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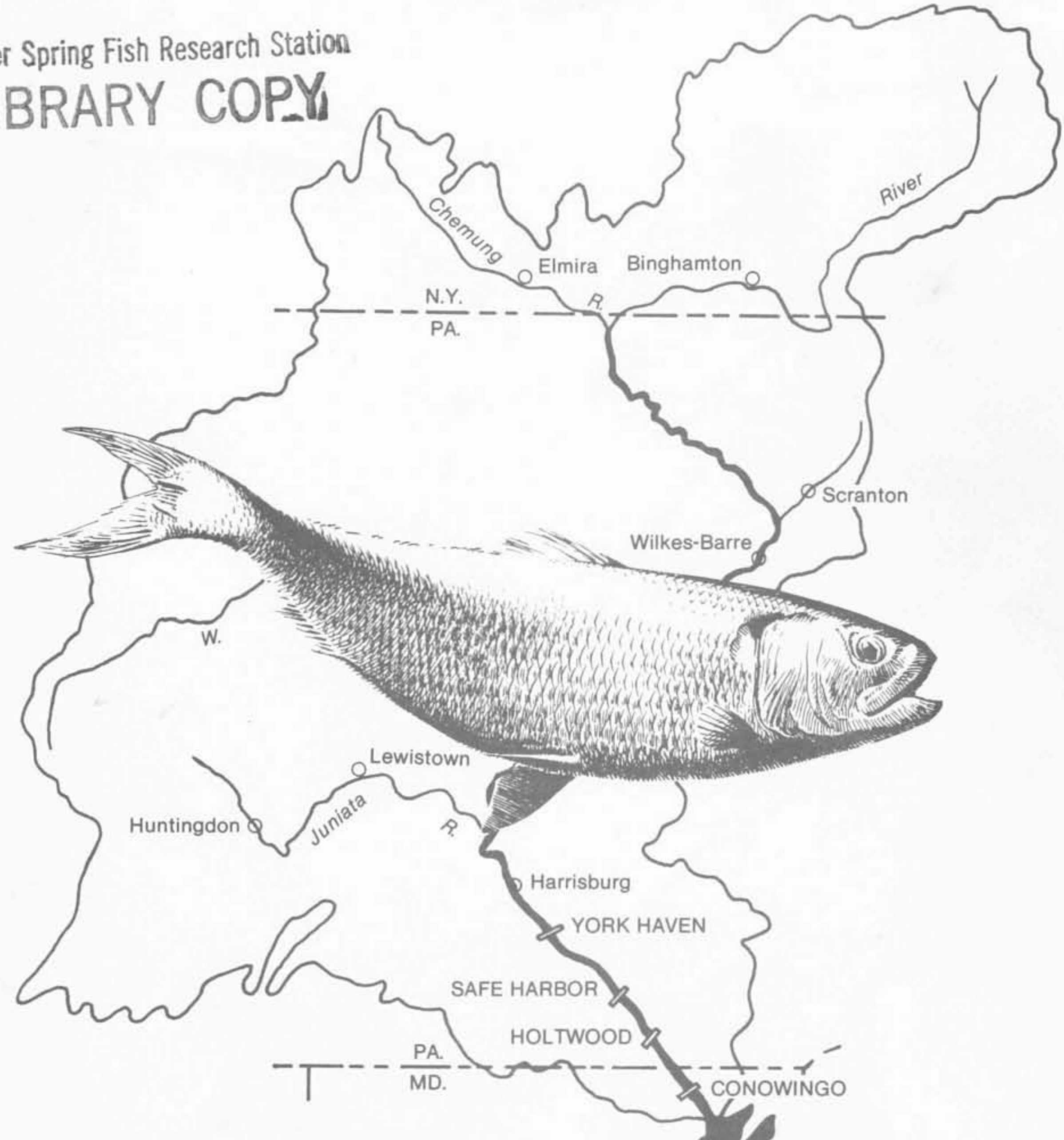
Restoration of American Shad to the Susquehanna River

ANNUAL PROGRESS REPORT

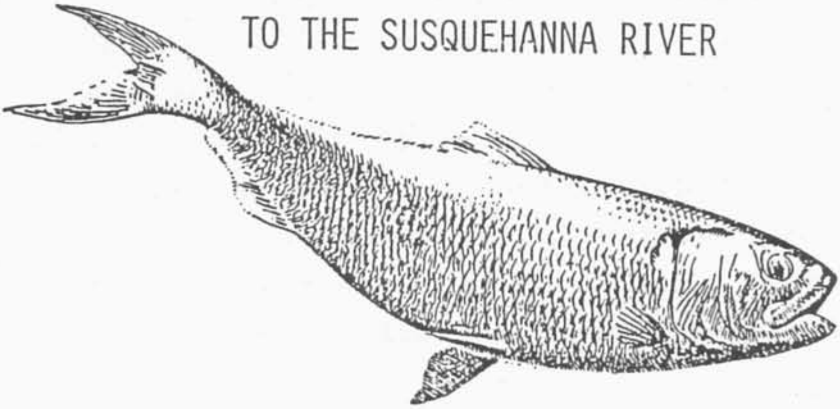
—1987—



SUSQUEHANNA RIVER
ANADROMOUS FISH RESTORATION COMMITTEE

FEBRUARY 1988

RESTORATION OF AMERICAN SHAD TO THE SUSQUEHANNA RIVER



ANNUAL PROGRESS REPORT

1987

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
PHILADELPHIA ELECTRIC COMPANY
PENNSYLVANIA FISH COMMISSION
YORK HAVEN POWER COMPANY

FEBRUARY 1988

EXECUTIVE SUMMARY

The 1987 Annual Report of the Susquehanna River Anadromous Fish Restoration Committee discusses results of numerous studies and activities aimed at demonstrating that American shad can be restored to the river. This is the third year of a 10-year program to rebuild stocks based on hatchery releases and natural production of shad from adult releases above dams, collection and transport of adults returning to Conowingo Dam, and monitoring juvenile shad outmigration from the river. The restoration program represents a continuing commitment of state and federal fishery resource agencies and private utility companies to return shad and other diadromous fishes to historic spawning and nursery habitat above dams in the Susquehanna River.

The American shad population in the extreme upper Chesapeake Bay and lower Susquehanna River was estimated to number about 26,700 fish in 1987. This was based on recapture of 111 tagged individuals from a marked population of 393 shad. Most of these fish were tagged in the Conowingo tailrace by Maryland DNR biologists, and most returns came from the fish trap at that dam. The estimated stock size in 1987 was 28% larger than in 1986 and seven times greater than that of 1984.

The trap and lift at Conowingo Dam (rm 10) operated for 60 days during 1 April thru 12 June, 1987. A total of 2.6 million fish were collected, the great majority of which were gizzard shad, white perch and channel catfish. Catch of <u>Alosa</u> species included 7,667 American shad, 5,861 blueback herring, 357 alewife, and 35 hickory shad. The American shad catch was the highest recorded for this facility since operations began in 1972, exceeding the 1986 catch by 48%. Peak catch periods were 24-28 April, 1-3 May, and 13-17 May when 1,571, 1,017 and 2,385 shad were collected respectively. The largest one-day catch ever recorded (1,359 shad) occurred on 16 May. Catch per effort was three times greater on weekends than weekdays and 72% of the shad were collected at water temperatures at or below 65°F. Overall sex ratio of American shad in the collection

was 2.9 : 1.0 favoring males. Males were aged II-VII (mean 4.2) and females were III-VII (mean 5.1). About 11% of fish examined showed previous spawning checks on scales.

A total of 7,202 American shad were transported upstream from Conowingo. Of these, 6,851 were stocked at Long Level in Lake Clarke, and 351 were stocked in Conowingo Pond. Transport mortalities amounted to 302 fish (4%) and 141 fish died at the trap. Thirty-one of the shad released at Long Level were radiotagged and tracked in the river. Seventeen of these fish (55%) moved upstream at least 5 miles from the release point and nine (29%) reached York Haven Dam, 20 miles upstream. Fish tagged and released early in the season displayed a stronger urge to swim upriver than later arrivals.

Another source of natural production of shad in the river in 1987 involved the transfer of 7,300 prespawned adults from the Hudson River to the north branch Susquehanna. During the period 20 April through 9 May, 2,050 shad were stocked at Oakland, PA (rm 353), 2,250 were released directly into the river at Beach Haven, PA (rm 167), and 3,000 were stocked into a 45' by 275' net enclosure at Beach Haven. Overall survival was estimated at about 80%. The purpose for confining shad in the net pen was to force reproduction and avoid rapid downrunning as was experienced in prior years. Spawning occurred here nightly for about 4 weeks and survivors were released from the pen on 5 June.

In addition to stocking prespawned adult shad above dams in 1987, the Pennsylvania Fish Commission continued their intensive culture efforts at Van Dyke, Thompsontown and Benner Spring. During April and May, 4.43 million shad eggs were delivered to Van Dyke from the Pamunkey and James rivers (VA) and 5.06 million came from the Delaware River. June collections on the Columbia River (OR) produced an additional 23.5 million eggs. Overall viability of eggs was 48% and production amounted to 9.6 million fry and about 81,500 fingerlings. All shad produced at Van Dyke were marked with tetracycline. The 5.17 million fry stocked in the Juniata

River received a single TC immersion marking, while the 4.43 million fry stocked below Conowingo Dam in Maryland were double-marked. Fingerlings reared at Thompsontown and Benner Spring received a triple immersion tag to distinguish then from fry plants in the river. These fish were further marked with TC-laced feed. Tag retention for all lots examined was 100%.

Cultural research conducted by the PFC in 1987 included multiple immersion and feed tag trials, egg disinfection concentrations, feed tests, controlled quick release stocking of fry, and egg and fry enumeration studies. Three new fingerling production ponds, each about 0.6 acre, were constructed on PFC property at Upper Spring Creek.

A considerable amount of effort was devoted to assessing abundance, growth, movements and source of juvenile American shad during late nursery and outmigration periods in the Susquehanna. Shad were collected at Amity Hall on the lower Juniata River with seines during 31 July through 10 September. Four collecting dates produced 256 shad in 13 hauls and the fish averaged 80 mm fork length. No shad were taken here during late September through mid-October.

A 20-ft. diameter cast net was used at York Haven Dam during 9 September through 29 October. A total of 440 shad ($\bar{x}$=110mm) were taken in 44 casts. This gear was used at Holtwood during 17 September - 23 November to collect 225 shad in 67 casts and an 8-ft. x 8-ft. lift net was used by RMC to collect an additional 856 shad at Holtwood during 10 September through 20 November. This gear also took 65 shad at Safe Harbor. Cooling water strainers at Safe Harbor and Conowingo produced 95 and 14 shad respectively during autumn cleanouts.

A special effort was made in 1987 to collect shad passing through Conowingo Dam. Meter and half-meter nets and a 5-ft^2 platform net were suspended from the dam in the project discharge for a total of 178 fishing hours during 5 October through 3 December. A total of 26

American shad and over 3,000 gizzard shad were collected with this gear. Seventeen of the American shad were taken in a single 4 1/4 hour set of a one meter net on 21 October.

Maryland DNR conducted weekly juvenile sampling at select sites in the lower river and upper Chesapeake Bay during 8 July through 29 October. Three juveniles and one yearling shad were collected in 130 seine hauls and 99 otter trawl runs. Outmigration assessment in the river below Conowingo was conducted on 10 dates between 4 November - 15 December using 200-ft. and 300-ft seines at six sites. No young shad were taken in 77 hauls.

Almost 400 juvenile shad from river collections were assessed for the presence of the tetracycline tag indicating hatchery origin. Of all fish examined from Amity Hall to Conowingo, 94.8% were marked. Only a single collection at Holtwood on 17 September, the first sample date there, showed a high proportion of unmarked fish (13 of 16). This indicates that very little natural production occurred from Hudson River adult transplants and that wild fish from spawning of Conowingo transfers apparently moved downstream through the impoundments well ahead of the migration of hatchery fish. In 1987, average size of shad was considerably smaller than in past years and migration was earlier, probably in response to high flows in September.

The juvenile shad migration past York Haven was assessed for relative abundance using a single hydroacoustic transducer in the forebay during 30 September through 9 November. Average daily flux density (targets/m^2/hour) over the study period was almost identical to that measured in 1986. Most migration at this point occurred during the dusk to dawn period and several peaks or waves of migration were detected.

Hudson River adult transfers, radiotelemetry studies, egg collection, hatchery operation and improvements, hydroacoustic evaluation and much of the juvenile assessment effort were funded from the settlement agreement reached with upstream licensees in 1985. Philadelphia Electric Company covered costs for fish lift operations and shad transfers from Conowingo Dam. Maryland Department of Natural Resources funded the adult shad population assessment and juvenile shad surveys in the river below Conowingo Dam. The Pennsylvania Fish Commission contributed substantially to pond construction, mark detection analysis and juvenile recovery in the river.

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

Richard St. Pierre
Susquehanna River Coordinator

TABLE OF CONTENTS

JOB II (continued)

JOB III. AMERICAN SHAD HATCHERY OPERATIONS, 1987

M. L. Hendricks, T. R. Bender, and V. A. Mudrak
Pennsylvania Fish Commission
Benner Spring Fish Research Station
State College, PA

JOB IV. JUVENILE AMERICAN SHAD OUTMIGRATION ASSESSMENT

Leroy M. Young
Pennsylvania Fish Commission
Bellefonte, PA

JOB V. SPECIAL STUDIES

Task 1. RADIOTELEMETRY STUDIES ON DISPERSAL AND BEHAVIOR OF ADULT AMERICAN SHAD TRANSPLANTED FROM THE CONOWINGO FISH LIFT TO THE SUSQUEHANNA RIVER AT LONG LEVEL, PA - 1987

RMC Environmental Services
Muddy Run Ecological Laboratory
Drumore, PA

Task 2. HYDROACOUSTIC MONITORING OF JUVENILE AMERICAN SHAD PASSAGE AT YORK HAVEN HYDROELECTRIC PROJECT - 1987

Barnes-Williams Environmental Consultants
Binghamton, New York
and
Richard St. Pierre
U.S. Fish and Wildlife Service
Harrisburg, Pennsylvania

JOB VI. SUMMARY OF OPERATION OF THE CONOWINGO DAM FISH PASSAGE FACILITY IN THE SPRING OF 1987

RMC Environmental Services
Muddy Run Ecological Laboratory
Drumore, Pennsylvania

JOB VII. POPULATION ASSESSMENT OF ADULT AMERICAN SHAD IN THE UPPER CHESAPEAKE BAY

N. Butowski, T. Jarzynski and D. Weinrich
Maryland Department of Natural Resources, Estuarine Fisheries
Annapolis, Maryland

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

National Environmental Services, Inc.
Lancaster, Pennsylvania

and

Ecology III, Inc.
Susquehanna SES Biological Laboratory
Berwick, Pennsylvania

1.1 BACKGROUND OF ADULT SHAD TRANSFER OPERTIONS ON THE SUSQUEHANNA RIVER

Adult shad transplant operations were first conducted from the Connecticut River to the Susquehanna River on an experimental basis in 1980. A total of 193 adult American shad were transplanted in three trips. In 1981, the Technical Committee, SRAFRC, set a minimum goal to transfer 1,000 gravid shad with a survival of 75%. It was desired that the sex ratio be 1:1, male to female. A total of 1,486 shad were transported to the Susquehanna from the Connecticut in 1981, the survival rate was 78%. In 1982, the Hudson River was added to the transport operation and 2,287 and 1,176 shad were transferred from the Connecticut and Hudson rivers respectively.

From 1980 through 1986, 25,444 adult shad were transferred from out-of-basin sources and released to the Susquehanna River. The objective of this out-of-basin transfer of shad was part of an overall attempt to reestablish native populations of the American shad in the Susquehanna River (Susquehanna River

Anadromous Fish Restoration Committee 1987). If these adults spawned in the Susquehanna River, their offspring would imprint on that stretch of the river before migrating to the sea in early autumn. Then, hopefully, after four or five years at sea, these same shad as adults would return to their natural waters to spawn, thus completing the reproductive cycle.

1.2 Hudson River Shad Transfer Program 1982-1986

Past experience 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 netting. In 1982, operations began utilizing gill-nets as the primary gear, however shad capture was shifted to haul seine when low survival resulted. The success of the haul seine as a means to capture live shad and improvements in transport methods and quality control made the Hudson River a viable source for the adult shad transport program. From 1982 through 1986, 19,169 prespawned adult shad were successfully captured from the Hudson River and transferred to the Susquehanna River; survival to stocking was approximately 83%.

1.3 Adult Shad Transplant Program, 1987

1.3.1 Oakland, N.Y. Release Site

After careful review by the SRAFRC technical member, a second release site for Hudson River adult shad was selected at Oakland, PA. This site was chosen for several reasons with the most important being the natural impoundment or basin created by the Oakland dam providing a pool from which shad can reproduce naturally. The Oakland site location is also relatively closer from the Hudson River capture site than the Berwick release site, however, road conditions and routes proved that only one hour could be saved despite a difference of 70-100 miles between each release site. The Oakland site is also maintained by the PFC and therefore cooperation for use of this ramp based on mutual interests proved feasible.

The Oakland site served as the principle release site until it was determined that the Berwick site was available. Flood waters and high Susquehanna river stages did not permit placement of the net holding pen at Berwick even though large numbers of shad were captured and ready for transport as early as April 20.

1.3.2 Beach Haven Release Site

Prespawned adult American shad were also transported to the Susquehanna SES Biological Laboratory near Berwick, Pennsylvania.

Shad were held in the net enclosure because radiotagging studies done on shad brought from the Hudson River in previous years (RMC Environmental Services 1986 and Susquehanna River Anadromous Fish Restoration Committee 1987) revealed that tagged fish migrated downriver soon after stocking, some at a rate of 30 miles per day. Since this downriver exodus most likely occurred before these shad had spawned, their progeny could not have possibly imprinted on the upper Susquehanna River. Therefore, it was reasoned that if imprinting of larval shad was to be accomplished on this stretch of the river, it would be necessary to hold the adults while they spawned.

1.3.3 Site, Schedule and Collecting Methods

All shad were collected from the West Shore of Rodgers Island seining site in the vicinity of Catskill and immediately north of the Rip Van Winkle Bridge. Operational timetables were contingent on tidal conditions. Generally, fishing activities took place between 0600 and 2000 hours.

A 500 x 12-foot haul seine with 2 inch square mesh wings and 1-inch square mesh bag was utilized to collect shad. The seine operations were directed through mutual agreement with a commercial fisherman and Project Manager to ensure that the operation was carried out in the most effective manner. Crews ranging from 10-12 technicians worked cooperatively with the commercial fisherman contracted to collect shad. 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 the fishermen, 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 of the net. Crews worked to capture shad, transport them to a shore-based site and load the tank truck.

Shad collected in the seine were immediately hand-brailed from the bag to water filled tanks mounted in 18-foot boats. One system consisted of a 400-gallon oval fiberglass tank; the other boat supported two 245-gallon round galvanized stocktanks. Water was 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. The oxygen injection system consisted of an LK oxygen cylinder, regulator and a section of BioWeave tubing. Air flow was controlled by the regulator and an in-line ball valve with oxygen dispersion through the BioWeave tubing at the base of each tank.

The number of fish in each tank was determined by several factors including water temperature, river conditions, and site location. The typical load for the 400-gallon oval tank was 70 fish and 40 fish for each of the 245-gallon round tanks. The shuttle boats, after loading, were driven to a landing site at the Catskill Marina, Catskill, NY.

At the shoreline 3-5 shad were individually hand-brailed from the stock tank into a 15-gallon round galvanized metal wash tub filled with water. Transport trucks were backed down to the river bank and the tubs of shad were lifted to the opening of the transport tank and fish deposited into the tank. The process was continued until all shad were loaded.

1.3.4 Description of Transfer Equipment

Each transport tank is about 4-feet high and 8-feet in diameter and has a 1,100-gallon capacity. The top is removable and shad were loaded through a 2-foot square hatch on the tank. Unloading is accomplished by removing the outside circular cap by a gate release located on the back of the tank. A portable shoot, fitted with a flexible discharge tube, is attached below the unloading hatch to direct tank water and shad into the river.

1.3.4 continued

Water circulation is created by two Fresh-Flo (model #TT, 12-VDC) aerators 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 aerator's intake screens. An oxygen injection system provides a continuous amount of oxygen into the tank. Two 3-HP gasoline driven trash pumps are used for filling the tanks and are also available as a back up system in the event that there is a problem with the Fresh-Flo aerators.

1.3.5 Water Procurement and Conditioning

Water for each of the transport units was procured at the ICC Quarry, Hudson, NY. Water from the quarry was typically 5-10 degrees F below that of the Hudson River.

Water was treated with 80 pounds of Solar Salt (0.9% solution) and 100 ml of a Silicone Based Antifoam Solution (diluted to 500 ml with distilled water). This treatment was based on shad transport studies conducted by the PFC during the 1983 program.

1.3.6 Temperature/Oxygen Monitoring

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 was maintained by an aeration system which is an integral part of the transport tank. Dissolved oxygen (ppm) and temperature (degrees F) were monitored daily for the Hudson and Susquehanna rivers and each of the transport tanks.

1.3.7 Quality Control

To ensure optimum conditions for capture and transport of American shad, quality control was a significant part of the JOB I program design. Improvements were a cooperative effort between various agencies. The NYDEC, USF&WS, and the PFC were available for consultation as necessary during the program.

Gear modifications, the addition of the Oakland site and an improved net pen at Beach Haven are some of the changes that were incorporated into the program over the years.

1.4 Results and Discussion

1.4.1 Shad Transplant and Survival

Shad were collected from the Hudson River between 20 April and 9 May. Collection operations were started earlier than in past years to ensure that a greater number of prespawn shad could

1.4.1 continued

be transferred. Some 7,300 prespawned shad were transported from the Hudson River. Transport mortality for all shipments was less than 10% (Table 1). Of the 7,300 shad hauled, some 2,050 were released at Oakland, NY with the remaining 5,250 transported to Berwick, PA.

The time necessary to conduct transport operations on the Hudson River depended on the number of fish taken in the haul seine, the location of the seining site, and weather conditions. The average operational day took 4-6 hours, and typical travel time from the Hudson River (NY) to release sites was 5-6 hours.

1.4.2 Oakland Release Site

The Oakland site served as a good location for the release of Hudson River shad due to its proximity to the collection site, Fish Commission maintenance and control, relationship to the Oakland dam impoundment, and served as an alternate site from Berwick during flood conditions. Prior to and during the release of fish at Oakland the River receded leaving large deposits of mud on the ramp which had to be cleared, to permit trucks to move in and out freely. The mud was cleared by the PFC by moving debris into the River which created a mud catch-basin. This was not known by NES drivers as they were releasing fish after dark and did not observe the submerged substrate. As a result several hundred shad (Table 1a) could not "reach" the river channel and eventually died.

1.4.3 Berwick, PA Releases

A 45 x 275-ft net enclosure was formed by "pocketing" a 500-ft seine (2-in bar mesh) along the west shoreline immediately downriver from the laboratory's boat ramp. The outer edge of the seine was held in position by attaching the upriver end of the floatline to a pontoon boat that was permanently anchored in the river. To prevent shad from escaping over the net, the floatline was suspended above the river surface by draping it over four, 16-ft jon boats that were evenly spaced along the river-edge of the seine. The bottom of the seine was secured with rocks that were positioned along the leadline by a scuba diver.

The net enclosure was stocked with 3,000 shad from 27 April through 3 May 1987 (Table 1b). From 300 to 450 shad (150 fish per truck load) were delivered each day. River depth and temperature decreased overall throughout this 7-day period. Transport mortality (dead on arrival) was estimated at 20%. The 605 dead fish were dissected and sexed as 349 males and 255 females.

The 2,250 American shad delivered after 5 May were released directly into the Susquehanna River to avoid possible crowding in the net enclosure (Table 1c). Transport mortality, although estimated from incomplete data, was probably the same as found for the shad stocked in the enclosure.

1.4.3 continued

Daily mortality was monitored on the initial stock of 2,400 adult American shad held in the net enclosure from 4 May through 5 June 1987 (Table 2). Throughout this 33-day period, 858 dead shad (36%) were removed from the enclosure. Although mortality ranged from at least 5 to 94 fish per day, large numbers of fish died from 30 May through 3 June when river temperature increased to 23 C and above. Even when the depth decreased to less than 4.5 ft, it appeared that flow was always sufficient for an adequate exchange of fresh river water to maintain the shad in the enclosure. However, mortality decreased substantially on both 26 May and 4 June when depth increased as a result of greater river flows suggesting that water exchange may not have been adequate. Regrettably, time did not allow for the measurement of dissolved oxygen concentrations within the enclosure throughout the retention period.

A chronology of observations and associated data collections were made on the shad in the net enclosure (Table 3). Spawning activity was first observed and documented on 9 May, but it probably had begun on 7 May or possibly even earlier. When spawning occurred, it usually began at dusk and occasionally continued until well after midnight. Spawning shad grouped themselves into several schools of from three to five fish which swam in a circular pattern while splashing at the surface.

Occasionally, a spawning school would swim near the upriver end of the net enclosure which was illuminated with a floodlight. When this occurred, it was evident that each spawning school was composed of one roe shad pursued by several bucks. Spawning did not occur on every night that observations were made, and its intensity decreased throughout the retention period.

On 11 May, several hundred shad eggs were collected in ½-m nets suspended near the surface from the jon boats. A scuba search also revealed a scattering of eggs on the bottom of the enclosure on the same day. On 14 May, fertilization was demonstrated when a shad fry was hatched in a laboratory aquarium. Several hundred shad eggs were collected in the ½-m nets until 20 May. Although several shad were hatched from eggs collected in these nets, no larvae were reared beyond two days.

Composite dip-net collections were made of larval fish in the net enclosure on 21, 25, and 26 May and on 2 and 4 June (Table 4). Unfortunately, identification of these fish revealed several common river species, but no American shad.

In general, adult American shad in the net enclosure seemed to adjust well to captivity. They usually swam slowly in a large circle around the enclosure while moving into the flow along the river edge of the net. Shad remained near the bottom on bright days, often giving the false impression that there were only a few in the enclosure. Upon nightfall, however, they would rise to the surface and continue their circular swimming pattern until after dusk when spawning activity would begin.

Within a week in the enclosure, the bodies of several shad were noticeably fungused which tended to impede swimming. Throughout the retention period, the most heavily fungused fish, on any given day, probably contributed to the mortality on the following day. Many shad also had "red" heads, possibly caused by rubbing along the enclosure net.

The study was concluded on 5 June when the remaining shad were released to the river as the net enclosure was dismantled. The discovery of about 150 dead shad in various stages of decay entangled in the net indicated that these fish had probably become entrapped in folds and corners of the netting and were unable to escape.

In conclusion, it was encouraging to show that American shad could be held in a net enclosure for up to five weeks and that at least some of these fish also spawned successfully. However,

1.4.3 continued

the relatively high mortality rates documented throughout the retention period indicated that future attempts at net enclosure spawning should be done with either smaller numbers of shad and/or larger enclosures to facilitate a greater exchange of fresh river water. Pertinent water chemistry data should also be obtained throughout the retention period to allow for a more detailed evaluation of water quality within the enclosure. In addition, improved techniques should be developed to determine egg viability and collection of larval shad within the enclosure and nearby in the river.

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RMC Environmental Services. 1986. Job V. Radiotelemetry studies on dispersal, spawning, and behavior of American shad transported to the North Branch Susquehanna River, 1985. In Restoration of American shad to the Susquehanna River, 1985 annual progress report. Susquehanna River Anadromous Fish Restoration Committee.

Susquehanna River Anadromous Fish Restoration Committee. 1987. Restoration of American shad to the Susquehanna River, 1986 annual progress report.

TABLE 1a. Total number and survival of prespawned adult American shad transferred from the Hudson river to Oakland, NY.

Period of Transport	Number of Transport Days	Number Transported	Dead on Arrival	Retrieved Dead Shad From River
20-26 April	5	2050	19	531

TABLE 1b. Daily stocking and mortality of 3,000 adult American shad held in a net enclosure (45 x 275 ft) in the Susquehanna River at the Susquehanna SES Biological Laboratory (Beach Haven, PA), 27 April through 3 May 1987.

Date	River*		Number Delivered	Dead on Arrival		Total Dead
	Temp (C)	Depth (ft)		Tank**	Net***	
27 Apr	13.7	7.4	450	12	70	82
28 Apr	12.9	7.1	300	10	70	80
29 Apr	12.1	6.8	450	14	88	102
30 Apr	11.8	6.6	450	52	75	127
01 May	11.4	6.8	450	33	--	33
02 May	11.6	6.6	450	18	95	113
03 May	11.2	6.4	450	31	36	67
Totals			3,000	170	434	604****

* Daily mean river temperature and level from continuous recorders located near maximum depth of enclosure.

** Dead shad found floating in tank upon arrival at Biological Laboratory.

*** Dead shad removed from net enclosure before the next delivery, except those from 1 May which were included with dead found on 2 May. Most of these dead shad had sunk to the bottom of the transport tank and were not obtainable until after each stocking.

**** 349 males; 255 females.

Table 1c.

Daily stocking and mortality of 2,250 adult American shad released into the Susquehanna River at the Susquehanna SES Biological Laboratory, 5 through 9 May 1987.

Date	River*		Number	Dead on Arrival		Total
	Temp (C)	Depth (ft)	Delivered	Tank**	River***	Dead
5 May	10.9	6.6	450	9	--	9
6 May	11.6	6.4	450	16	--	16
7 May	12.6	6.1	450	12	--	12
8 May	13.6	5.8	450	45	--	45
9 May	14.3	5.6	450	32	--	32
Totals			2,250	114		114

*Daily mean river temperature and level from continuous recorders located near maximum depth of enclosure.

**Dead shad found floating in tank upon arrival at Biological Laboratory.

***Dead shad were not removed from the river on a systematic basis. Mortalities, however, were probably similar to those found in the net when it was stocked (Table 1).

Table 2

Daily mortality (number found floating) in a stock of 2,400 adult American shad held in a net enclosure (45 x 275 ft) in the Susquehanna River at the Susquehanna SES Biological Laboratory, 4 May through 5 June 1987.

Date	River*		Mortality
	Temp (C)	Depth (ft)	
4-11 May	11.0-17.5	6.6-5.3	31
12 May	18.5	5.2	11
13 May	18.2	5.0	19
14 May	18.1	4.9	30
15 May	18.5	4.7	46
16 May	18.6	4.6	7
17 May	19.3	4.5	39
18 May	20.4	4.5	26
19 May	19.7	4.5	21
20 May	18.1	4.5	19
21 May	17.2	4.5	14
22 May	18.0	4.5	5
23 May	19.3	4.4	14
24-25 May	20.5-19.7	4.5-4.7	54
26 May	18.9	5.0	15
27 May	18.3	5.0	14
28 May	19.0	4.7	24
29 May	20.8	4.5	39
30-31 May	23.0-24.0	4.5-4.4	94
01 Jun	24.8	4.3	59
02 Jun	25.1	4.4	58
03 Jun	24.3	5.0	54
04 Jun	23.0	5.6	15
05 Jun	--	--	≅150**
Total			858

*Daily mean river temperature and level from continuous recorders located near maximum depth of enclosure

**Found entangled in net when it was removed from the river.

Table 3

A chronology of observations and data collections made on a stock of 2,400 adult American shad held in a net enclosure (45 x 275 ft) in the Susquehanna River at the Susquehanna SES Biological Laboratory, 4 May through 5 June 1987.

Date	Event
7 & 8 May	Suspected spawning behavior of shad reported by a NES driver.
8 May	Three egg collection nets (12-inch diameter mouth and 216-micron mesh) were suspended in the water near the surface along the river-edge of the net enclosure.
9 & 10 May	Spawning activity of shad was observed by T. V. Jacobsen, E-III, at 2030 h. This activity was confirmed as spawning by J. A. Nack, NES, at 2230 h. Spawning continued until at least 0100 h.
11 May	Several hundred shad eggs were found in the collection nets and preserved. Most were opaque (dead), but several were clear (alive). A 15-minute scuba search of the enclosure bottom by B. P. Mangan, E-III, revealed a scattering of many shad eggs. Most eggs were opaque, but some were clear. The majority of the eggs were found in pockets behind obstructions that blocked the current. Fewer eggs were found along the river-edge of the net and it was assumed that the swifter current at this location swept them downriver and out of the enclosure. A few dead adult shad were also found on the bottom.
12 May	Several hundred shad eggs were collected and most of them were preserved.
12-14 May	An attempt was made to hatch live eggs collected from 12-14 May. Most eggs died probably because they were not kept "rolling" in aquaria water.
13 May	Approximately 100 shad eggs were found in the collection nets.
14 May	Approximately 100 shad eggs were found in the collection nets. One shad fry from the net collections on 14 May (spawned on 13 May) was hatched and preserved. Spawning activity of shad was observed by L. S. Imes, E-III, at 2100-2200 h.

Date	Event
15 May	Several live eggs, spawned on 14 May, were "rolled" with air bubbles in aquaria and hatched on 18 May. They were preserved on 19 May.
18 May	Eggs spawned on 15-17 May were found in the collection nets. Some were placed in aquaria for rearing and the remainder were preserved.
19 May	Approximately 25 eggs were found in the collection nets.
20 May	Twenty-three eggs (18 alive) were found in the collection nets. Some were placed in aquaria. Spawning activity was observed at 2200 h by T. V. Jacobsen, but it was not nearly as intense as on 9 May.
21 May	No eggs were found in the collection nets. A composite dip-net collection was made of larval fish swimming at the surface within the net enclosure.
22 May	Three dead eggs were found in the collection nets.
24 May	Spawning activity of shad was observed by T. V. Jacobsen at 2100-2130 h. Spawning was more frequent then than observed on 20 May, but not nearly as intense as on 9 May.
25 May	A composite dip-net collection was made of larval fish swimming at the surface within the net enclosure.
26 May	A composite dip-net collection was made of larval fish swimming at the surface within the net enclosure.
27 May	No eggs were found in the collection nets.
28 May	One dead egg was found in the collection nets. A 15-minute scuba search of the enclosure bottom revealed 28 shad eggs; about half were clear. Three dead adult shad also were found.

Date	Event
29 May	Two dead eggs were found in the collection nets.
1 Jun	No eggs were found in the collection nets.
2 Jun	One dead egg was found in the collection nets. A composite dip-net collection was made of larval fish swimming at the surface within the net enclosure.
3 Jun	No eggs were found in the collection nets.
4 Jun	No eggs were found in the collection nets. The collection nets were removed from the river, A composite dip-net collection was made of larval fish swimming within 2 feet of the surface throughout the net enclosure. Very limited spawning activity was observed at 2100-2130 h by T. V. Jacobsen
5 Jun	Shad were released as the enclosure net was removed from the Susquehanna River

Table 4

Species and number of larval fish found in five composite dip-net samples collected from a net enclosure containing adult American shad in the Susquehanna River at the Susquehanna SES Biological Laboratory, 21 May through 4 June 1987.

Species	Collection Date				
	21 May	25 May	26 May	2 Jun	4 Jun
American shad	0	0	0	0	0
Common carp	0	5	17	0	0
Comely shiner	0	0	0	0	1
Spottail shiner/minnow species	62	121	193	39	50
Quillback	15	137	8	81	32
White sucker/shorthead redhorse/ northern hog sucker	243	346	118	220	90
Darter species	0	0	1	0	0

JOB II. AMERICAN SHAD EGG COLLECTION PROGRAM

National Environmental Services, Inc.
Lancaster, PA

2.1 Introduction

In September 1970, an agreement was signed between the various utilities (Philadelphia Electric Power Company, Susquehanna Electric Company, Pennsylvania Power and Light Company, Safe Harbor Water Power Corporation, Metropolitan Edison Company, the States (Maryland, Pennsylvania and New York), and the Department of Interior for the implementation of a program for restoration of the American shad to the Susquehanna River. Part of the agreement called for a program to annually obtain 50 million or more artificially fertilized American shad eggs for transplantation to areas above existing dams on the Susquehanna River. The objective was to artificially develop a population of American shad which, as adults, would return to the river with the urge to migrate upriver above Conowingo and the other hydroelectric dams. The program began in the spring of 1971 and has continued annually to date. The 1987 results are included in this report.

From 1971 through 1974 all shad eggs were transplanted to the Susquehanna River and released at various sites. (Beginning in 1975 a few eggs were delivered to a hatchery for experimental culture and by 1978 virtually all eggs were delivered to hatcheries for culture and rearing.) Sites recommended by the Pennsylvania Fish Commission as most suitable for shad egg development, based on the previous experience of Carlson (1968), were used. (The primary sites were in the Juniata River at Muskrat Springs and the Yellow Breeches Creek at Hogestown.)

Hatching boxes were placed at each site to estimate hatching success. A subsample of eggs was placed in each box. Boxes were anchored in knee deep riffle areas and sampled daily until all viable eggs hatched. Hatching success was determined from examination of daily samples.

2.1.1 Hatchery Program

Since results from the direct release of shad eggs to the Susquehanna River and tributaries did not appear to result in a substantial population of juvenile shad, (probably due to high rates of early natural mortality), culture at hatcheries was considered in 1974 as a potential means to improve success of the egg transplant program. The purpose was to (1) attempt to increase the numbers of out-migrating shad through intensive rearing, on the assumption that a juvenile shad is equivalent to a great number of shad eggs in terms of probability of survival to adult, (2) establish whether or not intensive rearing operations were possible and feasible, and if so, to demonstrate such, (3) demonstrate the use of the Susquehanna River Basin by out-migrating juvenile shad and (4) conduct experiments concerning the culturing, handling, and transporting of shad.

Shad had not been raised in hatcheries for more than 25 years; it remained to be determined if it was feasible to use this method. At the recommendation of the Evaluation Subcommittee, Susquehanna Shad Advisory Committee, shad eggs (954,600) were delivered to Harrison Lake National Fish Hatchery, Charles City, Virginia in 1975 for experimental pond culture. Eggs were again (520,000) transferred to Harrison Lake in 1976, also at the request of the Evaluation Committee.

It was demonstrated at Harrison Lake that shad eggs could be hatched and young cultured in ponds. On the basis of this work, the Van Dyke Research Station for Anadromous Fishes was constructed in 1976 at Thompsontown, Pennsylvania, staffed by the Pennsylvania Fish Commission. The site was selected because it was desirable to culture shad at a location on the Susquehanna River above the hydroelectric dams. By this means shad would be raised in water of a quality to which these shad would home as adults.

2.2 Objective of Program

The SRAFRC goal for 1987 was to obtain sufficient number of shad eggs over a three month period to support the shad hatchery cultural program (Job III). Eggs were to be collected from five rivers - Pamunkey, James and Mattaponi (Virginia), Delaware (New Jersey-Pennsylvania) and the Columbia (Oregon-Washington). From 1971 to 1986 over 463 million eggs were collected for the program. A record 52.7 million eggs (1,535.7L) were sent to the Van Dyke Hatchery in 40 shipments in 1986. By comparison 25.6 million eggs were received in 1985 and 41 million in 1984. Total fry production in 1986 was a record 16.6 million compared to 7.9 million in 1985 and 13.5 million in 1984 (Hendricks et al 1986). Total fingerling production in 1986 was estimated at 72,525, compared to 115,000 in 1985 and 30,500 in 1984 (Hendricks et al 1986).

2.3 Methods

2.3.1 Egg Collection

Eggs were artificially fertilized in essentially the same method established by Kilcer (1973). A brief description of the procedure follows: Eggs were stripped from four to six spawning females into a dry collecting pan and fertilized with sperm from up to six males. After dry mixing eggs and sperm for several minutes, the eggs were allowed to set for 1-2 minutes, 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. The eggs were rinsed to remove dead sperm, unfertilized and broken eggs, and debris. Eggs were then poured into large plastic buckets filled with clean river water and allowed to soak for a minimum of one hour to become hardened. During this period, water was periodically drained and clean water added.

Once the eggs were hardened (about 1 hour), the water was drained and five liters each of eggs and clean water was placed in double plastic bags.

Pure oxygen was put into the bag containing eggs and the bag securely tied with rubber rings. The bags were shipped in card-board boxes with styrofoam container inserts. Each box was labeled to show river name, date, number of liters of eggs, water temperature and sex ratio of spawned fish.

2.3.2 Collection Areas

2.3.2.1 Pamunkey River, Virginia

NES biologists began egg collection efforts on the Virginia Rivers on 8 April, upon confirming reports that shad had been taken by fishermen in spawning condition. Biologists worked with commercial fishermen at Thompson's Landing, New Kent, Virginia, located approximately 4-6 miles upstream of Lester Manor. Up to 20 gill-nets, 4.75-6.00 inch mesh were set at any one time over a 2 mile stretch of river to catch adult shad. Netting was usually conducted between 1530 and 2200 hours, seven days per week. As fish were captured, they were shuttled to the shoreline; fish in spawning condition were then processed.

2.3.2.2 Mattaponi River

In 1973-1974, the Mattaponi River provided some 13.3 million shad eggs (Table 3) to the collection program. However, the American shad run on the Mattaponi River suffered a significant decline in number in the mid-1970's.

The last year that any shad eggs were shipped to the Van Dyke Hatchery was 1977 (0.57 million). In 1987 NES met with fishermen on the Mattaponi, and biologists were available to process shad eggs, when sufficient numbers were available.

2.3.2.3 James River

Grants Crossing and Berkley Plantation landings, two sites where spawning shad had been collected in previous years' efforts by commercial fishermen were investigated. Berkley Plantation is in the Charles City-Hopewell section of Virginia, directly below the Benjamin Harrison Bridge. Grants Crossing is approximately 10 river miles down river from Berkley Plantation.

Egg Collection efforts on the James river began on 24 April at Berkley Plantation Landing. Grants Crossing was not utilized because commercial fishing operations at the landing were only conducted during the early hours of the day, a period when it would be unlikely to find any spawning shad.

Commercial fishermen using gill-nets (4.75 - 6.00 inch mesh x 300 feet) worked together with biologists out of small row boats during egg collection operations. Eggs were stripped from spawning females and fertilized on the boat. Gill-netting was conducted from 1530 to 2200 hours.

2.3.2.4 Delaware River

In 1987, SRAFRC secured permission from the Delaware River Basin Fish and Wildlife Management Cooperative to collect some 5 million shad eggs from the Delaware river. PFC biologists conducted the collection program at Smithfield Beach, 8 miles upstream from East Stroudsburg, Pa., from 10 to 19 May. Shad were captured with 200 foot long x 6 feet deep anchored gill-nets, with sections of 4.75 - 6.00 inch mesh, set parallel to the current. Nets were set between dusk and midnight. Spawning shad were shuttled to the shore for processing.

2.3.2.5 Columbia River

The egg collection program on the Columbia River, Oregon-Washington was initiated on 1 June. Netting for shad was conducted on the north shoreline approximately two miles upstream at the Camas-Washougal Reef (Troutdale area). Shad were captured by gill-nets, as in previous years. Net dimensions were 150 fathoms in length, tapered in depth, with sections of 4.75 - 5.75 inch mono-filiment mesh. Typically, three 45-60 minute drifts were made nightly. Gill-netting was conducted from 1700 to 2300 hours.

2.4 Transportation

2.4.1 Pamunkey, James and Delaware Rivers

Shad eggs collected from East Coast rivers were packaged and shipped nightly by automobile to the Van Dyke Hatchery. This procedure has been conducted since 1983 with good results.

Personnel at the rivers arranged transportation and the drivers notified the hatchery nightly as to the number of liters shipped and the ETA of the shipment. The average delivery time from Delaware and Virginia rivers was approximately 3 and 6 hours respectively.

2.4.2 Columbia River

After packaging the eggs from the Columbia River, the boxes were transported by van to the Portland International Airport. Eggs were flown from Portland on either Eastern or United Airlines to Baltimore International Airport. Shipments were required at the airport by 2300 hrs (Pacific Time). Upon arrival of the shipments into Baltimore, eggs were transported by van to the hatchery. Approximate shipping time was 11-13 hours.

2.5 Collection Schedule

The shad egg collection schedule was based on experience gained over a 13 year period. Initiation of collection activities on any river was determined through communications with commercial 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 degrees F.

2.5 continued

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 Columbia River operation was based on the number of fishing days that the budget could support and/or the quality and quantity of eggs available.

2.6 Results and Discussion

2.6.1 Pamunkey River

Collection efforts began on 8 April on the Pamunkey River, Virginia and continued throughout the duration of the annual adult spawning run. Water temperatures ranged from 54 to 67 degrees F (Table 4). Egg collection efforts were halted on 8 May when commercial fishermen no longer caught shad in gill-nets. A total of 4.35 million eggs, were collected from the Pamunkey River in 1987.

2.6.2 Mattaponi River

In 1987 commercial fishermen at the Mattaponi Indian Reservation set their gill-nets a total of only nine days during the month of April. A biologist was sent to the river on those days,

2.6.2 continued

however, on no occasion were a sufficient number of ripe shad available for processing. No shad eggs were sent from the Mattaponi River to the Van Dyke Hatchery.

2.6.3 James River

From 1974 through 1983 the James River was a consistant source of shad eggs for the program, some 64 million shad eggs were collected over that period (Table 2). However, production from the James River has dropped off significantly since 1983 (1984-0.74, 1985-2.05, 1986-1.07 million shad eggs per year). In 1987 only 108 thousand shad eggs (Table 5) were collected from the James River.

The poor catch in 1987 was a result of poor commercial harvest of shad, compounded by weather conditions which prohibited fishermen from setting their nets (primarily due to high winds) and a general decrease in commercial fishing as a result of the moratorium on striped bass; all bass captured were required to be released.

2.6.4 Delaware River

Pennsylvania Fish Commission biologists conducted shad egg collection efforts on the Delaware River over a period of six days, from 10-19 May. Approximately 5 million eggs (Table 6) were shipped to the Van Dyke Hatchery over that period.

From the 5 million shad eggs collected, some 490 and 194 thousand fry were stocked in the Lehigh and Schuylkill rivers repectively, as part of the restoration of shad on those rivers.

2.6.5 Columbia River

Egg collection on the Columbia River began 1 June and continued through 22 June. Water temperatures ranged from 57 - 63 degrees F. Some 23.5 million shad eggs (Table 7) were sent to the Van Dyke Hatchery in 16 shipments.

In 1986 approximately 40 million shad eggs were collected from the Columbia river as compared to 23.5 million in 1987. The reasons for the reduction in the number of shad eggs in 1987 can be attributed to several factors: (1) extremely dry weather in northwestern Oregon resulted in low river conditions on the Columbia River which hampered net employment throughout June, (2) the number of eggs collected in 1987 was also reduced due to flight scheduling for egg shipments back to the East Coast. In 1986 flight arrangements allowed field crews sufficient time to harvest and process a greater number of shad. However, in 1987 egg shipments were required at Portland International Airport one hour earlier than 1986, consequently reducing the gill netting effort.

2.6.5.1 Experimental Netting on the Columbia River

In an effort to maximize the number of eggs collected and shipped from the Columbia River, field crews tried the following in 1987: (1) On 11 June biologists experimented by fishing later into the night and holding the eggs for shipment on the next days flight to the East Coast, (2) biologists tried gill-netting during the hours of 0200 - 0600 (June 12) to see if spawning shad were available at that time of the morning. The results for both experiments were discouraging.

By fishing later into the night a greater number of eggs were collected (approximately an increase of 10%), however, viability for that shipment was 36.3% compared to 46.9% average for all other shipments sent to Van Dyke during the week of 10-16 June. Consequently, the increase in the number of eggs was offset by the higher amount of dead eggs.

Fishing during the period of 0200 - 0600 hours also proved disappointing. Although, a significant number of fish were collected, very few shad were in spawning condition.

2.7 All Rivers Combined

The shad egg collection was conducted on four East Coast rivers and the Columbia River between 8 April and 22 June, 1987. The 1987 amount of eggs from the Virginia Rivers (James - 0.1 million, Pamunkey - 4.4 million) was significantly reduced by two major storms in Virginia during the middle and latter part of April. A total of seven fishing days were lost due to the weather and the impact of the storms on the shad run when fishing resumed was dramatic.

Some 5 million eggs were collected from the Delaware River over a six day period, while approximately 23.5 million eggs were collected from the Columbia River. In 1987 a grand total of 32,996,900 eggs (974.15 liters) (Table 2) were shipped to the Van Dyke Hatchery.

2.8 References

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TABLE 1. Sampling period for East and West Coast rivers for collection of American shad eggs, 1987.

RIVER	SAMPLING SCHEDULE DATES	# shp	TOTAL FISHING DAYS
Pamunkey	8 April - 8 May	1[illegible]	24
James	2 May - 8 May	1	5
Mattaponi	22 April - 30 April	0	9
Delaware	10 May - 19 May	6	6
Columbia	1 June - 22 June	16	16

TABLE 2. Collection data of the total volume and number of American shad eggs on the Pamunkey, James, Columbia and Delaware rivers, 1987.

RIVER	VOLUME OF EGGS SHIPPED (L)	TOTAL NUMBER OF EGGS
Pamunkey	124.62	4,350,200
James	3.08	108,100
Delaware	139.31	5,006,500
Columbia	707.40	23,532,100
TOTALS	974.15	32,996,900

TABLE 3. Total number (millions) of American shad eggs collected from the Pamunkey, Mattaponi, James, Potomac, Susquehanna, Delaware, Connecticut, Hudson and Columbia Rivers, 1971-1987.

Year	Pamunkey	Mattaponi	James	Potomac	Susquehanna	Delaware	Connecticut	Columbia	Hudson	Totals
1971	--	--	--	--	8.42	--	--	--	--	8.42
1972	--	--	--	--	7.10	--	--	--	--	7.10
1973	8.45	6.48	--	34.64	4.74	--	4.30	--	--	58.61
1974	9.75	6.80	19.20	5.56	--	--	0.53	8.18	--	50.02
1975	1.88	--	7.15	5.70	--	--	--	18.42	--	33.15
1976	--	--	--	--	--	4.10	--	54.80	--	58.90
1977	4.40	0.57	3.42	--	--	--	0.35	8.90	--	17.64
1978	6.90	--	10.11	--	--	--	--	--	--	17.01
1979	3.17	--	4.99	--	--	--	--	--	--	8.16
1980	6.73	--	6.83	--	--	--	--	--	--	13.56
1981	4.58	--	1.26	--	--	--	--	5.78	--	11.62
1982	2.03	--	1.25	--	--	--	--	22.57	--	25.85
1983	5.49	--	5.91	--	--	2.40	--	19.51	1.17	34.48
1984	9.83	--	0.74	--	--	2.64	--	27.88	--	41.09
1985	5.28	--	2.05	--	--	6.16	--	12.06	--	25.55
1986	5.62	--	1.07	--	--	5.86	--	39.97	--	52.52
1987	4.35	--	0.11	--	--	5.01	--	23.53	--	33.00
TOTALS	78.46	13.85	64.09	45.90	20.26	26.17	5.18	241.60	1.17	496.68

TABLE 4. Collection data from American shad eggs taken on the Pamunkey River, 1987.

Collection Date	Water Temperature (Degrees F)	Number of Adult Shad Male	Number of Adult Shad Female	Volume of Eggs Received at Hatchery (liters)	Weather Condition	Air Temperature (degrees F)
April 8	54	0	0	0	Cloudy	55-73
9	55	3	9	0	Clear	45-63
10	58	13	19	7.6	Clear	59-77
11	58	8	27	13.36	Rain	59-77
12	58	11	26	10.62	Rain	63-81
13	60	11	29	11.90	Clear	63-81
14	60	12	30	16.94	Cloudy	51-69
19	57	7	17	0	Cloudy	56-74
20	57	14	27	15.60	Cloudy	56-74
21	58	11	20	14.60	Cloudy	55-73
22	62	10	21	9.55	Clear	55-81
23	61	8	30	13.70	Cloudy	51-65
24	61	0	5	0	Rain	51-65
27	57	1	4	0	Clear	45-60
28	57	2	4	0	Clear	45-60
29	57	0	8	0	Clear	45-65
30	58	2	22	0	Clear	40-65
May 1	63	5	13	6.00	Clear	46-75
2	66	4	9	4.75	Rain	65-85
3	67	2	2	0	Rain	50-87
5	64	4	6	0	Clear	59-83
6	64	0	0	0	Clear	59-83
7	64	2	2	0	Clear	57-80
8	63	3	1	0	Clear	56-79

331 ♀ 124.626 4,350,200 Eggs

.38 L/♀ 13,000 Eggs/♀

TABLE 5. Collection data from American shad eggs taken on the James River, 1987.

Collection Date	Water Temperature (Degrees F)	Number of Adult Shad Male	Number of Adult Shad Female	Volume of Eggs Received at Hatchery (liters)	Weather Condition Air Temperature (degrees F)
May 5	63	2	1	0	Clear 59-83
6	63	6	5	3.08	Clear 59-83
7	62	2	2	0	Clear 57-80
8	62	2	5	0	Clear 56-79

TABLE 6. Collection data for American shad eggs taken on the Delaware River, 1987.

Date Shipped	Date Received	Volume Received (liters)	Eggs
May 10	11	22.40	881,700
11	12	27.30	990,000
12	13	23.29	873,800
14	15	25.14	775,900
17	18	27.80	1,036,100
19	20	13.38	449,000

TABLE 7. Collection data for American shad eggs taken on the Columbia River, 1987.

Collection Date	Water Temperature (Degrees F)	Number of Adult Shad Male	Number of Adult Shad Female	Volume of Eggs Received at Hatchery (liters)	Weather Conditio Air Temperature (degrees F)
June 1	57	73	71	62.90	Cloudy - 61
2	58	80	83	68.10	Clear - 63
3	59	70	76	63.50	Clear - 65
4	59	67	65	58.90	Clear - 65
5	59	40	47	31.76	Cloudy - 71
8	62	69	69	58.71	Clear - 75
9	61	54	56	48.10	Clear - 78
10	61	47	51	40.20	Clear - 71
11	61	48	50	42.87	Cloudy - 70
12	61	45	43	30.90	Cloudy - 75
15	62	20	24	12.00	Cloudy - 73
16	62	22	20	12.00	Clear - 78
17	62	60	87	61.50	Clear - 69
18	63	44	51	39.70	Clear - 81
19	63	50	56	41.40	Clear - 77
22	63	50	49	34.60	Clear - 75

89.8 ♀ 707.14L 32,996,900

.79L/♀ 36,744 Eggs/♀

JOB III. AMERICAN SHAD HATCHERY OPERATIONS, 1987

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INTRODUCTION

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 for American shad and to rear juveniles, both fry and fingerlings, for release into the Juniata and Susquehanna Rivers. 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. This year's effort was supported by funds provided from the settlement agreement between upstream hydroelectric project owners and intervenors in the FERC re-licensing proceedings related to shad restoration in the Susquehanna River.

