFT	1105	1030	
OPERATING TIME	6.17	5.50	250.11
FISHING TIME(HR)	4.92	4.50	191.71
AVE RIVER FLOW	26100	24200	
AVE WATER TEMP.	73.4	78.8	
ATTRACTANT USED?	NO	NO	
AMERICAN EEL	17	36	155
BLUEBACK HERRING	8	-	311
HICKORY SHAD	-	-	6
ALEWIFE	-	-	26
AMERICAN SHAD	7	-	167
GIZZARD SHAD	25900	10380	912,666
RAINBOW TROUT	-	-	5
BROWN TROUT	16	9	141
CARP	104	890	8,012
GOLDEN SHINER	-	-	8
COMELY SHINER	700	35	871
QUILLBACK	26	44	1,942
WHITE SUCKER	1	1	109
SHORTHEAD REDHORSE	-	-	3,467
WHITE CATFISH	5	15	77
YELLOW BULLHEAD	-	1	7
BROWN BULLHEAD	2	3	69
CHANNEL CATFISH	385	1525	20,479
WHITE PERCH	195	160	6,402
STRIPED BASS	29	48	181
ROCK BASS	4	2	158
REDBREAST SUNFISH	101	86	465
GREEN SUNFISH	-	1	7
PUMPKINSEED	14	13	104
BLUEGILL	81	37	284
SMALLMOUTH BASS	15	1	608
LARGEMOUTH BASS	1	-	8
WHITE CRAPPIE	19	14	57
BLACK CRAPPIE	-	-	6
YELLOW PERCH	45	46	487
WALLEYE	22	17	236
SEA LAMPREY	-	-	4
STRIPED BASS X WHITE BASS	27	38	282
TIGER MUSKIE	-	2	10
BROOK TROUT X LAKE TROUT	-	-	2
	27724	13404	957,821

TABLE 6.4.

Mean fork length (mm), age, and sex of American shad collected at the Conowingo Dam Fish Lift in 1984.

SEX	AGE	N	MEAN	RANGE MIN	RANGE MAX
M	III	13	324	293	368
M	IV	81	384	336	415
M	V	3	451	430	462
F	IV	3	410	396	424
F	V	10	471	436	515
F	VI	13	506	457	560
F	VII	11	538	502	568

TABLE 6.5.

Summary of American shad catch at various generation levels and operating status of Units No. 1 and 2, 1 May to 31 May, 1982 to 1984.

Total Discharge (1,000 cfs)	Unit 1	Unit 2	Minutes Fished	Total Shad Collected	Shad/hr
≤5	OFF	ON	575	19	2.0
≤5	OFF	OFF	4736	1121	15.3
			5311	1230	13.9
10-40	ON	ON	531	11	1.2
10-40	ON	OFF	30	0	0.0
10-40	OFF	ON	1509	203	8.1
10-40	OFF	OFF	2732	255	5.6
			4801	469	5.9
>40	ON	ON	13385	173	0.8
>40	ON	OFF	350	12	2.1
>40	OFF	ON	1278	30	1.4
>40	OFF	OFF	1626	65	2.4
			16639	280	1.0

Data limited to non-clean out lifts taken during periods of steady generation.

TABLE 6.6

Summary of fish lift operation by year, number of lifts and fishing time at various generation levels and operation status of Units No. 1 and 2 from 1 May to 31 May 1982 to 1984.

Total Discharge (1,000 cfs)	Unit 1	Unit 2	No. Of Lifts 1982	Minutes Fished 1982	No. Of Lifts 1983	Minutes Fished 1983	No. Of Lifts 1984	Minutes Fished 1984
≤5	OFF	ON	23	575	-	-	-	-
≤5	OFF	OFF	157	4571	6	150	1	15
			180	5146	6	150	1	15
10-40	ON	ON	5	171	4	120	23	240
10-40	ON	OFF	1	30	-	-	-	-
10-40	OFF	ON	46	1253	4	75	6	180
10-40	OFF	OFF	61	1937	17	445	16	350
			113	3391	25	640	45	770
>40	ON	ON	36	1181	358	6391	246	5813
>40	ON	OFF	12	350	-	-	-	-
>40	OFF	ON	30	898	8	230	5	150
>40	OFF	OFF	28	1006	22	620	-	-
			106	3435	388	7241	251	5963

