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Table of Contents

	page
List of Tables.....	iii
List of Figures.....	iv
Introduction.....	1
Job 1. Connecticut River Shad Studies.	
Methods.....	2
1A. Monitor the commercial and sport fisheries for American shad in the Connecticut River in 1997.....	2
1B. Determine the population size, sex ratio and age structure of the 1997 run of American shad in the Connecticut River.....	3
1C. Measure the relative abundance of juvenile American shad in the Connecticut River in 1997.....	4
1D. Evaluation of the current techniques and methodologies utilized to estimate the annual run.....	4
Job 2. Thames River Alosid Studies	
Methods.....	5
2A. Estimate the abundance of adult American shad in the Thames River in 1997 and characterize the run with regard to sex, length and age composition.....	5
2B. Monitor the sport fishery for American shad in the Thames River in 1997.....	5
2C. Measure the relative abundance of juvenile alosids in the Thames River in 1997.....	5
Job 3. Shortnose Sturgeon Investigation	
Methods.....	6
3A. Monitoring of movements and frequency of use of various discrete sections of the Connecticut River by adult and immature shortnose sturgeon.....	6

Job 1. Connecticut River Shad Studies.	
Results.....	7
1A. Monitor the commercial and sport fisheries for American shad in the Connecticut River in 1997.....	7
1B. Determine the population size, sex ratio and age structure of the 1997 run of American shad in the Connecticut River.....	7
1C. Measure the relative abundance of juvenile American shad in the Connecticut River in 1997.....	8
1D. Evaluation of the current techniques and methodologies utilized to estimate the annual run.....	9
Job 2. Thames River Alosid Studies	
Results.....	9
2A. Estimate the abundance of adult American shad in the Thames River in 1997 and characterize the run with regard to sex, length and age composition.....	9
2B. Monitor the sport fishery for American shad in the Thames River in 1997.....	10
2C. Measure the relative abundance of juvenile alosids in the Thames River in 1997.....	10
Job 3. Shortnose Sturgeon Investigation	
Results.....	11
3A. Monitoring of movements and frequency of use of various discrete sections of the Connecticut River by adult and immature shortnose sturgeon.....	11

List of Tables

	page
Table 1. Reported and adjusted total catch (numbers) and weight of shad taken by the commercial fishery, 1997.....	14
Table 2. Age-specific rates of instantaneous total (Z), commercial fishing (F), and extraneous (M) mortality rates of male and female shad between 1996 and 1997.....	15
Table 3. Expanded effort (hours), catch (numbers), change in catch from previous year (percent), and average catch per unit effort (CPUE) from recreational shad fishermen in the Connecticut portion of the Farmington and Connecticut Rivers, 1982-1997.....	16
Table 4. Expanded effort (hours), catch (numbers), percentage creel and released, and average catch per unit effort (CPUE) from recreational shad fishermen in the Connecticut portion of the Farmington and Connecticut Rivers, 1997.....	17
Table 5. Population estimates, adjusted commercial catch, spawning history, and age distribution of American shad in the Connecticut River from 1975 to 1997.....	18
Table 6. Population estimates, adjusted commercial catch, spawning history, and age distribution of American shad in the Connecticut River in 1997.....	19
Table 7. Total catch and percent composition of juvenile shad and blueback herring, 1978-1997.....	20
Table 8. Catch, effort and catch per effort of juvenile Connecticut River American shad from the 1997 seine survey. C = Total catch, E = Number of seine hauls.....	21
Table 9. Relative abundance index (CPUE) and mean daily growth rate (mm/day) of juvenile American shad for the 1966-1997 year classes and the relative abundance index of blueback herring from the 1978-1997 year classes.....	22
Table 10. Catch, effort and catch per effort of juvenile Connecticut River blueback herring from the 1997 seine survey. C = Total catch, E = Number of seine hauls.....	23
Table 11. Shortnose sturgeon capture information by date, area collected and method of take in the Connecticut River in 1997.....	24
Table 12. Shortnose sturgeon capture information by year in the Connecticut River.....	25

List of Figures

	page
Figure 1. The Connecticut River showing locations of concentrated fishing effort for recreational shad anglers.....	26
Figure 2. The Connecticut River showing locations of juvenile American shad sampling stations.....	27
Figure 3. The Thames River showing locations of juvenile clupeid sampling stations in 1997.....	28
Figure 4. Percent of juvenile American shad collected in the Connecticut River per week in 1997.....	29
Figure 5. Number of juvenile American shad collected in the Connecticut River per station in 1997.....	30
Figure 6. Percent of juvenile blueback herring collected in the Connecticut River per week in 1997.....	31
Figure 7. Number of juvenile blueback herring collected in the Connecticut River per station in 1997.....	32

**Bureau of Natural Resources
Fisheries Division
Project Summary**

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Purpose of Project

The project consists of three Jobs 1) Connecticut River Shad Studies, 2) Thames River Alosid Studies, and 3) Shortnose Sturgeon Investigation.

The major goal of the project is to collect information for management of the American shad population, and the recreational and commercial fisheries in the Connecticut River. This information is also utilized by the States of Massachusetts, New Hampshire and Vermont for management of their recreational shad fisheries and, the Atlantic States Fisheries Commission for the interstate fishery management of American shad from Maine to Florida. The data base for the Connecticut River shad population and its fisheries is the most comprehensive on the Atlantic coast and has proven invaluable in development of the interstate management plan for the migratory American shad resource.

This project has been expanded to the Thames River system where completion and operation of the Greenville Dam fishway on the Shetucket River (the first dam on the Shetucket/Quinebaug River systems) now provides access to upstream shad spawning areas. It is anticipated that the American shad population in the Thames River will expand. The adult spawning population size will be monitored by the number of shad passed through the fishway and by the number caught in the recreational fishery. Spawning success and potential population expansion will be estimated from the relative abundance of juveniles. This information will be utilized in restoration efforts (transplanting of adults) and management of the recreational fishery and fishway fish passage.

The project also includes continued low levels of effort on monitoring the seasonal movement patterns and habitat use of shortnose sturgeon in the Connecticut River. Previous efforts have estimated the population at 850 to 1,000 adult fish, identified five high use areas in the Connecticut River and documented a seasonal emigration of a high percentage of the population to the estuary area during the spring months. Earlier research efforts have reported the lack of immature fish in the population and subsequent studies have consistently failed to capture subadult or immature shortnose sturgeon, raising concerns about the long term viability of this population.

Job 1. Connecticut River Shad Studies.

Objectives: Determine the annual adult spawning population size, age structure, and sex ratio. Monitor the commercial and recreational fisheries (catch, harvest and effort) in the river. Determine the annual index of juvenile shad relative abundance.

Key Findings:

- The annual spawning run was estimated to be 659,478 fish.
- The commercial harvest was estimated to be 36,496 fish; the recreational catch and harvest were estimated to be 2,836 and 1,163 fish, respectively.
- The annual juvenile index of abundance was estimated to be 66.3.

Conclusions:

- The 1997 spawning population was very similar to the 1996 run (667,137) and not statistically different.
- The spawning population is much smaller than projected from juvenile indices (expected over 2 million fish).
- The commercial and recreational harvest increased (34% and 15% respectively) over 1996 levels, despite the run being slightly smaller or similar.
- The 1997 juvenile index can be characterized as strong (range 7.8 to 107.9 fish, 1978 to 1995)

Recommendations:

- Continued monitoring of the shad population.
- A reassessment of the methods of estimating population size is needed due to changes in the population size and the proportion of the population lifted over the Holyoke Dam.

Job 2. Thames River Alosid Studies

Objectives: Monitor the sport fishery, and measure the relative abundance of juvenile American shad. Note; adult shad passing through the Greenville Dam Fishway were enumerated by the City of Norwich as part of a fish passage evaluation study mandated by FERC as a condition of the project relicensing.

Key Findings:

- The shad fishery in the Thames River system is concentrated in the Shetucket River at two sites immediately below the Greenville dam; less than 50 shad were caught in the recreational fishery during 1997.
- A total of 2,860 shad were lifted and passed through the Greenville Dam Fishway in 1997.
- Two American shad juveniles were collected in the Thames River system, one above the Greenville Dam; and one below.

Conclusions:

- The Greenville Dam Fishway is successful in passing shad and provides access to the Greenville pool for a significant increase in spawning area.
- Visual observations of fish above the Greenville Dam, combined with low numbers of juvenile shad collected and large size of these fish suggest spawning was successful, although limited.

Recommendations:

- Explore areas above the Greenville Dam for selection of alternate and/or additional sampling sites for juvenile shad.
- Continue transplanting adult shad from the Connecticut River Holyoke Fishlift to “jump start” the Thames System shad population. These activities are conducted under the Sport Fish Restoration Project F-50D.

Job 3. Shortnose Sturgeon Investigation.

Objectives: Monitor the movements and use of discrete areas by shortnose sturgeon in the Connecticut River.

Key Findings:

- A tagged shortnose sturgeon from the Hudson River was collected in the lower Connecticut River. This is the first documented movement of a shortnose sturgeon from another river system to the Connecticut River.
- A high percentage of the population of shortnose sturgeon utilize the estuary during the spring months.

- A total of 34 shortnose sturgeon were captured with nine being recaptures of previously tagged fish

Conclusions:

- Unknown factors are limiting the population of shortnose sturgeon to less than 1,000 fish.
- Locations and abundance of immature sturgeon remain unknown.

Recommendations:

- Continued monitoring of the stock is required, including identification of factor(s) limiting to abundance.
- Additional effort is needed to investigate abundance and locations of immature sturgeon.

INTRODUCTION

The American shad (*Alosa sapidissima*) is an important resource to the State of Connecticut and all states where it occurs or restoration efforts are ongoing. Annual spawning migrations of shad in the Connecticut River support sport and commercial fisheries in the State of Connecticut, as well as recreational fisheries in upriver states. The Connecticut Department of Environmental Protection has conducted annual research studies on American shad in the Connecticut River since 1974 to monitor annual changes in stock composition. Information on the abundance of shad, age structure and sex ratio, the fisheries (both sport and commercial), and annual reproductive success are all important in the management of this species.

Restoration of American shad and other anadromous fishes in the Thames River moved ahead with the opening and operation of the fishlift at the Greenville Dam in Norwich in 1996. Small numbers (hundreds to several thousand) of American shad have been present in this system for many years, but little successful spawning was thought to occur. Information was needed on the age structure and sex ratio of American shad in the Thames River system, and to monitor reproductive success.

Shortnose sturgeon are the only native fish species in Connecticut currently listed as U.S. Federally Endangered. Collection of current information on this species is necessary to protect all life stages and critical habitats. Research efforts begun in 1988 have identified several important concentration areas where high percentages of the population gather for extended periods of time, estimated the numbers of shortnose sturgeon at 850 to 1,000 adult fish in the population, and examined seasonal movement patterns. Additional research is needed on the presence/abundance of juvenile or immature fish, the locations and movement patterns of these small fish, and measuring recruitment success.

This report contains information on studies conducted in the Connecticut and Thames Rivers on American shad and shortnose sturgeon in the Connecticut River from April 1, 1997 to March 31, 1998. Financial support was provided by the National Marine Fisheries Service and the State of Connecticut.

Methods

Job 1 Connecticut River Shad Studies

1A. Monitor the commercial and sport fisheries for American shad in the Connecticut River in 1997.

Commercial shad fishermen are required to report daily landings of American shad. Total landings are adjusted for under-reporting and culling of male shad by multiplying the total effort (days fished) by the mean catch/effort of the top five catch/efforts of that year (Savoy and Shake 1993; Savoy 1996). This assumes that the five top fishermen report their true landings. Estimates derived in this fashion may be higher than actually realized since it is highly unlikely that all fishermen are catching shad at such high rates. This approach results in a minimum estimate of escapement and is considered a conservative approach. Total fishing effort (Netdays) was determined from catch reports.

Instantaneous total mortality (Z), fishing mortality (F) and natural mortality (M) were estimated for each sex and age group (Ricker 1975). Total instantaneous mortality (Z_j) was expressed by:

$$Z_j = -\ln(R_j / N_{j-1}) \quad (3)$$

where: R_j = number of repeat spawners of age group (j),
 N_{j-1} = population size for age group (j) in year ($j-1$).

The age-specific annual fishing rates (u_j) were determined by:

$$u_j = C_j / N_j \quad (1)$$

where: C_j = adjusted commercial catch for each age group (j),
 N_j = population size for age group (j),

from which the instantaneous fishing rates (F_j) were estimated by:

$$F_j = -\ln(1-u_j). \quad (2)$$

The instantaneous rate of natural mortality (M_j) was calculated by :

$$M_j = Z_j - F_j. \quad (4)$$

Age-specific natural mortality was estimated as the difference between inriver commercial fishing mortality (F) and total mortality estimates (Z). Estimates of natural mortality include all

mortalities other than commercial fishing in the Connecticut River. This is necessary since no sex and age specific information is available from these other fisheries (i.e. trawl bycatch, oceanic gillnet, and in-river recreational fishery).

The sport fishery in the Connecticut River was monitored by conducting a roving creel survey during daylight hours of recreational fishermen within State waters (Figure 1) from April 1 through June 30, (the open season in the Connecticut River). Connecticut River anglers were canvassed one weekday and one weekend day per week. Survey methods are similar to those reported by Fraidenburg and Bargmann (1982) as being suitable for small sample areas and short time periods to provide relatively unbiased information. Anglers were interviewed to determine the number of shad caught, the disposition of that catch (creeled or released), how long they had been fishing at that site and whether they had finished fishing at that site. Creel census clerks also determined the number of anglers at that site, and other pertinent conditions such as weather conditions and time.

Catch per unit of effort (per hour), percentages creeled and released, and total effort were tabulated for each of the major shore sites from Hartford to the CT/MA state line, and for the entire Connecticut boat fishery separately. So as to not overexpand the recreational harvest by large numbers of anglers who did not catch any shad, anglers were placed into one of two groups: successful (caught one or more shad) or unsuccessful. Results were then tabulated for each group separately and expanded for total catch and effort. Information was expanded by weekly effort and summed for a season total.

1B. Determine the population size, sex ratio and age structure of the 1997 run of American shad in the Connecticut River.

The 1997 adult American shad population estimate, age structure and sex ratio were calculated from samples collected from both the commercial shad fishery and the Holyoke dam fishlift at Holyoke, MA. Information on the number of fish lifted daily, season lift total, number of lift days (days the lift is in operation), and the sex ratio at Holyoke was obtained from Massachusetts Cooperative Fishery Research Unit personnel. Sex determination was accomplished by visual inspection of the gonads of sacrificed fish. The final sex ratio was obtained by weighting the daily observed sex ratios by the number of fish lifted that day.

Annual population estimates were estimated using daily shad lift rates at the Holyoke dam. The shad population size was determined by dividing the number of American shad lifted by the number of days in which 99% of the total shad were passed. This rate was multiplied by a weighting coefficient (0.10) to adjust for lift improvements since 1976 and then multiplied by 1000 to scale the estimates to the proper magnitude (Crecco and Savoy 1985). Population estimates derived from Holyoke lift data were shown to be positively correlated ($r=0.68$, $P<0.01$) to population estimates derived from mark-recapture studies (1967-1978) and were positively correlated ($r=0.90$, $P<0.001$) to juvenile indices of abundance.

Age structure was derived from scale samples collected at commercial markets using only those fishermen known not to have culled their catch of male shad. Scales were removed from above the lateral line anterior to the dorsal fin. Scale samples, sex and fork length (cm) measurements were collected weekly over the entire shad run. Samples of 100-150 shad were collected per week. Adult shad were sexed, measured to fork length (mm) and 10-15 scales removed. All scale samples collected were separated by sex and stratified into 1 cm length groups. Scale samples were processed by cleaning with an ultrasonic cleaner and pressed onto acetate for aging. Representative numbers of scale samples per length group by sex were randomly selected for aging. Age determinations were made as the consensus of two or more readers of projected images (43x) counting annuli and spawning scars according to the criteria of Cating (1953). Repeat spawners were noted by the presence of spawning scar(s) at the periphery of the scale. The age and repeat spawning frequency were extrapolated to the entire population by direct proportion.

1C. Measure the relative abundance of juvenile American shad in the Connecticut River in 1997.

Juvenile American shad were collected weekly from July 16th through October 22nd at seven fixed stations located from Holyoke, MA to Essex, CT (Figure 2). Seine haul locations and techniques have remained similar to those employed in past Connecticut River shad investigations (Marcy 1976; Crecco et al. 1981). Sites were previously chosen based on location, physical conditions and accessibility. One seine haul per station was made during daylight hours with a 15.2 m nylon bag seine (4.6 mm mesh, 2.4 m deep, and 2.4 m bag) and 30.5 m lead ropes. Each haul was completed by using a boat to set the net approximately 30 m upstream and offshore of the site. Using the lead ropes, the seine was then towed in a downstream arc to the shore and beached. With small sample sizes (less than 500 fish), all clupeids (*Alosa sapidissima*, *A. aestivalis*, *A. pseudoharengus*, and *Brevoortia tyrannus*) were fixed in 4% formalin and returned to the laboratory. With large sample sizes, clupeids were subsampled volumetrically and unneeded fish returned to the water. Water temperature, weather conditions, time and tidal stage (when appropriate) were recorded for each station.

In the laboratory, juvenile clupeids were identified to species by the criteria of Lippson and Moran (1974) and counted. Up to 40 juvenile shad per haul were measured (TL mm) and stored in 67% isopropyl alcohol. Individual seine collections containing greater than 40 shad were randomly subsampled for length measurements. All other clupeids were only counted, although representative samples were archived in isopropyl alcohol along with the American shad for future study.