Production goals for 1987 included the stocking of 10-15 million 18-day-old shad fry, and 50-100 thousand fingerlings. All hatchery-reared American shad fry were marked by immersion in tetracycline (TC) bath treatments in order to distinguish hatchery reared outmigrants from juveniles produced by natural spawning of transplanted adults. Procedures were continued in 1987 to disinfect all eggs received at Van Dyke to prevent the spread of infectious diseases from out-of-basin sources.

Research conducted in 1987 focused on further refinements of tetracycline tagging, survival of eggs disinfected at various concentrations of iodophore, testing of a new dry feed, further testing of "controlled quick-release" for shad fry and refinement of the egg and mortality estimation procedures. Observations on siphoning vs netting of dead eggs, high mortalities at hatch, optimizing brine shrimp hatch, and viability of eggs incubated in a new egg jar will also be discussed.

EGG SHIPMENTS

Almost 33 million eggs (974.2L) were received in 34 shipments in 1987 (Table 1), representing the fourth largest total since the program began in 1976 (Table 2). Overall egg viability (which we define as the percentage which ultimately hatches) was 47.9% compared to 40.7% and 40.9% in 1986 and 1985, respectively. Egg viability was the fourth highest since 1976 (Table 2). Egg viability for the Pamunkey River was 51.1% as compared to 64.5%, 62.5%, and 55.3% for 1984, 1985, and 1986, respectively. Egg viability for the James River was 55.0% (one shipment). Egg viability for the Delaware River was 55.4% as compared to 31.2%, 50.5% and 57.9% for 1984, 1985, and 1986, respectively. Egg viability for the Columbia River improved dramatically from 39.2%, 24.5%, and 35.5% in 1984, 1985 and 1986 to 45.7% in 1987. Shipment 22 (Table 1) was lost in transit and arrived at Van Dyke approximately 6-8 hours late, resulting in 13.9% viability.

PRODUCTION

Survival, production and stocking of American shad fry are presented in Tables 2, 3 and 4. Survival of all fry from viable eggs to stocking was 70.1% (Table 4) compared to 72.8%, 76.2% and 75.6% in 1984, 1985 and 1986, respectively. Total fry production was 11.1 million (3rd highest) compared to 13.5 million, 7.9 million and 16.6 million in 1984, 1985 and 1986, respectively. Of the total fry production, 5.2 million were released in the Juniata River and 4.4 million in the Susquehanna River below Conowingo Dam. Approximately 815 thousand fry were stocked into ponds for fingerling production at various sites (Table 4) and 685 thousand fry were released into the Lehigh and Schuylkill Rivers.

Total fingerling production for 1987 was an estimated 81,500 (Table 4) compared to 30,500, 115,000 and 73,000 in 1984, 1985 and 1986, respectively. All fingerlings reared at Van Dyke, Thompsontown and Benner Spring were released into the Juniata River at Thompsontown.

SURVIVAL

Survival of all fry was 70.1% compared to 72.8%, 76.2%, and 75.6% in 1984, 1985 and 1986, respectively. Human error, neglecting to restore fresh water flow to tetracycline treated tanks on July 7, resulted in near complete mortality in six tanks. Excluding these tanks, survival was 76.4%.

Tanks of shad fry were grouped according to their survival patterns and displayed in Figure 1. Tanks with complete fry mortality due to human error were excluded. Tanks of shad fry that exhibited 18 day survival of less than 65% were characterized by high larval fry mortality within 2 days after hatch. This phenomenon was also noted in 1986 (Hendricks et al, 1986). In some tanks, fry experienced high mortality immediately after hatch and prior to exiting the hatching jar, resulting in large numbers of dead fry in the hatching jar. In other tanks, fry exited the jar but could be observed the next day lying on the tank bottom in dense layers, resulting in mortality due to suffocation. This phenomenon may be due to premature hatching, a decrease in water temperature or some other factor. In still other tanks, high mortalities occurred on the first day after hatch without exhibiting numbers of dead fry in the hatching jars or fry laying on the bottom. In any case, it is obvious from the last 2 year's data that the major mortality limiting factor in state-of-the-art American shad culture is during the period from fertilization to the first few days post-hatch. For example, considering only those 12 tanks from Figure 1 which experienced fry survival of less than 65%, combined survival from egg to 3 days of age averaged 33.2%. Mortalities from 3 days post-hatchto 17 days of age only accounted for another 10.4% for a total survival from egg to 17 days post-hatch of 22.8%. In the past, we have reported and analyzed data on egg viability and fry survival as though they were independent events. It is clear that these events are part of a biological continuum and should be analyzed as such. Time constraints do not permit such evaluations for this report; however, plans for 1988 include the collection of additional biological and environmental data, and modification of the evaluation process. These alterations should clarify shad survival and provide direction for future research.

TC TAGGING/RESEARCH

American shad fry stocked in the Juniata River received a single tetracycline (TC) tag administered by immersion in a 200 ppm tetracycline bath for 6 hours at 5 days of age (Table 3). Shad fry stocked in the Susquehanna River below Conowingo Dam received a "double" tag on days 5 and 12. American shad stocked as fingerlings in the Juniata River received a "triple" tag on days 5, 12 and 19 in addition to a unique tag administered by feeding TC laced feed for 3 consecutive days at an age in excess of 114 days (Table 3). Shad fingerlings reared by Delmarva Ecological Lab and stocked below Conowingo Dam were uniquely immersion tagged as fry at 5 and 19 days of age.

Verification of tag retention on production fish was accomplished by stocking groups of production fry in raceways or ponds, rearing them for at least 100 days and examining otoliths from 60 fish lots. Tag retention was 100% for all groups of fingerlings examined except for one untagged individual from Benner Spring pond 3. This individual lacked the 5 day tag and the feed tag (Table 5).

Research efforts directed at refining TC tagging continued in 1987; this included additional attempts at tagging using TC laced feed and attempts to determine the maximum number of unique immersion tags possible.

Attempts at producing a tag by feeding OTC laced feed (3 to 12 g/lb feed) in 1985 and 1986 were largely unsuccessful (Hendricks et al., 1985; Hendricks et al., 1986). One attempt in 1986 was marginally successful using 6 g OTC/lb food plus .75 g glucosamine/lb food, fed by automatic feeder. Our approach in 1987 was somewhat different. We attempted to determine the maximum concentration of TC which would be tolerated by the shad, when added to the food. Five rearing tanks were set up in the Van Dyke facility and stocked with 58 to 101, 96-day-old shad fingerlings from the rearing pond. Mortalities were monitored daily. Fish were fed for 16 days by automatic feeder for 5 seconds every 5 minutes. They were then starved for 2 days, and then fed TC laced feed for 3 days. Treatment concentrations corresponded to a mixture of 10, 20, 30, or 40 g TC + 0.75g glucosamine per pound of feed. A control was fed unlaced feed.

Feeding activity was monitored twice daily during the test and observations noted, as were mortalities. The fish were stocked 3 days after the TC laced feed was discontinued.

Mortalities associated with the test are reported in Table 6. Tanks C2 and C3 were inadvertently combined prior to stocking. Since initial density was determined by adding the number stocked to the total mortalities it was impossible to determine initial density for these tanks individually. Mortality associated with pond harvest and handling varied between tanks and was minimal after 4 days. Mortality during and after feeding the test feed was low and there was no evidence of increased mortality at the higher TC concentrations. Observations of feeding behavior were similar for all tanks and there was no evidence of feed rejection at higher TC concentrations. As a result of these tests, we chose to feed the remaining ponded fingerlings at a concentration of 40 g TC/lb food plus 0.75 g glucosamine/lb food. The TC laced feed was fed for 3 days preceeded by 2 days starvation. Fingerlings in all ponds fed well and no mortalities were observed due to the TC laced feed. At harvest, a 20 fish sample was frozen from each pond and otoliths were examined for tag retention. Tag retention was 100% for two of the three ponds and 95% for the third pond for a combined total of 98.3% (Table 5). The feed tag exhibited a highly visible, bright fluorescence. In some specimens it was possible to count the increments associated with the tag under UV light, and in all cases exactly three increments were involved.

The second objective of our tagging research for 1987 was to attempt to determine the maximum number of unique tags possible using current tagging methods. Toward that end, we attempted to determine how many days between tags were necessary to distinguish between single and double tags. American shad fry were tagged at 5 and 8, 5 and 9, and 5 and 10 days of age, grown out in raceways and examined for tags. Again, 100% tag retention was achieved and no double tags were mistaken for single tags (Table 5). In addition, fry tagged at 3 days of age also exhibited 100% tag retention.

Survival of experimentally tagged fry and verification lots is depicted in Figure 2. Although survival of fry tagged at day 3, day 5 and days 5 and 8 is well below survival of the other groups, it is apparent that most of that reduced survival can be attributed to mortalities during the first 3 days of life, prior to tagging. Survival after tagging is very similar among all groups and we conclude that tagging did not adversely affect survival in any of the tests.

EGG DISINFECTION RESEARCH

Disinfection of all American shad eggs for 10 minutes at 100 ppm free iodine has been standard practice at Van Dyke since 1984. The purpose of this effort is to prevent the spread of infectious diseases, particularly IHN, from the egg source rivers to Van Dyke and the Susquehanna River. Experience in 1985 emphasized the importance of close monitoring of pH during the disinfection process. In 1986, two tests were conducted to determine the effect of disinfection on egg viability under neutral pH conditions (Hendricks et al., 1986).

In the first test, eggs from two shipments were disinfected at 100 ppm free iodine and experienced significantly lower viability (x = 50.4%) than untreated controls (x = 76.3%). In the second test, there were no significant differences in egg viability (one shipment) between treatments disinfected at concentrations of 100, 75 and 50 ppm free iodine (x = 40.8%, 42.5%, and 41.1%, respectively). In 1987, we attempted to clarify the situation by conducting two additional tests.

The first test involved disinfection of lots of 50,000 eggs at 0, 25, 50, 75 and 100 ppm free iodine. Five replicates of the test were conducted, each with a different egg shipment (Pamunkey River). Eggs from each shipment were first well mixed in an egg net suspended in hatchery water. Three von Bayer counts were made using a 12-inch rule to determine the number of eggs per liter and thus, the volume required for 50,000 eggs. For each test concentration, the appropriate volume of eggs was measured in a graduated cylinder, screened on the bottom (dry volume). The eggs were then placed in an egg net in a 18.9L bucket with 10L of water. Two additional sets of 18.9L buckets were used as treatment and rinsing vessels. The second set contained 10L of water with a measured volume of iodine added to produce the appropriate test iodine concentration(0, 25, 50, 75 and 100 ppm). The third set of buckets each contained 10L of water for rinsing and transport of the eggs to the egg battery.

After measurement of the eggs into the first set of buckets, the egg nets were simultaneously lifted from the buckets, allowed to drain for 15 to 20 seconds, and placed in the treatment buckets. After 10 minutes the nets were simultaneously lifted from the treatment buckets, allowed to drain for 15-20 seconds and placed in the rinsing buckets. The buckets were then transported to the egg incubation room and the eggs placed into May-Sloan jars for incubation. Dead eggs floated to the surface and were netted off two days after fertilization, the day prior to hatch, and after hatch. Von Bayer enumerations were performed on the dead eggs and the total live eggs were calculated by subtracting the estimated number of dead from the total (50,000). Starting with 50,000 eggs in each trial allowed us to use ANOVA with the number of live eggs as the test statistic, as opposed to using bionomially distributed percentages which would require less powerful non-parametric analysis (Ott, 1977; Snedecor, 1956).

The data from this test are depicted in Table 7 and Figure 3. Mean egg survival decreased from 69.4% for the control to 50.0% for the 100 ppm iodine treatment. While there appears to be a clear trend toward lower egg survival at higher iodine concentrations (Figure 3) the difference was not significant at the .05 level (Table 7). This was primarily due to a great deal of variation between replicates, which is readily apparent from Figure 3.

The second test was designed to determine if egg disinfection would influence survival of American shad fry. Egg lots of

250,000 eggs per lot were disinfected at 0, 75 and 100 ppm free iodine. Four replicates were conducted, each with a different shipment of eggs (Delaware River). Procedures were the same as used in the previous test except the five egg jars for each treatment level were allowed to hatch into a single tank and fry mortalities were monitored for 17 days post-hatch when the fry were stocked.

The data for the test are depicted in Table 8 and Figure 4. The trend toward reduced egg survival at higher iodophore concentrations observed in the first test was not consistent in Test 2 (Figure 4). Shipments 16 and 17 exhibited this trend, however, shipments 14 and 15 experienced higher egg survival at 100 ppm free iodine than at 75 ppm. Survival of eggs and fry is also puzzling (Figure 4) and no clear trends are present. We offer no explanation for these apparently anomalous results, except to note that individual shipments of eggs appear to react differently to disinfection (Figures 3 and 4). A conservative approach would be to disinfect at the lowest possible iodine concentration needed for effective disease control. Since organic iodine compounds have been shown to be viricidal at 30 ppm and bactericidal at 75 to 100 ppm (Wood, 1979) we propose to disinfect future egg shipments at 80 ppm free iodine.

FEED RESEARCH

Two feed tests were conducted at Van Dyke in 1987. The first test examined the survival of American shad fry fed AP100 which had been purchased in 1986 and frozen for approximately 9 months prior to use. A control group was fed AP100 purchased in 1987. Both groups were fed 12 Artemia nauplii per fish per day plus 64.5 g dry diet per 250,000 fish per day.

The results (Table 9) indicate that good survival (89.4%) can be achieved using previously frozen dry feed. This allows us to purchase quantities of dry food sufficient for a record production year without risking wasteage if production is low.

The second feed test, conducted in 1987, tested Bio-Marine ABM4100 (125 micron) dry diet against the standard Zeigler AP100 (150 micron). Again, all tanks were fed 12 Artemia nauplii per fish per day plus 64.5 g dry diet per 250,000 fish per day. Three replicates were tested and the data is depicted in Table 9 and Figure 5. In every case, survival for the tank fed ABM4100 was higher than the control fed AP100. Examination of Figure 5, however, revealed that the difference in survival between tanks was largely determined prior to first feeding at 4 days of age. In order to test this, percent survival from 4 to 18 days was regressed against age for each of the dry feeds pooled. The resultant regression was Y = 82.9 - .832X for AP100 and Y = 94.9 - .889X for ABM4100, when Y = % survival and X = age in days. Note the lower slope for ABM4100, indicating that survival after 4 days of age was actually lower for ABM4100 than for AP100. The two slopes were tested by analysis of covariance and found to be significantly different at the .05 level ($F_{(1,86)} = 42.59$). We are reluctant to rely on this test, however, since each individual data point (% survival) is dependent on the previous days survival. In fact, the degrees of freedom could arguably be 5 since there were n = 6 tanks of fish tested (Ostrowski and Gerling, 1986).

Based on feeding observations the ABM4100 appeared to be inferior to AP100. Early morning feeding of shad fry on AP100 becomes almost frenzied as the fry grow older and become accustomed to the feeding regime. Such frenzied surface feeding on ABM4100 was not observed. Based on these observations we propose to test a different alternate diet in 1988.

"CONTROLLED QUICK RELEASE" STOCKING OF FRY

Current methodologies used in stocking American shad fry involve partial draining of the rearing tank, addition of salt, crowding the fry, and water brailing fry into 5-gallon buckets (for trips to Thompsontown Access area) or plastic bags (for longer trips to Benner Spring or below Conowingo Dam). Fry stocked at Thompsontown are then transported via truck to the site, tempered and stocked from the bucket, while those destined for longer trips are double-bagged with oxygen and transported in styrofoam coolers with ice packs (if necessary). Tempering and stocking is accomplished in the clear plastic bags.

In 1986, we developed and tested a method for "controlled quick-release" of American shad fry in an attempt to reduce handling and expedite the stocking process. The method is described in Hendricks et al. (1986).

In 1987, we replicated the test for a third time. Data from all three replicates is depicted in Table 10. Conventionally stocked fry in replicate 2 experienced high mortality due to an interruption in water flow unrelated to the test. In the remaining tests four-day survival of quick-released fry was slightly lower than for conventional methods.

Conventional stocking methods are labor intensive and time consuming. In 1987, preparation of four tanks of fry for transport to Lapidum, MD (oxygen filled bags) typically took approximately 12-15 man-hours of labor or 3-4 man-hours per tank. For shorter trips (buckets only) a tank could be prepared in 1 to 1-1/2 man-hours. For quick-release stocking in 1987, equipment set-up took approximately 3 man-hours. Draining one tank into the hauling unit took exactly 45 minutes. Equipment takedown, loading in a truck, and set-up at the stocking location took approximately 3 man-hours. We project a total of 9 man-hours for four tanks, a saving of 3 to 6 man-hours over conventional methods.

At the stocking site, the fry must be tempered and stocked. For conventional methods, these processes took an average of 3.4 man-hours (n = 7) in 1987. In the 1987 quick-release trial, draining of the fry from the hauling unit to the receiving tank (simulated river) took 30 minutes. Projected time for four tanks would therefore be 2 hours plus an estimated 1/2 hour for tempering, an additional 1/2 hour for equipment take-down at the stocking site and 1/2 hour for cleanup and disinfection of the unit prior to the next use. Since two men are involved, a total of 7 man-hours is projected for a net loss of 3.6 man-hours over conventional methods. All factors considered, the total time saving for quick-release would be -0.6 to 2.4 hours per trip. For trips to Thompsontown, conventional methods would be far superior to quick-release due to the excessive time involved in equipment set-up.

There are several distinct disadvantages in quick-release stocking. Foremost among these is the fact that a Class 3 driver's license is required to drive the towing vehicle. Many of our temporary employees have never driven standard shift vehicles, let alone towed a 7 ton trailer. Several weeks of practice would be needed for each driver to acquire the skills needed to safely drive the vehicle and pass the driver's test. This would negate any man-power savings over conventional methods.

In addition, the quick-release method is very equipment intensive as compared to conventional methods. Once the fry are loaded, conventional methods require only hip boots, a thermometer, and a makeshift clothesline used to hold bags for tempering. None of these items are absolutely essential. Quick-release methods require a 10 foot aluminum tripod; a 1 ton chain hoist; two 4 inch hoses with quick-release fittings; an oxygen cylinder, regulator and hose connector; a tempering pump with capacity to temper 750 gal of water in 30 minutes using 12V DC current (an item we have not yet located), and assorted hoses and electrical cords for the tempering pump. Most of these items are absolutely essential to ensure fry survival.

Based on the slightly lower survival of quick-released fry over conventional methods, the fact that minor man-power savings projected for quick-release would be negated by the time required for training and licensing of Class 3 drivers, and the equipment intensive nature of quick-release, we propose to discontinue testing of quick-release methods.

ENUMERATION STUDIES

The validity of all our research efforts and production totals at Van Dyke is based upon our system of enumeration. Basically, we enumerate egg shipments as they are measured into incubation jars then subtract dead eggs and dead fry as they are removed from the jars or rearing tanks. The remainder for each tank is then taken as the final density for totaling production or analysis of research. Obviously, this system relies on our ability to accurately estimate numbers of eggs and dead fry. Wiggins (pers. comm.) felt that the system was generally very good but noted that some tanks appeared to have more fry than the estimate would indicate. This could result from under-estimation of egg numbers or overestimating mortalities.

In 1987, we ran additional replicates of the egg enumeration studies begun in 1986, and tested three methods of estimating fry mortalities. Egg enumeration methods tested in 1987 were the standard von Bayer method, (von Bayer, 1910) wet volume method (300 egg sample), displacement method (300 egg sample) and displacement/wet volume method (300 egg sample). Methodology for the tests is outlined in Hendricks et al. (1986). In all, five hand-counted egg lots of .5L each were used, with 3 to 6 estimates (replicates) per lot. The raw data is displayed in Tables 11-14. Table 15 compares the percent error of estimate (accuracy) and coefficient of variation (precision) for the four methods. Regressions of the estimate on hand count were calculated for each of the four methods and are depicted in Figure 6. The von Bayer method was the best method overall. Mean percent error of estimate was -5.58 with a standard deviation of 6.4, while mean coefficient of variation was 8.24 (Table 15). The von Bayer method also had the highest correlation coefficient (r = .65) and a slope very close to 1 (Figure 6). The displacement and displacement/wet volume methods can be eliminated from consideration due to their low correlation coefficients (Figure 6). The wet volume method had a good coefficient of variation (Table 15) and a good correlation coefficient (Figure 6), but the estimate was an average of 18.0% too low and had a slope of 0.62.

In summary, we will continue to utilize the standard von Bayer method, but will consider the wet volume method as an alternative if egg handling research protocol requires a method other than von Bayer.

Methods of estimating fry mortalities at Van Dyke have been in question since very early in the program. A preliminary study in 1985 indicated that for small numbers of mortalities the mortality estimate was an average 1.67 times the hand count (unpublished data). It was presumed at that time that personnel were becoming lax in thoroughly mixing the dead fry and that the resultant sample was non-random, selecting for dead fry. In 1987, we tested three methods of mixing the fry to ensure a random sample.

Mortalities were siphoned from the rearing tank as per standard Van Dyke practice. The dead fry were then mixed by the appropriate method and a 40-50 ml sample of the water containing the dead fry was extracted with a plastic tube and squeeze bulb. The sample was measured to the nearest ml in a graduated cylinder and the dead fry in the sample counted by hand. The total sample volume was then measured and the estimate calculated by a simple proportion. After all three methods had been tested, the entire sample was preserved and counted by hand. The three mixing methods tested were the Van Dyke standard method, the spin only method, and the vertical cylinder method. The Van Dyke standard method involved swirling the bucket by hand while mixing the contents vertically using the plastic sampling tube, egg-beater fashion. The spin only method consisted of horizontally swirling the bucket by hand with no vertical mixing. The vertical cylinder method involved pouring the dead fry into a 15.2 cm diameter vertical cylinder and mixing thoroughly by bubbling air into the bottom of the cylinder via an air line from an air pump.

The data are presented in Table 16. As in the 1985 studies, the estimates were greater than the hand count with few exceptions. The mortality estimates were regressed against hand count specifying an intercept at 0, for each of the three mixing methods (Figure 7). The three methods produced remarkably similar regressions with slopes of 1.544, 1.523 and 1.563; and correlation coefficients of 0.99, 0.98, and 0.99 for the Van Dyke standard, spin only, and vertical cylinder methods, respectively.

From the data, it is obvious that there is gross over-estimation of fry mortalities and that the method of mixing is not the cause of the problem. The only possible conclusion is that the sampling device used, in some way, collects a non-random sample, selecting for dead fry. We plan to continue to use the Van Dyke standard method of mortality estimation, adjusting for the observed over estimation by dividing the estimate by 1.544. We feel confident in the accuracy of this procedure based upon the high correlation between the estimate and the hand count (r = 0.99, Figure 7).

OTHER STUDIES

The occurrence of numbers of dead fry in the hatching jars after hatch makes estimating mortalities difficult due to the presence of dead eggs as well as dead fry. Since the methods used to estimate dead eggs are fundamentally different from those used to estimate dead fry, the question arises as to which method to use. Even if no dead fry are present in the hatching jar the estimation procedure for dead eggs taken off after hatch is subject to error due to the presence of fungus and the tendency of the eggs to float. It had been suggested that siphoning off dead eggs (as opposed to the presently used netting method) would remove a greater percentage of the dead eggs prior to hatch, leaving fewer to remove and enumerate post-hatch. It was feared, however, that siphoning might result in egg breakage and therefore, erroneous mortality estimates. In order to test this we netted dead eggs from seven jars and measured wet volume in a pharmaceutical graduate. We then siphoned the eggs into another graduate and again measured the wet volume. If egg breakage occurred due to siphoning there should be a net loss in volume between the two sets of measurements. On another set of six jars we reversed the process, siphoning first and then netting, to assess breakage due to netting.

The data (Table 17) indicate no egg breakage due to siphoning in any of the seven jars. Netting, however, resulted in egg loss (breakage) in five of the six jars tested for a mean egg loss of 2.7%. Based on this test, we propose to utilize siphoning to remove dead eggs from hatching jars in lieu of netting.

Improving brine shrimp hatches at Van Dyke is desirable as a cost-saving measure and to reduce the number of unhatched cysts fed to the fry. Toward that end, two impromptu tests were conducted in 1987. The first test was designed to determine if preheating brine shrimp incubation water 24 hours in advance of its use produces hatches similar to those produced by preheating an hour in advance of use. The advantage of the 24 hour preheating time is that an immersion heater is not needed: The water is heated by the warm room air. Mean brine shrimp count for the three replicates tested was 19.2 nauplii per 0.1 ml for the 24 hour preheating time vs 27.3 nauplii per 0.1 ml for the 1 hour preheating time (Table 18). These data were tested with

ANOVA and found to be non-significant at the .05 level ($F = 6.75$), however, additional replicates might have resulted in significant differences. We postulate that reduced brine shrimp hatches for tanks preheated for 24 hours may be the result of bacterial action. Brine shrimp cultures typically contain heavy bacterial loads (Curry Woods, pers. comm.). The longer preheating time may simply give bacterial cultures, present on the walls of the tank from the previous days brine shrimp culture, time to proliferate. We know from experience that repeated culture of brine shrimp in a tank, without disinfecting the tank on a weekly basis, results in gradually decreasing hatches. This may explain the fact that little difference in hatch was observed between the two preheating times for the first replicate, while the second and third replicates resulted in extreme differences in hatch.

It has been suggested that manipulation of incubation time can also impact brine shrimp hatch. In order to test this a 30L batch of brine shrimp was incubated and counts determined after 17, 18, 19, 20, 21, 22.5, 23.5, and 41.5 hours of incubation. Three independent counts were made and the mean count plotted against incubation time (Figure 8). Maximum hatch was clearly between 19 and 23 hours of incubation, a result which is very easy to accommodate logistically, at Van Dyke. After 41.5 hours of incubation no brine shrimp could be found in the culture.

During the winter of 1987, a large number of 26 liter plastic jars were made available to us. We converted one of these jars into an egg incubation jar (the "Mega-jar") similar to a

May-Sloan jar by addition of a convex, false bottom, two influent water ports, four effluent water ports and bottom and top screens. The finished Mega-jar is 30.4 cm high and 33 cm in diameter. It has a capacity for approximately 420,000 eggs (12.5L), five times the capacity of a May-Sloan jar. Since four to six May-Sloan jars are normally placed on a rearing tank for hatch, a single Mega-jar would provide all the fry needed for a good density tank.

We compared egg viability for eggs incubated in the Mega-jar to eggs from the same shipment incubated in May-Sloan jars (Table 19). Egg viability in the Mega-jar (72.2%) was the highest viability achieved in any jar in 1987. Egg viability for the May-Sloan jars combined, from the same shipment, was 64.4%, or 11.8% less than the Mega-jar. We cannot speculate on the reason for improved viability in the Mega-jar except to note that eggs rolled extremely well in the Mega-jar. Unfortunately, shipment 21 which had unusually high egg viability overall, experienced extremely high mortalities at and just after hatch (Figure 9). Tank I1, the tank which received fry from the Mega-jar experienced these mortalities to approximately the same degree as the tanks which received fry from May-Sloan jars (Figure 9). Although these high mortalities negated the high egg viability exhibited by the Mega-jar, we feel, based on Figure 9, that the underlying source of the problem was related to the shipment, not the jar.

The Mega-jar was tested again on shipment 30 (Table 19), but no additional eggs were available for a control. Egg viability for the second test was 47.1% as compared to 45.7% for the Columbia River shipments as a whole. Survival of fry from hatch to 17 days of age was a very respectable 82.5% (Figure 9).

Construction of three new 0.65 acre ponds at the Centre County, Upper Spring Creek site, is underway at this writing, and should be completed for use in 1988. In addition, bids have been solicited for a new furnace and heat exchanger at the Van Dyke hatchery.

FINGERLING CULTURE AND HARVEST

Fingerling American shad were cultured in four ponds (Table 3). Fingerlings cultured in the rearing pond at Van Dyke were utilized for a laboratory study dealing with tetracycline tagging (see TC Tagging/Research). A total of 309 were stocked in the Juniata River after the test was complete.

A crop of approximately 60,000 fingerlings was cultured in the Canal Pond at Thompsontown. In the past, we have stocked approximately 100,000 fry in the pond and fed them twice a day by hand. In 1987, we stocked approximately 162,000 fry and fed them using an automatic feeder in addition to hand feedings once per day.

Pond harvest was timed so that the final two hours of crowding and release was done under cover of darkness. After dark, the fish stopped schooling and became much more calm and more willing to enter the catch basin. The problems experienced in the past with fish becoming extremely nervous and panicing at the slightest noise or movement was not experienced after dark. We did, however, experience severe problems with algae. Surface algae had been skimmed from the pond for several days prior to harvest and did not cause a problem. However, much algae was suspended in the water column and as the fish became crowded so did the algae, entrapping many fish in blankets of algae. The severe algae problem forced us to release the fish prematurely, before all could be crowded in the kettle. The early release eliminated any possibility of volumetric enumeration of the fingerlings, therefore the 60,000 fish estimate is a visual estimate based on past experience and is subject to a wide margin of error.

Benner Spring Ponds 2 and 3 were harvested in early October (Table 3). Pond 2 was a night harvest; the last three stop planks were not pulled and fish were not brought into the catch basin until after dark. Darkness seemed to calm the fish and they were not nearly as skittish as during daylight hours; there was very little jumping and splashing around. The pond drained well and algae was not nearly the problem it had been in the past. The fish were bucketed from the catch basin and moved to raceways in the "tar-buggy." The tar-buggy is a steel transport tank fitted with a quick-release valve but no hose attachment. Upon release, the fish drop from the tar-buggy into the raceway. The tar-buggy is also fitted with an air pump to maintain D.O. levels. Salt and polyaqua were added to the transport water before the fish were placed in it. Once in the raceway, the fish appeared to be lethargic, and did not exhibit schooling behavior. The following morning, approximately 20,600 mortalities were removed from the raceways, and the remaining fish, 7,050 were stocked at Thompsontown. Approximately 1,500 dead were removed from the pond and catch basin. Total production for Pond 2 was approximately 29,100 fingerlings averaging 121 mm in length and 16.4 g in weight.

Pond 3 was harvested during daylight, and moved to raceways in the gooseneck trailer. The gooseneck unit is a fiberglass quick-release unit utilizing flexible hose to direct the fish into the raceway. Pure oxygen is bubbled into the tank to maintain D.O. levels. The gooseneck unit is much larger than the tar-buggy and requires fewer trips. Once again, algae was not much of a problem, but post-harvest mortalities were still quite high. Approximately 33,800 fingerlings averaging 116 mm in length and 14 g in weight were transferred to raceways from Pond 3. An additional 2,400 dead were removed from the pond and catch basin. The following day, approximately 19,800 dead (58%) were removed from the raceway. The remaining 14,100 fingerlings were stocked at Thompsontown.

The results of this year's Benner Spring shad fingerling harvest were quite disappointing. The fish were in good shape prior to harvest, but it appeared that there were too many for the size of the catch basin. The larger size of the catch basins in the new shad ponds at Upper Spring Creek should alleviate this problem next year. In addition, if shad are reared in Benner Spring ponds next year, the catch basin will be modified with angle aluminum so that a group of fish can be allowed to enter the catch basin, the basin will be planked, the fish harvested, and another group allowed to enter the catch basin. In this way, it will not be necessary for all the fish in the pond to come into the catch basin at one time.

Overall, the two Benner Spring ponds produced approximately 65,500 fingerlings (16% survival from fry) but only about 21,000 (32%) of those produced were successfully stocked. Average length for these fish was 118.5 mm (range 80 mm - 146 mm) and average weight was 15.1 g (range 4.5 g - 29.0 g). It is anticipated that some experimental work will be conducted next year relative to harvest techniques for ponded shad and algae control in rearing ponds.

SUMMARY

A total of 34 egg shipments (33 million eggs) was received at Van Dyke in 1987. Total egg viability was 47.9% and survival to stocking was 70.1%, resulting in production of 11.1 million fry. The majority of the fry were stocked in the Juniata River (5.2 million) with lesser numbers stocked in the Susquehanna River below Conowingo Dam (4.4 million), the Lehigh River (491 thousand) and the Schuylkill River (195 thousand).

A total of 81,500 fingerlings were produced at Van Dyke and Benner Spring and stocked into the Juniata River. Approximately 191 thousand fry were supplied to Delmarva Ecological Lab for grow-out in ponds in Elkton, Maryland, resulting in the planting of 25 thousand fingerlings below Conowingo Dam.

All American shad fry stocked in the Juniata River received a single tag by immersion in 200 ppm tetracycline for 6 hours at 5 days of age. All fry stocked below Conowingo Dam received a double tag at 5 and 12 days of age. All fingerlings stocked above Conowingo Dam received a triple tag at 5, 12, and 19 days of age in addition to a unique tag produced by feeding TC laced feed for 3 consecutive days at an age in excess of 114 days. All fingerlings stocked below Conowingo Dam (D.E.L. ponds) received a unique double tag at 5 and 19 days of age. Experimental immersion tags were administered to research lots of fry at 3, 5 & 8, 5 & 9 and 5 & 10 days of age. Otolith analysis indicated that all research and production lots of fish experienced tag retention of 100% except for one lot of pond reared fingerlings.One of the twenty individuals analyzed from this lot exhibited no 5 day tag and no feed tag; however, the 12 and 19 day tags were clearly visible.

The relationship between egg survival and concentration of iodophore used during disinfection was examined. In one test, mean egg survival decreased with increasing iodophore concentration (five replicates) but the difference was not statistically significant. In a second test (four replicates) this trend was not consistent and both mean egg survival and mean egg and fry survival showed no relationship to iodophore concentration.

Comparison of a new dry diet, Bio-Marine ABM4100, to the standard Zeigler AP100 resulted in higher survivals for tanks fed ABM4100 (three replicates). Close examination of the data indicated that the differences were apparent prior to first feeding and therefore unrelated to the feed. The ABM4100 appeared to be less favored by the fry than the AP100.

Survival of fry stocked by "controlled quick-release" methodology was compared to conventional methods. Four-day post stocking survival was slightly lower for quick-released fry than for conventional methods (two replicates). Other factors, such as the time required to train drivers and the equipment intensive nature of the quick-release process, negate the utility of the technique.

Four methods of enumerating eggs were tested for accuracy and precision. The best overall method was judged to be the von Bayer method currently in use at Van Dyke. Three methods of estimating fry mortalities were tested by comparing the estimate to a hand count. All three methods grossly overestimated fry mortalities by a surprisingly consistent rate of approximately 1.5 to 1. The currently used method, incorporating a correction factor will be used in the future.

In other studies, removal of dead eggs by siphoning was shown to be superior to netting, preheating of brine shrimp culture water for 1 hour was shown to be superior to preheating for 24 hours, and maximum brine shrimp hatch was achieved after 19 to 23 hours of incubation. A new larger capacity egg jar was constructed and test results indicated improved egg viability in a controlled experiment (one replicate).

RECOMMENDATIONS FOR 1987

1. Disinfect all egg shipments at 80 ppm free iodine.
2. Continue to stock one-half of production fry below Conowingo Dam (up to 5 million fry).
3. Tag all production fish according to a schedule to be approved by SRAFRC.
4. Attempt to utilize otolith microstructure to distinguish between hatchery reared and wild American shad. (Proposal to be transmitted under separate cover.)
5. Choose and test a commercially available substitute for AP100 larval diet.
6. Construct and test additional new 12.5L egg incubation jars.
7. Continue to utilize the von Bayer method for enumerating eggs.
8. Remove dead eggs from incubation jars by siphon.
9. Continue to utilize the standard method of enumerating mortalities but adjust the resulting estimate by dividing by a factor of 1.544.
10. Preheat brine shrimp culture water for 1 hour prior to addition of the cysts and incubate cysts for approximately 20 hours prior to harvest.
11. Adjust our methods of analysis of survival to reflect the continuum of events from egg take to stocking of fry. Remove as many dead eggs as

possible, as they die. Note the presence of dead fry in hatching jars and enumerate them using fry enumeration techniques.

12. Implement American shad fingerling culture strategies in newly constructed ponds at Upper Spring Creek complex. Evaluate harvest techniques and algae control strategies to maximize survival of pond-harvested American shad.

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Figure 1. Survival for three groups of American shad fry, Van Dyke, 1987.

Group 1: S ≥ 85% (n=21)

Group 2: 65% ≤ S < 85% (n=42)

Group 3: S < 65% (n=12)

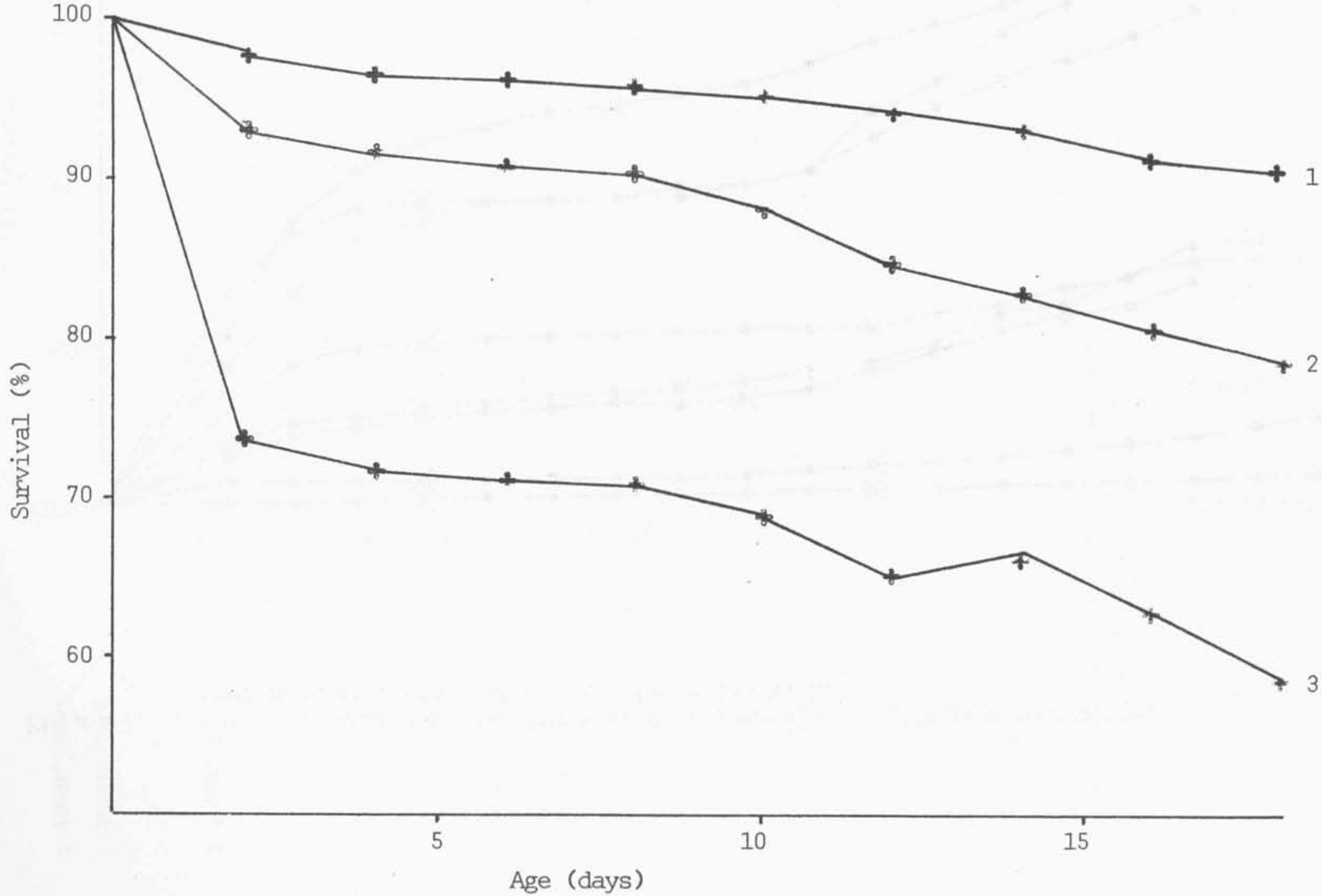

Figure 2. Survival of American shad fry tagged by immersion in 200ppm tetracycline, 6 hour bath at various ages. X - immersion bath.

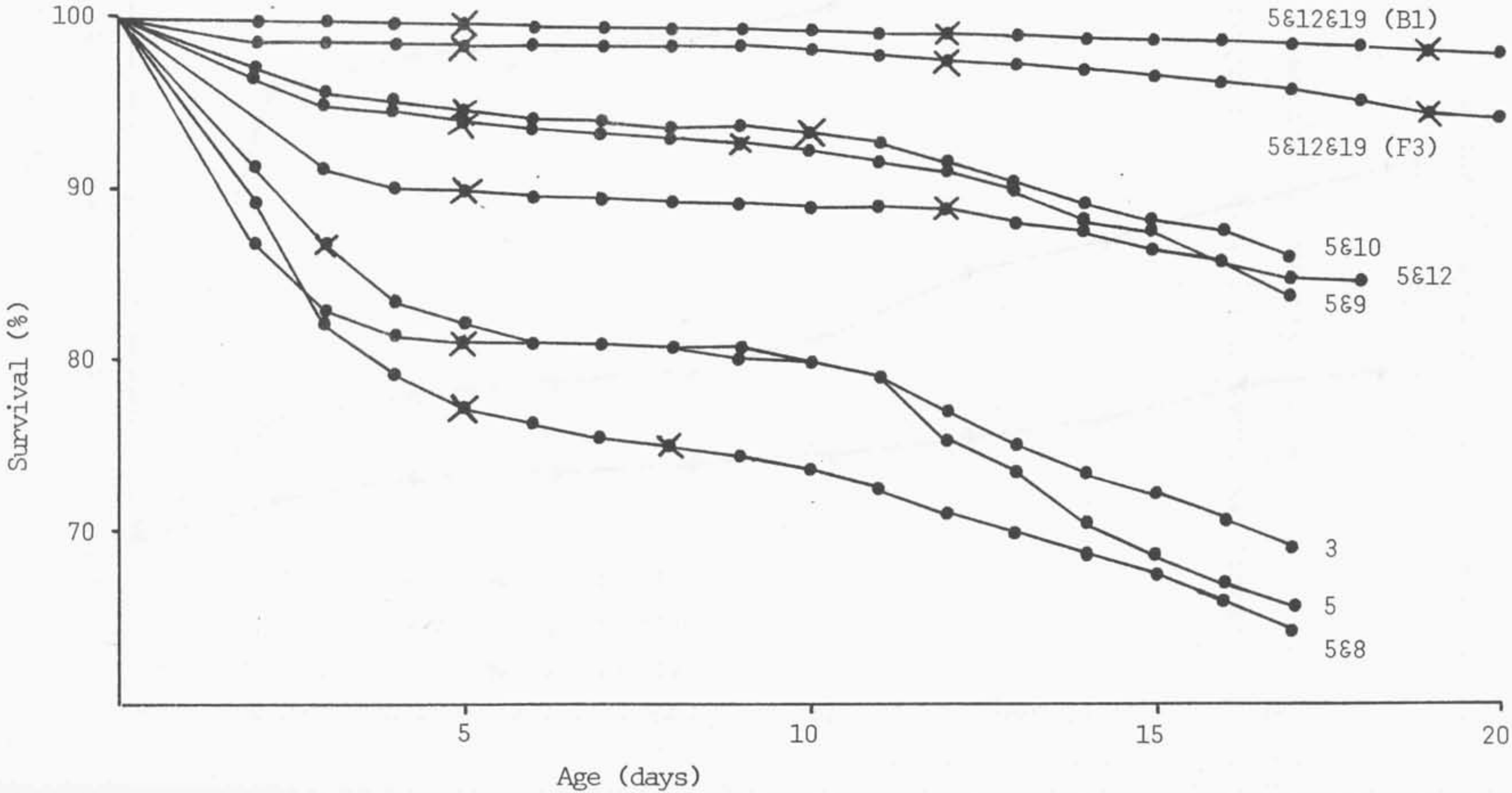

Figure 3. American shad egg survival after disinfection with Argentyne for 10 minutes, 1987. 50,000 eggs treated per lot. Treatment approximately 7 hours after fertilization.

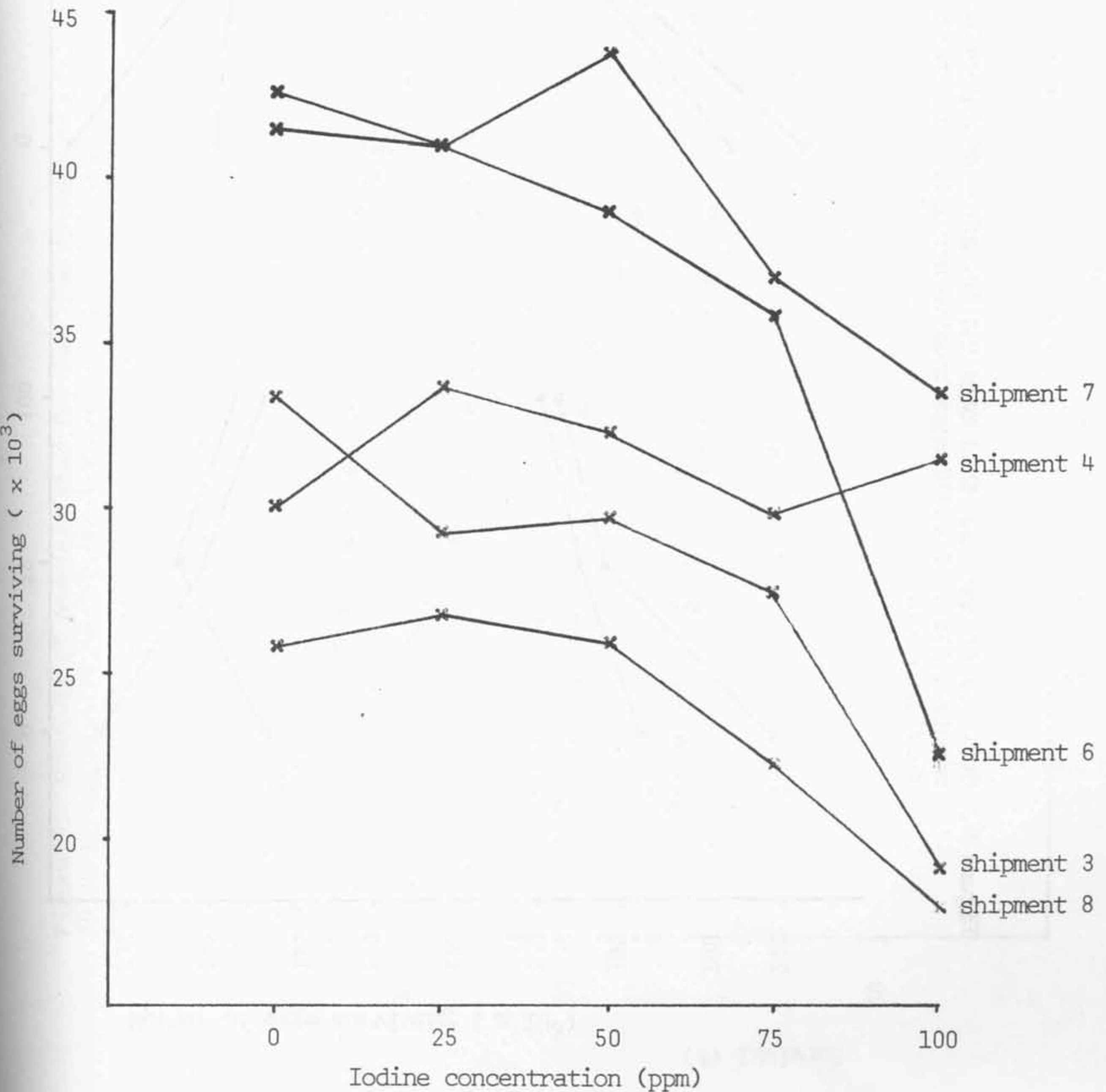

Figure 4. Survival of American shad eggs and fry after disinfection with Argentyne for 10 minutes, 1987. 250,000 eggs treated per lot. Treatment approximately 7 hours after fertilization.

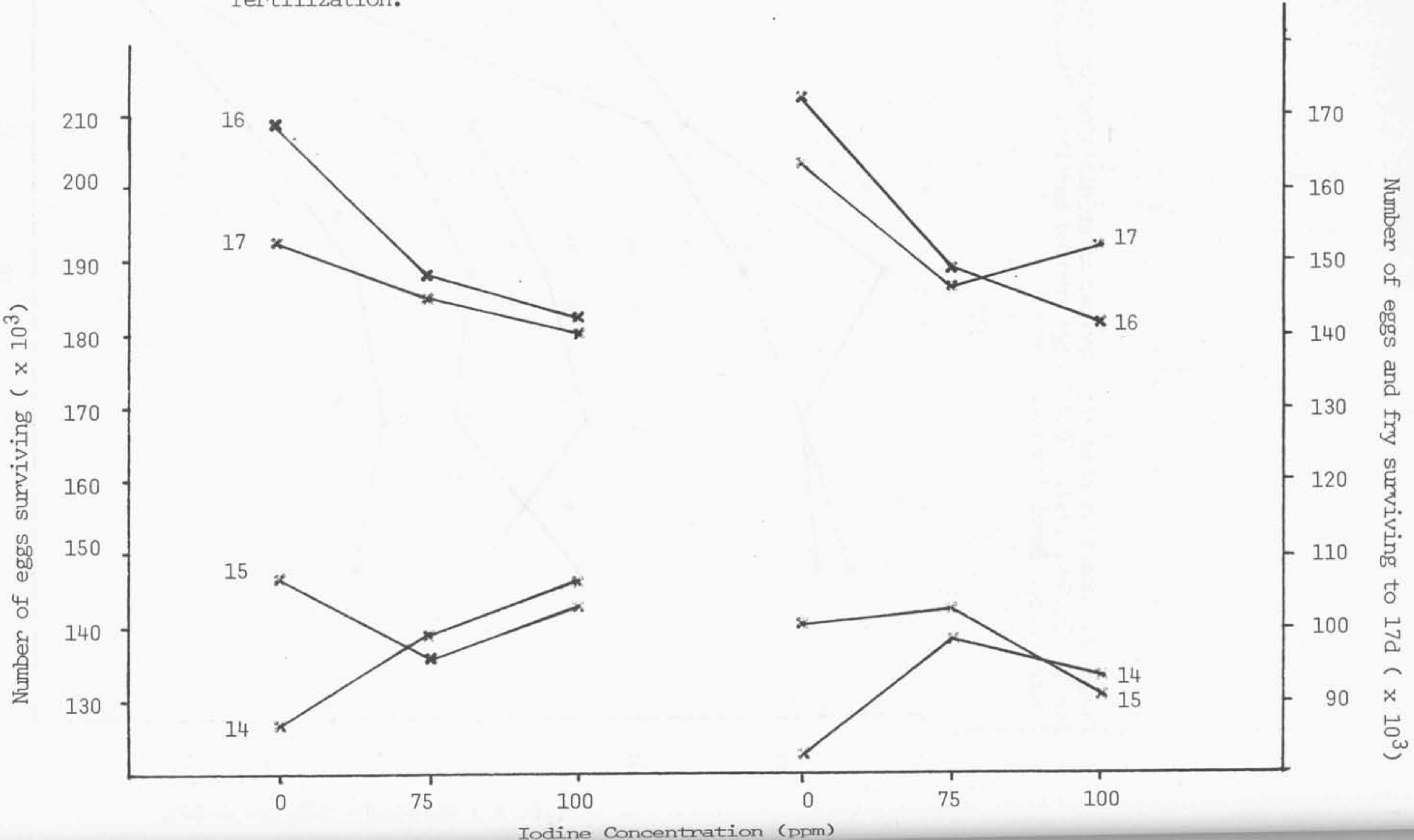

Figure 5. Survival of American shad fry fed live *Artemia* nauplii (12 nauplii/fish-day) plus 150 micron AP100 larval diet(64.5g/250,000fish-day) vs. live *Artemia* nauplii (12 nauplii/fish-day) plus 125 micron ABM4100 (64.5g/250,000fish-day), Van Dyke, 1987.

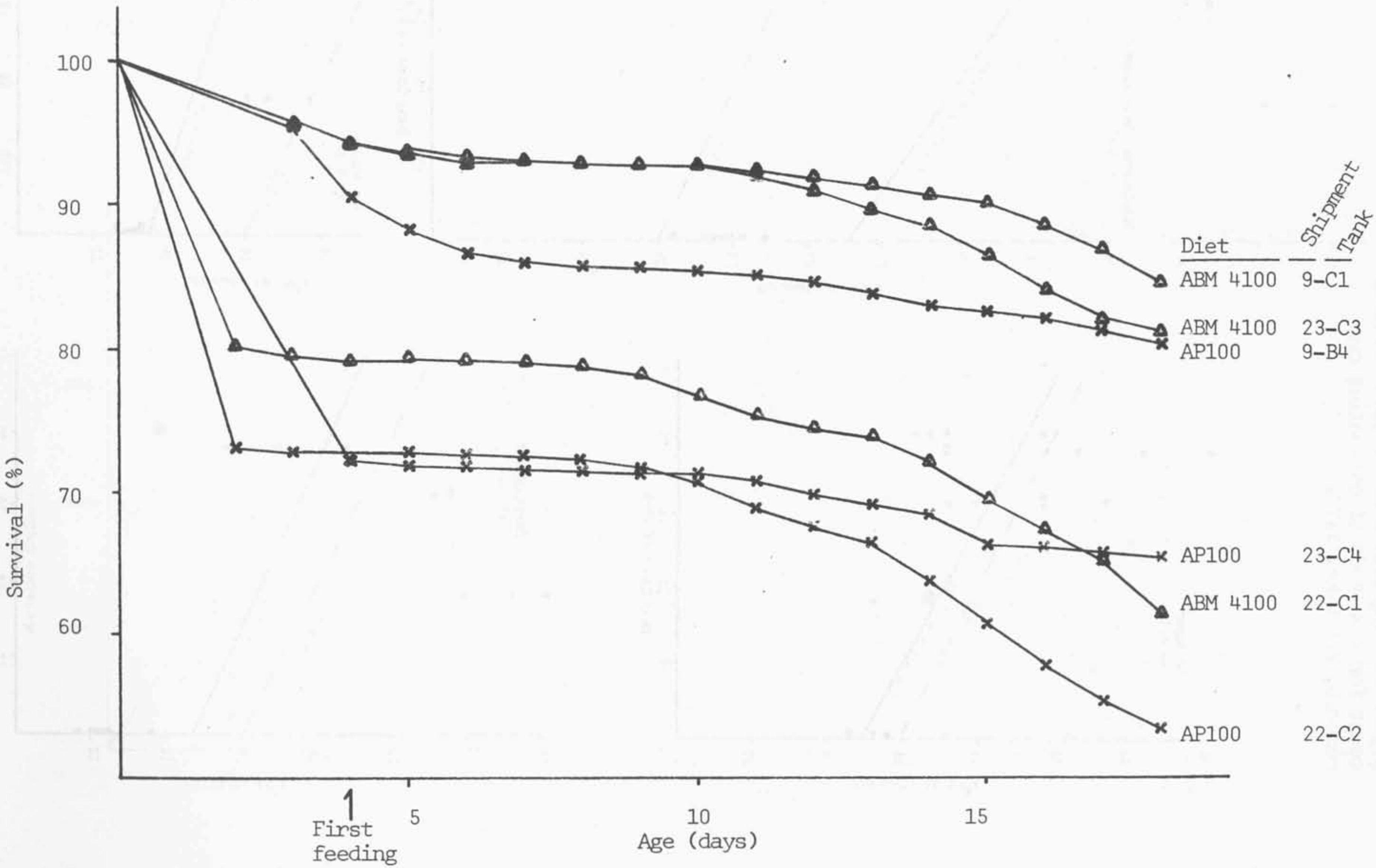

Figure 6. Regression of estimate on hand count for 4 methods of estimating egg numbers, Van Dyke, 1987.

