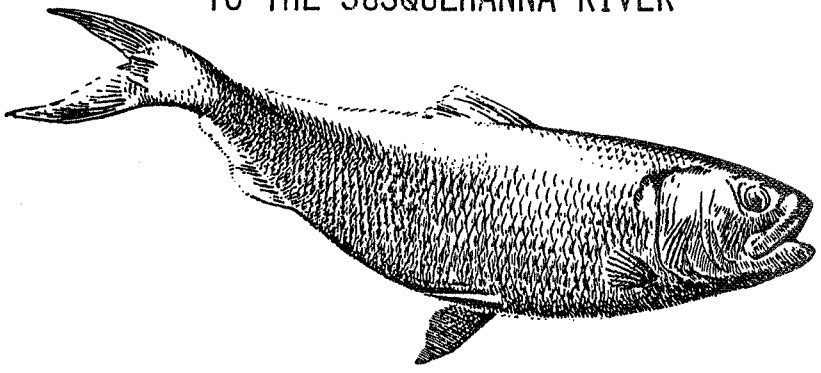
RESTORATION OF AMERICAN SHAD

TO THE SUSQUEHANNA RIVER



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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
NATIONAL MARINE FISHERIES SERVICE
PHILADELPHIA ELECTRIC COMPANY
PENNSYLVANIA FISH COMMISSION
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JOB I. TRANSFER ADULT AMERICAN SHAD TO THE SUSQUEHANNA RIVER FROM OUT-OF-BASIN SOURCES

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1.1 INTRODUCTION

In 1981, 1,165 pre-spawned adult shad were transported by NES from the Connecticut River and released live to the Susquehanna River at Tunkhannock, PA. During the evaluation studies juvenile American shad were collected in the Susquehanna River between Beach Haven and Wilkes-Barre, PA., confirming natural reproduction. The success of this effort were encouraging and led SRAFRC to expand the adult transplant program. In 1982, a minimum of 3,000 pre-spawned adults were to be captured and trucked to the Susquehanna River, with at least 75% survival. Approximately 2,000 were to be taken from the lift at Holyoke Dam, Connecticut River. The remaining 1,000 were to be taken from the Hudsdon River.

The adult shad transplantation operation was conducted on two rivers, the Connecticut and Hudson. On the Connecticut it was a continuation and expansion of the 1981 out-of-basin transfer program. This operation was conducted by the PFC, using the Mount Pleasant (PA) Fish Cultural Station as a center of operations. The techniques and logistics for the Connecticut River (Holyoke Dam)

operation were mostly worked out through review of the 1980 and 1981 SRAFRC programs. The Hudson River out-of-basin-transfer was new. This operation differed from that of the Connecticut River in that the collection of adult shad was not through a facility such as that at Holyoke, but by use of various collecting gear (nets). This program was conducted by NES.

The two operations for obtaining adult shad for out-of-basin-transfer were co-ordinated by NES. NES and PFC, jointly co-ordinated manpower and resources in a manner as to best achieve the goals of SRAFRC. Although the operations operated independently, plans were made to integrate use of transportation facilities (truck and tank) to take best advantage of the availability of adult shad from both rivers. Described below are the programs as they were conducted on each river.

1.2 DELAWARE RIVER ADULT TRANSFER

The 1982 work plan directed NES to, with co-operation from the PFC and USF and WS, investigate the feasibility of capturing adult shad from the Delaware River for future use in the Susquehanna River restoration efforts. This task was completed. In 1982 the SRAFRC did not attempt to collect adult shad from the Delaware River. The Delaware River "Shad Committee" approved the release of shad for transfer to the Susquehanna River, but generally

preferred that the operation not be conducted out of Lambertville, NJ, where the New Jersey Fish and Game Department was already working with Mr. Fred Lewis to obtain shad for transfer to the Raritan River, New Jersey. It was the suggestion of this group that the SRAFRC examine the feasibility of developing a haul seine or other capture site upstream from Lambertville for collection of pre-spawned adult shad. Thus in 1982, the SRAFRC effort was solely directed toward site evaluation on the upper Delaware River to determine the potential for adult shad collection.

1.3 CONNECTICUT RIVER PROGRAM

1.3.1 Source of Shad

Adult American shad were obtained from the fish list at Holyoke Dam (RM 74) on the Connecticut River, Holyoke, Massachusetts (Figure 1.1). The transfer operation was conducted from 12 May through 2 June. The program was designed to transfer shad on a daily basis to optimize achievement of goals set by the SRAFRC.

1.3.1.1 Loading Shad

Generally, shad were loaded between 1000 and 1300 hrs on a daily basis, six days a week. Variations in time of loading occurred because the lift facility use is shared with Rhode Island, New Hampshire, and Massachusetts resource agencies, which are also conducting adult shad transfer programs. Since the SRAFRC operation required the longest transfer distance, the New England resource agencies usually cooperated by allowing the truck(s) destined for the Susquehanna River to load first in the morning. Shad were netted from the Holyoke counting flume after they had been hydraulically raised to that level by the lift. They were placed in a cart which was then lowered to a loading platform for direct release into the transport tank.

1.3.1.2 Release Site Susquehanna River

Shad were released to the Susquehanna River at the Pennsylvania Fish Commission's Tunkhannock Access Area, south of Tunkhannock, Pennsylvania (Figure 1.2). The 300 mile trip from Holyoke to the Tunkhannock release site required approximately 6-7½ hrs travel time. At the release site, the truck was backed down the access ramp to the shoreline. The circulation pumps were shutdown, loading port cover removed, and release hatch cover raised. Shad

were then released directly into the Susquehanna River.

1.4 MATERIALS AND EQUIPMENT

1.4.1 Tank Description

The transport tank has a 1,500 gallon capacity, and is 4 ft high and 8 ft in diameter. The top is removable. Shad are loaded through a 2 ft square hatch on the top. The hatch is sealed with a cover comprised of two layers of plexiglass separated by fine Nitex netting. Holes in the plexiglass allow for equalization of internal and external pressure which reduces changes of gas supersaturation. Unloading is accomplished through a square hatch by a gate release located on the back of the tank. A portable shoot, which extends 1-ft beyond the truck bed, is attached below the unloading hatch and directs both water and shad into the River.

1.4.1.1 Water Circulation

A counter-clockwise current is created by two 3 H.P. gasoline driven centrifugal pumps. Each pump has an individual pressure discharge to the tank, located tangential along the inner tank wall. Pressure discharges are located at different

heights to create equal current throughout the water column in the tank. A common return suction to the pumps is located at the bottom center of the tank. Each pump is equipped with a "bleeder valve" which introduces air into the system during pumping.

1.4.1.2 Aeration

Aeration of the system is controlled by air intake valves on the suction side of each pump. A direct relationship exists between the amount of aeration and strength of the current. Opening air valves and increasing the amount of air in the lines causes a reduction in the current and reduces the rate of aeration. Approximately 80% water and 20% air are continually delivered to the tanks by the pumps.

1.5 METHODS

1.5.1 Tank Capacity for Shad

Up to 150 adult shad may be transferred at one time, based on experience of the Rhode Island Fish and Game Department transportation program which used a tank of the same size and design. Shad were transferred from Holyoke to the Pawcatuck River, RI., a distance of approximately 150 miles. The typical number

transferred in the above program was 120-130 shad. In 1981, NES transferred up to 100 shad per load in a smaller tank than that used in 1982. In the 1982 operation loads of up to 150 shad were transferred and reduced to 125 shad or fewer when mortality was greater than about 20%. Survival in the early stages of transfer in 1981 were 79-94% when 100 fish were loaded. With increasing river temperatures (Connecticut River) the number of shad transported in 1982 was reduced to about 100 per load. This determination ultimately was made by drivers who observed shad condition upon release at Tunkhannock.

1.5.1.1 Counting Shad

The number of shad loaded was determined as they were released from the carts to the transport tank. At the release site dead shad were retrieved (see below) and the total number tallied.

1.5.1.2 Sex Ratio

Sex ratio of shad transferred was determined by examination of the sex ratio in the daily catch of the Holyoke lift. It was assumed that the daily sex ratio in the transfer operation approximates that in the lift. These data are also used by New England resource agenices in estimation of sex ratios. Data were made available to NES at the seasonal termination of Holyoke lift operation.

1.6 TEMPERATURE AND OXYGEN MAINTENANCE

1.6.1 Temperature

Temperature in the transport tank is not controllable. No cooling is necessary until water temperature is more than 70° F. Water temperature differential between the Connecticut River and the Susquehanna River was measured and every effort was made to minimize increases in temperature during transport.

1.6.1.1 Dissolved Oxygen

Dissolved oxygen (DO) was maintained by an aeration system which is an integral part of the transport tank. Aeration is regulated by a petcock valve. DO levels were maintained by water circulation through pumps. Aeration of the system is controlled by air intake valves on the suction side of each pump. A direct relationship exists between the amount of aeration and the strength of the current. Opening air valves and increasing the amount of air in the lines causes reduction in the current and limits the rate of exchange of water carrying oxygen.

1.7 MONITORING DISSOLVED OXYGEN AND TEMPERATURE

1.7.1 Transporation Tank

Dissolved oxygen (DO) and temperature were monitored with an oxygen meter. A small opening on the top edge of the tank provided

access to the release hatch cover. Water temperature and dissolved oxygen were measured through this opening during transfer. Measurements were made prior to securing the tank for travel and at 2-hr intervals thereafter until arrival at the release site. A final water temperature and dissolved oxygen reading was made in the tank prior to stocking.

1.7.1.1 Susquehanna River

Dissolved oxygen and temperature of the River was measured at the release site after release of shad.

1.7.1.2 Suppressed Shad

Some mortality of shad occurred during transfer. In 1981 it varied from 6 to 43%. Arrangements were made by the PFC to dispose of any suppressed (dead) shad. It was advised that drivers wait for approximately 15 minutes to retrieve any fish which died in transit or immediately after release. Normally these shad were collected within a short distance along the shoreline from the release point.

1.7.1.3 Assistance to Connecticut River Basin Fish and Wildlife Management Cooperative.

The Connecticut River Basin Cooperative (CRBC) requested that the SRAFRC assist in transferring shad from Holyoke Dam (RM 74) to the Vernon Dam Pool (RM 110) on the Connecticut River. The details of this operation were worked out after a meeting of "shad haulers" in Westboro, MA on 9 April. NES attended this meeting and represented the SRAFRC on the matter of assisting the CRBC.

1.8 HUDSON RIVER TRANSFER PROGRAM

1.8.1 INTRODUCTION

NES captured pre-spawned adult shad from the Hudson River and transferred them to a release site on the upper Susquehanna River, in New York State. NES met with the NYDEC on 4 March 1982 to discuss this operation. Prior experience by NES on the Hudson River suggested that a substantial adult shad population was available for the transfer program. However, unlike on the Connecticut River, there were no means for capture of adult shad other than by netting. It was, therefore, necessary to develop a viable program using methods of capture which had not been rigorously tested for

transfer purposes. Experience of others in collection of adult shad by gillnet, principally for tagging operations, and by pound net for transfer operations, suggested that these gears could be used effectively to capture shad for live release. The latter method was used on the Susquehanna River in the early 1950's and in the early 1960's. Shad were captured in the vicinity of Havre de Grace and transferred, in some cases, to above Safe Harbor Dam.

1.9 METHODS

1.9.1 Schedule

The Hudson River program was conducted from 6-24 May. The effort was primarily on a seven-day per week basis. The time of day that the operation was conducted was contingent on tidal conditions; when the tide was running full, haul seines and gillnets could not be used effectively. Generally, fishing activities took place between 0900 and 2000 hrs.