The relative abundance of juvenile American shad was calculated as the arithmetic mean catch per seine haul from all stations and all dates sampled. An index of per diem growth in length (mm/day) for juvenile American shad was determined by linear regression of mean length for each collection date against time in days, the slope being an estimate of daily growth. The relative abundance of juvenile blueback herring was calculated in a manner similar to that used for American shad.

1D. Evaluation of the current techniques and methodologies utilized to estimate the annual run.

Methods currently in use for estimating the annual shad population were reassessed. Discussions and analyses included examination of alternative methods of estimating the annual spawning run including mark recapture efforts, fisheries independent techniques such as hydroacoustics, and relative stock size estimates such as by fishing various gears either directly by DEP staff or through subsidizing commercial fishermen to derive a measure of abundance.

Job 2 Thames River Alosid Studies

2A. Estimate the abundance of adult American shad in the Thames River in 1997 and characterize the run with regard to sex, length and age composition.

The abundance of adult American shad in the Thames River in 1997 was derived from an estimate of the number of fish lifted over the Greenville Dam plus those shad trucked in from outside the system. No adjustments to this total for numbers of shad below the Greenville Dam are thought to be necessary given the limited amount of habitat below the dam. Characterization of the run of American shad by sex, length and age were conducted by subsampling at the fishlift facility. A subsample of shad was taken with the number of fish collected based on the number of fish lifted during the previous day. The annual sex ratio will be extrapolated from the weighted daily totals.

2B. Monitor the sport fishery for American shad in the Thames River in 1997.

The sport fishery in the Thames River was monitored by conducting a roving creel survey during daylight hours of recreational fishermen within State waters from April 10 through June 7. Anglers were canvassed one weekday and one weekend day per week. Survey methods are similar to those used in the Connecticut River and cited above (Job 1B) except that the area canvassed by the creel clerks was much smaller. In the Thames system, only the area from Norwich harbor to the base of the Greenville Dam was regularly canvassed for anglers. Occasional trips further south were made episodically. Anglers were interviewed to determine the number of shad caught, the disposition of that catch (creeled or released), how long they had been fishing at that site and whether they had finished fishing at that site. Creel census clerks also determined the number of anglers at that site, and other pertinent conditions such as weather conditions and time.

Catch per unit of effort, percentages creeled and released, and total effort were tabulated for the upper Thames River for all shore sites combined. Given the small size of the fishery in past years, it was not thought to be necessary to subdivide anglers into successful and unsuccessful as is done in the Connecticut river system. Information was expanded by weekly effort and summed for a season total.

2C. Measure the relative abundance of juvenile alosids in the Thames River in 1997.

Juvenile clupeids were collected weekly from June 5th through October 16th. As many as eighteen different stations were sampled weekly over the season in attempts to find the best possible sites (Figure 3), however, usually only 14 were sampled each week. Sites above the dam were sampled with a 7.6 m bag seine (4.6 mm mesh, 2.4 m deep, and 1.5 m bag) during daylight hours. This seine was employed by having one person act as a stationary anchor in approximately 1.2 m of water with a second individual walking out the length of the seine. The net was then brought into shore in a downstream arc with the downstream end of the net slightly ahead of the upstream end to retain fish. This technique is different from that used downstream of the Greenville dam and on the Connecticut River where a boat is used to set the net upriver and offshore of the site. This was not possible above the dam because of shallow water depths and lack of adequate boat launch facilities. Sites below the Greenville dam were chosen based on location, physical conditions and accessibility. One seine haul per station was made during daylight hours with a 15.2 m nylon bag seine (4.6 mm mesh, 2.4 m deep, and 2.4 m bag) and 30.5 m lead ropes. Each haul was completed by using a boat to set the net approximately 30 m upstream and offshore of the site. Using the lead ropes, the seine was then towed in a downstream arc to the shore and beached. With small sample sizes (less than 500 fish), all clupeids (*Alosa sapidissima*, *A. aestivalis*, *A. pseudoharengus*, and *Brevoortia tyrannus*) were fixed in 4% formalin and returned to the laboratory. With large sample sizes, clupeids were subsampled volumetrically and unneeded fish returned to the water. Water temperature, weather conditions, time and water height (tidal stage below the dam sites, river levels above) were recorded for each station.

In the laboratory, clupeids were separated (American shad, blueback herring, alewives, and menhaden) based on the criteria of Lippson and Moran (1976). Up to 40 randomly selected individuals per species (shad, blueback herring, and alewives) per collection site per week were measured to total length (mm). Collections of individual species greater than 40 were randomly subsampled for length measurements. Representative samples of all alosids were archived in 67% isopropyl alcohol for future study. Indices of juvenile abundance will be derived upon final selection of seine sites and further analyses of the data. The relative abundance of juvenile blueback herring and alewives will be calculated in a manner similar to that used for American shad.

Job 3. Shortnose Sturgeon Investigation

Job 3A. *Monitoring of movements and frequency of use of various discrete sections of the Connecticut River by adult and immature shortnose sturgeon.*

The movements and frequency of use of discrete areas of the Connecticut River by shortnose sturgeon were assessed primarily by telemetry. Five sturgeon were thought to have active transmitters from previous years. To increase that number, additional fish were collected by gillnets and bottom trawl. Collections were made May 1 through June, all netting efforts in 1997 were restricted to the estuary region of the Connecticut River due to logistical constraints. Gill nets of

Six different mesh size were utilized 7.6, 8.9, 10.2, 12.7, 15.2, and 17.8 cm. All nets were comprised of a single mesh and were 30.5 m long by 1.8 m deep. The two smaller mesh nets were made of monofilament twine while the larger size mesh nets were constructed of multi-filament webbing. The nets were set on the bottom parallel to river flow for five hours. Four or five nets of various sizes were set in one general location per sampling day. Bottom trawl collections were made with a 30 ft flat net with 4 inch stretched mesh and a 1/4 inch codend liner. Ten minute tows were made against the current at 3 knots boat speed. All shortnose sturgeon were scanned with a PIT tag reader and examined for other tags. If no PIT tag was found, despite the presence of other tags, a PIT tag was implanted into the musculature on the left side below the dorsal fin.

RESULTS

Job 1. Connecticut River Shad Studies

Job 1A. Monitor the commercial and sport fisheries for American shad in the Connecticut River in 1997.

The number of commercial shad fishing licenses sold in 1997 in decreased by approximately twenty percent to 21, the lowest number in recent years (Table 1). The number of boats (11) utilized in 1997 also decreased slightly from 1996 (13), but the number of days fished (300) remained the same. The adjusted commercial harvest increased by 34% (table 5).

Age and sex specific mortality rates were highly variable and incalculable in some instances due to small sample size/population abundance (Table 2). Fishing mortality (F) is always constant in these iterations by virtue of the age distribution being derived from scale samples taken in commercial markets. Instantaneous fishing mortality rates of 0.05 and 0.03 (females and males, respectively) suggest that in river commercial fishing is not causing problems by harvesting too many fish.

Creel census of shad fishermen was conducted from April 9 through June 13. Fishermen exhibited only a modest increase (5.8%) in the number of hours fished (8,350) over 1996 levels, but the catch increased by 15% to 2,836 (Table 3). Although these numbers are significantly lower than catch and effort levels throughout the 1980s and early 1990s, catch per unit of effort numbers in 1997 compared to recent years demonstrate an encouraging trend. We can not attribute this very slight increase in catch and cpue directly to an increase in the number of shad available because the 1997 run was slightly smaller than the 1996 run. Catch rates for the sport fishery were highly variable (Table 4). No information is available on the sport fishery in the Massachusetts section of the Connecticut River at this time.

1B. Determine the population size, sex ratio and age structure of the 1997 run of American shad in the Connecticut River.

A total of 299,448 American shad were lifted at the Holyoke dam (Mass. Coop. Fish. Unit, unpub. report) in 70 days of operation from April 18 through July 15, 1997 (no lifts on some days)(Table 5). Information on the daily lift numbers of American shad at the Holyoke Dam indicate that the number of shad lifted was slightly greater than the number lifted in 1996 (276,289). Utilizing this information without further adjustments results in a 1997 population estimate of 659,478 adult shad for the entire Connecticut River basin (Table 6). This is a slight decline from the estimated 667,00 in the 1996 run, but these two runs should be considered equal and not statistically different from each other. While the moderate run sizes in 1996 and 1997 are not cause for special concern, it should be noted that the number of returning adults should have been over 2.0 million (Savoy 1996) in both years based on the strong juvenile year classes throughout the late

1980s and early 1990s.

The sex ratio of the 1997 run was 59.0:41.0 males to females. The dominance of males in the run is slightly higher than other years (Table 5), but more typical of other years than the predominance of females seen in 1993 and 1994. Sex composition of the run has been derived from information collected at the Holyoke fish lift which is upstream of the both the commercial and sport fisheries, however, the combined impact of these fisheries is not thought to be great enough to change the composition of the run.

A total of 1,133 scale samples was collected at commercial markets from April through May. Analyses of the 1997 run based on interpretation of scales suggests that five year old fish dominated the run. Both males (79%) and females (82%) were largely from the very strong 1992 year class (JI = 97.4), which had been the largest on record until the 1994 year class (JI = 107.9). Unfortunately, while the 1992 year class dominated the 1997 run on a percent composition basis, the numbers of adults recruiting back to the Connecticut River are far less than expected from such strong year class production.

1C. Measure the relative abundance of juvenile American shad in the Connecticut River in 1997.

Juvenile collections in the Connecticut River were made from July 16 through October 22. A total of 104 seine hauls was made with an average catch of 66.3 juvenile American shad per haul. The number of juvenile American shad collected in the seine survey in 1997 (6,307) was almost double the number collected in 1995 and 1996 (Table 7). Several of the weekly collection totals were greater than 500 fish which also supports the strong year-class designation for 1997.

Catches of American shad (Table 8) by station and over time (Figure 4) were highly variable ranging from zero to 1,528. The incidence of zero counts was moderately high (28%), but the zero counts were primarily the result of two stations. The Enfield and Essex stations both produced zero catches approximately 80% of the time. They each accounted for only 6 and 14 shad, respectively. All stations had positive collections at some time during the season and all are stations are useful in corroborating the strong index. The three stations in the lower river accounted for only 10% of the total catch (Figure 5), despite sampling until 10/22. The northernmost site (Holyoke) accounted for 75% of the total catch for the year (Table 8). The arithmetic mean catch of juvenile American shad from all stations and all dates was used as the relative index of abundance and catches suggest that the 1997 year class is strong with a value of 66.3 (Table 9). This is the ninth strong yearclass in the last eleven years (since 1987) and even the two lowest years in this time span were greater than 20, which formerly was considered a moderate to strong yearclass. Recent strong yearclasses had index values of 79.6, 97.4 and 107.9. The index of per diem growth in length (mm/day) for juvenile American shad was calculated as 0.310 which is larger than expected with a strong year class.

Numbers of juvenile blueback herring collected increased dramatically from 4,765 in 1996 to 26,227 in 1997 (Table 7). This is the largest number collected since 1988 and reverses a declining

trend in numbers since 1990. In contrast to juvenile shad collections discussed above, where the lower three stations only accounted for 10% of the annual catch, the lower three stations accounted for 98% of the catch of blueback herring (Table 10)(Figure 6). This pattern of the lower three sites producing greater than 90% of the herring collected has been seen for the last few years. The Glastonbury site only produced 1% of the total catch in 1997. The maximum catch for a single haul was 3,568 collected at the Deep River site. This site accounted for 56% of the total annual catch. Catches were fairly evenly distributed over time (Figure 7). The resulting index value for relative abundance of blueback herring is 270.9, the highest index seen since 1988 and the fourth highest since the index was established in 1978.

1D. Evaluation of the current techniques and methodologies utilized to estimate the annual run.

Several discussions were held with members of the Connecticut River Atlantic Salmon Commission American Shad Technical Committee concerning the reliability and validity of the current population estimation techniques. All members agreed that it would be worthwhile to conduct a large scale mark-recapture study to estimate population size and examine alternate methods of estimating the annual shad run. Lack of funding was considered a major obstacle at this time. Two proposals for outside funding were developed but neither were funded. Tagging activities will be deferred until adequate funding is obtained to conduct a true cooperative effort with all Connecticut River basin states.

Job 2. Thames River Alosid Studies

2A. Estimate the abundance of adult American shad in the Thames River in 1997 and characterize the run with regard to sex, length and age composition.

The Greenville Dam Fishlift passed a total of 2,860 American shad in 84 days of operation from March 26 through June 30. The majority of shad passage occurred from April 23 to May 29 with 50% of total passage occurring by 5/12/97. An additional 131 American shad were trucked into this system after having been captured at the Holyoke Fishlift on the Connecticut River. These fish were released into the upper portion of the Shetucket River on June 10 and 17. The total of 2,991 adult shad is considered the minimum estimate of the number of potential spawners in that system.

Scale samples and collection of biological information (sex, length and weight) of shad were taken at the fishlift, but samples were gathered sporadically. Only 57 fish were sampled for age and sex determination on four dates. Additionally, lifting had taken place for over a month and almost 40% of the run had passed before sample collection was initiated. Therefore, analyses may not be indicative of the total run because of these sampling problems. Composition of the run in the Thames was slightly different from the Connecticut River. Although females were still dominated by 5 year olds from the 1992 year class, four year olds comprised the greatest percentage of the

males. Three year old males comprised approximately 14% of the male run. In a very general sense, the run in the Thames was comprised of younger fish than those seen in the Connecticut River.

2B. Monitor the sport fishery for American shad in the Thames River in 1997.

Creel census activities were conducted in the Thames River system from April 10 to June 7. Analyses indicate that the majority of the sport fishing effort in the Thames River system below the Greenville Dam is directed towards striped bass. Only the two sites (East and West sides) immediately below the dam were found to have any fishing effort directed at American shad. Future creel census surveys can ignore other sites such as Norwich Harbor and other areas downriver based on several years of lack of fishing effort for shad and absence of shad in the catches at these other sites.

A total of 42 shad were documented by creel clerks in the Thames River system. Of these, 38% were creeled and 62% released. Expanded totals from the recreational fishery for American shad in the Thames River suggest that very low numbers of shad (less than 200) were captured.

2C. Measure the relative abundance of juvenile alosids in the Thames River in 1997.

Collections of juvenile alosids in the Thames River system were conducted from June 5 through October 16, 1997. A total of 240 seine hauls were made with as many as 16 sites being sampled per week in efforts to collect juvenile alosids and finalize seine site selection. Only two American shad were collected by seining all year. One juvenile shad was collected above the Greenville Dam, and one juvenile shad was collected at the first site below the dam. Few juveniles of any kind were caught before July 15 (only 1+ alewives). Juvenile menhaden dominated the catches from mid-July to early September with 16,116 collected. Blueback herring were second most abundant with 944 collected, although a single haul in the lower river accounted for 560 of these. A total of 213 alewives was collected over the entire season. All clupeids collected (17,513) were collected in the lower Thames River below the Greenville Dam, except for a single juvenile American shad. Several attempts were made to locate additional or alternate seine sites above the dam. Problems of lack of adequate access and suitable seine sites remain. Additional work will be required in future years to locate suitable sites. Several attempts were made employing electrofishing gear above the Greenville dam to determine where suitable sites might be located that contained alosids. Several locations produced juvenile shad, but none of these locations were suitable for seining (deep water, debris, or lack of shore access). Additionally, juvenile shad were observed in bypass operations at the Greenville dam conducted in late October. Several fish were captured, confirming the species identification as American shad. The large size of all juvenile shad collected (electrofishing and trapping) indicates small numbers relative to available habitat. Final seine site selection will await the availability of adequate numbers of juveniles are collected to do a realistic assessment.

Job 3 Shortnose Sturgeon Investigation

3A. Monitoring of movements and frequency of use of various discrete sections of the Connecticut River by adult and immature shortnose sturgeon.

Movements and frequency of use of various discrete sections of the Connecticut River by adult and immature shortnose sturgeon were monitored through ultrasonic telemetry. Shortnose sturgeon were collected throughout the lower Connecticut River from below the Holyoke Dam to the river mouth. Gill nets were the predominant gear used but trawling was conducted on several occasions. Biological information (general health, length, weight, and sex if possible) was taken from all sturgeon captured.