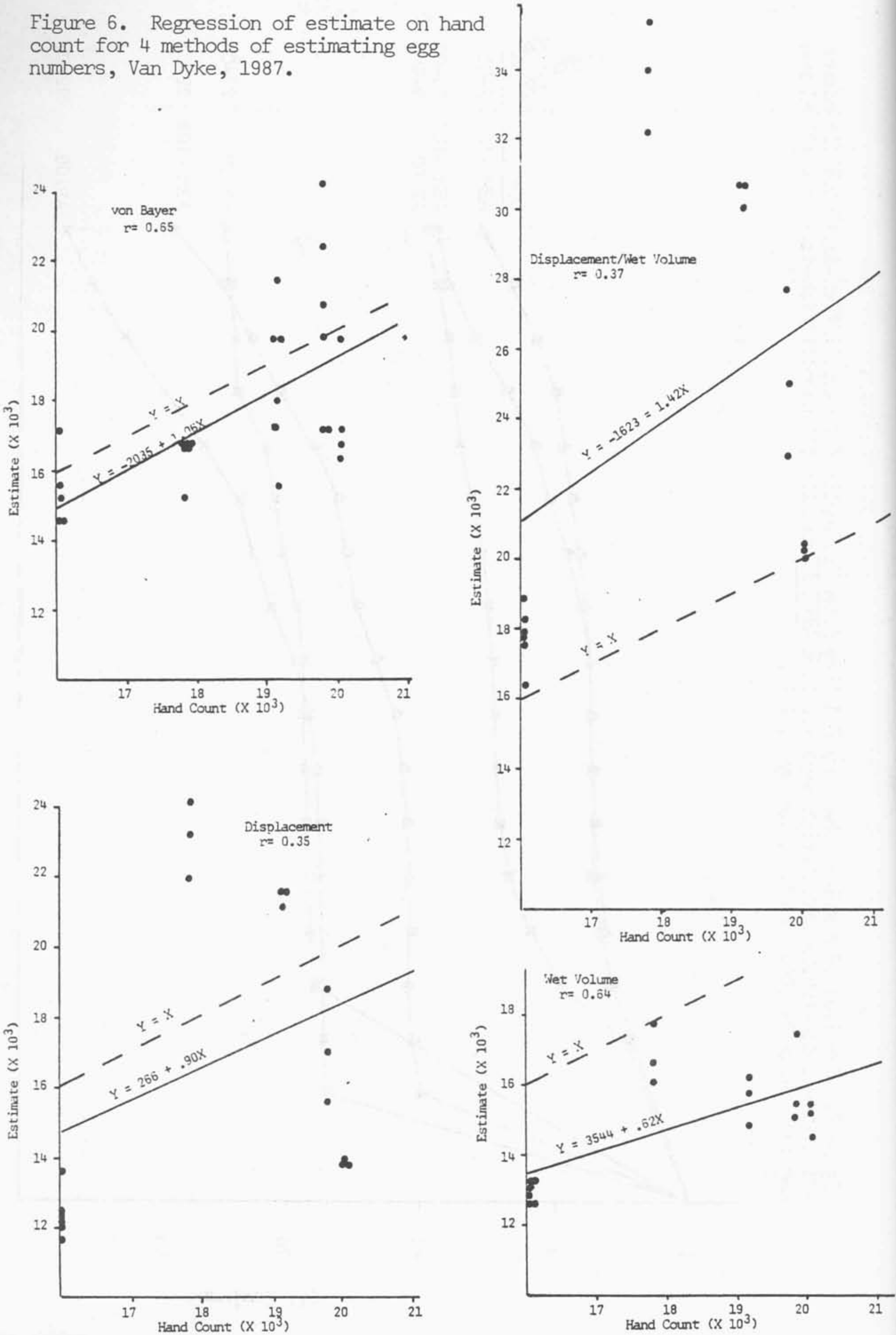

Figure 7. Regression of mortality estimate on hand count for 3 methods of estimating mortalities, Van Dyke, 1987.

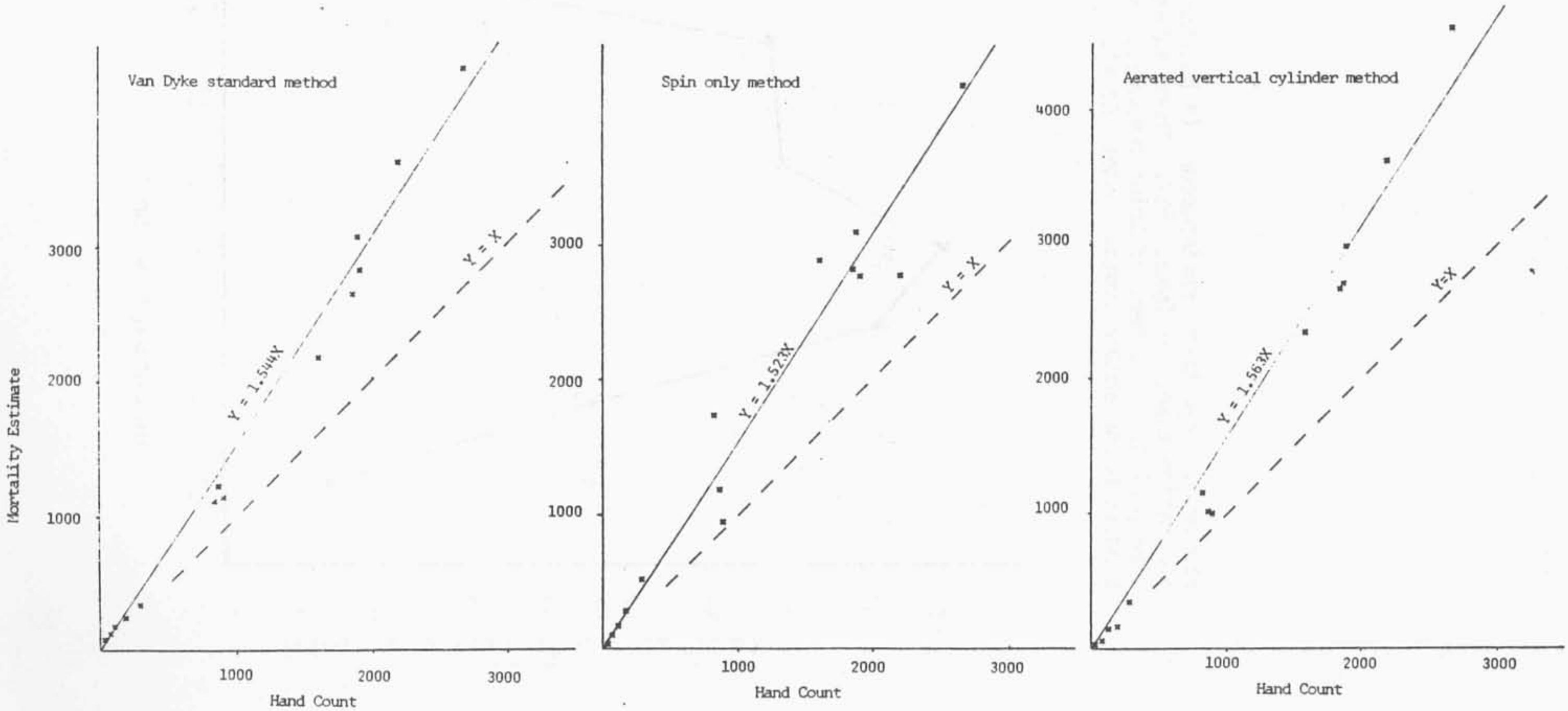

Figure 8. Mean brine shrimp count (# hatched nauplii/0.1ml) vs. incubation time, Van Dyke, 1987. Three subsamples counted per time period. 30 liters of brine prepared, 156g solar salt, 99g Sanders brine shrimp cysts. Note: At 41.5 hrs count was zero.

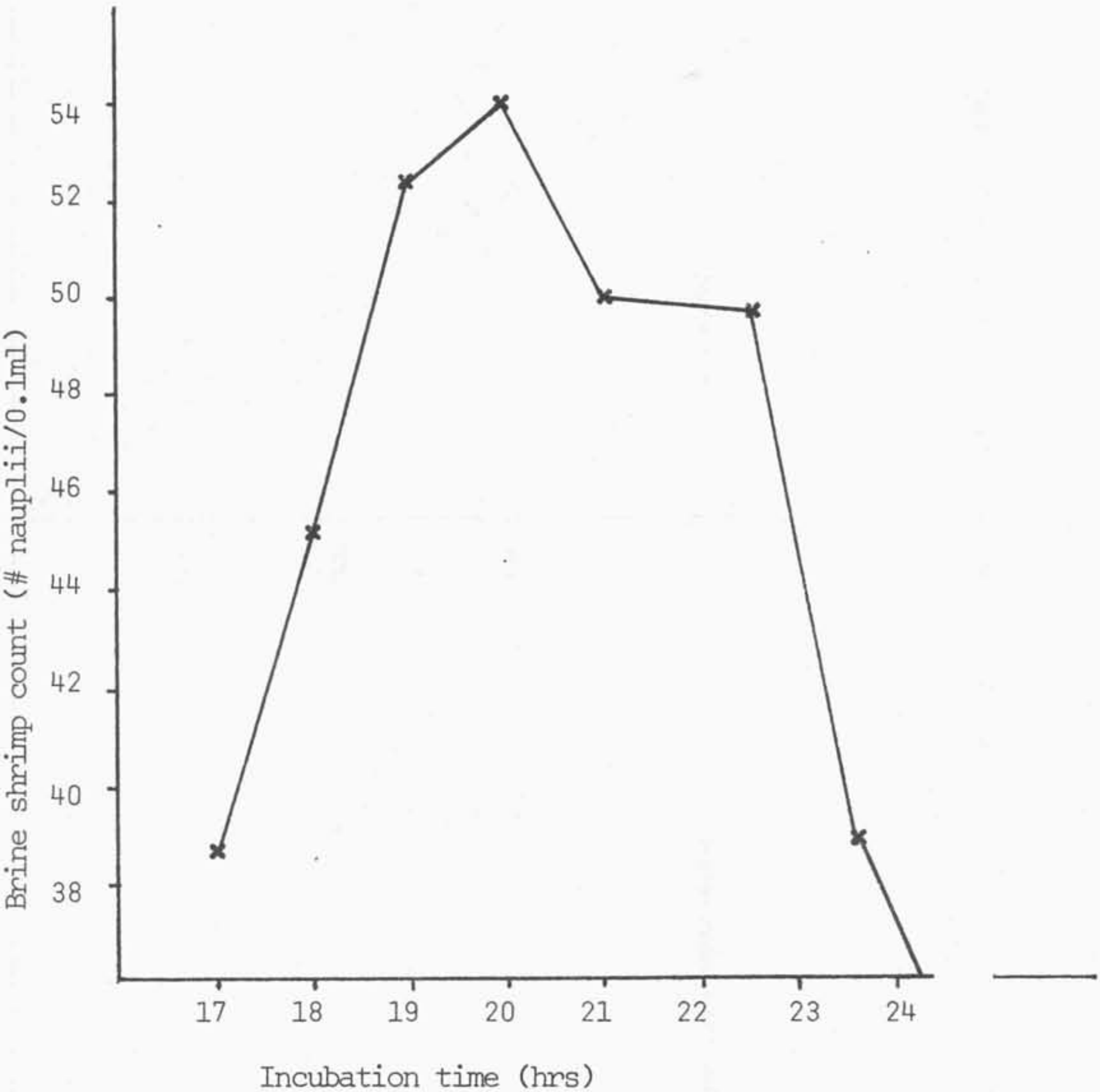

Figure 9. Survival of American shad fry from eggs incubated in 2.5L capacity May-Sloan jars (✚) vs. eggs incubated in new 12.5L capacity mega-jars (●).

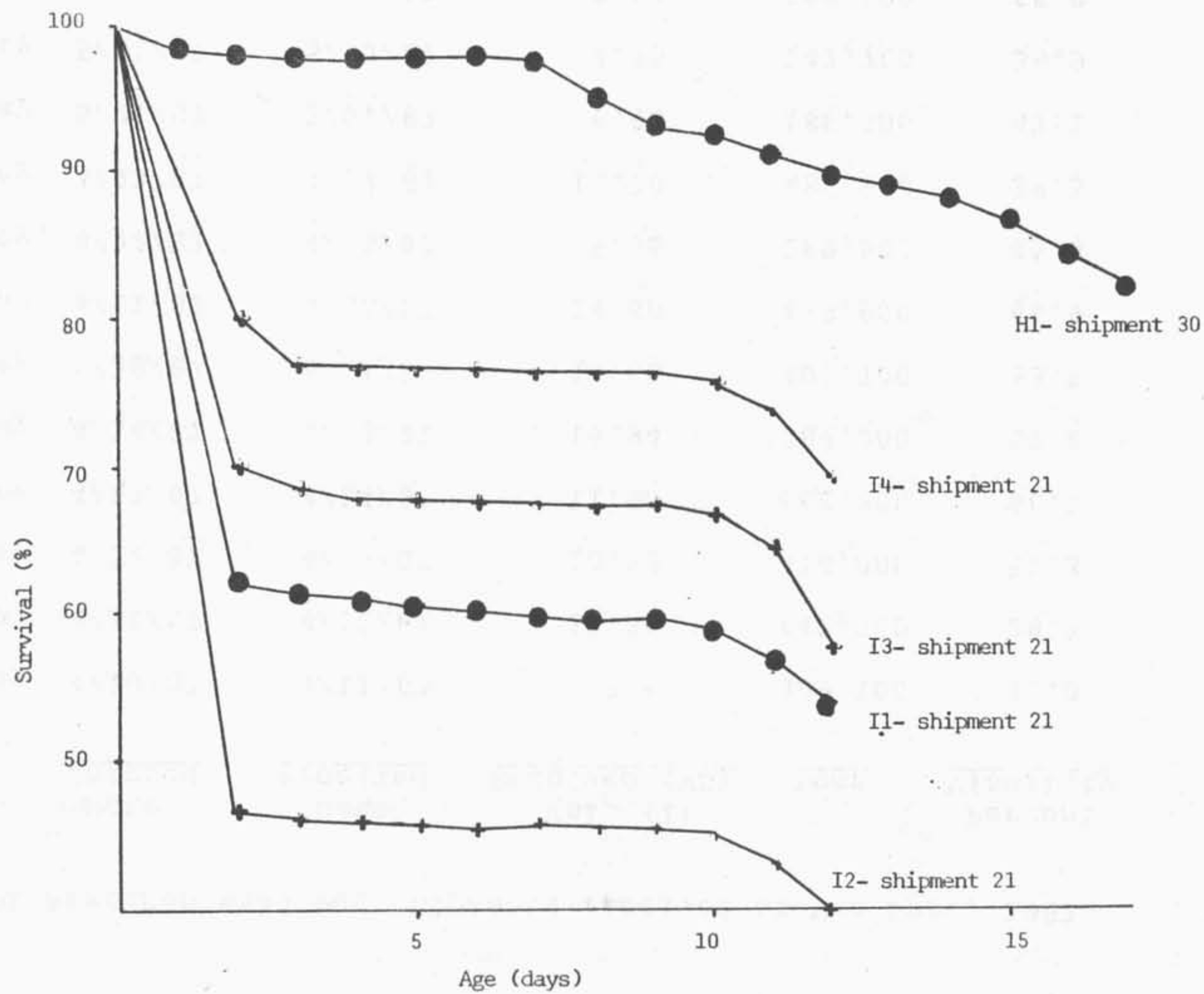

Table 1. Summary of American shad egg shipments received at Van Dyke, 1987.

Shipment Number	River	Date Shipped	Date Received	Vol. (1) Received (VD)	Eggs	Percent Viability	Viable Eggs	Sac Fry
1	Pamunkey	4/10/87	4/11/87	7.6	309,100	37.0	114,500	112,940
2	Pamunkey	4/11/87	4/12/87	13.36	442,000	28.7	127,000	126,240
3	Pamunkey	4/12/87	4/13/87	10.62	414,000	52.3	216,300	214,390
4	Pamunkey	4/13/87	4/14/87	11.90	668,800	68.7	459,400	457,880
5	Pamunkey	4/14/87	4/15/87	16.94	584,200	57.8	337,500	336,710
6	Pamunkey	4/20/87	4/21/87	15.60	405,700	53.9	218,600	200,500
7	Pamunkey	4/21/87	4/22/87	14.60	419,900	66.9	280,700	261,300
8	Pamunkey	4/22/87	4/23/87	9.55	289,500	45.8	132,600	128,600
9	Pamunkey	4/23/87	4/24/87	13.70	482,800	39.5	190,900	182,700
10	Pamunkey	5/01/87	5/02/87	6.00	186,500	47.1	87,800	87,700
11	Pamunkey	5/02/87	5/03/87	4.75	147,700	39.9	58,900	58,570
12	James	5/06/87	5/07/87	3.08	108,100	55.0	59,400	58,300
13	Delaware	5/10/87	5/11/87	22.40	881,700	28.6	251,900	236,800
14	Delaware	5/11/87	5/12/87	27.30	990,000	54.0	534,600	438,300
15	Delaware	5/12/87	5/13/87	23.29	873,800	54.9	479,500	445,300
16	Delaware	5/14/87	5/15/87	25.14	775,900	77.0	597,200	555,200
17	Delaware	5/17/87	5/18/87	27.80	1,036,100	70.3	728,500	687,700
18	Delaware	5/19/87	5/20/87	13.38	449,000	40.0	179,400	157,000

Shipment Number	River	Date Shipped	Date Received	Vol. (1) Received (VD)	Eggs	Percent Viability	Viable Eggs	Sac Fry
19	Columbia	6/01/87	6/02/87	62.90	2,022,800	42.3	856,400	655,400
20	Columbia	6/02/87	6/03/87	68.10	2,231,100	55.2	1,230,500	1,136,300
21	Columbia	6/03/87	6/04/87	63.50	2,002,300	66.7	1,335,100	880,500
22	Columbia	6/04/87	6/05/87	58.90	1,976,700	13.9	275,500	211,700
23	Columbia	6/05/87	6/06/87	31.76	1,119,200	39.6	443,000	363,700
24	Columbia	6/08/87	6/09/87	58.71	1,956,200	46.7	914,400	845,200
25	Columbia	6/09/87	6/10/87	48.10	1,545,000	52.1	805,100	752,900
26	Columbia	6/10/87	6/11/87	40.20	1,329,800	46.9	623,600	556,800
27	Columbia	6/11/87	6/12/87	42.87	1,543,300	36.3	559,500	545,600
28	Columbia	6/12/87	6/13/87	30.90	1,088,900	41.9	456,200	449,800
29	Columbia	6/15/87	6/16/87	12.00	397,000	37.9	150,300	127,000
30	Columbia	6/16/87	6/17/87	12.00	415,100	47.1	195,400	192,400
31	Columbia	6/17/87	6/18/87	61.50	2,034,400	44.4	903,900	876,600
32	Columbia	6/18/87	6/19/87	39.70	1,293,300	53.7	694,800	681,900
33	Columbia	6/19/87	6/20/87	41.40	1,432,400	42.5	608,500	535,000
34	Columbia	6/22/87	6/23/87	34.60	1,144,600	62.1	711,200	675,500
	Pamunkey River		Totals	124.62	4,350,200	51.1	2,224,200	2,167,530
	James River			3.08	108,100	55.0	59,400	58,300
	Delaware River			139.31	5,006,500	55.4	2,771,100	2,520,300
	Columbia River			707.14	23,532,100	45.7	10,763,400	9,486,300
			Grand Total	974.15	32,996,900	47.9	15,818,100	14,232,430

Table 2. Annual Summary of Van Dyke production from 1976-1987.

Year	Egg Vol. (L)	Egg No. (x 6)	Egg Viability (%)	No. of Viable Eg (x 6)
1976	120.3	4.0	52.0	2.1
1977	145.8	6.4	46.7	2.9
1978	381.2	14.5	44.0	6.4
1979	164.8	6.4	41.4	2.6
1980	347.6	12.6	65.6	8.2
1981	286.0	11.6	44.9	5.2
1982	624.3	25.9	35.7	9.2
1983	938.6	34.5	55.6	19.2
1984	1,157.3	41.1	45.2	18.6
1985	814.3	25.6	40.9	10.1
1986	1,535.7	52.7	40.7	21.4
1987	974.2	33.0	47.9	15.8

Shad Stocked (Includes Lehigh and Schuylkill Rivers)

Year	Fry	Fingerlings	Total
1976	518,000	266,000	784,250
1977	968,901	34,509	1,003,410
1978	2,124,000	6,379	2,130,379
1979	629,500	34,087	663,587
1980	3,526,275	5,050	3,531,325
1981	2,029,650	23,620	2,053,270
1982	5,018,800	40,700	5,059,500
1983	4,047,610	98,300	4,145,910
1984	11,995,690	30,500	12,026,190
1985	6,959,990	114,538	7,074,528
1986	15,866,935	61,245	15,928,180
1987	10,273,805	81,459	10,355,264

Year	Fish Stocked/ Eggs Received	Fish Stocked/ Viable Eggs
1976	19.4	37.3
1977	15.9	34.2
1978	14.0	33.0
1979	10.4	25.1
1980	28.3	43.1
1981	17.7	39.3
1982	19.6	54.8
1983	12.0	21.6
1984	-	72.8*
1985	27.9	68.2*
1986	30.2	74.4
1987	31.4	65.5

Total Shad Stocked from 1976 to 1987 = 64,755,793

*Eggs and fish that were not used for stocking purposes were not include

Table 3. Summary of American shad stocking and fish transfer activities, Van Dyke, 1987.

* All tetracycline tags administered at 200 ppm, 6 hour bath except feed tag administered at 40g TC/lb feed + .75g glucosamine/lb food.

**Fish transferred to ponds, raceways and other facilities.

***Data supplied by Delmarva Ecological Lab.

Date	Tanks(s)	Number	Tagging (days)*	Location	Origin	Age (days)	Size
5/6	J1	12,000**	5 & 12 & 19	Rearing Pond	Pamunkey	20	Fry
5/6	J1	21,530**	5 & 12 & 19	Settling Pond	Pamunkey	20	Fry
5/7	A1	120,370	5	Thompsontown	Pamunkey	18	Fry
5/7	J2	71,470	5	Thompsontown	Pamunkey	20	Fry
5/11	B2, F4	181,600	5 & 12	Lapidum, MD	Pamunkey	20, 21	Fry
5/11	F1	203,420	5 & 12	Lapidum, MD	Pamunkey	21	Fry
5/12	F3	162,345**	5 & 12 & 19	Canal Pond	Pamunkey	21	Fry
5/12	B1	409,250**	5 & 12 & 19	B.S. Ponds (2)	Pamunkey	21	Fry
5/15	A2	186,710	5	Thompsontown	Pamunkey	18	Fry
5/18	B3	5,000**	5 & 12	B.S.Raceway F3	Pamunkey	18	Fry
5/18	B4	5,000**	5 & 12	B.S.Raceway F4	Pamunkey	17	Fry
5/18	A3,A4,B3	358,280	5 & 12	Lapidum, MD	Pamunkey	18	Fry
5/19	B4	62,960	5	Thompsontown	Pamunkey	19	Fry
5/19	C1	94,990	5	Thompsontown	Pamunkey	19	Fry
5/26	C2	71,660	5	Thompsontown	Pamunkey	18	Fry
5/27	C3	51,620	5	Thompsotown	Pamunkey	18	Fry
5/30	C4	40,120	5	Thompsontown	James	18	Fry
6/1	D1	1,000**	5 & 10	B.S.Raceway D3	Delaware	14	Fry
6/1	D2	1,000**	5 & 9	B.S.Raceway D4	Delaware	14	Fry
6/1	D3	1,000**	5 & 8	B.S.Raceway E3	Delaware	14	Fry
6/1	D4	1,000**	3	B.S.Raceway E4	Delaware	14	Fry
6/1	E1	5,000**	5	B.S.Raceway F4	Delaware	13	Fry

Table 3 (continued).

Date	Tanks(s)	Number	Tagging (days)*	Location	Origin	Age (days)	Size
6/4	D1,D2,D3,D4	194,575	3, 5 & 8 5 & 9, 5 & 10	Schuylkill R.	Delaware	17	Fry
6/5	E1,E2,E3, E4, F2	490,730	5	Lehigh R.	Delaware	17, 15	Fry
6/8	G1,G2,G3,G4	624,975	5 & 12	Lapidum, MD	Delaware	17	Fry
6/10	F1, F3	191,040**	5 & 19	Del.Ecol.Lab	Delaware	20	Fry
6/11	H1	163,780	5	Thompsontown	Delaware	18	Fry
6/11	H2	146,370	5	Thompsontown	Delaware	18	Fry
6/12	H3	152,100	5	Thompsontown	Delaware	19	Fry
6/13	H4	140,130	5	Thompsontown	Delaware	18	Fry
6/22	I1	161,120	5	Thompsontown	Columbia	12	Fry
6/22	I2	118,440	5	Thompsontown	Columbia	12	Fry
6/22	I3	214,100	5	Thompsontown	Columbia	12	Fry
6/22	I4	253,420	5	Thompsontown	Columbia	12	Fry
6/27	A1	187,510	5	Thompsontown	Columbia	18	Fry
6/27	A2	145,860	5	Thompsontown	Columbia	18	Fry
6/28	A3	118,580	5	Thompsontown	Columbia	19	Fry
6/28	A4	107,840	5	Thompsontown	Columbia	19	Fry
6/29	B1,B2,B3,B4	1,047,860	5 & 12	Lapidum, MD	Columbia	19	Fry
7/1	C1	85,370	5	Thompsontwon	Columbia	19	Fru
7/1	C2	69,920	5	Thompsontown	Columbia	19	Fry
7/3	C3	153,480	5	Thompsontown	Columbia	19	Fry
7/3	C4	154,300	5	Thompsontown	Columbia	19	Fry
7/4	E1	186,390	5	Thompsontown	Columbia	18	Fry
7/4	E2	171,040	5	Thompsontown	Columbia	18	Fry
7/5	E3	265,140	5	Thompsontown	Columbia	19	Fry
7/6	D1,D2,D3,D4	748,340	5 & 12	Lapidum, MD	Columbia	20	Fry
7/7	E4	167,410	5	Thompsontown	Columbia	20	Fry
7/7	F1	195,380	5	Thompsontown	Columbia	20	Fry
7/7	F2	115,950	5	Thompsontown	Columbia	20	Fry
7/8	F3,F4,G1,G3	629,325	5 & 12	Lapidum, MD	Columbia	20, 19	Fry
7/9	G2	155,225	5	Thompsontown	Columbia	20	Fry
7/10	G4	105,780	5	Thompsontown	Columbia	18	Fry
7/11	H1	161,180	5	Thompsontown	Columbia	18	Fry
7/12	I3	158,900	5	Thompsontown	Columbia	18	Fry

Table 3 (continued).

Date	Tanks(s)	Number	Tagging (days)*	Location	Origin	Age (days)	Size
7/12	I4	194,110	5	Thompsontown	Columbia	18	Fry
7/14	I1	165,150**	5	Trans. to K1	Columbia	20	Fry
7/14	I2	183,015**	5	Trans. to K2	Columbia	20	Fry
7/17	A1,A2,J4	614,910	5 & 12	Lapidum, MD	Columbia	18, 19	Fry
7/19	K1	104,450	5	Thompsontown	Columbia	25	Fry
7/19	K2	126,615	5	Thompsontown	Columbia	25	Fry
8/14	Rearing Pond	309	5 & 12 & 19 Feed (115-117)	Thompsontown	Pamunkey	120	Fing.
8/25	Canal Pond	60,000	5 & 12 & 19 Feed (119-121)	Thompsontown	Pamunkey	126	Fing.
10/8	BS Pond 2	7,050	5 & 12 & 19 Feed (142-144)	Thompsontown	Pamunkey	170	Fing.
10/16	BS Pond 3	14,100	5 & 12 & 19 Feed (142-144)	Thompsontown	Pamunkey	178	Fing.

	Number	Age at TC Tagging: Immersion	Age at TC Tagging: Feed	Stocking Location	Size
Stocking Summary	5,179,790	5	-	Thompsontown	Fry
	4,408,710	5 & 12	-	Lapidum, MD	Fry
	194,575	3, 5 & 8 5 & 9, 5 & 10	-	Schuylkill R.	Fry
	490,730	5	-	Lehigh R.	Fry
	309	5 & 12 & 19	115-117	Thompsontown	Fing.
	60,000	5 & 12 & 19	119-121	Thompsontown	Fing.
	21,150	5 & 12 & 19	142-144	Thompsontown	Fing.
	25,000***	5 & 19	-	Elkton, MD	Fing.

Table 4. Production and utilization of juvenile American shad at the Van Dyke Research Station, 1987.

Fry released into the Juniata River	5,179,790
Fry released into the Susquehanna River below Conowingo Dam	4,408,710
Fry released into the Lehigh River	490,730
Fry released into the Schuylkill River	194,575
Fry released into ponds at Van Dyke and Ancillary Facilities	195,875
Fry provided to Benner Spring Research Station	428,250
Fry provided to Delmarva Ecological Lab	191,040
Total Fry Production	11,088,970
Total Number of Viable Eggs	15,818,100
Survival (%) of all fry	70.1%
Fingerlings Released into the Juniata River:	
From the Rearing Pond (Van Dyke)	309
From the Canal Pond (Thompsontown)	60,000
From the Benner Spring Ponds	21,150
Total Fingerling Production	81,459

Table 5. Summary of tetracycline tagging research, Van Dyke, 1987. CP - Canal Pond, BSP2 - Benner Spring Pond 2, BSP3 - Benner Spring Pond 3. Immersion tags all 200 ppm tetracycline, 6 hour bath. Feed tags all 40 g TC/lb food, plus .75 g glucosamine/lb food, fed to satiation for 3 days after 2 days of starvation.

Tank/ Pond Raceway	Shipment #	Date Collected	Tag Type	Age at Tagging (days)	18 Day Survival (%)	Tag Efficiency % 1°	2°	3°	4°	No. Examined For Tags	Age (days)
E-1/F-4	14	9/3	Bath	5	65.7	100.0				60	107
B-3/F-3	8	9/3	Bath	5, 12	84.6	100.0	100.0			60	126
D-4/E-4	13	9/3	Bath	3	69.1	100.0				30	108
D-3/E-3	13	9/3	Bath	5, 8	64.2	100.0	100.0			30	108
D-1/D-3	13	9/3	Bath	5, 10	86.0	100.0	100.0			30	108
D-2/D-4	13	9/3	Bath	5, 9	83.8	100.0	100.0			30	108
F-3/CP	5	8/25	Bath Feed	5, 12,19/ 119-121	95.1	100.0	100.0	100.0	100.0	20	126
B-1/BSP2	4	10/8	Bath Feed	5, 12, 19/ 142-144	98.3	100.0	100.0	100.0	100.0	20	170
B-1/BSP3	4	10/16	Bath Feed	5, 12, 19/ 142-144	98.3	95.0	100.0	100.0	95.0	20	178

Table 6. Mortality of American shad fingerlings fed various concentrations of tetracycline laced feed, Van Dyke, 1987. *Tanks erroneously combined prior to stocking. **TC laced feed administered.

Tank	B1	B2	B3	C2	C3
TC Concentration (g TC/lb food)	Control	10	20	30	40
Glucosamine Concentration (g/lb food)	Control	0.75	0.75	0.75	0.75
Initial Density	101	58	79	*167	

Daily Mortality

Day	B1	B2	B3	C2	C3
1	16	1	14	8	2
2	6	1	4	6	0
3	2	0	1	0	0
4	1	1	3	1	1
5-18	5	4	2	6	0
**19	0	0	1	2	0
**20	0	0	1	2	0
**21	0	1	0	0	0
22	0	0	0	0	0
23	0	1	1	0	0
24	0	0	1	0	1
Total	30	9	28	25	4
Final Density	71	49	51	138	
Survival	70%	84%	65%	83%	

Table 7. American shad egg survival after disinfection with Argentyne disinfectant for 10 minutes, 1987. 50,000 eggs treated per lot. Treatment approximately 7 hours after fertilization.

	Number of Live Eggs				
Argentyne Concentration (ppm)	0	25	50	75	100
Shipment 3	33,200	29,200	29,800	27,500	19,200
4	30,100	33,700	32,400	30,000	31,700
6	42,700	41,100	39,100	36,000	22,600
7	41,700	41,100	43,900	37,100	33,500
8	25,900	27,000	26,100	22,500	18,100
Total	173,600	172,100	171,300	153,100	125,100
Mean	34,720	34,420	34,260	30,620	25,020
Mean % Survival	69.4	68.8	68.5	61.2	50.0

F = 1.82 no significant difference at a = .05

Table 8. Survival of American shad eggs and fry after disinfection with Argentyne disinfectant for 10 minutes, 1987. 250,000 eggs treated per lot. Treatment approximately 7 hours after fertilization.

		Shipment									
	Iodophore	14		15		16		17		Mean	
	Concentration	No.	%	No.	%	No.	%	No.	%	No.	%
No. of eggs surviving (x10^2)	Control	1,264	50.6	1,467	57.8	2,090	83.6	1,923	76.9	1,686	67.4
	75 ppm	1,393	55.7	1,359	54.4	1,881	75.2	1,851	74.0	1,621	64.8
	100 ppm	1,465	58.6	1,430	57.2	1,821	72.8	1,803	72.1	1,630	65.2
No. of fry surviving to 17 days (x10^2) (% of initial egg total)	Control	830	33.2	1,001	40.2	1,728	69.1	1,638	65.5	1,299	52.0
	75 ppm	981	39.2	1,029	41.2	1,489	59.6	1,464	58.6	1,241	49.6
	100 ppm	933	37.3	910	36.4	1,417	56.7	1,521	60.8	1,195	47.8
Fry Survival, hatch to day 17	Control		65.7		68.2		82.7		85.2		77.1
	75 ppm		70.4		75.7		79.2		79.1		76.5
	100 ppm		63.7		63.6		77.8		84.4		73.3

Table 9. Survival of American shad fry fed different dry diets (64.5 g/250,000 fish-day) as a supplement to live brine shrimp (12 brine shrimp/fish-day) at Van Dyke, 1987.

Dry Diet	Tank	Shipment	Hatch Date	Initial Tank Density		18-day Survival (%)
AP100-1986 (Frozen)	A4	7	4/30	116,800		89.4
AP100-1987 (Fresh)	A3	7	4/30	163,800		86.5
AP-100	B4	9	5/1	78,400		80.3
	C2	22	6/12	132,000		53.7
	C4	23	6/14	244,000		65.7
					$\bar{x}$	66.6
ABM-4100	C1	9	5/1	112,500		84.4
	C1	22	6/12	143,500		61.9
	C3	23	6/14	199,000		81.0
					$\bar{x}$	75.4

Table 10. Four-day survival of quick-released and conventionally released American shad fry, 1986 and 1987.

Replicate	Tank	Initial Density	20 Day Density	20 Day S (%)	24 Day Density	24 Day 4 Day (%)	Total Survival
1-86	QR 13/K1	146,300	72,850	49.8	48,850	62.9	31.3
1-86	Conventional 14/K2	162,200	103,180	63.6	74,080	71.8	45.7
2-86	QR 11/K2	298,100	232,080	77.9	184,780	79.6	69.1
2-86	Conventional 12/K1	221,200	184,480	83.4	23,400*	12.7*	12.6
3-87	QR I1/K1	277,900	165,150	72.5	122,850	74.4	53.9
3-87	Conventional I2/K2	222,100	183,015	82.4	139,515	76.2	62.8

*Water flow to tank shut off, mortalities unrelated to stocking methods.

Table 11. Estimated numbers of eggs in five lots of American shad eggs using the von Bayer dry volume method, Van Dyke, 1986 and 1987.

Lot	Hand Count	# In 12" Trough	Vol.	von Bayer Dry Volume Estimate	% Error of Estimate
A-86	20,158	94	.5L	17,049	-15.4
		98	.5L	19,689	-2.3
		92	.5L	16,274	-19.3
		93	.5L	16,655	-17.4
			$\bar{x}$	17,417	-13.6
		Standard deviation		1547	
			C.V.	8.88	
B-86	16,096	90	.5L	15,198	-5.6
		89	.5L	14,532	-9.7
		89	.5L	14,532	-9.7
		89	.5L	14,532	-9.7
		91	.5L	15,545	-3.4
		94	.5L	17,049	5.9
			$\bar{x}$	15,231	-5.4
		Standard deviation		987	
			C.V.	6.48	
C-87	19,846	98	.5L	19,689	-0.8
		94	.5L	17,049	-14.1
		98	.5L	19,689	-0.8
		100	.5L	20,690	4.2
		103	.5L	22,323	12.5
		105	.5L	24,133	21.6
			$\bar{x}$	20,596	3.8
		Standard deviation		2438	
			C.V.	11.84	
D-87	19,188	100	.5L	20,690	7.8
		98	.5L	19,689	2.6
		94	.5L	17,049	-11.2
		98	.5L	19,689	2.6
		91	.5L	15,545	-19.0
		95	.5L	17,873	-6.9
			$\bar{x}$	18,422	-4.0
		Standard deviation		1,940	
			C.V.	10.50	
E-87	17,838	92	.5L	16,273	-8.8
		90	.5L	15,197	-14.8
		93	.5L	16,655	-6.6
		93	.5L	16,655	-6.6
		92	.5L	16,273	-8.8
		93	.5L	16,655	-6.6

Table 12. Estimated number of eggs in five lots of American shad eggs using the wet volume method with 300 egg samples, Van Dyke, 1986 and 19

		Wet Volume - 300 egg sample			
Lot	Hand Count	Wet Vol. Sample	Wet Vol. of Lot	Estimate	% Error of Estimat
A-86	20,158	14.5	700	14,483	-28.2
		13.5	680	15,111	-25.0
		13.5	690	15,333	-23.9
			$\bar{x}$	14,976	-25.7
		Standard deviation		441	
			C.V.	2.94	
B-86	16,096	15.5	650	12,581	-21.3
		15.0	650	13,000	-19.2
		15.0	660	13,200	-18.0
		15.5	660	12,774	-20.6
		15.5	660	12,581	-21.8
		15.0	660	13,200	-18.0
			$\bar{x}$	12,889	-19.9
		Standard deviation		286	
			C.V.	2.22	
C-87	19,846	11.5	590	15,391	-22.4
		10.2	590	17,352	-12.6
		11.8	590	15,000	-24.4
			$\bar{x}$	15,391	-19.8
		Standard deviation		1,260	
			C.V.	7.92	
D-87	19,188	10.0	540	16,200	-15.6
		11.0	540	14,727	-23.2
		10.3	540	15,728	-18.0
			$\bar{x}$	15,552	-19.0
		Standard deviation		752	
			C.V.	4.84	
E-87	17,838	10.2	600	17,647	-1.1
		10.8	600	16,667	-6.6
		11.2	600	16,071	-9.9
			$\bar{x}$	16,795	-5.8
		Standard deviation		796	
			C.V.	4.74	

Table 13. Estimated number of eggs in five lots of American shad eggs using the water displacement method with 300 egg samples, Van Dyke, 1986 and 1987.

Lot	Hand Count	Sample Displacement	Displacement - 300 Egg Sample Lot Dis- placement	Estimate	% Error of Estimate
A-86	20,158	10.40	480	13,846	-31.3
		10.20	470	13,824	-31.4
		10.20	470	13,824	-31.4
			$\bar{x}$	13,831	-31.4
		Standard deviation		13	
			C.V.	0.09	
B-86	16,096	11.10	445	12,027	-25.3
		11.00	445	12,136	-24.6
		11.10	460	12,432	-22.8
		10.85	480	13,272	-17.5
		11.90	460	11,597	-27.9
		10.80	490	13,611	-15.4
			$\bar{x}$	12,512	-22.3
		Standard deviation		775	
			C.V.	6.20	
C-87	19,846	7.10	400	16,901	-14.8
		6.40	400	18,750	-5.5
		7.70	400	15,584	-21.5
			$\bar{x}$	17,078	-14.0
		Standard deviation		1,590	
			C.V.	9.31	
D-87	19,188	5.30	380	21,509	12.1
		5.40	380	21.111	10.0
		5.30	380	21,509	12.1
			$\bar{x}$	21,376	11.4
		Standard deviation		230	
			C.V.	1.08	
E-87	17,838	5.10	410	24,118	35.2
		5.30	410	23,207	30.1
		5.60	410	21,964	23.1
			$\bar{x}$	23,096	29.5
		Standard deviation		1,081	
			C.V.	4.68	

Table 14. Estimated number of eggs in five lots of American shad eggs using a combination displacement/wet volume method with 300 egg samples, Van Dyke, 1986 and 1987.

		Displacement/Wet Volume Method - 300 Egg			
Lot	Hand Count	Sample Displacement	Wet Vol. of Lot	Estimate	% Error of Estimate
A-86	20,158	10.40	700	20,192	0.2
		10.20	680	20,000	-0.8
		10.20	690	20,294	0.7
			x̄	20,162	<0.1
		Standard deviation		149	
			C.V.	0.73	
B-86	16,096	11.10	650	17,563	9.1
		11.00	660	17,727	10.1
		11.10	660	17,837	10.8
		10.85	660	18,248	13.4
		11.90	650	16,387	1.8
		10.80	660	18,883	17.3
			x̄	17,683	9.9
		Standard deviation		701	
			C.V.	3.96	
C-87	19,846	7.10	590	24,930	25.6
		6.40	590	27,656	39.4
		7.70	590	22,987	15.8
			x̄	25,191	26.9
		Standard deviation		2,345	
			C.V.	9.31	
D-87	19,188	5.30	540	30,566	59.3
		5.40	540	30,000	56.4
		5.30	540	30,566	59.3
			x̄	30,377	58.3
		Standard deviation		327	
			C.V.	1.08	
E-87	17,838	5.10	600	35,294	97.9
		5.30	600	33,962	90.4
		5.60	600	32,143	80.2
			x̄	33,800	89.5
		Standard deviation		1582	
			C.V.	4.68	

Table 15. Comparison of American shad egg enumeration methods, Van Dyke, 1986 and 1987.

Method		% Error of Estimate	Coefficient of Variation
von Bayer (dry)	A-86	-13.6	8.88
	B-86	-5.4	6.48
	C-87	3.8	11.84
	D-87	-4.0	10.50
	E-87	-8.7	3.50
	$\bar{x}$	-5.5	8.24
Standard deviation		6.4	
Wet Volume (300 egg)	A-86	-25.7	2.94
	B-86	-19.9	2.22
	C-87	-19.8	7.92
	D-87	-19.0	4.84
	E-87	-5.8	4.74
	$\bar{x}$	-18.0	4.53
Standard deviation		7.3	
Displacement (300 egg)	A-86	-31.4	0.09
	B-86	-22.3	6.20
	C-87	-14.0	9.31
	D-87	11.4	1.08
	E-87	29.5	4.68
	$\bar{x}$	-5.4	4.27
Standard deviation		25.2	
Displacement/ Wet Volume (300 egg)	A-86	0.1	0.73
	B-86	9.9	3.96
	C-87	26.9	9.31
	D-87	58.9	1.08
	E-87	89.5	4.68
	$\bar{x}$	37.1	3.95
Standard deviation		36.9	

Table 16. Comparison of mean American shad fry mortalities estimated by three methods, Van Dyke, 1987. Method 1: spin only. Method 2: Van Dyke standard. Method 3: aerated vertical cylinder.

		Mean Estimated Mortalities (5 Replicates)			% Error of Estimate			Coefficient Of Variation Among Replicates		
Tank	Hand Count	Method 1	Method 2	Method 3	Method 1	Method 2	Method 3	Method 1	Method 2	Method 3
C4	28	34	41	25	21	46	-11	1.1	.06	1.5
C3	62	108	120	62	74	94	0	.54	.41	.72
C4	106	168	129	131	58	22	24	.58	.44	.65
H1	178	295	235	162	66	32	-9	.24	.23	.41
E3	280	529	337	340	89	20	21	.30	.51	.34
D3	816	1739	1127	1160	113	38	42	.09	.27	.21
F3	858	1193	1224	1027	39	43	20	.12	.21	.18
H4	889	958	1149	1014	08	29	14	.21	.12	.11
D4	1600	2883	2177	2346	80	36	47	.13	.18	.11
E2	1859	2821	2651	2672	52	43	44	.19	.11	.12
H2	1872	3117	3087	2698	66	65	44	.19	.06	.14
C4	1900	2770	2822	2990	46	48	57	.08	.16	.06
E1	2191	2761	3641	3725	26	66	70	.04	.13	.12
E3	2671	4188	4339	4614	57	62	73	.11	.10	.15
				Mean	57	46	34	.28	.21	.34

Table 17. Comparison of dead egg loss caused by siphoning vs netting dead eggs, Van Dyke, 1987.

Jar	Initial Handling	Initial Wet Vol. (L)	Test Handling	Final Wet Vol. (L)	Net Loss (L)	
408	Netting	0.85	Siphon	0.85	0	)
409	Netting	1.00	Siphon	1.00	0	) Loss due
410	Netting	0.95	Siphon	0.95	0	) to
411	Netting	0.825	Siphon	0.825	0	) siphoning
412	Netting	1.025	Siphon	1.025	0	)
413	Netting	1.00	Siphon	1.00	0	)
414	Netting	1.00	Siphon	1.00	0	)
415	Siphon	0.80	Netting	0.775	0.025	)
416	Siphon	1.00	Netting	0.95	0.05	)
417	Siphon	0.875	Netting	0.85	0.025	) Loss due
418	Siphon	0.925	Netting	0.90	0.025	) to
419	Siphon	0.95	Netting	0.925	0.025	) netting
420	Siphon	0.90	Netting	0.90	0	)

Table 18. Effect of preheating time on brine shrimp hatch, Van Dyke, 1987. All counts taken after approximately 24 hours of incubation.

Preheating Time (h)	Test Date	Count (# Shrimp/.1 ml)		Mean Count
24	5/15	21, 23, 26, 24		23.5
24	5/16	19, 17, 20		18.6
24	5/17	16, 15, 16		15.6
			$\bar{x}$ =	19.2
1	5/15	26, 26, 23, 23		24.5
1	5/16	35, 29, 30		31.3
1	5/17	38, 22, 18		26.0
			$\bar{x}$ =	27.3

Table 19. Viability of American shad eggs incubated in 2.5L capacity May-Sloan jars vs new 12.5L capacity Mega-jars. Brackets indicate when jars have been combined.

Shipment	Egg Jar	Jar Capacity	# of Eggs	# Viable Eggs	% Viable	Rearing Tank
21	195	2.5L	78,800)			
21	196	2.5L	78,800)	139,700	59.1	
21	197	2.5L	78,800)			I4
21	201	2.5L	78,800)			
21	202	2.5L	78,800)	149,500	63.2	
21	203	2.5L	78,800)			
21	214	2.5L	78,800)	77,400	69.7	
21	215	2.5L	32,200)			
21	198	2.5L	78,800)			
21	199	2.5L	78,800)	131,300	55.5	
21	200	2.5L	78,800)			I2
21	207	2.5L	78,800)			
21	208	2.5L	78,800)	167,800	71.0	
21	209	2.5L	78,800)			
21	204	2.5L	78,800)			
21	205	2.5L	78,800)	158,700	67.1	
21	206	2.5L	78,800)			
21	210	2.5L	78,800	48,600	61.7	I3
21	211	2.5L	78,800)	107,000	67.9	
21	212	2.5L	78,000)			
21	213	2.5L	78,000	54,900	69.7	
21	007	12.5L	394,100	302,200	76.2	I1
30	007	12.5L	415,100	195,400	47.1	H1

JOB IV. JUVENILE AMERICAN SHAD OUTMIGRATION ASSESSMENT

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INTRODUCTION

The 1987 juvenile outmigration assessment was a continuation of studies initiated in 1981 to evaluate the effectiveness of adult, fry and fingerling stockings in developing an American shad (Alosa sapidissima) population imprinted to the Susquehanna River. Primary emphasis has been placed on comparing the relative effectiveness of the three stocking methods and documenting growth, abundance and physiological condition of juvenile shad and the temporal distribution of the outmigration.

The 1987 program was very similar to that conducted in 1986 (Young 1987). One major change this year was the termination of seining efforts in the North Branch and mainstem Susquehanna River upstream of York Haven Dam. The primary reason for these collections in previous years was to verify reproduction of adult shad transferred from the Hudson River to Beach Haven on the North Branch and points upstream. Since tetracycline (TC) marking makes such assessments possible by checking marking rates at York Haven Dam, it was determined that collections further upstream were no longer necessary.

The 1987 program included the following elements:

1. Seining at Amity Hall (RM 2) on the Juniata River to collect fish for baseline TC marking rate information and add to our data base on the temporal distribution of the outmigration, juvenile shad growth rates, the incidence of physical deformities, and abundance.

2. Cast net sampling at York Haven and Holtwood Dam forebays, seining at Wrightsville, and strainer/screen sampling at Safe Harbor Dam, Holtwood Dam, Peach Bottom Atomic Power Station (APS), and Conowingo Dam to provide fish for TC mark rate analysis and update the data base relative to those needs listed in 1 above.

3. Seining, meter net sampling, and the use of other specialized stationary gear in the Conowingo tailrace and Susquehanna Flats to verify successful passage of shad through all lower river dams, evaluate the effectiveness of fry stocking efforts in this region, and develop relative abundance indices of juvenile outmigrants.

In addition to these efforts, information was also solicited from resource agencies and environmental consultants who collected shad in programs not directly related to the juvenile evaluation program.

This report includes information provided by Mike Hendricks (Pennsylvania Fish Commission); Tom Koch and Joe Nack (National Environmental Services, Inc.); Ted Jacobson (Ecology III); Paul Heisey, Chris Frese and Timothy Brush (RMC Environmental Services); Ted Rineer (SHWPC); Dale Weinrich (Maryland Department of Natural Resources); and plant personnel at York Haven, Safe Harbor, and Holtwood Dams. The author expresses his appreciation to each of these individuals.

METHODS

North Branch Susquehanna River and Juniata River at Amity Hall

As mentioned previously, there was no seining conducted in the North Branch during 1987. Sampling in this region was limited to daily checks of intake screens at the Susquehanna Steam Electric Station, Beach Haven, from 9 Septembèr through 16 Ocotber and ichthyoplankton tows in the vicinity of the Beach Haven net pen (Job I). Both efforts were conducted by Ecology III.

NES and PFC personnel repeated their routine collection efforts at Amity Hall (RM 2) which were initiated in 1984. On each of seven dates between 31 July and 14 October seining was conducted with a 150 ft. x 6 ft. bag seine (1/2-inch bar mesh) at a standard site located several hundred yards downstream of the PFC access area (Figure 4.1). On most dates three seine hauls were conducted, beginning at 1/2 hour after sunrise and repeated at 1/2 hour intervals (Table 4.1). Fork lengths and total lengths were measured for up to 35 fish per sample, and fish were subsequently frozen in water to be analyzed later for TC marks. Fish collected other than shad were identified by species and released.

Migration Through Susquehanna River Hydroelectric Impoundments

Sampling areas on the Susquehanna River downstream of the Juniata River confluence (RM 85) are shown in Figure 4.1. NES sampled the York Haven Dam forebay (RM 56) with a 20 ft. x 3/8 inch bar mesh cast net on eight occasions between 9 September and 29 October (Table 4.2). Sampling intervals were one to two weeks.

PFC/NES personnel sampled at Wrightsville (RM 43) on eight occasions between 16 July and 8 October (Table 4.3). Sampling gear consisted of a 300 ft. x 7 ft. x 3/8 inch bar mesh haul seine on each date and a 215 V DC boat mounted electrofishing unit on 16 July. All seine hauls were conducted on the west shoreline between the PA Rt. 462 and U.S. Rt. 30 bridges.

Sampling at Safe Harbor Dam (RM 32) consisted of daily checks of the cooling water intake strainers from 8 October when shad were first observed by plant personnel, to 6 December (Table 4.4) and 8 ft. x 8 ft. lift net samples collect on six occasions between 1 October and 23 October by RMC (Table 4.5). The purpose of the RMC sampling was to collect test fish for use in radiotelemetry studies.

NES sampled the Holtwood Dam forebay (RM 25) with cast nets on eight occasions between 17 September and 23 November (Table 4.6). As at York Haven, sampling intervals were one to two weeks. RMC also sampled at Holtwood Dam, again using a lift net to collect shad for their radiotelemetry studies. Lift net sampling was conducted on 35 days between 10 September and 8 December (Table 4.7). Holtwood plant personnel again made daily checks of revolving screens throughout the migration period.

RMC sampled intake screens at Peach Bottom APS and strainers at Conowingo Dam during 1987. Peach Bottom screens were sampled weekly from 19 October through 23 November. Sampling effort was reduced in 1987 at Peach Bottom compared to previous years because of a plant shutdown and the fact that only one circulation pump was in operation. Conowingo strainers were sampled weekly from 15 October through 10 December.

