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INTRODUCTION

This report contains information on studies conducted in Connecticut waters on American shad (*Alosa sapidissima*), shortnose sturgeon (*Acipenser brevirostrum*), Atlantic sturgeon (*Acipenser oxyrhynchus*) and other anadromous fish including the river herrings (blueback herring, *Alosa aestivalis*, and alewife *Alosa pseudoharengus*) from April 1, 1992 to March 31, 1993. Financial support was provided by the National Marine Fisheries Service and the State of Connecticut.

American shad are part of an ongoing restoration effort in the Connecticut River and are an important resource to the State of Connecticut and other Connecticut River basin states. The annual spawning run supports valuable sport and commercial fisheries. The Connecticut Department of Environmental Protection (DEP) began American shad studies in 1974 and has continued to monitor annual changes in population size, the contribution of each year class to the annual spawning population, and the amount of commercial fishing mortality (Jones et al. 1976; Minta 1977; Minta et al. 1979; Crecco et al. 1981, 1982).

The Connecticut DEP has been conducting investigations on sturgeon in Connecticut waters since 1988. Information on the numbers of shortnose and Atlantic sturgeon, their seasonal movement patterns, locations of critical habitats, and concentration areas was examined. Additional information on the age and sex composition of the stocks are needed. This report

does not provide specific locations of sturgeon; this information is specifically withheld to protect the stock from intentional or unintentional exploitation.

Other species of native anadromous fish which are the focus of interest if not directed studies include, rainbow smelt (*Osmerus mordax*), sea lamprey (*Petromyzon marinus*), gizzard shad (*Dorosoma cepedianum*), hickory shad (*Alosa mediocris*), and striped bass (*Morone saxatilis*). Information on gizzard shad indicates that this species is becoming established in Connecticut and needs to be monitored for potential interactions with native clupeids. Hickory shad and striped bass are also present but neither of these species are thought to spawn in State waters. Current information on these species is needed. All of the above types of information are frequently used in habitat and environmental assessments and in permit review processes.

Job 1. Population Dynamics of Connecticut River American Shad

METHODS

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

The adult American shad population estimates, age structure and sex ratio were taken from samples collected from the commercial shad fisheries and information obtained from the Holyoke fishlift at Holyoke, MA. Information on the total number of fish lifted, daily lift total, sex ratio and number of lift days (days the lift is in operation) were all obtained from Massachusetts Cooperative Fishery Research Unit personnel. American shad were sexed 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.

Age structure was derived from scale samples collected at commercial markets using only those fishermen known not to cull their catch for 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 scars at the periphery of the scale. Scale radius and distance to each annulus were measured from the focus to the posterior scale edge.

Back calculated fork length (cm) at each annulus was estimated by the Dahl-Lea method (Ricker 1975):

$$L_n = S_n L_t / S_t \qquad (1)$$

where: S_n = projected distance from the scale focus to the nth annulus;

L_n = estimated length at the nth annulus;

L_t = fork length of the fish at capture;

S_t = projected scale radius.

Annual population estimates were derived using daily fish lift rates at the Holyoke dam located in Holyoke, Massachusetts. The shad population size was estimated by dividing the number of American shad lifted annually by the number of days in which 99% of the fish were passed. This rate was multiplied by a weighting coefficient (0.10) to adjust for lift improvements and then multiplied by 1000 to scale the estimates to the proper magnitude (Crecco and Savoy 1985A). Estimates derived in this manner were shown to be positively correlated ($r=0.68$, $P<0.01$) to population estimates derived from commercial statistics (1967-1978) and positively correlated ($r=0.90$, $P<0.001$) to subsequent juvenile indices of abundance.

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

Commercial shad fishermen are required by statute 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. This assumes that none of the five top fishermen over-report their true landings.

Instantaneous total mortality (Z), fishing mortality (F) and natural mortality (M) were estimated for each sex and age group. The age-specific annual fishing rates (u_j) were determined by:

$$u_j = C_j / N_j \qquad (2)$$

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:

$$F_j = -\ln(1-u_j). \qquad (3)$$

Total instantaneous mortality (Z_j) was expressed by:

$$Z_j = -\ln(R_j / N_{j-1}) \qquad (4)$$

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

$$M_j = Z_j - F_j. \qquad (5)$$

Age specific natural mortality was estimated as the difference between commercial fishing mortality (F) and total mortality estimates (Z). Our estimate of natural mortality thus includes all mortalities other than that associated with commercial fishing in the Connecticut River (oceanic commercial

fishing mortality, and recreational fishing mortality).

The sport fishery in the Connecticut River was monitored by conducting a roving creel census of recreational fishermen within State waters (Figure 1) from April 1 through June 15. Anglers were canvassed one weekday and one weekend day per week. Occasionally, two days per week or weekend were sampled when resources permitted. 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 split into groups of those that successfully caught one or more shad and those that were unsuccessful. Results were then tabulated for each group separately and expanded for total catch and effort.

Anglers were interviewed to determine the number of shad caught, the disposition of that catch, how long they had been fishing at that site and whether they were finished fishing at that site. Creel census clerks also determined total angler use of that site, and other pertinent conditions (Field sheet Appendix 1). Catch per unit of effort, 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-based fishery separately. Information was expanded by weekly effort and summed for a season total.

Investigations of the sport fishery for American shad in the Thames River were conducted in a similar manner, although a less intensive sampling scheme was employed and anglers were not split into successful and unsuccessful groups.

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

Juvenile American shad were collected weekly from the second week in July through the third week in October at seven fixed stations located from Holyoke, Massachusetts to Essex, Connecticut (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). 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. All clupeids (*Alosa sapidissima*, *A. aestivalis*, *A. pseudoharengus*, and *Brevoortia tyrannus*) were fixed in 4% formalin and returned to the laboratory. Water temperature, weather conditions, time and tidal stage (when appropriate) were recorded for each station.

In the laboratory, juvenile clupeids were separated to species by the criteria of Lippson and Moran (1974) and counted. All juvenile shad were measured to total length (mm) and stored in 67% isopropyl alcohol.

The relative abundance of juvenile American shad was calculated as the arithmetic mean catch per unit of effort 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.

RESULTS

Job 1A.

A record number of American shad (721,764) were lifted at the Holyoke dam (Mass. Coop. Fish. Unit unpub. report) in 1992, far exceeding the previous record number of shad lifted in 1983 (530,000). The high number of shad passed at Holyoke is a result of recruitment of the strong 1986 and 1987 yearclasses.

The population estimate for the 1992 run is 1,628,039 (Table 1). The sex ratio of the 1992 shad run was evenly distributed, with 51.8% of the run being comprised of males and 48.2% females. Annual sex ratios of the Connecticut River American shad population are variable, fluctuating with year-class strength.

Mean backcalculated lengths at age are reported for males and females, separately (Tables 2, 3) and are similar to values reported (Crecco et al. 1981) from fish taken in a pound net, which was thought to be nonselective for length.

Job 1B.

Thirty three commercial shad fishing licenses were issued in 1992 (Table 4), a drop of 25 % from the 44 issued in 1991. The number of boats fishing decreased correspondingly to 16 and

likewise the number of fishing days declined to 410. Commercial fishermen reported landing 30,939 American shad. Adjustment for culling males and underreporting brought the total to 50,039.