Thirty-four shortnose sturgeon were collected in the lower Connecticut River in 1997. Collection efforts included both gill netting and trawling. Gill nets accounted for 95% of the effort and 94% of the shortnose sturgeon captured. Sixty-seven gill nets were set over 14 dates for a total of 346 hours. Two shortnose sturgeon were collected with trawl gear in a single haul on the first set of the year. However, only 6 tows were made on two dates in 1997 as nets were snagged and destroyed on both sampling dates, ending further trawling efforts. Two immature juvenile Atlantic sturgeon were also collected during the netting for shortnose. All netting effort was confined to the estuary region for logistical reasons. Of the thirty-four shortnose handled, nine were recaptures of previously tagged fish. Several of these nine were notable recaptures for different reasons. Two sturgeon with PIT tags were found to have different number sequences than those utilized by CT DEP and thus were attributed to USGS staff working in Massachusetts waters. USGS/BRD staff were notified of the appropriate information including date, location and method of capture as well as length and weight information. Two notable recaptures occurred on June 9th. One of these recaptures was a shortnose sturgeon originally tagged in the Hudson River two years previously. When tagged in the Hudson, at river mile 87 on March 27, 1995 the fish was 575 mm FL, so it met the New York definition of a mature adult (TL>50.0 cm). This is the first documented movement of shortnose sturgeon between these two river systems that we are aware of. The recapture of this sturgeon highlights the value of external tags. This fish reportedly had a PIT tag from New York but it was not found by CT staff and so an additional PIT tag was added upon recapture. The cooperative floy tag was instrumental in identifying this fish as a migrant from the Hudson River. PIT tags are valuable for their longevity, small size and lack of tag induced problems but lack of standardization of placement location and incompatibility among manufacturers is a problem that needs to be addressed on a regional basis. The second of the notable recaptures taken on this day was captured in the same net as the Hudson River sturgeon. This sturgeon was the fish that had been 'rescued' from a small plunge pool in a Connecticut River tributary. We had speculated (Savoy 1996 Annual Report for 1995 Activities) that this sturgeon had likely been put there by well intentioned individual as the pool was over 3.5 miles up a shallow rocky intermittent stream. The last of these notable recaptures was a shortnose sturgeon originally collected on May 7, 1997 and surgically implanted with an ultrasonic transmitter. Upon recapture on May 19, 1997, the surgical wound was found to be well healed and the sutures were removed. This is the fourth such 'short'

term recovery (within 35 days) of shortnose sturgeon which have had surgical procedures performed on them. Two short term recaptures of implanted sturgeon that occurred during warm water period both healed rapidly. One sturgeon was recaptured only 7 days after implantation. This wound had not completely healed because the first stitch had broken allowing the wound to open slightly. An implantation that occurred in November (11/13/89) and was recaptured in winter (01/31/90)(cool water period - water temperature less than 14 C) did not heal over the 79 day period.

The addition of the thirty four shortnose sturgeon collected in netting efforts in the Connecticut River in 1997 (Table 11) brings the total number of shortnose sturgeon captured to date to 412 (Table 12). Shortnose sturgeon collected in 1997 ranged from 64.5 cm TL (57.0 FL) to 114.0 cm TL (103.0 FL) and 2.1 to an estimated 25 kilograms in weight. This weight was estimated as it exceeded the range of available scales. The heaviest sturgeon captured in 1997 was notable as the heaviest sturgeon collected to date since 1988. The longest sturgeon collected to date (05/11/95) had a greater length at 120.0 cm TL but it was estimated to be approximately 20 kg in weight. All shortnose sturgeon collected in 1997 were mature adults based on length. No examinations for determination of sex were made.

Five ultrasonic transmitters were surgically implanted into shortnose sturgeon in 1997 using similar techniques to those employed in previous years. Wax coated transmitters were placed into the posterior portion of the body cavity. Early in the season, two transmitters from previous years (1 in 1995 and 1 in 1996) were still active and providing useful information. Tracking activities took place on 46 occasions from February through December (Table 3).

Shortnose sturgeon with ultrasonic transmitters active in 1997 had similar movement patterns to fish tagged in previous years. Although small numbers of fish have been tracked each year, ultrasonic telemetry of shortnose sturgeon has documented consistent utilization (39 of 42 active transmitters from 1989-1997) of the estuary region of the Connecticut River during the spring months each year. While it is still speculative at this time, life history studies support our contention that this must be one of the most important feeding areas in the river. It is clear that to enhance and maintain this population of shortnose sturgeon, they should not be deprived of access to this area which is likely provides important food resources. Currently, the Holyoke dam in Massachusetts lacks suitable downstream passage facilities for sturgeon, thus sturgeon that are lifted over the Holyoke dam are blocked from returning to the estuary or at risk of injury or mortality in the process of passing downstream. The current policy of passing shortnose sturgeon over the dam should be reassessed pending development of adequate downstream passage for sturgeon.

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Table 1. Reported and adjusted total harvest (numbers) and weight of shad taken by the commercial fishery, 1992-1997.

	1992	1993	1994	1995	1996	1997
Number of male shad reported	7171	5173	1812	1862	2298	2812
Number of female shad reported	23768	17790	19400	12299	13660	18743
Total number	30939	22963	21212	14161	15958	21555
Adjusted number of male shad	17075	7770	28881	6565	6275	10612
Adjusted number of female shad	32964	24588	10108	19480	20916	25884
Adjusted Total number	50039	32358	38989	26045	27191	36496
Adjusted Total weight (metric tons)	101.1	67.6	68.2	69.5	56.9	75.0
Number of licensed fishermen	33	33	39	39	26	21
Number of boats	16	16	17	19	13	11
Number of fishing days	410	400	350	400	300	300

Table 2. Age-specific rates of instantaneous total (Z), commercial fishing (F) and extraneous (M) mortality rates of male and female shad between 1996 and 1997.

	Age Group			
	4/5	5/6	6/7	7/8+
FEMALE SHAD				
1996 population	68967	250994	137934	11306
1996 catch	3067	11162	6134	503
1997 repeats	11555	5777	578	
Z	1.79	3.77	5.47	
F	0.05	0.05	0.05	0.05
M	1.74	3.72	5.42	
	Age Group			
	3/4	4/5	5/6	6/7
MALE SHAD				
1996 population	1742	74890	109723	10450
1996 catch	56	2388	3498	333
1997 repeats	22234	44468	3706	
Z		0.52	3.39	
F	0.03	0.03	0.03	0.03
M		0.49	3.36	

Table 3. Expanded effort (hours), harvest (numbers), change in harvest from previous year (percent), and average catch per unit effort (CPUE) from recreational shad fishermen in the Connecticut portion of the Farmington and Connecticut Rivers, 1982 - 1997.

Year	Effort	Catch	% Change in Catch	CPUE
1982	25280	17518		0.69
1983	19721	11846	-32.4	0.60
1984	23207	17094	44.3	0.74
1985	19536	7482	-56.2	0.38
1986	19522	6912	-7.6	0.35
1987	18292	7843	13.5	0.43
1988	17795	6424	-18.1	0.36
1989	10508	5243	-18.4	0.50
1990	13677	9687	84.8	0.71
1991	25278	17600	81.7	0.70
1992	34027	29323	66.6	0.86
1993	21865	10813	-63.1	0.49
1994	22310	5318	-50.8	0.24
1995	13439	1348	-74.7	0.10
1996	7891	2462	82.6	0.31
1997	8350	2836	15.2	0.34

Table 4. Expanded effort (hours), catch (numbers), percentage creeled and released, and average catch per unit effort (CPUE) from recreational shad fishermen in the Connecticut portion of the Farmington and Connecticut Rivers, 1997.

Site	Effort	Catch	% Creeled	% Released	CPUE
Wilson	1326	551	52	48	0.42
Farmington	3592	698	26	74	0.19
91 West	468	61	25	75	0.13
EnfieldA	118	3	100	0	0.03
EnfieldB	600	239	37	63	0.40
All Other Combined	626	84	60	40	0.14
Total Shore	6728	1636	50	50	0.24
140 Bridge	0	0	0	0	0.00
Boats	1621	1200	32	68	0.74
Total Comb.	8350	2836	41	59	0.34

EnfieldA and EnfieldB are above and below the Enfield dam, respectively.

Table 5. Population estimates, numbers lifted at Holyoke, Connecticut sport catch, adjusted commercial catch, sex ratio of female American shad, and numbers of adult blueback herring lifted at the Holyoke dam in the Connecticut River from 1975-1997.

YEAR	SHAD POPULATION	SHAD LIFT	SPORT CATCH	COMMER HARVEST	SEX RATIO	BLUEBACK HERRING
1975	847530	114137		123344	0.37	1625
1976	936900	346702		138650	0.49	4745
1977	361890	202997		97024	0.66	32932
1978	560700	144698		85962	0.37	34953
1979	557010	255753		73321	0.47	39461
1980	685080	376276		88329	0.48	198000
1981	909270	377124		97684	0.34	419733
1982	939330	294834	17518	81132	0.37	586808
1983	1574460	528185	11846	99328	0.34	454242
1984	1231110	496879	17094	88579	0.49	482954
1985	727560	481668	7482	89303	0.43	630000
1986	748440	352122	6912	117770	0.52	517521
1987	587520	271974	7843	64732	0.42	356846
1988	647640	294157	6424	77179	0.33	343363
1989	979440	353819	5243	72996	0.56	286259
1990	816480	363825	9687	57642	0.41	392157
1991	1195920	523153	17600	70479	0.28	412380
1992	1628039	721764	29323	50039	0.48	312863
1993	749227	340431	10813	32358	0.68	103447
1994	325558	180807	5318	38989	0.65	31766
1995	303973	190295	1348	26045	0.34	112136
1996	667137	276289	2462	27191	0.30	55011
1997	659478	299448	2836	36496	0.41	63945

Table 6. Population estimates, adjusted commercial harvest, spawning history, and age distribution of American shad in the Connecticut River in 1997.

FEMALE SHAD						
	Age group					
	4	5	6	7	8+	Total
Adjusted commercial harvest	2323	21349	2157	55		25884
Population size	24265	223011	22532	578		270386
% Population	9.0	82.5	8.3	0.2		
Repeat spawners		11555	5777	578		17910
% Repeats		5.2	25.6	100		
MALE SHAD						
	Age group					
	4	5	6	7	8+	Total
Adjusted commercial harvest	2122	8389	101			10612
Population size	77818	307568	3706			389092
% Population	20.0	79.0	1.0			
Repeat spawners	22234	44468	3706			70408
% Repeats	28.6	14.5	100			

Table 7. Total catch and percent composition of juvenile shad and blueback herring, 1978-1997.

Year	Total number of shad	% shad	Total number of bluebacks	% bluebacks
1978	1,680	8.3	18,463	91.7
1979	824	9.9	7,493	90.1
1980	1,777	9.0	18,047	91.0
1981	1,165	9.0	11,822	91.0
1982	391	6.9	5,301	93.1
1983	1,574	4.2	36,172	95.8
1984	67	3.0	28,598	97.0
1985	1,148	6.0	17,697	94.0
1986	1,532	9.7	14,289	90.3
1987	4,205	14.4	24,952	85.6
1988	2,234	7.0	29,680	93.0
1989	5,914	31.0	13,148	69.0
1990	4,143	14.7	24,132	85.3
1991	5,331	24.0	16,954	76.0
1992	10,424	37.6	17,328	62.4
1993	7,876	38.1	12,784	61.9
1994	10,791	48.2	11,582	51.8
1995	3,082	26.9	8,374	73.1
1996	3,716	43.8	4,765	56.2
1997	6,307	19.4	26,227	80.6

Table 8. Catch, effort and catch per effort of Connecticut River juvenile American shad from the 1997 seine survey. C = Total catch, E = Number of seine hauls.

AMERICAN SHAD

Date	<u>Station</u>							C	E	C/E
	Holyoke	Enfield	Wilson	Glastonbury	Salmon R.	Deep River	Essex			
7/16	826	0	191	4	0	40	-	1061	6	176.83
7/23	573	0	274	0	5	0	1	853	7	121.86
7/30	481	0	10	8	18	0	0	517	7	73.86
8/06	313	0	41	2	38	0	0	394	7	56.29
8/13	15	2	253	14	40	5	0	329	7	47.00
8/20	12	1	3	1	52	4	3	76	7	10.86
8/27	479	0	222	7	28	19	0	555	7	79.29
9/03	317	3	28	1	37	28	0	414	7	59.14
9/10	1528	0	6	12	56	8	0	1610	7	230.00
9/17	0	0	10	5	45	0	-0	60	7	10.00
9/24	29	0	2	2	34	20	0	87	7	12.43
10/01	17	0	16	3	16	32	10	94	7	13.43
10/08	27	0	0	8	39	18	0	92	7	13.14
10/14	133	0	1	5	22	4	0	165	7	23.57
10/22	2	0	1	0	16	5	6	30	7	4.29

- No seine sample taken.

Table 9. Relative abundance index (CPUE) and mean daily growth rate (mm/day) of juvenile American shad for the 1966-1997 year classes and the relative abundance index of blueback herring from the 1978-1997 year classes.

Year class	Abundance index ^{1/} of American shad	Mean daily growth (mm/day)	Abundance index of Bluebacks
1966	32.8	0.460	
1967	20.2	0.742	
1968	11.1	0.987	
1969	19.0	0.775	
1970	27.8	0.435	
1971	65.7	0.268	
1972	15.3	0.613	
1973	12.7	0.536	
1974	-	-	
1975	-	-	
1976	-	-	
1977	-	-	
1978	18.6	0.415	209.8
1979	47.9	0.382	107.0
1980	21.3	0.238	222.8
1981	12.5	0.315	127.1
1982	7.8	0.759	64.6
1983	16.6	0.449	393.2
1984	11.2	0.622	433.4
1985	15.9	0.433	229.8
1986	17.0	0.406	158.8
1987	44.3	0.216	265.4
1988	24.0	0.296	319.1
1989	61.6	0.185	137.0
1990	43.0	0.240	251.4
1991	49.4	0.188	156.7
1992	97.4	0.267	161.9
1993	79.6	0.333	129.1
1994	107.9	0.205	114.7
1995	22.8	0.304	73.5
1996	37.2	0.201	49.6
1997	66.3	0.310	270.9

1/ Data from 1966-1973 were taken from Marcy (1976) at stations corresponding to those of 1978-1997.

Table 10. Catch, effort and catch per effort of Connecticut River juvenile blueback herring from the 1997 seine survey. C = Total catch, E = Number of seine hauls.

BLUEBACK HERRING

<u>Station</u>											
Date	Holyoke	Enfield	Wilson	Glastonbury	Salmon R.	Deep River	Essex	C	E	C/E	
7/16	0	0	0	2	63	849	-	914	6	152.33	
7/23	5	6	0	4	20	1314	1238	2587	7	369.57	
7/30	5	0	0	0	2	2428	2	2437	7	348.14	
8/06	1	0	12	6	22	5	0	46	7	6.57	
8/13	0	0	26	94	193	910	0	1223	7	174.71	
8/20	0	0	22	1	2032	12	0	2067	7	295.29	
8/27	64	0	5	2	964	229	873	2137	7	305.29	
9/03	44	5	1	2	256	2744	1	3050	7	436.14	
9/10	0	0	0	120	1094	482	2	1698	7	242.57	
9/17	0	0	1	0	116	824	41	982	7	163.67	
9/24	0	0	8	0	0	0	2	10	7	1.43	
10/01	0	0	6	1	1316	3568	108	4999	7	714.14	
10/08	0	0	0	0	514	490	32	1036	7	148.00	
10/14	1	0	1	0	696	820	1520	3038	7	434.00	
10/22	0	0	0	0	4	103	77	184	7	26.29	

- No seine sample taken.

Table 11. Shortnose sturgeon capture information by date, area collected and method in the Connecticut River in 1997.

Date	No. Collected	Area	Method
05/07	3	Saybrook	Gill Net
05/19	1	Saybrook	Gill Net
05/29	4	Saybrook	Gill Net
06/04	2	Saybrook	Trawl
06/09	10	Saybrook	Gill Net
06/11	5	Saybrook	Gill Net
06/16	7	Saybrook	Gill Net
06/18	2	Saybrook	Gill Net
Total	34		

Table 12. Shortnose sturgeon capture information by year in the Connecticut River.

Year	Collected	Recaptures	No. Tagged	Mortalities	Other
1988	48	1	45	2	
1989	80	11	64	5	
1990	59	7	49	3	
1991	74	14	60	0	
1992	50	13	37	0	
1993	14	7	5	1	1
1994	20	7	12	0	1
1995	11	2	9	0	
1996	22	7	14	0	1
1997	34	9	25	0	
Total	412	78	320	11	3

Figure 1. The Connecticut River showing locations of concentrated recreational fishing effort for shad (X=shore access; O=boat ramp).