Daily subsamples of up to 52 shad from each of the above sites were measured (FL) and frozen in water for subsequent tetracycline analysis. All remaining fish were released alive immediately after capture.

Juvenile Assessment Downstream from Conowingo Dam

RMC sampled the Conowingo tailrace (RM 10) with three types of experimental gear during 1987. A 1.0 m diameter hoop net (1/2-in. mesh) secured to the stoplog gallery with a 150-ft rope was deployed below the small turbine units on 18 occasions and below the large units on one occasion between 5 October and 3 December (Table 4.8). A 1/2-meter diameter hoop net anchored to the gallery railing with a 300-ft. rope was deployed on six occasions below the large units between 13 October and 12 November. The third gear type was a 5-ft. x 5-ft. platform net anchored by two ropes below small unit No. 5. The platform net was deployed six times between 13 October and 12 November. This same gear was used by RMC during the 1983 project year.

The Maryland Department of Natural Resources (MDNR) continued their two-phased juvenile assessment work below Conowingo Dam. The initial phase of this work, which runs from July through October (see Job VII), consists of weekly collections of one otter trawl tow and one seine haul (200' x 10' with 1/4" stretched mesh) at each of eight sites located in the lower Susquehanna River and Susquehanna Flats (Figure 4.2). This phase of the MDNR study is designed to measure yearclass strength resulting from shad reproduction in this region, and relative abundance of hatchery tagged shad fry stocked at Lapidum. A total of 4.4 million shad fry were stocked this year at Lapidum.

The second or outmigration phase of the MDNR study consisted of one seine haul at each of six sites (Figure 4.2) twice per week in November and December (Tables 4.9 and 4.10). NES and PFC provided assistance to the MDNR on four occasions during 1987 in an attempt to increase total sampling effort. All juvenile shad collected in the above sampling efforts were frozen in water and transported to the PFC Benner Spring Laboratory for otolith analysis.

Tetracycline Mark Detection Analysis

As noted under Job III all hatchery reared shad were marked with tetracycline (TC) to allow later differentiation from the progeny of adult transfers. The 5.18 million fry stocked at Thompsontown were given a single 200 ppm immersion mark at 5 days of age. The 4.4 million fry stocked below Conowingo Dam at Lapidum were given a double immersion tag on days 5 and 12. A total of 81,459 fingerling shad were stocked at Thompsontown. All received a triple immersion tag on days 5, 12 and 19, as well as a feed tag. A total of 191,000 double immersion marked fry were provided to the Delmarva Ecological Lab for subsequent rearing to fingerling size in ponds. The 25,000 fingerlings which survived were stocked in the Elk River at Elkton, MD. All TC marking procedures are summarized in Table 3 of Job III.

As mentioned earlier, juvenile shad collected from the field were frozen in water, usually within 3-5 hours of capture, and transported to the PFC Benner Spring Research Lab for analysis. Otoliths from up to 52 fish from each daily sample were surgically removed, mounted on slides with permount, ground and polished on both sides, and viewed microscopically under UV light for detection of the fluorescent TC ring(s).

Ninety-five shad were examined from Amity Hall, 203 from York Haven, one from Wrightsville, 18 from Safe Harbor, 184 from Holtwood, 26 from the Conowingo Dam and tailrace and 4 from the lower river. A total of 526 control specimens were also examined. Differences in mark rates between Amity Hall and York Haven would indicate reproduction of Hudson River adults which were stocked at Beach Haven (Job I), while differences between rates at either of these sites and Holtwood would indicate reproduction of adult shad transported from the Conowingo fish lift to the Safe Harbor Pool (Job VI). Marking rates at the three sites were compared using a K-sample binomial test for equal proportions (Marascuilo and McSweeney, 1977). Samples at the remaining sites were not compared statistically.

RESULTS

North Branch Susquehanna River and Juniata River at Amity Hall

No American shad were collected during the daily intake screen sampling from 9 September through 16 October at the Susquehanna SES or in numerous ichthyoplankton tows made in the vicinity of the Beach Haven net pen (Job I). As in previous years, shad were readily collected at the Amity Hall site (Juniata RM 2). A total of 256 shad were collected in 21 seine hauls and catches ranged from 44.7 to 0.8 fish per haul for the four samples collected between 31 July and 10 September (Table 4.1). Temperature ranged from 81°F to 70°F during this period. No shad were collected in the three later attempts as water termperature declined from 62°F on 24 September to 49°F on 14 October. Shad ranged in size from 48-105 mm FL and sample means ranged from 78 mm on 31 July to 99 mm on 1 September (overall mean size = 80 mm). Ten fish species other than American shad were also collected at Amity Hall (Table 4.11).

York Haven Dam (RM 56)

In 36 cast net throws at York Haven from 9 September to 20 October, 440 American shad were collected (Table 4.2). Water temperature ranged from 71°F to 52°F during this period. Catch rates ranged from 0.3 fish per cast on the first sample date to 54.3 fish per cast on 8 October. Peak catches were observed between 18 September and 14 October and the overall mean catch per effort was 12.2. No shad were collected on 29 October as water temperature declined to 46°F and sampling was terminated.

Fork lengths of collected shad ranged from 91 to 136 mm at York Haven (Table 4.2). Daily sample means ranged from 102 mm on 24 September to 127 mm on 9 September and the combined mean was 110 mm. The only other species collected with cast nets at York Haven were spottail (Notropis hudsonius) and spotfin shiners (N. spilopterus) and these were collected on 27 September only. Spotfins were particularly abundant and hundreds were collected.

Wrightsville (RM 43)

In 45 minutes of electrofishing and 18 seine hauls distributed among eight different sample dates at Wrightsville, only one American shad was collected. This fish was collected on 2 September at a water temperature of 72°F and measured 113 mm. Though 14 other species were collected at Wrightsville (Table 4.11), numbers of all fish were typically low. One reason for these low catches is believed to be a failure to sample the deeper water of the seine site adequately. A large section of the 300-ft. seine was replaced prior to the 1987 sampling season and the effective depth of the heavily tarred net was found to be 6 feet or less compared to 7 feet in previous years.

Safe Harbor Dam (RM 32)

American shad were first collected from strainers at Safe Harbor Dam on 8 October and 95 were collected from this date through 8 November (Table 4.4

The highest daily catches were seen on 8 October (12 fish) and 12 October (19 fish). Daily catches never exceeded 3 fish after 18 October. Although the identification of these fish was not verified this year, Safe Harbor officials stated that all fish reported were American shad and not gizzard shad, of which hundreds were also observed. Water temperature during the time of shad occurrence ranged from 58°F on 8 October to 49°F on 8 November.

RMC collected 65 shad in 131 lifts with the lift net at Safe Harbor for an overall catch rate of 0.5 shad per lift (Table 4.5). Shad were first collected with the lift net on 1 October, seven days earlier than they were seen in the strainers. Water temperature at that time was 64°F. Daily catch rates declined from 0.66 shad/lift on 1 October to zero on 14 and 18 October, then increased to 1.2 shad/lift on 23 October, the last collection date.

Holtwood Dam (RM 25)

A total of 1,054 juvenile shad and 27 adult shad were collected with cast nets by NES and lift nets by RMC in the Holtwood forebay. RMC collected shad in their first attempt on 10 September, and in 407 lifts through 8 December, 832 juvenile and 24 adult shad were taken (Table 4.7). Daily catch rates averaged 2.3 juvenile shad per lift and ranged from 12.3 on 20 October to zero on 12 November and all attempts after 20 November. Catches never exceeded 3.0 fish per lift before 13 October or after 6 November. Water temperature declined from 72°F on the first sample date to 47°F on 20 November, the last day shad were observed. The highest daily catch of adult shad was eight on 18 September and catches of up to three adults per day occurred sporadically through 2 November, the last day adults were seen.

As noted earlier, the purpose of the RMC collections was to provide juvenile shad for a radiotelemetry study. Of the 832 juveniles collected, 223 were transported to the RMC Muddy Run Lab for tagging experiments, 541 were transported upstream and released with radiotagged fish at various sites below Safe Harbor Dam, and the remaining 68 juveniles were released immediately at the collection site. All adult shad were released immediately after capture.

NES collected 222 juveniles and 3 adult shad in 67 cast net samples in the forebay (Table 4.6). The mean daily catch rate prior to 23 November when no shad were taken, was 3.6 fish per cast and peak catches of 24 - 27.5 shad/cast occurred on 14, 20 and 29 October. Catches did not exceed 1 fish per cast on any other date. The 3 adult shad collected by NES were taken on 17 September, the first sample date.

Fork lengths of juvenile shad ranged from 89 to 143 mm at Holtwood and averaged 110 mm (Table 4.6). Daily means ranged from 107 mm on 14 October to 138 mm on 13 November. The 3 adult shad collected by NES ranged from 415 to 460 mm total length. At least five fish species other then American shad were collected at Holtwood (Table 4.11) but gizzard shad were by far the most abundant. No juvenile shad were collected from the revolving screens at the Holtwood SES this year.

Peach Bottom (RM 18) to Conowingo Dam (RM 10)

No American shad were collected at Peach Bottom this year which was not unexpected since water intake was limited to one circulator pump. Fourteen shad were collected by RMC in the strainers at Conowingo Dam (Table 4.4). Shad were first taken in this manner on 22 October and were last taken on 25 November, though sampling continued through 10 December.

One additional shad was taken by RMC on 3 October with an otter trawl near a boat dock about 8 miles upstream from the dam on the east shoreline.

Conowingo Dam Tailrace

Twenty-six American shad were collected by RMC in their experimental netting effort in the Conowingo tailrace (Table 4.8). The first fish was taken on 16 October and the last on 23 November. The peak catch of 17 fish occurred on 21 October. Water temperature during the period ranged from 56°F to 45°F. All of the shad collected in the tailrace were taken below the small turbine units with the 1 meter diameter hoop net. Numerous difficulties were experienced with the other two gears used. The half meter hoop net was used below the large units only and the net was difficult to retrieve from the very turbulent waters there. On 12 November this net was destroyed when the net was torn from the frame. The major problem experienced with the 5-ft x 5-ft frame net was the frequent entanglement of the submerged frame with the anchor ropes resulting from constantly changing flows and turbulence in the tailrace.

A total of 178.38 net hours were expended with the three gears; 15.91 hours with the 0.5 m hoop net, 137.67 hours with the 1.0 m net, and 24.8 hours with the frame net. Sampling occurred at various times of day, with 43 total net hours expended before noon, 64 net hours expended from noon to 6 p.m., and 72 net hours between 6 p.m. and shutdown. All but two of the shad collected were netted after 6 p.m. (Table 4.8).

Only 3 of the 26 shad were alive at the time the net was retrieved. One fish was decapitated, several had minor hemorrhaging in the head, and most were missing some scales. Lacerations were not evident on the dead shad. It was not possible to determine whether the netting procedure or turbine passage was the primary cause of the injuries and mortalities observed. It should be noted that 3,570 fish from five other species were taken in the experimental gear. These included 3,558 gizzard shad, nine channel catfish, one comely shiner, one black crappie and one pumpkinseed (Table 4.8).

Results Below the Conowingo Tailrace

Four shad were collected this year in the waters downstream of the Conowingo tailrace. All were taken by otter trawl during the juvenile recruitment phase of the Maryland DNR program (Table 4.12). Three shad were taken at the Battery Island site, one each on 4 August, 22 September, and 19 October. The remaining shad, aged by both scales and otoliths as I+ was collected on 14 July at Tydings Park. The juveniles ranged from 104 to 134 mm total length and the yearling was 144 mm.

No shad were taken in 51 hauls with the 200-ft seine and 26 hauls with the 300-ft seine during the outmigration phase of the study (Tables 4.9 and 4.10). Water temperatures declined from 60°F when this phase of the study commenced on 4 November to 38°F on 15 December when it ended. Thirty-eight species other than shad were collected in the Maryland portion of the Susquehanna River this year (Table 4.11).

Tetracycline Mark Analysis

Results of the TC marking analysis are presented in Table 4.13. Marking rates approached 95-100% at all sites above the Conowingo tailrace except Holtwood (90.8%). All four shad collected below the Conowingo tailrace were unmarked. The three juveniles were determined to be of wild origin, whereas the yearling showed an otolith pattern resembling that of hatchery fish.

Marking rates at Amity Hall, York Haven and Holtwood, when compared using the K-sample binomial test for equal proportions (Marascuilo and McSweeney, 1977), were found to be different at the α = .05 significance level. Scheffé type *post hoc* comparisons (ibid.) revealed that marking rates at Holtwood (90.8%) differed from those at both Amity Hall (98.9%) and York Haven (99.5%). The 95% confidence intervals for the marking rate at Holtwood was determined to be 85.8% to 97.8% using the method presented in Zar (1984: 378). Confidence intervals at York Haven and Amity Hall were calculated to be 97.2 - 100% and 94.3 - 100%, respectively.

It should be noted that of the 17 unmarked fish collected at Holtwood, 13 were collected on 17 September, the first NES sampling date, and the resulting marking rate for that date was only 19%. This raises the possibility that substantial numbers of wild fish could have emigrated prior to the start of the juvenile evaluation program. One final observation is that 27 juveniles bore the feed mark which was given to fish stocked as fingerlings (Table 4.13).

Deformities

Of 515 juvenile American shad examined, 16 (3.1%) exhibited a physiological deformity. The 95% confidence intervals for deformity rate in the total population was calculated to be 1.8% to 5.1% using the method presented in Zar (1984: 378) for binomially distributed statistics. Thirteen (81%) of the deformed fish had the same shortened lower jaw anomaly which has been seen in previous years. Two of these were collected at Amity Hall, four at York Haven and seven at Holtwood. One fish collected at Amity Hall had an extremely short lower caudal fin lobe. One fish from Holtwood had a shortened operculum, and one fish from Safe Harbor had both jaw and operculum deformities.

DISCUSSION

Abundance

In 1987 there were more adult shad transported to the Susquehanna from both the Hudson River and the Conowingo trap than in any previous year of the program. Also, fingerling plants were the second highest since 1981 (Table 4.14). The number of shad fry stocked above Conowingo, however, was exceeded in three of the past 6 years and represented only 53% of the number stocked in 1986 (Table 4.14). The catch rates of juvenile outmigrants at various sites gave conflicting results in comparing annual abundance resulting from the above stockings (Table 4.14). Catch rates from Amity Hall and the Safe Harbor strainers were the second highest recorded yet, exceeded only by catches in 1984, and the strainer catch at Conowingo was larger than that for any previous year. Conversely, the lift net catch rate at Holtwood Dam was the lowest since this gear was first used in 1985. At York Haven, hydroacoustic flux densities of migrating shad were almost the same as those seen last year. Of all gears mentioned, the hydroacoustic and strainer collections are believed to have the highest probability of reflecting actual abundance for reasons discussed in earlier reports. If this is true, the size of the 1987 juvenile shad population could be viewed as roughly equivalent to that in 1986 above York Haven

Dam, and higher than in 1986 at sites below York Haven. However, the fact that catches were so low at Holtwood this year gives cause for reservation in drawing this conclusion below York Haven. Since the vast majority of specimens collected downstream of York Haven were of hatchery origin, the main reason for the above pattern (if it is representative of true abundance) to occur would be lower mortalities from turbines and other factors at York Haven and other points downstream compared to 1986. Another possible explanation would be that abundance increased downstream of York Haven due to the reproduction of adult shad transported to the Safe Harbor pool from the Conowingo lift, coupled with non-representative samples of these fish for TC analysis. This does not seem likely since the TC analyses from sites at or in the vicinity of Safe Harbor and Conowingo dams were done at the same time that the strainer collections were made (Tables 4.4 and 4.13).

Similar hydroacoustic flux densities at York Haven in 1986 and 1987, despite much higher fry stocking in 1986, suggests natural mortality was much higher last year. It is also possible that increased fingerling stockings in 1987 may have moderated the effect of reduced fry stocking to some degree.

Catches of juvenile shad in the Susquehanna River below Conowingo Dam and the Susquehanna Flats were much lower in 1987 than in 1986 (Table 4.14). The fact that no marked juveniles were collected in this region compared to 11 last year suggests that the fry stocking effort at Lapidum was less successful this year than last. The stocking rates were quite similar between years (Table 4.14). Despite this year's poor results, the fact that success was achieved in 1986 is cause for continued stocking of fry at Lapidum. The fact that wild fish were again collected below Conowingo this year is encouraging and suggests that natural reproduction in the Flats may be increasing. However, the low numbers collected preclude more definitive conclusions.

Timing of Migration

The juvenile shad outmigration appeared to begin and end earlier in 1987 than in most previous years. No shad were seen at Amity Hall this year after 10 September (Table 4.1). By comparison, the earliest date of zero occurrence since 1984 had been 14 October at this site. At York Haven, shad were already present on 9 September, the first collection date (Table 4.2), while shad have been observed at York Haven during September in only one of the previous 4 years. The first occurrence at York Haven is usually in mid-October. At Holtwood Dam, shad were collected as early as 10 September this year (Table 4.7), compared to mid-October to early November in preceding years.

The observed change in the timing of the run could have been a function of the timing of major flow events. Outmigration is largely dictated by water temperature and flow. Major pulses in downstream movement typically begin as temperature drops below 60°F and few fish are seen at temperatures below 40°F. Usually autumn rains result in high river flows simultaneously with the drop in temperature. In 1987, fewer shad were found at each site even though temperatures were for the most part warmer than in previous years. For example, the temperature at which shad were last seen at Amity Hall was 70°F in 1987 compared to an average of 61°F in the three previous years.

This same pattern was also seen at York Haven (58°F in 1987 vs. an average of 47°F in 4 previous years), Safe Harbor (49°F vs. 43°F), and Holtwood (44°F vs. 40°F). It is likely then that early high flows and not lower than normal temperatures were a major factor contributing to earlier outmigration in 1987. Flows at Holtwood approached 60,000 cfs in mid-September this year, then declined to under 25,000 cfs for the entire month of October. Conversely, in each year since 1984, flows have typically been under 10-15,000 cfs during September, then increased significantly in October and/or November (see previous SRAFRC reports).

Comparison of Fry, Fingerling, and Adult Stocking

The results of the tetracycline marking analysis show that the vast majority of the shad run in the region upstream from Conowingo Dam was comprised of hatchery reared fish. Marking rates approached or exceeded 95% at all sites above the Conowingo tailrace (Table 4.13). The fact that no viable fry were taken with ichthyoplankton nets in the vicinity of the adult holding pen at Beach Haven, and the marking rate of 99.5% at York Haven suggests that the Hudson River adult transfers were ineffective. Although reproduction of adult shad transferred from out-of-basin sources was verified in 1981 and 1983 in the Susquehanna, the lack of fish in other years and the extremely low numbers of unmarked juveniles at York Haven in both 1986 (6.5%) and 1987 is evidence that the cost-benefit relationship of this program is extremely poor. There is a slight possibility that Hudson River shad released at Beach Haven actually spawned at York Haven or further downstream and the progeny migrated to Holtwood Dam, where marking rates were lowest, before they were collected.

A more likely source of the unmarked fish at Holtwood however is reproduction of adult shad transferred above Safe Harbor from the Conowingo lift. Radiotelemetry studies have shown that these fish are more likely to exhibit typical spawning behavior after stocking than are the Hudson River fish (RMC, 1987).

As mentioned previously, the marking rate of 90.8% at Holtwood was the lowest observed upstream of the Conowingo tailrace. It should be noted that 13 of the total of 17 unmarked shad at Holtwood were collected during the week of 13 September, the first date from which fish were analyzed. Figure 4.3 shows that the RMC lift net catch per unit effort was higher on their first sampling attempt in September than in three subsequent attempts, after which catches again increased. Because shad were already present on the first attempt at Holtwood, the magnitude of what appears to be an early peak in the run is unknown. The fact that the marking rate was very low (19%) suggests a major portion of the run at this time was made up of wild fish. Therefore, some unknown proportion of the run of naturally produced shad was probably missed. Earlier sampling will be needed next year at Holtwood to make certain that samples are collected proportionate to the run.

The recapture of 27 juveniles which had been marked as fingerlings (Table 4.13) allows a comparison of the relative effectiveness of fry to fingerling stocking. Recapture rates were determined using numbers of marked fish recovered after 14 August, the first day fingerlings were stocked (Job III). Using this method, the recapture rate of marked fish was 0.033% (27 recovered/81,459 stocked) for fingerlings compared to

0.008% (417 recovered/5,179,790 stocked) for fry. If the recovery rate for fry and fingerlings accurately portrayed the true relative proportions of fish from the two sources, then the stocking of one fingerling was equivalent to the stocking of 4.1 fry (0.033/0.008). It should be recognized that errors in enumeration of stocked fry and fingerlings are possible with the current techniques and this factor could obviously affect the analysis of recovery rates. The accuracy of the comparisons of fry and fingerling stocking should improve greatly in the future if enumeration and juvenile sampling techniques improve as anticipated.

Growth

The juvenile shad collected this year were smaller than in previous years. The largest juvenile collected anywhere in the system during 1987 was 143 mm FL at Holtwood Dam. Mean length for all shad was 110 mm at both York Haven and Holtwood (Tables 4.2 and 4.6). Conversely, shad in excess of 165 mm were collected in each of the 3 previous years, and average size at the lower river hydroprojects has typically ranged from 125 mm to 140 mm. The reason for this apparent change in growth rate is unclear.

Deformities

The rate of physiological deformities increased to 3.1% this year from 1.6% in 1986. The fact that the incidence of deformity remains quite low suggests that this problem does not pose a significant threat to the restoration effort.

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Table 4.1. Juvenile American shad seine collections (150' x 6' x ½" bar mesh) at Amity Hall (RM 2) on the Juniata River, July-October, 1987.

Date	Time	Shad catch	Effort (# hauls)	Catch/ effort	Mean FL(mm)	Length range(mm)	Water temp(°F)
7/31	0630-0730	134	3	44.7	78	48-90	81
8/13	0650-0750	61	3	20.3	83	61-101	78
9/1	0700-0830	3	4	0.8	99	94-105	75
9/10	0710-0810	58	3	19.3	80	63-90	70
9/24	0745-0845	0	3	0	-	-	62
10/4	1750-1850	0	3	0	-	-	60
10/14	0750-0820	0	2	0	-	-	49
	Totals	256	21	19.7*	80	48-105	

*7/31 thru 9/10 only

Table 4.2. Juvenile American shad cast net collections (20' dia. x 3/8" bar mesh in the York Haven forebay (RM 56), September-October, 1987.

Date	Time	Shad catch	Effort (#casts)	Catch/ effort	Mean FL(mm)	Length range(mm)	Water temp(°F)
9/9	0735-0900	3	12	0.3	127	118-136	69
9/18	0800-0807	75	2	37.5	103	95-120	71
9/24	1340-1413	53	10	5.3	102	93-113	64
9/27	0710-0729	64	3	21.3	117	101-131	63
10/8	0830-0851	163	3	54.3	112	91-132	56
10/14	1040-1050	46	2	23.0	111	91-133	52
10/20	1215-1245	36	4	9.0	110	93-129	58
10/29	0835-0915	0	8	0.0	-	-	46
	Totals	440	44	12.2*	110	91-136	

*excludes 10/29

Table 4.3 Juvenile American shad seine (300' x 7' x 3/8" bar mesh) and electrofishing (215v DC) collections at Wrightsville (RM 43) on the Susquehanna River, July-October, 1987.

Date	Time	Shad catch	Effort (# hauls)	Catch/ effort	Mean FL(mm)	Length range(mm)	Water temp(°F)
7/16	1040-1130	0	3	0	-	-	79
7/16	1320-1430	0	3/4 hr*	0	-	-	79
7/31	1030-1100	0	2	0	-	-	86
8/13	1050-1135	0	2	0	-	-	82
9/2	0700-0735	1	2	0.5	113	-	72
9/10	1105-1140	0	2	0	-	-	74
9/24	1100-1130	0	2	0	-	-	62
9/27	0932-1005	0	2	0	-	-	61
10/8	1001-1101	0	3	0	-	-	56
	Totals	1	18	-	-	-	

*electrofishing

Table 4.4. Summary of juvenile American shad collections from strainers at Safe Harbor (RM 32) and Conowingo (RM 10) dams, 8 October - 10 December, 1987.

Date	Safe Harbor No. shad	Safe Harbor Temp(°F)	Conowingo No. shad
10/8	12	58	-
10/9	4	58	-
10/10	4	57	-
10/11	2	57	-
10/12	19	56	-
10/13	6	55	-
10/14	5	55	-
10/15	5	55	-
10/16	9	55	-
10/17	6	56	-
10/18	5	56	-
10/19	2	58	-
10/22	-	-	5
10/23	1	57	-
10/24	2	56	-
10/28	2	53	-
10/29	3	52	3
10/30	3	51	-
10/31	1	50	-
11/1	2	50	-
11/2	1	50	-
11/5	-	-	2
11/8	1	49	-
11/25	-	-	4
TOTALS	95		14

Table 4.5. Number of juvenile American shad collected by RMC with 8' x 8' lift net in Safe Harbor forebay, October, 1987.

Date	Water temp(°F)	Number of lifts	Number of shad	Catch per lift
10/1	64.4	64	42	0.66
10/7	57.2	24	14	0.58
10/13	54.5	20	3	0.15
10/14	53.6	13	0	0.0
10/18	54.5	5	0	0.0
10/23	55.4	5	6	1.20
	Totals	131	65	0.50

Table 4.6. Juvenile American shad cast net (20 ft x 3/8" bar mesh) collections in the Holtwood forebay (RM 25), September-November, 1987.

Date	Time	Shad catch	Effort (# casts)	Catch/ effort	Mean FL(mm)	Length range(mm)	Water temp(°F)
9/17	1115-1247	9 juv's 3 adults	18	0.5	118 430(TL)	106-130 415-460(TL)	70.5
9/27	1220-1320	7	16	0.4	110	89-143	64.7
10/14	1300-1305	55	2	27.5	107	92-122	53.6
10/20	1507-1520	97+	4	24.3+	108	90-128	55.4
10/29	1115-1125	50	2	25.0	113	90-138	52.7
11/6	0930-1020	2	10	0.2	132	128-135	50.0
11/13	1105-1137	2	10	0.2	138	137-139	44.1
11/23	1525-1551	0	5	0.0	-	-	39.9
	Totals	222 juv's 3 adults	67	3.6*	110 430(TL)	89-143 415-460(TL)	

*excludes 11/23

Table 4.7. Number of American shad (juvenile and adult) collected by RMC with an 8'x 8' lift net in the Holtwood forebay during September-December, 1987.

Date	Water temp. (°C)	Total Lifts	Total Shad *	Adults (released)	Juvenile Shad Trans. to RMC Lab	Juvenile Shad Rel. w/ tel.fish	Juvenile Shad CPE** (No./lift)
10 Sep	22.0	10	17	4	13	-	1.3
18 Sep	21.8	10	15	8	-	-	0.7
25 Sep	17.5	10	5	0	-	-	0.5
30 Sep	18.8	10	1	0	-	-	0.1
5 Oct	15.0	15	25	0	25	-	1.7
7 Oct	14.5	30	17	1	-	-	0.5
13 Oct	12.5	10	30	0	30	-	3.0
14 Oct	12.0	5	32	0	-	32	6.4
15 Oct	12.0	17	26	0	-	26	1.5
16 Oct	11.0	17	56	2	-	54	3.2
17 Oct	12.5	12	51	0	-	51	4.3
18 Oct	12.5	8	55	2	-	53	6.9
19 Oct	12.5	17	28	3	-	25	1.5
20 Oct	13.0	3	37	0	-	31	12.3
21 Oct	13.0	3	26	0	-	26	8.7
22 Oct	13.5	4	33	0	-	26	8.3
26 Oct	13.0	26	11	0	8	-	0.4
27 Oct	11.5	28	32	0	3	29	1.1
28 Oct	11.0	20	23	0	-	23	1.2
29 Oct	11.5	17	45	2	14	27	2.6
30 Oct	10.0	7	20	1	-	19	2.9
31 Oct	10.8	3	30	0	-	30	10.0
2 Nov	10.5	7	26	1	-	25	3.7
4 Nov	11.5	8	86	0	47	32	10.8
5 Nov	10.5	4	46	0	-	32	11.5
6 Nov	10.0	11	50	0	50	-	4.5
12 Nov	7.0	12	0	0	-	-	0.0
16 Nov	5.0	20	4	0	4	-	0.2
18 Nov	7.5	25	14	0	14	-	0.6
20 Nov	8.5	10	15	0	15	-	1.5
23 Nov	-	11	0	0	-	-	0.0
3 Dec	5.0	10	0	0	-	-	0.0
4 Dec	-	10	0	0	-	-	0.0
7 Dec	3.5	9	0	0	-	-	0.0
8 Dec	5.0	9	0	0	-	-	0.0
Totals		407	856	24	223	541	2.3***

* includes adults
** juvenile only
*** excludes collections after 23 Nov.

Table 4.8. Summary of 1987 juvenile American shad netting in the Conowingo tailrace by RMC Environmental Services.

DATE	WATER TEMP	UNIT TYPE	GEAR	EFFORT (NET HOURS)	# SHAD	OTHER SPECIES [1]
05 OCT	60.8	SMALL	1 M	9.10	0	BC(1) CC(2) GS(5)
12 OCT	57.6	SMALL	1 M	3.32	0	
13 OCT	58.1	LARGE	1/2 M	3.70	0	GS(3)
		SMALL	1 M	15.23	0	GS(22)
		SMALL	5 X 5	9.33	0	GS(3)
16 OCT	54.5	LARGE	1/2 M	7.42	0	GS(32)
		SMALL	1 M	21.94	1	GS(2)
		SMALL	5 X 5	9.00	0	CC(1) GS(12)
20 OCT	55.8	LARGE	1/2 M	0.87	0	
		SMALL	1 M	4.97	0	GS(3)
		SMALL	5 X 5	2.22	0	GS(19)
21 OCT	55.4	SMALL	1 M	4.27	17	GS(152)
23 OCT	55.4	SMALL	1 M	4.16	3	CC(1) GS(46)
		SMALL	5 X 5	2.00	0	CC(1) GS(188)
26 OCT	52.7	SMALL	1 M	3.48	0	CC(1) GS(19)
		SMALL	5 X 5	2.25	0	GS(29)
29 OCT	54.5	LARGE	1 M	4.55	0	GS(8)
		SMALL	1 M	8.33	0	GS(14)
02 NOV	53.6	SMALL	1 M	13.90	1	CC(1) GS(107)
05 NOV	51.8	LARGE	1/2 M	2.17	0	CS(1)
		SMALL	1 M	7.05	0	GS(3)
09 NOV	51.8	LARGE	1/2 M	1.75	0	
		SMALL	1 M	4.80	1	GS(32)
12 NOV	44.6	LARGE	1/2 M	*	0	
		SMALL	1 M	4.03	0	CC(2) GS(2622)
		SMALL	5 X 5	*	0	
16 NOV	47.3	SMALL	1 M	5.97	1	GS(22)
19 NOV	45.6	SMALL	1 M	6.59	1	GS(23)
23 NOV	44.6	SMALL	1 M	6.20	1	GS(72)
02 DEC	44.6	SMALL	1 M	4.81	0	GS(74)
03 DEC	44.6	SMALL	1 M	4.97	0	GS(46) PS(1)
				======	====	
				178.38	26	

[1] BC = BLACK CRAPPIE, CC = CHANNEL CATFISH, CS = COMELY SHINER, GS = GIZZARD SHAD, PS = PUMPKINSEED.

* INCOMPLETE SET - GEAR BREAKDOWN

Table 4.9. Sample dates, times, and effort for seine collections (200'x 10'x 1/4" bar mesh and 300' x 7' x 3/8" bar mesh) downstream from Conowingo Dam during the Maryland DNR juvenile shad outmigration study, November-December, 1987.

Date	Time	Collectors	No. sites	Effort (# hauls) 200' net	300' net	Water temp(°F)
11/4	0845-1200	DNR,PFC,NES	6	6	5	52-60
11/9	0825-1030	DNR	6	6	0	53-54
11/16	0840-1105	DNR	6	6	0	43-50
11/18	0845-1245	DNR,PFC,NES	6	6	7	50-55
11/24	0835-1030	DNR	5	5	0	43-45
12/1	0900-1100	DNR	6	6	0	41-45
12/3	0900-1045	DNR	5	5	0	40-41
12/8	0950-1400	DNR, NES	6	6	8	39-41
12/10	0850-1030	DNR	5	5	0	42-43
12/15	0830-1200	NES	3	0	6	38
			Totals	51	26	

Table 4.10. Locations sampled and seining effort during the 1987 Maryland DNR juvenile shad outmigration study below Conowingo Dam.

Station name	Effort (# seine hauls) 200' net	300' net	total
Wild Duck Cove	9	5	14
Spoil Island	8	5	13
Tydings Park	9	5	14
Quarry	9	2	11
Lapidum	7	3	10
Happy Valley Branch	9	6	15
Totals	51	26	77

Table 4.11. List of fish species collected at various juvenile shad evaluation sites on the Juniata and Susquehanna rivers, 1987.

Species	Amity Hall	York Haven	Wrights-ville	Holt-wood	Cono-wingo	below Cono.
American eel	-	-	-	-	-	X
Atlantic menhaden	-	-	-	-	-	X
bay anchovy	-	-	-	-	-	X
channel catfish	-	-	X	X	X	X
white catfish	-	-	-	-	-	X
brown bullhead	-	-	-	-	-	X
Atlantic needlefish	-	-	-	-	-	X
banded killifish	-	-	-	-	-	X
mummichog	-	-	-	-	-	X
inland silverside	-	-	-	-	-	X
rough silverside	-	-	-	-	-	X
white perch	-	-	-	-	-	X
str.bass x white bass	-	-	-	-	-	X
striped bass	-	-	-	-	-	X
tiger musky	-	-	-	-	-	X
gizzard shad	X	-	X	X	X	X
blueback herring	-	-	-	-	-	X
alewife	-	-	-	X	-	X
American shad	X	X	X	X	X	X
quillback	-	-	X	-	-	X
white sucker	-	-	X	-	-	X
common carp	-	-	X	X	-	X
golden shiner	X	-	-	-	-	-
Miss. silvery minnow	-	-	-	-	-	X
comely shiner	X	-	X	-	X	X
spotfin shiner	X	X	X	-	-	-
satinfin shiner	-	-	-	-	-	X
spottail shiner	X	X	X	-	-	X
rock bass	X	-	-	-	-	X
redbreast sunfish	X	-	X	-	-	X
bluegill	X	-	X	X	-	X
green sunfish	X	-	-	-	-	-
pumkinseed	-	-	X	-	X	X
longear sunfish	-	-	-	-	-	X
largemouth bass	-	-	-	-	-	X
smallmouth bass	X	-	X	-	-	X
white crappie	-	-	-	-	-	X
black crappie	-	-	-	-	X	X
unid. crappie	-	-	X	-	-	-
walleye	-	-	X	-	-	-
yellow perch	-	-	-	-	-	X
tesselated darter	-	-	-	-	-	X
shield darter	-	-	-	-	-	X
hogchoker	-	-	-	-	-	X

Table 4.12 Summary of American shad caught during the 1987 juvenile survey in the upper Chesapeake Bay.

Date	Station	Gear type	Number caught	Total length (mm)	Weight (g)	Marking results
7/14/87	Tydings Park	OT	1	145*	25	unmarked**
8/4/87	Battery Island	OT	1	118	10	unmarked
9/22/87	Battery Island	OT	1	137	18	unmarked
10/19/87	Battery Island	OT	1	130	14	unmarked

*Yearling.
**Exhibited otolith growth pattern typical of hatchery fish.

Table 4.13. Analysis of TC marking of juvenile American shad collected in the Susquehanna River Basin, 1987. Number of juveniles exhibiting fingerling tag in parenthesis. x - collection made, no shad collected.

Week of:	Amity Hall	York Haven	Wrightsville	Safe Harbor	Holtwood	Conowingo Reservoir & Tailrace	Below Conowingo
7/12	-	-	x	-	-	-	0/1 (yearling)
7/26	31/32	-	x	-	-	-	-
8/2	-	-	x	-	-	-	0/1
8/9	31/31	-	x	-	-	-	-
8/30	2/2	-	1/1	-	-	-	-
9/6	30/30	2/3	-	-	-	-	-
9/13	-	32/32	-	-	3/16	-	-
9/20	x	33/33	x	-	3/3	-	0/1
9/27	-	35/35	x	17/18	8/8	-	-
10/4	-	35/35 (1)	x	-	2/3	-	-
10/11	x	35/35 (1)	-	-	50/52 (2)	2/2	-
10/18	-	30/30 (8)	-	-	49/50 (7)	18/19	0/1
10/25	-	x	-	-	48/48 (8)	-	-
11/1	-	-	-	-	2/2	1/1	-
11/8	-	-	-	-	2/2	1/1	-
11/15	-	-	-	-	-	2/2	-
11/22	-	-	-	-	-	1/1	-
% Marked	98.9%	99.5%	100%	94.4%	90.8%	96.2%	0.0%
	94/95	202/203 (10)	1/1	17/18	167/184 (17)	25/26	0/4

Note: 1. All of the 309 pond or raceway reared specimens examined exhibited the day 5 immersion tag.
2. All of the 61 raceway reared specimens examined exhibited the double tag at days 5 & 12.
3. All of the 92 Elkton pond reared specimens examined exhibited the double tag at days 5 and 19. All but one (98.9%) were distinguishable from the double tag on days 5 and 12.
4. 63 of 64 (98.4%) of the pond reared specimens examined exhibited the triple tag (days 5, 12 and 19) and feed tag. One of the 64 exhibited neither the day 5 tag nor the feed tag but did exhibit the 12 and 19 day tags.

Table 4.14. Summary of American shad stockings and collections of juvenile American shad at selected sites in the Susquehanna River, 1981-1987.

	Year						
	1981	1982	1983	1984	1985	1986	1987
Stocking							
Out-of-basin adults (estimated live)	1,165	2,565	4,310	3,777	2,834	4,991	6,000
Conowingo adults	0	842	64	0	967	4,265	7,202
Fry (above Conowingo)	2.03M	5.02M	4.05M	11.99M	6.23M	9.70M	5.18M
Fry (below Conowingo)	0	0	0	0	0	5.17M	4.41M
Fingerlings	23,600	40,700	98,300	30,500	115,200	61,200	81,549
Juveniles Collected							
North Branch	yes	no	yes	no	no	no	no
Amity Hall (Seine C/f)*	-	-	-	70.4	8.9	11.4	19.7
York Haven Hydro-coustics (targets/ m^2/hr)	-	-	-	-	-	0.69	0.71
Safe Harbor (strainers)	17	36	41	112	15**	28	95
Holtwood (lift net C/f)***	-	-	-	-	9.6	7.4	2.2
Peach Bottom (screens)	7	115	31	38	26	341	0*****
Conowingo strainers	1	0	1	3	11	2	14
Below Conowingo	0	1	0	1	1	23****	3

*C/f calculated for last 6 samples prior to the time of 0 occurrence.
**First year five new turbines on line.
***RMC lift net C/f during September-December and prior to time of 0 occurrence. Number of lifts = 378 in 1985, 394 in 1986, 379 in 1987.
****14 of these fish collected in regular MDNR Survey; 9 collected incidentally in other surveys.
*****Plant shutdown.

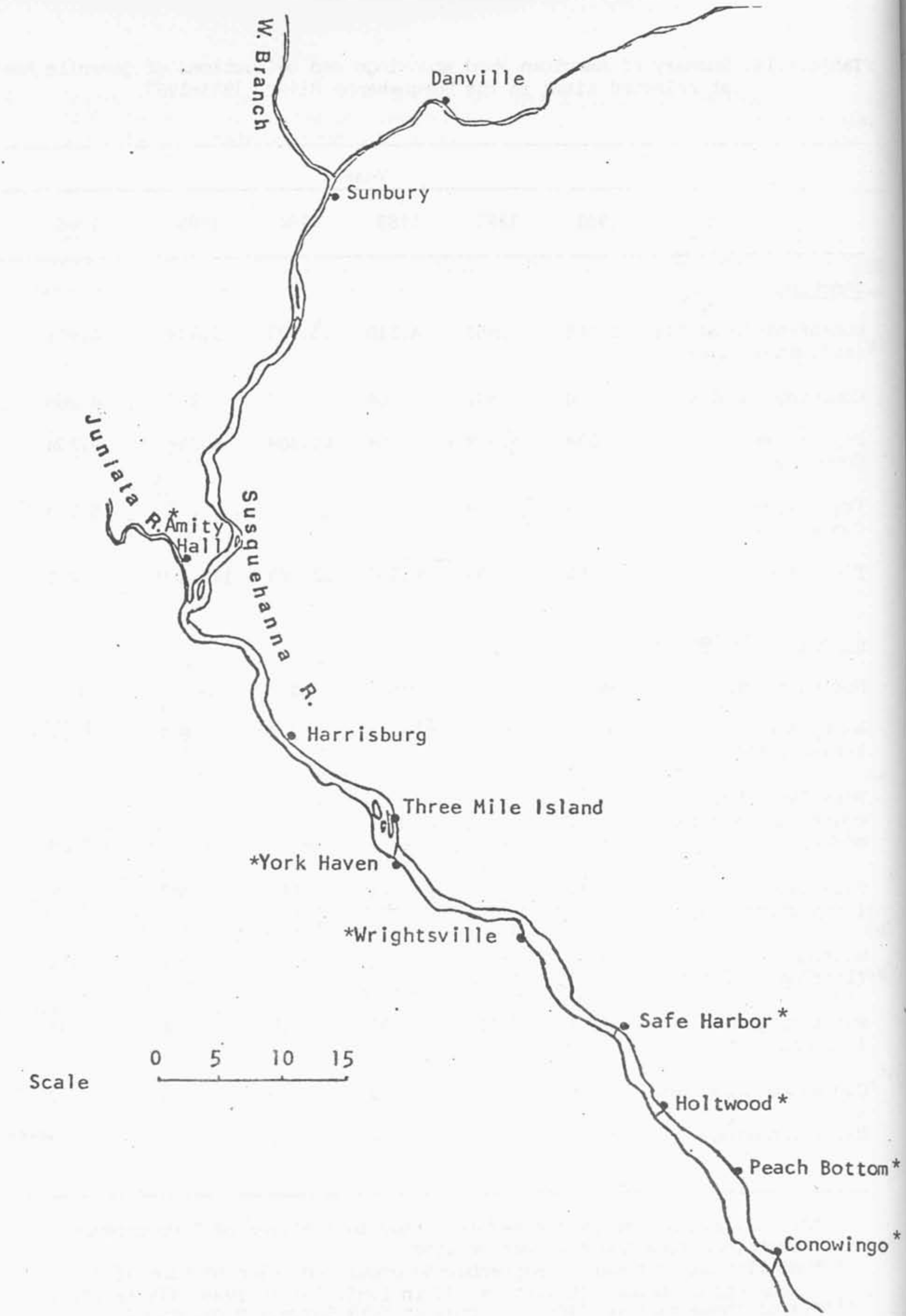

Figure. 4.1. 1987 Juvenile American shad collection sites (*) on the Susquehanna and Juniata River.

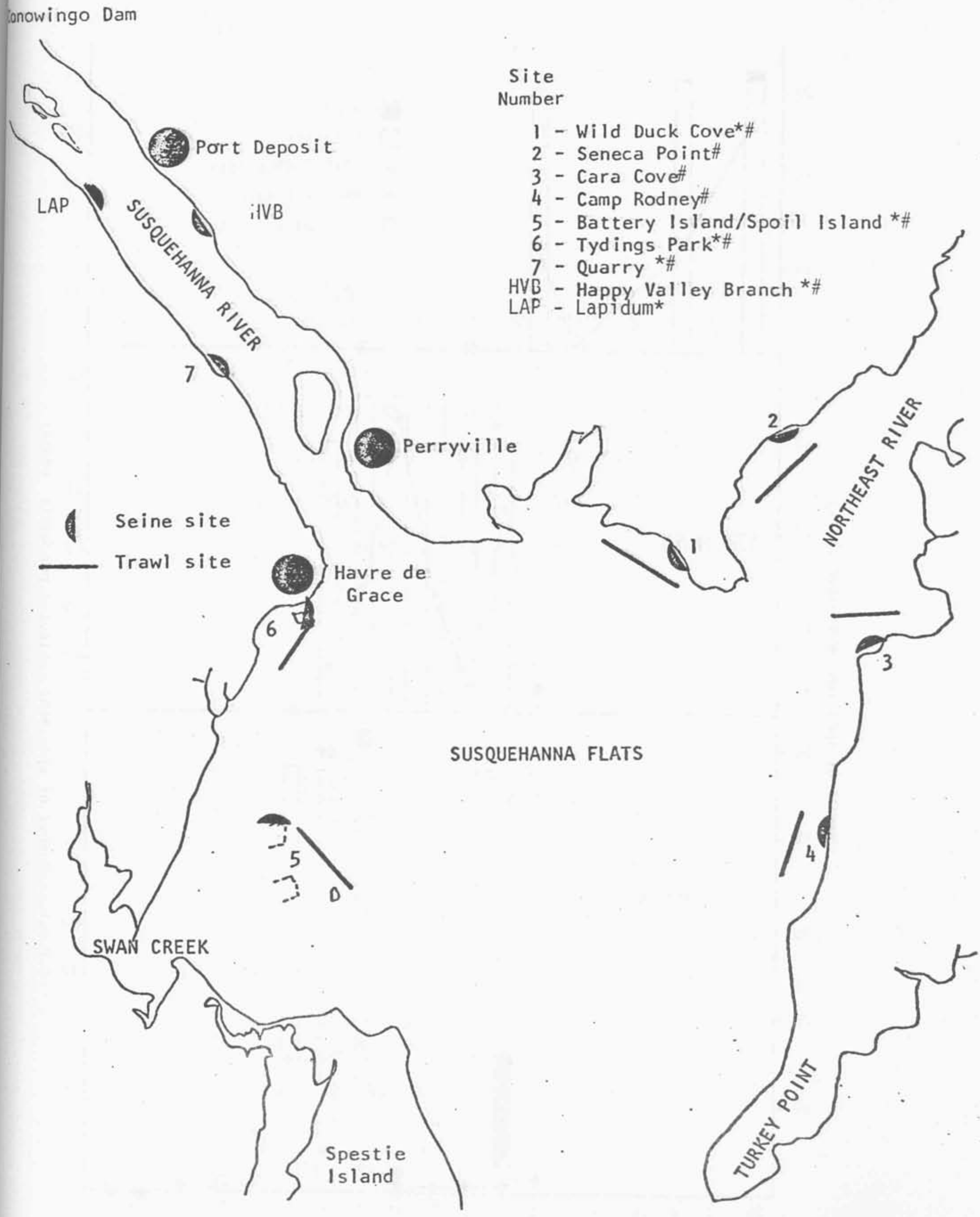

Figure 4.2. Seine and trawl stations for the 1987 Maryland DNR Bay American Shad juvenile recruitment survey (#) and seine stations for the 1987 outmigration study (*).

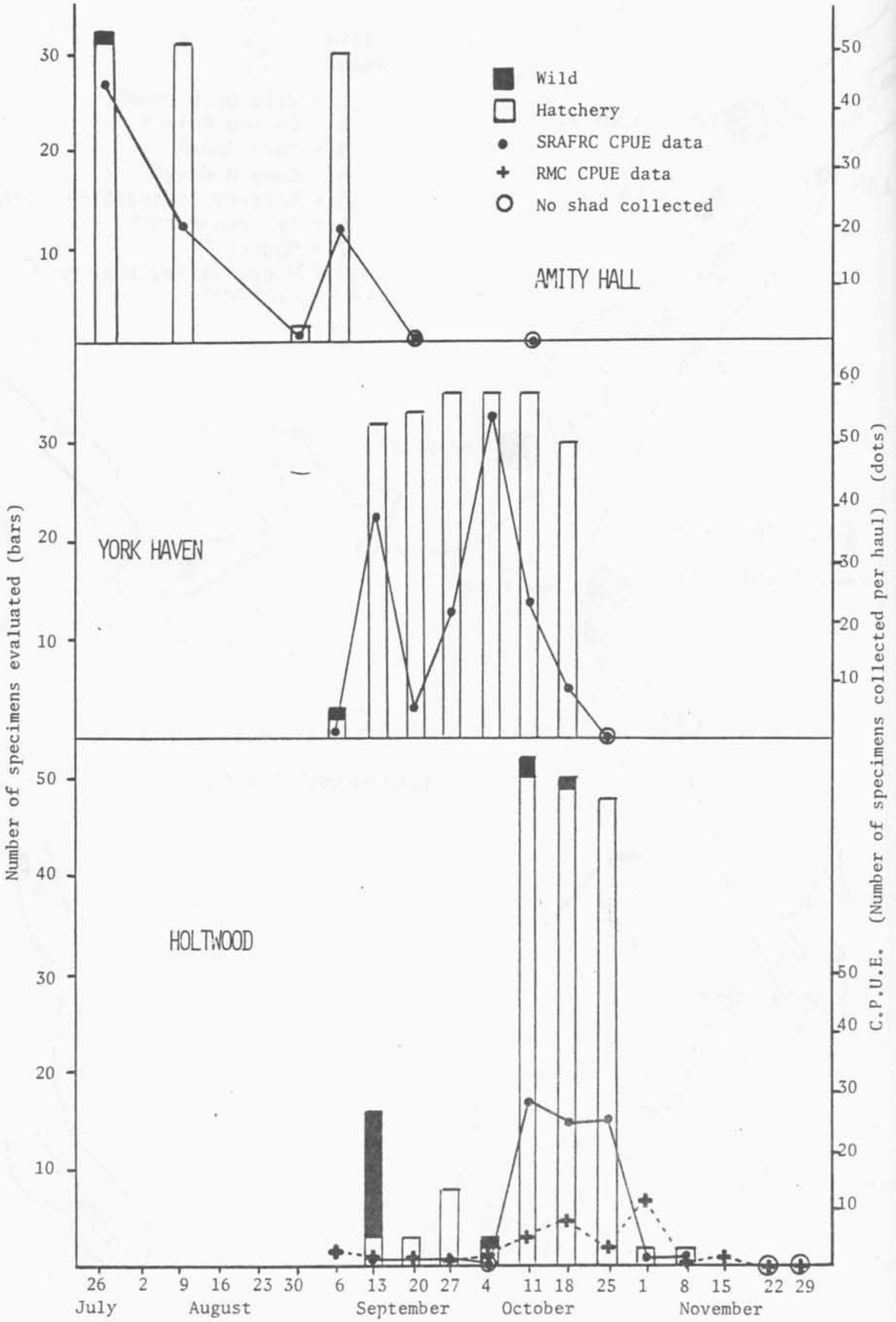

Figure 4.3. Comparison of number of specimens evaluated for OTC marks to RMC lift net and SRAFRC cast net catch per unit effort and OTC marking results by date for Amity Hall, York Haven Dam and Holtwood Dam, 1987.

RADIO TELEMETRY STUDIES ON DISPERSAL AND BEHAVIOR OF ADULT AMERICAN SHAD TRANSPLANTED FROM THE CONOWINGO FISH LIFT TO THE SUSQUEHANNA RIVER AT LONG LEVEL, PENNSYLVANIA, 1987

Prepared For

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Fish Restoration Committee

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INTRODUCTION

Radiotagging studies of behavior and spawning patterns of transplanted American shad, Alosa sapidissima from the Hudson River in 1985 and 1986 revealed that these shad moved rapidly downstream and congregated at the lower river hydroelectric stations. However, most of the Susquehanna shad captured at the Conowingo Fish Lift and released upstream of the York Haven Hydroelectric Dam in 1986 dispersed throughout the river to such a degree that few fish were found in the same area (RMC 1986). In response to this, the Susquehanna River Anadromous Fish Restoration Committee (SRAFRC) recommended that all shad captured in 1987 at the Conowingo Fish Lift be released in Lake Clarke, between Safe Harbor and York Haven dams to increase the chance of a successful spawn due to confinement. This 24 mile portion of the Susquehanna River consists of approximately nine miles of impounded water (Lake Clarke) and 15 miles of riverine area between Columbia and York Haven Dam.

Most of the shad taken at the Conowingo Fish Lift in 1987 were transported to the Long Level launch area (RM 37) on Lake Clarke. A subsample of these was radio tagged and monitored extensively to determine dispersal and movement rates, identify possible spawning sites, determine effects of confinement between the two hydro projects upon release, and provide gross mortality estimates of turbine passage at Safe Harbor and Holtwood dams.

METHODS

American shad for this study were collected from the Conowingo Fish Lift and radio tagged on four occasions (April 26, May 1, 10, and 31). These time periods covered the early, mid, and late run of shad in the Susquehanna River. An additional group of shad previously tagged and released into the Conowingo tailrace were recaptured in the Conowingo Fish Lift and transported to Long Level on five occasions (Tables 1 and 2). These fish were tagged for a Susquehanna River Technical Committee (STRC) study on entrance placement for a second fish lift at the Conowingo Hydrostation.

Each shad was held in a water filled container while a 10 x 55 mm cylindrical radio transmitter was gently inserted into it's stomach. Each transmitter weighed 10.5 g and was equipped with a 240 mm whip antenna. Shad were placed in holding tanks after tagging.

Radio tagged shad were released into Lake Clarke at the Long Level access area (Figure 1) along with untagged fish (generally 100 or more) and monitored several times within the first 12 h after release. Thereafter shad were monitored twice weekly either by boat, truck, or airplane. They were tracked by boat in the three impoundments and the York Haven area to determine exact locations. General locations of shad in the vicinities of hydroelectric stations were determined from shore and vehicle scans. The entire study area from York Haven Dam to the river mouth (Figure 1) was monitored using a Cessna 172 aircraft.

Previous studies (RMC 1985, 1986) indicated that shad concentrated in the forebays of hydroelectric stations, therefore intensive monitoring occurred at Safe Harbor, Holtwood, and Conowingo stations (Table 1). Additionally, York Haven Dam and tailrace were monitored daily when possible from late April to late May. Safe Harbor was checked regularly from late April through June. Holtwood was monitored periodically in May and almost daily in June and early July. Conowingo Pond was monitored daily from mid-May through early July (Table 1).

Ichthyoplankton samples were taken at night on four occasions to confirm suspected spawning areas (Table 3). A 1 m plankton net was set just under the surface for 10 minutes downstream of radio tagged shad. Variables measured and recorded for each collection included water and air temperature, water depth, date, time, and location. Samples were preserved in 10% formalin, identified, and enumerated.