Instantaneous rates (F, M, and Z) for 1992 (Table 5) were similar to those seen during the last 5 years. Approximately 2% of the males and 4% of the females were removed due to commercial fishing. While the above estimates do have error associated with small sample sizes and the corresponding extrapolations, they serve to indicate the relative magnitude of the components and trends over time, as well as to graphically demonstrate the small percentage of the run lost to commercial fishing effort.

In contrast to the decline in the commercial landings, the number of shad caught in 1992 (29,323) (Table 6) by recreational fishermen in the Connecticut River was the highest seen since 1982 and continues the increasing trend in catches begun in 1990. Catch per unit of effort values for the Enfield sites (both above and below) continued to rise, reaching a new high in 1992 of 1.68 and 1.35, respectively. This is nearly double the catch rates seen in the recent past.

Anglers fishing from boats were only slightly more efficient (0.97 fish per hour) than the average shore fisherman (0.72 fish per hour) in 1992, although catch rates of boat fishermen were similar to those seen in 1991. Boat fishermen still accounted for almost 70% of the catch despite the improved catch rates of shore based fishermen in 1992. Catch and effort at the Route 140 bridge site showed a slight increase over the low 1990 and 1991 levels (Savoy and Shake 1991, 1992). Although the new Route 140

bridge was open to fishing, neither the level of effort nor fishing success have returned to those recorded prior to 1990. Access continued to be limited due to the presence of construction equipment and lack of parking.

The recreational shad fishery at the Greenville Dam on the Thames River continues to be a small but locally important fishery. Catches and levels of effort have varied markedly over the last 5 years (Table 7)

Job 1C.

Catches of juvenile shad in 1992 were five times the average annual catch. A total of 10,424 shad were collected, almost double the previous record of 5,914 collected in 1989. This record catch resulted in a relative index of abundance of 97.4 (Table 8). The inverse relationship between juvenile abundance indices and juvenile daily growth rates continued in 1992 and follows the long-term trend observed since 1978 (Figure 3). This relationship serves as an important independent measure to confirm the magnitude of the relative abundance index. Temporally, catches peaked in late July with a second slightly smaller peak in late September (Figure 4). The 1992 catches have resulted in a succession of six strong year classes in a row. This succession of strong year classes indicates that adult recruitment in the mid 1990's will surpass levels seen since prior to the heavy fishing effort after WWII (Crecco and Savoy 1987).

Analyses of juvenile catch by station (Table 9, Figure 5) demonstrates that in 1992 the Wilson station accounted for 50.5%

of the total catch of American shad, and was ranked number one similar to 1991. This is in contrast to the strong yearclasses of 1990 and 1987, where the Holyoke site accounted for 51% of the juvenile shad collected. The Holyoke site accounted for 42.5% of the catch in 1992. Together these two sites accounted for 93% of the total catch in 1992.

Whereas the majority of juvenile American shad (*Alosa sapidissima*) were obtained from the upper portion of the Connecticut River, the southernmost sampling stations continue to contribute the majority of juvenile blueback herring (*A. aestivalis*) collected in the seine survey (Table 10). In 1992, as in all years from 1987 - 1990, the combined catches from the Salmon River, Deep River and Essex stations accounted for greater than 90% of the total juvenile blueback catches in each year (Savoy and Shake 1990).

As in all past years, total abundance of blueback herring were greater than shad, however, the percentage of shad climbed to 37.6% of the total juvenile catch (Table 11).

Job 2. Status of Sturgeon in Connecticut

Methods

Job 2A. To collect information on the numbers, locations, movements and life histories of shortnose and Atlantic sturgeon in the waters of the State of Connecticut.

Netting efforts using both gill nets and skiff trawls were made weekly to capture sturgeon in the Connecticut River. Gill nets were constructed of a single mesh size of 10.0, 12.7, 15.2, 17.8 or 20.3 cm stretch mesh of multifilament nylon and were 30.5 m long by 1.8 m deep. Nets were set on the bottom, parallel to the current flow. Net sets were made throughout the mainstem Connecticut River in Connecticut waters. Net sets ranged from 1 to 26 hours in duration. Typically, four nets were set at one time in a single location when overnight sets were made. When short net sets of 1 to 4 hours were planned, 2 to 4 nets were fished. Short net sets were used to obtain sturgeon for ultrasonic tagging, and to reduce mortalities associated with warm water temperatures (>20°C). The numbers and species of other fish captured in gill net sets were also noted. All sturgeon captured were pooled for analyses regardless of capture method.

A 9.75 m x 7.01 m flat seam bottom trawl with a 6.35 mm mesh codend liner was used in the winter and early spring months when water temperatures were below 15°C. Information previously collected (Savoy 1991) indicated that the sturgeon become inactive once the water temperature dropped below 10°C and therefore became insusceptible to passive gear types such as gill nets.

All shortnose sturgeon obtained were measured to fork and total lengths (mm), weighed (kg), and Carlin tagged. Care was taken to minimize stress while handling and tagging the fish by keeping the fish in water at all times. All fish captured from a single net or tow were removed and placed into a live car before processing. The live car was .9 m x .9m x .75 m deep and constructed of 2.0 cm netting which allowed full water flow through the live car. Sturgeon were supported by cradling the fish lengthwise under their abdomen during all out-of-water experiences. Individual sturgeon were transferred into a 1.35 m long by 25 cm wide by 25 cm deep water filled examination box one at a time for processing. All sturgeon were examined for wounds, scars, deformities, morphometric counts, general condition, measured to length and tagged in this box. Sturgeon were placed on a flattened mesh sling and suspended from a spring scale to accurately measure weight (Jennings 1989). After weighing, sturgeon were placed into the river and allowed to remain in the sling until they voluntarily swam away. The timing and character of this movement was also noted.

Shortnose sturgeon were tagged with orange color carlin dangler tags (6 mm x 16 mm) wired to the base of the left side of the dorsal fin by passing a doubled 0.0126 mm stainless steel wire through each end of the tag (Figure 6). The two ends of the doubled wire were twisted together and cut off to protrude 10-15 mm. Approximately 3-5 mm of extra wire was left on both sides of the dorsal fin to allow for growth of the fish. The protruding wires on the right side were bent backwards to lie along the base

of the dorsal fin to reduce drag and to prevent catching foreign material. The tag legend stated a three digit tag number, and "CT D.E.P. (203) 443-0166".

Atlantic sturgeon were tagged with an international orange color vinyl Floy tube tag (2 mm x approx. length 30.0 cm). This tag bore a one line legend of "(a 5 digit number) CT DEP MARINE FISHERIES (203) 443-0166". The tube tag was inserted near the base of the dorsal fin using a large bore hypodermic needle. The tag was inserted through the needle, the needle removed and the ends knotted together in an overhand knot.

Wax coated ultrasonic transmitters were surgically implanted within the anterior portion of the body cavity of sturgeon. After examination and external carlin tagging, the sturgeon were rolled over onto their backs and the water levels manipulated to cover the gills as much as possible while keeping the ventral side dry. An antiseptic solution (Betadine) was swabbed on before and after the implantation procedure. A single incision was made on the ventral side slightly behind the pectoral girdle and just off the midline of the fish. The incision was kept as small possible (approx. 40 mm) to allow insertion of the sonic tag and closed with 3/0 nonabsorbable monofilament sutures. Nonabsorbable sutures were used to ensure the wound healed before the stitches disintegrated and it was not thought that the suture material would cause any long term problems. Upon completion of transmitter implantation and weighing, sturgeon were held in the mesh sling off the side of the boat or placed into the live car until recovered.