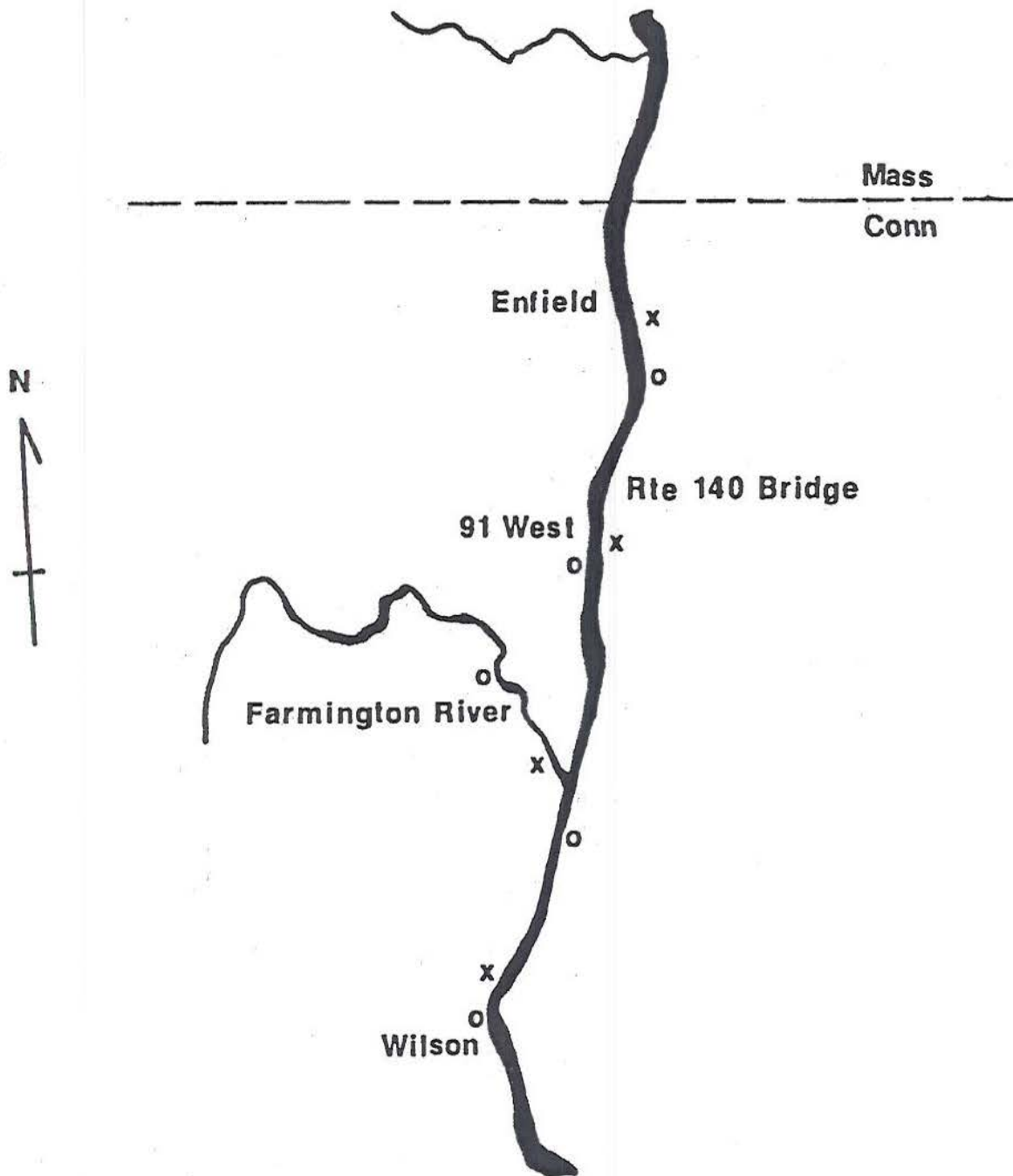


Figure 2. The Connecticut River showing locations of juvenile American shad sampling stations.

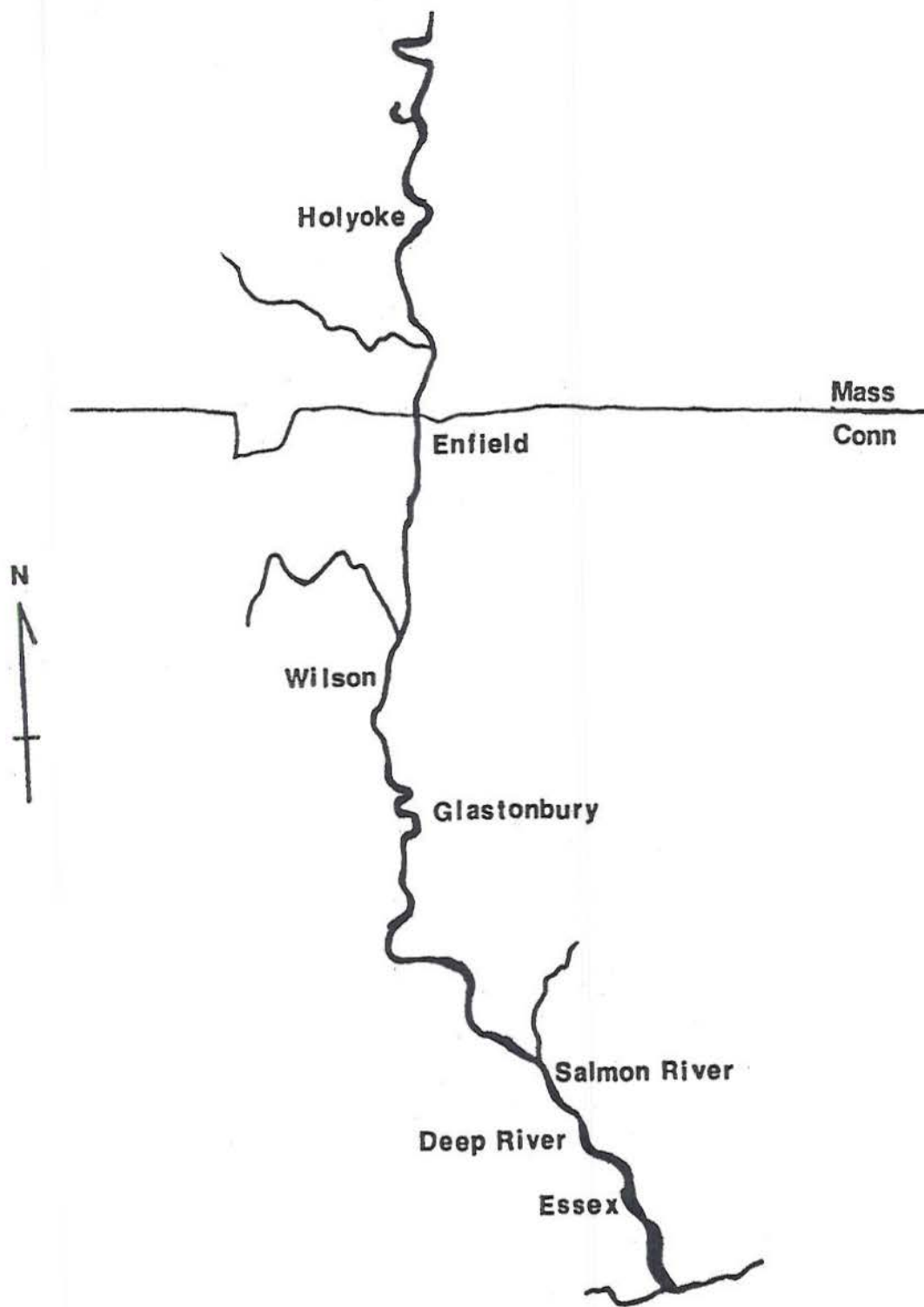


Figure 3. The Thames River showing locations of juvenile clupeid seine sampling in 1997 (A = sampling sites above the Greenville Dam; B = sampling sites below the Greenville Dam).

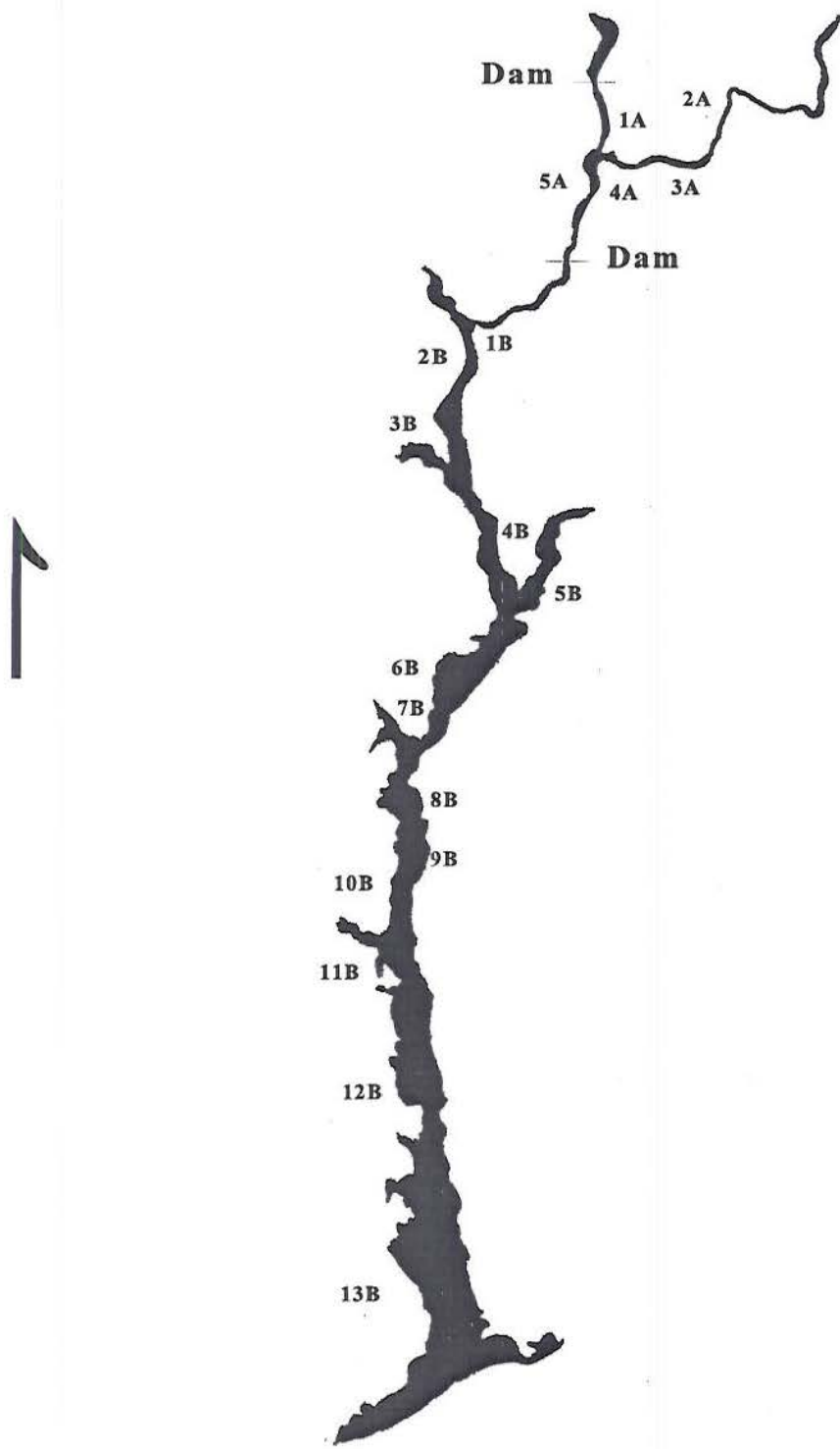


Figure 4. Percent of juvenile American shad collected in the Connecticut River per week in 1997.

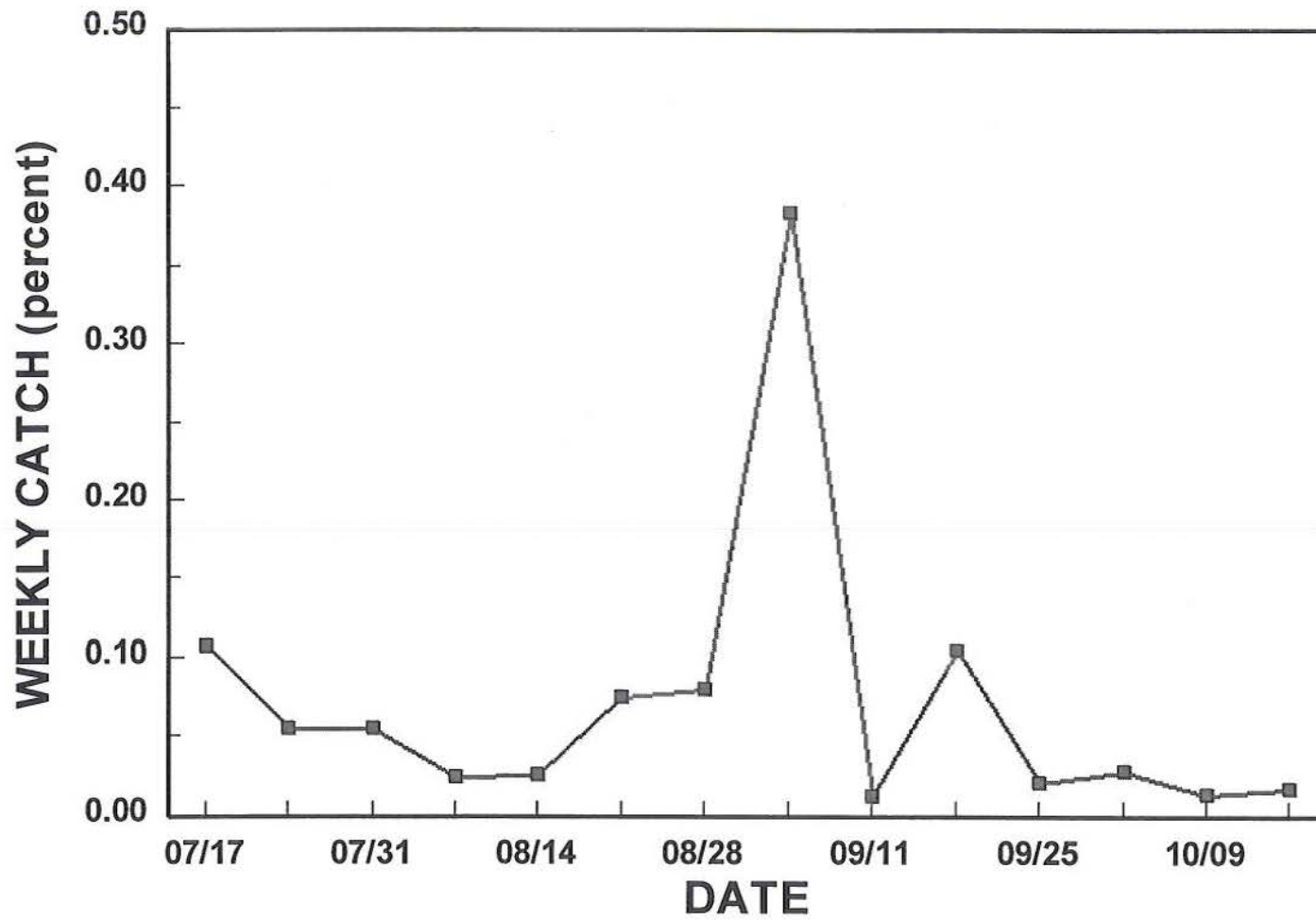


Figure 5. Number of juvenile American shad collected in the Connecticut River per station in 1997.

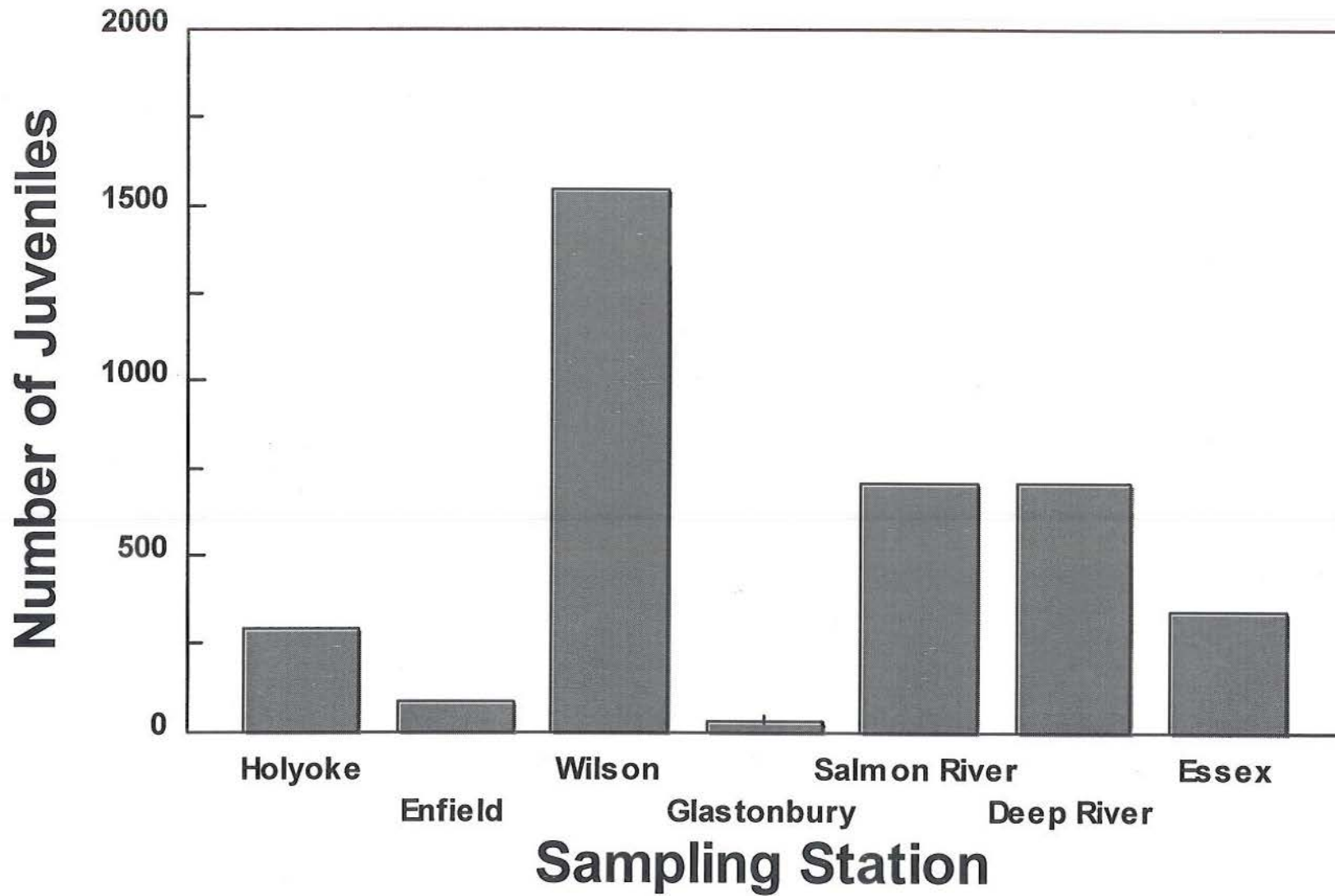


Figure 7. Percent of juvenile blueback herring collected in the Connecticut River per week in 1997.