RESULTS

Dispersal Patterns

A total of 34 shad (26 SRAFRC and 8 SRTC) was radio tagged and released at Long Level (Tables 1 and 2, Figures 2-6). Twenty were males and 14 were females. Two tagged shad and at least 22 untagged shad died on 10 May during transport. An additional tagged shad died on 31 May.

Shad did not extensively utilize the riverine area downstream of the York Haven Hydrostation. Seventeen (55%) of the 31 fish released moved upstream (≥5 mile) into the riverine section within 2 weeks after release (Table 2 and Figures 2-6). These fish consisted of 6 females and 11 males and 5 were SRTC fish. They remained in the riverine area from 1 to 51 days. Nine (29%), of these shad continued upstream to York Haven Station. These shad reached the York Haven area in 1 to 17 days after release; seven of these reached York Haven within 5 days. Only one female migrated to the York Haven area. It was released in the initial group and arrived within two days. This female remained there for nine days; dropped back to Lake Clarke for five days and then returned to York Haven for four more days.

One or more tagged fish was in the vicinity of York Haven Station from 2 May to 9 June (Table 4). The maximum ever present was seven. The period of high congregation occurred from 11-22 May when four to seven fish were present most of the time.

The remaining 14 (45%) shad never left Lake Clarke. Eight of these fish were never located upstream of the release site and the others moved less than fives mile upstream (Table 2, Figures 2-6).

Fish tagged and released early in the season had a stronger urge to move upstream (Table 5). Seven of 16 (44%) shad released between 26 April and 3 May moved upstream to York Haven Dam. No shad released late in the run (31 May-2 June) migrated to York Haven. Additionally, only one fish failed to move upriver ≥1 mile early in the run. Five of eight (62%) shad released late in the season failed to move upriver (Table 5). However, the initial dropback reaction often observed after handling and tagging was generally absent in the released shad.

Behavior At Hydrostations

Shad that migrated upstream to York Haven were found primarily between the station tailrace and the upper end of Brunner Island (Figure 7). Five were occasionally found in the Conewago Falls area. Two moved to the base of the main dam; one was in a pool on the west side of Three Mile Island (TMI) for 13 days and the other on the west side near the head race wall for 8 days.

Twenty-five (81%) radio tagged shad moved downstream to Safe Harbor Dam within 35 days of release (Table 2). Six (19%) of the 31 tagged shad were never located at or below Safe Harbor. Three were last located in the York Haven area and three others disappeared from Lake Clarke. Down running shad spent from 0 to 20 days in the vicinity of Safe Harbor Dam. Most were located in the forebay and several ranged freely in the impoundment.

Fifteen (48%) shad were known to have successfully passed Safe Harbor Dam (Table 2). Thirteen of these were located at Holtwood Dam between 5 and 39 days after stocking, and remained above the dam for up to 36 days. They freely utilized the lower portion of Lake Aldred. One returned to Safe Harbor tailrace five days after reaching Holtwood.

Two (6%) shad were found in Conowingo Pond. One was located near Holtwood, the other across from Peach Bottom Atomic Power Station, 35 and 44 days after release, respectively.

Spawning

Spawning was monitored in the vicinity of York Haven Station by sampling for eggs immediately downstream of radio tagged shad (Table 3). Eleven collections were taken on May 12, 14, 21, and 25. Collections were made below the main dam, in the tailrace, and along the northeast shore of Brunner Island. Four shad eggs were collected on the first sampling night. Two possible shad eggs were collected, one each on the first and final nights. Water temperature during the sampling period varied from 60.8 F to 68.2 F.

Turbine Passage

Twenty-one of the 25 shad located at Safe Harbor were known to have passed through the turbines during the period of monitoring. Six of these ceased movement in the tailrace. The estimated downstream passage mortality at Safe Harbor from these limited data was 29% (6/21).

Thirteen active fish were located at Holtwood, and two were last located in Lake Aldred. Mortality was noted on only 2 of 13 that were located at Holtwood. Both of these individuals ceased movement in the tailrace. The deep water below the Holtwood tailrace (>100 ft) could have limited detection of other radio tagged fish. No tagged fish were located at Conowingo Dam.

DISCUSSION

Confinement of shad between Safe Harbor and York Haven did not appear to increase congregation of migrating shad. Only about one half of the shad tagged at the Conowingo Fish Lift moved upstream ≥5 mile after release. The percentage of Susquehanna fish that moved upstream was similar to that observed the previous year when fish were released near Harrisburg (RMC 1986). Although the percentage of tagged shad that reached York Haven was relatively low, fish released early in the run demonstrated a much stronger urge to move upriver. Almost half of these reached York Haven while no fish stocked late in the run moved upstream.

The York Haven Dam resticted upstream migration of shad. However, these fish did not congregate in a single area where extensive spawning could result. Occasionally two tagged fish (usually males) were in close proximity, but normally they were scattered throughout the area. Most of these fish remained in the York Haven area long enough to spawn.

The increased water temperature at the release site during the latter part of the run may restrict the upstream movement of shad. Most female shad trapped and transported were taken in the latter part of the run and did not show a strong urge to continue movement upstream. At this time capture and release site temperatures varied by as much as 10 F. The paucity of tagged female fish at York Haven in conjunction with their late arrival at Conowingo suggests that a large proportion of the females transported to Lake Clarke later in the run may not have contributed substantially to a successful spawn. The actual number of females that moved into riverine areas may have even been less than that depicted by tagged specimens. During at least the first half of the shad run the sex ratio of transported shad was about 1 female to 5 males but for the tagged specimens it was about 1 female to 2 males.

Residency time of shad at Safe Harbor and Holtwood dams tagged in 1987 was similar to that in 1986. However, a higher percentage of tagged shad reached Safe Harbor and Holtwood in 1987. This is not surprising since in 1986 shad traveled greater distances and had to pass Dock Street and York Haven dams prior to reaching Safe Harbor and Holtwood.

The absence of radio tagged shad in Conowingo Pond is not explicable. Conowingo Pond was monitored more extensively in 1987 than 1986. However, it is possible that some tagged fish after passing Holtwood might have died and settled in water too deep for transmitter signal reception. Some tagged fish may have rapidly moved out of the area or settled in deep water in Conowingo Pond during a period when the fish were not being tracked.

The number of shad eggs per sample was substantially less in 1987 than in 1986. Cooler and erratic water temperatures may have contributed to the poor sampling success in 1987. The sampling plan specified that collections be made at water temperatures $\geq$ 65 F. The first sample was collected on 12 May at 68 F. Unexpectedly, temperatures dropped to 61 F and did not rise again until the end of May.

Because a large number of eggs was collected in the tailrace below the York Haven Station in 1986, a sample was again taken in the approximate area in 1987. It did not produce any eggs. The absence of eggs may have been related to cooler water temperatures. A substantial number of fish were present in the York Haven forebay during sampling in both years, but the water temperature was 13 F higher in 1986 than in 1987 (74 F vs 61 F).

The effects of confinement on the spawning success of shad are inconclusive at present. Other concurrent studies on juvenile shad assessment and otolith analysis may provide necessary clues for further evaluation of spawning success.

Gross mortality estimates (25% in 1985, 46% in 1986 and 29% in 1987) at Safe Harbor only provide minimal insight into the fate of adult shad. These estimates do not distinguish between the mortality of pre and postspawned shad. Natural mortality of postspawned fish cannot be estimated from these data. The disappearance of shad, study design, possibility of tag regurgitation, and small sample size preclude determination of accurate estimates of turbine passage.

SUMMARY OF FINDINGS

1. A total of 31 American shad was radio tagged and released into Lake Clarke at Long Level (RM 37) to determine the spawning areas downstream of York Haven Dam, area usage, and effect of confinement of shad between two dams. These fish were trapped in the Conowingo Fish Lift and trucked upstream for release.
2. Most of the radio tagged shad released at Long Level did not display a strong urge to migrate upstream to the York Haven Dam, a distance of 20 miles. Although 55% (17) of the shad moved upstream $\geq$5 miles from the point of release only 29% (9) reached York Haven.
3. Fish tagged and released early in the season had a stronger urge to move upstream. Almost half of the shad (7 of 16 or 44%) released in late April and early May reached York Haven while none released late in the run (31 May and 2 June) moved to York Haven.
4. Males displayed a stronger urge to move upstream than females. Only one female reached York Haven.
5. Those shad which moved to York Haven used the area primarily between the York Haven tailrace and Brunner Island. They did not appear to congregate in any one area.
6. Shad arrived at York Haven in 1 to 17 days, but most made it within 5 days.

7. Tagged shad were present at York Haven for more than a month (2 May-9 June) with a peak abundance during 11-22 May.
8. Few shad eggs (4) were found in the eleven collections taken in the vicinity of several tagged shad near York Haven.
9. Fish moved throughout the Safe Harbor forebay and frequently moved back into the impoundment. Several moved back upriver.
10. Twenty-five of the tagged shad moved downstream to the Safe Harbor Station within 35 days of stocking.
11. Twenty-one shad were known to have passed through the Safe Harbor Station. Six of these became stationary downstream of the station.
12. Thirteen active shad were located at Holtwood. Only four fish were found downstream of this station; two were inactive. Deep water (>100 ft) downstream of this station probably limited the detection of some radio tagged fish.
13. Radio tagging is a viable technique to monitor passage of tagged shad at the hydrostations.

RECOMMENDATIONS

Although stocking shad in Lake Clarke confined them between the two hydrostations with 13 miles of riverine habitat congregation of both sexes in specific areas did not occur. Consequently, it is likely that spawning activity was limited. However, if otolith analysis confirms that juvenile production from stocked fish was low, several actions should be considered.

1. Stock shad in Lake Clarke into a holding area. This would encourage the availability of sufficient number of both sexes to successfully spawn. The confined fish could be held until they spawned and/or they could be held until ripe and then artificially propogated in a hatchery.
2. Consider returning the late running shad to the Conowingo tailrace instead of transporting them upstream. Probability of the two sexes coming in contact with each other is greater there than in upstream areas later in the season.
3. Although incidental estimates of turbine passage of adult shad were obtained a well designed radio telemetry study specifically directed to provide a definitive answer on the turbine passage is needed.

LITERATURE CITED

RMC. 1985. Radiotelemetry studies on dispersal, spawning, and behavior of the American shad transported to the North Branch of the Susquehanna River. Drumore, PA. 44 pp.

RMC. 1986. Radiotelemetry studies on dispersal and behavior of adult American shad from the Hudson and Susquehanna rivers transported to two release sites in the Susquehanna River. Drumore, PA. 101 pp.

TABLE 1

Monitoring schedule of radio tagged shad released in the Susquehanna River at Long Level (RM 37), April-May 1987.

Date	Location Monitored	Method
April		
26-27	Long Level to Saginaw (RM 37-52)	Boat, Vehicl
	Tagged 7 shad	
28	Safe Harbor Dam to York Haven Dam (RM 32-56)	Vehicle, Shor
May		
1	Safe Harbor Dam to York Haven Dam (RM 32-56)	Vehicle, Shor
	Tagged 7 shad	
2	Long Level to York Haven Dam (RM 37-56)	Vehicle, Shor
3	Released 1 tagged SRTC shad	
	Released 2 SRTC shad	
5	Safe Harbor Dam to York Haven Dam (RM 32-56)	Vehicle, Shor
7	Conowingo Dam to York Haven Dam (RM 10-56)	Airplane, Veh
8	York Haven Area (RM 56)	Shore
10	Safe Harbor Dam to York Haven Dam (RM 32-56)	Vehicle
	Tagged 7 shad	
11	Holtwood Dam (RM 24)	Shore
	Safe Harbor Dam to York Haven Dam (RM 32-56)	Vehicle, Shor
12	Safe Harbor Dam to York Haven Dam (RM 32-56)	Boat, Vehicle
	Sampled for shad eggs	
13	Holtwood Dam (RM 24)	Shore
	Safe Harbor Dam (RM 32)	Shore
14	Mouth of river to York Haven Dam (RM 0-56)	Shore
	Sampled for shad eggs	
	York Haven Area (RM 56)	Boat
15	York Haven Area (RM 56)	Shore
16	Safe Harbor Dam (RM 32)	Shore
18	Safe Harbor Dam (RM 32)	Shore
	York Haven Area (RM 56)	Shore
19	Safe Harbor Dam (RM 32)	Shore
	Holtwood Dam (RM 24)	Shore
	York Haven Dam (RM 56)	Boat
20	Safe Harbor Dam (RM 32)	Shore
21	Safe Harbor Dam to York Haven Dam (RM 32-56)	Boat, Vehicl
	Sampled for shad eggs	

continued

TABLE 1

Continued.

Date	Location Monitored	Method
22	Mouth of river to York Haven Dam (RM 0-56)	Airplane
23	Conowingo Pond (RM 10-24)	Boat
24	Safe Harbor Dam (RM 32)	Shore
	Conowingo Pond (RM 10-24)	Boat
25	York Haven Area (RM 56)	Boat
	Conowingo Pond (RM 10-24)	Boat
	Sampled for shad eggs	
26	Holtwood Dam (RM 24)	Shore
	Safe Harbor Dam, (RM 32)	Shore
27	Mouth of river to York Haven Dam (0-56)	Airplane
	Holtwood Reservoir (Lake Aldred) (RM 24-32)	Boat
28	Holtwood Dam (RM 24)	Shore
	Safe Harbor Dam (RM 32)	Shore
29	York Haven Dam (RM 56)	Shore
	Safe Harbor Dam (RM 32)	Shore
	Holtwood Dam (RM 24)	Shore
30	Holtwood Dam (RM 24)	Shore
	Safe Harbor Dam (RM 32)	Shore
31	Safe Harbor Dam (RM 32)	Shore
	Holtwood Dam (RM 24)	Shore
	Wrightsville Area (RM 40-42)	Vehicle
	Tagged 5 shad and released 2 SRTC shad	
June		
1	Safe Harbor Dam to York Haven Dam (RM 32-56)	Boat, Vehicle
	Holtwood Dam (RM 24)	Shore
2	Upper Chesapeake Bay to York Haven Dam (RM 0-56)	Airplane
	Released 1 SRTC shad	
3	Safe Harbor Dam (RM 32)	Shore
	Holtwood Dam (RM 24)	Shore
4	York Haven Dam (RM 56)	Shore
	Safe Harbor Dam (RM 32)	Shore
	Holtwood Dam (RM 24)	Shore
5	Mouth of River to York Haven (RM 0-56)	Airplane
	Holtwood Dam (RM 24)	Shore
6	Safe Harbor Dam (RM 32)	Shore
7	Safe Harbor Dam (RM 32)	Shore

continued

TABLE 1

Continued.

Date	Location Monitored	Method
8	York Haven Dam (RM 56)	Shore
	Safe Harbor Dam (RM 32)	Shore
	Holtwood Dam (RM 24)	Shore
9	Mouth of River to York Haven (RM 0-56	Airplane
10	Safe Harbor Dam (RM 32)	Shore
	Holtwood Dam (RM 24)	Shore
11	Holtwood Dam (RM 24)	Shore
12	Mouth of River to York Haven (RM 0-56)	Airplane
13	Safe Harbor Dam (RM 32)	Shore
14	Safe Harbor Dam (RM 32)	Shore
	Holtwood Dam (RM 24)	Shore
15	Mouth of River to York Haven (RM 0-56)	Airplane
	Conowingo Pond (RM 10-24)	Boat
16	Safe Harbor Dam (RM 32)	Shore
	Holtwood Dam (RM 24)	Shore
	Conowingo Pond (RM 10-24)	Boat
17	Safe Harbor Dam (RM 32)	Shore
	Holtwood Dam (RM 24)	Shore
	Conowingo Pond (RM 10-24	Boat
18	Safe Harbor Dam (RM 32)	Shore
	Holtwood Dam (RM 24)	Shore
	Conowingo Pond (RM 10-24)	Boat
	York Haven Area (RM 56)	Shore
19	Holtwood Dam (RM 24)	Shore
	Conowingo Pond (RM 10-24)	Boat
20	Safe Harbor Dam (RM 32)	Shore
	Holtwood Dam (RM 24)	
	Conowingo Pond (RM 10-24)	Boat
21	Safe Harbor Dam (RM 32)	Shore
22	Holtwood Dam (RM 24)	Shore
	Conowingo Pond (RM 10-24)	Boat
23	Safe Harbor Dam (RM 32)	Shore
	Holtwood Dam (RM 24)	Shore
	Conowingo Pond (RM 10-24)	Boat
24	Safe Harbor Dam (RM 32)	Shore
	Holtwood Dam (RM 24)	Shore
	Conowingo Pond (RM 10-24)	Boat
25	Mouth of River to York Haven (RM 0-56)	Airplane
	Holtwood Dam (RM 24)	Shore
	Conowingo Pond (RM 10-24)	Boat

continued

TABLE 1

Continued.

Date	Location Monitored	Method
26	Holtwood Dam (RM 24)	Shore
	Conowingo Pond (RM 10-24)	Boat
27	Safe Harbor Dam (RM 32)	Shore
	Holtwood Dam (RM 24)	Shore
	Conowingo Pond (RM 10-24)	Boat
28	Holtwood Dam (RM 24)	Shore
29	Holtwood Dam (RM 24)	Shore
	Safe Harbor Dam (RM 32)	Shore
	Conowingo Pond (RM 0-24)	Boat
July		
1	Holtwood Dam (RM 24)	Shore
	Conowingo Pond (RM 10-24)	Boat
2	Holtwood Dam (RM 24)	Shore
	Conowingo Pond (RM 10-24)	Boat
6	Holtwood Dam (RM 24)	Shore

TABLE 2

Movement patterns of radio-tagged adult American shad released at Long Level (RM 37), April - May 1987. Data in parentheses are best estimates.

Fish Number	Sex	Release Date	Max Dist. Traveled 8-16 h after	Max Dist. Traveled Upstream	No. Days to Reach York Haven	Days Spent at York Haven	No. Days to Reach Safe Harbor	Days Spent at Safe Harbor	No. Days to Reach Holtwood	Days Spent at Holtwood	No. Days to Reach Cono. Pond	Date of Last Location	Last Fix Location	Status
22	F	26 Apr	4	12	-	-	31	7	39	3	44	9 Jun	Peach Bottom	Alive
91	M	26 Apr	2	6	-	-	16	(1)	35	-	35	31 May	Below Holtwood	Alive
*121	M	2 May	-	20	5	26	(34)	-	38	22	-	1 Jul	Holtwood	Alive
*144	M	3 May	-	20	5	25	(>30)	-	-	-	-	2 Jun	York Haven	Alive
*153	M	3 May	-	19	2	51	(>53)	-	-	-	-	25 Jun	Below Brunner Island	Alive
194	M	26 Apr	3	20	2	24	28	3	31	22	-	18 Jun	Holtwood	Alive
232	M	26 Apr	1	6	-	-	26	2	30	19	-	14 Jun	Holtwood	Alive
242**	F	26 Apr	15	20	2,1	9,5	31	8	-	-	-	4 Jun	Safe Harbor Tailrace	Dead
*260	M	16 May	-	3	-	-	11	2	14	27	-	27 Jun	Holtwood	Alive
372	F	26 Apr	3	3	-	-	(>11)	-	-	-	-	7 May	Long Level Area	Alive
393	M	26 Apr	-2	20	14	11	40	-	-	-	-	19 Jun	Safe Harbor Tailrace	Dead
*420	M	2 Jun	-	0	-	-	3	1	9	-	-	11 Jun	Holtwood	Alive
520	M	1 May	0	19	17	15	(35)	-	-	-	-	5 Jun	Lake Aldred	Alive
532	M	1 May	2	2	-	-	(>1)	-	-	-	-	2 May	Long Level	Alive
542	F	1 May	1	4	-	-	13	1	-	-	-	22 May	Safe Harbor	Alive
558	M	1 May	-1	0	-	-	6	0	-	-	-	7 May	Safe Harbor Tailrace	Dead
572	F	1 May	2	9	-	-	(>10)	-	-	-	-	11 May	Accomac	Alive
*620	M	31 May	-	0	-	-	5	20	-	-	-	25 Jun	Safe Harbor	Alive
632	M	1 May	0	0	-	-	5	1	6	-	-	7 May	Holtwood	Alive
*670	F	16 May	-	14	-	-	12	5	(20)	0	-	5 Jun	Holtwood Tailrace	Dead
682	F	1 May	2	12	-	-	21	(1)	-	-	-	27 Jun	Safe Harbor Tailrace	Dead
722	F	10 May	1	1	-	-	2	0	-	-	-	16 May	Safe Harbor	Dead
732	M	10 May	0	0	-	-	2	1	17	-	-	27 May	Holtwood Tailrace	Dead
752	M	10 May	1	19	4	1	(15)	-	19	5	-	2 Jun	Holtwood	Alive
*790	F	31 May	5	7	-	-	(3)	-	5	36	-	6 Jul	Holtwood	Alive
833	F	10 May	Dead at Release									10 May	Long Level	Dead
852	M	10 May	1	19	4	(>46)	(>51)	-	-	-	-	25 Jun	York Haven	Alive
862	F	10 May	1	1	-	-	12	-	-	-	-	22 May	Lake Clarke	Alive
903	M	10 May	Dead at Release									10 May	Long Level	Dead
954	M	31 May	-	0	-	-	1	-	-	-	-	2 Jun	Lake Aldred	Alive
964	F	31 May	-	0	-	-	2	-	-	-	-	9 Jun	Safe Harbor Tailrace	Dead
973	F	31 May	-	0	-	-	1	3	-	-	-	4 Jun	Safe Harbor Tailrace	Dead
984	F	31 May	Dead at Release									1 Jun	Long Level	Dead
993	M	31 May	-	13	-	-	9	1	18	4	-	22 Jun	Holtwood	Alive

* American shad tagged for SRTC study, recaptured at the Fish Lift, and transported to Long Level

** Fish No. 242 went to York Haven, dropped down to Lake Clarke then returned to York Haven

TABLE 3

Shad eggs collected by a 1-meter plankton net near York Haven, May 1987.

Location	York Haven Area			
River Mile(s)	55,55.1,55.2	56.6	55.2	55.6,55.7
Date	12 May	14 May	21 May	25 May
Number of Samples	3	4	2	2
Time(s)	2136-2146 2211-2221 2238-2248	2130-2140 2202-2212 2218-2228 2235-2245	2204-2214 2221-2231	2210-2220 2255-2305
Water Temperature (F)	68.2	66.2	60.8	60.8
Number of Shad Eggs	4	0	0	0
Number Possible Shad Eggs	1	0	0	1
Other	23	0	2	181
*Radio Tagged Shad in Area	141(M) 194(M)	121(M) 242(F)	852(M) 153(M) 194(M)	153(M)

* Listed by Tag Frequency (Sex)

How were dates chosen??

TABLE 4

Number of active radio tagged shad in the vicinity of the York Haven tailrace, forebays of Safe Harbor, and Holtwood, and in Conowingo Pond, April-July 1987.

Date	York Haven Tailrace	Safe Harbor Forebay	Holtwood Forebay	Conowingo Pond
April				
28	1	0	-	-
May				
1	0	0	-	-
2	1	0	-	-
5	1	0	-	-
7	4	1	1	-
8	3	-	-	-
10	3	0	-	-
11	4	1	0	-
12	5	1	-	-
13	-	0	0	-
14	7	1	0	0
15	5	-	-	-
16	-	0	-	-
18	3	0	-	-
19	5	0	0	-
20	-	1	-	-
21	5	1	-	-
22	4	4	0	0
23	-	-	-	0
24	-	1	-	0
25	2	-	-	-
26	-	1	1	-
27	3	4	2	0
28	-	2	1	0
29	3	0	3	-
30	-	0	3	0
31	-	2	-	1
June				
1	1	3	2	-
2	4	3	1	0
3	-	0	0	-
4	2	2	0	-

continued

TABLE 4

Continued

Date	York Haven Tailrace	Safe Harbor Forebay	Holtwood Forebay	Conowingo Pond
5	2	3	4	0
6	-	0	-	-
7	-	0	-	-
8	2	0	5	-
9	2	1	5	1
10	-	1	3	-
11	-	-	5	-
12	0	0	4	0
13	-	0	-	-
14	-	0	3	-
15	2	1	4	0
16	-	1	1	0
17	-	0	0	0
18	1	0	5	0
19	-	-	4	0
20	-	0	1	0
22	-	-	4	0
23	-	0	2	0
24	-	1	0	0
25	1	1	2	0
26	-	-	2	0
27	-	0	0	0
28	-	-	0	-
29	-	0	1	0
July				
1	-	-	1	0
2	-	-	1	0
6	-	-	1	-

TABLE 5

Movement patterns of early, mid, and late run radio tagged American shad, 1987.

Time Period	Number Live Specimens Released	Number (%) moved		
		Riverine Area	York Haven	≤1 mile
Early 26 April-3 May	17	12(71)	7(41)	1(6)
Mid 10-16 May	7	3(43)	2(29)	3(43)
Late 31 May-2 June	7	2(29)	0	5(71)
Total	31	17(55)	9(29)	9(29)

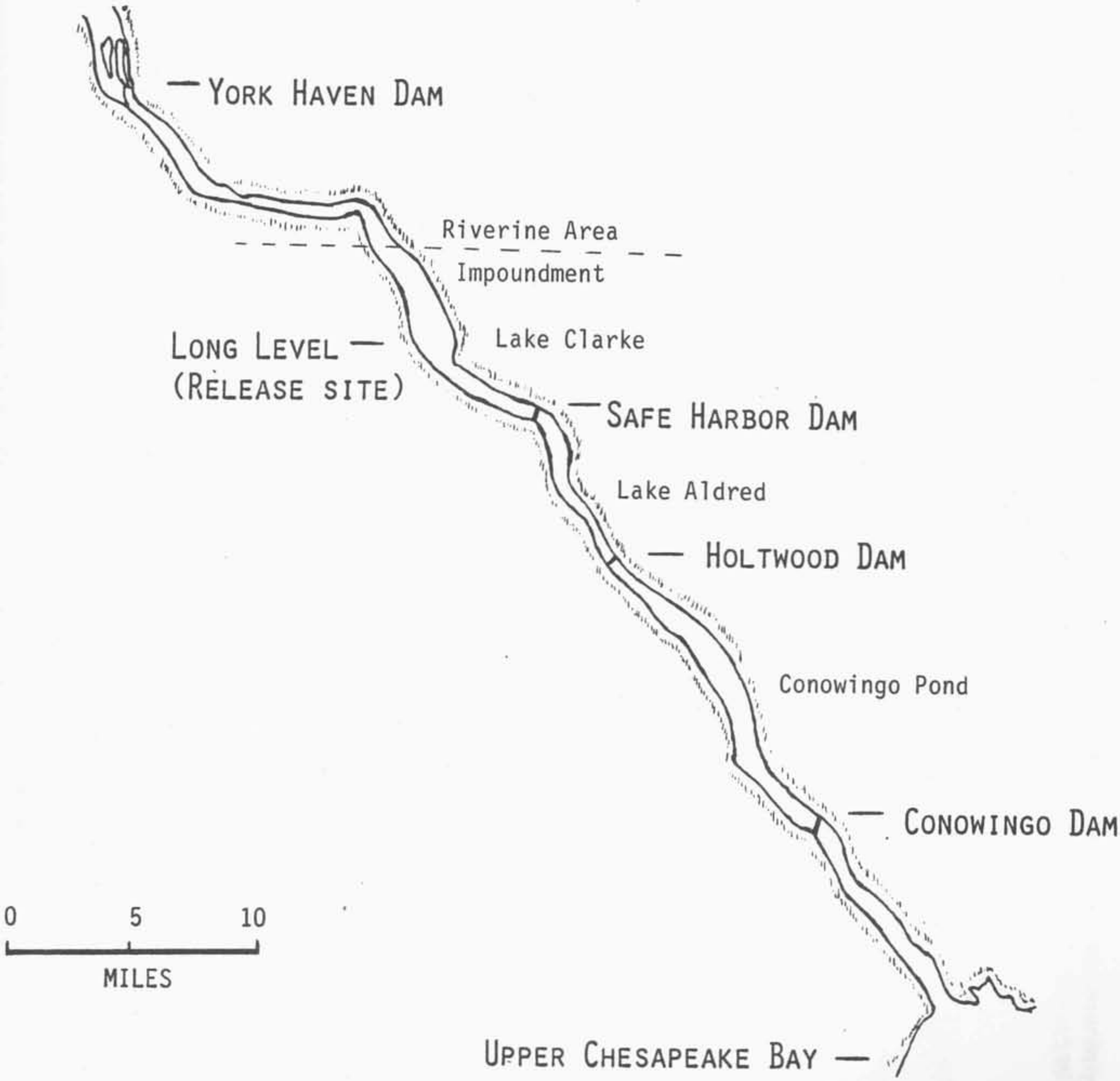

FIGURE 1
Areas monitored for radio tagged shad, 1987.

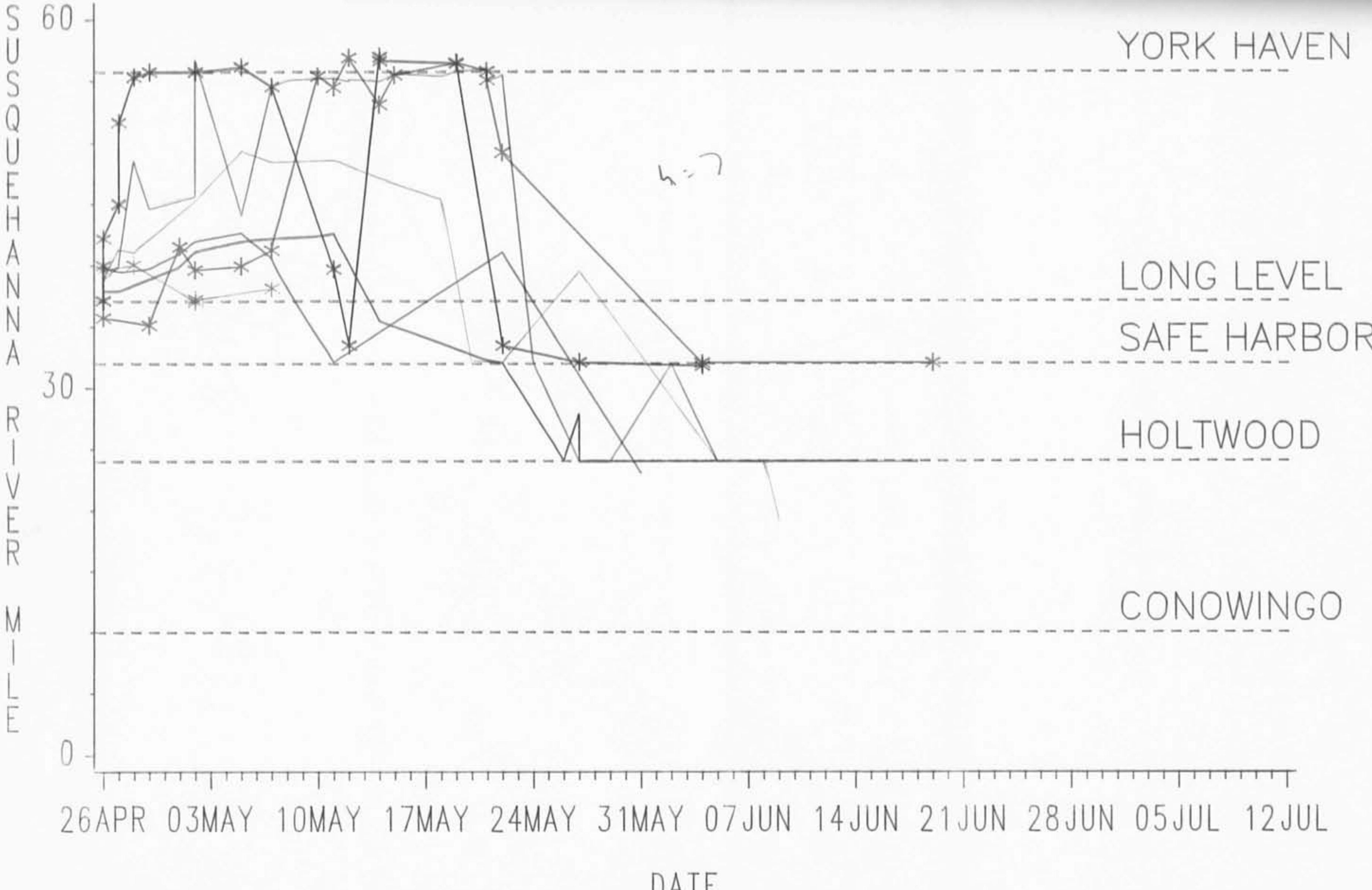

FIGURE 2
Dispersal patterns of adult radio tagged American shad collected at the Conowingo Fish Lift and released into the Susquehanna River at Long Level (RM 37), 26 April 1987.

RMC

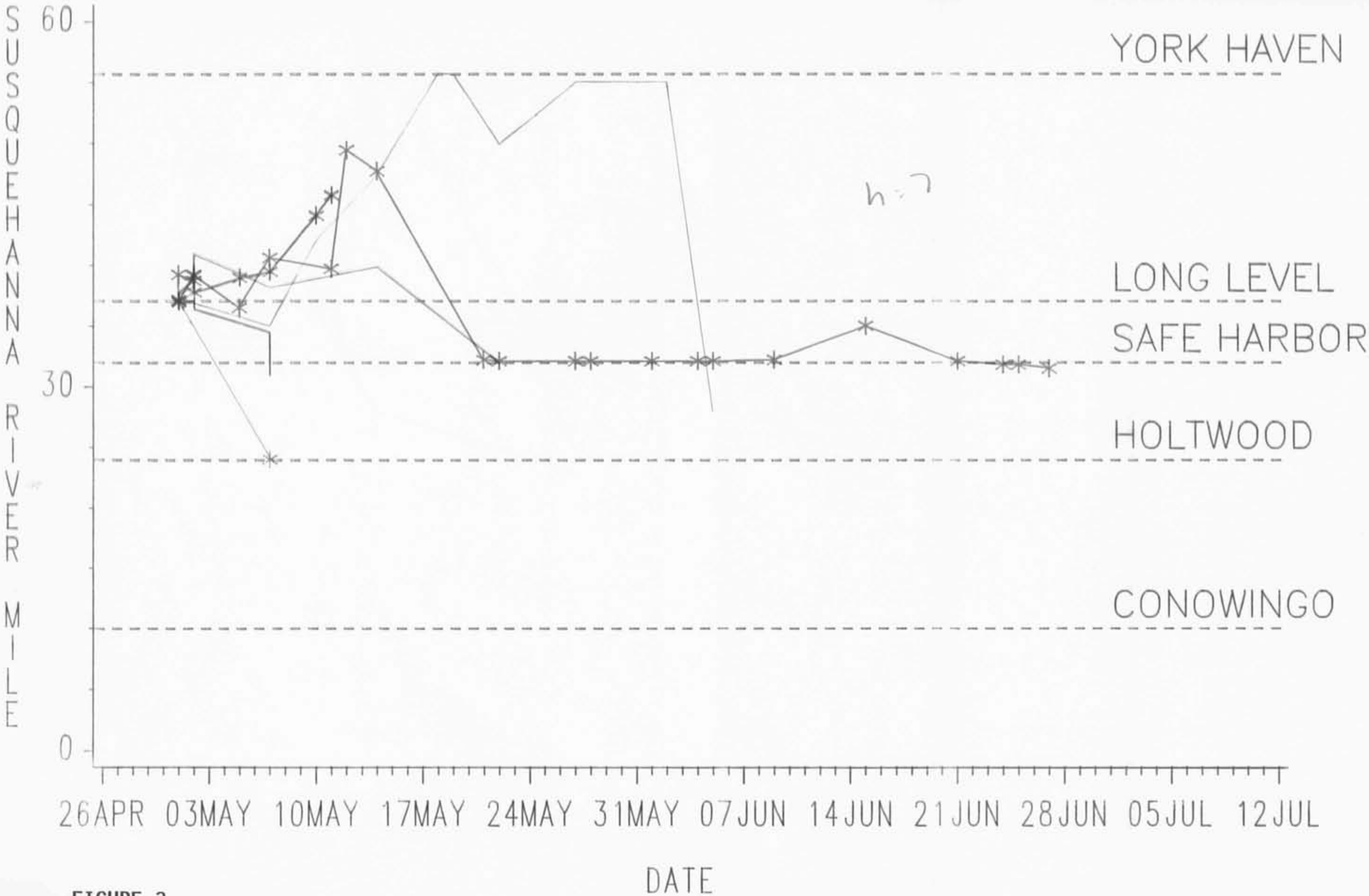

FIGURE 3
Dispersal patterns of adult radio tagged American shad collected at the Conowingo Fish Lift and released into the Susquehanna River at Long Level (RM 37), 1 May 1987.

RMC

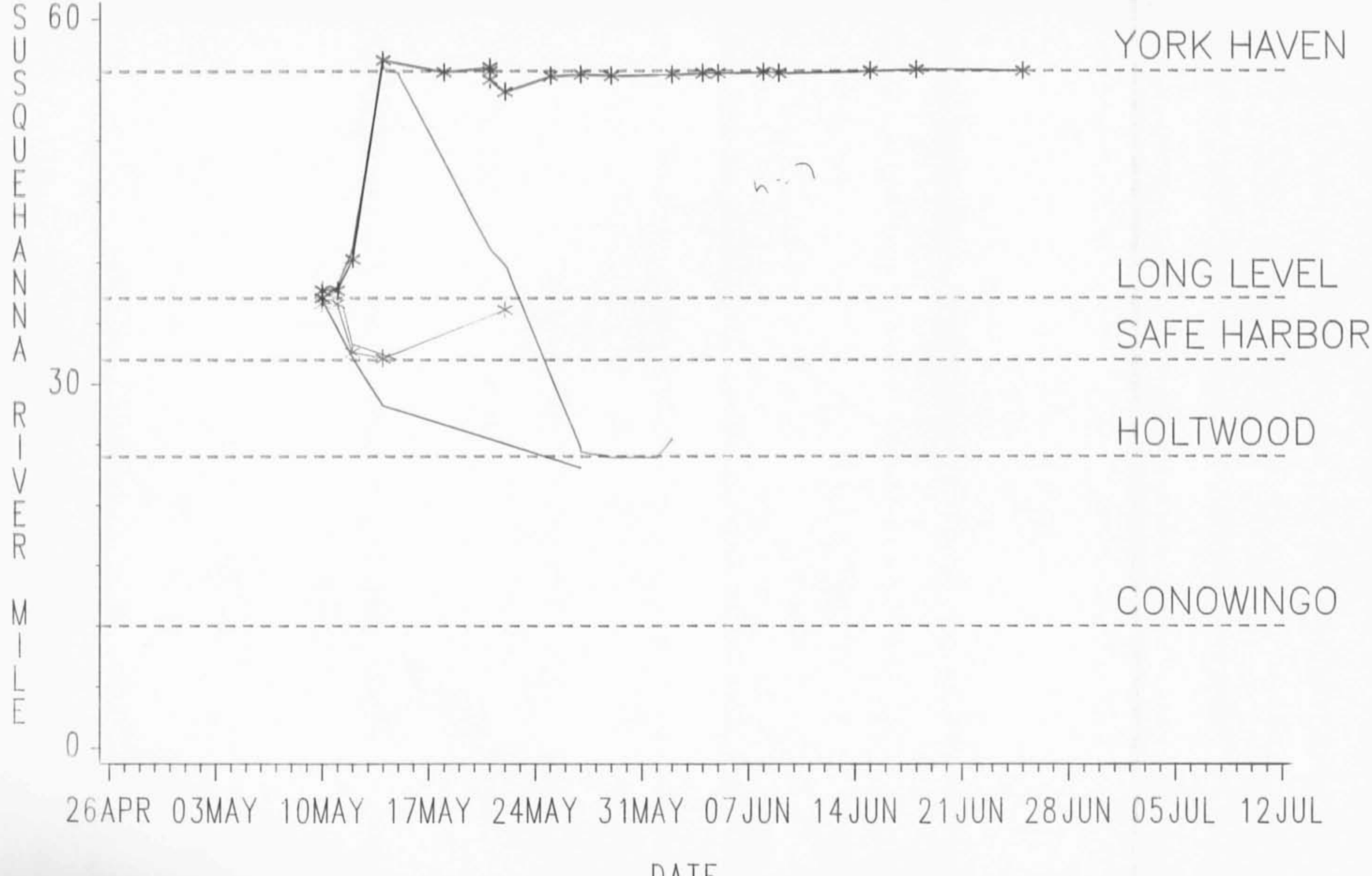

FIGURE 4
Dispersal patterns of adult radio tagged American shad collected at the Conowingo Fish Lift and released into the Susquehanna River at Long Level (RM 37), 10 May 1987.

RMC

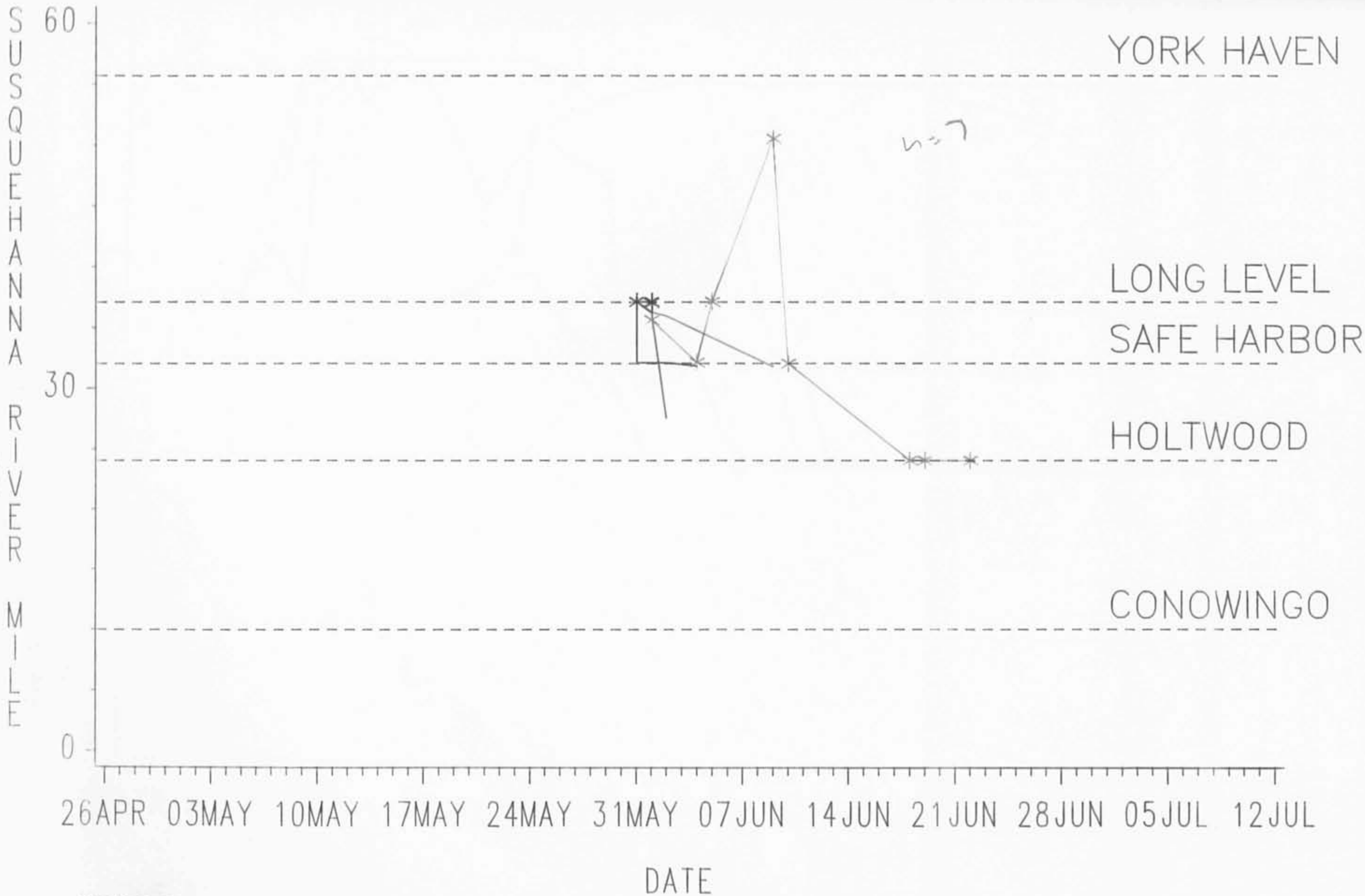

FIGURE 5
Dispersal patterns of adult radio tagged American shad collected at the Conowingo Fish Lift and released into the Susquehanna River at Long Level (RM 37), 31 May 1987.

RMC

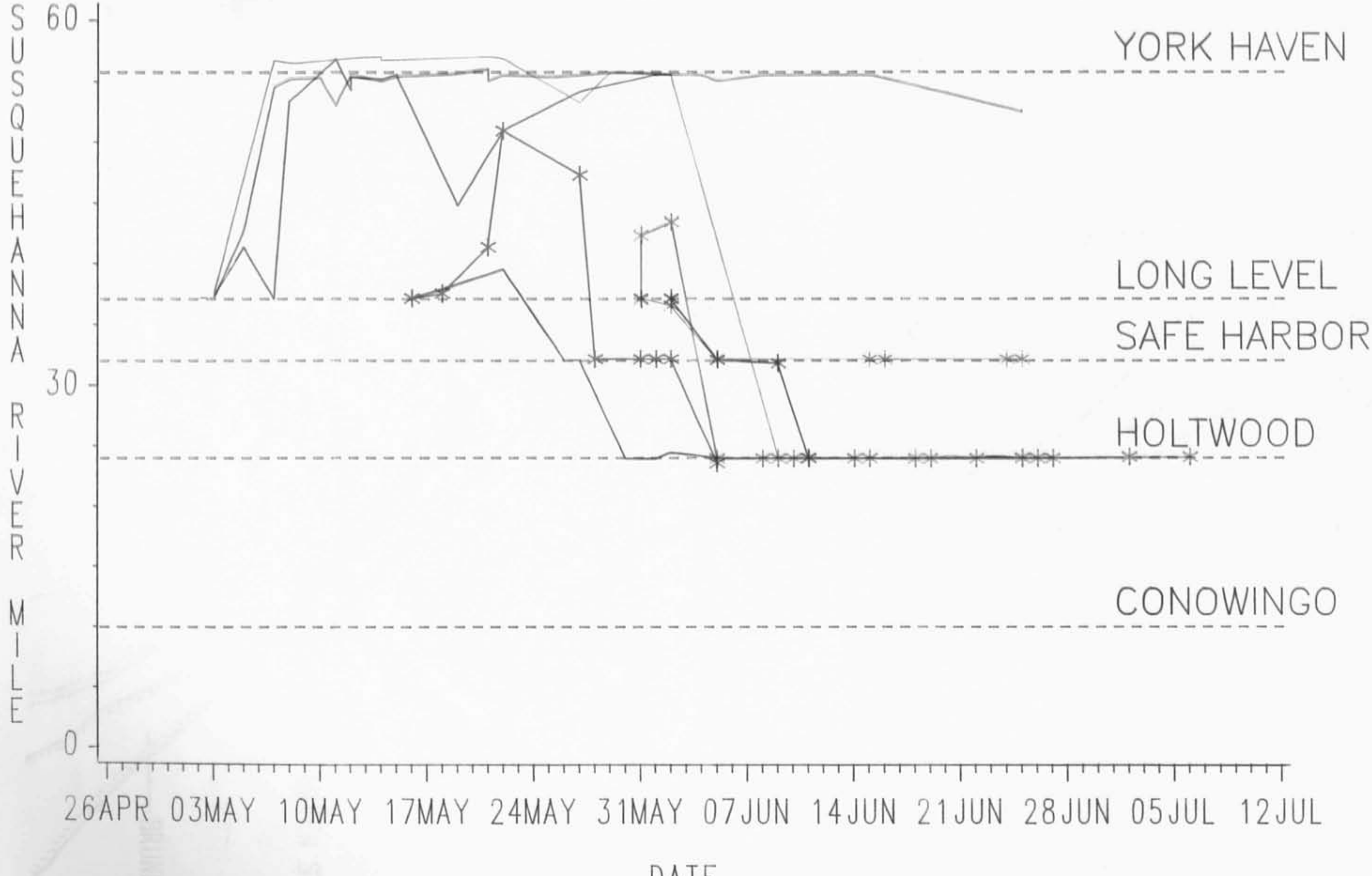

FIGURE 6
Dispersal patterns of radio tagged adult American shad tagged for an SRTC study below Conowingo Dam, recaptured in the Conowingo Fish Lift, and released on 5 occasions into the Susquehanna River at Long Level (RM 37), 1987.

RMC

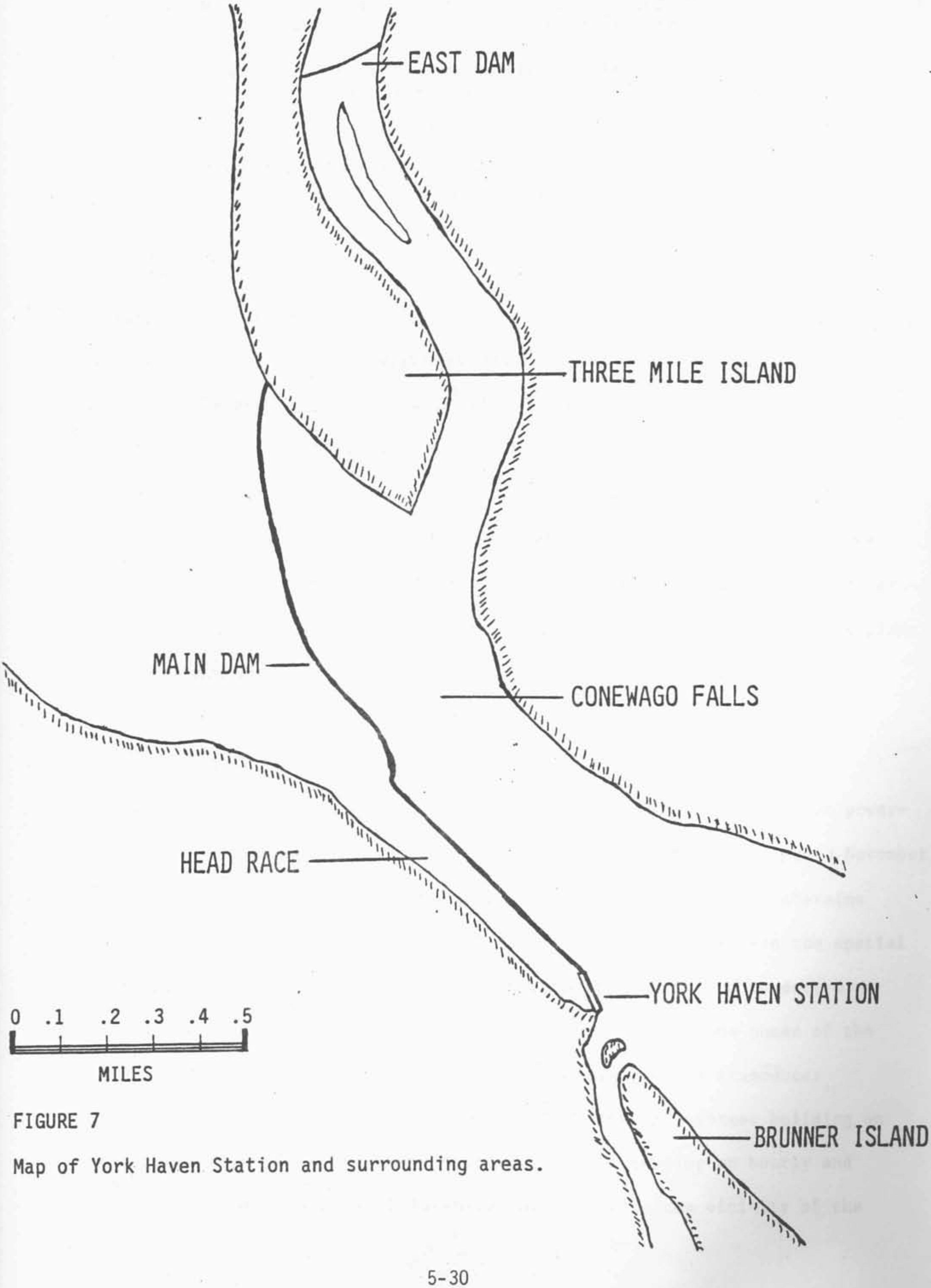

FIGURE 7

Map of York Haven Station and surrounding areas.

JOB Vb. HYDROACOUSTIC MONITORING OF JUVENILE AMERICAN SHAD PASSAGE AT YORK HAVEN HYDROPROJECT - 1987

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and

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Introduction

The York Haven hydroelectric project is located at river mile 55 on the Susquehanna River. The powerhouse has 20 turbines with a rated capacity of 19,600 kW and uses approximately 16,000 cfs of river flow at full generation with an effective head of 22-23 feet. All shad reared at the Van Dyke hatchery which are stocked into the Juniata River, and any natural production of shad from adult transfers to the river above dams must pass York Haven during their autumn migration from the river. Means of passing this project are through operating turbines (Francis and Kaplans), over the dam crest during spilling, or through a small trash sluice during cleaning operations.

Shad passage into the forebay (headrace) and through the York Haven powerhouse was assessed using hydroacoustics during 15 October through 3 November 1986 (BWEC, 1987). The objectives of the 1986 study were to determine the movement pattern of shad into the lower forebay, to assess the spatial and temporal distribution of shad in the forebay area, and to determine which avenues the juveniles used to exit the forebay. One phase of the 1986 study included a fixed location horizontally-aimed transducer connected to an acoustic sensor/processor at the transformer building on the west shore of the forebay which was used to develop an hourly and daily index of abundance of juvenile shad entering the vicinity of the powerhouse and trash sluice. The 1987 study at York Haven was designed to repeat that effort during peak weeks of outmigration to allow for comparison of variation in relative abundance and timing of migration past this project.

Methods

Theory and mechanics of hydroacoustic sensing technology were described in past annual reports to SRAFRC (BWEC, 1986; 1987). The 1987 survey of the lower forebay utilized the same transducer as was used for this purpose in 1986. The 10° beam width transducer was mounted to a length of PVC pipe at the north corner of the transformer/office building complex, lowered to a water depth of about 10 feet, and aimed diagonally across the forebay toward the upstream end of the powerhouse at the opposite shore (Fig. 1). The position and direction were the same as in 1986 with the signal beam projected almost perpendicular to the flow as it entered the forebay. The slight deviation of the beam from perpendicular to flow allowed information to be collected concerning direction of movements of targets.