We had proposed to tag Atlantic sturgeon with 90 day ultrasonic transmitters, however, logistical problems prevented all but a single Atlantic from being surgically implanted.

Sturgeon bearing ultrasonic transmitters were relocated as frequently as possible given logistical constraints. Exact locations were determined as closely as possible by triangulating signals which were then plotted on charts. These locations were later converted into latitude and longitude coordinates.

Population estimates of the numbers of shortnose sturgeon were estimated using the Schumacher, Schnabel, and Chapman equations (Ricker 1975).

For all equations:

M_t = the total number of marked fish at large at the start of the tth day;

$M = \Sigma M_t$, total number marked;
C_t = total sample taken on day t;

R_t = number of recaptures in the sample C_t;

$R = \Sigma R_t$, total recaptures during the experiment.

Schumacher's equation is expressed by:

$$\frac{1}{N} = \frac{\Sigma(M_t R_t)}{\Sigma(C_t M_t^2)}, \qquad (6)$$

and the corresponding variance on N is given by:

$$\mathrm{Var}\left(\frac{1}{N}\right) = \frac{s^2}{\Sigma C_t M_t^2} \qquad (7)$$

where:

$$s^2 = \frac{\Sigma(R_t^2/C_t) - (\Sigma R_t M_t)^2 / \Sigma(C_t M_t^2)}{M-1} \quad (7)$$

Schnabel's model is given by:

$$N = \frac{\Sigma(C_t M_t)}{R}, \quad (8)$$

and the corresponding variance by:

$$\mathrm{Var}\left(\frac{1}{N}\right) = \frac{R}{(\Sigma C_t M_t)^2}. \quad (9)$$

Chapman's model as expressed by:

$$N = \frac{\Sigma(C_t M_t)}{(R+1)} \quad (10)$$

where the 95% confidence limits are derived by assuming that the recaptures (R) follow a Poisson distribution.

Results

A total of 50 shortnose sturgeon were captured during this project segment, 13 of which were recaptures. The total number of shortnose sturgeon captured to date is 311 and of these 255 were tagged and released. There have been 10 mortalities over the course of the study, but none have occurred during the last two segments (1991-1993). Shortnose sturgeon ranged from 50.5 to 120.0 cm in total length and varied from 0.8 to 14.0 kg in

weight. The mean and median lengths (TL) of shortnose sturgeon captured was identical (85.0) suggesting that the range of lengths of shortnose sturgeon susceptible to the gears are normally distributed. The length frequency distribution of sturgeon was generally similar among years (Figure 7) which indicates that no major changes to the population structure are occurring over the short term.

Effort was subdivided into overnight gill net sets and daytime short duration net sets. Overnight sets were made on three occasions equaling 298.7 hours of effort resulting in 13 shortnose sturgeon. Short net sets were made on 23 occasions for a total of 246.5 hours and caught a total of 31 shortnose sturgeon.

The population estimate of shortnose sturgeon above 50 cm TL (size fully recruited to gear) in the Connecticut River between the Holyoke Dam and Long Island Sound increased slightly from previously reported estimates (Savoy 1991). The number of recaptures increased from 33 to 46 resulting in a small increase in the population estimate but this also increased the precision of those estimates. The estimate from the Schumacher equation changed from 889.7 to 894.8 with 95% confidence interval from 799 to 1018. The Schnabel equation produced an estimate of 874.7 and the Chapman point estimate was 856. All three formulas produce very similar estimates ($\bar{x}$ = 875.2).

Eleven shortnose sturgeon had ultrasonic transmitters active in 1992, six of which were implanted in 1992. The remaining five active transmitters were implanted in 1991. One transmitter

implanted in 1992 provided no information and was thought to be a transmitter failure, however, this fish was relocated in the lower river in May of 1993. The remaining ten transmitters were relocated an average of once a week.

Generally, movement patterns were similar among all years despite differences in location where fish were tagged. Exceptions among years were the differences between winters of 1991/1992 and 1992/1993 and the previous two study winters. No sonically tagged sturgeon were found to be overwintering in the Portland area. The Portland/Middletown area had previously been the most important concentration area for shortnose sturgeon with 9 of 15 sturgeon with ultrasonic transmitters remaining there. Another difference among years was that only a single sturgeon was located in Hartford during the summer months of 1991 and no sturgeon were found there in 1992. However, the Fall of 1992 saw intensive use of the area immediately below Hartford for the first time. Four sturgeon remained in this area for several months making many small (1-2 km) movements.

Shortnose sturgeon have repeatedly demonstrated directed movements to the estuary portion of the river in late April through mid May. Each year, all (total 38 in 5 years) sonically tagged sturgeon have moved to the estuary. Sturgeon remain in this area for approximately 30 to 35 days and mean departure time is between the second and third weeks of June. Movement north out of this area is more gradual than the apparent mass movement down to this area. Downstream movement into the lower river is associated with high flows. These high flows result in

displacement of the salt wedge from the Connecticut River affording shortnose sturgeon access to this area without having to tolerate salinity influences. Movement Northward is split among shortnose sturgeon, with some sturgeon leaving before the saltwater wedge returns and some after. The timing of northward movement is not solely due to increasing salinities as shortnose sturgeon are able to withstand both high salinities and rapid changes in salinity. We have observed sturgeon moving from 0 ppt into 15 ppt in the course of a couple of hours, and other sturgeon that remained stationary and allowed salinity to increase around them with a flood tide. The importance of the lower Connecticut River estuary is demonstrated by the fact that all sturgeon with sonic transmitters active over two spring seasons moved to the estuary region in both consecutive springs. This estuarial movement includes both pre and post spawners. Prespawners are assumed in that these sturgeon later moved to the spawning grounds previous to the spawning period and remained until the spawning period (late April - early May). Movement to the spawning area varied, some sturgeon moved rapidly and directly from the estuary to the spawning grounds while others slowly made their way North. This Northward movement to the spawning ground occurred in the summer for some fish while others waited until the fall. Postspawners are defined as those sturgeon that moved directly from the spawning grounds to the lower river. This downstream movement of postspawners is usually fairly rapid with sturgeon appearing in the estuary only days after having been on the spawning grounds.

In the Connecticut River, Atlantic sturgeon continued to be very limited in distribution in 1992, only 5 Atlantic sturgeon were captured. These sturgeon are usually found in the lower river (km 10-26) within the area of the salt wedge during the summer months. Only a single Atlantic sturgeon has been captured North of this area in the 5 years of directed sturgeon studies.