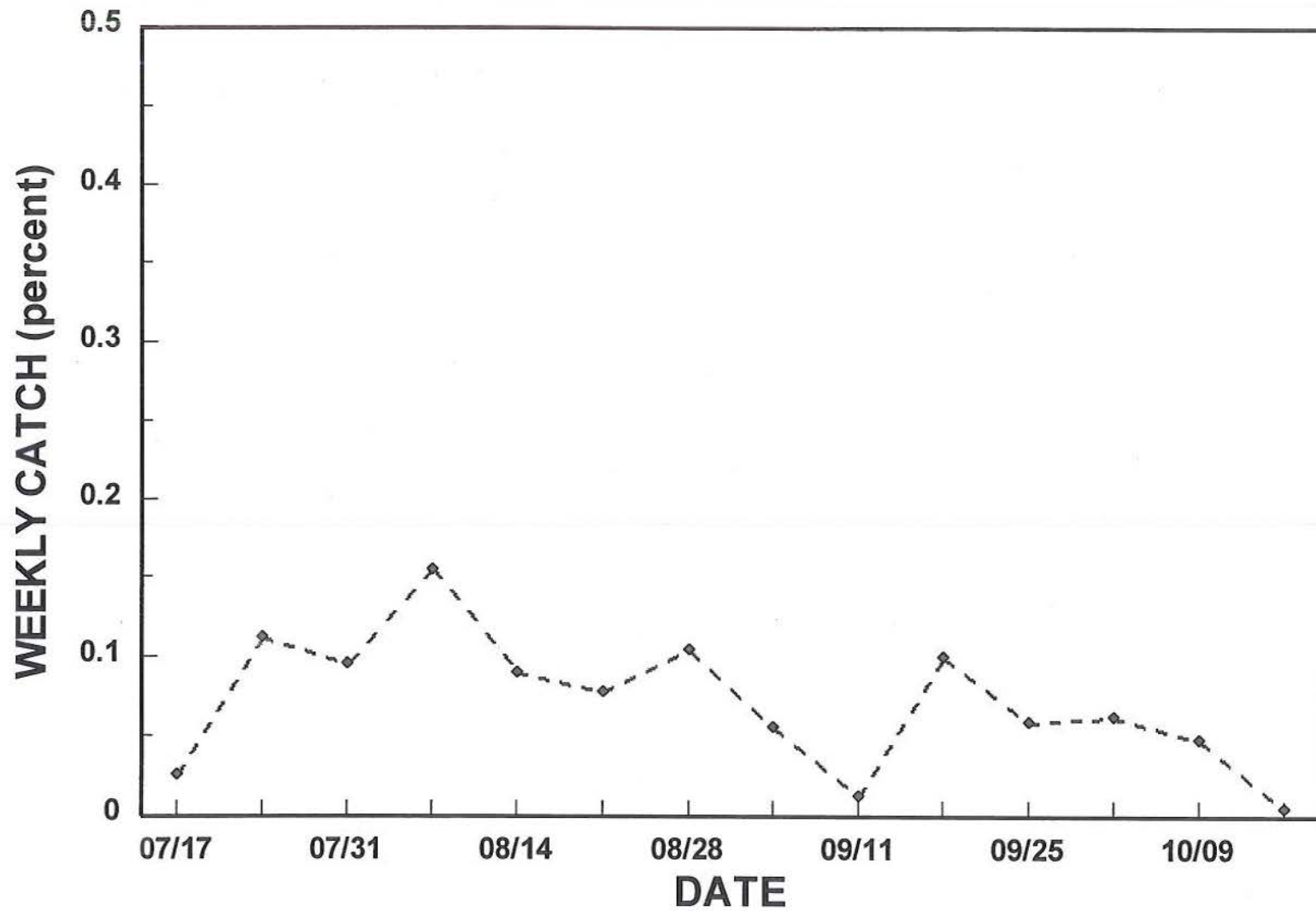
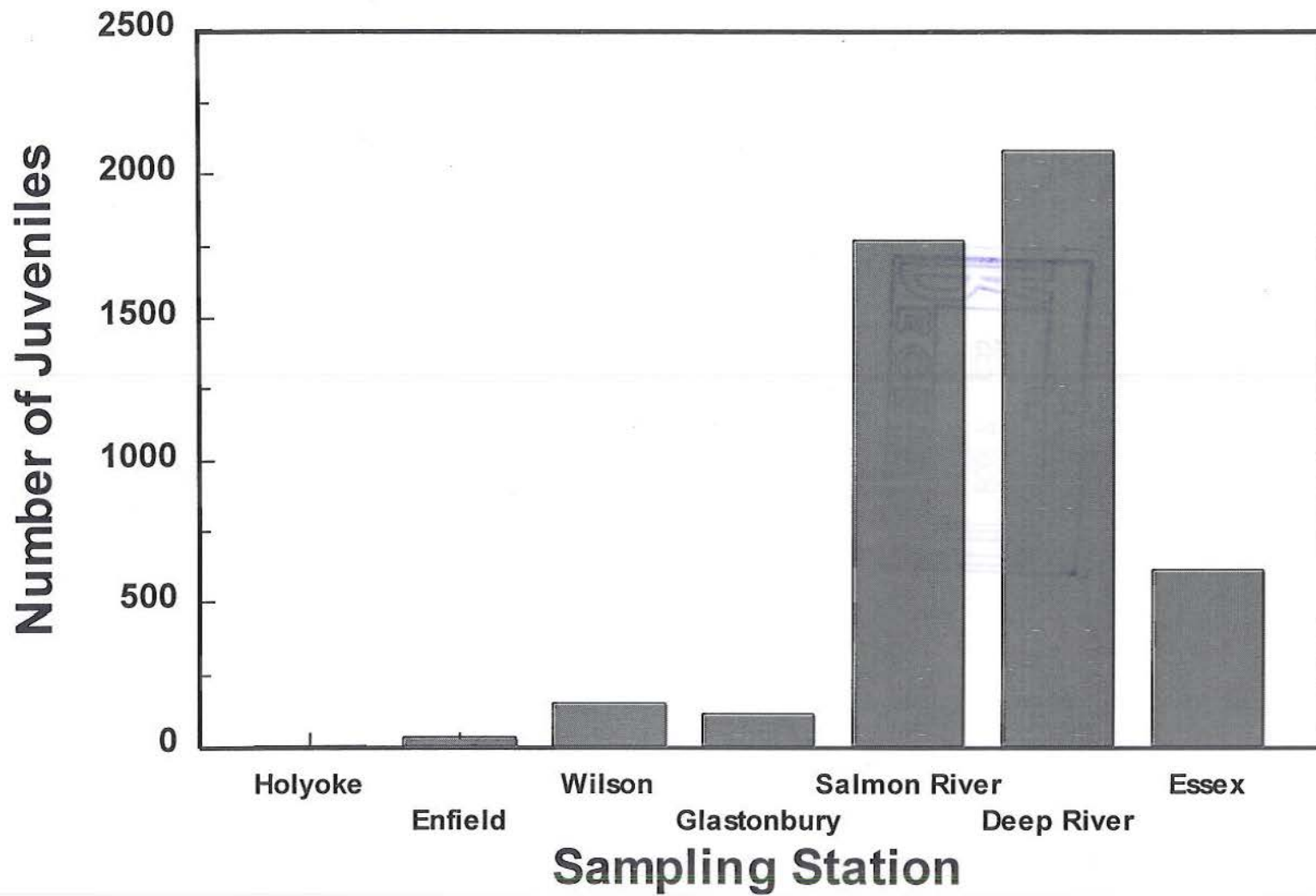


Figure 6.
Number of juvenile blueback herring collected in the Connecticut River per station in 1997.



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region
State, Federal & Constituent Programs Division



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Table of Contents

	page
List of Tables.....	4
List of Figures.....	5
Introduction.....	6
Job 1. Population Dynamics of American Shad in the CT River.	
Methods.....	7
1A. To determine population size, age structure, and sex ratio annual of the 1996 American shad, population in the Connecticut River.....	7
1B. To monitor both the commercial and sport fisheries for American shad in the Connecticut River in 1996.....	7
1C. To measure the relative abundance of juvenile American shad in the Connecticut River in 1996.....	9
Job 2. Population Dynamics of American Shad in the Thames River	
Methods.....	9
2A. To monitor the sport fishery for American shad in the Thames River in 1996.....	9
2B. To measure the relative abundance of juvenile American shad in the Thames River in 1996.....	10
Job 1. Population Dynamics of American Shad in the CT River.	
Results.....	11
1A. To determine annual abundance of adult American shad, population size, age structure, and sex ratio in the Connecticut River.....	11
1B. To monitor both the commercial and sport fisheries for American shad in the Connecticut River.....	12
1C. To measure the relative abundance of juvenile American shad in the Connecticut River.....	13

Job 2. Population Dynamics of American Shad in the Thames River

Results.....13

2A. To monitor the sport fishery for American shad in the Thames River in 1996.....13

2B. To measure the relative abundance of juvenile American shad in the Thames River in 1996.....14

List of Tables

	page
Table 1. Population estimates, adjusted commercial catch, spawning history, and age distribution of American shad in the Connecticut River from 1975 to 1996.....	16
Table 2. Population estimates, adjusted commercial catch, spawning history, and age distribution of American shad in the Connecticut River in 1996.....	17
Table 3. Reported and adjusted total catch (numbers) and weight of shad taken by the commercial fishery, 1996.....	18
Table 4. Age-specific rates of instantaneous total (Z), commercial fishing (F), and extraneous (M) mortality rates of male and female shad between 1995 and 1996.....	19
Table 5. Expanded effort (hours), catch (numbers), change in catch from previous year (percent), and average catch per unit effort (CPUE) from recreational shad fishermen in the Connecticut portion of the Farmington and Connecticut Rivers, 1982 - 1996.....	20
Table 6. Expanded effort (hours), catch (numbers), percentage creel and released, and average catch per unit effort (CPUE) from recreational shad fishermen in the Connecticut portion of the Farmington and Connecticut Rivers, 1996.....	21
Table 7. Total catch and percent composition of juvenile shad and blueback herring, 1978-1996.....	22
Table 8. Catch, effort and catch per effort of juvenile American shad from the 1996 seine survey. C = Total catch, E = Number of seine hauls.....	23
Table 9. Catch, effort and catch per effort of juvenile blueback herring from the 1996 seine survey. C = Total catch, E = Number of seine hauls.....	24
Table 10. Relative abundance index (CPUE) and mean daily growth rate (mm/day) of juvenile American shad for the 1966-1996 year classes and the relative abundance index of blueback herring from the 1978-1996 year classes.....	25

List of Figures

	page
Figure 1. The Connecticut River showing locations of concentrated fishing effort for recreational shad anglers.....	26
Figure 2. The Connecticut River showing locations of juvenile American shad sampling stations.....	27
Figure 3. The Thames River showing locations of juvenile clupeid sampling stations in 1996.....	28
Figure 4. Percent of juvenile American shad collected in the Connecticut River per week in 1996.....	29
Figure 5. Number of juvenile American shad collected in the Connecticut River per station in 1996.....	30
Figure 6. Percent of juvenile blueback herring collected in the Connecticut River per week in 1996.....	31
Figure 7. Number of juvenile blueback herring collected in the Connecticut River per station in 1996.....	32

INTRODUCTION

The American shad (*Alosa sapidissima*) is an important resource to the State of Connecticut and the other Connecticut River basin states (MA, VT, & NH). Annual spawning migrations of shad support valuable sport and commercial fisheries in Connecticut, as well as important recreational fisheries in the up river states. The Connecticut Department of Environmental Protection has conducted annual studies of the American shad in the Connecticut River since 1974 to monitor the population and the fisheries.

The major goal of this project is to collect information for management of the American shad population, and the recreational and commercial fisheries in the Connecticut River. This information is also utilized by the states of Massachusetts, New Hampshire and Vermont for management of their recreational shad fisheries and, the Atlantic States Fisheries Commission for the interstate fishery management of American shad from Maine to Florida. The data base for the Connecticut River shad population and its fisheries is the most comprehensive on the Atlantic coast and has proven invaluable in development of the interstate management plan for the migratory American shad resource. Information on abundance, age structure, sex ratio, harvest and effort in the commercial and recreational fisheries, and annual reproductive success have proven important in management of the species and in predicting the magnitude of spawning runs.

This project has been expanded to the Thames River system where a remnant American shad spawning run exists. Completion and operation of the Geenville Dam fishway on the Shetucket River (the first dam on the Shetucket/Quinebaug River systems) now provides access to historical shad spawning areas. It is anticipated that the American shad population in the Thames system will rapidly expand. The adult spawning population size will be monitored by the number of shad passed through the fishway and by the number caught in the recreational fishery. Spawning success and potential population expansion will be estimated from the relative abundance of juveniles. This information will be utilized in restoration efforts (transplanting of adults) and management of the recreational fishery and fishway fish passage.

This report contains information on studies conducted in the Connecticut and Thames River systems from April 1, 1995 to March 31, 1996. Financial support was provided by the National Marine Fisheries Service and the State of Connecticut.

**Bureau of Natural Resources
Fisheries Division
Project Summary**

Project: Anadromous Fish Studies in Connecticut Waters
Federal Aid Project : AFC24 (National Marine Fisheries Service)
Year: 1996
Report Type: Annual Performance Report
Availability of Funding: Competitive (annually)
Funding: \$50,000 (annually)
State Match: \$50,000

Purpose of Project

The project consists of two Jobs 1) Population dynamics of American shad in the Connecticut River and, 2) Population dynamics of American shad in the Thames River System.

The major goal of the project is to collect information for management of the American shad population, and the recreational and commercial fisheries in the Connecticut River. This information is also utilized by the states of Massachusetts, New Hampshire and Vermont for management of their recreational shad fisheries and, the Atlantic States Fisheries Commission for the interstate fishery management of American shad from Maine to Florida. The data base for the Connecticut River shad population and its fisheries is the most comprehensive on the Atlantic coast and has proven invaluable in development of the interstate management plan for the migratory American shad resource.

This project has been expanded to the Thames River system where a remanent spawning run exists. Completion and operation of the Geenville Dam fishway on the Shetucket River (the first dam on the Shetucket/Quinebaug River systems) now provides access to historical shad spawning areas. It is anticipated that the American shad population in the Thames River will rapidly expand. The adult spawning population size will be monitored by the number of shad passed through the fishway and by the number caught in the recreational fishery. Spawning success and potential population expansion will be estimated from the relative abundance of juveniles. This information will be utilized in restoration efforts (transplanting of adults) and management of the recreational fishery and fishway fish passage.

Job 1. Population Dynamics of American Shad in the Connecticut River.

Objectives: Determine the annual adult spawning population size, age structure, and sex ratio. Monitor the commercial and recreational fisheries (catch, harvest and effort) in the river. And, determine the annual index of juvenile shad relative abundance.

Key Findings:

- The annual spawning run was estimated to be 667,137 fish.
- The commercial and recreational harvest were estimated to be 27,191, and 2,462 fish, respectively.
- The annual juvenile index of abundance was estimated to be 37.2.

Conclusions:

- The 1996 spawning population continues to increase from a low of approximately 300,000 fish observed in 1994, and is approaching the long term average of 800,000 fish.
- The spawning population is much smaller than projected from juvenile indices (expected approximately 2 million fish).
- The 1996 juvenile index can be characterized as moderately strong (range 7.8 to 107.9 fish, 1978 to 1995) and should produce moderate spawning runs in 4-6 years of approximately 1 million fish.
- Predation by striped bass may be depressing the size of the shad population.
- The commercial and recreational harvest continues to decline. Few commercial fishermen are participating in the fishery and recreational effort appears to be shifting to striped bass.

Recommendations:

- Continued monitoring of the shad population.
- A reassessment of the methods of estimating population size is needed due to changes in the population size and the proportion of the population lifted over the Holyoke Dam.

Job 2. Population Dynamics of American Shad in the Thames River.

Objectives: Monitor the sport fishery, and measure the relative abundance of juvenile American shad. Note; estimates of the shad adult spawning run size and population structure must be collected by the City of Norwich as part of the FERC operating agreement for the Greenville Dam Fishway.

Key Findings:

- The shad fishery in the Thames River system is concentrated in the Shetucket River at two sites immediately below the Greenville dam; less than 200 shad were caught in the recreational fishery during 1996.

- A total of 925 shad were lifted and passed through the Greenville Dam Fishway in 1996; it is believed that this number approximates the total run size.
- No American shad juveniles were collected above Greenville Dam; a small number of juvenile shad were collected in the lower Thames River.

Conclusions:

- A remnant spawning population and small recreational fishery continue to exist in the Thames River System despite extremely limited past spawning area.
- The Greenville Dam Fishway is successful in passing shad and provides access to the Greenville pool for a significant increase in spawning area.
- Lack of success in collecting juvenile shad above Greenville Dam may not be indicative of spawning success, but rather selection of suitable sampling locations. Juvenile shad collected in the lower Thames River could have strayed in from Long Island Sound.

Recommendations:

- Continue monitoring the recreational fishery as an indicator of the spawning population size and to assess fishing mortality for use in management of this fishery.
- Explore areas above the Greenville Dam for selection of alternate and/or additional sampling sites for juvenile shad.
- Continue transplanting adult shad from the Connecticut River Holyoke Fishlift to "jump start" the Thames System shad population. These activities are conducted under the Sport Fish Restoration Project F-50D.