1.9.1.2 Capture of Shad

American shad were collected from the Hudson River in the vicinity of Greenport, NY (Figure 1.1). A crew of up to six biologists worked with a crew organized by a commercial fisherman contracted to collect shad. Both the biologists and commercial fisherman

worked cooperatively to capture shad, transport them to a shore-based site and load the tank truck.

Gillnets were the primary gear employed for the first week, since they were a known means for shad capture. Shad were tended on an immediate basis to ensure that any captured were released quickly to minimize stress. Handling was also kept to a minimum. The shad collected were transferred to a 12 x 20 x 10 ft deep holding tank, with 1 in mesh netting. The tank was used to contain the fish until an adequate number were collected to be transferred to a live tank. Although all precautions were taken in the care of shad, high scale loss resulted and most died. Only 33 shad were ever transferred to the transport tank alive.

As a result of the above experience, shad capture was shifted to haul seine, on an experimental basis. A 450 x 10 ft haul seine with 1 in stretch mesh was used to collect shad. The seine operation was directed by the commercial fisherman to ensure that operations were carried out in the most effective manner. The seine was hauled along the shoreline in a sector of River where shad were known to be abundant based on gill net captures. The operation began as soon as the tide changed from ebb to uptide. This condition is necessary to minimize manpower needs in hauling the seine. Three people were needed to lay out the seine from a boat while an

additional three were needed to pull the opposite end of the net along the shoreline. The entire seine was ultimately pulled to shore with shad being concentrated in the bag section of the net. The process was repeated until a sufficient number of shad were captured to make a truck load.

1.9.1.3 Transfer of Fish from Capture Site to Tank Truck

Shad collected in the haul seine were immediately dip netted from the haul seine to a 300-gal. stock tank mounted in a 16-ft. boat. Oxygen was provided by an agitator which was plugged into a gasoline generator. A small 12 volt pump was also used to generate a small flow in the tank. Electricity for the pump was provided by a 12 volt marine battery. As many as 75 shad were loaded into the stock tank. The boat and tank were then driven to the shore-based loading site. The number of fish loaded into the stock tank was determined by several factors including, water temperature, number of shad available and distance from the capture site to the tank truck. It was ultimately determined that 50 fish were the maximum number to transfer in any one load.

1.9.1.4 Transfer of Shad to Tank on Truck

At the shoreline, shad were dip-netted from the stock tank into a galvanized metal wash tub filled with water. They were immediately carried to the truck, a distance of about 150 ft. The shad were then lifted by hand to the opening of the transfer tank and dumped into it. Usually, 4-6 shad were placed in the tub. The process was continued until all shad had been loaded.

1.9.1.5 Transfer of Shad to Susquehanna River

Adult shad were trucked from the Hudson, NY area and released to the Susquehanna River at NYSDEC access sites. Three potential sites were selected. These were as follows: (1) Owego (Tioga County), (2) Sidney (Otsego County), on the north bank of the River at the intersection of NY Route 7 and New Route 8, and (3) Oneonta (Otsego County), off NY Route 205 at the westerly city limits of Oneonta. The Owego site (Figure 1.2) was considered the prime site and the Sidney site a secondary site. The principal reason for using the Owego site was that it is downstream from a dam at Binghamton, and the Oakland Dam, on the Big Bend portion of the river in Pennsylvania.

1.9.1.6 Tank Capacity for Shad

The minimum load to be transferred was 50 shad. They were

accumulated in the transport tank until that number was reached before transfer to the Susquehanna River. The capacity of the tank was about 150 shad.

1.9.1.7 Duration of Adult Transfer

NES conducted the adult transfer program on a week to week basis beginning on 3 May. The progress in the number of adult shad transferred and their survival was assessed at the end of one week. Following conference with members of the SRAFRC Technical Committee it was deemed appropriate to continue after the first week. The 1982 Hudson River Transfer was terminated on 19 May. One basis for not continuing the operation was if adult shad survival to the Susquehanna River was less than 50% on a consistent basis. This did not occur.

1.9.1.8 Temperature and Oxygen

Monitoring of temperature and oxygen were conducted in the same manner as described for the Connecticut River transfer operation.

1.9.1.9 Cooperation Between NES and NYDEC

The NYDEC was available for technical consultation, as necessary, during the course of carrying out the Hudson River program. They were informed on a regular basis as to the progress of the effort.

1.10 RESULTS

1.10.1 Connecticut River Transfer

1.10.1.1 Numbers of Shad Transplanted and Survival

The transport of adult shad from the Connecticut River to the Susquehanna River began on 12 May. This was about one week later than initiation of the operation in 1981. Rain and resulting high waters prevented operation of the Holyoke lift prior to 12 May. Water temperatures were also lower than usual.

A total of 1,934 shad was transferred to the Susquehanna River by the PFC in 18 days of hauling between 12 May and 2 June (Table 1.1). Four days in this period were used to haul shad above Vernon Dam, VT (see below). The number transported in any one load varied from 74 to 150. Most loads were in the range of 100-125 shad. An additional 353 fish were transported by NES in three loads between 25 and 29 May. This brought the grand total transported to 2,287. A total of 1,573 pre-spawned American shad were released at Tunkhannock alive.

The Connecticut River cooperative group was assisted by the PFC on four separate days in hauling pre-spawned shad above Vernon Dam. These were on 18-19 and 26-27 May. Approximately 125 shad were hauled in each load which brought the total to about 500. This assistance was provided as part of an agreement in using the facilities also participated in the program.

The average survival of shad transported by the PFC was 81% (Table 1.1). On a daily basis it ranged from 60-95%. The NES percent survival was less (59%) but this was attributed mostly to only 15% survival of a load transported on 26 May. In this situation, mechanical problems with the truck caused the time from Holyoke to Tunkhannock to be extended to about 8 hours. On 25 and 29 May the percentage survival was 95 and 82%, respectively. The overall survival was 69% when the PFC and NES operations are considered together.

The survival estimate is based on the number of live fish released to the River. Some follow up work by the PFC in the area of the releases suggests that the mortality might be higher. On at least one occasion a PFC crew went out in a boat and looked for dead shad lying on the bottom. Relatively large numbers were found in an area immediately downstream from the release site. The dead shad included some which had been dead for a long period of time and others that were recently dead. It suggests that some post release mortality occurred.

The survival of shad in the 1982 transfer operation from the Connecticut River to the Susquehanna River was more than that observed in 1981. The PFC observations suggest that survival after release may not have been as good as that in 1981. In 1982, a year of very high flow, the number of days of

spilling at Holyoke were greater than that in 1981. As a result, the shad were subjected to high water velocity in the spillway prior to entering the lift. It was noted by those operating the facility that the condition of the shad was worse than that observed in 1981, when there was very little spill. Thus, the overall condition of the shad being trucked was less than that of shad captured in 1981. They may not have been able to survive the rigors of travel as well. New England resource agencies trucking shad also observed a lower survival of the shad in 1982.

1.10.1.2 Sex Ratio

Variations in the sex ratio of adult shad transferred from the Connecticut River to the Susquehanna River occurred on a daily basis. The daily sex ratio of shad taken in the Holyoke lift were used to estimate the ratio of sexes transferred (Table 1.4). On the dates on which transfers took place, the overall ratio was 65.7% males versus 30.5% females or 2:1. Generally, the percentage of females increased in the Holyoke lift catch as the season progressed while males decreased. The percentage of the catch which was males was sometimes as high as 86.7% on the days on which transfers took place. The highest percentage of females was 60%.

1.10.1.3 Water Temperature and Oxygen

The water temperature was 49°F on the first day of transfer (12 May) and increases to 65°F at the termination of transfer (Table 1.1). The average temperature during transfer was 62°F. Water temperature during transfer increased as much as 10°F between Holyoke and the release site but was usually less than 5°F.

Dissolved oxygen was not measured consistently in the transfer from the Connecticut River. On dates when it was measured by NES (Table 1.2) there was a decrease of anywhere from 2-4 ppm during transfer. Dissolved oxygen, generally, was in the range of 6-10 ppm when shad were loaded at Holyoke. If we use 1981 data, it appears that dissolved oxygen decreases about 3 ppm, on average, during transfer. The NES data from 1982 is consistent with this, even though taken on only three dates.

1.10.2 Hudson River

1.10.2.1 Numbers of Shad Transplanted and Survival

Shad were collected from the Hudson River from 6 through 19 May. The operation was terminated when the general abundance of shad in the Hudson River had decreased to a point where it was no longer feasible to collect them by haul seine in large numbers.

A total of 1,176 pre-spawned American shad were transferred from the Hudson River to the Susquehanna River and released at Owego, New York (Table 1.2). Of these, 992 were released alive. One load, on 6 May, was of 38 shad collected by gillnet. Some 15 of these survived. The number of shad trucked in any one load varied from 48-159 for fish collected by haul seine. Load size varied more as a function of availability of fish rather than any physical conditions, such as increase in temperature.

Survival of shad caught by gillnet was 60%. For those captured by haul seine the survival to the release site ranged from 64 to 96%. It averaged 82%. Generally, the condition of fishes taken by haul seine appeared to be much better than that for fishes taken from the Holyoke lift, as described above. There was a minimum amount of handling of shad in the Hudson haul seine operation. Gillnet operation placed a relatively greater amount of stress on the shad and this was obvious in the survival rate to the release site. The average time from capture to release for fishes taken from the Hudson River was somewhat less than that for shad taken at Holyoke. The travel time from the Hudson River collection site to Owego was typically about four hours.

1.10.2.2 Water Temperature and Dissolved Oxygen

Water temperature during the time of capture ranged from 55.8-64.4°F (Table 1.3). Generally, the increase in temperature during transit was about 5°F although in the early part of transfer it was less than 2°F. Water temperature in the Susquehanna River was usually higher than that in the Hudson River. On 6 May the differential was 4°F (56 versus 60°F) and by 19 May it was almost 10°F (61.7 versus 71.5°F). Whether or not this affected survival is not known.

Dissolved oxygen was usually about 6 ppm (5.8-6.9 ppm) on the Hudson River during the transfer operation. Slight decreases occurred during transfer, usually less than 1 ppm. Oxygen is certainly not seen as a limiting factor in the trucking of shad between the two rivers.

1.11 COMPARISON WITH 1980 TO 1981 RESULTS

The number of shad transferred from the Connecticut River to the Susquehanna River (Table 1.5) ranged from 193 (1980) to 2,287 (1982). Survival has averaged 72%. The number released alive has ranged from 114 (1980) to 1,573 (1982).

1.12 SUMMARY

1.12,1 GOAL

In 1981, 1,165 pre-spawned adult shad were transferred from the Connecticut River and released alive to the Susquehanna River at Tunkhannock, PA. In evaluation studies, juvenile American shad were collected in the Susquehanna River between Beach Haven and Wilkes-Barre, PA., confirming natural reproduction. The success of this effort encouraged SRAFRC to expand the adult transplant program. In 1982, a minimum of 3,000 pre-spawned adults were to be captured and trucked to the Susquehanna River, with at least 75% survival. Approximately 2,000 were to be taken from the lift at Holyoke Dam, Connecticut River. The remaining 1,000 were to be taken from the Hudson River. The Pennsylvania Fish Commission was assigned the lead role on the Connecticut River and National Environmental Services that on the Hudson River.

1.12.2 RESULTS

The results were as follows:

1. Pre-spawned adult American shad were obtained from the Holyoke fish lift, Connecticut, and transferred to the Susquehanna River by the Pennsylvania Fish Commission from 12 May through 2 June, 1982. NES assisted after the Hudson River operations were concluded.