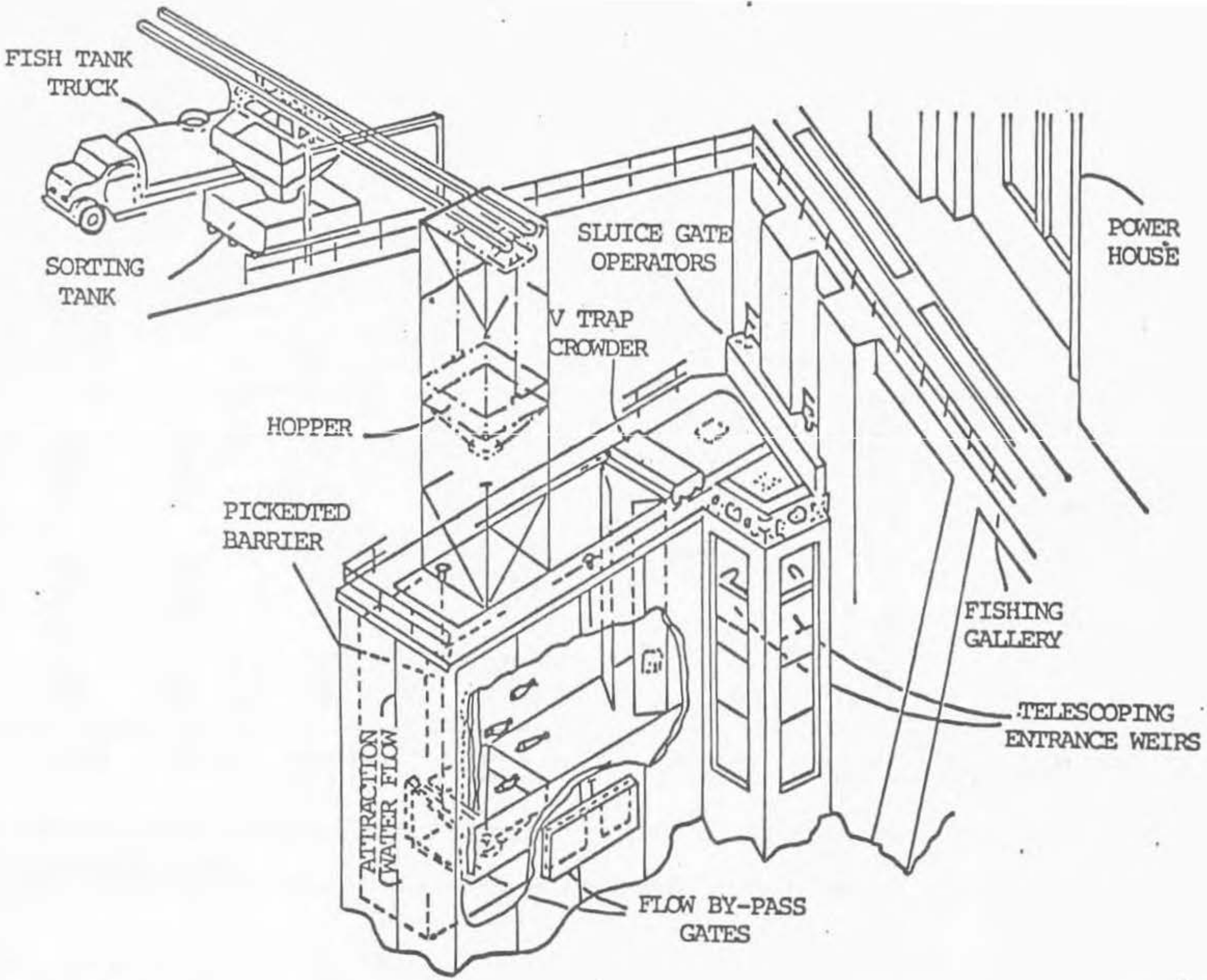
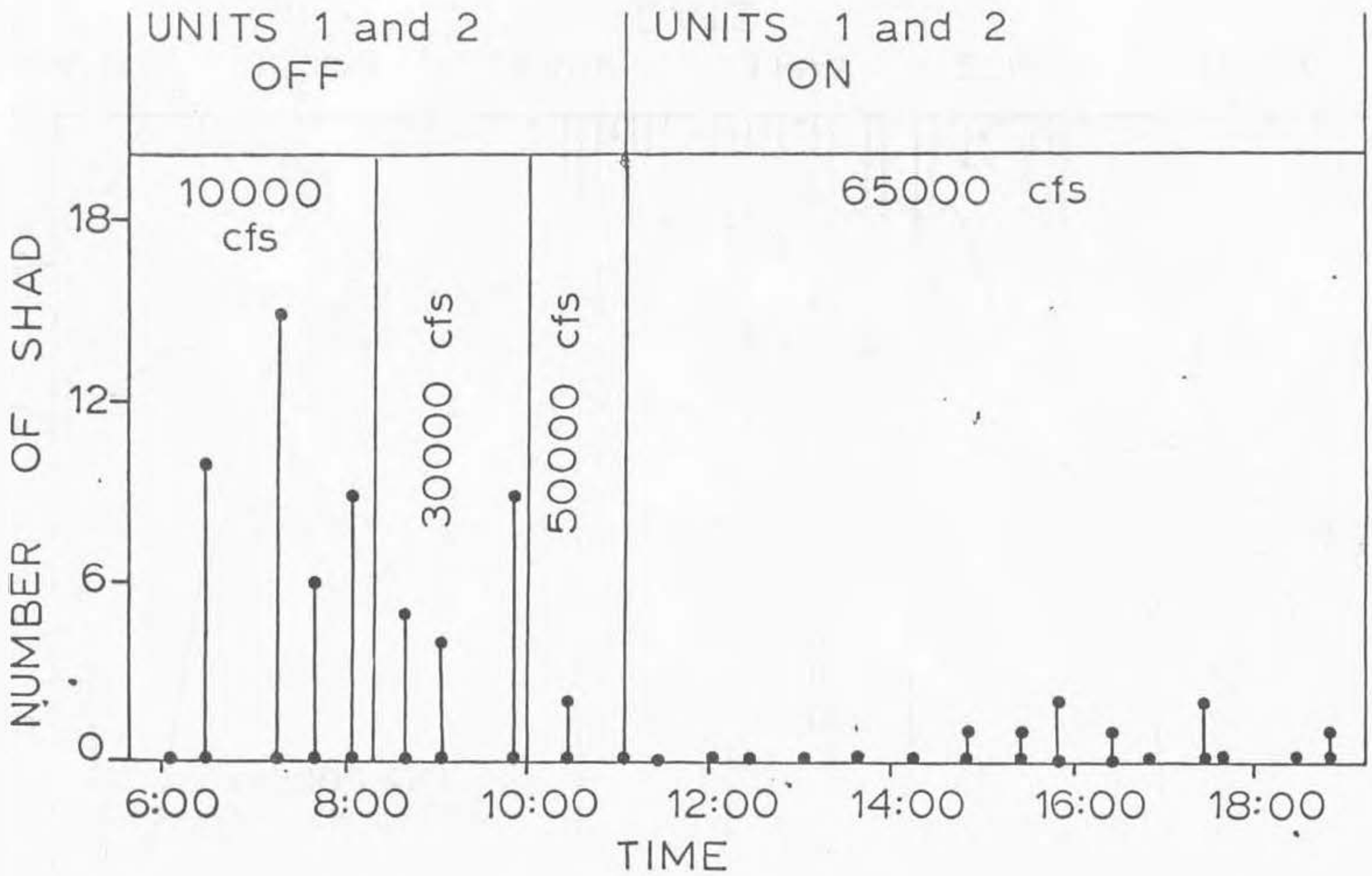