METHODS

Job 1. Population Dynamics of Connecticut River American Shad

Job 1A. To determine annual abundance of adult American shad, population size, age structure, and sex ratio in the Connecticut River.

The 1996 adult American shad population estimate, age structure and sex ratio were calculated from samples collected from both the commercial shad fishery and the Holyoke dam fishlift at Holyoke, MA. Information on the number of fish lifted daily, season lift total, number of lift days (days the lift is in operation), and the sex ratio at Holyoke was obtained from Massachusetts Cooperative Fishery Research Unit personnel. Sex determination was accomplished by visual inspection of the gonads of sacrificed fish. The final sex ratio was obtained by weighting the daily observed sex ratios by the number of fish lifted that day.

Annual population estimates were estimated using daily shad lift rates at the Holyoke dam. The shad population size was determined by dividing the number of American shad lifted by the number of days in which 99% of the total shad were passed. This rate was multiplied by a weighting coefficient (0.10) to adjust for lift improvements since 1976 and then multiplied by 1000 to scale the estimates to the proper magnitude (Crecco and Savoy 1985). Population estimates derived from Holyoke lift data were shown to be positively correlated ($r=0.68$, $P<0.01$) to population estimates derived from mark-recapture studies (1967-1978) and were positively correlated ($r=0.90$, $P<0.001$) to juvenile indices of abundance.

Age structure was derived from scale samples collected at commercial markets using only those fishermen known not to have culled their catch of male shad. Scales were removed from above the lateral line anterior to the dorsal fin. Scale samples, sex and fork length (cm) measurements were collected weekly over the entire shad run. All scale samples collected were separated by sex and stratified into 1 cm length groups. Scales were dried, cleaned and pressed onto acetate slides with a roller press. Projected scale impressions (13x) were aged by counting annuli using the criteria of Cating (1953). Repeat spawners were noted by the presence of spawning scar(s) at the periphery of the scale.

Job 1B. To monitor both the commercial and sport fisheries for American shad in the Connecticut River.

Commercial shad fishermen are required to report daily landings of American shad. Total landings are adjusted for under-reporting and culling of male shad by multiplying the total effort (days fished) by the mean catch/effort of the top five catch/efforts of that year. This assumes that the five top fishermen report their true landings. Estimates derived in this fashion may be higher than actually realized since it is highly unlikely that all fishermen are catching shad at such high rates. This approach results in a minimum estimate of escapement and is considered a more conservative approach.

Instantaneous total mortality (Z), fishing mortality (F) and natural mortality (M) were estimated for each sex and age group (Ricker 1975). Total instantaneous mortality (Z_j) was expressed by:

$$Z_j = -\ln(R_j / N_{j-1}) \quad (3)$$

where: R_j = number of repeat spawners of age group (j),
 N_{j-1} = population size for age group (j) in year (j-1).

The age-specific annual fishing rates (u_j) were determined by:

$$u_j = C_j / N_j \quad (1)$$

where: C_j = adjusted commercial catch for each age group (j),
 N_j = population size for age group (j),
from which the instantaneous fishing rates (F_j) were estimated by:

$$F_j = -\ln(1-u_j). \quad (2)$$

The instantaneous rate of natural mortality (M_j) was calculated by :

$$M_j = Z_j - F_j. \quad (4)$$

Age-specific natural mortality was estimated as the difference between inriver commercial fishing mortality (F) and total mortality estimates (Z). Estimates of natural mortality include all mortalities other than commercial fishing in the Connecticut River. This is necessary since no sex and age specific information is available from these other fisheries (i.e. trawl bycatch, oceanic gillnet, and in-river recreational fishery).

The sport fishery in the Connecticut River was monitored by conducting a roving creel survey during daylight hours of recreational fishermen within State waters (Figure 1) from April 1 through June 30, (the open season in the Connecticut River). Connecticut River anglers were canvassed one weekday and one weekend day per week. Survey methods are similar to those reported by Fraidenburg and Bargmann (1982) as being suitable for small sample areas and short time periods to provide relatively unbiased information. Anglers were interviewed to determine the number of shad caught, the disposition of that catch (creeled or released), how long they had been fishing at that site and whether they had finished fishing at that site. Creel census clerks also determined the number of anglers at that site, and other pertinent conditions such as weather conditions and time.

Catch per unit of effort (per hour), percentages creeled and released, and total effort were tabulated for each of the major shore sites from Hartford to the CT/MA State line, and for the entire Connecticut boat fishery separately. So as to not overexpand the recreational harvest by large numbers of anglers who did not catch any shad, anglers were placed into one of two groups: successful (caught one or more shad) or unsuccessful. Results were then tabulated for each group separately and expanded for total catch and effort. Information was expanded by weekly effort and summed for a season total.

Job 1C. To measure the relative abundance of juvenile American shad in the Connecticut River.

Juvenile American shad were collected weekly from July 14th through October 19th at seven fixed stations located from Holyoke, MA to Essex, CT (Figure 2). Seine haul locations and techniques have remained similar to those employed in past Connecticut River shad investigations (Marcy 1976; Crecco et al. 1981). Sites were previously chosen based on location, physical conditions and accessibility. One seine haul per station was made during daylight hours with a 15.2 m nylon bag seine (4.6 mm mesh, 2.4 m deep, and 2.4 m bag) and 30.5 m lead ropes. Each haul was completed by using a boat to set the net approximately 30 m upstream and offshore of the site. Using the lead ropes, the seine was then towed in a downstream arc to the shore and beached. With small sample sizes (less than 500 fish), all clupeids (*Alosa sapidissima*, *A. aestivalis*, *A. pseudoharengus*, and *Brevoortia tyrannus*) were fixed in 4% formalin and returned to the laboratory. With large sample sizes, clupeids were subsampled volumetrically and unneeded fish returned to the water. Water temperature, weather conditions, time and tidal stage (when appropriate) were recorded for each station.

In the laboratory, juvenile clupeids were identified to species by the criteria of Lippson and Moran (1974) and counted. Up to 40 juvenile shad per haul were measured (TL mm) and stored in 67% isopropyl alcohol. Individual seine collections containing greater than 40 shad were randomly subsampled for length measurements. All other clupeids were only counted, although representative samples were archived in isopropyl alcohol along with the American shad for future study.

The relative abundance of juvenile American shad was calculated as the arithmetic mean catch per seine haul from all stations and all dates sampled. An index of per diem growth in length (mm/day) for juvenile American shad was determined by linear regression of mean length for each collection date against time in days, the slope being an estimate of daily growth. The relative abundance of juvenile blueback herring was calculated in a manner similar to that used for American shad.

Job 2. Population Dynamics of American Shad in the Thames River

Job 2A. To monitor the sport fishery for American shad in the Thames River.

The sport fishery in the Thames River was monitored by conducting a roving creel survey during daylight hours of recreational fishermen within State waters from April 1 through June 15. Anglers were canvassed one weekday and one weekend day per week. Survey methods are similar to those used in the Connecticut River and cited above (Job 1B). Anglers were interviewed to determine the number of shad caught, the disposition of that catch (creeled or released), how long they had been fishing at that site and whether they had finished fishing at that site. Creel census clerks also determined the number of anglers at that site, and other pertinent conditions such as weather conditions and time.

Catch per unit of effort, percentages creeled and released, and total effort were tabulated

for the upper Thames River for all shore sites combined and for the boat fishery separately. Given the small size of the fishery in past years, it was not thought to be necessary to subdivide anglers into successful and unsuccessful as is done in the Connecticut river system. Information was expanded by weekly effort and summed for a season total.

Job 2B. To measure the relative abundance of juvenile American shad in the Thames River.

Juvenile clupeids were collected weekly from June 6th through October 17th. As many as fifteen different stations were sampled weekly over the season in attempts to find the best possible sites (Figure 3). Stations were subdivided into those above Greenville Dam and below based on different river conditions and sampling strategies. Sites above the dam were sampled with a 7.6 m bag seine (4.6 mm mesh, 2.4 m deep, and 1.5 m bag) during daylight hours. This seine was employed by having one person act as a stationary anchor in approximately 1.2 m of water with a second individual walking out the length of the seine. The net was then brought into shore in a downstream arc with the downstream end of the net slightly ahead of the upstream end to retain fish. This technique is different from that used downstream of the Greenville dam and on the Connecticut River where a boat is used to set the net upriver and offshore of the site. This was not possible above the dam because of shallow water depths and lack of adequate boat launch facilities. Sites below the Greenville dam were chosen based on location, physical conditions and accessibility. One seine haul per station was made during daylight hours with a 15.2 m nylon bag seine (4.6 mm mesh, 2.4 m deep, and 2.4 m bag) and 30.5 m lead ropes. Each haul was completed by using a boat to set the net approximately 30 m upstream and offshore of the site. Using the lead ropes, the seine was then towed in a downstream arc to the shore and beached. With small sample sizes (less than 500 fish), all clupeids (*Alosa sapidissima*, *A. aestivalis*, *A. pseudoharengus*, and *Brevoortia tyrannus*) were fixed in 4% formalin and returned to the laboratory. With large sample sizes, clupeids were subsampled volumetrically and unneeded fish returned to the water. Water temperature, weather conditions, time and water height (tidal stage below the dam sites, river levels above) were recorded for each station.

In the laboratory, juvenile clupeids were identified to species by the criteria of Lippson and Moran (1974) and counted. Up to 40 individuals of each of the alosid species were measured (TL mm) per seine collection. Collections of individual species greater than 40 were randomly subsampled for length measurements. Representative samples of all alosids were archived in 67% isopropyl alcohol for future study.

The relative abundance of juvenile American shad was calculated as the arithmetic mean catch per seine haul from selected stations and all dates sampled. The relative abundance of juvenile blueback herring and alewives was calculated in a manner similar to that used for American shad.

RESULTS

Job 1A. To determine annual abundance of adult American shad, population size, age structure, and sex ratio in the Connecticut River.

A total of 276,289 American shad were lifted at the Holyoke dam (Mass. Coop. Fish. Unit unpub. report) in 66 days of operation from April 16 through August 14, 1996. Utilizing Holyoke lift information, the population estimate for the Connecticut River in 1996 was 667,137. Several problems were encountered in estimating the population size in 1996 by the usual formula, mainly that the number of days between the opening of the lift and close of operations (the denominator) was much greater than the number of days when the lift was operated. The lift was not operated for at least 12 days during the season due to high and turbid water. On some days, lifts were possible but fish counts could not be obtained as the water was so turbid that observers could not see through the observation window in the lift flume. However, if the number of days of operation were utilized as in past years, the population estimate would be larger than anecdotal information from both the commercial and sport fisheries suggest. It remains unclear what alternate weighting factor should be used, so the simplest approach of only including days when counts were possible was used for calculating the denominator.

With some caution necessary because of estimation techniques, the 1996 run was up from low levels seen in 1994 and 1995 (Table 1). While this is likely a function of good recruitment from the strong juvenile year classes throughout the late 1980s and early 1990s, it should be noted that, although 1996 had what would be considered a moderate number of adults in the run, the number of returning adults should have been close to 2.5 million (Savoy 1996).

The sex ratio of the 1996 run was 70.5:29.5 males to females. The dominance of males in the run is slightly higher than other years (Table 1), but more typical of other years than the predominance of females seen in 1993 and 1994. Sex composition of the run has been derived from information collected at the Holyoke fish lift which is upstream of the both the commercial and sport fisheries, however, the combined impact of these fisheries is not thought to be great enough to change the composition of the run, particularly as recreational fishermen are not thought to cull their catch given the low numbers of fish harvested in recent years.

The population of both male and female shad was dominated by five year olds from the 1991 year class (Table 2). The very strong 1992 year class was moderately well represented in males and it is possible that the limited presence of four year old females is partly a function of reduced sample sizes for ageing fish in recent years. The very low numbers and small percentage of the run that three year old males constitute is in keeping with the greater than normal losses of virgin shad seen in 1994 and 1995 that have been attributed to predation losses (Savoy 1996). Numbers and percentages of repeat spawners were typical of most years. Repeat spawners were not overly dominant as a percentage because of recruitment from the strong year classes in the early 1990s. These strong year classes would be expected to have a somewhat delayed maturation schedule due to density dependent factors limiting growth. These smaller fish would then mature at a slightly later date.

Job 1B. To monitor both the commercial and sport fisheries for American shad in the Connecticut River.

The number of commercial shad fishing licenses sold in 1996 decreased by approximately one third to 26, the lowest number in recent years (Table 3). The number of boats (13) utilized in 1996 also decreased from 1995 at a similar rate to license holders, but the number of days fished decreased at a slower rate, from 400 down to 300 in 1996. This may be a function of the low stock sizes and poor catches reducing the pool of fishermen to only those more serious about harvesting shad and trying to make a living from fishing. The adjusted number of shad landed in 1996 (27,191) was up only slightly from adjusted 1995 landings (26,045)(Table 3) despite much higher stock abundance. This small increase in total landings resulted in a 50% increase in landings on a per boat or fisherman basis since fewer boats and fishermen landed slightly higher number of fish in 1996 over 1995.

Mortality rates were highly variable and incalculable in some instances due to small sample size/population abundance (Table 4). Fishing mortality (F) is always constant in these iterations by virtue of the age distribution being derived from scale samples taken in commercial markets. Instantaneous fishing mortality rates of 0.21 and 0.03 (females and males, respectively) suggest that commercial fishing is not causing problems by harvesting too many fish. Rates on male shad are especially low and may be due, in part, to the very small size of males recruiting from the recent strong year classes and that these small shad would not be susceptible to the relatively large fixed mesh sizes (5-5 1/2" stretched mesh) used in the fishery. Among females, estimates of total mortality (Z) of both age 4/5 and 5/6 suffered from too few representatives in the sample group to accurately estimate mortality rates

Expanded total catch from the recreational fishery for American shad within the State of Connecticut (2,462 shad) increased by 83% (Table 5) from the very low 1995 catch (1,348 shad)(Table 5). No information is available on the sport fishery in the Massachusetts section of the Connecticut River at this time. In contrast to the increase in catch, effort continued to decline and reached the lowest levels seen since 1982 (Table 5). This continued decline is likely a function of poor catches in recent years, but may also be related to a general shift of the recreational fishery to target striped bass in the Connecticut River above Hartford, CT in the usual shad fishing areas. Overall catch per unit of effort (0.31) made a moderate increase from the very low levels seen in 1995 (0.10) but was still lower than expected given the modest number of adult fish available. Catch rates (catch per unit effort) were quite variable among sites and methods ranging from 0.0 to 0.59 (Table 6). Boat fishermen typically account for the majority of the catch and generally have much higher catch rates (cpue = 0.59) than shore-based fishermen (cpue = 0.14). Boat based fishermen only accounted for just over one third of the effort in 1996, but 72% of the total catch. The percentages of shad creel and released were close to 50:50 (47% creel, 53% released, Table 6) which was somewhat surprising given the low numbers of fish caught and the relatively long time to catch a fish (average cpue = 0.31, hence approximately 3 hours to catch a fish).

Job 1C. To measure the relative abundance of juvenile American shad in the Connecticut River.

The total number of juvenile American shad collected in the seine survey in 1996 (3,716) was only a modest increase from the number seen in 1995 (3,082)(Table 7), despite an almost doubling of the adult shad run. This is additional evidence that, above some threshold number of female parent stock, the potential number of eggs is not the prime factor in determining year class strength. Catches of American shad (Table 8) by station and over time (Figure 4) were highly variable ranging from zero to 1,360. The incidence of zero counts was moderately low (32%) which supports the index as moderately strong. All stations had positive collections at some point although the three stations in the lower river accounted for 47% of the total catch (Figure 5). The upriver site of Wilson accounted for 42% of the total catch for the year, however, it is worth noting that almost 88% of this site total occurred in a single collection (09/04/96, Table 8). This high catch may have been an indication of fish emigrating from upriver areas, however, no other site had a comparable catch to track the movement of these juveniles in the river. The arithmetic mean catch of juvenile American shad from all stations and all dates was used as the relative index of abundance and catches suggest that the 1996 year class is moderately strong with a value of 37.2 (Table 10). The index of per diem growth in length (mm/day) for juvenile American shad was calculated as 0.201 (Table 10), also supporting the estimate of a moderately strong year class. The slow growth rate is consistent with density dependent growth of juveniles as described in previous reports (Crecco et al. 1981).

Numbers of juvenile blueback herring continued to decline and reached the lowest total number collected since 1978 (Table 7). In contrast to juvenile shad collections discussed above, collections of blueback herring juveniles were more consistent in both space and time (Table 9)(Figure 6). The lower three collection sites accounted for 94% of the herring collected (Figure 7). The upriver site of Holyoke produced only a single herring all year. Surprisingly, the Glastonbury site, typically a stronghold of blueback herring, only produced 2% of the total catch. Individual sites had collections ranging from zero to only 485. Typically in past years, large collections of blueback herring were measured in multiples of thousands. The incidence of zero counts (43%) was higher than that for shad and the relative abundance index was estimated as 49.6 (Table 10). The declining trend in relative abundance of blueback herring fell to a new low in 1996 and does not bode well for future adult recruitment to the Connecticut River.

Job 2A. To monitor the sport fishery for American shad in the Thames River.