2. Adult shad were released to the Susquehanna River at Tunkannack, PA.

3. A total of 1,934 shad was transferred on 18 separate days of hauling by the PFC. The number transported in any one load varied from 74 to 150. An additional 353 shad were transported by NES. The grand total transferred was 2,287. A total of 1,573 were released alive. This resulted in a survival rate during transfer of 69%.

4. The sex-ratio of adults transferred was 2:1 in favor of males. This was comparable to the sex ratio observed in 1981.

5. Water temperature of the Connecticut River ranged from 49°-65°F during the transfer period and averaged 62°F. The increase during transfer was usually less than 5°F. Dissolved oxygen was generally in the range of 6-10ppm when shad were loaded at Holyoke. On average, a decrease of about 3ppm occurred during transfer.

6. Adult transfer operations were conducted on the Hudson River, near Greensport, NY. Shad were obtained by haul seine from 6-19 May. Some effort was made to collect shad by gillnet but survival was low.

7. A total of 1,176 pre-spawned American shad were transferred from the Hudson River to the Susquehanna River and released at Owego, NY. Some 992 were released alive. This resulted in an average survival rate of 82%.

8. The shad were hauled in a total of 11 trips. The number

of fish hauled per load ranged from 79-159.

9. Water temperature during the time of capture ranged from 55°-64°F. It increased about 5°F during the transfer period. Dissolved oxygen was usually about 6ppm on the Hudson River during transfer. The decrease in transfer was usually less than 1ppm.

TABLE 1.1

Data on Pre-spawned Adult Shad Transferred from the Connecticut River to Susquehanna River by Pennsylvania Fish Commission, 1982. All Fishes released at Tunkhannock, PA.

Date	Number Transported	Number Dead	Number Alive	Percent Survival	Temperature (°F) Start	Temperature (°F) Finish	Dissolved Oxygen (ppm) Start	Dissolved Oxygen (ppm) Finish
May 12	94	10	84	89	49	58	-	-
13	74	7	68	91	50	59	9	9
14	125	27	98	78	51	61	9	9
15	117	37	80	68	52	70	9	9
17	125	30	95	76	55	65	9	9
18	Hauled Fish to Vermont, Above Vernon Dam							
19	" " " " " " "							
19	100	14	86	86	-	-	-	-
20	100	27	73	73	-	-	-	-
21	147	28	119	81	62	70	-	-
22	147	22	125	85	65	64	6	8
24	150	6	144	96	58	64	-	-
25	150	29	121	81	60	-	6	7
26	Hauled Fish to Vermont, Above Vernon Dam							

Continued

TABLE 1.1 Continued

Date	Number Transported	Number Dead	Number Alive	Percent Survival	Temperature (°F) Start	Temperature (°F) Finish	Dissolved Oxygen (ppm) Start	Dissolved Oxygen (ppm) Finish
May 27	Hauled Fish to Vermont, Above Vernon Dam							
27	125	35	90	72	65	65	6	6
28	124	64	60	48	-	-	-	-
29	120	13	107	89	58	65	6	6
June 1	120	6	114	95	-	-	-	-
2	116	12	104	90	62	67	9	8
TOTAL	1934	558	1376	81	58	64	8	8
	NES Statistics of Pre-Spawned Adult Shad, Connecticut River to Susquehanna River							
25	120	25	95	79	61	63	10.5	8.2
26	135	115	20	15*	61	-	9.2	5.2
29	98	16	82	84	64	66	7.5	5.2
TOTAL	353	156	197	59	62	65	9.1	6.2
GRAND TOTAL	2287	714	1573	81	58	64	-	-

* Omitted from grand total; low survival caused by truck breakdown.

TABLE 1.2

Data on Pre-spawned Adult Shad Transferred from the Hudson River to Susquehanna River by National Environmental Services, Inc. All fishes Released at Owego, NY.

Date	Number Transported	Number Dead	Number Alive	Percent Survival	Temperature (°F) Start	Temperature (°F) Finish	Dissolved Oxygen (ppm) Start	Dissolved Oxygen (ppm) Finish
May 6	38	15	23	60	56	60	6.2	5.7
9	80	10	70	87	63	61	6.0	5.6
10	48	4	44	92	56	58	6.9	5.5
11	145	20	125	86	60	-	6.4	5.2
12	125	11	114	91	57	58	6.3	5.6
14	150	35	115	77	60	65	6.1	6.8
15	145	6	139	96	61	-	6.1	5.3
16	112	14	98	86	62	68	5.8	5.6
17	79	16	63	80	64	68	6.2	5.4
18	95	35	60	64	61	72	5.9	5.5
19	159	18	141	89	62	72	6.0	6.2
TOTAL	1,176	184	992	82	$\bar{x}$= 60	65	6.2	5.7

TABLE 1.3

Record of Dissolved Oxygen and Temperature during Transport of Adult American Shad by National Environmental Services, Inc. from the Hudson and Connecticut Rivers to the Susquehanna River, 1982.

Date	Trip#	DO (ppm) Start	2 Hrs	4 Hrs	6 Hrs	Finish	Temperature (°F) Start	2 Hrs	4 Hrs	6 Hrs	Finish	Susq.R.
						HUDSON						
May 6	1	6.2	5.6	5.7	-	5.7	56.0	60.0	60.0	-	60.0	60.0
9	2	6.0	5.7	5.5	-	5.6	62.6	62.6	61.7	-	61.7	61.0
10	3	6.9	6.6	6.0	3.2	5.5	55.8	58.0	61.0	63.5	62.6	62.6
11	4	6.4	6.2	4.8	5.2	5.2	60.0	61.0	64.4	65.8	61.0	59.0
12	5	6.3	5.4	5.2	-	5.6	57.2	59.0	59.0	61.0	61.0	59.0
14	6	6.1	5.0	4.2	5.3	6.8	60.0	63.0	63.0	63.0	63.0	65.0
15	7	6.1	6.0	3.5	5.4	5.3	61.0	62.2	64.4	64.4	64.0	66.0
16	8	5.8	5.4	4.8	5.8	5.6	62.0	63.3	64.0	64.5	65.0	68.0
17	9	6.2	5.2	5.2	5.2	5.4	64.4	64.0	64.4	64.4	68.5	68.0
18	10	5.9	5.2	5.2	5.6	5.5	61.0	61.0	61.2	64.4	65.0	71.6
19	11	6.0	5.0	4.2	6.5	6.2	61.7	63.5	66.2	68.0	68.0	71.5
						CONNECTICUT						
May 25	1	7.6	5.6	6.2	6.2	6.2	61.6	62.6	-	-	65.8	62.6
26	2	9.2	6.5	5.5	6.2	5.2	61.2	67.1	68.0	71.6	70.7	63.0
29	3	7.5	6.4	4.0	5.2	3.5	63.5	66.2	68.0	-	69.8	66.2

TABLE 1.4

Sex Ratio of Adult Shad in the Holyoke Fish Lift, 10 May - 13 July, 1982. Asterisk(*) indicates dates on which Shad were transferred to Susquehanna River.

Date	Percent Male	Percent Female
May 10	73.3	26.7
11	53.3	46.7
12 *	80.0	20.0
13 *	80.0	20.0
14 *	86.7	13.3
15 *	80.0	20.0
16	DELAYED MAINTENANCE DRAWDOWN	
17 *	53.3	46.7
18	76.7	23.3
19 *	73.3	26.7
20 *	73.3	26.7
21 *	65.0	35.0
22 *	63.3	36.7
23	66.7	33.3
24 *	80.0	20.0
25 *	53.3	46.7
26	93.3	6.7
27 *	40.0	60.0
28 *	63.3	36.7
29 *	43.3	56.7
30	40.0	60.0
31	53.3	46.7
June 1 *	53.3	46.7
2 *	63.3	36.7
3	46.7	53.3
4-11	HIGH WATER - NO LIFTS	
12	33.3	66.7
13	33.3	66.7
14	46.7	53.3
15	33.3	66.7
16	53.3	46.7
17	78.6	21.4

Continued

TABLE 1.4 Continued

Date		Percent Male	Percent Female
June	18	63.6	36.4
	19	-	-
	20	66.7	33.3
	21	33.3	66.7
	22	-	-
	23	-	-
	24	66.7	33.3
	25	-	-
	26	-	-
	27	-	-
	28	58.1	41.9
	29	-	-
	30	HIGH WATER - NO LIFTS	
July	1-5	" " " "	
	6-9	CANAL DRAWDOWN	
	10	61.5	38.5
	11	-	-
	12	-	-
	13	50	50

TABLE 1.5

Comparison of pre-spawned adult American shad transfers from Connecticut River (1980-82) and Hudson River (1982) to Susquehanna River.

Year	Number Trips	Number Transported	Number Alive	Percent Survival	Temperature (°F) Start	Finish	Dissolved Oxygen (ppm) Start	Finish
				CONNECTICUT RIVER				
1980	3	193	114	59	57	64	8.9	5.9
1981	9	1,486	1,165	78	65	72	7.0	6.1
1982	19	2,287	1,573	81	58	64	-	-
TOTAL	31	3,966	2,852	72	60	67	7.9	6.0
				HUDSON RIVER				
1982	11	1,176	992	82	60	65	6.2	5.7
GRAND TOTAL	42	5,142	3,844	75	60	66	7.0	5.8