FIGURE 6-1

Schematic drawing of Conowingo Dam Fish Collection Facility, Anonymous (1972).

FIGURE 6.2

Effects of dam discharges and operation of Units No. 1 and 2 on catch of American shad on 27 May 1984.



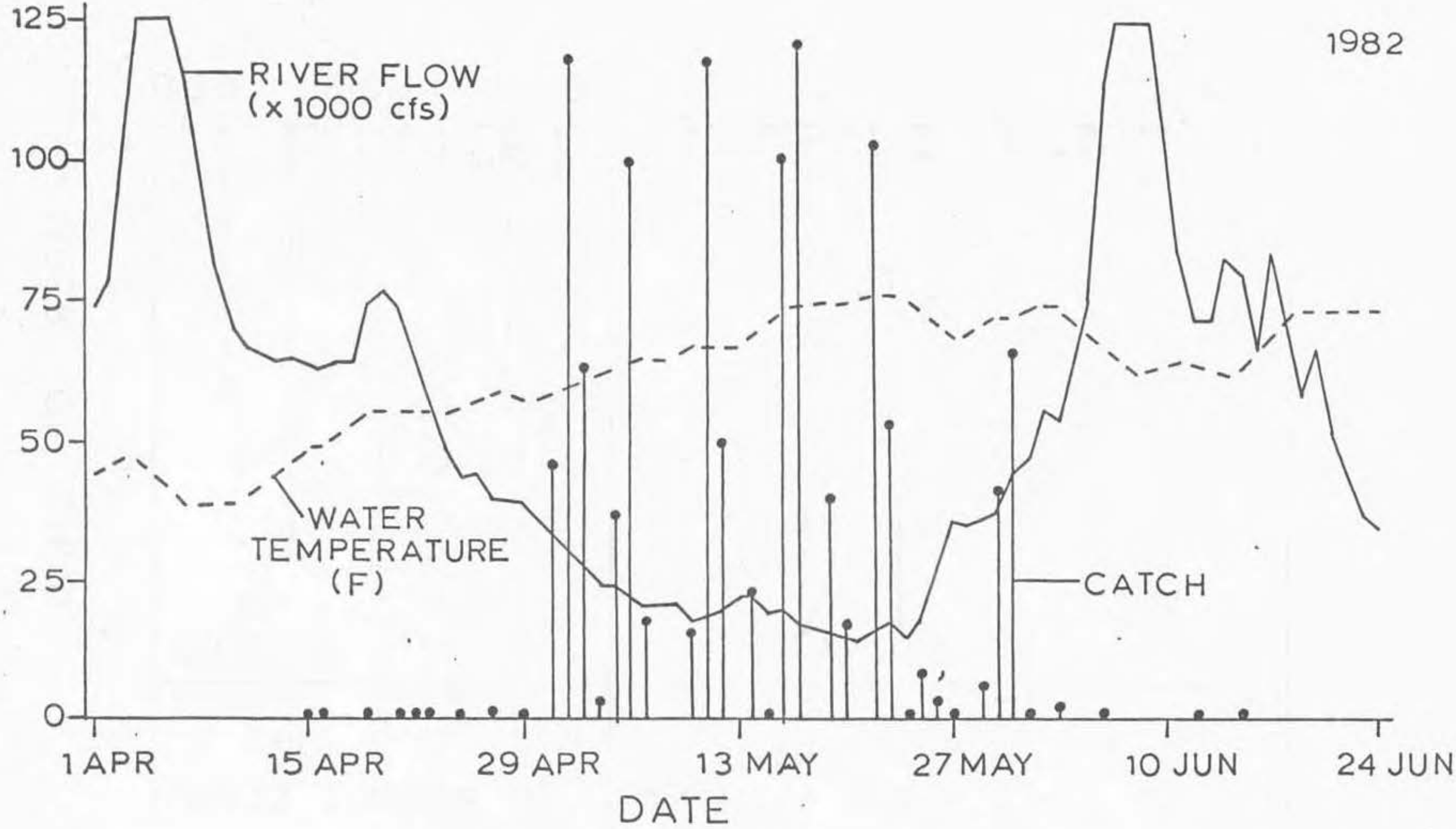


FIGURE 6.3

Effects of river flow and water temperature (F) on the catch of American shad for 1982.