Population estimates of Atlantic sturgeon in the Connecticut River in 1992 were not calculated because of lack of recaptures. One of the five Atlantic sturgeon captured was surgically implanted with an ultrasonic transmitter. However, this fish did not provide long-term information. This fish remained where released (captured 6/23) for between 3 to 8 days (relocated 6/26) after which it moved north approximately 5.5 miles and remained in a deep hole for between 4 and 10 days (relocated 7/1 7/2, missing 7/9). Thereafter the sturgeon either moved out of the river or experienced transmitter failure as it was never heard again. We were able to capture 3 other Atlantic sturgeon after this date (2 on 8/11 and 1 on 8/31) in the same location where the sonic transmitter was last heard. Information to suggest that this implanted sturgeon may have emigrated out of the river early is that a second Atlantic sturgeon captured in the same netting effort was recaptured in Cape Cod Bay by a commercial fisherman approximately five weeks after being tagged in the Connecticut River. Lengths (TL) of all Atlantic sturgeon captured in the Connecticut River were similar to the lengths for shortnose sturgeon as would be expected since the same gears are employed, from 70.5 to 103.5 cm. The mean size (92.5 cm TL) and

weight of Atlantic sturgeon (4.96 kg) was slightly greater than that of shortnose sturgeon (85.0 cm TL, 4.47 kg) because a single larger Atlantic sturgeon was captured. An additional 28 Atlantic sturgeon were captured in Long Island Sound in 1992 by Connecticut Marine Fisheries personnel. These Atlantic sturgeon were also tagged with the orange vinyl Floy tube tags. Atlantic sturgeon captured in Long Island Sound were similar in size (TL 90.3 - 127.0 cm) to those seen in past years and to those captured in the Connecticut River. One half of Atlantic sturgeon recaptures (3 out of 6 in 5 years) have taken place out of Long Island Sound (Maryland, New Jersey, Cape Cod Bay), supporting the beliefs of extensive coastal movements.

Low numbers (0-50) of immature Atlantic sturgeon are present in the estuarine portions of the Connecticut's rivers during the summer months annually. It is likely, although impossible to state with absolute certainty, that Atlantic sturgeon native to the Connecticut waters are extinct. Reliable anecdotal reports (Cole Wilde, Director Fish & Game, unpub) indicate that a few large sturgeon (6-8 ft) were seen in the Connecticut River below the Enfield Dam as late as the 1960's, however, no confirmed reports of large sturgeon can be found for over 20 years. The seasonal presence of Atlantic sturgeon in the lower Connecticut River and other estuaries outside their natal river during the summer months is consistent with Dovel and Berggren's (1983) explanation of wandering immature Atlantic sturgeon.

Job 3 General Anadromous Fish Investigations

Methods

Job 3A To collect distribution, relative abundance, and stream specific habitat utilization information on the other anadromous species in Connecticut waters.

Assessment activities included site visitation, participating in environmental assessment activities and determining effects of permitted activities. Qualitative abundance of anadromous species in individual coastal streams and rivers were determined through use of site visits, fish traps, seines, gill nets and trawl gear. Fish traps were deployed in coastal tributaries and streams throughout Connecticut before the spring spawning runs began. The traps were then checked as frequently as possible and species composition, sex, spawning condition and water temperature recorded. Sampling with gillnets, seine and trawl gear were conducted as time, manpower and need dictated.

Job 3B. To restore or improve anadromous fish runs in the coastal rivers and streams of Connecticut and to assess the success of restocking efforts.

Restocking and supplementing of present fish runs are conducted in those coastal streams and rivers that have experienced beneficial changes in water quality, habitat or fish access. Transplanting activities would also be preceded by examination of resources present and fish sustaining capabilities including spawning and nursery habitat available. Efforts to

improve spawning runs would also include minor stream channel alterations or construction of low-cost fishways to improve fish access. Results of these efforts were to be assessed through monitoring egg, larval or juvenile abundance.

Job 3C To conduct efforts to determine the presence of rainbow smelt, seasonality, and what gear types should be employed to collect them.

Sampling efforts where conducted in the Connecticut and Thames Rivers and in tributary streams using trawls, seines, and direct observation.

Results

Job 3A.

Several plans and applications were reviewed for potential impacts on anadromous fishes including bridge projects and demolitions. Many smaller proposals were handled by the environmental assessment biologist with consultations to determine what measures would be appropriate to protect anadromous fish runs. Through the use of fish traps, the Hammonasett River was found to still have an alewive run. An experimental fish counter was placed in the outlet to Brides Lake. The counter was checked and reset to zero each day. Several attempts were also made to calibrate the counter, but the preliminary results are still considered unreliable. Useful information includes that the duration of the run was from 4/07/92 through 5/26/92. Additional tunnels will be added and further calibration will occur in 1993.

Site visitations were also made to other streams including frequent visits made to monitor current status of several fish

ladders and several local strong runs of river herring including Latimer Brook, and Gortons Pond.

Job 3B.

No restocking or transplanting of alewives or bluebacks occurred during this project segment.

Job 3C.

Trawling efforts were successful in collecting Rainbow smelt in both the Thames and Connecticut Rivers on several occasions. We are unable to qualitatively assess the different size trawls as the true abundance of smelt is unknown. Many attempts were unsuccessful in capturing any species of fish so these gear trials were considered especially unreliable.

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Table 1. Population estimates, adjusted commercial catch, spawning history, and age distribution of American shad in the Connecticut River in 1992.

FEMALE SHAD

	Age group					
	4	5	6	7	8+	Total
Adjusted commercial catch	1002	16340	15335	287		32964
Population size	23855	388983	365050	6827		784715
% Population	3.04	49.57	46.52	0.87		
Repeat spawners		20460	37527	6827		64814
% Repeats		5.26	10.28	100		

MALE SHAD

	Age group					
	4	5	6	7	8+	Total
Adjusted commercial catch	3389	9646	3780	260		17075
Population size	167400	476394	186712	12818		843324
% Population	19.85	56.49	22.14	1.52		
Repeat spawners	6445	38636	17103	12818		75002
% Repeats	3.85	8.11	9.16	100		

Table 2. Mean backcalculated fork lengths (cm) of male shad by year class and age (years) taken from commercial scale samples in 1992.

Age Group		Year Class	Sample Size	Ave ForkLength	Freshwater Stage	I	II	III	IV	V	VI	VII
IV		1988	26	41.23	10.64	20.25	28.87	36.95	41.22	-	-	-
	SE			0.325	0.615	0.611	0.505	0.397	0.322			
V		1987	74	44.34	10.65	20.46	27.64	35.42	40.93	44.33	-	-
	SE			0.240	0.249	0.366	0.316	0.262	0.234	0.239		
VI		1986	29	47.45	9.98	18.98	27.09	35.13	41.08	45.10	47.45	-
	SE			0.470	0.419	0.474	0.468	0.445	0.451	0.455	0.470	
VII		1985	2	49.00	11.43	15.98	25.37	33.46	40.01	45.10	48.02	49.00
	SE			0.000	3.102	1.251	1.668	3.036	1.896	1.869	0.303	0.000

Table 3. Mean backcalculated fork lengths (cm) of female shad by year class and age (years) taken from commercial scale samples in 1992.

Age Group		Year Class	Sample Size	Ave ForkLength	Freshwater Stage	I	II	III	IV	V	VI	VII
IV		1988	7	44.71	12.31	22.40	31.51	38.99	44.71	-	-	-
	SE			0.837	1.625	0.974	1.087	1.274	0.837			
V		1987	114	47.04	10.73	20.81	29.26	37.21	43.22	47.04	-	-
	SE			0.220	0.225	0.321	0.303	0.263	0.234	0.220		
VI		1986	107	50.19	10.34	20.75	29.34	36.57	42.42	47.06	50.18	-
	SE			0.183	0.230	0.378	0.317	0.233	0.215	0.195	0.183	
VII		1985	2	52.50	14.88	22.89	32.42	38.73	43.92	48.29	51.08	52.50
	SE			0.500	4.825	0.043	1.088	0.351	0.973	0.160	0.698	0.500

Table 4. Reported and adjusted total catch (numbers) and weight of shad taken by the commercial fishery, 1992.