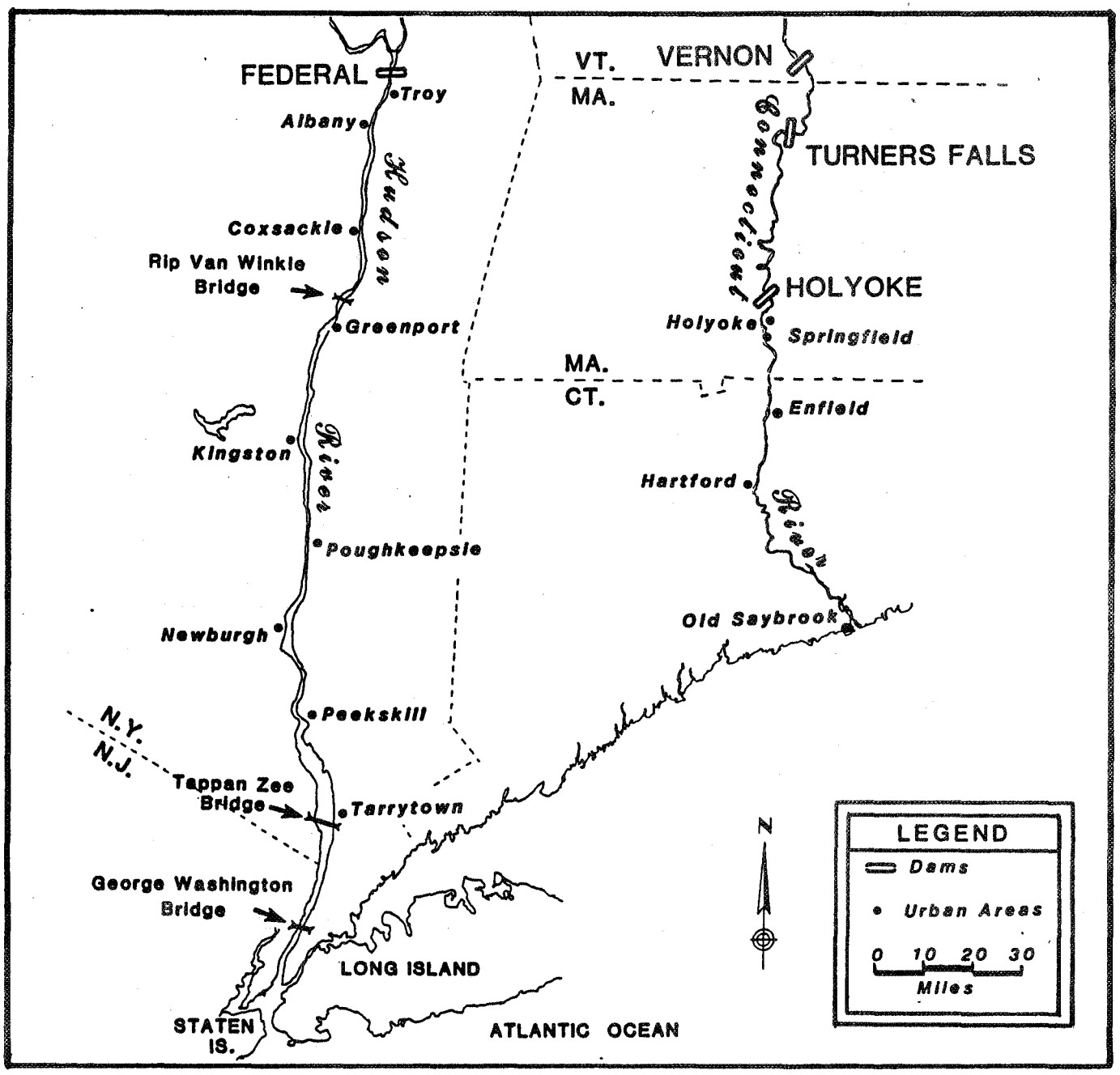

Figure 1.1. Map showing collection sites for adult American shad on the Hudson River (Greenport) and Connecticut River (Holyoke), 1982.

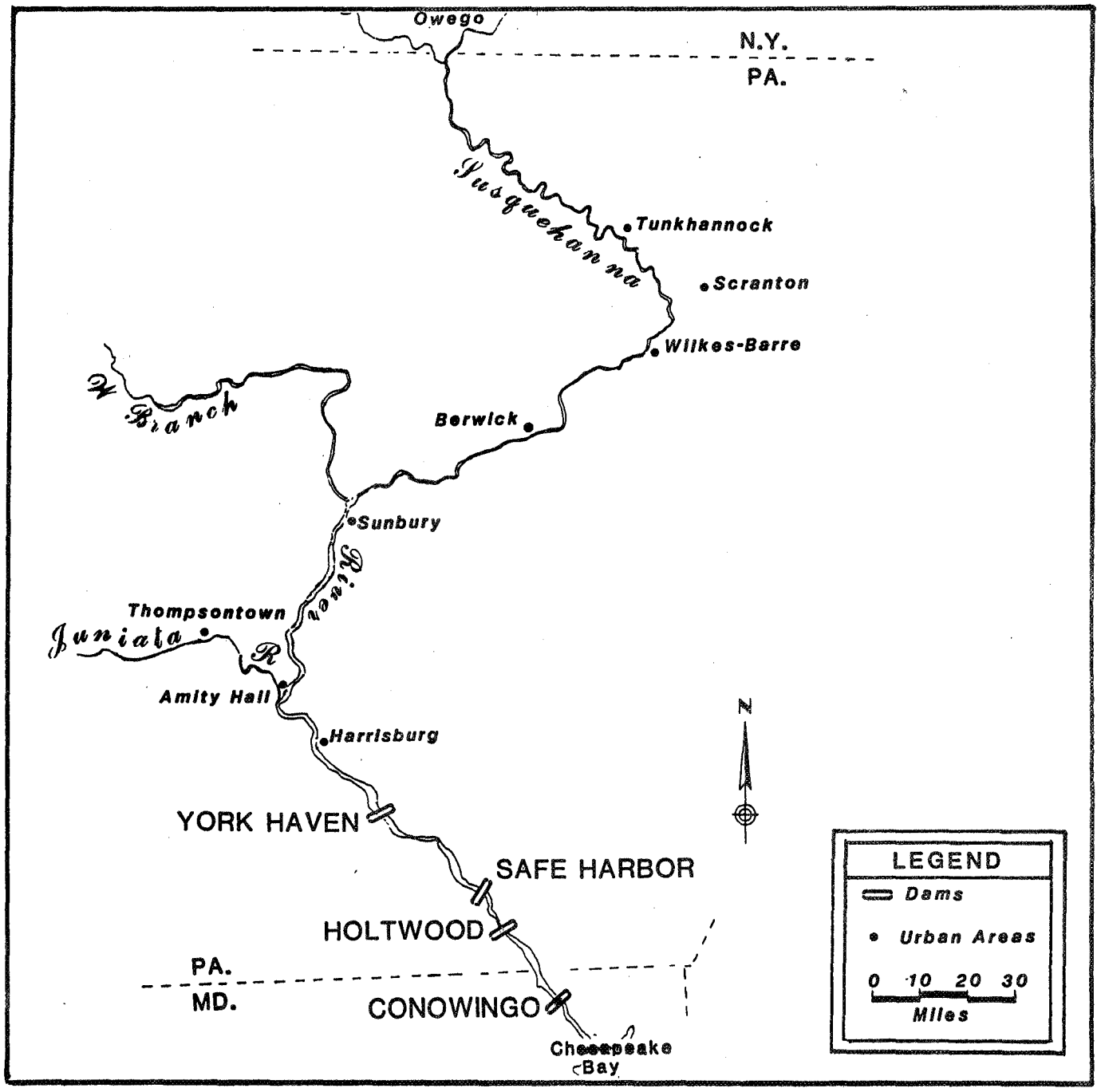

Figure 1.2. Map showing location of release sites of adult American shad to Susquehanna River drainage, Owego, NY and Tunkhannock, PA, 1982.

JOB II. AMERICAN SHAD EGG COLLECTION PROGRAM

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2.1 INTRODUCTION

The objective of this program is to provide viable, artificially fertilized shad eggs to the hatchery program (Job III). Ultimately, this will contribute to development of a stock of shad which return to the Susquehanna River with the urge to migrate upstream past dams to spawn. In 1981, 11.6 million eggs were collected which resulted in production of 2 million fry at the PFC Van Dyke Hatchery. In 1982 the production target was 10 million fry, based on the collection goal of 60 million viable shad eggs. The primary East Coast Rivers considered as sources for eggs were the James and Pamunkey rivers, Virginia. The feasibility of obtaining eggs from other rivers was investigated by NES and it was determined by the SRAFRC that the Mattaponi River (Virginia) and Hudson River (New York) be incorporated into the program.

Since target numbers of eggs were not obtained from East Coast sources, operations were also carried out on the Columbia River, Oregon - Washington. NES confirmed that commercial fishermen were available to collect adult shad and would cooperate with SRAFRC efforts.

NES developed the necessary East and West Coast contacts for acquiring eggs and providing rapid shipment to the hatchery. Arrangements were made for personnel to conduct the program and transport eggs to Van Dyke. The PFC provided a biologist to assist in operations on Virginia rivers. NES coordinated efforts to arrange for Mr. Richard St. Pierre, USF & WS, to assist in the West Coast effort.

2.2 SURVEY OF RIVERS

The shad egg collection program was initially conducted only in the Susquehanna River between Havre de Grace and Perryville, Maryland in 1981 and 1972 (Robbins and Nack, 1982). When the original goal of 50 million eggs was not deemed attainable in this locality, the effort was expanded to include other rivers along the East Coast. These included the Potomac, Mattaponi, Pamunkey, and James rivers. The Connecticut, Delaware and Hudson rivers were later included. From 1973 through 1976 various of these rivers were used as a source of artificially fertilized eggs. Eggs were obtained from adult shad collected in the commercial fishery, almost exclusively by gill net. Attempts were made to use shad obtained from pound nets and staked gill nets but with generally little success. Shad taken from staked gill nets were usually not alive and eggs were in poor condition.

Over the last ten years the populations of American shad in the various rivers have fluctuated and, in some cases, declined to a point where sufficient numbers are not taken by commercial fishermen to make an egg collection program worthwhile. This has been the case for the Susquehanna River where the commercial fishery was banned in 1980 in order to allow revitalization of stocks. The populations on some other rivers may also be questionable with reference to sufficient numbers for egg collection. The declining stocks resulted in a decline in commercial fishermen activities on the rivers. For example, the reduction in the availability of shad eggs in 1976 resulted in expansion of the program to include the Columbia River on the West Coast. By use of this river the goal of 50 million eggs, established in 1971 agreements, was reached.

The variability in populations of American shad and the availability of commercial fishermen became relatively less important to the program by 1977 when emphasis was shifted to hatchery rearing and production. With initiation of this program the annual goal did not usually exceed 20 million eggs. Previous experience on the Virginia rivers suggested that this number of eggs could be obtained in the Virginia rivers. Thus, no systematic efforts were made to expand the program by increasing the number of commercial fishermen utilized. From 1973 through 1976 surveys of the rivers and availability of fishermen were conducted in anticipation of

meeting the annual goal of 50 million eggs. Following the decrease in demand through changes in the program, no concentrated effort was made to optimize the number of eggs which were to be collected through adding additional fishermen.

With expansion of the program in 1982 to include a goal of some 60 million viable American shad eggs, it became necessary to survey the rivers on the East coast to determine which were capable of providing sufficient numbers of shad which could be used in the egg collection effort. Also, a need existed to determine if additional commercial fishermen were available who might participate in the program. Over the past 10 years a list of commercial fishermen who participated in the program was maintained or compiled for each of the rivers in which the program was conducted. Not all were used in the last several years and, in fact, some are no longer active in the fishery. We know, from experience in 1981, that the Columbia River has a large stock of American shad. However, the commercial fishery has changed substantially since eggs were collected in 1976; markets for shad have decreased, thereby reducing the number of fishermen, and some fishermen have retired.

2.3 SCIENTIFIC COLLECTING PERMITS

Scientific collecting permits were obtained for rivers where plans were made to collect eggs. The permits were obtained from the state agencies responsible for management of the rivers. Every attempt was made to have terms of the scientific collecting permit defined so that large sections of a river being fished by commercial fishermen could be utilized. In conjunction with the permits, a liasion was developed and maintained with appropriate resource agency personnel.

All permits were issued to National Environmental Services, Inc. Copies of the permits were provided to each field biologist employed in the program. At the conclusion of the 1982 program, a summary report was prepared and sent to each agency issuing permits.

Waterways patrolmen (PA or VA) or conservation officers (NY) were contacted when the programs on the various rivers began. They were kept informed of the activities and the scope of the program, as required, until such time it was concluded. They were notified of our departure upon conclusion of the program on any of the rivers.

In 1982, for the first time, a Seafood Buyers Boat or Truck License (SBBT) had to be purchased. In the previous ten years of egg collection in Virginia a letter from the Commonwealth of Virginia Marine Resources Commission served as a permit.

2.4 METHODS

2.4.1 Egg Collection

Eggs were collected from ripe adult shad taken in gill nets by commercial fishermen. They were artificially fertilized in essentially the same manner as established by Kilcer (1973). A brief description follows:

Eggs were stripped from two or three spawning females into a collecting pan and then fertilized with sperm from one or more males. After mixing eggs and sperm for several minutes, a small amount of water was added to the mixing pan and the gametes stirred again. The contents were allowed to settle for a few minutes to optimize fertilization. Fertilized eggs were then poured into large plastic buckets filled with clean river water. The eggs were allowed to soak for several hours, with periodic mixing to provide aeration, to become water hardened. Water was then drained from the eggs. Scales, sticks and other debris were removed.