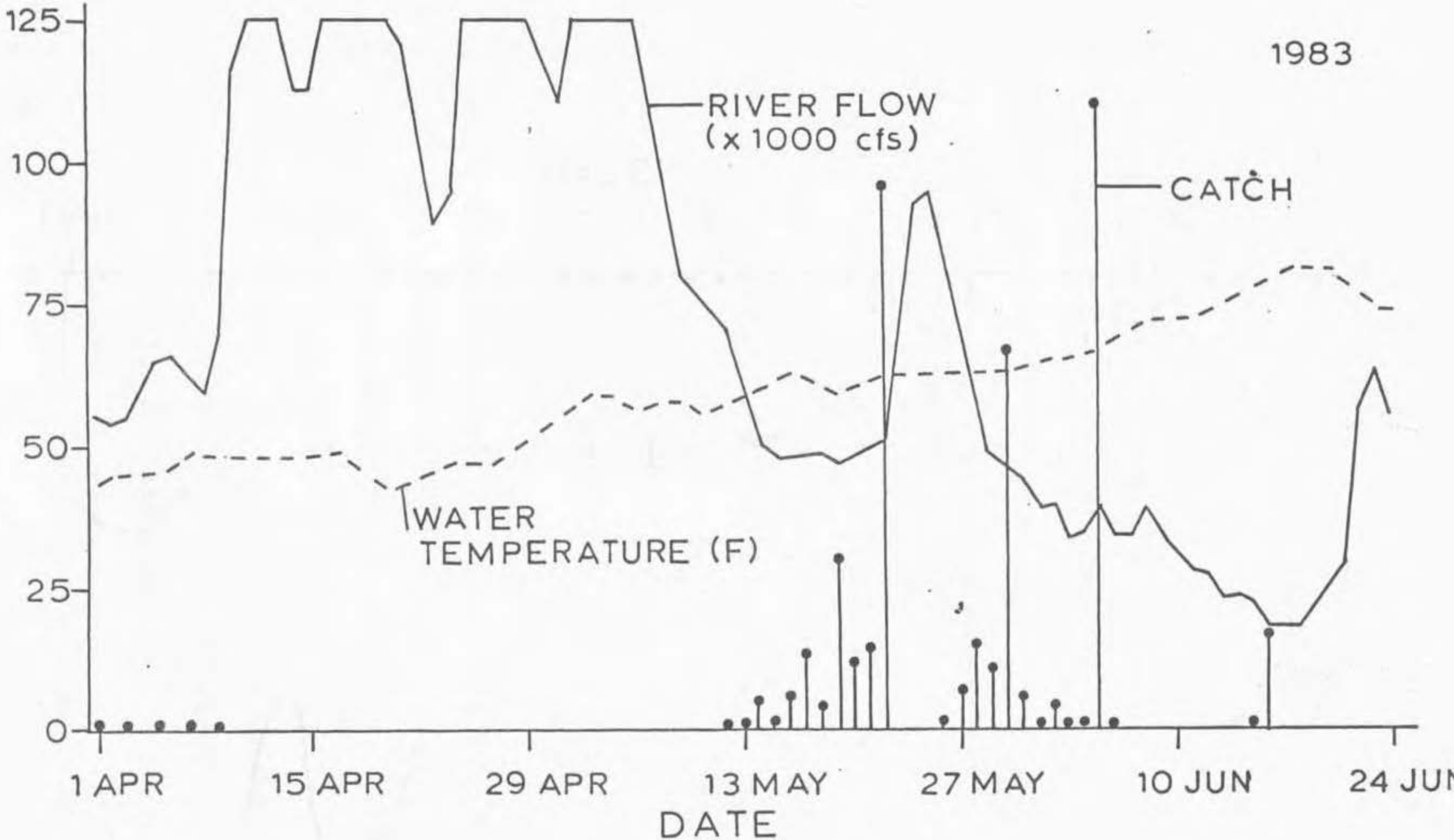


FIGURE 6.4

Effects of river flow and water temperature (F) on the catch of American shad for 1983.