Number of male shad reported	7,171
Number of female shad reported	23,768
Total number	30,939
Adjusted number of male shad	17,075
Adjusted number of female shad	32,964
Adjusted Total number	50,039
Adjusted Total weight (metric tons)	101.9
Number of licensed fishermen	33
Number of commercial gill nets	16
Number of fishing days	410

Table 5. Age-specific rates of instantaneous total (Z), commercial fishing (F) and extraneous (M) mortality rates of male and female shad between 1991 and 1992.

	Age Group				
	3/4	4/5	5/6	6/7	7/8+
FEMALE SHAD					
1991 population		3371	116174	104389	11785
1992 repeats		20460	37527	6827	0
Z		-	1.13	2.73	
F		0.04	0.04	0.04	
M		-	1.09	2.69	
MALE SHAD					
1991 population		127608	363914	94535	14106
1992 repeats	6445	38636	17103	12818	0
Z	-	1.19	3.06	2.00	
F	0.02	0.02	0.02	0.02	
M	-	1.17	3.04	1.98	

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, 1992.

Site	Effort	Catch	% Creeled	% Released	CPUE
Wilson	1205	968	55	45	0.80
Farmington	4698	2147	50	50	0.46
91 West	2254	1099	61	39	0.49
EnfieldA	1061	1782	16	84	1.68
EnfieldB	935	1262	13	87	1.35
All Other Combined	1999	1446	48	52	0.72
Total Shore	12152	8704	40	60	0.72
140 Bridge	725	180	93	07	0.25
Boats	21150	20439	18	82	0.97
Total Comb.	34027	29323	50	50	0.86

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

Table 7. Expanded effort (hours), catch (numbers), percentage creeled and released, and average catch per unit effort (CPUE) from recreational shad fishermen in the Thames River, 1988-1991.

Site	Effort	Catch	% Creeled	% Released	CPUE
1988	521	71	17	83	0.14
1989	98	20	67	33	0.20
1990	215	187	19	81	0.87
1991	165	99	9	91	0.60
1992	112	31	0	100	0.28

Table 8. Relative abundance index (CPUE) and mean daily growth rate (mm/day) of juvenile American shad for the 1966-1992 year classes and the relative abundance index of blueback herring from the 1978-1992 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

1/ Data from 1966-1973 were taken from Marcy (1976) at stations corresponding to those of 1978-1992.

Table 9. Catch, effort and catch per effort of juvenile American shad from the 1992 seine survey. C = Total catch, E = Number of seine hauls.

AMERICAN SHAD

	Station									
DATE	Holyoke	Enfield	Wilson	Glastonbury	Salmon R.	Deep R.	Essex	C	E	C/E
7/15	115	1	286	0	4	2	31	439	7	62.7
7/22	10	0	170	2	6	0	3	191	7	27.4
7/29	337	2	2690	2	34	0	11	3076	7	439.4
8/05	366	2	391	0	72	5	7	843	7	120.4
8/12	78	4	248	0	44	13	18	405	7	57.9
8/19[1]	393	0	598	12	5	10	2	1020	7	145.7
8/26	870	0	52	0	9	9	2	942	7	134.6
9/02	101	0	0	0	0	10	2	113	7	16.1
9/09	73	0	780	-	5	0	2	860	6	143.3
9/16	75	0	27	8	3	16	0	129	7	18.4
9/23	66	0	20	1	9	4	0	100	7	14.3
9/30	1790	0	0	1	10	14	5[2]	1820	7	260.0
10/07	147	0	7	0	4	5	12	175	7	25.0
10/14	5	0	0	0	18	1	10[2]	34	7	4.9
10/21	0	0	0	3	261	5	1	270	7	38.6
10/28	-	-	-	-	0	0	7[2]	7	3	2.3

- No seine sample taken.
1 Exceptionally high water.
2 High water, alternate site.

Table 10. Catch, effort and catch per effort of juvenile blueback herring from the 1992 seine survey. C = Total catch, E = Number of seine hauls.

BLUEBACK HERRING

	Station									
DATE	Holyoke	Enfield	Wilson	Glastonbury	Salmon R.	Deep R.	Essex	C	E	C/E
7/15	36	1	6	0	1543	4444	104	6134	7	876.3
7/22	0	0	2	3	524	183	0	712	7	101.7
7/29	12	4	2	14	364	125	40	561	7	80.1
8/05	70	2	4	0	1469	10	23	1578	7	225.4
8/12	5	0	6	0	1094	1082	1	2188	7	312.6
8/19[1]	103	0	9	12	172	2052	2	2350	7	335.7
8/26	325	2	9	0	146	278	32	792	7	113.1
9/02	53	0	0	0	0	288	9	350	7	50.0
9/09	36	0	9	-	129	3	2	179	6	29.8
9/16	182	0	0	9	97	60	1	349	7	49.9
9/23	43	0	0	0	537	238	0	818	7	116.9
9/30	603	0	0	0	121	26	68[2]	818	7	116.9
10/07	119	0	0	1	7	1	4	132	7	18.9
10/14	0	0	0	1	169	4	2[2]	176	7	25.1
10/21	0	0	0	0	120	2	11	133	7	19.0
10/28	-	-	-	-	0	0	58[2]	58	3	19.3

- No seine sample taken.
1 Exceptionally high water.
2 High water, alternate site.

Table 11. Total catch and percent composition of juvenile shad and blueback herring, 1978-1992.

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	867	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