Then, five liters each of eggs and clean water were placed in double plastic bags.

Pure oxygen was put into bags containing eggs. The bags were then secured tightly with two rubber bands and electrical tape. The package was then placed into styrofoam containers, sealed with tape and placed in a cardboard box for shipment. Each box was labeled to show river name, date, number of liters of eggs, shipment water and river water temperature.

2.4.2 Collection Areas

2.4.2.1. Mattaponi River, Virginia

Prior to implementaion of the 1982 egg collection program, the Mattaponi River potential as an egg collection site was determined by NES. The Mattaponi Reservation has two landing areas which were utilized for the SRAFRC program. NES made arrangements with the Mattaponi Indians to work cooperatively in shad egg collection. One biologist was stationed at the Mattaponi Reservation (RM 50) and also supervised collections at the Chesapeake and Turners landing sites. Collection effort was made between 1800 and 2200 hrs.

NES biologist and the Mattaponi Indian commercial fisherman agreed that no eggs would be collected for the SRAFRC program until their egg collecting boxes were filled. This policy was also maintained in working with the Pamunkey Indians on the Pamunkey River. Arrangements were made to transfer eggs via vehicle to another biologist on the Pamunkey River, at the Lester Manor Station.

2.4.2.2. Pamunkey River, Virginia

Biologists worked with commercial fishermen at Thompsons Landing, New Kent, Virginia (RM 48), and at Lester Manor, near the Pamunkey Indian Reservation (RM 53). The landing is located on the southern bank of the Pamunkey River approximately 4-6 miles upstream from Lester Manor. Both locations proved to be viable areas for catching adult spawning shad in the past. Netting was usually conducted between 1700 and 2200 hours. Efforts were made to collect eggs from Monday through Saturday.

2.4.2.3. James River, Virginia

Generally, shad migrate up the James River and begin spawning at a time when shad are completing spawning activity on the

Pamunkey River. Some overlap in availability of ripe shad may occur between rivers. On 14 April NES and PFC biologists met with commercial fishermen on the James River, Berkley Plantation Landing, to determine when was the best time to start egg collection efforts. Communications on the shad activities were ongoing with commercial fishermen on the James, while activities were underway on the Pamunkey River.

Egg collection efforts ultimately began on the James River on 28 April. Biologists remained at the Pamunkey River collecting sites, as needed, to collect eggs during the transition period from the Pamunkey to the James River. Eggs collected on the Pamunkey River were transferred via automobile to the Berkley Plantation location during this period for processing and packaging.

Two stations were used during collection on the James River (Figure 2.1), one at the Berkley Plantation (RM 55) and the other approximately five miles upriver at an area known as Grants Crossing (RM 60). Both locations are in the Charles City-Hopewell, Virginia area just below the Benjamen Harrison Bridge. Commercial fishermen, using gillnets, and biologists worked together out of small boats during egg collection operations. Gillnetting was conducted from about 1800 to 2200.

2.4.2.4. Hudson River

Shad egg collection on the Hudson River in past years has not been highly successful. This may be due to either seasonal timing of collection or the time of day at which commercial fishermen fish. In 1980 and 1981 collection efforts were transferred from the James River to the Hudson River following notification that ripe shad had been taken by commercial fishermen. By the time biologists reached the River, spawning fish were no longer available. In order to optimize the collection of shad eggs from the Hudson River in 1982, NES contracted for the services of a commercial fisherman and qualified egg collectors were ready to collect and artificially fertilize eggs whenever ripe shad were captured. NES worked closely with the NYDEC in developing the program on the Hudson River.

Egg collection began on the Hudson River after a survey of several commercial fishermen was taken to determine if fishermen would assist. A list of commercial fishermen who use gillnets from the Mid-Hudson Bridge in Poughkeepsie to the Rip Van Winkle Bridge, Hudson/Catskill was obtained from the NYDEC. From this list several fishermen who fish near the Kingston-Rhinecliff Bridge were contacted before shad were present in the River. Eight

different commercial fishermen agreed to assist in egg collection operations from Kingston to Catskill-Hudson. (Figure 2.2) NES biologists stationed in Kingston, New York contacted these fishermen daily to determine when and how many spawning shad were caught.

A New York State DEC biologist worked with the Kingston fishermen daily to collect scale samples from which age classifications were determined. NES and the NY biologists agreed to assist during egg collection activities to determine when and where spawning shad were caught. NES biologists were in contact with the DEC biologist daily during each fishing operation. NES biologists also visited with the Kingston area fishermen to review egg collection operations.

NES also worked with a commercial fisherman gillnetting near Hudson, New York. Fishing was conducted from a private landing located on the east shoreline approximately ½ mile downriver from the Rip Van Winkle Bridge. Fishermen drifted 500-750 foot gillnets in the river channel between the mouth of the Roeliff Jansen Kill Creek and Catskill Creek, a distance of approximately five river miles. Monofilament nylon gillnets with mesh sizes between 4.75 and 5.75 inches were drifted from ½ hour to three hours depending on tidal conditions, and ship/barge traffic in

the fishing area. Two or three drifts were made daily.

Fishing on the Hudson River was conducted between 0700 and 1900 hours, depending on the tide and weather. Operations were not continued long after darkness due to the danger associated with commercial ship and tanker traffic. When the work began on the Hudson River, fishing efforts ceased between 0700 on Friday to 0700 on Saturday in compliance with NYDEC regulations. This lift period was cancelled later in the season by the NYDEC when extensive algae blooms were shown to interfere with the efficiency of fishing for shad, particularly by gillnets.

2.4.2.5. Columbia River

The egg collection program was initiated on the Columbia River, Washington-Oregon because of the relatively low numbers of eggs collected from the Mattaponi, Pamunkey, James and Hudson rivers. Operations previously conducted on the Columbia River in 1973, 1974, 1977 and 1981, indicated that it was a reliable source of eggs.

Two biologists with collection equipment, arrived in Portland, Oregon on 10 June. Another biologist was added to the

crew on the West coast. They met with a commercial fisherman on 14 June at a fishing site 15 miles east of Portland on the south shore of the Columbia River. The first effort was made that evening. Ultimately biologists worked with three commercial fishermen. Each crew consisted of one commercial fisherman with his boat and gear and one or two biologists, depending on numbers of ripe shad available.

Netting was conducted on the north shoreline in an area known as the Camas-Washougal Reef. This reef is characterized by 10-30 foot water depths a bottom with rocky substrate and scattered logs and trees. Shad were caught in a 100 fathom long, Japanese super crystal gillnet drifted downriver over the reef. A series of two to four drifts were made, depending on the number of fish available and drift time. Unlike the east coast rivers, there is no tidal action on the Columbia River at the Washougal Reef. Each drift must be made very carefully to avoid contact with sport fishermen's lines, docks and the rocky bottom.

2.5 TRANSPORTATION

2.5.1 Mattaponi, Pamunkey, James Rivers

Shad eggs collected from the Pamunkey and J ames rivers were driven, after packaging, from each collection site on the rivers to the Byrd International Airport, Sandston, Virginia. A van was used to deliver boxes of eggs to the airport. Piedmont Aviation, a small charter service, was employed to fly eggs from Sandston to Lancaster. Personnel at the Van Dyke Hatchery, and NES personnel in Lancaster were notified each night when eggs were ready to be flown to Lancaster. Preparations were then made for pickup (Lancaster) and delivery times (Van Dyke). Arrangements were also made between personnel from the Lamar Fish Cultural Development Center and Van Dyke for delivery of a proportion of eggs to Lamar.

On two separate occassions eggs collected for transport had to be held over night due to equipment failure with Piedmont line. These eggs were sent on the next available flight.

2.5.2 Hudson River

Arrangements were made for transportation of eggs from the Hudson River to Lancaster, PA. Eggs ready for shipment were to be transferred directly from the collection site to Carroll Air Service,

a small charter service located and operated out of Kingston, New York, and flown to Lancaster, The system was never used because no eggs were collected.

2.5.3 Columbia River

Eggs collected from the Columbia River were packaged and readied for delivery to the airport using the same procedures described for other rivers. A van was used to transfer eggs to the United Airlines Terminal at the Portland International Airport. Eggs were delivered to the airport one half hour before flight departure (2330 hrs). They were flown from Portland to Chicago, and then transferred to a flight destined for Baltimore. Eggs were then delivered by van to the Van Dyke Hatchery.

A one hour layover was unavoidable during this transfer in Chicago. However, the United Airlines Small Package Delivery Service was the only feasible transport available. Any flight arrangements by other airlines or routes would have taken additional time, critical in egg survival.

2.6 COLLECTION SCHEDULE

The experience of some ten years was used in development of schedules for operations on each river selected for the program

(Table 2.1). The beginning of egg collection on any river was determined through communication with commercial fishermen; they inform NES when ripe shad are available. Collection usually began when water temperature was 55-60°F.

The egg collection operation on rivers was terminated when less than five liters of eggs were taken on five consecutive nights. The peak volume of eggs is taken at a temperature range of 58-67°F. Termination of collection was not initiated until the temperature peak of 67°F was reached. The manpower allocation for a particular river was decreased after the peak, but at least one collector remained available until the conditions for departure were met.

2.7 QUALITY CONTROL

Every effort was made to follow procedures proven effective in collection, artificial fertilization, and shipment of American shad eggs. The methods have been tested and refined over a period of ten years. The viability of eggs from the Pamunkey and James Rivers in 1982 was very good and demonstrates that previous quality control measures were effective. Results of viability were disappointing on the Columbia River in 1981 and special measures were

taken to assure that this did not occur in 1982.

NES worked in cooperation with PFC personnel at the Van Dyke Research Station to maintain and improve, where possible, quality control relative to the egg collection operation. Of special interest was improvement of the viability of eggs obtained from the Columbia River. The potential factors considered in 1981 were discussed in that annual report (Robbins and Nack, 1982). It was critical to establish the factors which affected viability of Columbia River eggs, as soon as possible in the season. Every effort was made to do so. The following considerations were given to this matter:

(1) Egg collection procedures were reviewed in detail with the PFC before beginning efforts on the Columbia River. Modifications derived from the 1982 experience on the Virginia rivers which improved quality control were incorporated into the procedures used on the Columbia River.

(2) Shipment procedures were evaluated and improvments made.

(3) Nitrogen supersaturation of Columbia River water was investigated as to its effect on egg viability. Nitrogen content of water used for shipping eggs was measured. It was supersaturated and measures were taken to reduce it to a level acceptable for shipment of eggs.

Detailed plans for consideration of potential problems on the Columbia River with respect to egg viability were developed in cooperation with PFC. A monitoring program was developed on viability which identified problems. Efforts were made to resolve problems in the course of the operation. The results are given in the PFC report on the Van Dyke 1982 operation.

2.8 RESULTS

2.8.1. Mattaponi, Pamunkey and James rivers, Virginia

Egg collection operations began in Virginia on 12 April. Fewer eggs were collected than in previous years. A total of 3,279,000 eggs were collected from Virginia rivers (Table 2.2-2.3). Of these, some 2 million were viable. Total viability was 61.5%, ranging from 61% on the Pamunkey River to 62% on the James River.

No eggs were collected from the Mattaponi River. Operations were terminated on 28 April.

A total of 2,029,000 eggs were collected from the Pamunkey River. Water temperature during the period of collection ranged from 57-61°F. The eggs from the Pamunkey River were sent to the Van Dyke Hatchery, in nine separate shipments between 12 - 30 April. Of the number collected, some 1.2 million were viable.