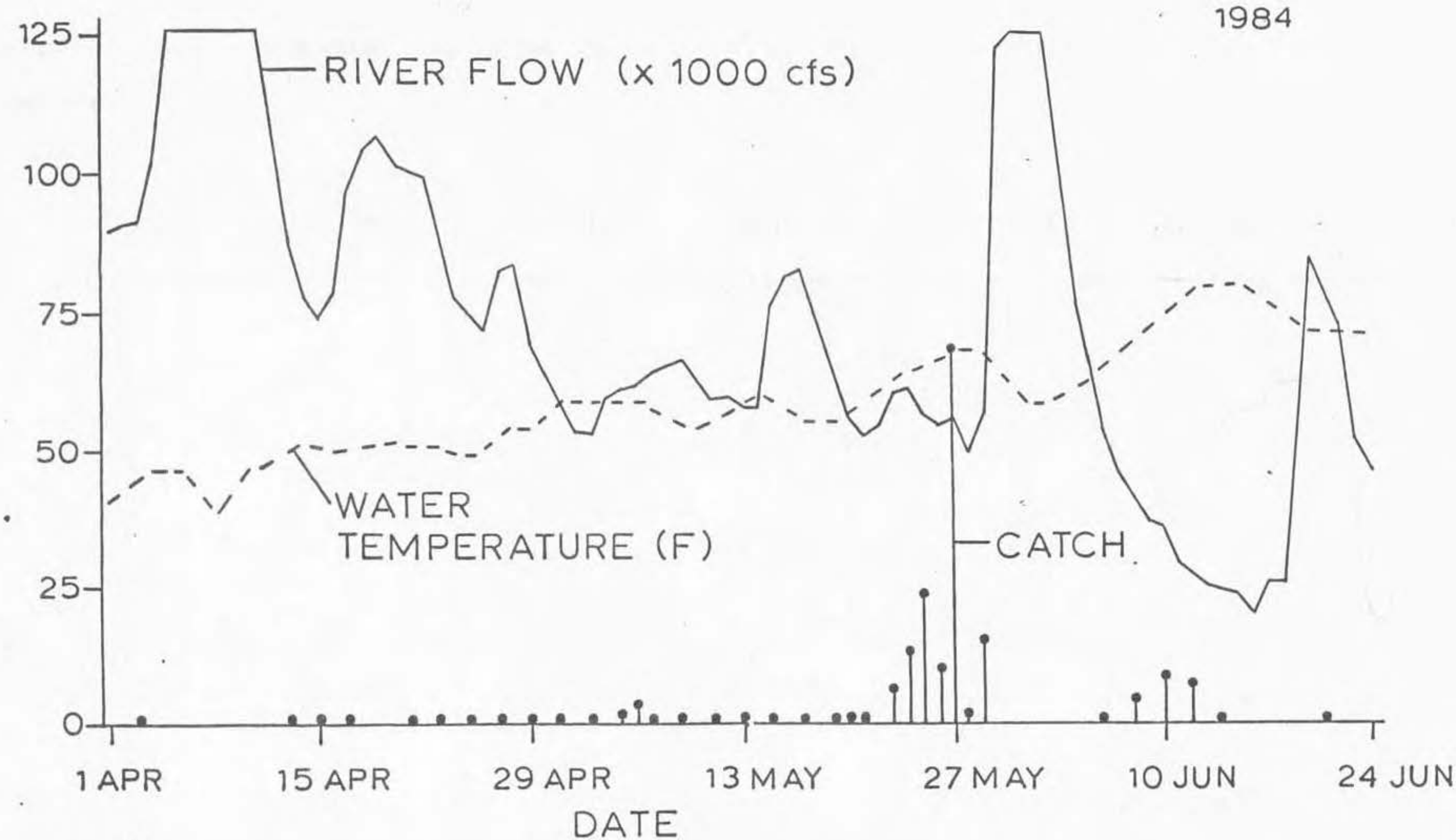


FIGURE 6.5

Effects of river flow and water temperature (F) on the catch of American shad for 1984.