The transducer was mated to a Koden CVS-8800 acoustic sensor connected to a Commodore SX-64 portable computer with dot-matrix printer. These items were set up inside the building to avoid weather damage. Barnes-Williams personnel delivered, set-up and calibrated the equipment on September 29. Plant staff at York Haven routinely checked the equipment, changed data tapes and sent daily records to B-W for analysis.

Results

Data were collected starting at 8:00 a.m. on 30 September and continued until 2:00 p.m. on 9 November. Over this time period samples were taken during 932 out of a possible 967 hours (96.4% coverage). Mean flux density (MFD) was calculated in the same manner as in 1986:

$$\frac{\text{mean target density} \times \text{volume sampled per hour}}{\text{sampled cross-sectional area}}$$

Raw data provided to SRAFRC (not included in this report) were in the form of mean volume backscatter, total number of samples, and mean flux density for each hour and each day of sampling. Variance and standard deviation were calculated for each daily mean and composite hourly time periods over the course of the monitoring. Daily MFD values ranged from a low of .0023 targets/m^2/hr on 9 November to a high of 1.797 targets/m^2/hr on 4 November (Table 1 and Fig. 2).

Based on daily MFD's over the course of the survey, target numbers appeared to peak on four occasions; 7 October (1.22), 20 October (1.75), 26 October (1.21), and 4 November (1.80). Lowest daily MFD's were recorded for 3 October (0.25), 22 October (0.23), 28-29 October (0.23-0.21), and 6-8 November (0.20-0.06). Sampling was discontinued after 1400 hours on 9 November. An attempt to correlate river flow and water temperature with daily mean flux densities shows no obvious trends (Fig. 3). A high flow episode occurred during 31 October through 4 November (peak 26,600 cfs on 2 Nov.) with water temperatures of 48-50°F. These conditions may relate to the peak daily MFD observed on 4 November, but this is inconclusive and such episodes were not apparent for other peak target days.

The cross-sectional area acoustically sampled was approximately 187 m^2. The average daily flux density over the length of the study period was 0.709 targets/m^2/hr. Assuming a total cross-sectional area of 645 m^2 at the monitoring site, an index value of approximately 10,975 targets (shad) per day was calculated (.709 targets/m^2hr x 645 m^2 x 24 hr.). This compares to an average index value of 0.687 and 10,600 targets/day in 1986. These numbers should not be construed as absolute average fish counts, but are only useful for annual comparison of relative indices of abundance.

Shad targets entering the forebay were concentrated in an area of water approximately 15-25 m away from the transducer face. As pointed out in 1986, this band of fish movement coincided with a water velocity band of approximately 1.5 fps. Because the sidescan transducer was aimed obliquely to direction of flow and fish movement, swimming direction of the targets could be determined. It appeared that fish movement during this survey was always downstream toward the powerhouse and repeat counting did not occur.

Mean flux densities for each hour of each day were pooled for the 41 days of the study (Table 2). Graphically displayed in Figure 4, hourly MFD peaked at 1800 hrs. at a value of 1.18; maintained an hourly average of about 0.97 between 1900 - 0400 hrs.; declined abruptly to 0.38 by 0700 hrs. and maintained this hourly average throughout the day until 1600 hrs., followed by a rapid increase. Compared to 1986 data the MFD for morning and afternoon periods were lower in 1987 but higher for dusk, dawn and overnight periods. Peak periods were the same in both years, occurring during dusk (1700-2000 hrs) and late night (0000-0400 hrs). Also, period of lowest MFD (0700-1200 hrs) was the same in both years. Most shad migration past the York Haven assessment site occurs during the period from late afternoon until dawn.

Discussion

The hydroacoustic data presented here provides an index of American shad passage in the lower forebay at York Haven, not absolute numbers. The hydroacoustic beam does not sample the entire water cross section and the data must be extrapolated. The degree of precision of the equipment is dependent on several variables such as orientation of the targets to the beam, location of targets in the beam, and grouping of targets as they pass through the beam. However, as an index of fish passage the results are useful and should be reproducible.

Emigration of juveniles may be initiated by the combination of a flow event and a coincident decrease in temperature. Discharge, water temperature and study day were shown to be correlated to the mean flux density at the 90% confidence interval in 1986. Only a minor flow peak was observed in 1987 (31 October) and this may relate to the peak day MFD recorded 4 days later.

In 1986 approximately 9.9 million shad fry and 42,000 fingerlings were released from PA Fish Commission hatcheries into the Juniata River. Over the period 15 October through 3 November, mean flux density measured at the forebay transducer was 0.687 targets/m^2/hr. Very high MFD values on the first two days of assessment indicated that the early part of the outmigration had been missed. Cast net sampling at weekly intervals near the York Haven trash sluice indicated first appearance of shad on 9 October and peak catch rate on 20 October (Young, 1987). A seasonal peak in the acoustic survey was also noted on 20-21 October, 1986. Over 93% of the shad examined from net collections at York Haven in 1986 were of hatchery origin.

In 1987, 5.2 million fry and 81,000 fingerlings were stocked in the Juniata River and these reduced numbers might have been expected to show a lower index of abundance at the York Haven monitor compared to 1986. However, this year's hydroacoustic survey produced an average index value almost identical to that of last year. Average catch per effort of shad(CPUE) using cast nets during peak weeks in 1987 was considerably higher than in 1986 (20.5 vs 10.5). Also it appeared in 1987 that even though the hydroacoustic survey was advanced by 2 weeks, the early part of the migration passed York Haven in September (see Job IV). Ninety-one percent of the shad collected with nets at York Haven were taken between 18 September and 14 October. Virtually all were of hatchery origin.

Hydroacoustic results are difficult to compare with cast net survey data. Cast net CPUE is influenced by date, weather conditions, time of day, and spread of the net in individual throws. Nevertheless, certain similarities in the results of the two surveys warrant discussion. The first acoustic peak occurred on 7 October and coincided closely with the peak cast net CPUE of 54.3 on 8 October. Where the two efforts overlapped, the low point in the acoustic survey occurred on 29 October, the same date that cast net CPUE fell to zero. A cast net CPUE value slightly above average (23) was recorded for 14 October, while MFD at the forebay monitor was also slightly above average (.83). The only remaining common sampling date was 20 October when the acoustic survey produced the second highest MFD for the study period (1.75) and cast net CPUE fell to less than half of average (9.0). The cast net samples were taken between 1200-1300 hrs on the 20th, which coincided with the lowest hourly MFD period recorded that day at the acoustic monitor (average MFD during 0900-1300 hrs was 1.0). Very high MFD values on the order of 2.1 to 2.8 were recorded after 1400 hrs and were largely responsible for the peak assessment day.

Cast net sampling was discontinued after 29 October. However the acoustic survey indicated that a final and major pulse of fish passed the monitor site on 4 November (MFD=1.80) followed by a precipitous decline until equipment was removed from the river on 9 November. Abundance of targets on a daily and seasonal basis did not appear to be directly related to hatchery stocking rates or river flow conditions in 1987. Though cast net data appear to support acoustic information generated for common dates, regression analysis indicated a very weak correlation. Nevertheless, hydroacoustic monitoring at York Haven offers valuable comparative index of abundance information and addresses a high priority objective of SRAFRC's Downstream Migrant Study Plan.

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TABLE 1
DAILY MEAN FLUX DENSITIES
YORK HAVEN POWER STATION

DATE	MEAN	TOT. # OF SAMPLES	VARIANCE	STANDARD DEVIATION
SEPT. 30	.3305	16	.06973	.264064
OCT. 1	.4948	23	.13929	.373215
OCT. 2	.352	24	.12829	.358175
OCT. 3	.2466	24	.0537	.231732
OCT. 4	.3111	24	.04211	.205207
OCT. 5	.4327	24	.21895	.46792
OCT. 6	.9267	24	.6069	.779037
OCT. 7	1.2191	24	.95976	.979673
OCT. 8	.5722	24	.25278	.502772
OCT. 9	.592	24	.42601	.652694
OCT. 10	.3669	24	.14785	.384512
OCT. 11	.706	24	.41407	.643482
OCT. 12	.8807	24	.63287	.795531
OCT. 13	.6597	24	.39449	.628084
OCT. 14	.8281	23	.28298	.531958
OCT. 15	.8591	24	.34873	.590533
OCT. 16	.875	24	.53158	.729095
OCT. 17	1.1088	24	.93447	.966679
OCT. 18	.9578	24	.53359	.730472
OCT. 19	1.1398	24	.37156	.609557
OCT. 20	1.7485	23	.32771	.572459
OCT. 21	1.2799	24	.60542	.778087
OCT. 22	.2267	24	.04551	.21333
OCT. 23	.4909	24	.20199	.449432
OCT. 24	.9014	19	.45105	.671602
OCT. 25	.9762	21	.27127	.520835
OCT. 26	1.2099	18	.45055	.67123
OCT. 27	.9371	24	.22142	.470552
OCT. 28	.2298	24	.06206	.249118
OCT. 29	.2148	19	.09448	.307375
OCT. 30	.4579	18	.10252	.320187
OCT. 31	.6587	24	.11491	.338983
NOV. 1	.7293	24	.11189	.334499
NOV. 2	.8802	24	.09169	.302803
NOV. 3	.6915	24	.13489	.367273
NOV. 4	1.7972	24	1.08277	1.040562
NOV. 5	.7321	24	.41866	.647039
NOV. 6	.2046	24	.02387	.154499
NOV. 7	.1546	24	.01916	.138419
NOV. 8	.0558	17	.03172	.178101
NOV. 9	2.3E-03	15	0	0

TABLE 2
HOURLY MEAN FLUX DENSITIES
YORK HAVEN POWER STATION

TIME	MEAN	TOT. # OF SAMPLES	VARIANCE	STANDARD DEVIATION
0000	1.0346	38	.47788	.691288
0100	.9808	37	.43957	.663
0200	1.02	38	.56417	.751112
0300	.8944	38	.42272	.650169
0400	.9492	37	.57488	.758208
0500	.8182	36	.48027	.693015
0600	.6801	37	.30085	.548497
0700	.3864	38	.16141	.401758
0800	.3725	39	.18947	.435281
0900	.3124	40	.15517	.393916
1000	.3308	40	.19304	.439363
1100	.3489	40	.12855	.358538
1200	.42	40	.19077	.436772
1300	.4088	40	.28473	.5336
1400	.4118	40	.27461	.524032
1500	.4523	39	.26114	.511018
1600	.4823	39	.36053	.600441
1700	.6844	40	.59318	.770181
1800	1.1778	40	.91158	.954766
1900	1.1138	40	.78975	.888678
2000	.9543	40	.43863	.662291
2100	.8919	39	.39742	.630412
2200	.9105	39	.33754	.580981
2300	.9825	38	.43377	.658612

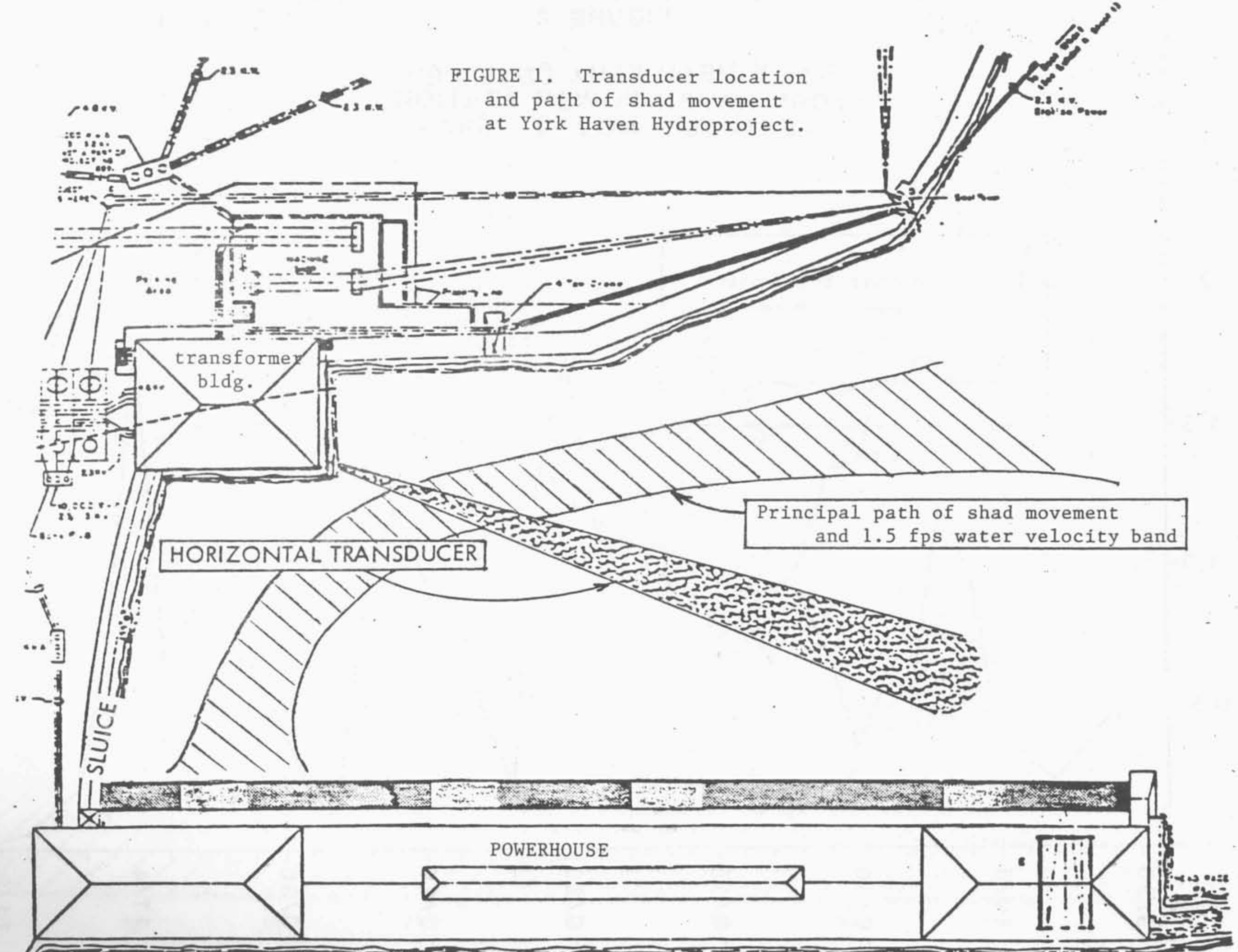


FIGURE 1. Transducer location and path of shad movement at York Haven Hydroproject.

FIGURE 2

DAILY MEAN FLUX DENSITIES
YORK HAVEN POWER STATION
SEPT. 30 - NOV. 9, 1987

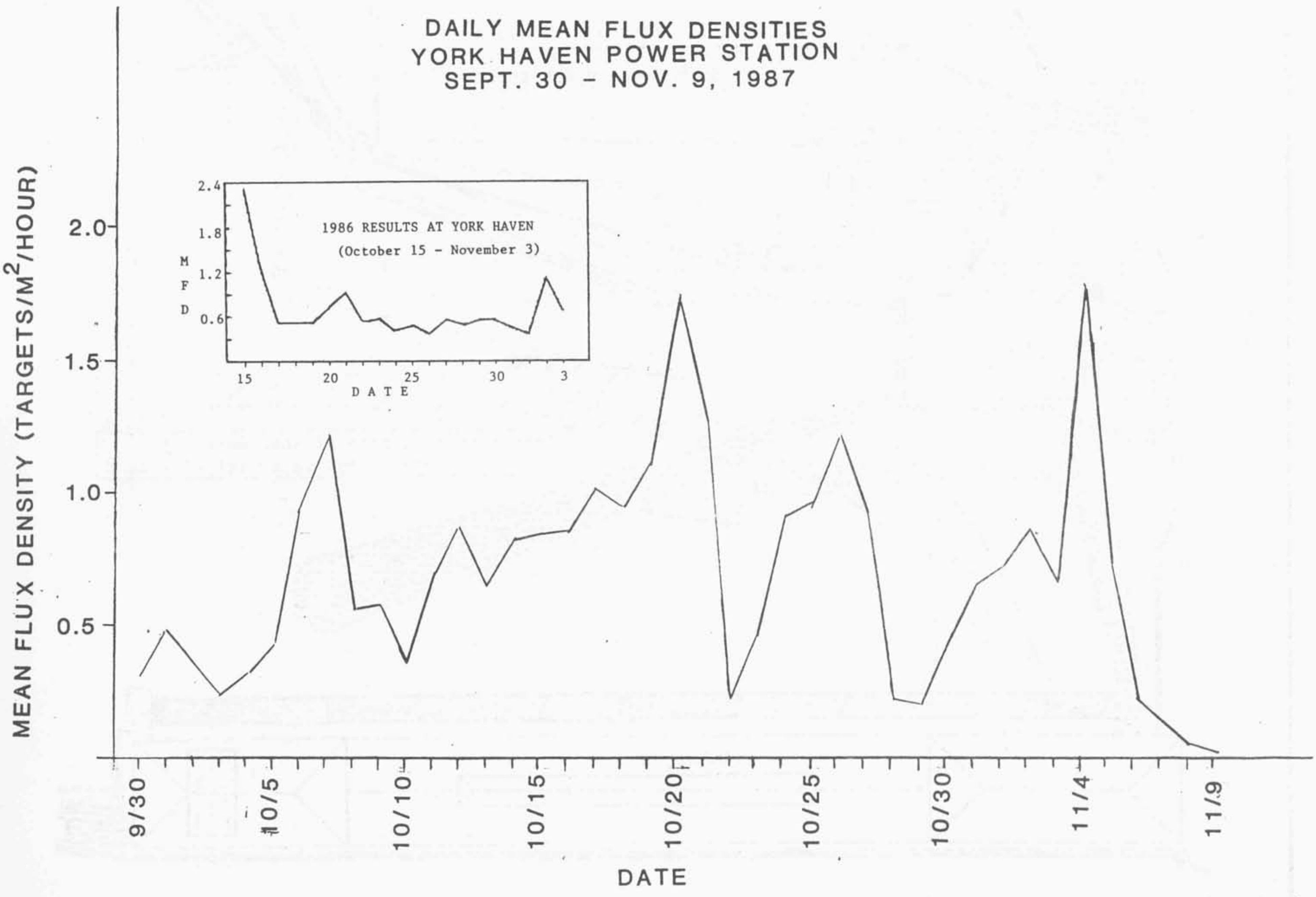


Fig. 3. Index of American shad abundance at the York Haven forebay, Sept. 30 - Nov. 9, 1987 with average daily river flow and water temperature.

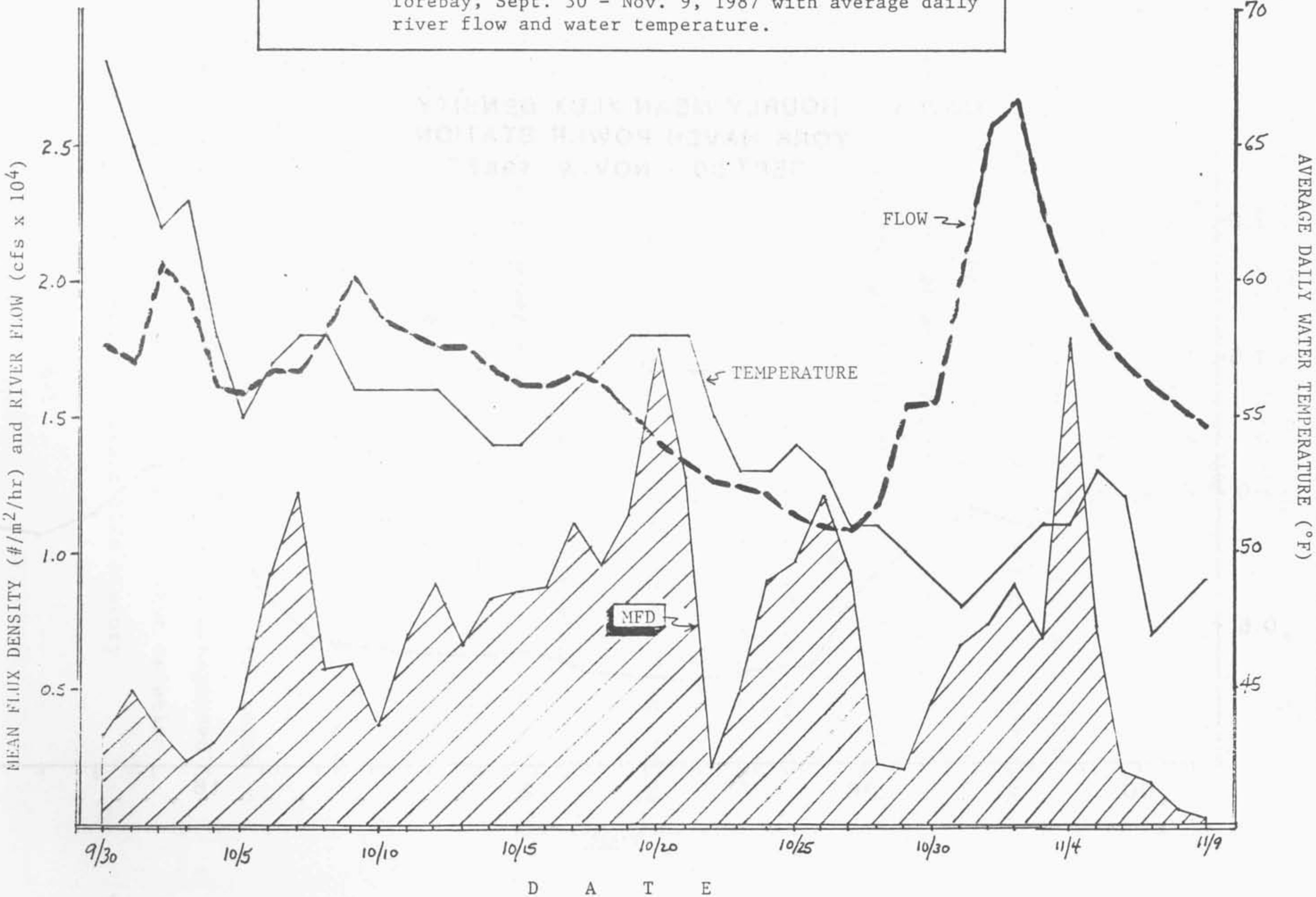
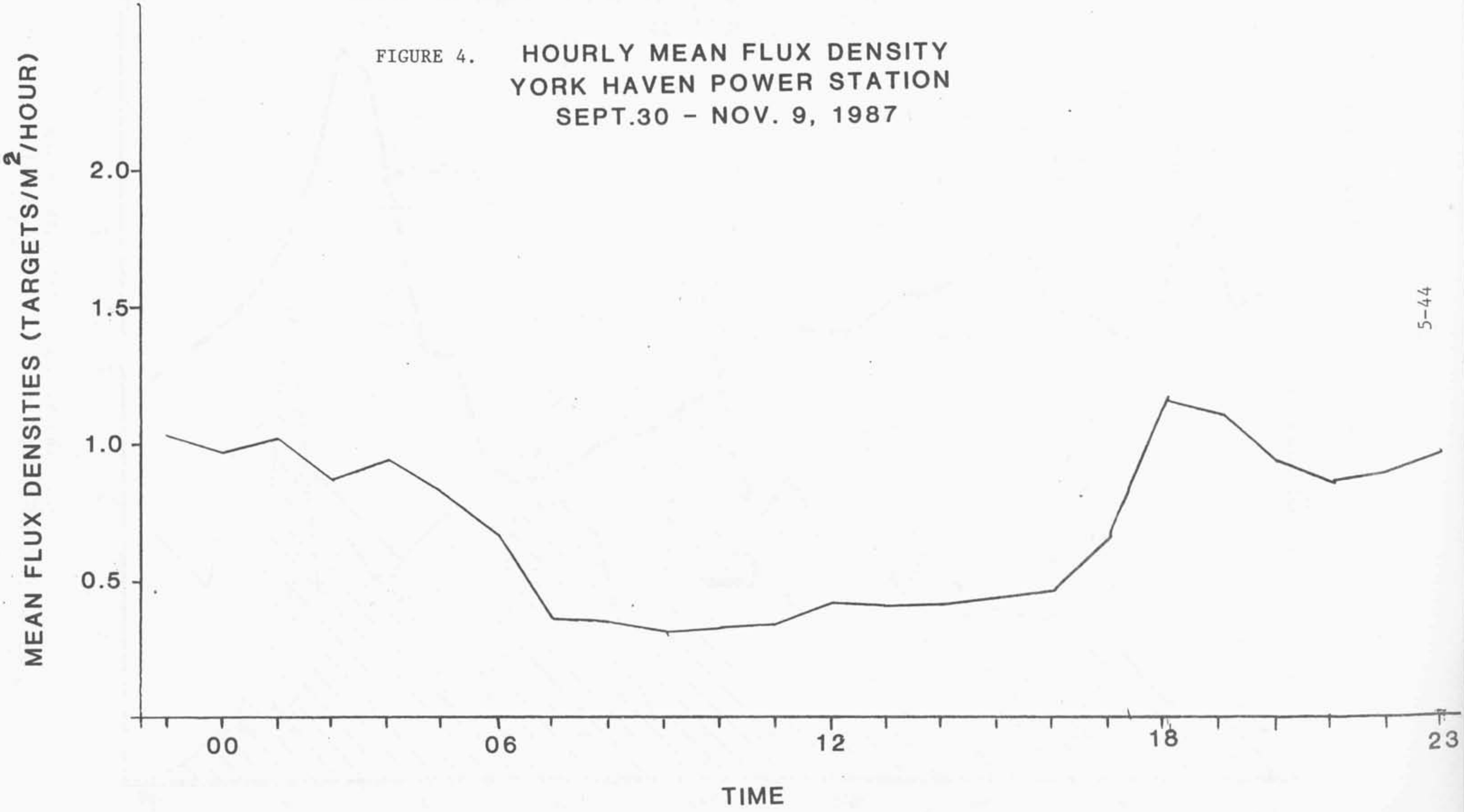


FIGURE 4. HOURLY MEAN FLUX DENSITY
YORK HAVEN POWER STATION
SEPT.30 - NOV. 9, 1987



JOB VI. SUMMARY OF OPERATION OF THE CONOWINGO DAM FISH PASSAGE FACILITY IN SPRING 1987

RMC ENVIRONMENTAL SERVICES
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INTRODUCTION

The Conowingo Dam Fish Passage Facility (hereafter 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. In accordance with the restoration plan, the operational goal of the Lift had been to monitor fish populations below Conowingo Dam and transport as many migratory fishes (American eel, river herrings, American shad, and striped bass) upriver as possible. Support for the operation and maintenance of the Lift is provided by the Philadelphia Electric Power Company (PECO) and the Susquehanna Power Company.

The Conowingo Hydroelectric Station is operated as a run of the river peaking power station. The maximum rated peak discharge from its eleven units is 85,000 cfs. Natural river flow in excess of 85,000 cfs is released over the spillway. Generally, under efficient operation conditions, total discharge from the seven (1-7) small (5,000 cfs each, and the four (8-11) large units (10,000 cfs each) is 75,000 cfs.

Objectives of the 1987 operation were to (1) contribute to restoration efforts by the trap and transfer of prespawned American shad to upstream localities, (2) monitor relative abundance of *Alosa* species, (3) obtain life history information from selected migratory and resident fishes, (4) monitor species composition, and (5) assist the Maryland Tidewater Administration in assessing the American shad population in the upper Chesapeake Bay.

METHODS

Prior to the operation of the Lift, surveys were conducted to detect the arrival of alosids into the lower river area. Alternate day herring checks at Deer Creek were initiated on 16 March. Since no herring were observed and American shad were being collected at the Lift, the herring checks were terminated on 22 April. During this period water temperatures varied from 40.0 to 61.7 F.

Preparations for the operation of the Lift began during early March and included a series of steps to make the lift reliable and operable at 120,000 cfs in accordance with the Federal Energy Regulatory Commission (FERC) order issued on January 7, 1987. The steps taken, and agreed to by the Susquehanna River Technical Committee (SRTC), are presented in Table 6-1. Lift operation was consistent with and followed 1987 SRTC and Susquehanna River Anadromous Fish Restoration Committee (SRAFRC) work plans.

Lift operation commenced on 1 April and occurred on an alternate half-day basis through 5 April. Due to increased river flows (>230,000 cfs) on 5 April weir gate and crowder motors had to be removed at the end of the day. Operation resumed during the afternoon of 12 April; the Lift was operated on an alternate half day basis from 13 to 19 April. With the collection of 22 American shad on 21 April daily operation of the Lift started (0700 hrs to approximately 1900 hrs) and continued to 8 June. Operation of the Lift was reduced to a half day basis on 9 and 10 June, and terminated on 12 June due to the advanced sexual condition of American shad and the limited numbers collected.

Beginning in late April, PECO modified the normal pattern of station generation at Conowingo Dam to enhance Lift effectiveness when the natural river flows and electrical power demand permitted. Generally, Turbine Units No. 1 and/or 2 were kept off until all others had been placed into service and were taken out of service first when going to off peak generation. This modified generation scheme was maintained through 8 June and terminated when the catch of American shad in a post-spawned condition indicated the 1987 run of shad was over.

The mechanical aspect of Lift operation in 1987 was similar to that described in RMC (1983). Fishing time and/or lift frequency was determined by fish abundance and the time required to process the catch. However, due to large numbers of gizzard shad, and on occasion carp, two modifications implemented in 1985 to maximize collection of American shad were utilized (RMC 1986). Operation "Fast Fish"* (RMC 1986) was employed on an as needed basis and resulted in increased fishing time during periods of heavy fish activity by reducing mechanical delays associated with normal lift operation. On several occasions, as a result of changes in water levels in the tailrace, large numbers of gizzard shad were attracted to the lift. In an effort to maximize the collection of American shad, either weir gate 1 or 2 (Figure 6.1) was closed and fish that had accumulated were lifted rapidly within minutes. After most fish had been removed, the operation of the Lift was changed back to the normal operational mode.

Attraction velocity and flow at the Lift were similar to those maintained since 1982 (RMC 1983). Based on the 1982 data, hydraulic conditions were maintained in the area of the Lift between the crowder and weir gate entrances similar to that reported in RMC (1983). Modifications to weir gates and house service unit settings were made during periods of heavy fish concentration and were similar to those maintained in 1985 (RMC 1986).

Since 1972 a continuous minimum flow of 5,000 cfs through Conowingo Dam has been maintained from 15 April through 15 June. Generally, Unit Nos. 5 and/or 6 were used in 1987 to release the continuous minimum flow. The minimum release from

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*Operation "Fast Fish" is leaving crowder in normal fishing position and raising hopper as necessary to remove fish that accumulated in the holding channel.

either Unit No. 5 and/or 6 was based on results of 1982 and experience at other fish passage facilities which showed that passage effectiveness increased when competition was reduced between the attraction flow from the passage devices and the flow releases from other sources. However, on a test basis, Unit Nos. 1, 2, 3, 4 and 7 were used in an attempt to gain information on adult shad behavior with respect to flow utilizing radio telemetry.

Fishes were processed as reported earlier (RMC 1983). Fishes were either counted or estimated (when large numbers were present) and released back to the tailrace. Length, weight, sex, and scale samples were taken from blueback herring, hickory shad, alewife, striped bass, and striped bass x white bass hybrid. The use of scientific and common names of fishes collected (Table 6.2) followed Bailey et al. (1970). Most life history information (i.e. length, weight, sex and spawning condition) and scale samples were taken from shad that died in handling and/or transport.

American shad scales were cleaned, mounted, and aged according to Cating (1953). The procedures employed to determine age structure and spawning history of shad were similar to those used by Maryland Department of Natural Resources (DNR), and had been validated through an exchange of scale samples in 1982 and 1983.

Holding and Transport of Shad

Generally, transport occurred whenever 50 or more green or gravid shad were collected in a day, or at operator's discretion. Based on results of holding experiments conducted in 1986, American shad were held overnight or for several days to accumulate sufficient numbers of shad for transport, thus increasing the efficiency of the transport program. Four black circular tanks (2-800 gal., 2-1,100 gal.), continually supplied with river water, were used as holding tanks. The aeration system utilized bottled oxygen and/or compressed air. Also, each tank was fitted with a cover to prevent escape and reduce stress.

Transportation of American shad was accomplished utilizing one 800 and three 1,100 gallon circular transfer units. All transfer units were equipped similarly to the system used in 1985 (RMC 1986). The holding and handling procedures employed during transport were similar to those used in previous years.

RESULTS

The relative abundance of fishes has fluctuated since 1972 (Table 6.3). Fluctuations have resulted primarily from changes in species abundance and modification to Lift and turbine operation. Prior to 1980, alosids (primarily blueback herring) and white perch dominated the catch, from 1980-1987 the catch was generally dominated by gizzard shad, white perch, and channel catfish.

In 60 days of Lift operation (1 April through 12 June, 1987) 2,593,445 fish of 46 taxa were caught (Table 6.3 and 6.4). Predominant species in order of numerical abundance were gizzard shad, white perch, comely shiner, and channel catfish. Alosids (blueback herring, alewife, hickory shad and American shad) comprised less than 0.6% of the total catch.

The catch of gizzard shad (2,488,618) in 1987 was the highest recorded for any species since operation began in 1972, and comprised 96% of the total (Table 6.3). The daily catch (Table 6.4) was also dominated by gizzard shad and ranged from 698 (5 April) to 238,500 (24 May). Most gizzard shad collected during late May and June were from the 1986 year class (1 year olds).

The large number of gizzard shad in the tailrace and operation "Fast Fish" were prime contributing factors to the record catch in 1987. Modifying normal weir gate openings, in combination with operation "fast fish" on seventeen days when gizzard shad and/or carp numbers were excessive, also resulted in an increased catch rate of American shad on 11 of those 17 days (Table 6.5).

American Shad

The 1987 catch of American shad (7,667) at the Lift was the highest recorded since Lift operation began in 1972 (Table 6.3). Ninety-five percent (7,292) of the shad collected were transported. One hundred-five shad (unmarked) were released back to the tailrace. Thirty-two were tagged; 4 were floy tagged and 28 were radio tagged. The remainder were comprised of RMC tag recaptures, resource agency recaptures (Maryland DNR, Government of Canada, Department of Fisheries and Oceans), handling and holding mortalities.

A total of 141 American shad (1.8%) died during daily operation at the Lift. Mortalities resulted from mechanical operation of the Lift, and handling and holding procedures. The mortality at the Conowingo Fish Lift was within the range of mortality (1-3%) observed at the Holyoke Fish Lift where handling procedures are generally non-existent; shad swim through a flume to gain access to the area upstream of the dam.

American shad were first observed at the Lift on 17 April (Table 6.4 and Figure 6.2). Most shad were collected from 22 April through 31 May. Examination of the daily catch during this period indicated that the shad catch varied daily but reflected three peak periods of abundance. The largest collection of shad (2,385) occurred from 13 to 17 May. Other periods of increased abundance occurred from 24 to 28 April, and 1 May to 3 May when 1,571 and 1,017 shad were taken, respectively.

The daily catch of American shad exceeded 200 individuals on 15 days (Table 6.4 and Figure 6.2). Prior to 1987, the highest daily catch of American shad at the Lift was 861 on 1 June 1986. The largest catch in 1987 was 1,359 on 16 May. This represented approximately 18% of the total catch.

As in the past, the catch per effort (CPE) of American shad varied by station generation and time of day (Table 6.6). The CPE was approximately three fold higher when one unit was in operation (Table 6.7). Also, the CPE was three times higher during weekend operation. Generally, during weekend and week day periods, the total CPE was greatest during the morning (0700-0900 hrs) and evening (1500-1900 hrs) periods.

American shad were collected at water temperatures of 51.8 to 74.3 F and at natural river flows of 14,200 to 72,700 cfs (Table 6.4 and Figure 6.2). Seventy-two percent of the shad were collected at water temperatures $\leq$65 F (Table 6.8). Water temperature during the period of peak shad abundance (22 April to 31 May) varied from 57.2 to 69.9 F.

Transport of Adults

The trap and transport of prespawned American shad to upstream spawning areas is the primary objective of Lift operation and contributes to the American shad demonstration program. Prespawned American shad were transported from 23 April through 7 June. Most American shad were stocked above Safe Harbor Dam at Safe Harbor Water Power Corporation's public boat ramp at Long Level. Two loads of shad were stocked into Conowingo Pond. One load with 26 radio tagged shad was released at Philadelphia Electric Company's Dorsey Park ramp, the other load of 220 shad was released at the Pennsylvania Fish Commission's Muddy Creek Access. Shad were released at the Pennsylvania Fish Commission's access due to a transport truck breakdown.

A total of 7,202 (94% of 1987 catch) American shad was transported to potential upstream spawning areas with an overall stocking survival of 95.8% (Table 6.9). Over 72% of the observed transport mortality occurred on 28 April when 218 shad died as a result of a tank failure (release seal broke on the transport unit; roughly 95% of the water drained out). Transportation of shad occurred on 26 days and was accomplished in 42 trips. Generally, individual trips averaged 1.5 hours. The number of trips per day varied from one to six; load size varied from 65 to 264 fish per trip. Excluding the 100% mortality that resulted from equipment malfunction, trip survival varied from 92.5 to 100%. Shad were collected and transported at water temperatures between 56.3 to 73.4 F.

The transport of a large number of shad afforded the opportunity to estimate the potential contribution of these fish to the demonstration program. The potential egg deposition of shad was calculated assuming an average fecundity of 200,000 eggs/female. Of the 1,787 females transported, 85 died, resulting in 1,702 being stocked upstream. The estimated potential egg deposition of these 1,702 fish was 340 x 10^6 eggs. The fate of these eggs, survival to fry, and juvenile stage is unknown. In contrast, the hatchery operated by Pennsylvania Fish Commission received

39 x 10^6 eggs and released 11.1 x 10^6 fry and 84,000 juveniles (see Job III).

Based on 1986 results, holding facilities were improved to allow shad collected on a given day to be held overnight or for several days, based on operator's discretion to maximize transport operations and release of larger schools of fish. A total of 1,848 shad was held over at the Lift at least one night (Table 6.10). The number of shad held over varied from 2 to 205. A total of 68 shad died in the holding tanks; 35 were males and 33 were females. Fifty-one mortalities occurred on 30 May. Although the exact cause of this mortality is unknown, it appears that cessation of flow in the tanks caused the deaths since, DO was in excess of 11.0 ppm.

Sex and Age Composition of American Shad

Visual macroscopic inspection of shad was made to determine the daily and seasonal sex ratios. The age composition of American shad trapped at the Lift was determined for selected samples from tagging, mortalities from handling, transport operations, and those scaled and released back to the tailrace. Therefore, this information is provided only to observe general trends.

The sex of 5,804 American shad was determined; 4,031 were males and 1,273 were females (Table 6.11). Generally, males dominated the catch during the early and middle of the season; females dominated the catch at the end of the season. The average ratios (m/f) from 17 to 30 April, 1 to 15 May, and 16 to 30 May were 8.5:1, 3.5:1 and 2.0:1, respectively (Table 6.12). Although females dominated the catch at the end of the season (31 May-12 June) the average ratio was close to 1:1 (m/f). An interesting note was that the average sex ratio for shad collected at the Lift (2.9:1), and those caught by hook and line (2.4:1) by the Maryland DNR in the tailrace was similar.

Four hundred sixty-nine scale samples were taken, 407 (87%) were successfully aged (Table 6.13). Males were II to VII years old, IV year olds dominated. Females were III to VII years old; V year olds dominated. Thirty males (11.5%) and 16 females (10.9%) were repeat spawners; 3 males and 2 females, were double repeat spawners. Also, the scales from the 1984 Maryland DNR tag recaptured shad were regenerated, however, this fish could have spawned four times.

The sex ratio of mortalities (2.2:1) differed slightly from that observed for all shad collected (2.9:1). However, the data were separated to determine if the age composition of dead shad was different (Table 6.14). Results indicated that, the age composition of males and females in the two samples was similar. Also, the age composition from samples taken at the Lift and by hook and line in the tailrace (see Section VII) was generally similar.

Tag and Recapture

Floy tagging was limited in 1987 because the primary objective of Lift operation was to maximize the trap and transport of prespawned American shad. Four shad were tagged; one was recaptured (Table 6.15). One shad tagged in 1986 was captured twice.

One hundred twenty-three shad marked by resource agencies were captured at the Lift; 121 were tagged by the Maryland DNR (see Job VII) and one was tagged by personnel of the Department of Fisheries and Oceans, Canada (Table 6.16).

The shad tagged by the Department of Fisheries and Oceans, Canada was captured twice, on 14 May and 7 June. This fish was tagged in the Bay of Fundy (Minas Basin, Nova Scotia) on 9 June 1985 (Dadswell, pers. comm.).

The Maryland DNR marked a total of 393 shad in three locations using four gears in the Upper Chesapeake Bay. A total of 106 of the 121 Maryland DNR tagged shad captured at the Lift were first time captures and accounted for over 95% of the returns Maryland received in 1987. The Lift captured 27% of all the shad marked by the Maryland DNR (Table 6.18).

One hundred fourteen of the Maryland recaptures were tagged on the east side of the tailrace, five from the lower river and two from the Susquehanna Flats. Ninety-nine (30.1%) of those marked in the tailrace were captured at the Lift once. Eight shad collected in 1987 were captured twice (Table 6.17). Six shad collected were tagged in previous years; five from 1986 and one from 1984.

Some 54 American shad were fitted with radio tags and released in the Conowingo tailrace; 28 were captured at the Lift and 26 were angled from the east side of Conowingo tailrace (Table 6.19). Ten (18.5%) telemetered shad were recaptured at the Lift; five were tagged at the Lift and five were tagged by angling. The capture rate of telemetered shad was lower than that for Maryland DNR floy tagged shad (18.5% vs 27%). However, 20 radio tagged fish left the tailrace and never returned. Adjusting for this, 29.4% of the telemetered shad that either remained in, or returned to the tailrace were recaptured at the Lift.

River Herring and Hickory Shad

The combined catch of river herring (blueback and alewife) and hickory shad declined from that observed in 1986 (RMC 1987), and was much lower than historic levels (Table 6.3).

A total of 357 alewife was collected, with the first capture on 1 April (Table 6.4). Sixty-one percent of the catch occurred from 21 April through 15 May at water temperatures of 51.8 F to 66.4 F.

A total of 5,861 blueback herring was collected. Blueback herring typically arrive later than alewife and were first collected on 23 April. Over 97% were collected from 10 through 31 May. Water temperature ranged from 60.8 to 69.9 F during this period. It is interesting to note, on 17 May 3,671 blueback herring (64% of total catch) were collected at a water temperature of 65.3 F.

The hickory shad catch (35) continued to be small. Hickory shad were first captured on 17 April. Most (94%) were caught from 17 April through 10 May.

DISCUSSION

As in earlier years, the catch of shad was much higher on weekends than on weekdays (Table 6.6; Figure 6.3). A total of 4,322 shad was caught on 17 days of operation on weekends versus 3,337 shad on 43 weekdays of operation. The CPE (catch/hr) was 28.2 and 8.8 on weekends and weekdays, respectively. The run of shad is primarily dictated by natural river flows and water temperature and occurs in waves. The size of the catch is primarily dictated by the variations in station discharge (peak load vs reduced generation), natural river flows, and the nature of the shad run (changes in rate of immigration). Station discharge is dictated by natural river flows, peak power demand and minimum flow requirements. On weekends there is little peak power demand, and if natural river flows are low, the station either shuts down (up to 14 April) or discharges 5,000 cfs. If natural river flows are high the station must discharge higher flows. Generally, peak shad collections in 1987 were coincident with weekends (Figure 6.3).

The Lift catch indicates that an increased number of shad were available for capture in the tailrace in 1987. The total CPE from 1982 through 1987 (years of modified operation) was 8.3, 2.7, 2.3, 4.6, 11.9, and 15.1, respectively (Table 6.20).

Generally, the CPE in 1986 and 1987 was 43 and 82% higher than that observed in 1982. The catch rates in 1983 and 1984 were similar and much lower. Excluding 1984, a high flow year, catch rates in all years were highest at station discharge less than or equal to 5,000 cfs. Although catch rates in 1987 were highest at 1 unit discharge (≤5,000 cfs) it is the first year that a larger percentage (68%) of the season catch was collected at higher levels of station discharge (2 or more unit operation, ≥10,000 cfs).

Examination of the 1987 transport information showed that the major objective was satisfied; 94% (7,202) of the shad collected were transported to upstream spawning habitat. In 1986 approximately 85% (4,289) of the shad collected were transported. Improved holding facilities, combined with an increased number of shad transported per trip improved the efficiency of the transport program in 1987 compared to that in 1986. Survival in both years was similar as was the number of trips taken; 42 trips in 1986 and 43 trips in 1987.

Based on the 1987 transport experience, it may be feasible to move up to 6,000 shad per day in 1988. This number was calculated based on the following assumptions:

(a) Six transport units;

(b) Each transport unit would make four trips per day (assumes 3 hr round trip);

(c) 250 shad would be transported per trip.

Thus, large numbers of shad can be transported over a 30 to 45 day period if they were available.

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TABLE 6.1.

The status of steps taken prior to 1 April 1987 to make the Conowingo Dam Fish Lift reliable and operable at 120,000 cfs, 1987.

STEPS
1. Inspect above and below water line and perform repairs as required. STATUS: Completed, resulted in replacement of steel grating (between weir gates and crowder, repaired the rail that crowder moves on, and insertion of steel plate in holding channel where hopper rests.
2. Perform preventive maintenance including: a) Check out entire electrical system and replace any worn or corroded contacts; b) Replace flat gasket on hopper with a permanent J seal to assure retention of water during lifting of the fish to the sorting tanks; c) Clean out holding channel of any trash which may have accumulated over the fall and winter seasons; d) Calibrate weir gates to assure proper attraction flow; e) Recondition pumps which provide water to the fish sorting areas; f) Overhaul weir gate and crowder motors; STATUS: Items A through F completed.
3. Provide a standby crane or block and tackle system so that the weir and crowder motors can be removed when the station discharge flow goes above 120,000 cfs and subsequently reinstalled before the flow drops back down to 120,000 cfs. Additionally, the conduit to these motors will be checked for water tightness prior to operation, cracks will be sealed, and any worn junction box gaskets will be replaced. When water levels approach the level of the conduit, the conduit will be pressurized to further assure that the conduit will remain dry and that the crowder and weir gates can operate up to and including 120,000 cfs. STATUS: Completed. During spring a crane was available on site as needed to install and remove the crowder and weir gate motors.
4. The licensees will also maintain on hand at the Dam various spare components and hoses. These will enable rapid repair in the event of an unforeseen breakdown of the lift. STATUS: Completed. Spare hoses, electrical components and a water supply pump were on hand.

TABLE 6.2

List of scientific and common names of fishes collected at the Conowingo Dam Fish Passage Facility, 1972 through 1987.

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
Coregonus artedii	Lake herring
Salmo gairdneri	Rainbow trout
Salmo trutta	Brown trout
Salvelinus fontinalis	Brook trout
S. fontinalis x *S. namaycush*	Splake
Family - Esocidae	Pikes
Esox lucius	Northern pike
Esox masquinongy	Muskellunge
Esox niger	Chain pickerel
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

continued

TABLE 6.2.

Continued.

Scientific Name	Common Name
Family - Cyprinidae (continued)	
Notropis amoenus	Comely shiner
Notropis hudsonius	Spottail shiner
Notropis procne	Swallowtail shiner
Notropis rubellus	Rosyface shiner
Notropis spilopterus	Spotfin shiner
Notropis spp.	Minnows
Pimephales notatus	Bluntnose minnow
Rhinichthys atratulus	Blacknose dace
Rhinichthys cataractae	Longnose dace
Family - Catostomidae	Suckers
Carpiodes cyprinus	Quillback
Catostomus commersoni	White sucker
Erimyzon oblongus	Creek chubsucker
Hypentelium nigricans	Northern hog sucker
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 insignus	Margined madtom
Noturus spp.	Madtoms
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

continued

TABLE 6.2.

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
Percina caprodes	Logperch
Percina peltata	Shield darter
Stizostedion vitreum vitreum	Walleye

TABLE 6.3.

Comparison of annual catch of fishes at the Conowingo Dam Fish Lift, 1 April through 15 June, 1972-1987.

Year	1972	1973	1974	1975	1976	1977	1978	1979	1980
No. Days	54	62	58	55	63	61	35	29	30
No. of Lifts	817	1527	819	514	684	707	358	301	403
Est. Oper. Time(hr)	608	996	500	307	375	413	212	187	221
Fishing Time(hr)	313	623	222	189	252	245	136	123	117
No. of Species	40	43	42	41	38	40	44	37	42
American eel	805	2050	91937	64375	60409	14601	5878	1602	377
Blueback herring	58198	330341	340084	69916	35519	24395	13098	2282	502
Hickory shad	429	739	219	20	-	1	-	-	1
Alewife	10345	144727	16675	4311	235	188	5	9	9
American shad	182	65	121	87	82	165	54	50	139
Gizzard shad	24849	45668	119672	139222	382275	742056	55104	75553	275736
Atlantic menhaden	-	-	112	-	506	1596	-	-	16
Trouts	1	-	-	-	-	-	-	-	-
Rainbow trout	34	67	20	24	54	291	70	15	23
Brown trout	172	286	483	219	427	700	261	324	258
Brook trout	1	3	4	1	-	2	23	-	4
Rainbow smelt	-	-	-	-	-	-	-	-	-
Palomino(Rainbow trout)	-	-	-	-	-	-	-	-	-
Chain pickerel	-	1	10	-	-	1	-	-	-
Northern pike	-	2	2	-	-	2	2	4	3
Muskellunge	20	104	9	7	12	48	14	5	27
Redfin pickerel	-	-	-	-	-	-	-	-	-
Minnows	-	-	-	-	-	-	-	-	-
Goldfish	-	27	1	9	4	1	-	-	-
Carp	4370	16362	34383	15114	6755	16256	11842	14946	8879
River chub	-	-	-	-	-	-	-	-	1
Golden shiner	165	430	437	751	1622	652	221	304	35
Comely shiner	5	252	3870	2079	740	769	1152	1707	761
Spottail shiner	34	137	2036	268	1743	8107	8506	1533	849
Swallowtail shiner	-	-	-	-	-	-	-	-	-
Rosyface shiner	1	-	-	1	-	-	-	-	-
Spotfin shiner	103	40	3011	1231	45879	7960	3751	41	314
Bluntnose minnow	-	-	-	-	-	-	4	-	-
Blacknose dace	-	-	-	-	-	-	-	-	-
Longnose dace	-	-	1	-	-	-	4	-	-
Shiners	264	3	-	-	-	-	-	-	-
Quillback	7119	27780	14565	8388	9882	6734	2361	5134	2929
White sucker	363	1034	286	152	444	282	189	906	1145
Creek chubsucker	3	3	1	-	-	-	-	-	-
Northern hog sucker	-	2	-	1	5	-	3	6	13
Shorthead redhorse	1097	4420	434	445	1276	1724	697	2183	1394
White catfish	3070	6394	2200	6178	1451	3081	982	515	605
Yellow bullhead	7	45	1	32	2	47	25	13	18
Brown bullhead	510	5328	1612	740	451	2416	125	284	675
Channel catfish	61042	55084	75663	74042	41508	90442	48575	38251	38929
Margined madtom	-	-	-	-	-	-	-	-	-
Madtoms	-	-	-	-	-	-	-	-	-
Tadpole madtom	-	-	-	-	-	-	-	-	-
Mummichog	-	-	-	-	1	-	-	-	-
White perch	50991	647493	897113	511699	568018	224843	113164	43103	26971
Striped bass	3142	495	1150	174	13	1196	934	260	904
Rock bass	66	32	31	46	227	128	50	46	88
Redbreast sunfish	707	2056	1398	3040	3772	8377	4187	3466	1524
Green sunfish	3	-	4	39	81	168	25	-	16
Pumpkinseed	229	2578	2579	1000	878	1687	512	323	446
Bluegill	567	1423	927	3058	2712	5442	1361	813	942
Smallmouth bass	182	298	119	153	327	701	262	374	455
Largemouth bass	82	80	23	19	33	14	22	22	41
White crappie	4457	664	4371	9290	2987	1003	673	384	100
Black crappie	8	4	25	45	86	199	103	53	15
Tessellated darter	-	1	4	1	-	-	1	-	-
Yellow perch	5955	1090	682	494	2904	735	526	379	373
Logperch	-	-	-	-	-	-	27	-	-
Shield darter	-	-	-	-	-	-	-	-	-
Walleye	1840	2734	1613	369	2267	2140	967	2491	4153
Banded darter	-	-	-	-	-	-	1	-	-
Atlantic needlefish	1	-	-	1	-	-	-	-	-
Lampreys	-	-	-	-	-	-	-	-	-
Sea lampreys	-	2	-	2	29	11	1	3	1
Lake herring	-	1	-	-	-	-	-	-	-
Striped bass x white bass	-	-	-	-	-	-	270	273	2674
Tiger muskie	-	-	-	-	-	-	13	132	34
Brook trout x Lake trout	-	-	-	-	-	-	-	-	-
Striped bass x White perch	-	-	-	-	-	-	-	-	-
Total	241419	1300345	1617888	917043	1175616	1169161	276045	197769	372379

TABLE 6.3.

Continued.