A total of 1,250,000 eggs, some 772,000 viable, were collected from the J ames River between 28 April and 3 May. Operations began when water temperature was 61° F and concluded when it reached 72° F. Theee were sent to Van Dyke in three separate daily shipments.

2.8.2 Hudson River

Vigorous attempts by NES biologists amd commercial fishermen began on the Hudson River on 3 May 1982 when water temperature was 56° F. Two NES biologists stationed in Hudson, New York were responsible for egg collection. Reports from commercial fishermen confirmed that shad had begun their annual spawning runs. Although, hundreds of " hard" roe shad were taken by seine and gillnet, no spawning shad were obtained. Egg collection efforts extended over 35 miles of River. Collection efforts were terminated in the last week of May at which time river water temperature had reached 70° F.

2.8.3 Columbia River

Egg collection on the Columbia River began on 14 June and continued through 1 July. Water temperatures ranged from 53 - 62° F. A total of 22,579,000 eggs, of which some 7.2 million were viable, were sent to the Van Dyke Hatchery in 16 separate shipments. Viability for 1982 was increased by 100% over 1981, from about 15% to 31% (Tables 2.2 and 2.3).

2.8.4 ALL RIVERS COMBINED

The shad egg collection operation was conducted between 12 April and 24 May on four East Coast rivers and the Columbia River (Oregon-Washington). Combined, the total number of eggs collected was 25.9 million. Of these, some 11.4 million were viable. Most eggs (87%) were obtained from the Columbia River. Even though the viability of eggs was lower (about 32% versus about 61%) the greater volume of eggs collected on the Columbia resulted in more viable eggs for the program.

2.9 COMPARISONS WITH 1971 TO 1981 RESULTS

The total number of eggs collected in 1982 was the largest number obtained since 1976 (Table 2.4). Virtually all of the increase can be attributed to the efforts on the Columbia River where 22.57 million eggs were collected. The result on the James River was about the same as in 1981. A substantial decrease occurred on the Pamunkey River; the number of eggs taken was the fewest since 1975. Over the last ten years the reliability of the East Coast rivers as a source of eggs has become more and more tenuous. The Columbia River remains as the most reliable source of artificially fertilized shad eggs.

2.10 SUMMARY

2.10.1 GOAL

The 1982 goal of the SRAFRC was to obtain 60 million viable American shad eggs, principally from East Coast rivers (James, Pamunkey, and Hudson). The Columbia River on the West Coast was considered as a contingency in the event the quantity of eggs desired was not available from East Coast rivers. Eggs were to be provided to the Van Dyke Hatchery, Pennsylvania Fish Commission, and the Lamar Fish Cultural Development Center, U.S. Fish and Wildlife Service.

2.10.2 RESULTS

1. Shad eggs were collected from ripe adult shad taken in gillnets by commercial fishermen in an effort which began 12 April 1982 on the Mattaponi River, Virginia, and concluded on 1 July on the Columbia River, Washington-Oregon. Other East Coast rivers sampled included the Pamunkey and James rivers, Virginia, and the Hudson River, New York. Columbia River efforts began when it was obvious that the goal would not be reached through operations on the latter rivers.

2. A total of 25.8 million eggs were collected; 11.4 million were viable. Viability on the James and Pamunkey rivers was good (more than 60%). It was much improved on the Columbia River (31% in 1982 versus 14% in 1981). Efforts to resolve nitrogen supersaturation problems encountered on the Columbia River in 1981 were successful. No eggs were collected on the Mattaponi and Hudson rivers.

TABLE 2.1 Sampling period for East Coast and West Coast rivers for collection of American shad eggs.

SAMPLING SCHEDULE		
RIVER	DATES	TOTAL DAYS
Mattaponi	12-28 April	17
Pamunkey	17-28 April	17
James	28 April-3 May	6
Hudson	3-24 May	23
Columbia	14 June-1 July	18

TABLE 2.2

Collection data for American shad eggs taken on Pamunkey, James and Columbia rivers, 1982. (Percent viability and number of eggs data furnished by the Pennsylvania Fish Commission)

Shipment Number	Collection date and River	Water Temperature (°F)	Number of Adult shad	Vol. (L)	Eggs	Percent Viability
1	4/17/82 Pamunkey	57	11	4.2	250,000	0
2	4/19/82 Pamunkey	59	9	4.4	177,000	78.8
	4/20/82 Pamunkey	59	14	6.2	233,000	80.0
3	4/21/82 Pamunkey	60	15	7.4	313,000	71.8
4	4/25/82 Pamunkey	60	8	2.7	212,000	28.1
	4/26/82 Pamunkey	60	10	5.4	241,000	62.0
5	4/28/82 Pamunkey	61	16	8.4	325,000	71.9
	4/28/82 James	61	77	12.4	496,000	55.2

Continued

TABLE 2.2 Continued

Shipment Number	Collection date and River	Water Temperature (°F)	Number of Adult shad	Vol. (L)	Eggs	Percent Viability
6	4/29/82 Pamunkey	62	11	3.9	157,000	71.8
	4/29/82 James	68	27	4.0	151,000	80.6
7	4/30/82 Pamunkey	62	8	3.3	121,000	81.4
	4/30/82 James	70	56	9.2	420,000	71.1
8	5/3/82 James	72	25	3.6	183,000	40.2
9	6/14/82 Columbia	53	-	20.2	813,000	23.0
10	6/15/82 Columbia	53	-	55.3	2,633,000	31.1
11	6/16/82 Columbia	53	-	54.3	2,344,000	26.2
12	6/16/82 Columbia	54	-	-	-	0
	6/17/82 Columbia	54	-	44.7	2,438,000	36.9
13	6/18/82 Columbia	56	-	37.0	1,879,000	39.1

Continued

TABLE 2.2 Continued

Shipment Number	Collection date and River	Water Temperature (°F)	Number of Adult shad	Vol. (L)	Eggs	Percent Viability
14	6/21/82 Columbia	56	-	51.3	1,874,000	31.9
	6/21/82 Columbia	57	-	35.3	1,708,000	27.9
15	6/22/82 Columbia	56	-	45.9	1,771,000	37.0
16	6/23/82 Columbia	58	-	18.8	689,000	48.5
17	6/24/82 Columbia	59	-	37.1	1,289,000	48.6
18	6/25/82 Columbia	60	-	21.7	815,000	44.0
19	6/26/82 Columbia	60	-	24.8	733,000	19.0
20	6/29/82 Columbia	62	-	28.7	1,018,000	9.9
21	6/30/82 Columbia	61	-	41.8	1,444,000	15.7
22	7/1/82 Columbia	61	-	32.3	1,131,000	38.7
TOTALS		59		624.3	25,858,000	44.0

TABLE 2.3

Total Viability and Number of Shad Eggs Collected from Pamunkey, James, and Columbia Rivers, 198

RIVER	TOTAL EGGS	TOTAL VIABILITY
Pamunkey	2,029,000	60.64%
James	1,250,000	61.78%
Columbia	22,579,000	31.83%

TABLE 2.4
Total number (millions) of American shad eggs collected from the Pamunkey, Mattaponi, James Potomac, Susquehanna, Delaware, Connecticut and Columbia rivers, 1971-1982.

YEAR	PAMUNKEY	MATTAPONI	JAMES	POTOMAC	SUSQUEHANNA	DELAWARE	CONNECTICUT	COLUMBIA	TOTAL
1971	-	-	-	-	8.42	-	-	-	8.4
1972	-	-	-	-	7.00	-	-	-	7.1
1973	8.45	6.48	-	34.64	4.74	-	4.30	-	58.6
1974	9.75	6.80	19.20	5.56	-	-	0.53	8.18	50.0
1975	1.88	-	7.15	5.70	-	-	-	18.42	33.2
1976	-	-	-	-	-	4.10	-	54.80	58.9
1977	4.40	0.57	3.42	-	-	-	0.35	8.90	17.6
1978	6.90	-	10.11	-	-	-	-	-	17.0
1979	3.17	-	4.99	-	-	-	-	-	8.2
1980	6.73	-	6.83	-	-	-	-	-	13.6
1981	4.58	-	1.26	-	-	-	-	5.78	11.6
1982	2.03	-	1.25	-	-	-	-	22.57	25.8

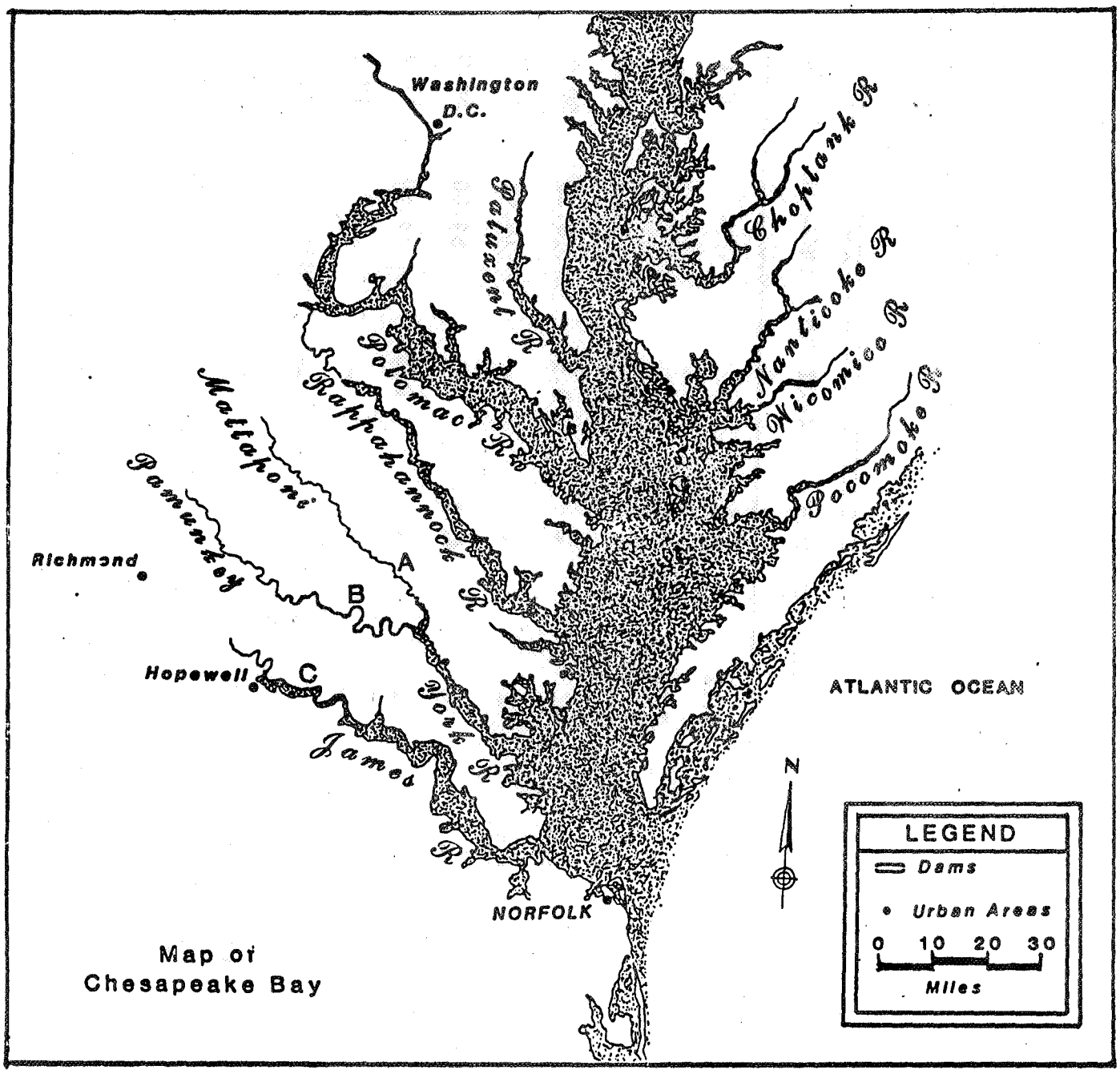

Figure 2.1. Location of American shad egg collection sites on the Mattaponi (A), Pamunkey (B), and James (C) rivers, 1982.