Job VII. POPULATION ASSESSMENT OF ADULT AMERICAN SHAD IN THE UPPER CHESAPEAKE BAY - 1984.

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7.1 INTRODUCTION

Prior to the late 1970's, American shad had been an important part of Maryland's commercial and sport fisheries. Beginning in colonial times and continuing through the late 1960's, shad catches ranked near the top in both pounds landed and dock-side value (Mansuetti and Kolb, 1953. Walburg and Nichols, 1967). Sport angling for shad, although a relatively recent phenomenon as compared to the commercial fishery, had generated many hours of recreation throughout the State.

Historically, the principal shad river in Maryland has been the Susquehanna. Until 1980, a commercial shad fishery had existed in this region for over 200 years while a successful sport fishery had been ongoing there since the 1930's. Commercial dockside landings of American shad from 1962 through 1973 averaged 204,000 pounds. Forste (MTA in-file data) estimated the value of sport angling for shad on the Susquehanna River in 1970 to be $3.9 million.

Because of a sharp, continuous decline in the reported harvest of American shad since the mid 1970's, Maryland closed its waters to shad fishing on April 4, 1980. The most precipitous decline occurred on the Susquehanna drainage which saw landings drop from approximately 180,000 pounds in 1970 to only 2,300 for 1979.

Concerned by the seriousness of this situation, the Tidewater Administration of Maryland's Department of Natural Resources proposed a long term investigation of American shad in the upper Chesapeake Bay. The primary objective of this study was to assess the status of head-of-the-Bay shad stocks, specifically those utilizing the Susquehanna River drainage. The information obtained would be used to formulate management policies designed to restore American shad to stable, harvestable levels. To meet this objective, five separate jobs were initiated: estimation of adult spawning population, characterization of brood stock, sport angling survey, juvenile recruitment assessment, and literature review and survey.

7.2 METHODS AND MATERIALS

Basic capture, holding, and tagging procedures for 1984 differed little from previous years and are described in the SRAFRC 1982 and 1983 annual reports. Collecting gear employed for 1984 was a single 500' x 8' x 5¼" stretch mesh anchor gill net set off Port Deposit, Maryland and rod and reel fished from a small boat anchored in the tailrace of Conowingo Dam. Pound nets were not used in 1984 because of late start-up by the commercial operator.

7.3 RESULTS

Tables 7.1 and 7.2 present effort and catch data for 1984. As in 1983 anchor net effort was reduced over other years because of high river flows. However, hook and line effort increased in 1984; 11 trips vs. 2 in 1983. Of the 221 adult shad captured and tagged, 13 were subsequently recaptured; 10 within the study area and 3 outside. Table 7.3 provides specific information concerning these 10 fish while a general summarization is presented below:

a) 2 were by commercial gears
   1 was by hook and line
   7 were by Fish lift

b) 3 were tagged from gill nets
   7 were tagged by hook and line

c) 1 fish was recaptured upstream from its initial capture location
   1 fish was recaptured downstream from its initial capture location
   8 were recaptured in the same general location

d) Shortest period at large = 3 days
   longest period at large = 23 days
   average period at large = 11 days

Upper Bay shad population estimates for 1984 were again calculated using both the Peterson Index (3,814) and the Schaefer Method (3,537). Tables 7.4 and 7.5 show how these two estimates were derived.

7.4 DISCUSSION

High river flows during the spring of 1984 reduced gill net tagging effort. Because of safety reasons and net fishing catchabilities, the anchor gill net cannot be used to capture shad until Conowingo Dam reduces turbine schedule to one small unit. Normal spring flows permit this schedule from approximately midnight to 6:00 AM. However, any high river flows must be compensated for with an increase in turbine usage.

With respect to gill net efficiency, anchor gill net CPUE was nearly as good as in 1983 and far superior than for the first 3 years of this study (Table 7.6), possibly indicating a larger run size than estimated.

Hook and line success for 1984 was much greater than the previous year when only 2 trips were made and a total of 11 shad caught by this gear. Increased success in capturing adult shad for tagging by hook and line could also indicate a larger run size than the estimate but this conclusion is somewhat clouded by the substantial increase in hook and line effort.

7.5 SUMMARY OF POPULATION ASSESSMENT

The estimates of the number of adult shad utilizing the upper Chesapeake Bay for 1984 as calculated by the Peterson and Schaefer methods were 3,814 and 3,537, respectively. This compares with 1983 estimates of 7,127 and 8,031 for these two statistics.

Increase in hook and line captured shad along with continued high anchor gill net efficiency indicate a possible larger spawning run for 1984 than presented by the two formal estimates.

7.6 ADULT POPULATION CHARACTERIZATION

The following information was collected from adult American shad during the 1984 tagging operation. Table 7.7 breaks down these spawners into their respective age groups and also notes incidence of repeat spawning.