Year	1981	1982	1983	1984	1985	1986	1987
No. Days	37	44	29	34	55	59	60
No. of Lifts	490	725	648	519	1118	831	1414
Est. Oper. Time(hr)	275	502	299	251	542	546	639
Fishing Time(hr)	·178	336	224	192	421	449	532
No. of Species	48	48	41	35	41	43	46
American eel	11329	3961	1080	155	550	364	1662
Blueback herring	618	25249	517	311	6763	6327	5861
Hickory shad	1	15	5	6	9	45	35
Alewife	129	3433	50	26	379	2822	357
American shad	328	2039	413	167	1546	5195	7667
Gizzard shad	1156662	1226374	950252	912666	2182888	1714441	2488618
Atlantic menhaden	42	-	1	-	1	-	-
Trouts	2	-	-	-	-	-	-
Rainbow trout	219	20	2	5	70	9	14
Brown trout	207	219	225	141	175	65	83
Brook trout	3	5	2	-	1	-	-
Rainbow smelt	-	-	-	-	-	-	1
Palomino (rainbow trout)	-	-	-	-	-	-	1
Chain pickerel	1	-	-	-	-	-	-
Northern pike	-	5	1	-	-	2	-
Muskellunge	1	4	-	-	15	-	-
Redfin pickerel	-	-	-	-	-	-	1
Minnows	-	1	-	-	-	-	-
Goldfish	1	-	-	-	-	-	-
Carp	18313	15362	16273	8012	6729	2930	4607
River chub	-	-	-	-	-	-	-
Golden shiner	155	92	216	8	292	23	40
Comely shiner	281	14214	3176	871	5141	582	21199
Spottail shiner	31	315	2132	-	3525	6247	155
Swallowtail shiner	3	-	-	-	-	1	-
Rosyface shiner	-	8	-	-	-	-	-
Spotfin shiner	524	622	501	-	2695	695	796
Bluntnose minnow	-	-	-	-	-	-	-
Blacknose dace	-	2	-	-	-	-	-
Longnose dace	-	-	-	-	-	-	-
Shiners	-	6	-	-	-	-	-
Quillback	3622	1617	4679	1942	957	2327	1881
White sucker	1394	582	412	109	776	853	263
Creek chubsucker	4	2	-	-	-	-	5
Northern hog sucker	1	-	-	-	-	2	4
Shorthead redhorse	6533	6974	7558	3467	3362	2057	3583
White catfish	2199	565	224	77	1094	284	917
Yellow bullhead	36	61	10	7	21	35	41
Brown bullhead	531	338	179	69	461	134	163
Channel catfish	55528	40941	12559	20479	15200	18898	11699
Margined madtom	-	6	-	-	-	3	-
Madtoms	-	1	-	-	-	-	-
Tadpole madtom	-	1	-	-	-	-	-
Mummichog	-	1	-	-	-	-	-
White perch	83363	53527	23151	6402	68344	56977	29995
Striped bass	3277	60	23	181	213	194	1337
Rock bass	381	138	269	158	122	200	231
Redbreast sunfish	1007	1335	401	465	3366	1433	1471
Green sunfish	28	91	16	7	133	15	64
Pumpkinseed	306	848	228	104	1013	402	490
Bluegill	1299	1184	587	284	6048	1654	2436
Smallmouth bass	881	1095	1003	608	1081	666	536
Largemouth bass	13	20	17	8	67	75	69
White crappie	231	303	450	59	345	199	272
Black crappie	20	39	46	6	45	51	19
Tessellated darter	2	-	-	-	1	-	1
Yellow perch	1007	724	387	487	2145	2267	632
Logperch	-	-	-	-	1	1	1
Shield darter	1	-	-	-	-	-	-
Walleye	2645	504	663	236	609	380	267
Banded darter	-	-	-	-	-	-	1
Atlantic needlefish	2	-	-	-	-	-	-
Lampreys	-	-	2	-	-	-	-
Sea lamprey	55	56	8	4	164	26	21
Lake herring	-	-	1	-	-	-	-
Striped bass x white bass	39	160	355	282	1377	1713	5895
Tiger muskie	53	56	16	10	73	35	30
Brook trout x Lake trout	-	-	-	2	-	2	5
Striped bass x white perch	-	-	-	-	-	10	19
Total	1353308	1403175	1028090	957821	2317797	1830641	2593445

TABLE 6.4 DAILY SUMMARY OF FISHES COLLECTED AT THE CONOWINGO DAM FISH LIFT IN SPRING 1987.

DATE	01 APRIL	03 APRIL	05 APRIL	12 APRIL	13 APRIL	15 APRIL	17 APRIL
NO. OF LIFTS	10	11	11	7	13	13	15
FIRST LIFT	715	702	600	1130	605	630	607
LAST LIFT	1300	1240	1138	1539	1200	1255	1200
OPERATING TIME(HR)	5.75	5.63	5.63	4.15	5.92	6.42	5.88
FISHING TIME(HR)	4.75	4.97	4.83	2.58	4.68	4.00	4.40
AVE RIVER FLOW	51200	91900	102700	96600	81600	77500	72700
AVE WATER TEMP(F)	52.7	49.7	49.1	51.8	50.0	51.8	51.8
AMERICAN EEL	2	3	1	1	1	-	-
BLUEBACK HERRING	-	-	-	-	-	-	-
HICKORY SHAD	-	-	-	-	-	-	3
ALEWIFE	1	-	-	-	3	-	2
AMERICAN SHAD	-	-	-	-	-	-	1
GIZZARD SHAD	1126	1645	698	4000	28727	5912	27462
RAINBOW TROUT	-	1	-	-	1	-	-
BROWN TROUT	-	-	-	-	-	-	1
RAINBOW SMELT	-	-	-	-	-	-	1
PALOMINO (RAINBOW TROUT)	-	-	-	-	-	-	-
REDFIN PICKEREL	-	-	-	-	-	-	-
CARP	-	-	-	1	1	-	-
GOLDEN SHINER	-	-	-	-	-	-	-
COMELY SHINER	-	-	-	-	-	-	-
SPOTTAIL SHINER	-	-	-	-	-	-	-
SPOTFIN SHINER	-	-	-	-	-	-	-
QUILLBACK	-	-	-	-	-	-	-
WHITE SUCKER	32	12	2	-	1	3	4
CREEK CHUBSUCKER	-	-	-	-	-	-	-
NORTHERN HOG SUCKER	-	-	-	-	-	-	-
SHORTHEAD REDHORSE	1	-	-	1	2	14	26
WHITE CATFISH	-	-	1	-	-	-	-
YELLOW BULLHEAD	-	-	-	-	-	-	-
BROWN BULLHEAD	1	-	-	-	-	-	-
CHANNEL CATFISH	8	3	-	10	2	-	1
WHITE PERCH	1	-	-	-	-	-	-
STRIPED BASS	-	-	-	-	-	-	-
ROCK BASS	2	-	-	-	-	-	-
REDBREAST SUNFISH	-	-	-	-	-	-	-
GREEN SUNFISH	-	-	-	-	-	-	-
PUMPKINSEED	-	-	-	-	-	-	-
BLUEGILL	-	-	-	-	-	-	-
SMALLMOUTH BASS	-	-	-	-	-	1	1
LARGEMOUTH BASS	-	-	-	-	-	-	-
WHITE CRAPPIE	-	-	-	-	-	-	-
BLACK CRAPPIE	-	-	-	-	-	-	-
TESSELLATED DARTER	-	1	-	-	-	-	-
YELLOW PERCH	12	2	-	-	-	1	-
LOGPERCH	-	-	-	-	-	-	-
WALLEYE	2	-	-	-	-	-	-
BANDED DARTER	-	-	-	-	-	-	-
SEA LAMPREY	-	1	-	1	-	-	-
STRIPED BASS X WHITE BASS	27	17	3	47	97	133	160
TIGER MUSKIE	1	-	-	-	-	-	-
BROOK TROUT X LAKE TROUT	-	-	-	-	-	-	-
STRIPED BASS X WHT PERCH	1	-	-	-	-	-	-
TOTAL	1217	1685	705	4061	28835	6064	27662

DATE	19 APRIL	21 APRIL	22 APRIL	23 APRIL	24 APRIL	25 APRIL	26 APRIL
No. OF LIFTS	13	23	39	24	34	29	30
FIRST LIFT	600	605	602	605	604	603	603
LAST LIFT	1235	1653	1800	1750	1759	1745	1736
OPERATING TIME(HR)	6.58	10.80	11.97	11.75	11.92	11.70	11.55
FISHING TIME(HR)	5.25	9.05	9.23	10.08	9.60	9.63	9.73
AVE RIVER FLOW	66400	56300	48900	43800	42500	38000	37300
AVE WATER TEMP(F)	51.8	55.4	57.2	56.3	59.2	59.0	59.0
AMERICAN EEL	3	2	2	3	3	2	3
BLUEBACK HERRING	-	-	-	1	-	-	1
HICKORY SHAD	-	3	-	1	3	3	-
ALEWIFE	2	21	16	12	26	3	14
AMERICAN SHAD	3	22	89	80	233	386	356
GIZZARD SHAD	5570	34005	31822	19125	39375	21068	41675
RAINBOW TROUT	-	-	-	-	-	-	1
BROWN TROUT	-	1	2	2	2	2	4
RAINBOW SMELT	-	-	-	-	-	-	-
PALOMINO (RAINBOW TROUT)	-	-	-	-	-	-	-
REDFIN PICKEREL	-	-	-	-	-	-	-
CARP	-	4	55	14	13	1	1
GOLDEN SHINER	-	-	2	4	2	1	2
COMELY SHINER	-	-	-	-	-	-	1
SPOTTAIL SHINER	-	-	-	51	25	51	6
SPOTFIN SHINER	-	-	-	-	-	-	-
QUILLBACK	1	2	113	65	37	4	-
WHITE SUCKER	6	25	39	4	16	3	1
CREEK CHUBSUCKER	-	-	-	-	-	-	-
NORTHERN HOG SUCKER	-	-	-	-	2	-	-
SHORTHEAD REDHORSE	9	158	271	166	146	104	35
WHITE CATFISH	-	-	-	-	1	2	-
YELLOW BULLHEAD	-	-	-	-	2	1	-
BROWN BULLHEAD	-	-	-	-	1	1	2
CHANNEL CATFISH	1	98	218	84	239	104	124
WHITE PERCH	-	1	6	6	96	13	48
STRIPED BASS	1	1	1	3	2	-	-
ROCK BASS	-	-	5	14	12	3	8
REDBREAST SUNFISH	-	-	-	1	8	5	1
GREEN SUNFISH	-	-	-	-	-	-	-
PUMPKINSEED	-	-	-	-	11	-	6
BLUEGILL	-	1	2	7	61	61	70
SMALLMOUTH BASS	-	8	28	7	14	3	6
LARGEMOUTH BASS	-	-	2	-	1	2	6
WHITE CRAPPIE	1	2	10	3	3	5	19
BLACK CRAPPIE	-	-	-	-	1	-	3
TESSELLATED DARTER	-	-	-	-	-	-	-
YELLOW PERCH	-	2	4	11	12	14	9
LOGPERCH	-	-	-	-	-	-	1
WALLEYE	1	3	3	2	5	3	2
BANDED DARTER	-	-	-	-	-	-	1
SEA LAMPREY	1	1	1	-	-	1	-
STRIPED BASS X WHITE BASS	157	552	489	319	236	141	143
TIGER MUSKIE	-	-	1	2	3	1	3
BROOK TROUT X LAKE TROUT	1	-	1	1	-	-	-
STRIPED BASS X WHT PERCH	-	4	1	1	3	-	-
Total	5757	34916	33183	19989	40594	21988	42552

TABLE 6.4

CONTINUED.

DATE	27 APRIL	28 APRIL	29 APRIL	30 APRIL	01 MAY	02 MAY	03 MAY
NO. OF LIFTS	39	25	25	24	34	24	33
FIRST LIFT	603	603	557	601	600	631	553
LAST LIFT	1745	1738	1748	1742	1800	1800	1759
OPERATING TIME(HR)	11.70	11.58	11.85	11.68	12.00	11.48	12.10
FISHING TIME(HR)	9.85	9.63	10.30	9.20	10.47	10.02	10.75
AVE RIVER FLOW	40200	40800	37500	34300	32100	31800	33200
AVE WATER TEMP(F)	60.8	59.0	60.0	59.0	58.2	59.0	60.0
AMERICAN EEL	1	4	3	6	4	9	2
BLUEBACK HERRING	-	1	-	-	1	-	-
HICKORY SHAD	-	3	1	1	2	-	3
ALEWIFE	1	3	-	-	-	1	-
AMERICAN SHAD	393	203	69	55	322	381	314
GIZZARD SHAD	41500	25675	23100	36700	38125	5827	30625
RAINBOW TROUT	-	1	-	1	-	-	-
BROWN TROUT	4	4	-	-	1	-	1
RAINBOW SMELT	-	-	-	-	-	-	-
PALOMINO (RAINBOW TROUT)	-	-	-	-	-	-	-
REDFIN PICKEREL	-	-	-	-	-	-	-
CARP	37	41	17	36	1	-	1
GOLDEN SHINER	-	-	-	-	1	2	1
COMELY SHINER	-	-	-	-	-	-	-
SPOTTAIL SHINER	10	10	2	-	-	-	-
SPOTFIN SHINER	-	-	-	-	-	-	-
QUILLBACK	19	-	1	5	-	-	2
WHITE SUCKER	8	6	2	2	-	1	2
CREEK CHUBSUCKER	-	-	-	-	3	-	-
NORTHERN HOG SUCKER	-	2	-	-	-	-	-
SHORTHEAD REDHORSE	42	61	56	154	229	31	115
WHITE CATFISH	-	2	1	1	1	-	-
YELLOW BULLHEAD	-	1	2	-	-	-	-
BROWN BULLHEAD	1	7	1	7	2	-	1
CHANNEL CATFISH	68	126	71	125	55	37	22
WHITE PERCH	15	125	43	303	156	544	193
STRIPED BASS	-	1	-	-	-	2	1
ROCK BASS	2	16	3	10	2	8	4
REDBREAST SUNFISH	-	4	1	2	1	1	-
GREEN SUNFISH	-	1	-	-	-	-	-
PUMPKINSEED	1	4	2	2	1	3	-
BLUEGILL	27	21	22	44	32	61	19
SMALLMOUTH BASS	33	14	11	7	16	3	15
LARGEMOUTH BASS	-	1	1	2	2	3	5
WHITE CRAPPIE	4	16	8	4	6	2	4
BLACK CRAPPIE	-	2	-	-	-	-	-
TESSELLATED DARTER	-	-	-	-	-	-	-
YELLOW PERCH	13	6	9	5	5	2	1
LOGPERCH	-	-	-	-	-	-	-
WALLEYE	4	1	1	3	3	4	-
BANDED DARTER	-	-	-	-	-	-	-
SEA LAMPREY	2	-	1	1	-	1	-
STRIPED BASS X WHITE BASS	25	30	135	176	212	139	641
TIGER MUSKIE	3	-	1	-	1	2	-
BROOK TROUT X LAKE TROUT	-	-	-	-	-	-	1
STRIPED BASS X WHT PERCH	-	1	1	-	-	3	-
TOTAL	42213	26393	23565	37652	39184	7067	31973

CONTINUED.

DATE	04 MAY	05 MAY	06 MAY	07 MAY	08 MAY	09 MAY	10 MAY
NO. OF LIFTS	23	26	28	18	34	30	34
FIRST LIFT	600	600	605	603	600	606	605
LAST LIFT	1800	1759	1800	1800	1733	1740	1818
OPERATING TIME(HR)	12.00	11.98	11.92	11.95	11.55	11.57	12.22
FISHING TIME(HR)	10.13	10.58	9.57	8.40	9.47	10.38	10.80
AVE RIVER FLOW	33800	37500	45000	46200	42500	32500	35000
AVE WATER TEMP(F)	60.0	59.0	57.2	59.0	58.1	59.0	60.8
AMERICAN EEL	32	4	4	3	5	5	5
BLUEBACK HERRING	-	-	-	-	2	1	318
HICKORY SHAD	-	1	2	-	-	5	2
ALEWIFE	10	15	9	8	3	9	2
AMERICAN SHAD	96	72	42	17	7	46	338
GIZZARD SHAD	10175	9326	25230	10066	50900	28030	31250
RAINBOW TROUT	-	-	-	-	-	-	-
BROWN TROUT	-	-	1	1	3	1	3
RAINBOW SMELT	-	-	-	-	-	-	-
PALOMINO (RAINBOW TROUT)	-	-	-	-	-	-	-
REDFIN PICKEREL	-	-	-	-	-	-	-
CARP	-	-	5	3	1	1	2
GOLDEN SHINER	2	-	-	-	-	4	1
COMELY SHINER	-	-	-	-	-	-	-
SPOTTAIL SHINER	-	-	-	-	-	-	-
SPOTFIN SHINER	-	-	-	-	-	-	-
QUILLBACK	-	-	-	-	10	1	1
WHITE SUCKER	3	3	2	1	4	6	-
CREEK CHUBSUCKER	-	-	-	-	-	-	-
NORTHERN HOG SUCKER	-	-	-	-	-	-	-
SHORTHEAD REDHORSE	91	70	85	67	51	78	38
WHITE CATFISH	-	-	5	2	-	1	1
YELLOW BULLHEAD	-	1	1	1	1	1	-
BROWN BULLHEAD	2	9	1	5	5	-	-
CHANNEL CATFISH	35	58	37	53	38	32	22
WHITE PERCH	117	424	471	315	604	412	728
STRIPED BASS	-	-	-	-	3	1	4
ROCK BASS	3	6	5	4	4	-	6
REDBREAST SUNFISH	2	1	-	2	2	-	5
GREEN SUNFISH	-	-	-	1	-	-	1
PUMPKINSEED	2	4	2	1	-	4	4
BLUEGILL	13	63	25	30	16	21	29
SMALLMOUTH BASS	6	2	20	7	10	3	23
LARGEMOUTH BASS	-	-	3	-	-	2	3
WHITE CRAPPIE	-	6	1	1	2	4	7
BLACK CRAPPIE	-	-	-	-	-	2	4
TESSELLATED DARTER	-	-	-	-	-	-	-
YELLOW PERCH	12	8	8	9	3	4	6
LOGPERCH	-	-	-	-	-	-	-
WALLEYE	-	-	2	4	4	-	4
BANDED DARTER	-	-	-	-	-	-	-
SEA LAMPREY	2	-	-	-	-	-	3
STRIPED BASS X WHITE BASS	67	6	35	18	102	348	330
TIGER MUSKIE	1	1	1	1	-	-	-
BROOK TROUT X LAKE TROUT	-	-	-	-	-	-	-
STRIPED BASS X WHT PERCH	-	-	-	-	1	-	1
Total	10671	10080	25997	10620	51781	29022	33141

TABLE 6.4

CONTINUED.

DATE	11 MAY	12 MAY	13 MAY	14 MAY	15 MAY	16 MAY	17 MAY
NO. OF LIFTS	24	20	28	31	25	29	30
FIRST LIFT	602	600	602	603	603	600	630
LAST LIFT	1753	1620	1735	1800	1806	1800	1750
OPERATING TIME(HR)	11.85	10.33	11.55	11.95	12.05	12.00	11.33
FISHING TIME(HR)	9.45	8.85	9.47	10.23	10.08	10.92	9.85
AVE RIVER FLOW	29500	27000	23600	24000	21900	20900	20300
AVE WATER TEMP(F)	61.7	62.6	64.4	65.3	64.4	64.4	65.3
AMERICAN EEL	9	3	15	6	16	22	12
BLUEBACK HERRING	24	2	8	81	130	171	3671
HICKORY SHAD	-	-	-	1	-	-	-
ALEWIFE	3	1	1	2	53	-	13
AMERICAN SHAD	17	88	244	215	288	1359	280
GIZZARD SHAD	13670	7253	42070	54900	32950	38275	40800
RAINBOW TROUT	-	-	-	-	-	-	-
BROWN TROUT	1	2	4	2	1	1	5
RAINBOW SMELT	-	-	-	-	-	-	-
PALOMINO (RAINBOW TROUT)	1	-	-	-	-	-	-
REDFIN PICKEREL	-	-	-	-	-	-	-
CARP	46	4	1	4	1	206	172
GOLDEN SHINER	1	-	1	3	1	-	-
COMELY SHINER	-	-	-	-	-	2511	75
SPOTTAIL SHINER	-	-	-	-	-	-	-
SPOTFIN SHINER	-	-	-	-	-	-	-
QUILLBACK	68	13	4	10	5	10	61
WHITE SUCKER	7	4	3	2	2	2	6
CREEK CHUBSUCKER	1	-	1	-	-	-	-
NORTHERN HOG SUCKER	-	-	-	-	-	-	-
SHORTHEAD REDHORSE	137	138	232	144	101	78	65
WHITE CATFISH	7	7	1	2	5	5	1
YELLOW BULLHEAD	1	1	1	4	5	2	-
BROWN BULLHEAD	5	4	1	1	6	7	3
CHANNEL CATFISH	70	55	671	554	220	203	29
WHITE PERCH	1739	960	1958	1736	979	526	564
STRIPED BASS	4	-	5	3	1	-	7
ROCK BASS	11	15	18	19	3	4	3
REDBREAST SUNFISH	35	64	27	36	26	12	22
GREEN SUNFISH	15	3	1	-	-	-	4
PUMPKINSEED	21	28	20	24	-	3	14
BLUEGILL	52	90	50	61	45	61	27
SMALLMOUTH BASS	29	19	18	30	17	33	16
LARGEMOUTH BASS	-	4	3	1	2	1	1
WHITE CRAPPIE	12	14	13	14	1	5	6
BLACK CRAPPIE	-	-	1	-	-	-	1
TESSELLATED DARTER	-	-	-	-	-	-	-
YELLOW PERCH	14	13	7	14	2	13	20
LOGPERCH	-	-	-	-	-	-	-
WALLEYE	19	2	7	13	9	2	6
BANDED DARTER	-	-	-	-	-	-	-
SEA LAMPREY	-	-	1	-	-	1	-
STRIPED BASS X WHITE BASS	38	77	109	48	61	29	37
TIGER MUSKIE	-	1	1	-	1	-	-
BROOK TROUT X LAKE TROUT	-	-	-	-	-	1	-
STRIPED BASS X WHT PERCH	-	-	-	-	-	-	-
TOTAL	16057	8865	45497	57930	34931	43543	45921

CONTINUED.

DATE	18 MAY	19 MAY	20 MAY	21 MAY	22 MAY	23 MAY	24 MAY
NO. OF LIFTS	25	24	20	25	26	24	29
FIRST LIFT	603	600	605	602	602	602	600
LAST LIFT	1733	1800	1806	1800	1739	1725	1706
OPERATING TIME(HR)	11.50	12.00	12.02	11.97	11.62	11.38	11.10
FISHING TIME(HR)	9.03	9.95	10.38	9.68	9.45	9.63	9.37
AVE RIVER FLOW	18700	18900	24000	29100	26300	23700	24900
AVE WATER TEMP(F)	67.1	66.2	67.1	66.2	66.2	68.0	68.9
AMERICAN EEL	15	58	55	25	95	143	6
BLUEBACK HERRING	71	49	17	58	12	503	107
HICKORY SHAD	-	1	-	-	-	-	-
ALEWIFE	1	1	1	39	15	17	10
AMERICAN SHAD	18	23	23	3	79	9	2
GIZZARD SHAD	15753	17865	9191	70950	28125	31697	238500
RAINBOW TROUT	-	-	-	-	-	-	-
BROWN TROUT	1	4	-	2	-	1	1
RAINBOW SMELT	-	-	-	-	-	-	-
PALOMINO (RAINBOW TROUT)	-	-	-	-	-	-	-
REDFIN PICKEREL	-	-	-	-	-	-	-
CARP	153	111	58	47	878	4	37
GOLDEN SHINER	1	-	-	1	-	1	4
COMELY SHINER	1960	-	-	12	-	80	95
SPOTTAIL SHINER	-	-	-	-	-	-	-
SPOTFIN SHINER	-	-	-	-	-	80	25
QUILLBACK	26	19	14	20	236	3	1
WHITE SUCKER	5	1	4	2	4	2	2
CREEK CHUBSUCKER	-	-	-	-	-	-	-
NORTHERN HOG SUCKER	-	-	-	-	-	-	-
SHORTHEAD REDHORSE	99	89	38	75	101	54	8
WHITE CATFISH	13	15	63	16	3	25	-
YELLOW BULLHEAD	-	1	-	-	-	1	-
BROWN BULLHEAD	2	4	2	3	-	4	-
CHANNEL CATFISH	51	128	393	239	175	300	93
WHITE PERCH	413	1238	653	730	500	402	417
STRIPED BASS	10	2	3	7	8	36	117
ROCK BASS	7	1	2	3	2	-	1
REDBREAST SUNFISH	58	13	50	35	59	33	106
GREEN SUNFISH	-	-	1	2	-	-	4
PUMPKINSEED	16	1	15	33	-	-	4
BLUEGILL	119	14	31	40	50	22	88
SMALLMOUTH BASS	22	7	5	7	15	2	6
LARGEMOUTH BASS	2	2	3	-	1	1	1
WHITE CRAPPIE	8	5	5	13	1	1	6
BLACK CRAPPIE	1	-	-	-	-	-	-
TESSELLATED DARTER	-	-	-	-	-	-	-
YELLOW PERCH	54	18	19	59	2	10	37
LOGPERCH	-	-	-	-	-	-	-
WALLEYE	3	7	6	3	15	5	8
BANDED DARTER	-	-	-	-	-	-	-
SEA LAMPREY	-	-	-	1	1	1	-
STRIPED BASS X WHITE BASS	73	178	42	163	160	7	4
TIGER MUSKIE	-	-	-	1	-	-	-
BROOK TROUT X LAKE TROUT	-	-	-	-	-	-	-
STRIPED BASS X WHT PERCH	-	-	-	1	1	-	-
Total	18955	19855	10694	72590	30538	33444	239690

TABLE 6.4

CONTINUED.

DATE	25 MAY	26 MAY	27 MAY	28 MAY	29 MAY	30 MAY	31 MAY
NO. OF LIFTS	24	22	24	26	28	29	30
FIRST LIFT	608	615	605	604	602	600	600
LAST LIFT	1744	1745	1830	1736	1800	1750	1733
OPERATING TIME(HR)	11.60	11.50	12.42	11.53	11.97	11.83	11.55
FISHING TIME(HR)	10.12	9.75	10.32	9.32	10.10	10.03	9.15
AVE RIVER FLOW	22400	18900	19700	18600	18300	17500	18000
AVE WATER TEMP(F)	67.1	68.0	66.2	66.2	68.0	68.0	69.9
AMERICAN EEL	90	29	32	44	35	13	41
BLUEBACK HERRING	130	43	177	39	58	20	50
HICKORY SHAD	-	-	-	-	-	-	-
ALEWIFE	9	3	-	6	7	4	5
AMERICAN SHAD	67	64	70	38	57	94	569
GIZZARD SHAD	149500	89000	52600	110150	110575	187000	95800
RAINBOW TROUT	1	-	-	-	-	1	-
BROWN TROUT	2	4	1	-	-	-	1
RAINBOW SMELT	-	-	-	-	-	-	-
PALOMINO (RAINBOW TROUT)	-	-	-	-	-	-	-
REDFIN PICKEREL	-	-	-	-	-	-	-
CARP	16	13	-	49	2	60	205
GOLDEN SHINER	2	2	-	-	-	-	-
COMELY SHINER	65	-	-	-	-	-	-
SPOTTAIL SHINER	-	-	-	-	-	-	-
SPOTFIN SHINER	10	-	-	-	1	-	-
QUILLBACK	2	3	-	28	1	8	100
WHITE SUCKER	6	3	3	4	1	1	2
CREEK CHUBSUCKER	-	-	-	-	-	-	-
NORTHERN HOG SUCKER	-	-	-	-	-	-	-
SHORTHEAD REDHORSE	5	38	16	36	4	-	1
WHITE CATFISH	64	72	48	17	42	15	5
YELLOW BULLHEAD	3	1	1	-	1	-	-
BROWN BULLHEAD	7	9	11	2	8	5	-
CHANNEL CATFISH	391	515	938	252	414	207	46
WHITE PERCH	730	1075	2750	649	974	886	526
STRIPED BASS	104	162	17	51	42	47	34
ROCK BASS	7	1	1	8	1	1	-
REDBREAST SUNFISH	83	174	23	17	31	12	37
GREEN SUNFISH	4	-	-	-	-	-	1
PUMPKINSEED	15	89	4	8	1	2	1
BLUEGILL	60	196	18	45	19	58	24
SMALLMOUTH BASS	5	-	1	19	2	9	10
LARGEMOUTH BASS	-	2	3	-	1	2	1
WHITE CRAPPIE	3	6	-	2	1	2	-
BLACK CRAPPIE	2	1	-	-	-	-	-
TESSELLATED DARTER	-	-	-	-	-	-	-
YELLOW PERCH	20	34	5	11	1	3	8
LOGPERCH	-	-	-	-	-	-	-
WALLEYE	13	16	8	5	5	6	7
BANDED DARTER	-	-	-	-	-	-	-
SEA LAMPREY	-	-	-	-	-	-	-
STRIPED BASS X WHITE BASS	11	18	9	7	6	3	6
TIGER MUSKIE	-	-	1	-	-	-	-
BROOK TROUT X LAKE TROUT	-	-	-	-	-	-	-
STRIPED BASS X WHT PERCH	-	-	-	-	-	-	-
TOTAL	151427	91573	56737	111487	112290	188459	97480

CONTINUED.

DATE	01 JUNE	02 JUNE	03 JUNE	04 JUNE	05 JUNE	06 JUNE	07 JUNE
NO. OF LIFTS	24	23	22	16	24	23	23
FIRST LIFT	603	600	602	602	600	555	556
LAST LIFT	1742	1804	1750	1802	1800	1735	1800
OPERATING TIME(HR)	11.65	12.07	11.80	12.00	12.00	11.67	12.07
FISHING TIME(HR)	9.37	9.53	9.75	9.30	10.50	10.07	10.15
AVE RIVER FLOW	15200	14200	15000	15000	16700	19300	19400
AVE WATER TEMP(F)	69.9	69.9	71.6	72.5	72.6	73.4	73.4
AMERICAN EEL	101	44	127	64	133	41	119
BLUEBACK HERRING	29	17	59	1	6	2	1
HICKORY SHAD	-	-	-	-	-	-	-
ALEWIFE	-	-	1	1	2	-	-
AMERICAN SHAD	78	68	122	12	33	25	161
GIZZARD SHAD	66950	40500	18045	35100	65100	97900	29995
RAINBOW TROUT	-	1	-	1	2	-	2
BROWN TROUT	-	4	1	4	2	2	3
RAINBOW SMELT	-	-	-	-	-	-	-
PALOMINO (RAINBOW TROUT)	-	-	-	-	-	-	-
REDFIN PICKEREL	1	-	-	-	-	-	-
CARP	202	183	327	45	117	321	783
GOLDEN SHINER	-	-	-	-	-	1	-
COMELY SHINER	4845	7100	-	10	2130	550	100
SPOTTAIL SHINER	-	-	-	-	-	-	-
SPOTFIN SHINER	1	-	-	1	325	250	103
QUILLBACK	27	41	100	32	85	53	494
WHITE SUCKER	2	4	1	-	-	-	1
CREEK CHUBSUCKER	-	-	-	-	-	-	-
NORTHERN HOG SUCKER	-	-	-	-	-	-	-
SHORTHEAD REDHORSE	9	11	-	1	1	1	-
WHITE CATFISH	30	66	138	59	7	7	18
YELLOW BULLHEAD	-	-	1	3	-	-	-
BROWN BULLHEAD	2	2	12	5	-	1	2
CHANNEL CATFISH	320	888	693	187	311	178	188
WHITE PERCH	628	855	1255	800	526	262	96
STRIPED BASS	89	35	37	17	43	55	51
ROCK BASS	3	-	1	-	1	-	1
REDBREAST SUNFISH	61	52	74	35	20	19	61
GREEN SUNFISH	12	1	3	1	1	-	1
PUMPKINSEED	9	13	12	18	11	3	15
BLUEGILL	80	86	90	42	26	58	59
SMALLMOUTH BASS	9	5	1	-	1	2	2
LARGEMOUTH BASS	1	-	-	-	-	-	-
WHITE CRAPPIE	7	2	8	1	3	-	10
BLACK CRAPPIE	-	-	-	-	-	-	1
TESSELLATED DARTER	-	-	-	-	-	-	-
YELLOW PERCH	33	13	5	1	5	4	10
LOGPERCH	-	-	-	-	-	-	-
WALLEYE	15	10	7	3	1	2	3
BANDED DARTER	-	-	-	-	-	-	-
SEA LAMPREY	-	-	-	-	-	-	-
STRIPED BASS X WHITE BASS	-	-	-	-	-	-	3
TIGER MUSKIE	2	-	-	1	-	-	-
BROOK TROUT X LAKE TROUT	-	-	-	-	-	-	-
STRIPED BASS X WHT PERCH	-	-	-	-	-	-	-
Total	73546	50001	21120	36445	68892	99737	32283

TABLE 6.4

CONTINUED.

DATE	08 JUNE	09 JUNE	10 JUNE	12 JUNE	TOTALS
NO. OF LIFTS	20	8	10	9	1414
FIRST LIFT	600	607	600	605	
LAST LIFT	1734	1200	1215	1200	
OPERATING TIME(HR)	11.57	5.88	6.25	5.92	639.16
FISHING TIME(HR)	9.87	5.37	5.58	5.30	532.25
AVE RIVER FLOW	17100	18700	15300	14800	
AVE WATER TEMP(F)	74.3	74.3	74.3	73.4	
AMERICAN EEL	117	17	1	21	1,662
BLUEBACK HERRING	-	-	-	-	5,861
HICKORY SHAD	-	-	-	-	35
ALEWIFE	-	-	-	1	357
AMERICAN SHAD	26	4	5	1	7,667
GIZZARD SHAD	24735	12065	3965	28900	2,488,618
RAINBOW TROUT	-	-	1	-	14
BROWN TROUT	-	-	1	-	83
RAINBOW SMELT	-	-	-	-	1
PALOMINO (RAINBOW TROUT)	-	-	-	-	1
REDFIN PICKEREL	-	-	-	-	1
CARP	304	5	5	13	4,607
GOLDEN SHINER	-	-	-	-	40
COMELY SHINER	65	1500	100	-	21,199
SPOTTAIL SHINER	-	-	-	-	155
SPOTFIN SHINER	-	-	-	-	796
QUILLBACK	82	16	40	18	1,881
WHITE SUCKER	1	-	-	-	263
CREEK CHUBSUCKER	-	-	-	-	5
NORTHERN HOG SUCKER	-	-	-	-	4
SHORTHEAD REDHORSE	-	-	-	-	3,583
WHITE CATFISH	31	36	25	56	917
YELLOW BULLHEAD	3	1	-	-	41
BROWN BULLHEAD	4	4	-	1	163
CHANNEL CATFISH	591	225	218	285	11,699
WHITE PERCH	129	183	140	95	29,995
*STRIPED BASS	111	69	23	127	1,337
ROCK BASS	-	-	-	-	231
REDBREAST SUNFISH	41	21	34	64	1,471
GREEN SUNFISH	-	2	1	4	64
PUMPKINSEED	15	2	18	28	490
BLUEGILL	46	41	33	80	2,436
SMALLMOUTH BASS	3	-	2	1	536
LARGEMOUTH BASS	4	-	-	-	69
WHITE CRAPPIE	4	-	3	8	272
BLACK CRAPPIE	-	-	-	-	19
TESSELLATED DARTER	-	-	-	-	1
YELLOW PERCH	23	7	1	8	632
*LOGPERCH	-	-	-	-	1
WALLEYE	5	3	-	2	267
BANDED DARTER	-	-	-	-	1
SEA LAMPREY	-	-	-	-	21
STRIPED BASS X WHITE BASS	7	-	11	3	5,895
TIGER MUSKIE	-	-	-	-	30
BROOK TROUT X LAKE TROUT	-	-	-	-	5
STRIPED BASS X WHT PERCH	-	-	-	-	19
TOTAL	26347	14201	4627	29716	2,593,445

6-32

TABLE 6.5.

Total catch and catch per hour of American shad by date and weir gate setting during modified lift operation at Conowingo Dam Fish Lift, 1987.

DATE		# ONE WEIR GATE OPEN	# TWO WEIR GATE OPEN	BOTH WEIR GATE OPEN	TOTAL
MAY 16	# SHAD		801	557	1,358
	HRS FISHING	0.0	3.5	7.4	10.9
	CATCH/HR FISHING	-	228.86	75.27	124.59
MAY 18	# SHAD	8	2	5	15
	HRS FISHING	2.0	1.9	3.4	7.3
	CATCH/HR FISHING	4.00	1.05	1.47	2.05
MAY 19	# SHAD		13	10	23
	HRS FISHING	0.0	1.9	7.5	9.4
	CATCH/HR FISHING	-	6.84	1.33	2.45
MAY 20	# SHAD		23		23
	HRS FISHING	0.0	10.3	0.0	10.3
	CATCH/HR FISHING	-	2.23	-	2.23
MAY 21	# SHAD		2	-	2
	HRS FISHING	0.0	7.2	2.0	9.2
	CATCH/HR FISHING	-	0.28	-	0.22
MAY 24	# SHAD	1		1	2
	HRS FISHING	1.7	0.0	6.7	8.4
	CATCH/HR FISHING	0.59	-	0.15	0.24
MAY 25	# SHAD		67	-	67
	HRS FISHING	0.0	9.4	0.5	9.8
	CATCH/HR FISHING	-	7.13	-	6.84
MAY 26	# SHAD	1	63	-	64
	HRS FISHING	5.3	3.7	0.3	9.3
	CATCH/HR FISHING	0.19	17.03	-	6.88
MAY 28	# SHAD		19	18	37
	HRS FISHING	0.0	4.0	4.7	8.7
	CATCH/HR FISHING	-	4.75	3.83	4.25
MAY 29	# SHAD		-	57	57
	HRS FISHING	0.0	0.4	9.6	10.0
	CATCH/HR FISHING	-	-	5.94	5.70
MAY 30	# SHAD		30	63	93
	HRS FISHING	0.0	3.8	5.8	9.5
	CATCH/HR FISHING	-	7.89	10.86	9.79
MAY 31	# SHAD		76	490	566
	HRS FISHING	0.0	3.3	5.1	8.4
	CATCH/HR FISHING	-	23.03	96.08	67.38
JUN 03	# SHAD		12	110	122
	HRS FISHING	0.0	3.0	5.8	8.8
	CATCH/HR FISHING	-	4.00	18.97	13.86
JUN 05	# SHAD		5	16	21
	HRS FISHING	0.0	1.1	9.2	10.3
	CATCH/HR FISHING	-	4.55	1.74	2.04
JUN 06	# SHAD		3	21	24
	HRS FISHING	0.0	3.3	5.8	9.1
	CATCH/HR FISHING	-	0.91	3.62	2.64
JUN 07	# SHAD		17	144	161
	HRS FISHING	0.0	3.6	6.3	9.9
	CATCH/HR FISHING	-	4.72	22.86	16.26
JUN 08	# SHAD		7	10	17
	HRS FISHING	0.0	0.9	7.5	8.4
	CATCH/HR FISHING	-	7.78	1.33	2.02
	Total	10	1,140	1,502	2,652
		9.0	61.3	87.6	157.9
		1.11	18.60	17.15	16.80

Need effort

TABLE 6.6.

Comparison of catch per effort (hr) of American shad on weekdays vs weekend days by generation (cfs) at the Conowinog Dam Fish Lift, 18 April through 12 June 1987.

	Lift Time	5,000 cfs Catch/hour	10-20,000 cfs Catch/hour	25-40,000 cfs Catch/hour	45,000 cfs + Catch/hour	Total Catch/hour
Weekdays	Morning 5-9	7.6	8.0	14.2	3.2	6.0
	Mid-AM 9-11	17.3	4.3	5.4	3.8	4.9
	Mid-day 11-3	3.0	14.9	12.3	4.9	5.9
	Late PM 3-12	18.8	13.2	42.9	14.1	19.0
	Mean Weekday	11.9	11.2	25.8	5.6	8.8
Weekend	Morning 5-9	41.4	18.3	1.1	1.2	21.5
	Mid-AM 9-11	36.5	5.8	7.5	3.1	10.8
	Mid-Day 11-3	15.6	32.0	49.1	11.4	27.9
	Late PM 3-12	65.5	13.1	51.4	0.0	48.3
	Mean Weekend	29.9	15.8	33.1	5.7	14.4

Why?

TABLE 6.7.

Comparison of the American shad catch, catch per effort, and effort between low (one or less unit generation) and high discharges (two or more unit generation) at the Conowingo Dam Fish Lift, 1 April to 12 June 1987.

Generation Status	No. Shad Caught	Total Minutes Fished	No. Lifts	Shad Catch Per Hour
High ??	2428	4870	248	29.91
Low	5239	27066	1166	11.61
Total	7667	31936	1414	14.40

TABLE 6.8.

Catch of American shad in the Conowingo Dam Fish Lift by water temperature, 1 April to 12 June 1987.

Water Temp.(F)	Hours Fishing	Catch		
		Number	Catch/Effort	Percent
$\leq$ 65	281.12	5521	19.64	72.0
> 65	251.15	2146	8.54	28.0
Total	532.27	7667	14.40	100.0

TABLE 6.9.

SUMMARY OF TRANSPORTATION OF AMERICAN SHAD FROM CONOWINGO DAM FISH LIFT, 23 APRIL TO 7 JUNE, 1987.

DATE	NO. COLLECTED	WATER TEMP (F)	NO. TRANSPORTED	LOCATION	OBSERVED MORTALITY	PERCENT SURVIVAL	DO (PPM) START	DO (PPM) FINISH	WATER TEMP (F) AT STOCKING LOCATION
23 APR	80	56.3	99	LONG LEVEL	0	100.0	20.0	13.0	59.9
24 APR	233	59.2	192	LONG LEVEL	2	99.0	20.0	20.0	60.8
			105	LONG LEVEL	0	100.0	17.8	11.6	57.4
25 APR	386	59.0	170	LONG LEVEL	0	100.0	11.2	11.4	59.4
			191	LONG LEVEL	2	99.0	20.0	20.0	59.0
26 APR	356	59.0	190	LONG LEVEL	0	100.0	20.0	15.5	59.0
			186	LONG LEVEL	0	100.0	12.8	11.4	59.0
27 APR	393	60.8	166	LONG LEVEL	0	100.0	15.2	11.4	60.8
			218	*	218	0.0	15.0	20.0	60.8
29 APR	69	60.0	205	LONG LEVEL	0	100.0	17.2	12.2	58.6
30 APR	55	59.0	113	LONG LEVEL	0	100.0	12.8	13.8	59.0
01 MAY	322	58.2	245	LONG LEVEL	0	100.0	17.2	15.2	59.2
02 MAY	381	59.0	200	LONG LEVEL	1	99.5	19.0	20.0	60.8
			239	LONG LEVEL	0	100.0	20.0	17.2	60.8
03 MAY	314	60.0	195	LONG LEVEL	0	100.0	17.8	17.0	62.6
			128	LONG LEVEL	0	100.0	17.4	13.6	61.3
06 MAY	42	57.2	170	LONG LEVEL	0	100.0	18.6	12.4	59.2
10 MAY	338	60.8	251	LONG LEVEL	16	93.6	11.0	15.5	66.2
			181	LONG LEVEL	11	93.9	12.0	15.0	64.4
12 MAY	88	62.6	99	LONG LEVEL	0	100.0	16.0	15.0	69.8
13 MAY	244	64.4	226	LONG LEVEL	0	100.0	12.6	19.0	71.6
14 MAY	215	65.3	220	LONG LEVEL	0	100.0	16.0	13.2	66.2
15 MAY	288	64.4	239	LONG LEVEL	0	100.0	20.0	15.0	69.1
16 MAY	1359	64.4	202	LONG LEVEL	2	99.0	16.0	18.0	66.6
			241	LONG LEVEL	0	100.0	17.8	16.6	69.8
			163	LONG LEVEL	0	100.0	-	-	68.9
			220	MUDDY CREEK	17	92.3	17.8	17.8	-
			264	LONG LEVEL	6	97.7	19.0	17.9	68.0
			198	LONG LEVEL	4	98.0	20.0	17.8	68.0
17 MAY	280	65.3	118	LONG LEVEL	0	100.0	12.3	13.0	73.0
			209	LONG LEVEL	0	100.0	13.4	12.2	71.6
22 MAY	79	66.2	131	PEACH BOTTOM	0	100.0	20.0	11.6	68.9
27 MAY	70	66.2	198	LONG LEVEL	0	100.0	9.2	9.0	67.1
30 MAY	94	68.0	124	LONG LEVEL	0	100.0	14.8	12.2	78.8
31 MAY	569	69.9	231	LONG LEVEL	4	98.3	8.0	14.0	80.6
			212	LONG LEVEL	16	92.5	14.0	8.5	80.6
			93	LONG LEVEL	0	100.0	14.4	11.8	80.6
01 JUN	78	69.9	73	LONG LEVEL	0	100.0	12.8	11.4	82.4
02 JUN	68	69.9	65	LONG LEVEL	0	100.0	19.0	12.6	83.3
03 JUN	122	71.6	113	LONG LEVEL	2	98.2	15.0	12.0	75.2
07 JUN	161	73.4	90	MUDDY RUN	1	98.9	6.0	8.0	74.8
			119	LONG LEVEL	0	100.0	13.4	8.8	74.8
Total			7292		302	95.9			

* 100% mortality due to equipment malfunction.

TABLE 6.10.

Summary of American shad caught, transported and held over night at the Conowingo Dam Fish Lift, Spring 1987.

DATE	NO. COLLECTED	NO. TRANSPORTED	NO. HELD OVER NIGHT
01 APR	0	0	0
03 APR	0	0	0
05 APR	0	0	0
12 APR	0	0	0
13 APR	0	0	0
15 APR	0	0	0
17 APR	1	0	0
19 APR	3	0	0
21 APR	22	0	21
22 APR	89	0	104
23 APR	80	99	69
24 APR	233	297	0
25 APR	386	361	24
26 APR	356	376	0
27 APR	393	384	3
28 APR	203	0	205
29 APR	69	205	59
30 APR	55	113	0
01 MAY	322	245	73
02 MAY	381	439	11
03 MAY	314	323	0
04 MAY	96	0	93
05 MAY	72	0	155
06 MAY	42	170	27
07 MAY	17	0	44
08 MAY	7	0	44
09 MAY	46	0	97
10 MAY	338	432	0
11 MAY	17	0	17
12 MAY	88	99	0
13 MAY	244	226	15
14 MAY	215	220	0
15 MAY	288	239	44
16 MAY	1359	1288	58
17 MAY	280	327	0
18 MAY	18	0	16
19 MAY	23	0	38
20 MAY	23	0	55
21 MAY	3	0	59
22 MAY	79	131	0
23 MAY	9	0	8
24 MAY	2	0	10
25 MAY	67	0	75
26 MAY	64	0	134
27 MAY	70	198	4
28 MAY	38	0	41
29 MAY	57	0	91
30 MAY	94	124	0
31 MAY	569	536	0
01 JUN	78	73	2
02 JUN	68	65	0
03 JUN	122	113	0
04 JUN	12	0	8
05 JUN	33	0	38
06 JUN	25	0	56
07 JUN	161	209	0
08 JUN	26	0	24
09 JUN	4	0	26
10 JUN	5	0	0
12 JUN	1	0	0
Total	7667	7292	1848

TABLE 6.11.

The daily sex of American shad collected at the Conowingo Dam Fish Lift with the sex of mortalities that occurred during transport, holding and at the lift in 1987.

Date	Daily Catch	No. of Shad Sexed Males	Females	Ratio (m/f)	Transport Mortality Males	Females	Holding Mortality Males	Females	Lift Mortality Males	Females
17 Apr	1	1	0	1:0						
19 Apr	3	3	0	3:0						
21 Apr	22	17	4	4.2:1						
22 Apr	89	74	15	4.9:1				4		2
23 Apr	80	79	1	79:1			2	3		
24 Apr	233	214	19	11.2:1	2		2	1	1	
25 Apr	386	361	25	14.4:1	2					
26 Apr	356	109	18	6.1:1					2	1
27 Apr	393	346	44	7.9:1					1	1
28 Apr	203	140	19	7.4:1	180	38				
29 Apr	69	60	8	7.5:1						
30 Apr	55	47	8	5.9:1				1		
1 May	322	288	34	8.5:1					1	
2 May	381	112	16	7:1		1		1		1
3 May	314	284	30	9.5:1						1
4 May	96	81	14	5.8:1						1
5 May	72	63	9	7:1						
6 May	42	34	8	4.2:1						
7 May	17	17	0	17:0						
8 May	7	5	2	2.5:1						
9 May	46	32	14	2.3:1						
10 May	338	100	33	3.0:1	9	18		1		
11 May	17	15	2	7.5:1						
12 May	88	57	27	2.1:1					1	1
13 May	244	88	48	1.8:1						
14 May	215	81	49	1.6:1					1	1
15 May	288	225	62	3.6:1					1	
16 May	1359	322	124	2.6:1	18	11		29	5	9
17 May	280	96	40	2.4:1						
18 May	18	12	6	2.0:1						
19 May	23	17	6	2.8:1						
20 May	23	17	6	2.8:1						
21 May	3	0	3	0:3						
22 May	79	60	19	3.2:1						
23 May	9	7	2	3.5:1						
24 May	2	1	1	1:1						
25 May	67	43	23	1.9:1						
26 May	64	41	18	2.3:1						
27 May	70	46	24	1.9:1						
28 May	38	27	11	2.4:1				1		
29 May	57	33	23	1.4:1						
30 May	94	48	46	1:1			31	20		1
31 May	569	89	125	0.7:1	4	16			1	
1 Jun	78	47	31	1.5:1						1
2 Jun	68	42	25	1.7:1						1
3 Jun	122	52	70	0.7:1	2					5
4 Jun	12	5	6	0.8:1						
5 Jun	33	13	20	0.6:1						
6 Jun	25	6	19	0.3:1				1		1
7 Jun	161	58	96	0.6:1					1	
8 Jun	26	10	16	0.6:1						1
9 Jun	4	3	1	3:1						1
10 Jun	5	2	3	0.6:1						
12 Jun	1	0	1	0:1						
Total	7,667	4,031	1,273		217	84	35	62	15	29

3.2:1 2.6:1 .6:1 .5:1

.8:1 excluding 4/28

♀ die easier during lift & holding

TABLE 6.12.

Extrapolated summary of the number of American shad collected by date and sex at the Conowingo Dam Fish Lift, 1987.

Date	No. of Males	No. of Females	Ratio (m/f)
17-30 Apr	1,692	198	8.5:1
1-15 May	2,989	857	3.5:1
16-30 May	556	271	2.0:1
31 May-12 Jun	456	648	0.7:1
Total	5,693	1,974	2.9:1

TABLE 6.13.

Mean, minimum, and maximum fork length (mm); age; and spawning history of American shad by sex, collected at the Conowingo Dam Fish Lift, 1987.

Sex	Age	N	Spawning History: No. Virgins	No. Repeats: Single	No. Repeats: Double	Fork Lengths: mean	min	max
MALE	2	1	1			257	257	257
	3	41	41			342	275	380
	4	143	128	15		377	320	440
	5	56	48	6	2	432	373	481
	6	17	12	4	1	463	442	506
	7	2		2		518	489	546
Subtotal		260	230	27	3	390	257	546
FEMALE	3	2	2			361	337	385
	4	43	41	2		408	373	470
	5	49	42	6	1	467	390	560
	6	39	35	3	1	492	459	557
	7	14	11	3		530	494	564
Subtotal		147	131	14	2	461	337	564
Total		407	361	41	5	415	257	564

TABLE 6.14.

Mean, minimum, and maximum fork length (mm); age; and spawning history of American shad by disposition, collected at the Conowing Dam Fish Lift, 1987.

Sex	Disposition	Age	N	Spawning History			Fork Lengths		
				No. Virgins	No. Repeats		mean	min	max
					Single	Double			
FEMALE	DIED HANDLING	4	7	7			414	386	453
		5	11	9	2		462	425	504
		6	8	6	1	1	487	459	521
		7	2	2			535	528	541
	Total		28	24	3	1	463	386	541
	DIED TRANSPORT	3	2	2			361	337	385
		4	35	33	2		407	373	470
		5	37	32	4	1	469	390	560
		6	29	27	2		493	460	557
		7	12	9	3		529	494	564
	Total		115	103	11	1	460	337	564
	RELEASED	4	1	1			408	408	408
		5	1	1			470	470	470
		6	2	2			495	494	495
	Total		4	4	0	0	467	408	495
Total			147	131	14	2	461	337	564
MALE	DIED HANDLING	3	2	2			358	357	358
		4	6	6			388	354	432
		5	3	3			445	432	452
		6	1		1		480	480	480
		7	1		1		489	489	489
	Total		13	11	2	0	411	354	489
	DIED TRANSPORT	3	36	36			342	275	380
		4	137	122	15		376	320	440
		5	50	43	6	1	432	373	481
		6	16	12	3	1	462	442	506
		7	1		1		546	546	546
	Total		240	213	25	2	389	275	546
	RELEASED	5	3	2		1	434	419	444
	Total		3	2	0	1	434	419	444
	TAGGED	2	1	1			257	257	257
		3	3	3			337	298	359
	Total		4	4	0	0	317	257	359
Total			260	230	27	3	390	257	546
Combined total			407	361	41	5	415	257	564

TABLE 6.15.

American shad tag and recapture information from Conowingo Dam Fish Lift, 1987.

Date Tagged	Number Tagged	Length (mm) at Tagging	Date Recaptured	Days Free
7 Apr	1	257	26 Apr	9
9 Apr	3	359 298 354		

TABLE 6.16.

Daily number of American shad floy-tagged, and number of recaptures of shad previously tagged by RMC and other agencies at the Conowingo Dam Fish Passage Facility, 1987.

Date	Number Tagged	RMC Tag Recaptures	Non-RMC Recaptures
17 Apr	1	0	0
19 Apr	3	0	0
22 Apr	0	0	0
23 Apr	0	0	0
24 Apr	0	0	0
25 Apr	0	1	0
26 Apr	0	1*	0
27 Apr	0	0	0
1 May	0	0	1
2 May	0	0	1
3 May	0	0	0
4 May	0	0	1
5 May	0	0	1
10 May	0	0	1
12 May	0	0	0
13 May	0	0	2**
14 May	0	1*	4***
15 May	0	0	1
16 May	0	0	32
17 May	0	0	9
19 May	0	0	1
20 May	0	0	3
21 May	0	0	0
22 May	0	0	4
23 May	0	0	1
25 May	0	0	2
26 May	0	0	2
29 May	0	0	4
30 May	0	0	8
31 May	0	0	32
1 Jun	0	0	2
2 Jun	0	0	2
3 Jun	0	0	3
5 Jun	0	0	1
6 Jun	0	0	1
7 Jun	0	0	4***
Total	4	3	123

* Same fish tagged at Lift in 1986 captured twice.
** Tag number recorded for one shad was Maryland zip code.
*** One shad tagged by Department of Fisheries and Oceans, Canada, captured twice.

TABLE 6.17.

Data for American shad tagged by Maryland Department of Natural Resources in the upper Chesapeake Bay and recaptured at the Conowingo Dam Fish Lift, 1987.