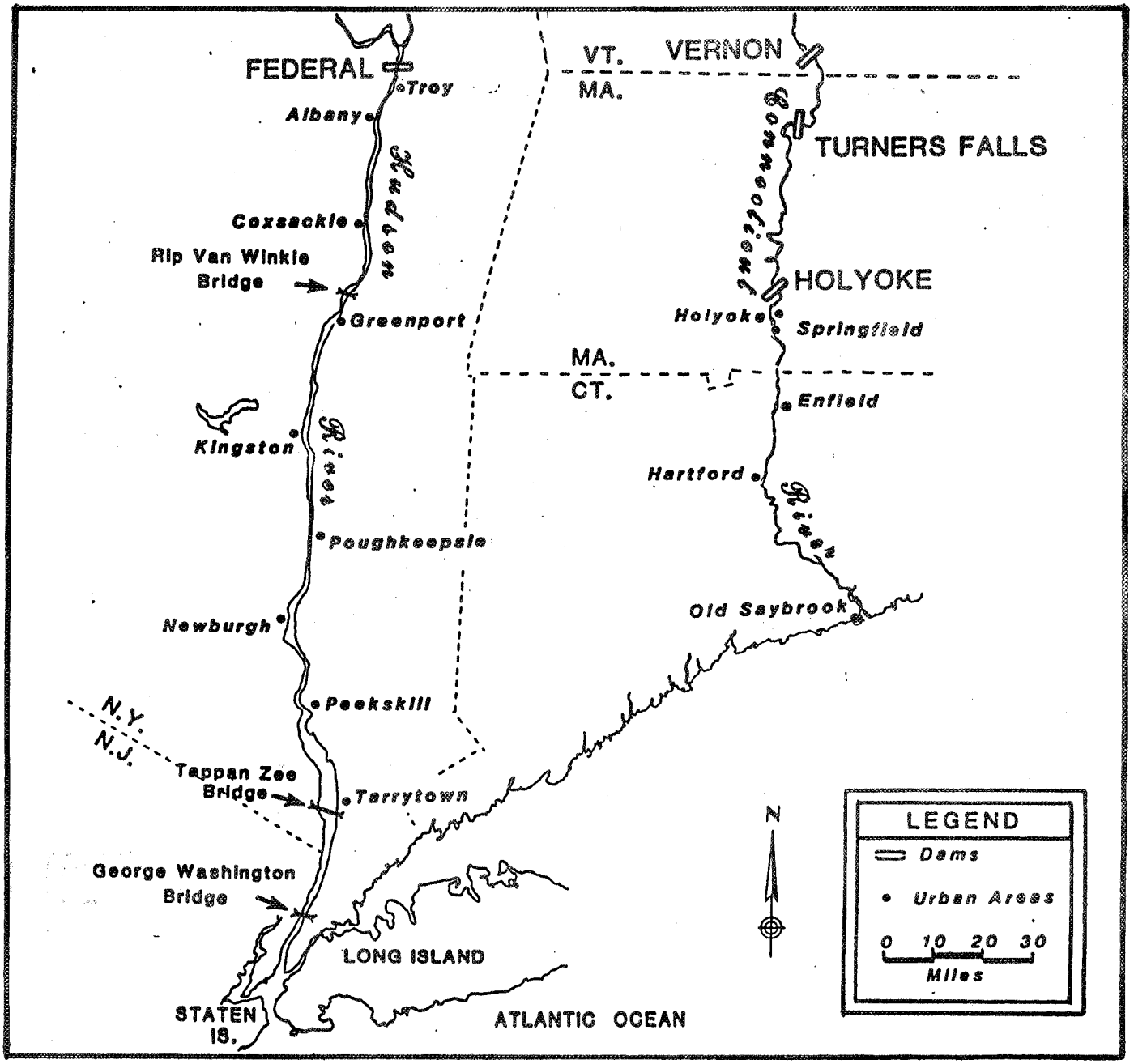

Figure 2.2. Location of American shad egg collection sites (Kingston to Greenport, NY) on the Hudson River, 1982.

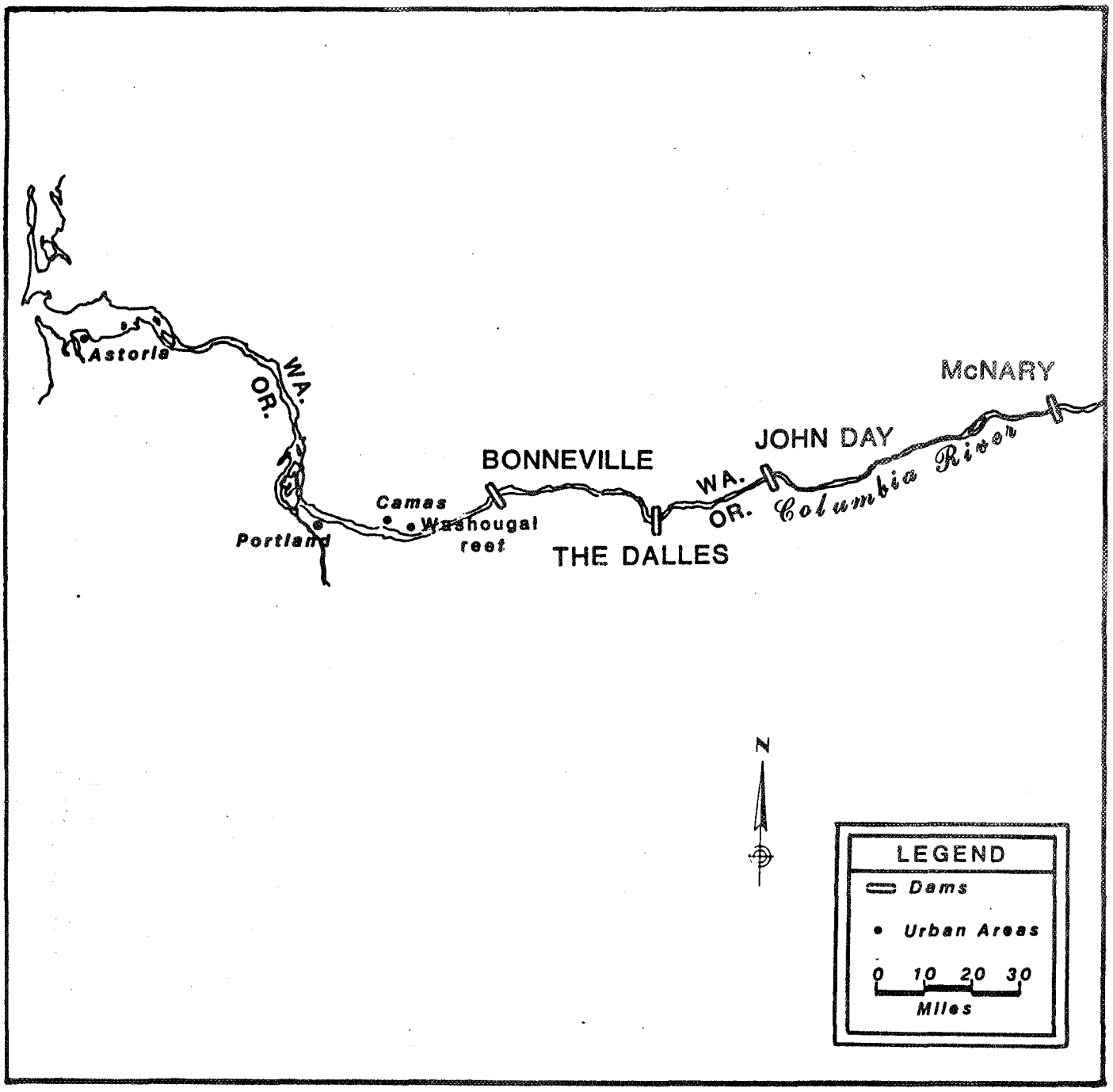

Figure 2.3. Location of American shad egg collection site (Washougal Reef) on the Columbia River, 1982.

JOB III. AMERICAN SHAD CULTURE AND RESEARCH AT THE PENNSYLVANIA FISH COMMISSION VAN DYKE HATCHERY

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INTRODUCTION

The Pennsylvania Fish Commission continued to participate in the effort to restore diadromous fish to the Susquehanna River system. This year (1982) the Van Dyke Research Station released a record 5 million juvenile American shad into the Juniata River. Moreover, the further refinement of fish culture techniques coupled with the availability of extensive pond culture permitted the planting of strong active juveniles that will hopefully survive to someday return as adults to the Conowingo tailrace. All fish stocked were exposed to phenethyl alcohol, an imprinting agent to be used as a chemical attractant at the Conowingo Dam fish collection facility.

This year's effort was supported by funds provided from the settlement agreement between upstream utilities, the Pennsylvania Fish Commission, and the Susquehanna River Basin Commission.

Egg Shipments

Twenty-two egg shipments were provided to the Van Dyke Research Station for Anadromous Fishes by National Environmental Services, Incorporated (Table 1). Eggs were received from three sources, the Pamunkey and James Rivers in Virginia, and the Columbia River, Oregon. Virginia river eggs were received from 17 April to 3 May, and Columbia River eggs began 14 June and continued until 1 July.

A total of 25.8 million eggs were received for incubation and rearing at Van Dyke. Average viability for the eggs received in 1982 was 36 percent resulting in 9.2 million viable eggs. The average viability was substantially reduced by the poor quality of eggs received from the Columbia River. Egg viability was relatively high for the Pamunkey and James Rivers. The Pamunkey River provided 2 million eggs of which 59 percent were viable; and the James River, 1.2 million eggs, 61 percent of which were viable. These high viabilities were in sharp contrast to the 32 percent viability (17 percent higher than in 1981) for the Columbia River's 22.6 million eggs (Table 2).

The Van Dyke Research Station transferred 4.4 million eggs, 37 percent viable, to the Lamar Fish Cultural Development Center (Table 3). Resultant fry and fingerling were used for research purposes.

Conditions Which May Influence Egg Viability

An effort was made between egg collection and hatchery personnel to determine the cause of the low viability of Columbia River eggs. Most comparisons were not replicated and were not conducted as controlled tests; therefore, results may be inconclusive. The comparisons were as follows: eggs collected at night versus those collected in daylight; eggs received

moist versus those received in water; eggs shipped in water with a total dissolved gas saturation of 100 percent or less versus eggs shipped in water supersaturated in dissolved gases; eggs fertilized with one male versus an equal quantity of eggs fertilized with 2 or 3 males (exact number of males was not reported); and difference in shipment time (Table 4).

There were certain conditions tested which had definite impact on egg viability — shipment procedures, transportation time, and the male to female ratio (Table 4 and 5). Eggs received moist (via broken shipping bag) had a lower viability (26 percent) than eggs received in water (41 percent). Shipments which arrived on schedule yielded a higher egg viability (Table 5) than those which were late. Viability was reduced to 6 percent when an aliquot of eggs was fertilized with one male, as compared to 27 percent viability when 2 or 3 males were used. There appeared to be no significant difference in viability between eggs collected at night and eggs collected in daylight ($P<2$ percent), nor between eggs shipped in water with different gas saturation levels ($P<4$ percent).