Variable	No. of Fish Observed	
	♂	♀
Sex	121	130
Sex ratio	1	1.07
length	121	130
weight	1	1
age	121	130

Comparison between 1984-1983:

Slight shift in sex ratio to almost 50:50

Definite shift to younger age groups primarily with hook and line captured adults

Increased incidence of repeat spawners; 9.2% in 1984 vs. 4.3 for 1983

7.7 SPORT ANGLING SURVEY

The 1984 DNR lower Susquehanna River creel survey began on April 7 and continued through June 29. The following information was collected during this period.

A. Effort/Catch Data:

- estimated # anglers = 20,230
- estimated hours fished = 60,787
- estimated catch = 137,979

B. Estimated Sport Catch of American Shad

1980 = 8
1981 = 118
1982 = 266
1983 = 132
1984 = 351

C. Catch Per Angler Hour and Hours to Catch 1 Fish 1983-1984

	1983		1984	
Species	CPAH	HTC	CPAH	HTC
White Perch	1.190	0.8	0.744	1.3
Striped bass	0.027	37.2	0.298	3.4
Channel catfish	0.248	4.0	0.208	4.8
Herring	0.008	124.9	0.013	75.7
American shad	0.001	1,311.3	0.006	172.4

D. A significant change was noted for the estimated sport catch of hickory shad in 1984. Catch and catch/effort data for this species are presented as follows:

Year	Est. Catch	CPAH	HTC
1980	27	0.0002	5,000
1981	39	0.0002	5,000
1982	10	0.0001	10,000
1983	0	0.0	-
1984	292	0.0048	208.3

E. Key Points 1984 vs 1983:

- -170% increase in estimated sport catch of American shad
- -Significant change in catch and angler success for hickory shad
- -Decrease in both estimated angler pressure (32%) and total catch (64%) over the previous year

7.8 JUVENILE RECRUITMENT SURVEY

Collection techniques were identical for the 1984 Department of Natural Resources upper Bay juvenile recruitment survey. Sampling was with a 200' x 10' x ¼" small haul seine and a 16' headrope modified otter trawl. Sampling was on a bi-weekly basis with 8 seines and 6 trawl stations being sampled. No young-of-the-year American shad were collected during this 1984 sampling. Catch compositions for 5 important finfish species is presented in Table 7.8.

Comparison of 1984 vs 1983 juvenile sampling noted increased catches for alewife and blueback herring, striped bass and white perch for 1984. However, numbers of young clupeids remains low, especially American shad. Reproduction for this species is still below detectable levels indicating either reduced egg production from the remnant brood stock, adverse environmental conditions, causing high egg and larval mortality, chemical contamination, or all of the above.

TABLE 7.1 Dates fished by gear type during the 1984 upper Chesapeake Bay American shad tagging operation.

	GEAR TYPES	
DATE	ANCHOR GILL NET	HOOK & LINE
May 4		X
5		
6		
7		
8		
9		
10	X	X
11	X	
12		
13		
14		X
15	X	X
16		X
17		
18		
19		
20		
21		X
22	X	X
23		
24		X
25		X
26		
27		
28		
29		X

TABLE 7.2 Comparison of the total catch, number tagged, number dead, and percent perceived net mortality by location and gear type for adult American shad captured during the 1984 upper Chesapeake Bay shad tagging program

ear Type	Location	Catch	#Tagged	#Dead	Mortality
nchor gill	Susq. River	125	122	3	2.4
ook & line	Susq. River	126	99***	5	-
ono. trap	Susq. River	158*	-	-	-
TOTALS		409	221	8	3.6%**

* Fish lift catch minus RMC recaptures of their tagged shad
** Final observed gear mortality based on DNR efforts only
*** 27 fish not tagged via hook & line capture below 350 mm length minimum

TABLE 7.3 Capture-recapture dates, locations and gear types for 10 American shad recaptures during 1984 program

ag ate	Recapture Date	Tagging Location	Gear	Recapture Location	Gear	Days at large
/11	5/22	Susq. R.	GN	Susq. R.	GN	11
/15	5/24	Susq. R.	GN	Susq. R.	FL	9
/16	5/26	Susq. R.	HL	Susq. R.	FL	10
/14	5/27	Susq. R.	HL	Susq. R.	FL	13
/14	5/27	Susq. R.	HL	Susq. R.	FL	13
/15	5/27	Susq. R.	HL	Susq. R.	FL	12
/16	5/27	Susq. R.	HL	Susq. R.	FL	11
/22	5/27	Susq. R.	HL	Susq. R.	FL	5
/24	5/27	Susq. R.	HL	Susq. R.	FL	3
/22	6/14	Susq. R.	GN	Susq. R.	GN	23

GN - gill net HL - hook & line FL - fish lift

TABLE 7.4 Population estimate of adult American shad utilizing the Susquehanna River, Susquehanna Flats, and the Northeast River for 1984 by the Petersen Index.