A total of 42 shad were documented by creel clerks in the Thames River system. Of these, 38% were creeled and 62% released. Expanded totals from the recreational fishery for American shad in the Thames River suggest that very low numbers of shad (less than 200) were captured. Most of the angling effort in the Thames system was expended in pursuit of striped bass. Numerous locations were canvassed but it appears that shad fishing was restricted to two 'sites', the east and west side of the Shetucket River immediately below the Greenville Dam. A total of 925 shad were passed in the Greenville fishlift and this approximate run size supports the estimate of the sport catch.

Job 2B. To measure the relative abundance of juvenile American shad in the Thames River.

Large numbers of alosids were collected in the Thames River system, although only two of 190 seine hauls had American shad juveniles. Both of these collections were made at sites well below the Greenville Dam, in areas that may have sampled fish from Long Island Sound. In both cases, only a single American shad juvenile was returned to the lab for positive identification. One of the positive collections for American shad contained over 8,700 juvenile menhaden. No alosids were collected from areas sampled above the Greenville dam despite approximately 1000 American shad and some number of alewives and blueback herring lifted at the dam.

Final determination of the relative abundance of the three alosid species will be made in 1997/1998, after an additional year of seine collections and site selections are made. In the interim, it is fair to say that the relative abundance of juvenile American shad in the Thames River for 1996 is low.

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Table 1. Population estimates, numbers lifted at Holyoke, Connecticut sport catch, adjusted commercial catch, sex ratio of female American shad, and numbers of adult blueback herring lifted at the Holyoke dam in the Connecticut River from 1975-1996.

YEAR	SHAD POPULATION	SHAD LIFT	SPORT CATCH	COMMER CATCH	SEX RATIO	BLUEBACK HERRING
1975	847530	114137		123344	0.37	1625
1976	936900	346702		138650	0.49	4745
1977	361890	202997		97024	0.66	32932
1978	560700	144698		85962	0.37	34953
1979	557010	255753		73321	0.47	39461
1980	685080	376276		88329	0.48	198000
1981	909270	377124		97684	0.34	419733
1982	939330	294834	17518	81132	0.37	586808
1983	1574460	528185	11846	99328	0.34	454242
1984	1231110	496879	17094	88579	0.49	482954
1985	727560	481668	7482	89303	0.43	630000
1986	748440	352122	6912	117770	0.52	517521
1987	587520	271974	7843	64732	0.42	356846
1988	647640	294157	6424	77179	0.33	343363
1989	979440	353819	5243	72996	0.56	286259
1990	816480	363825	9687	57642	0.41	392157
1991	1195920	523153	17600	70479	0.28	412380
1992	1628039	721764	29323	50039	0.48	312863
1993	749227	340431	10813	32358	0.68	103447
1994	325558	180807	5318	21212	0.65	31766
1995	303973	190295	1200	26045	0.34	112136
1996	667137	276289	1500	23400	0.30	55011

Table 2. Population estimates, adjusted commercial catch, spawning history, and age distribution of American shad in the Connecticut River in 1996.

FEMALE SHAD						
	Age group					
	4	5	6	7	8+	Total
Adjusted commercial catch	3067	11162	6134	503	50	20916
Population size	68967	250994	137934	11306	1131	470332
% Population	14.7	53.4	29.3	2.4	0.2	
Repeat spawners		9045	35049	11306	1131	56531
% Repeats		3.6	25.4	100	100	

MALE SHAD						
	Age group					
	3	4	5	6	7	Total
Adjusted commercial catch	56	2388	3498	333		6275
Population size	1742	74890	109723	10450		196805
% Population	0.9	38.1	55.8	5.3		
Repeat spawners		1742	20900	8708		31350
% Repeats		2.3	19.0	83.3		

Table 3. Reported and adjusted total catch (numbers) and weight of shad taken by the commercial fishery, 1992-1996.

	1992	1993	1994	1995	1996
Number of male shad reported	7171	5173	1812	1862	2298
Number of female shad reported	23768	17790	19400	12299	13660
Total number	30939	22963	21212	14161	15958
Adjusted number of male shad	17075	7770	28881	6565	6275
Adjusted number of female shad	32964	24588	10108	19480	20916
Adjusted Total number	50039	32358	38989	26045	27191
Adjusted Total weight (metric tons)	101.1	67.6	68.2	69.5	56.9
Number of licensed fishermen	33	33	39	39	26
Number of boats	16	16	17	19	13
Number of fishing days	410	400	350	400	300

Table 4. Age-specific rates of instantaneous total (Z), commercial fishing (F) and extraneous (M) mortality rates of male and female shad between 1995 and 1996.

	Age Group			
	4/5	5/6	6/7	7/8+
FEMALE SHAD				
1995 population	9987	48794	39378	3709
1996 repeats	9045	35049	11306	1131
Z	0.10	0.33	1.25	1.19
F	0.21	0.21	0.21	0.21
M		0.12	1.04	0.98
MALE SHAD				
	Age Group			
	3/4	4/5	5/6	6/7
1995 population	10077	67178	97408	20153
1996 repeats	1742	20900	8708	
Z	1.76	1.17	2.42	
F	0.03	0.03	0.03	
M	1.73	1.14	2.39	

Table 5. Expanded effort (hours), catch (numbers), change in catch from previous year (percent), and average catch per unit effort (CPUE) from recreational shad fishermen in the Connecticut portion of the Farmington and Connecticut Rivers, 1982 - 1996.

Year	Effort	Catch	% Change in Catch	CPUE
1982	25280	17518		0.69
1983	19721	11846	-32.4	0.60
1984	23207	17094	44.3	0.74
1985	19536	7482	-56.2	0.38
1986	19522	6912	-7.6	0.35
1987	18292	7843	13.5	0.43
1988	17795	6424	-18.1	0.36
1989	10508	5243	-18.4	0.50
1990	13677	9687	84.8	0.71
1991	25278	17600	81.7	0.70
1992	34027	29323	66.6	0.86
1993	21865	10813	-63.1	0.49
1994	22310	5318	-50.8	0.24
1995	13439	1348	-74.7	0.10
1996	7891	2462	82.6	0.31

Table 6. Expanded effort (hours), catch (numbers), percentage creeled and released, and average catch per unit effort (CPUE) from recreational shad fishermen in the Connecticut portion of the Farmington and Connecticut Rivers, 1996.

Site	Effort	Catch	% Creeled	% Released	CPUE
Wilson	332	25	83	17	0.08
Farmington	3951	515	41	59	0.13
91 West	106	4	0	100	0.04
EnfieldA	10	0	0	0	0.00
EnfieldB	251	56	75	25	0.22
All Other Combined	227	74	73	27	0.33
Total Shore	4877	674	54	46	0.14
140 Bridge	23	13	50	50	0.57
Boats	2991	1775	37	63	0.59
Total Comb.	7891	2462	47	53	0.31

EnfieldA and EnfieldB are above and below the Enfield dam, respectively.

Table 7. Total catch and percent composition of juvenile shad and blueback herring, 1978-1996.

Year	Total number of shad	% shad	Total number of bluebacks	% bluebacks
1978	1,680	8.3	18,463	91.7
1979	824	9.9	7,493	90.1
1980	1,777	9.0	18,047	91.0
1981	1,165	9.0	11,822	91.0
1982	391	6.9	5,301	93.1
1983	1,574	4.2	36,172	95.8
1984	67	3.0	28,598	97.0
1985	1,148	6.0	17,697	94.0
1986	1,532	9.7	14,289	90.3
1987	4,205	14.4	24,952	85.6
1988	2,234	7.0	29,680	93.0
1989	5,914	31.0	13,148	69.0
1990	4,143	14.7	24,132	85.3
1991	5,331	24.0	16,954	76.0
1992	10,424	37.6	17,328	62.4
1993	7,876	38.1	12,784	61.9
1994	10,791	48.2	11,582	51.8
1995	3,082	26.9	8,374	73.1
1996	3,716	43.8	4,765	56.2

Table 8. Catch, effort and catch per effort of juvenile American shad from the 1996 seine survey. C = Total catch, E = Number of seine hauls.

AMERICAN SHAD

Date	<u>Station</u>							C	E	C/E
	Holyoke	Enfield	Wilson	Glastonbury	Salmon R.	Deep River	Essex			
7/17	-	83	60	7	94	89	67	400	6	66.67
7/25	40	0	5	9	10	122	21	207	7	29.57
7/31	4	0	19	8	14	46	113	204	7	29.14
8/07	0	2	6	0	38	35	10	91	7	13.00
8/14	0	0	7	0	24	58	6	95	7	13.57
8/21	0	0	13	0	133	131	1	278	7	39.71
8/28	0	0	29	0	63	155	48	295	7	42.14
9/04	0	0	1360	0	61	0	0	1421	7	203.00
9/11	0	0	11	0	6	18	7	42	7	6.00
9/18	213	1	0	0	173	3	-	390	6	65.00
9/25	5	0	35	0	18	18	0	76	7	10.86
10/02	27	0	0	3	52	13	10	105	7	15.00
10/09	0	1	2	0	14	14	17	48	7	6.86
10/16	6	0	0	3	8	4	43	64	7	9.14

- No seine sample taken.

Table 9. Catch, effort and catch per effort of juvenile blueback herring from the 1996 seine survey. C = Total catch, E = Number of seine hauls.

BLUEBACK HERRING

Date	<u>Station</u>							C	E	C/E
	Holyoke	Enfield	Wilson	Glastonbury	Salmon R.	Deep River	Essex			
7/17	-	2	1	0	14	87	16	120	6	20.00
7/25	1	0	0	4	214	162	157	538	7	76.86
7/31	0	0	0	56	43	277	78	454	7	64.86
8/07	0	1	0	0	169	485	81	738	7	105.43
8/14	0	0	3	0	31	331	65	430	7	61.43
8/21	0	0	1	0	231	136	0	368	7	52.57
8/28	0	0	8	1	210	266	12	497	7	71.00
9/04	0	0	88	51	124	0	1	264	7	37.71
9/11	0	0	0	2	0	54	2	58	7	8.29
9/18	0	2	4	0	438	33	.	477	6	79.50
9/25	0	0	39	0	16	220	4	279	7	39.86
10/02	0	0	0	0	162	15	118	295	7	42.14
10/09	0	26	6	0	112	18	65	227	7	32.43
10/16	0	0	0	0	3	0	17	20	7	2.86

- No seine sample taken.

Table 10. Relative abundance index (CPUE) and mean daily growth rate (mm/day) of juvenile American shad for the 1966-1996 year classes and the relative abundance index of blueback herring from the 1978-1996 year classes.

Year class	Abundance index ^{1/} of American shad	Mean daily growth (mm/day)	Abundance index of Bluebacks
1966	32.8	0.460	
1967	20.2	0.742	
1968	11.1	0.987	
1969	19.0	0.775	
1970	27.8	0.435	
1971	65.7	0.268	
1972	15.3	0.613	
1973	12.7	0.536	
1974	-	-	
1975	-	-	
1976	-	-	
1977	-	-	
1978	18.6	0.415	209.8
1979	47.9	0.382	107.0
1980	21.3	0.238	222.8
1981	12.5	0.315	127.1
1982	7.8	0.759	64.6
1983	16.6	0.449	393.2
1984	11.2	0.622	433.4
1985	15.9	0.433	229.8
1986	17.0	0.406	158.8
1987	44.3	0.216	265.4
1988	24.0	0.296	319.1
1989	61.6	0.185	137.0
1990	43.0	0.240	251.4
1991	49.4	0.188	156.7
1992	97.4	0.267	161.9
1993	79.6	0.333	129.1
1994	107.9	0.205	114.7
1995	22.8	0.304	73.5
1996	37.2	0.201	49.6

^{1/} Data from 1966-1973 were taken from Marcy (1976) at stations corresponding to those of 1978-1996.

Figure 1. The Connecticut River showing locations of concentrated fishing effort for recreational shad anglers (X = shore access; O = boat ramp).

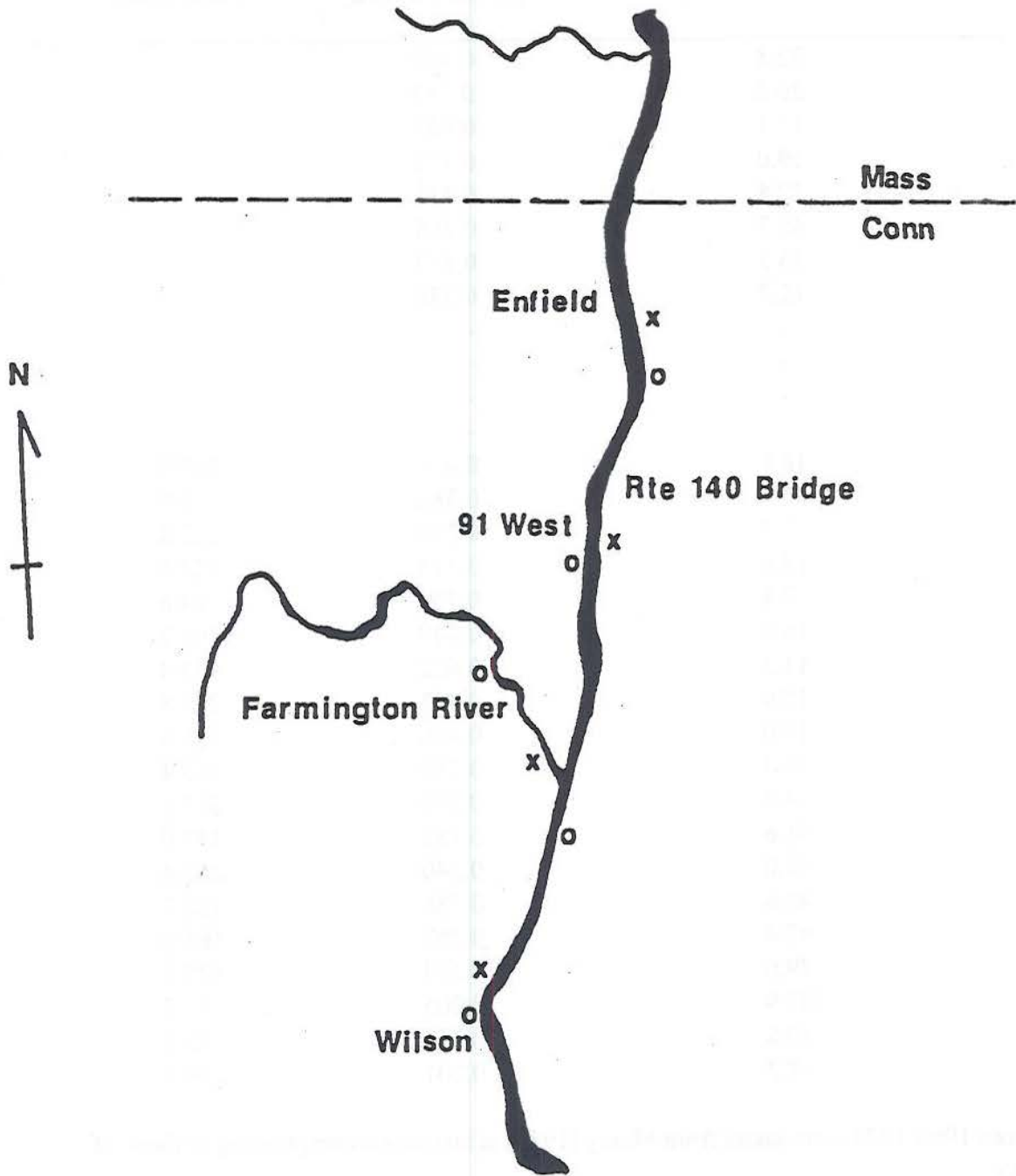
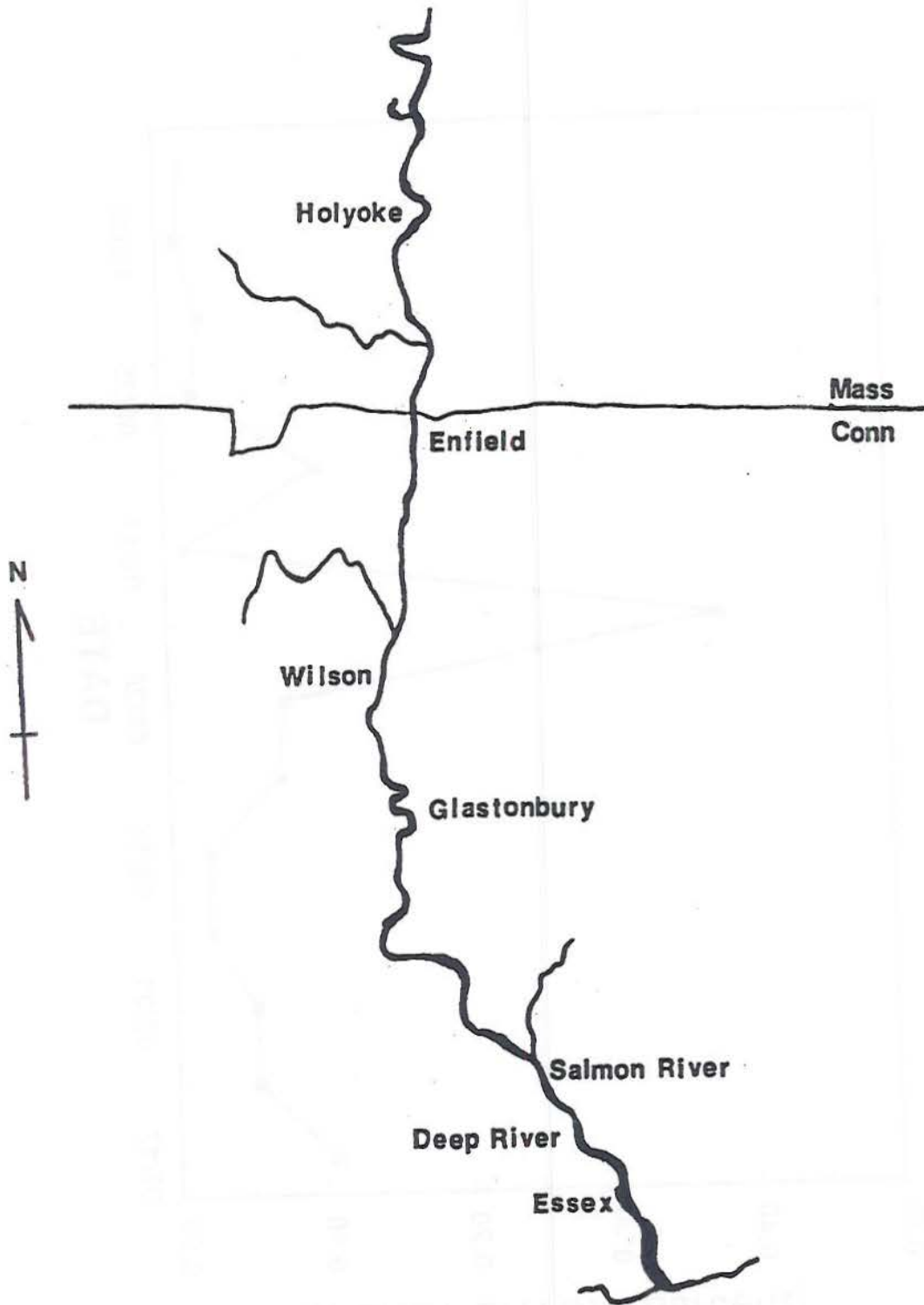


Figure 2. The Connecticut River showing locations of juvenile American shad sampling



stations.