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

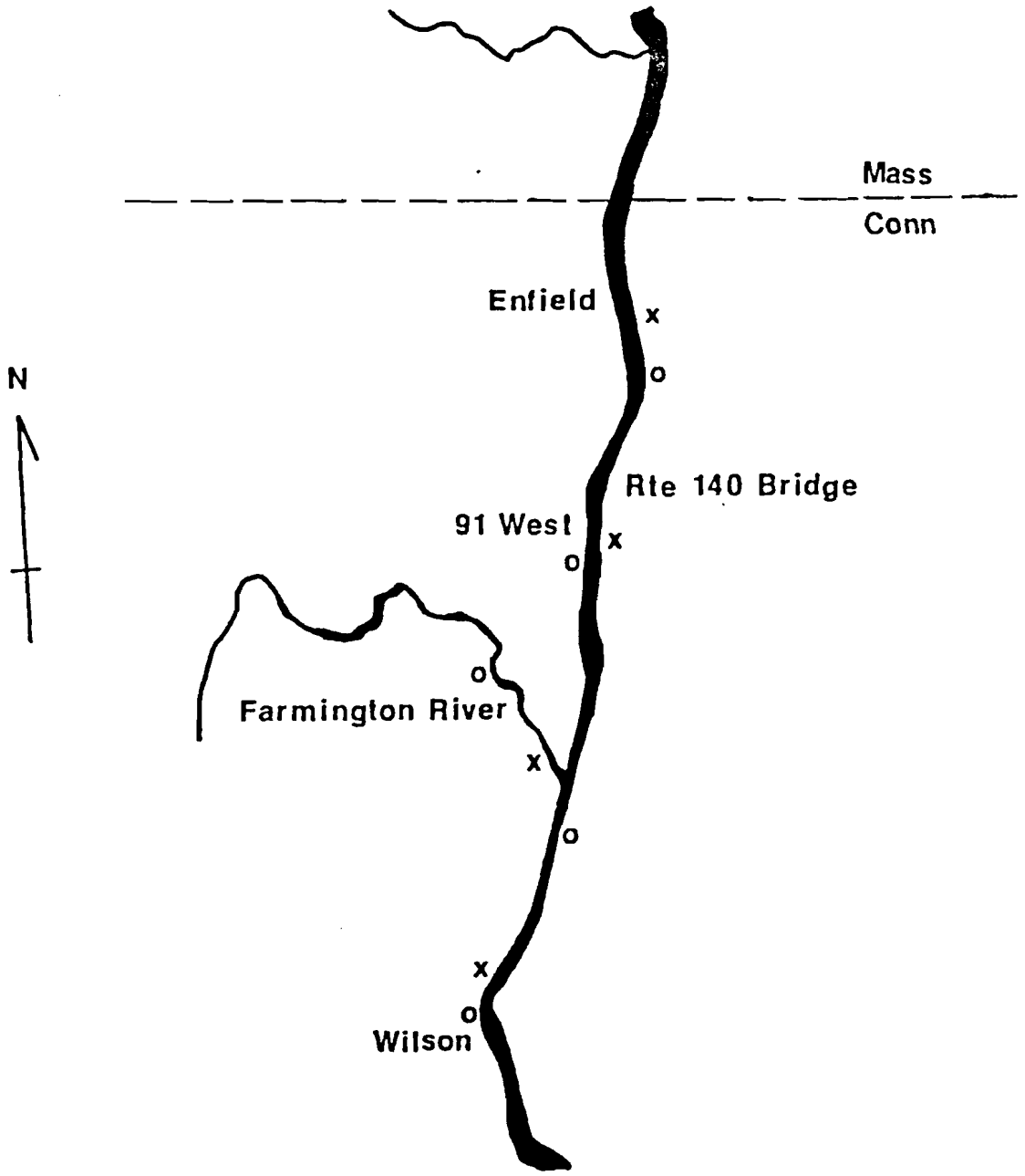


Figure 2. The Connecticut River showing locations of juvenile American shad sampling stations.

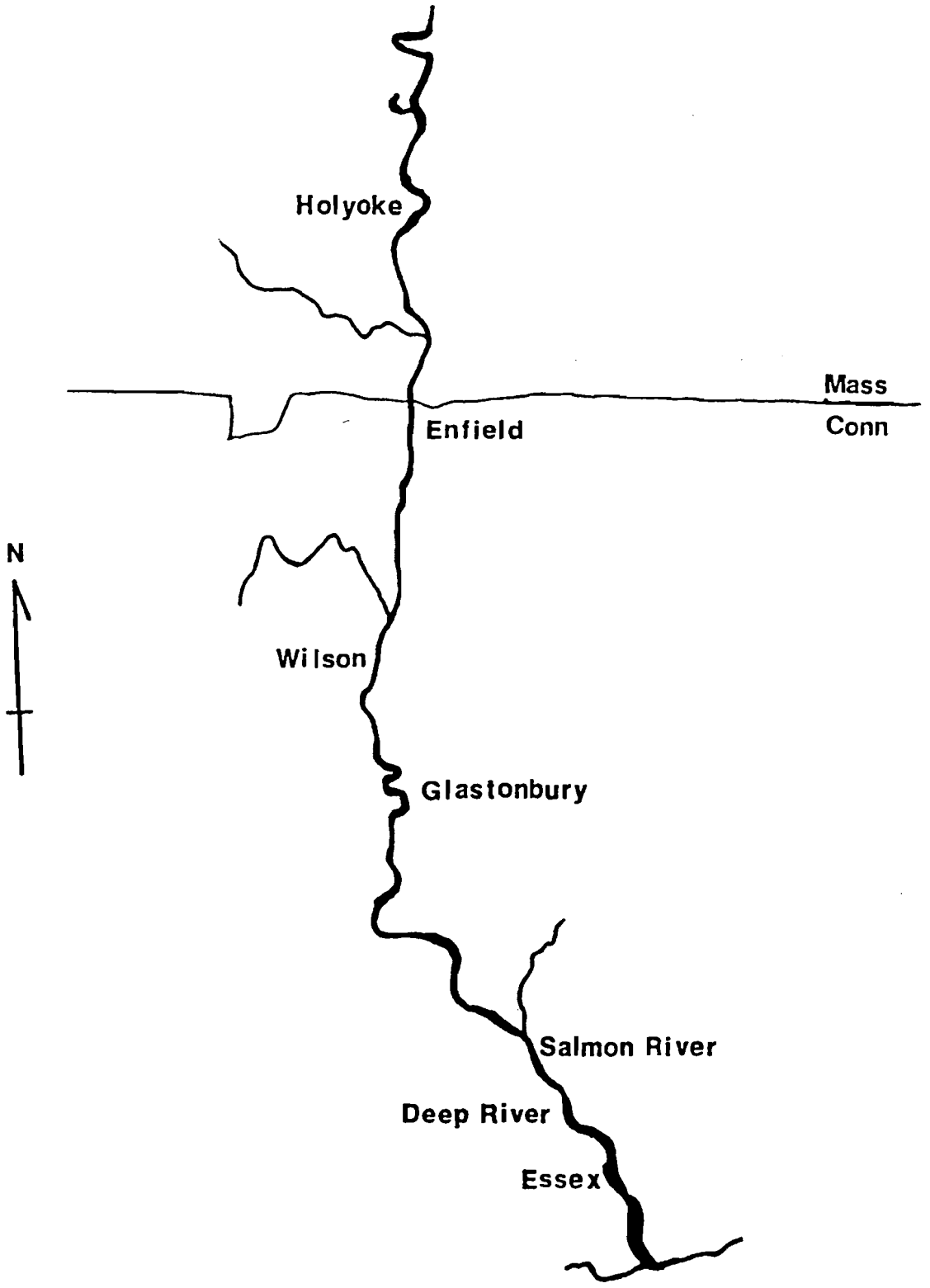


Figure 3. Relationship between relative index of abundance and daily growth rates for juvenile American shad from 1978 through 1992.