Chapman's Modification to the Petersen Index-

$$N = \frac{(M + 1)\ (C + 1)}{R + 1}$$

where N = population estimate
M = # of fish tagged
C = # of fish examined for tags
R = # of tagged fish recaptured

For the 1984 Survey -

C = 188
R = 10
M = 221

Therefore -

$$N = \frac{(221 + 1)\ (188 + 1)}{10 + 1}$$

$$= 3,814$$

From Ricker (1975): Calculation of sampling error using the recapture numbers in conjunction with a Poisson distribution approximation and acceptable confidence limits

Using Chapman (1951) -

$$N^* = \frac{(M + 1)\ (C + 1)}{R_t + 1}$$

where: R_t = tabular value (from Rickar p343)

$$\text{LOWER } N^* = \frac{(221 + 1)\ (188 + 1)}{18.4 + 1} = 2163 \text{ @ .95 confidence limits}$$

$$\text{UPPER } N^* = \frac{(221 + 1)\ (188 + 1)}{4.7 + 1} = 7361 \text{ @ .95 confidence limits}$$

TABLE 7.5 Population estimate of adult American shad using the Susquehanna River and Flats, and the Northeast River during 1984 by the Schaefer Method.

A. Recoveries of American shad tagged in successive weeks listed according to week of recovery; total tagged each week; and fish recovered.

Week of Recovery(j)	WEEK of TAGGING 1	2	3	4	5	6	7	tagged fish recovered (R_j)	total fish recovered (C_j)	C_j/R_j
1								0	0	0.00
2								0	0	0.00
3								0	41	0.00
4								0	131	0.00
5				2				2	83	41.5
6				6	2			7	113	16.1
7					1			1	18	18.1
Tagged fish recovered (R_j)	0	0	0	7	3	0	0	10		
Total fish tagged (M_j)	0	0	31	108	61	21	0	221	386	
M_j/R_j	0	0.0	0.0	15.4	20.3	0	0			

B. Computed totals of American shad in the Susquehanna River and Flats and the Northeast River during 1984.

Week of Recovery(j)	Week of Tagging 1	2	3	4	5	6	7	Totals
1	-	-	-	-	-	-	-	
2	-	-	-	-	-	-	-	
3	-	-	-	-	-	-	-	
4	-	-	-	-	-	-	-	
5	-	-	-	1,278	-	-	-	1,278
6	-	-	-	1,240	654	-	-	1,894
7	-	-	-	-	365	-	-	365
Totals	-	-	-	2,518	1,019	-	-	3,537

TABLE 7.6 Catch, effort and catch per unit effort (CPUE) for adult American shad captured by anchor gill nets during the 1980-1984 upper Chesapeake shad tagging program.

Anchor Gill Nets	Year	Total Catch	Yd^2-hours net fished	Yd^2-hours to catch 1 shad
	1980	115	31,600	275
	1981	228	59,591	261
	1982	277	93,200	336
	1983	213	8,311	39
	1984	125	7,822	63

TABLE 7.7 Age frequency distribution and spawning history by sex and gear type for adult American shad collected by Maryland DNR during 1984.

GEAR TYPE	SEX	AGE GROUP III	IV	V	VI	VII	TOTALS
Anchor Gill Net	m		10	27	7		44
	rpts.		1	12	3		16
	f		3	48	28	2	81
	rpts.			2	5		7
Hook & Line	m	30	33	8	5		76
	rpts.						
	f		11	24	19	3	48
Grand Totals	m	30	43	35	12		120
	rpts.		1	12	3		16
	f		14	72	38	5	129
	rpts.			2	5		7

TABLE 7.8 Juvenile catch composition of five species taken during juvenile recruitment survey in upper Chesapeake Bay and Susquehanna River, 1980-1984.

Species	Gear	1980		1981		1982		1983		1984	
		total	CPUE	total	CPUE	total	CPUE	total	CPUE	total	CPUE
American	hs	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
shad	ot	0	0.0	0	0.0	1	0.01	0	0.0	0	0.0
Blueback	hs	108	0.6	2	0.01	130	0.8	1	0.01	40	0.315
herring	ot	27	0.3	0	0.0	8	0.1	2	0.02	17	0.210
Alewife	hs	194	1.1	108	0.8	14	0.1	4	0.03	11	0.087
herring	ot	38	0.4	33	0.4	14	0.1	6	0.06	49	0.721
White	hs	1315	7.2	174	1.3	1660	10.1	208	1.5	914	7.197
perch	ot	1453	14.4	347	3.8	3973	37.8	553	5.5	2410	35.44
Striped	hs	55	0.3	8	0.1	235	1.4	8	0.06	22	0.173
bass	ot	8	0.1	0	0.0	49	0.5	2	0.02	10	0.147

hs=haul seine; ot=otter trawl

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