Figure 3. Percent of juvenile American shad collected in the Connecticut River per week in 1996.

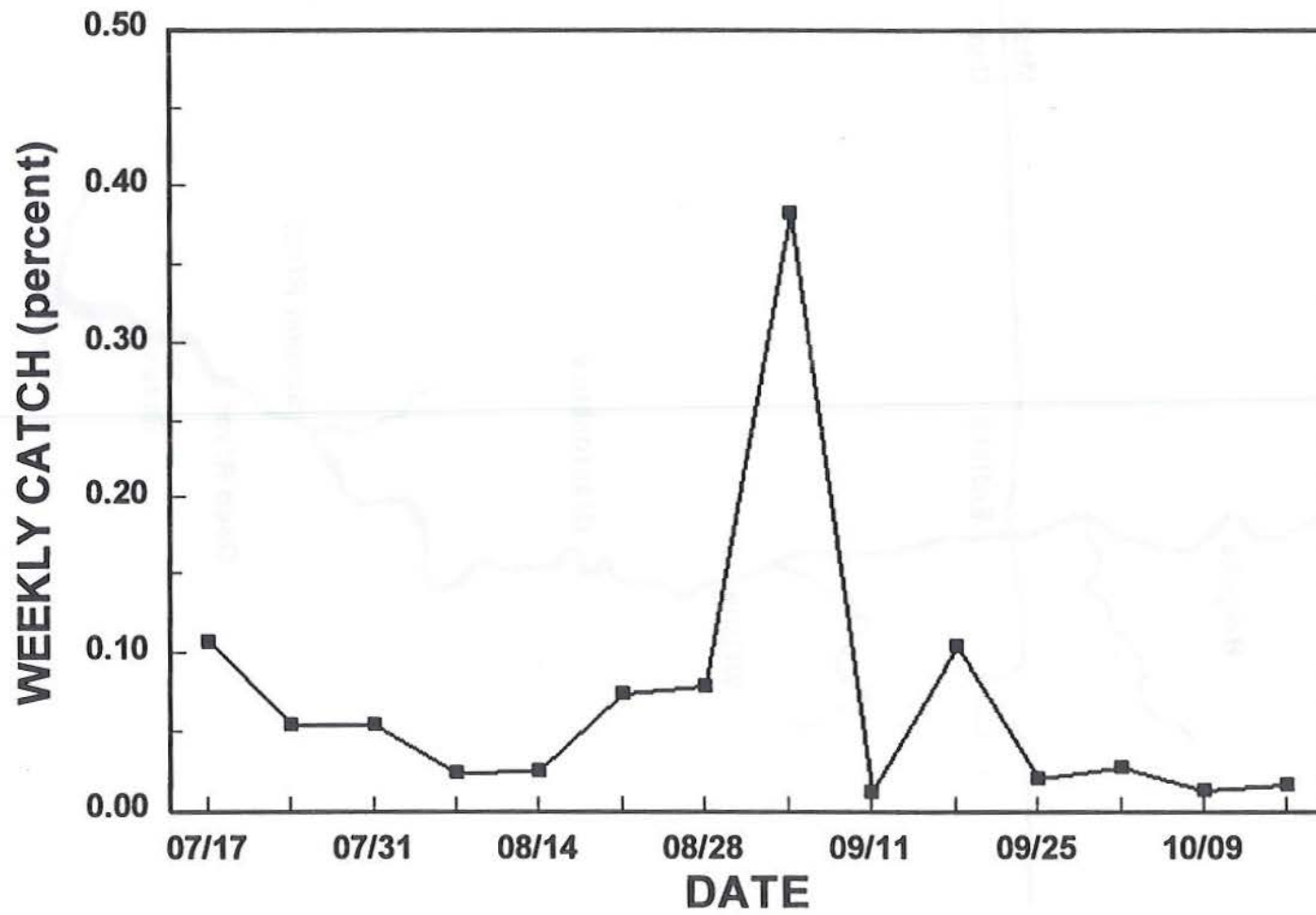


Figure 4. Number of juvenile American shad collected in the Connecticut River per station in 1996.

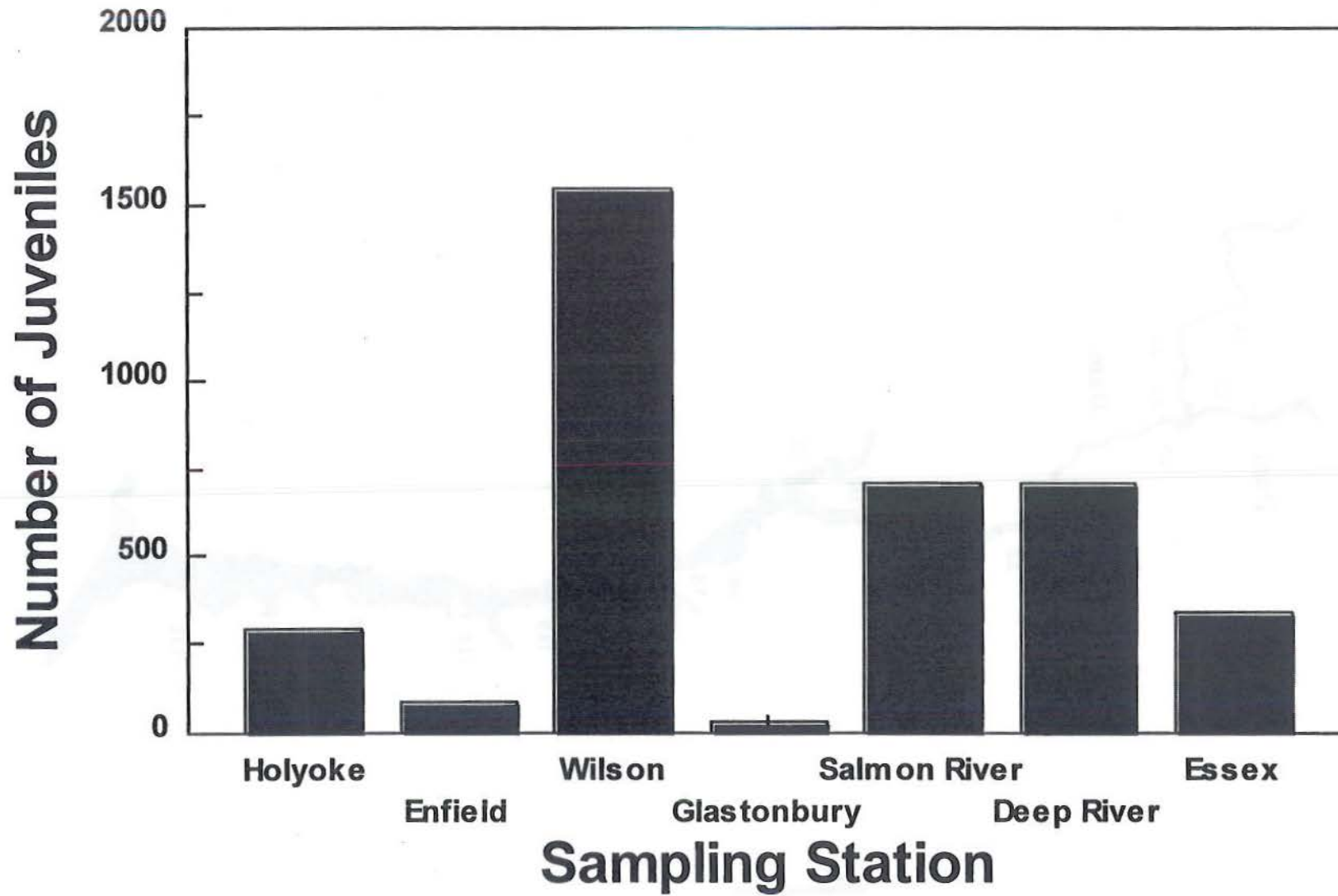


Figure 5. The Thames River showing locations of juvenile clupeid seine sampling in 1996 (A = sampling sites above the Greenville Dam; B = sampling sites below the Greenville Dam).

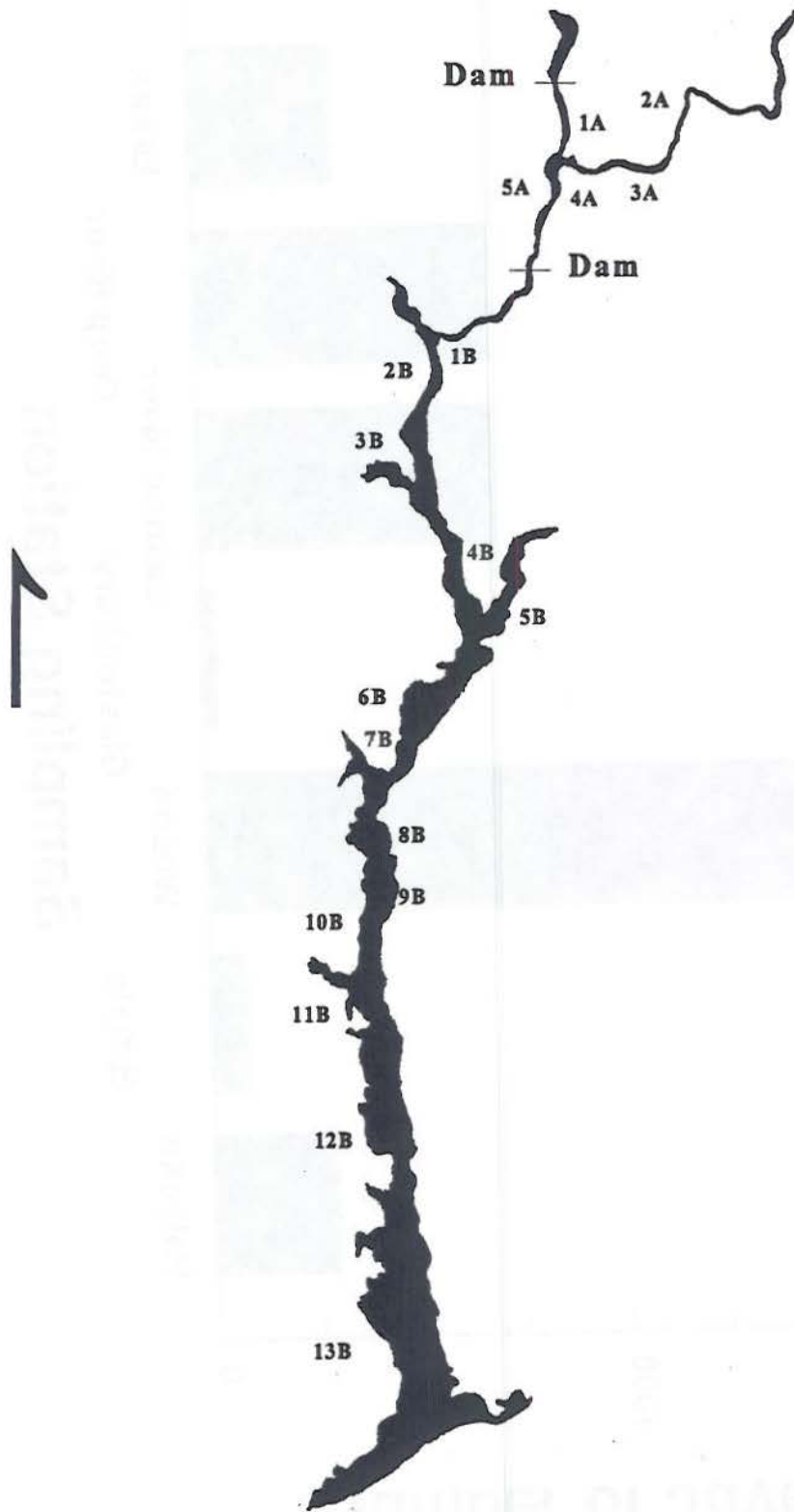


Figure 6. Percent of juvenile blueback herring collected in the Connecticut River per week in 1996.

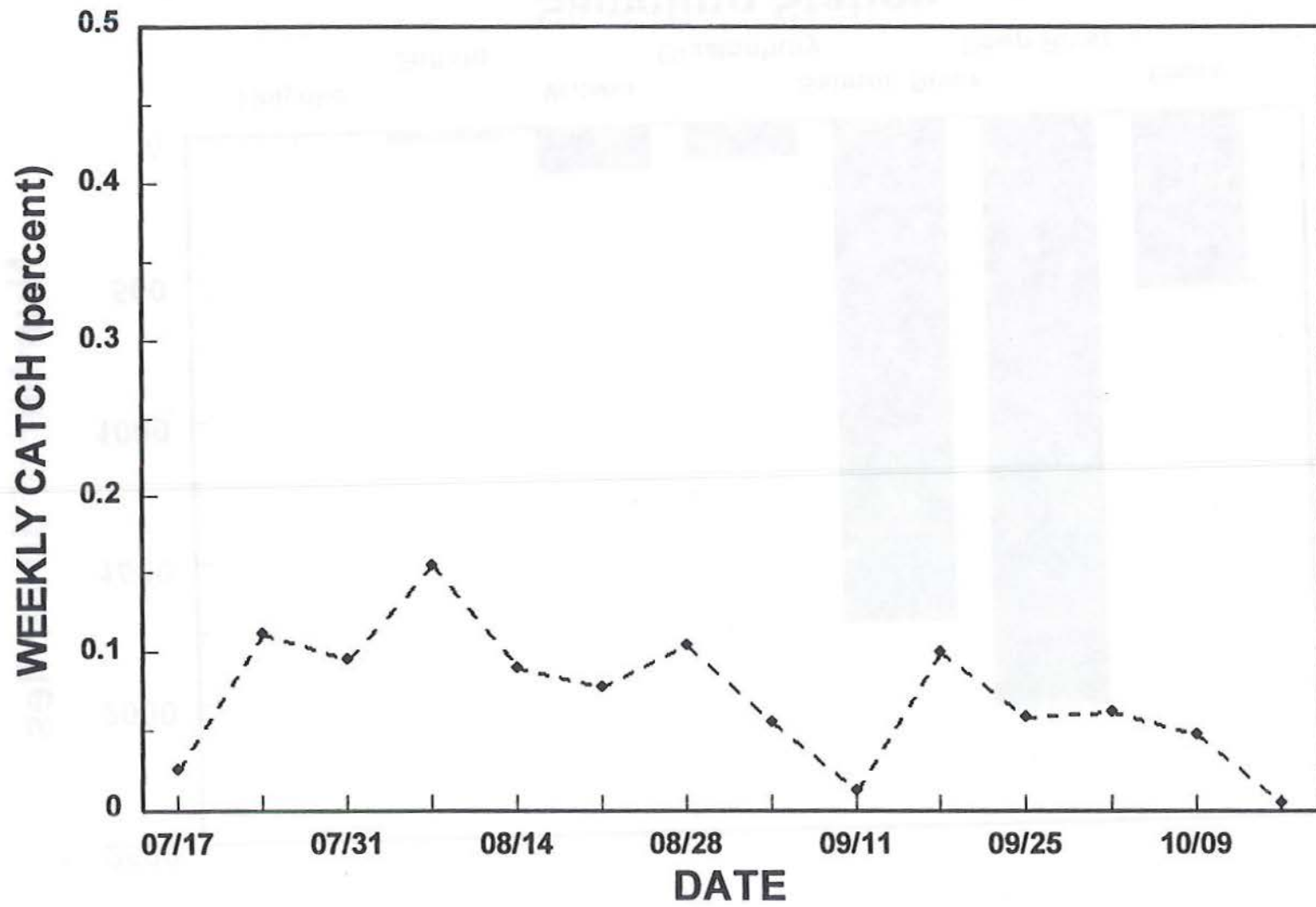


Figure 7. Number of juvenile blueback herring collected in the Connecticut River per station in 1996.