Tag Date	Recapture Date(s)	Gear Type	Days Free
14 May 1984	2 May	Hook and line*	1,082
8 May 1986	16 May	Hook and line*	373
8 May 1986	31 May	Hook and line*	388
13 May 1986	5 May	Hook and line*	357
15 May 1986	1 Jun	Hook and line*	381
18 May 1986	16 May	Anchor gill net**	363
22 Apr 1987	7 Jun	Pound net***	46
27 Apr 1987	1 May	Hook and line*	4
	3 Jun	Hook and line*	34
27 Apr 1987	13 May	Hook and line*	16
27 Apr 1987	16 May	Anchor gill net**	19
27 Apr 1987	16 May	Hook and line*	19
27 Apr 1987	29 May	Anchor gill net**	32
27 Apr 1987	31 May	Anchor gill net**	34
28 Apr 1987	20 May	Pound net***	22
29 Apr 1987	4 May	Hook and line*	5
29 Apr 1987	16 May	Hook and line*	17
30 Apr 1987	14 May	Hook and line*	14
30 Apr 1987	16 May	Hook and line*	16
	31 May	Hook and line*	15
30 Apr 1987	16 May	Hook and line*	16
30 Apr 1987	17 May	Hook and line*	17
4 May 1987	14 May	Hook and line*	10
4 May 1987	16 May	Hook and line*	12
4 May 1987	16 May	Hook and line*	12
4 May 1987	16 May	Hook and line*	12
4 May 1987	16 May	Hook and line*	12
4 May 1987	16 May	Hook and line*	12
4 May 1987	16 May	Hook and line*	12
4 May 1987	16 May	Hook and line*	12
4 May 1987	16 May	Hook and line*	12
4 May 1987	17 May	Hook and line*	13
4 May 1987	17 May	Hook and line*	13
4 May 1987	17 May	Hook and line*	13
4 May 1987	30 May	Hook and line*	26
4 May 1987	2 Jun	Hook and line*	29
5 May 1987	10 May	Hook and line*	5
5 May 1987	16 May	Hook and line*	11
5 May 1987	16 May	Hook and line*	11
5 May 1987	16 May	Hook and line*	11
5 May 1987	16 May	Hook and line*	11
5 May 1987	16 May	Hook and line*	11
5 May 1987	20 May	Hook and line*	15
	26 May	Hook and line*	6
5 May 1987	29 May	Hook and line*,*	24

continued

TABLE 6.17.

Continued.

Tag Date	Recapture Date(s)	Gear Type	Days Free
7 May 1987	14 May	Hook and line*	7
7 May 1987	15 May	Hook and line*	8
7 May 1987	16 May	Hook and line*	9
7 May 1987	16 May	Hook and line*	9
7 May 1987	16 May	Hook and line*	9
7 May 1987	23 May	Hook and line*	16
7 May 1987	30 May	Hook and line*	23
7 May 1987	31 May	Hook and line*	24
7 May 1987	31 May	Hook and line*	24
7 May 1987	31 May	Hook and line*	24
8 May 1987	16 May	Anchor gill net**	8
8 May 1987	16 May	Hook and line*	8
8 May 1987	16 May	Hook and line*	8
8 May 1987	16 May	Hook and line*	8
8 May 1987	17 May	Hook and line*	9
8 May 1987	25 May	Anchor gill net**	17
8 May 1987	3 Jun	Hook and line*	26
11 May 1987	16 May	Hook and line*	5
11 May 1987	17 May	Hook and line*	6
11 May 1987	17 May	Hook and line*	6
11 May 1987	17 May	Hook and line*	6
11 May 1987	19 May	Hook and line*	8
11 May 1987	22 May	Hook and line*	11
11 May 1987	22 May	Hook and line*	11
	31 May	Hook and line*	20
11 May 1987	26 May	Hook and line*	15
11 May 1987	30 May	Hook and line*	19
11 May 1987	30 May	Hook and line*	19
11 May 1987	31 May	Hook and line*	20
11 May 1987	31 May	Hook and line*	20
11 May 1987	31 May	Hook and line*	20
11 May 1987	31 May	Hook and line*	20
11 May 1987	6 Jun	Hook and line*	26
12 May 1987	20 May	Hook and line*	8
13 May 1987	16 May	Hook and line*	3
	2 Jun	Hook and line*	16
13 May 1987	16 May	Hook and line*	3
13 May 1987	16 May	Hook and line*	3
13 May 1987	22 May	Hook and line*	9
13 May 1987	22 May	Hook and line*	9
13 May 1987	30 May	Hook and line*	17
13 May 1987	31 May	Hook and line*	18
13 May 1987	31 May	Hook and line*	18
13 May 1987	31 May	Hook and line*	18
14 May 1987	16 May	Hook and line*	2

41

continued

TABLE 6.17.

Continued.

Tage Date	Recapture Date(s)	Gear Type	Days Free
14 May 1987	17 May	Hook and line*	3
	6 Jun	Hook and line*	20
14 May 1987	29 May	Hook and line*	15
14 May 1987	31 May	Hook and line*	17
14 May 1987	31 May	Hook and line*	17
14 May 1987	2 Jun	Hook and line*	19
14 May 1987	3 Jun	Hook and line*	20
18 May 1987	31 May	Hook and line*	13
18 May 1987	31 May	Hook and line*	13
	7 Jun	Hook and line*	7
18 May 1987	31 May	Hook and line*	13
19 May 1987	22 May	Hook and line*	3
19 May 1987	30 May	Hook and line*	11
19 May 1987	30 May	Hook and line*	11
19 May 1987	31 May	Hook and line*	12
19 May 1987	31 May	Hook and line*	12
19 May 1987	31 May	Hook and line*	12
20 May 1987	31 May	Hook and line*	11
20 May 1987	31 May	Hook and line*	11
20 May 1987	31 May	Hook and line*	11
20 May 1987	31 May	Hook and line*	11
20 May 1987	31 May	Hook and line*	11
20 May 1987	31 May	Hook and line*	11
21 May 1987	25 May	Hook and line*	4
21 May 1987	29 May	Hook and line*	8
21 May 1987	31 May	Hook and line*	10
21 May 1987	5 Jun	Hook and line*	15
26 May 1987	30 May	Hook and line*	4
26 May 1987	31 May	Hook and line*	5

* Tailrace
** Spencer Island
*** Susquehanna Flats
, Captured first time in anchor gill net

TABLE 6.18.

Summary of Maryland Department of Natural Resources American shad tag/ recapture information from the Conowingo Dam Fish Lift, 1987.

Location	Gear	No. Caught	No. Tagged	No. Captured At Lift	Percent Captured
East side of Conowingo Tailrace (200 ft below training wall)	Hook and line	398	329	99	30.1
Spencer Island Susquehanna River	Anchor gill net	73	54	5	9.2
Susquehanna Flats	Pound net	9	7	2	28.6
Spencer Island	Electro fishing	7	3	0	0
	Total	487	393	106	27.0

TABLE 6.19.

Summary of radio telemetered American shad tag/recapture information from the Conowingo Dam Fish Lift, 1987.

Gear Type	No. Tagged	No. Recaptured At Lift	% Recapture	No. Stayed and/or Came Back to Tailrace	% Recapture
Fish Lift	28	5	17.8	16	31.0
Hook and line	26	5	19.2	18	27.7
Total	54	10	18.5	34	29.4

TABLE 6.20.

Summary of American shad catch by generation, 1 May to 31 May 1982; 19 May to 6 June 1983; 23 May to 29 May 1984; 21 April to 27 May 1985; 5 April to 7 June 1986; 17 April to 12 June 1987, cleanout lifts included.

TOTAL DISCHARGE (X 1000 CFS)	UNIT 1	UNIT 2	1982 NO. LIFTS	1982 TIME (MINS.)	1982 TOTAL SHAD	1982 SHAD/HR	1983 NO. LIFTS	1983 TIME (MINS.)	1983 TOTAL SHAD	1983 SHAD/HR	1984 NO. LIFTS	1984 TIME (MINS.)	1984 TOTAL SHAD	1984 SHAD/HR
LE 5	OFF	OFF	157	4571	1179	15.5	19	495	125	15.2	1	15	0	0.0
LE 5	OFF	ON	23	575	19	2.0	-	-	-	-	-	-	-	-
LE 5	ON	OFF	1	15	1	4.0	-	-	-	-	-	-	-	-
Total			181	5161	1199	13.9	19	495	125	15.2	1	15	0	0.0
10-40	OFF	OFF	61	1937	138	4.3	33	930	70	4.5	8	165	54	19.6
10-40	OFF	ON	46	1253	202	9.7	-	-	-	-	-	-	-	-
10-40	ON	OFF	1	30	0	0.0	-	-	-	-	-	-	-	-
10-40	ON	ON	5	171	1	0.4	4	120	4	2.0	16	155	6	2.3
Total			113	3391	341	6.0	37	1050	74	4.2	24	320	60	11.3
*CHANGE	CHG	CHG	14	458	34	4.5	12	330	1	0.2	5	105	3	1.7
CHANGE	CHG	ON	-	-	-	-	3	85	1	0.7	2	60	0	0.0
CHANGE	OFF	CHG	7	210	107	30.6	3	85	3	2.1	-	-	-	-
CHANGE	OFF	OFF	38	1194	204	10.3	24	690	68	5.9	2	50	7	8.4
CHANGE	OFF	ON	15	405	35	5.2	-	-	-	-	-	-	-	-
CHANGE	ON	OFF	4	120	19	9.5	-	-	-	-	-	-	-	-
CHANGE	ON	ON	7	190	4	1.3	2	45	0	0.0	6	90	1	0.7
Total			85	2577	403	9.4	44	1235	73	3.5	15	305	11	2.2
+ 40	OFF	OFF	28	1006	46	2.7	21	600	19	1.9	-	-	-	-
+ 40	OFF	ON	30	898	21	1.4	1	30	1	2.0	5	150	8	3.2
+ 40	ON	OFF	12	350	12	2.1	-	-	-	-	-	-	-	-
+ 40	ON	ON	36	1181	3	0.2	225	5135	88	1.0	120	2729	58	1.3
Total			106	3435	82	1.4	247	5765	108	1.1	125	2879	66	1.4
Total			485	14564	2025	8.3	347	8545	380	2.7	165	3519	137	2.3

TOTAL DISCHARGE (X 1000 CFS)	UNIT 1	UNIT 2	1985 NO. LIFTS	1985 TIME (MINS.)	1985 TOTAL SHAD	1985 SHAD/HR	1986 NO. LIFTS	1986 TIME (MINS.)	1986 TOTAL SHAD	1986 SHAD/HR	1987 NO. LIFTS	1987 TIME (MINS.)	1987 TOTAL SHAD	1987 SHAD/HR
LE 5	OFF	OFF	205	4213	685	9.8	103	4287	3053	42.7	246	4842	2428	30.1
LE 5	ON	OFF	-	-	-	-	-	-	-	-	2	28	0	0.0
Total			205	4213	685	9.8	103	4287	3053	42.7	248	4870	2428	29.9
10-40	OFF	OFF	150	2905	110	2.3	153	4717	433	5.5	282	6488	2875	26.6
10-40	OFF	ON	-	-	-	-	3	77	1	0.8	-	-	-	-
10-40	ON	ON	11	22	0	0.0	3	43	0	0.0	2	30	0	0.0
Total			161	2927	110	2.3	159	4837	434	5.4	284	6518	2875	26.5
*CHANGE	CHG	CHG	2	32	0	0.0	19	777	44	3.4	32	801	50	3.7
CHANGE	CHG	OFF	-	-	-	-	1	30	3	6.0	5	112	3	1.6
CHANGE	CHG	ON	-	-	-	-	1	30	23	46.0	4	105	8	4.6
CHANGE	OFF	CHG	4	120	6	3.0	15	483	11	1.4	7	211	10	2.8
CHANGE	OFF	OFF	164	4509	340	4.5	126	4686	651	8.3	171	4932	920	11.2
CHANGE	OFF	ON	1	30	0	0.0	8	470	13	1.7	1	30	2	4.0
CHANGE	ON	ON	2	4	1	15.0	5	394	2	0.3	8	189	17	5.4
Total			173	4695	347	4.4	175	6870	747	6.5	228	6380	1010	9.5
+ 40	OFF	OFF	283	7747	377	2.9	166	5136	779	9.1	170	4955	852	10.3
+ 40	OFF	ON	8	241	4	1.0	69	2345	85	2.2	30	808	66	4.9
+ 40	ON	OFF	-	-	-	-	7	175	0	0.0	29	629	73	7.0
+ 40	ON	ON	15	45	1	1.3	58	2240	38	1.0	306	6227	355	3.4
Total			306	8033	382	2.9	300	9896	902	5.5	535	12619	1346	6.4
Total			845	19868	1524	4.6	737	25890	5136	11.9	1295	30387	7659	15.1

* change refers to variable discharge during a lift.

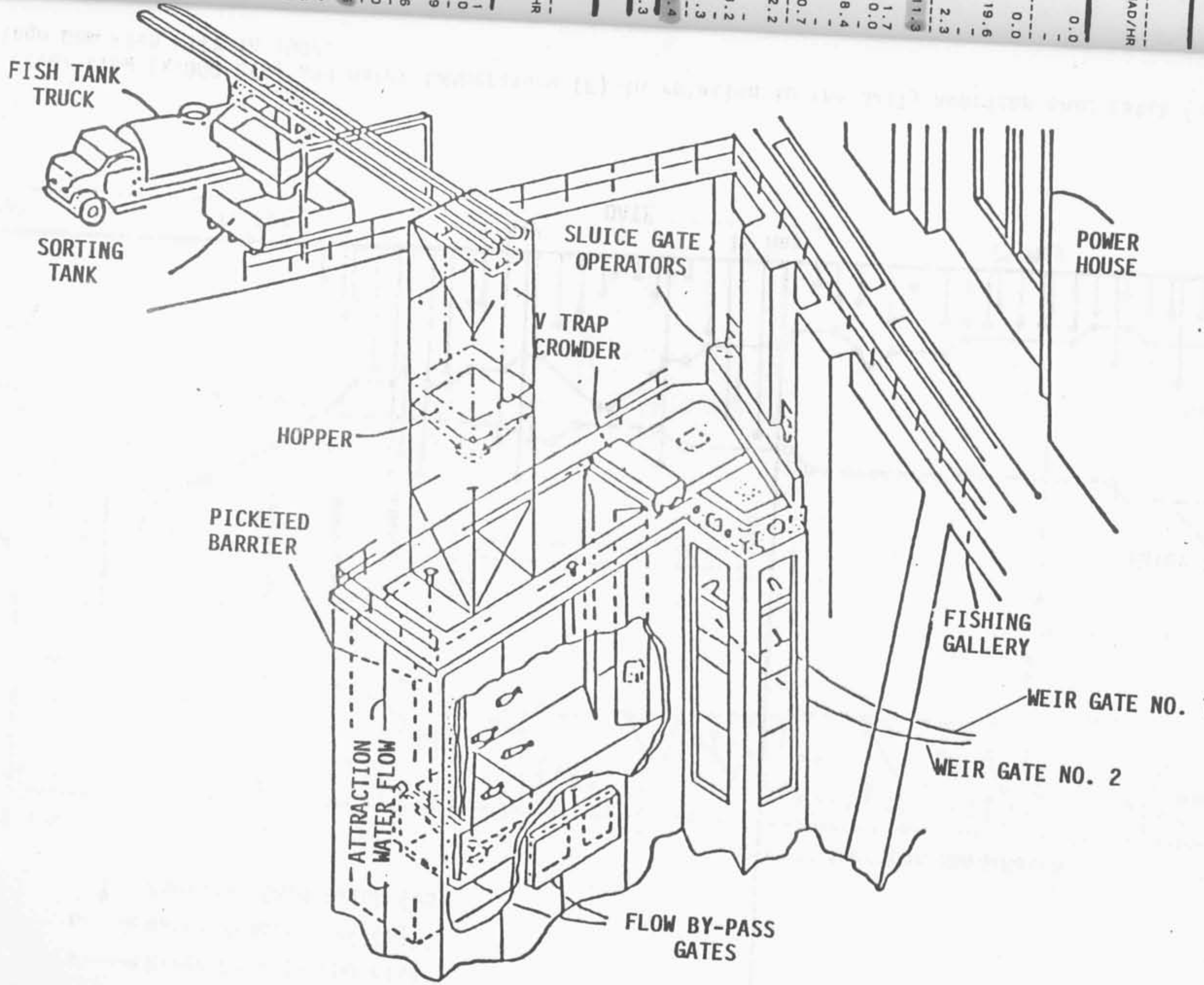

FIGURE 6-1.

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

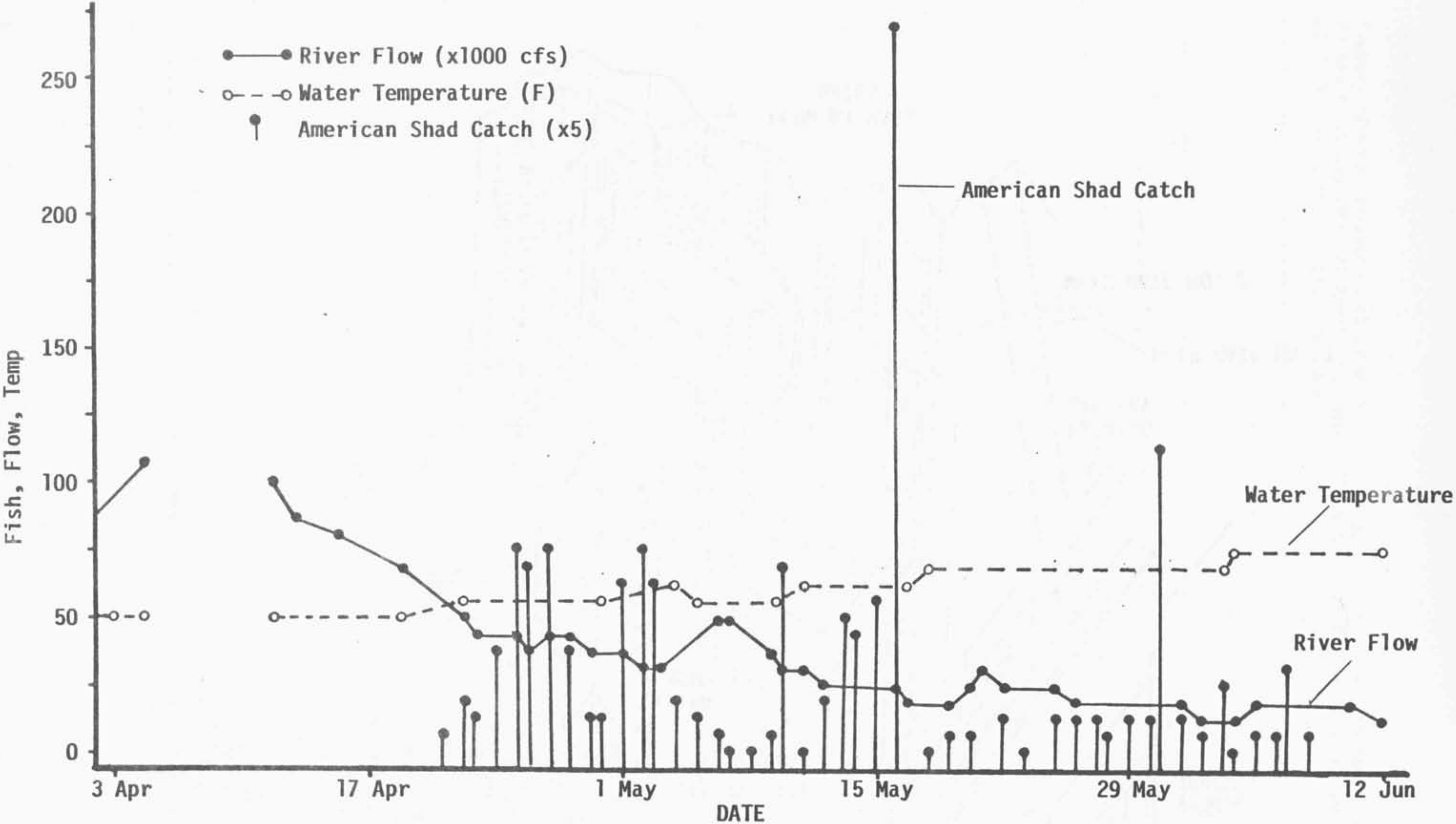

FIGURE 6.2.

A plot of river flow (x1000 cfs) and water temperature (F) in relation to the daily American shad catch (x5) at the Conowingo Dam Fish Lift in 1987.

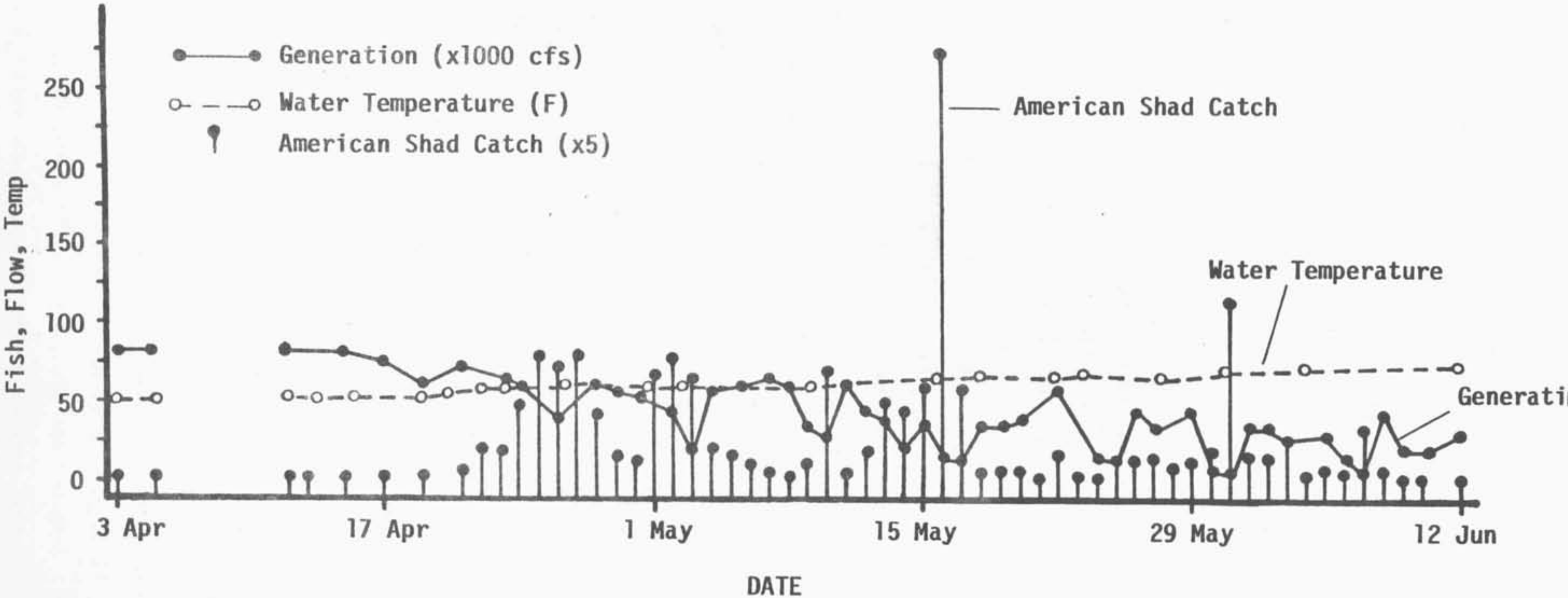

FIGURE 6.3.

A plot of generation (x1000 cfs) and temperature (F) in relation to the daily American shad catch (x5) at the Conowingo Dam Fish Lift in 1987. Generation is the average during daily lift operation.

JOB VII. POPULATION ASSESSMENT OF ADULT AMERICAN SHAD IN THE UPPER CHESAPEAKE BAY

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INTRODUCTION

The American shad fishery in Maryland waters of the Chesapeake Bay has been closed to commercial and sport fishing since 1980. Since that time, the Maryland Department of Natural Resources (MDNR) has monitored the number of adults present at the head of the Bay during the spring spawning season. Our yearly mark-recapture effort provides an estimate of the population abundance of American shad in the upper Bay. The Petersen Index and Schaefer methods for calculating abundance have been used for all population estimates from 1980 through 1987. Mark-recapture data also provides length, age, sex and spawning history data for adult population characterization. The adult work is followed by a juvenile recruitment survey to assess reproductive success. The information obtained through these activities, is used to formulate management policies and practices designed to restore American shad to stable, harvestable levels.

METHODS AND MATERIALS

Tagging procedures for 1987 followed the methodology established in previous years and are described in the SRAFRC 1982 and 1983 annual reports. Anchor gill net sampling during 1987 differed from previous years. Variable mesh size panels were used to reduce selectivity for larger, older adults. Two nets with different mesh sizes were set on two occasions. The net used on 27 April consisted of 4 1/2", 5", and 5 1/2" stretch mesh webbing while the one employed on 8 May consisted of 4", 5 1/4", and 5 1/2" stretch mesh. Twine size for both nets was #104 and each mesh size panel was 200 ft. long and 5 1/2 ft. deep. All other gill netting procedures remained unchanged (Weinrich et al. 1982). Hook and line and pound net samples were also taken during 1987 In addition, the feasibility of electrofishing for catching and tagging adult shad was tested. Tagging sites during 1987 are presented in Figure 1.

RESULTS

The majority of adult shad (81.7%) were captured by hook and line in the tailrace of the Conowingo Dam. Hook and line effort began on April 27th, encompassed 16 fishing days, and ended on May 26th. The gill net was set off Spencer Island on two nights, April 27th and May 8th, and captured 15% of the adults. The other two gears combined accounted for approximately 3% of the total catch. A commercial pound net at Rocky Point was sampled and fish were tagged on April 22nd, 28th, and May 8th. Electrofishing was conducted on May 18th off Spencer Island.

The 1987 tagging effort was the largest to date and 393 fish were successfully tagged (Table 1). Subsequently, 111 fish tagged in 1987 were recaptured. Six fish tagged during 1986 and one fish tagged during 1984 were also recaptured. Recapture data is summarized as follows:

a) 105 fish recaptured by the Conowingo Fish lift (does not include 8 double recaptures)
   3 fish recaptured by hook and line
   2 fish recaptured by gill net
   1 fish recaptured by pound net

b) 104 fish recaptured were tagged using hook and line
   5 fish recaptured were tagged using gill net
   2 fish recaptured were tagged using pound net

c) 101 fish recaptured in the same area as initially tagged
   7 fish recaptured upstream of their initial tagging
   3 fish recaptured downstream of their initial tagging

d) Shortest period at large: 1 day
   Longest period at large (1987 fish only): 46 days
   Mean number of days at large: 13.2 $\pm$ 7.4 days

e) 6 fish recaptured from 1986 tagging season:
   Shortest period at large: 357 days
   Longest period at large: 388 days
   Mean number of days at large: 372.2 $\pm$ 10.4 days

f) 1 fish recaptured from 1984 tagging season at large 1082 days

g) Mean number of days at large for double recaptures: 24.5 ± 6.2 days; range: 1-34 days
Mean number of days to first recapture: 8.3 ± 5.7 days
Mean number of days from first recapture to second recapture: 16.3 ± 8.8 days.

Population estimates for adult American shad in the lower Susquehanna River using the Petersen Index and Schaefer methods were 26,743 and 26,031, respectively (Tables 2 and 3a and b). The Petersen population estimates for all years, 1980-1987, including 95% confidence intervals, are compared in Figure 2. Overlapping and large confidence intervals between 1986 and 1987 values indicate questionable differences between years.

Gill net catch-per-unit-of-effort (CPUE) during 1987 varied depending on mesh size (Table 4). The 1987 gill net rates were calculated from small sample sizes and reflected reduced effort. Hook and line CPUE and number of fish tagged was the greatest to date (Table 5). The recapture rate for adult American shad was also the highest to date (Table 6). Recapture rates have varied from year to year and directly affect the population estimate ($r^2 = 0.9333$). As the amount of effort to capture and mark fish has changed over the years (increased hook and line effort in the tailrace and decreased gill netting effort in mid-river), so has the percentage of recaptures (Table 7).

ADULT POPULATION CHARACTERIZATION

The techniques for characterizing adult American shad according to length, age, sex and spawning history in 1987 remained unchanged from previous years. A total of 473 American shad were examined for physical characteristics during the 1987 tagging operations. Female length at age was consistently larger than the corresponding male length at age, regardless of gear type (Table 8). Mean fork length comparisons by gear type and sex were variable with no apparent trends. The 1987 spawning run was dominated by IV and V year-old fish (Table 9).

The overall sex ratio (male:female) was 1 : 0.3 (Table 10). Sex ratios varied with gear type and followed the 1986 results (1 : 0.3). Hook and line accounted for the lowest ratio of females while the gill net had the highest ratio of females. The percentage of repeat spawners during 1987 was 6.8% (Table 10) and was the third highest value since the project began in 1980. Female repeat spawners varied between 0.9% and 20% while male repeat spawners varied between 1 9% and 20%.

JUVENILE RECRUITMENT SURVEY

Weekly sampling for juvenile American shad began July 8th and continued through October 29th. Detailed descriptions of gear and materials can be found in previous SRAFRC reports. Juvenile sampling during 1987 consisted of 130 seine hauls and 99 otter trawls. A total of 3 juveniles and 1 yearling American shad were caught during the sampling period. The juveniles ranged in total length from 118mm to 137mm while the yearling was 145mm. The juveniles were collected at Battery Island and the yearling was collected at Tydings Park (Figure 3).

Total catch and CPUE for five important juvenile finfish species in the upper Bay are presented in Table 11. The 1987 catches of juvenile American shad, blueback herring, alewife herring, white perch and striped bass decreased from 1986. Record high levels of young alosids occurred in 1986.

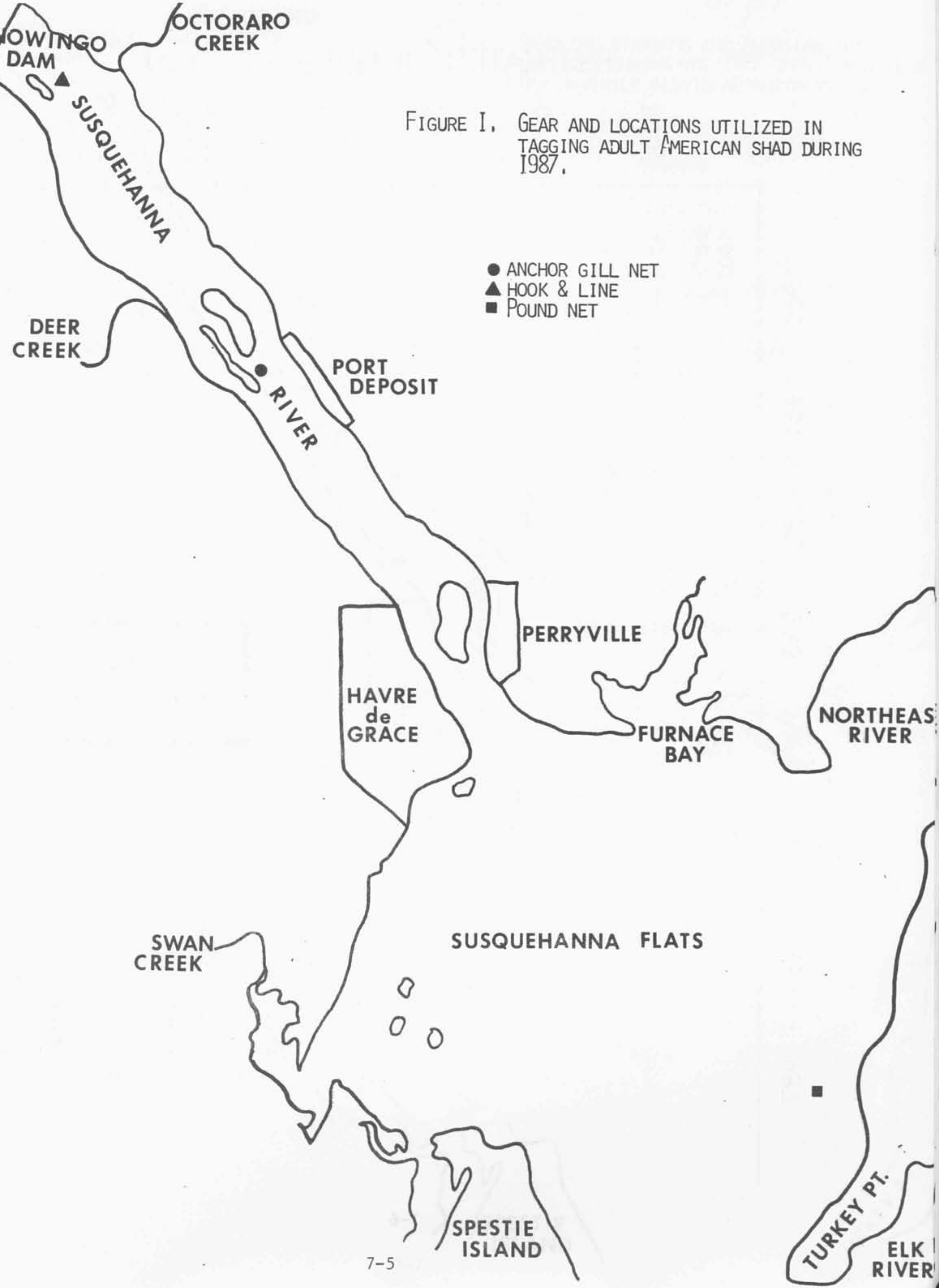

FIGURE I. GEAR AND LOCATIONS UTILIZED IN TAGGING ADULT AMERICAN SHAD DURING 1987.

FIGURE II. YEARLY COMPARISONS OF THE ESTIMATED ADULT AMERICAN SHAD POPULATION IN THE UPPER CHESAPEAKE BAY, 1980 - 1987.

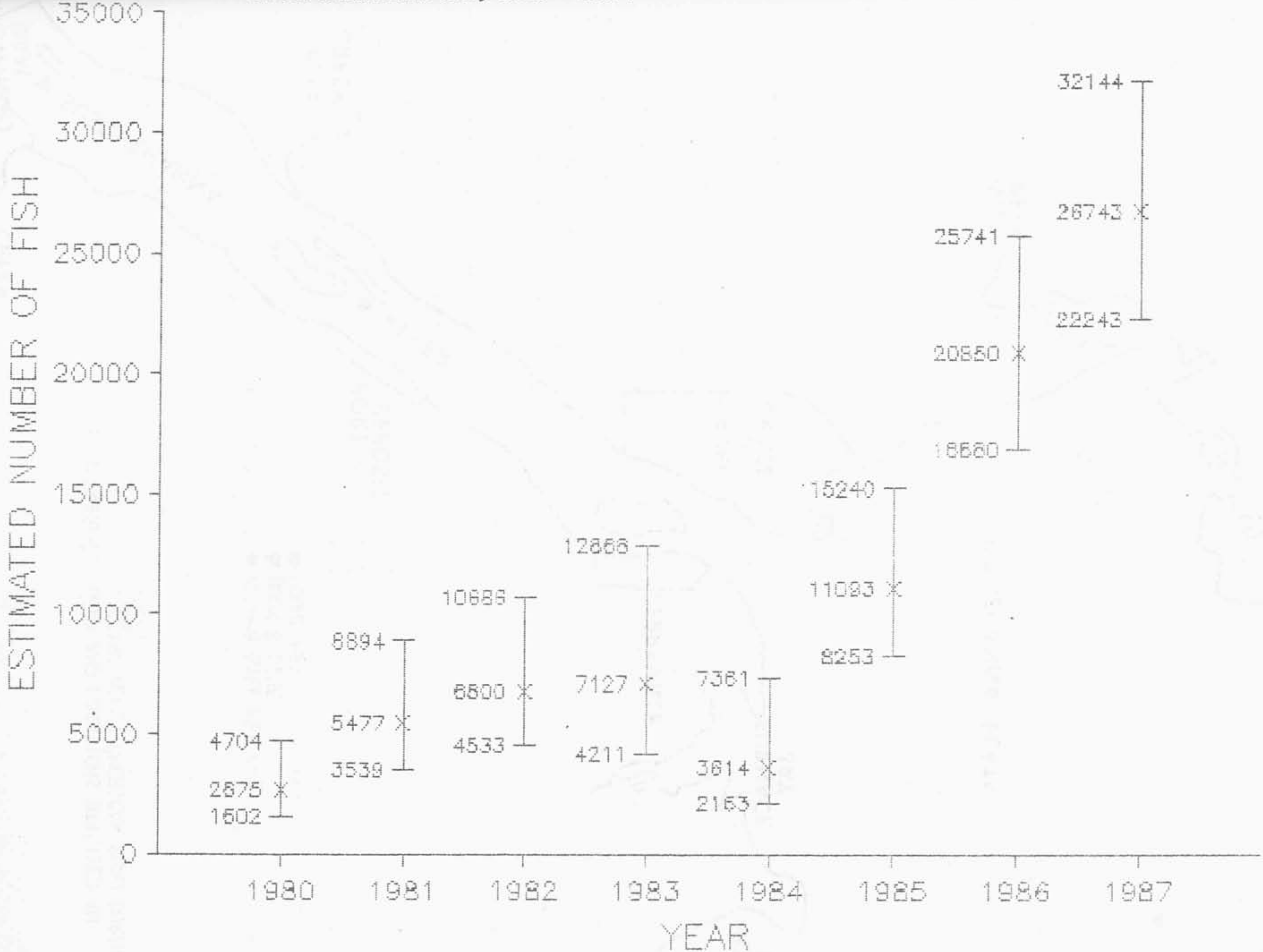

FIGURE III. SAMPLING STATIONS AND AMERICAN SHAD CAPTURED DURING THE 1987 UPPER CHESAPEAKE BAY JUVENILE ALOSID RECRUITMENT SURVEY.

NUMBER	STATION
1	Wild Duck Cove
2	Seneca Point
3	Cara Cove
4	Camp Rodney
5	Battery Island/Spoil Island
6	Tydings Park
7	Quarry
11	Happy Valley Branch

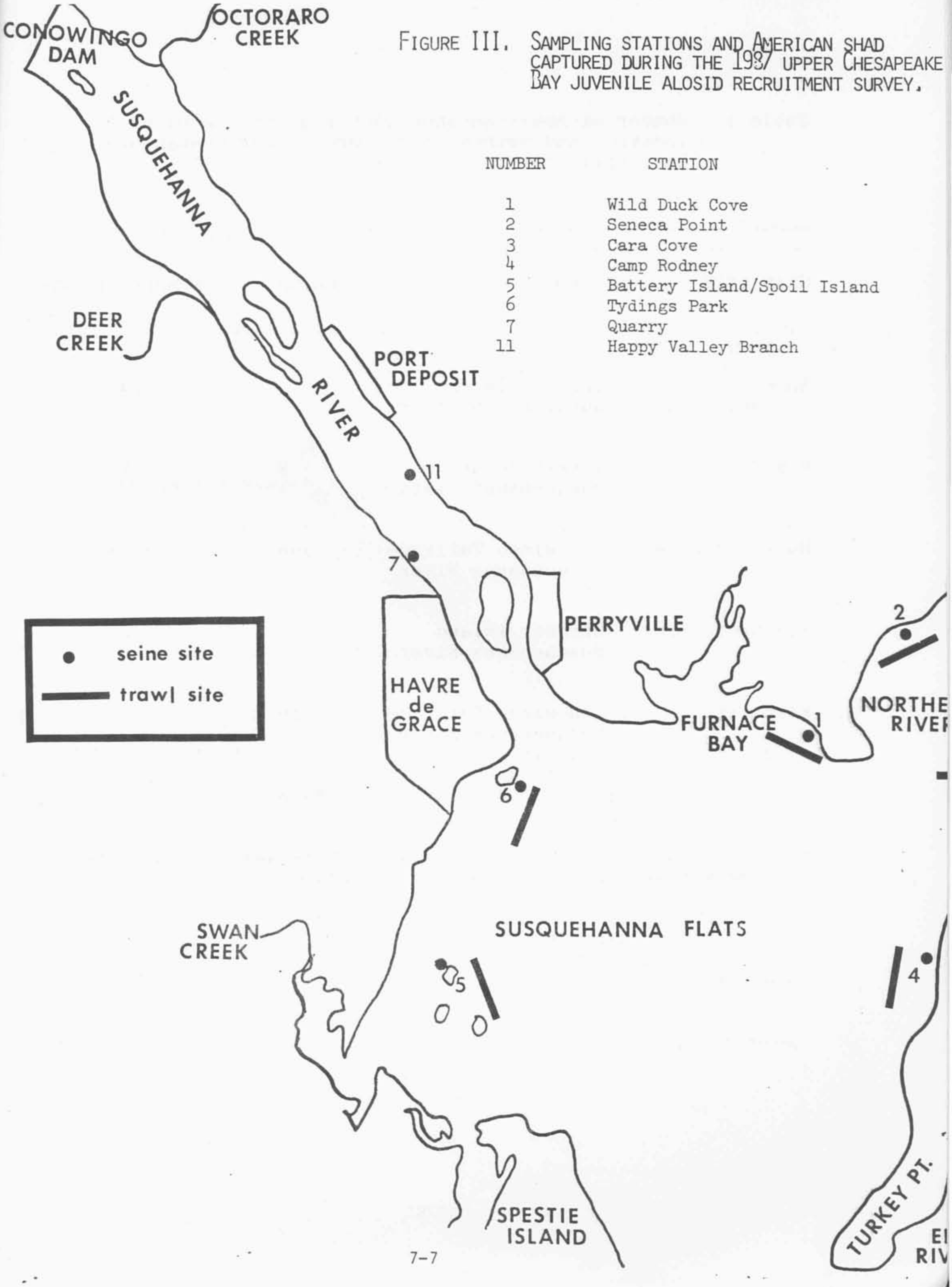

Table 1. Number of American shad captured and tagged by location and method of capture, upper Chesapeake Bay, April-May 1987.

GEAR TYPE	LOCATION	CATCH	NUMBER TAGGED
Anchor Gill Net	Spencer Island Susquehanna River	73	54
Pound Net	Turkey Point Susquehanna Flats	9	7
Hook and Line	Conowingo Tailrace Susquehanna River	398	329*
Electrofishing	Spencer Island Susquehanna River	7	3
Fish Lift	Conowingo Tailrace Susquehanna River	7516	
	TOTALS	8003	393

* Fish not tagged via hook and line capture were either below 350mm minimum length or in poor condition

Table 2. Population estimate of adult American shad in the Susquehanna River during 1987 using 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 1987 survey-

C = 7601
R = 111
M = 393

Therefore-

$$N = \frac{(393 + 1)(7601 + 1)}{(111 + 1)}$$

$$= 26,743$$

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 Ricker p343)

$$\text{Upper } N* = \frac{(393 + 1)(7601 + 1)}{92.18 + 1} = 32,144$$ @ .95 confidence limits

$$\text{Lower } N* = \frac{(393 + 1)(7601 + 1)}{133.66 + 1} = 22,243$$ @ .95 confidence limits

Table 3. Population estimate of adult American shad in the Susquehanna River during 1987 using 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 Tagging 1	2	3	4	5	6	7	Tagged Fish Recovery (Ri)	Total Fish Recovery (Ci)	Ci/Ri
Week of Recovery										
1								0	1897	0
2	2							2	1369	684.5
3	1	2	1					4	921	230.25
4	4	22	20	2				48	2248	46.83
5			7	3	1			11	312	28.36
6	2	3	15	19	4			43	970	22.56
7	1		1		1			3	263	78.67
Tagged Fish Recovered (Ri)	10	27	44	24	6					
Total Fish Tagged (Mi)	67	80	148	78	20	0	0			
Mi/Ri	6.7	2.9	3.4	3.3	3.3	0	0			

Table 3B. Computed totals of American shad in the Susquehanna River during 1987 using the Schaefer Method.

Week of Recovery (j)	Week of Tagging (i) 1	2	3	4	5	6	7	Total
1								0
2	9172							9172
3	1543	1363	774					3680
4	1255	3050	3147	304				7756
5			667	277	94			1038
6	302	200	1137	1393	300			3332
7	527		264		262			1053
Totals	12799	4613	5989	1974	656			26,031

Table 4. Comparisons of yearly catch, effort, and catch-per-unit-of-effort (CPUE) for adult American shad caught by different mesh size using the anchor gill net.

YEAR	MESH SIZE	SQ.YD.HRS. OF NET FISHED	TOTAL CATCH	CPUE	SQ.YD.HRS. NEEDED TO CATCH 1 SHAD
1980	5"	18,400	66	0.0036	278.78
	5 1/2"	13,200	49	0.0037	269.39
1981	5 1/4"	38,400	134	0.0035	286.57
	5 1/2"	20,978	94	0.0045	223.17
1982	4 1/2"	2,400	17	0.0071	141.18
	5 1/4"	35,200	210	0.0059	167.62
	5 1/2"	10,533	50	0.0047	210.66
1983	5 1/4"	8,311	212	0.0255	39.20
1984	5 1/4"	7,822	125	0.0159	62.58
1985	5 1/4"	10,667	159	0.0149	67.09
1986	5"	3,000	107	0.0356	28.04
1987	4"	570	4	0.0070	142.50
	4 1/2"	697	21	0.0301	33.19
	5"	697	21	0.0301	33.19
	5 1/4"	1503	17	0.0113	88.41
	5 1/2"	570	9	0.0158	63.33

Table 5. Catch, effort and catch per unit effort (CPUE) for adult American shad by hook and line during the 1982-1987 tagging program in the upper Chesapeake Bay.

YEAR	HOURS FISHED	TOTAL CATCH	CPUE		POP. EST.
			CPAH*	HTC**	
1982	-***	88	-	-	6800
1983	-***	11	-	-	7127
1984	52.0	126	2.42	0.41	3614
1985	85.0	182	2.14	0.47	11083
1986	147.5	437	2.96	0.34	20850
1987	108.8	399	3.67	0.27	26743

* Catch per angler hour
** Hours to catch 1 shad
***Hours fished not recorded

Table 6. Number of American shad marked by method, number recaptured and recapture rate, upper Chesapeake Bay, 1980-1987.

Year	Number Tagged	Number Recaptured (all methods, including trap)	Recapture Rate
POUND NET			
1980	89	9	10.11
1981	58	4	6.90
1982	76	5	6.58
1983	0	0	-
1984	0	0	-
1985	30	1	3.33
1986	0	0	-
1987	7	2	28.57
GILL NET			
1980	65	4	6.15
1981	186	13	7.00
1982	182	11	6.04
1983	207	12	5.80
1984	122	3	2.46
1985	134	7	5.22
1986	69	6	8.70
1987	54	5	9.26
HOOK AND LINE			
1980	0	0	-
1981	1	0	0
1982	81	5	6.17
1983	10	0	0
1984	99	7	7.07
1985	156	34	21.79
1986	267	79	29.59
1987	329	104	31.61
ELECTROFISHING			
1987	3	0	0

TOTAL FOR ALL GEAR TYPES, 1980-1986

Year	Percent Recapture Rate (# recaptured/# marked)
1980	8.44
1981	6.94
1982	6.19
1983	5.52
1984	4.52
1985	13.13
1986	25.30
1987	28.24

Table 7. Summary of adult American shad marked and recaptured during 1980-1987 tagging operations

YEAR	TOTAL NO. OF FISH MARKED	TOTAL NO. OF FISH RECAPTURED	PERCENT RECAPTURES	MEAN DAYS AT LARGE	SHORTEST DAYS AT LARGE	LONGEST DAYS AT LARGE
1981	245	18	7.3	15	2	35
1982	339	27	7.9	11	1	39
1983	217	12	5.5	7	2	20
1984	221	13	5.8	11	3	24
1985	320	42 (2 double recaptures)	13.1	11	2	34
1986	336	84 (7 double and 2 triple recaptures)	25.0	15	3	31
1987	393	111 (8 double recaptures)	28.2	13	1	46

Table 8. Mean fork lengths(mm) and length ranges by sex and age groups for adult American shad collected by gear type during the 1987 Chesapeake Bay tagging operation.

AGE GROUP	SEX	N	MEAN ± S.D.	RANGE Min.	Max.
A. Anchor Gill net					
III	M	5	349 ± 14.32	330	370
IV		26	371 ± 15.54	345	410
V		7	429 ± 25.78	400	470
VI		1	435		
III	F	1	380		
IV		11	418 ± 22.39	385	465
V		17	463 ± 28.13	415	510
VI		3	495 ± 39.69	450	525
B. Hook & Line					
II	M	1	238		
III		59	341 ± 32.31	280	405
IV		147	380 ± 27.23	280	445
V		60	431 ± 33.87	345	495
VI		1	430		
III	F	4	389 ± 10.31	375	400
IV		41	412 ± 26.34	380	495
V		64	464 ± 24.71	400	515
VI		3	527 ± 35.12	490	560
C. Pound Net					
III	M	1	310		
IV		3	402 ± 26.50	383	432
V		1	399		
V	F	6	500 ± 21.39	474	533
VI		4	497 ± 34.67	450	532
D. Electrofishing					
III	M	5	355 ± 7.07	350	365
IV		1	395		
IV	F	1	360		
E. Trap					
II	M	1	257		
III		41	342	275	380
IV		143	377	320	440
V		56	432	373	481
VI		17	463	442	506
VII		2	518	489	546
III	F	2	361	337	385
IV		43	408	373	470
V		49	467	390	560
VI		39	492	459	557
VII		14	530	494	564

Table 9 . Catch and age composition by sex and gear type for American sahd collected during the 1987 tagging program in the upper Chesapeake Bay.

Sex Gear	AGE GROUPS II	 III	 IV	 V	 VI	 VII
Male						
Anchor Gill net						
Number caught	-	5	26	7	1	-
Percent age comp.		12.8	66.7	17.9	2.6	
Hook and Line						
Number caught	1	59	147	60	1	-
Percent age comp.	0.3	22.1	54.9	22.4	0.3	
Pound net						
Number caught	-	1	3	1	-	-
Percent age comp.		20	60	20		
Electrofishing						
Number caught	-	5	1	-	-	-
Percent age comp.		83.3	16.7			
Trap						
Number caught	1	41	143	56	17	2
Percent age comp.	0.4	15.8	55.0	21.5	6.5	0.8
Female						
Anchor Gill net						
Number caught	-	1	11	17	3	-
Percent age comp.		3.1	34.4	53.1	9.4	
Hook and Line						
Number caught	-	4	41	64	3	-
Percent age comp.		3.6	36.6	57.1	2.7	
Pound net						
Number caught	-	-	-	6	4	-
Percent age comp.				60	40	
Electrofishing						
Number caught	-	-	1	-	-	-
Percent age comp.			100			
Trap						
Number caught	-	2	43	49	39	14
Percent age comp.		1.4	29.3	33.3	26.5	9.5

Table 10. Age frequency, number and repeat spawners by gear type and sex for adult American shad collected during the 1987 upper Chesapeake Bay tagging program.

GEAR TYPE	SEX	SEX RATIO	II	III	IV	V	VI	VII	% REPEAT SPAWNERS	TOTALS
Anchor Gill Net	M		0	5	26	7	1	0		39
	Rpts.			0	0	2	0		5.1	2
		1 : 0.82								
	F		0	1	11	17	3	0		32
	Rpts.			0	0	1	2		9.4	3
Hook & Line	M		1	59	147	60	1	0		268
	Rpts.		0	0	3	2	0		1.9	5
		1 : 0.42								
	F		0	4	41	64	3	0		112
	Rpts.			0	0	1	0		0.9	1
Pound Net	M		0	1	3	1	0	0		5
	Rpts.			0	1	0			20.0	1
		1 : 2.00								
	F		0	0	0	6	4	0		10
	Rpts.					1	1		20.0	2
Electro	M		0	5	1	0	0	0		6
	Rpts.			0	0				0	0
		1 : 0.17								
	F		0	0	1	0	0			1
	Rpts.				0				0	0
Trap	M		1	41	143	56	17	2		260
	Rpts.		0	0	15	8	5	2	11.5	30
		1 : 0.57								
	F		0	2	43	49	39	14		147
	Rpts.			0	2	7	4	3	10.9	16
TOTALS	M		2	111	320	124	19	2		578
	Rpts.		0	0	19	12	5	2	6.6	38
		1 : 0.52								
	F		0	7	96	136	49	14		302
	Rpts.			0	2	10	7	3	7.3	22
								TOTALS	6.8	880
										60

Table 11a&b. Total catch and catch-per-unit-of-effort for five juve
species by gear type during the years 1980-1987 in the
upper Chesapeake Bay juvenile recruitment survey.

SPECIES	1980	1981	1982	1983	1984	1985	1986	1987
A. TOTAL CATCH								
Alosa sapidissima (American shad)								
seine	0	0	0	0	0	0	8	0
trawl	0	0	1	0	0	1	6	3
Alosa aestivalis (blueback herring)								
seine	108	2	130	1	40	96	3484	40
trawl	27	0	8	2	17	16	1988	3
Alosa pseudoharangus (alewife herring)								
seine	194	108	14	4	11	99	175	6
trawl	38	35	19	6	49	171	241	13
Morone americana (white perch)								
seine	1315	174	1631	208	914	228	1686	101
trawl	1453	347	3973	553	2410	1014	3028	457
Morone saxatilis (striped bass)								
seine	55	8	235	8	22	8	60	6
trawl	8	0	49	2	10	1	37	1

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SPECIES	1980	1981	1982	1983	1984	1985	1986	1987
B. CATCH-PER-UNIT-OF-EFFORT								
Alosa sapidissima (American shad)								
seine	0	0	0	0	0	0	.06	0
trawl	0	0	.01	0	0	.02	.06	.03
Alosa aestivalis (blueback herring)								
seine	.59	.02	.79	.01	.3	.67	24.19	.31
trawl	.23	0	.08	.02	.3	.16	18.93	.03
Alosa pseudoharangus (alewife herring)								
seine	1.07	.78	.09	.03	.1	.69	1.22	.05
trawl	.38	.38	.18	.06	.7	1.71	2.3	.13
Morone americana (white perch)								
seine	7.23	1.26	9.95	1.53	7.2	1.58	11.71	.78
trawl	14.39	3.77	37.84	5.53	35.4	10.14	28.84	4.62
Morone saxatilis (striped bass)								
seine	.3	.06	1.43	.06	.2	.06	.42	.05
trawl	.08	0	.47	.02	.2	.01	.35	.01

LAST
PAGE