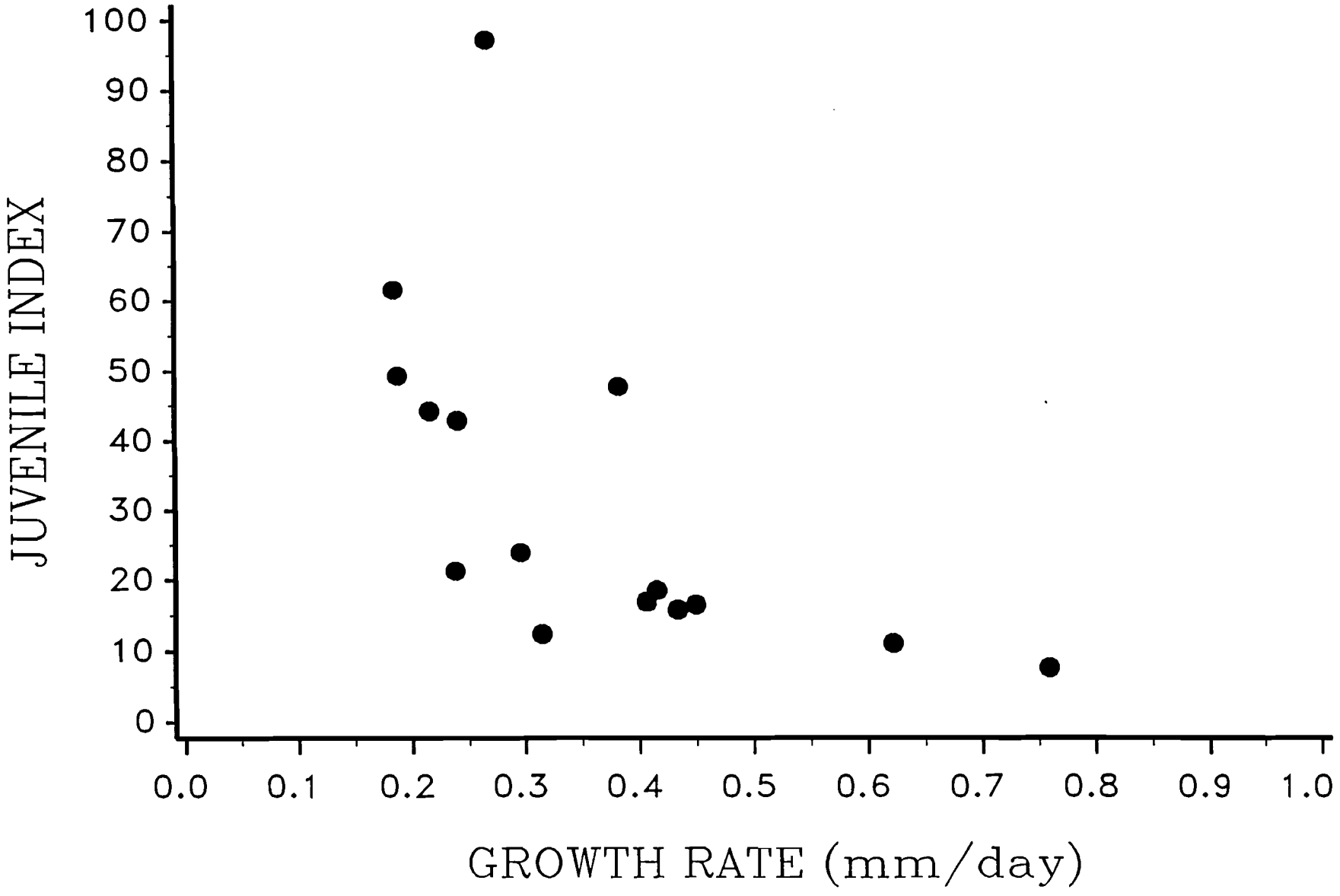


Figure 4. Number of juvenile American shad collected in the Connecticut River per week in 1992.

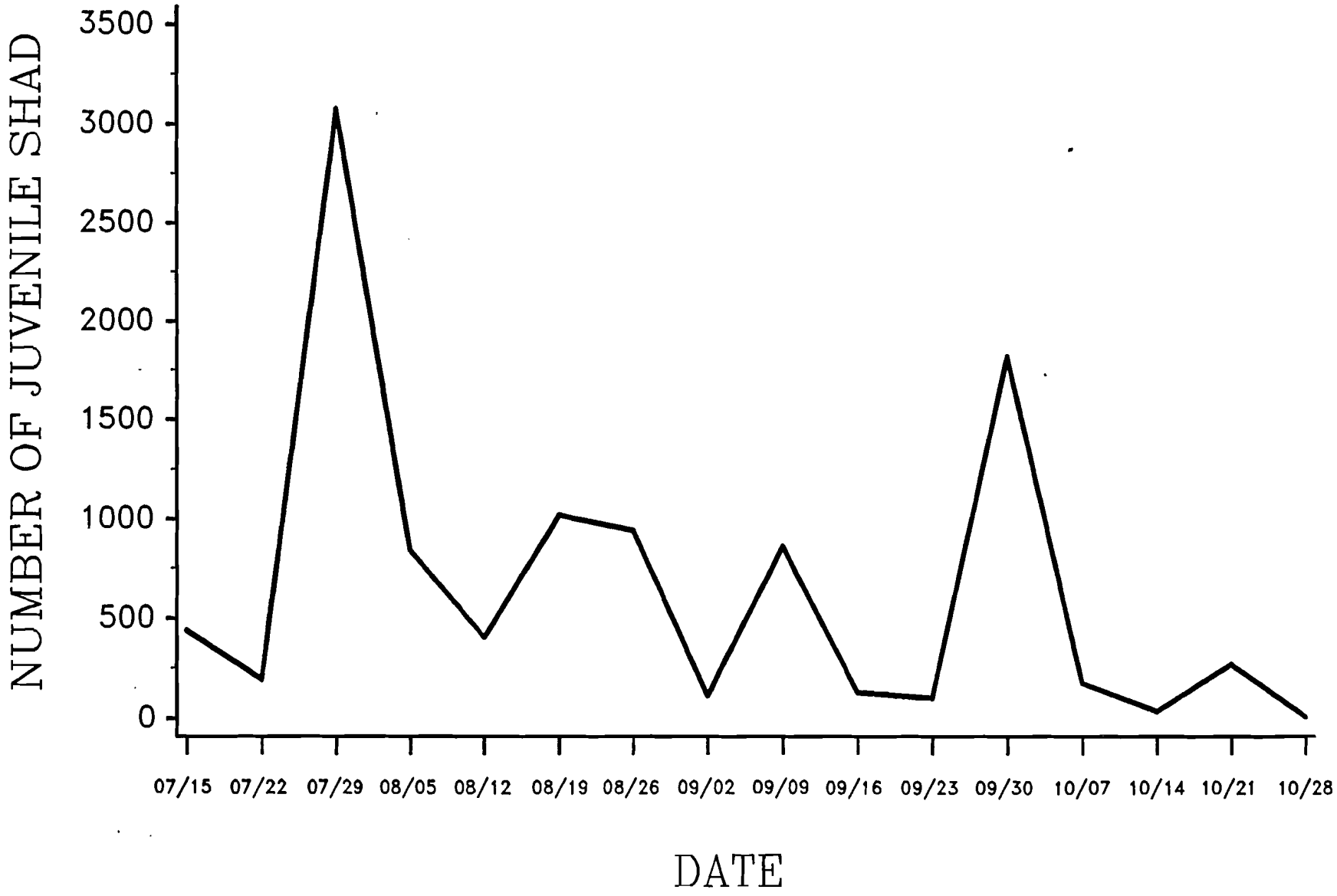


Figure 5. Number of juvenile American shad collected in the Connecticut River at each station in 1992.