Production

Twenty-three stockings in 1982 resulted in the release of a record 5 million juvenile American shad (Table 6); 5 million fry (14 to 32 days of age) and 41 thousand fingerlings (1 inch or greater in length). All fish were stocked in good condition at the Pennsylvania Fish Commission's Thompsontown Access Area (Table 7). Shad stocked were exposed to the chemical attractant, phenethyl alcohol, which was administered at a concentration of 1×10^{-4} ppm for 12 hours each day during the period the fish were held in tanks.

Hatchery survival to 18-days of age was better for fry of Virginia River origin than for Columbia River fry (Figure 1). Average survival for Columbia River fry was 60 percent, compared to 71 percent for Virginia River fry. Accumulative mortality over a 3-day hatch was higher for Columbia River fish (8 percent) than for Virginia River fish (4 percent).

The record number of viable eggs received, 9.2 million in 1982 versus 8.2 million in 1980, and the highest percent of viable eggs eventually stocked as fry, 55 percent in 1982 versus 43 percent in 1980, led to the record production of fry (Figure 2).

Facility Improvements

Anticipating a record number of eggs, several changes were incorporated into the hatchery operations. Egg incubation capabilities were increased from a maximum 170 liters, or 6.3 million eggs, to 230 liters or 8.5 million eggs. Equipment used to handle eggs was modified, and more efficient data sheets were developed. As a result, a time savings was realized, better measurement techniques were developed, and the amount of handling was reduced.

The large increase in fingerling production resulted from the construction of a new canal-pond at the Thompsontwon Access Area. The new pond, completed in June, accounted for half of the total fingerling production (>20,000). In the future, two crops of fingerlings can be reared annually in this pond.

Research

Preliminary research was conducted on several aspects of shad culture in 1982. Areas investigated included the effects of motion on egg viability

and a study testing the effects of density on handling mortality and fry survival at metamorphosis.

The Effect of Gentle Rolling During Incubation on Egg Viability

Historically, American shad eggs were gently "rolled" during incubation and this was considered to be an essential fish culture practice. This study was designed to determine if the gentle "rolling" motion did affect the viability of American shad eggs.

Test results demonstrated that there was no significant difference in viability between shad eggs rolled in the traditional fashion and eggs which remained motionless during incubation (type 1 error P = .01, sample statistic <t0.01). In test units containing 2,000 rolling eggs the mean number of eggs hatched was 1,603 (80 percent) with a standard deviation of 182. In identical units in which eggs were not rolled, the mean number of eggs hatched was 1,518 eggs (76 percent) with a standard deviation of 126 (Table 8).

The test data confirms what was observed on a production level; 1.1 million eggs which were rolled yielded a mean viability of 71 percent versus a 69 percent mean viability for 1.6 million eggs which remained motionless during incubation (Tables 9 and 10).

The Effect of Density on Handling Mortality

A density study was set up using 27-day-old American shad fry. The test had two objectives: one, determine if high handling mortality in experimental situations is density related; and two, determine if density related mortality in larval shad occurs when fry metamorphose into scaled fingerlings.

It was concluded that handling mortality was not density related (Tables 11a and 11b). Mean mortality for all test units was 63 percent (standard deviation was 0.06) after 72 hours. The mean mortality for high (5.9 fish/liter) and low density (0.5 fish/liter) tanks was equal (58 percent); however, the mortality ranged from 34 to 81 percent in individual test units. It was assumed that the physical stress of handling caused high mortality in experimental fish. Test results demonstrated the sensitivity of American shad fry but could not be extrapolated to a production situation, as handling techniques, feed and environment were not similar.

An attempt was made to determine the effect of density on fry survival during metamorphosis, however low survival made it impossible to demonstrate a density relationship.

SUMMARY

Personnel from the Van Dyke Research Station released a record 5 million American shad from the Pennsylvania Fish Commission's Thompsontown Access Area as part of the diadromous fish restoration effort on the Susquehanna River drainage. To attain this goal, the following changes were incorporated: improvement of facilities to accommodate the incubation of 26 million eggs; modification of culture techniques which resulted in a 12 percent increase in fish survival compared to 1980; and the construction of a canal-pond, at the Thompsontown Access Area, where 20,000 fingerlings were produced. Shad fry were exposed daily to an imprinting agent, phenethyl alcohol, to be used as a chemical attractant at the Conowingo Dam fish collection facility. Fish stocked as a result of the 1982 effort increased the total number of American shad stocked since 1976 to 15.2 million.

ACKNOWLEDGEMENTS

The program at Van Dyke could not continue without the support of the Benner Spring Research Staff, and the summer laborers and interns whose efforts extended beyond what was expected of them. A special thanks has to be given to those individuals who daily kept the program running: Dave Hampton, who has given 5 years of invaluable service; John Coll and Scott Salvatore, who returned as laborers after serving internships, strengthened our program immeasurably with experienced help; and Jim Kremmel from Juniata College who served an internship at Van Dyke during the spring.

TABLE 3.1

VAN DYKE

AMERICAN SHAD EGG DATA

1982

Shipment Number	River	Date Taken	Date Rcvd.	Vol. (ℓ) Shipped (NESI)	Vol. (ℓ) Received (VD)	Eggs	Percent Viability	Viable Eggs	Sac Fry
1	Pamunkey	4/17	4/18	4.0	4.2	250,000	0	0	0
2	Pamunkey	4/19	4/21	3.5	4.4	177,000	78.8	140,000	135,000
	Pamunkey	4/20	4/21	5.5	6.2	233,000	80.0	186,000	174,000
3	Pamunkey	4/21	4/22	8.0	7.4	313,000	71.8	225,000	221,000
4	Pamunkey	4/25	4/28	3.0	2.7	212,000	28.1	152,000	27,000
	Pamunkey	4/26	4/28	5.5	5.4	241,000	62.0	150,000	144,000
5	Pamunkey	4/28	4/29	7.0	8.4	325,000	71.9	234,000	232,000
	James	4/28	4/29	14.0	12.4	496,000	55.2	274,000	264,000
6	Pamunkey	4/29	4/30	5.0	3.9	157,000	71.8	113,000	109,000
	James	4/29	4/30	5.0	4.0	151,000	80.6	122,000	118,000
7	Pamunkey	4/30	5/1	2.5	3.3	121,000	81.4	98,000	94,000
	James	4/30	5/1	10.0	9.2	420,000	71.1	298,000	287,000
8	James	5/3	5/4	5.0	3.6	183,000	40.2	74,000	72,000
9	Columbia	6/14	6/15	30.0	20.2	813,000	23.0	187,000	181,000
10	Columbia	6/15	6/16	75.0	55.3	2,633,000	31.1	818,000	790,000
11	Columbia	6/16	6/17	60.0	54.3	2,344,000	26.2	615,000	575,000
12	Columbia	6/16	6/18	5.0	-	-	0	0	0
	Columbia	6/17	6/18	58.0	44.7	2,438,000	36.9	900,000	878,000
13	Columbia	6/18	6/19	45.0	37.0	1,879,000	39.1	735,000	656,000
14	Columbia	6/21	6/22 (am)	60.0	51.3	1,874,000	31.9	598,000	520,000
	Columbia	6/21	6/22 (pm)	45.0	35.3	1,708,000	27.9	477,000	520,000

TABLE 3.1 (cont)

VAN DYKE

AMERICAN SHAD EGG DATA

1982

Shipment Number	River	Date Taken	Date Rcvd.	Vol. (ℓ) Shipped (NESI)	Vol. (ℓ) Received (VD)	Eggs	Percent Viability	Viable Eggs	Sac Fry
15	Columbia	6/22	6/23	55.0	45.9	1,771,000	37.0	700,000	681,000
16	Columbia	6/23	6/24	16.0	18.8	689,000	48.5	335,000	318,000
17	Columbia	6/24	6/25	45.0	37.1	1,289,000	48.6	626,000	616,000
18	Columbia	6/25	6/26	25.0	21.7	815,000	44.0	359,000	345,000
19	Columbia	6/28	6/29	30.0	24.8	733,000	19.0	139,000	135,000
20	Columbia	6/29	6/30	30.0	28.7	1,018,000	9.9	101,000	91,000
21	Columbia	6/30	7/1	40.0	41.8	1,444,000	15.7	226,000	212,000
22	Columbia	7/1	7/2	30.0	32.3	1,131,000	38.7	437,000	431,000

TABLE 3.2

VAN DYKE HATCHERY

AMERICAN SHAD EGGS TOTALS

1982

Totals (all rivers)

Number of eggs received by Van Dyke	25,858,000
Volume of eggs shipped (NESI)	727.0 ℓ
Volume of eggs received by Van Dyke	624.3 ℓ
Average percent viability	35.7
Total number of viable eggs	9,226,000
Number of fry (at hatch)	8,840,000
Number of fry stocked	5,019,000
Number of fingerlingsstocked	40,700

Totals (broken down by river)

Pamunkey River, Virginia

Number of eggs received	2,029,000
Volume of eggs shipped (NESI)	44.0 ℓ
Volume of eggs received by Van Dyke	45.9 ℓ
Percent viability	59.4
Total number of viable eggs	1,205,000
Number of fry (at hatch)	1,151,000

James River, Virginia

Number of eggs received	1,250,000
Volume of eggs shipped (NESI)	34.0 ℓ
Volume of eggs received by Van Dyke	29.2 ℓ
Percent viability	61.4
Total number of viable eggs	768,000
Number of fry (at hatch)	740,000

Columbia River, Oregon

Number of eggs received	22,579,000
Volume of eggs shipped (NESI)	649.0 ℓ
Volume of eggs received by Van Dyke	549.2 ℓ
Percent viability	32.1
Total number of viable eggs	7,253,000
Number of fry (at hatch)	6,949,000

TABLE 3.3

LAMAR

AMERICAN SHAD EGG DATA

1982

Totals (all rivers)	
Number of eggs received	4,420,126
Volume of eggs received	109.5 ℓ
Average percent viability	37.1
Totals (broken down by river)	
Pamunkey River, Virginia	
Number of eggs received	154,650
Volume of eggs received	2.8 ℓ
Percent viability	0
James River, Virginia	
Number of eggs received	228,030
Volume of eggs received	6.0 ℓ
Percent viability	36.8
Columbia River, Oregon	
Number of eggs received	4,037,446
Volume of eggs received	100.7 ℓ
Percent viability	38.6

TABLE 3.4

VAN DYKE

1982

CONDITIONS EXAMINED DURING EGG COLLECTION

River	Shipment Date (Received)	Test Condition	Number of Eggs	Test Percent Viability	Control Condition	Number of Eggs	Control Percent Viability
Columbia	6/19/82	Eggs collected at night*	156,800	39.5	Eggs collected in daylight	1,495,600	41.1
Columbia	6/19/82	Eggs received dry (broken shipping container)	226,700	25.7	Eggs received in water	1,495,600	41.1
Columbia	6/25/82	Shipment made in supersaturated water** (Columbia River)	433,000	45.9	Shipment made in normally saturated water (Sandy River)	855,900	50.0
Columbia	6/29/82	10 liters of eggs fertilized by one buck***	270,500	6.2	10 liters of eggs fertilized by 4 to 6 bucks***	462,100	26.5

*Time of collection not reported.
**Percent saturations not reported.
***Number of females and exact number of males for control was not reported.