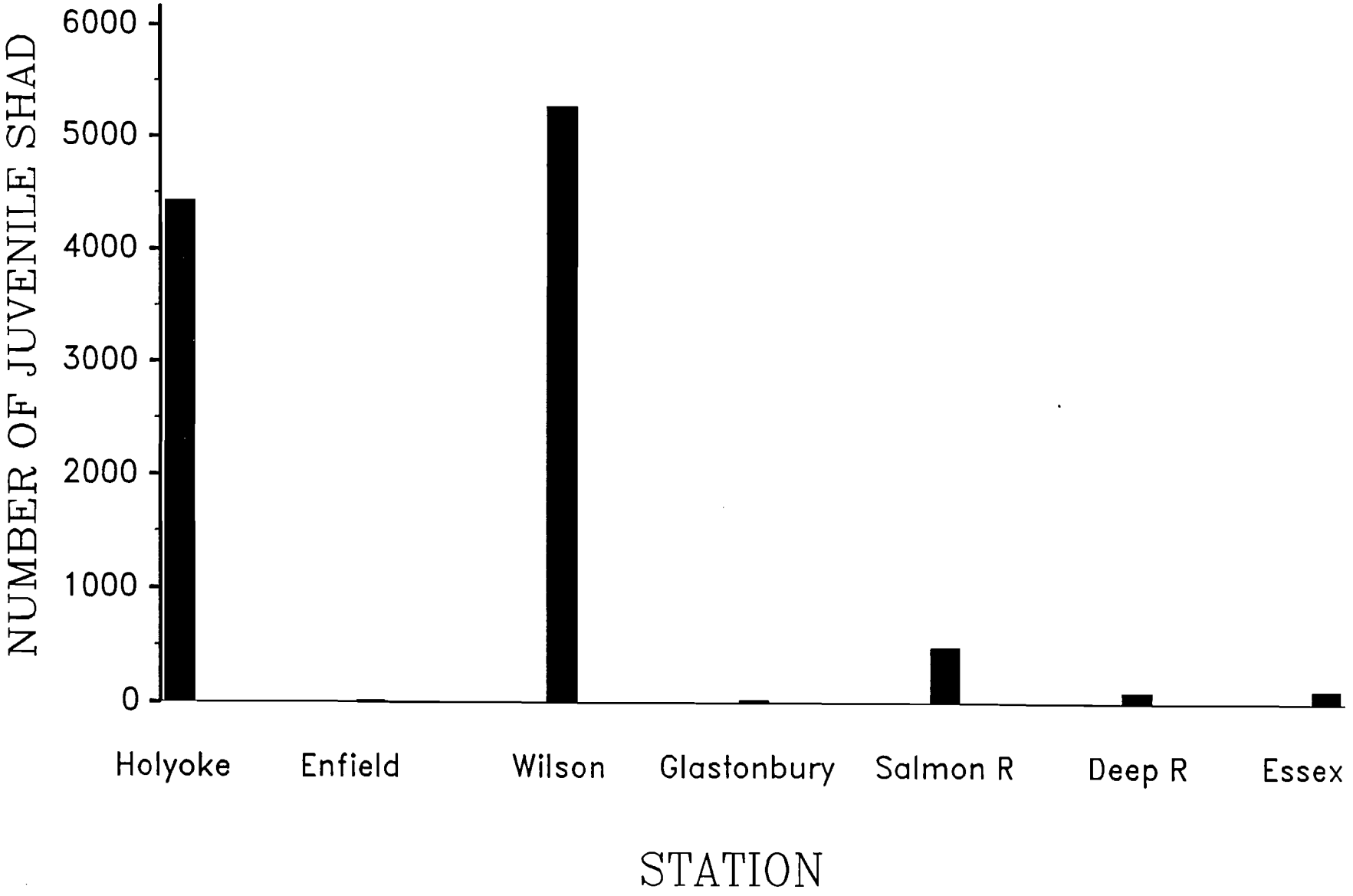


Figure 6. Method of carlin tag attachment on shortnose sturgeon dorsal fin.

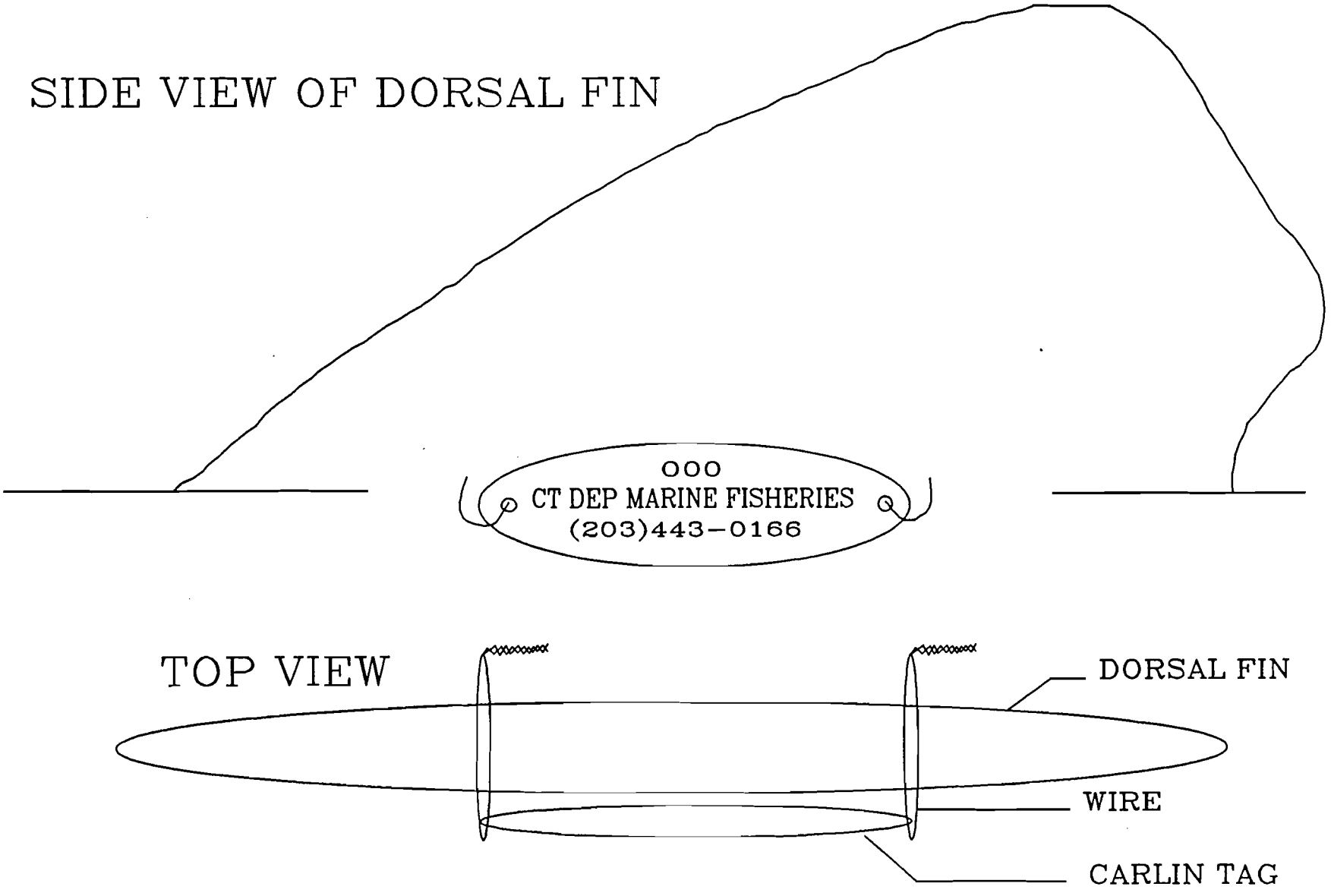
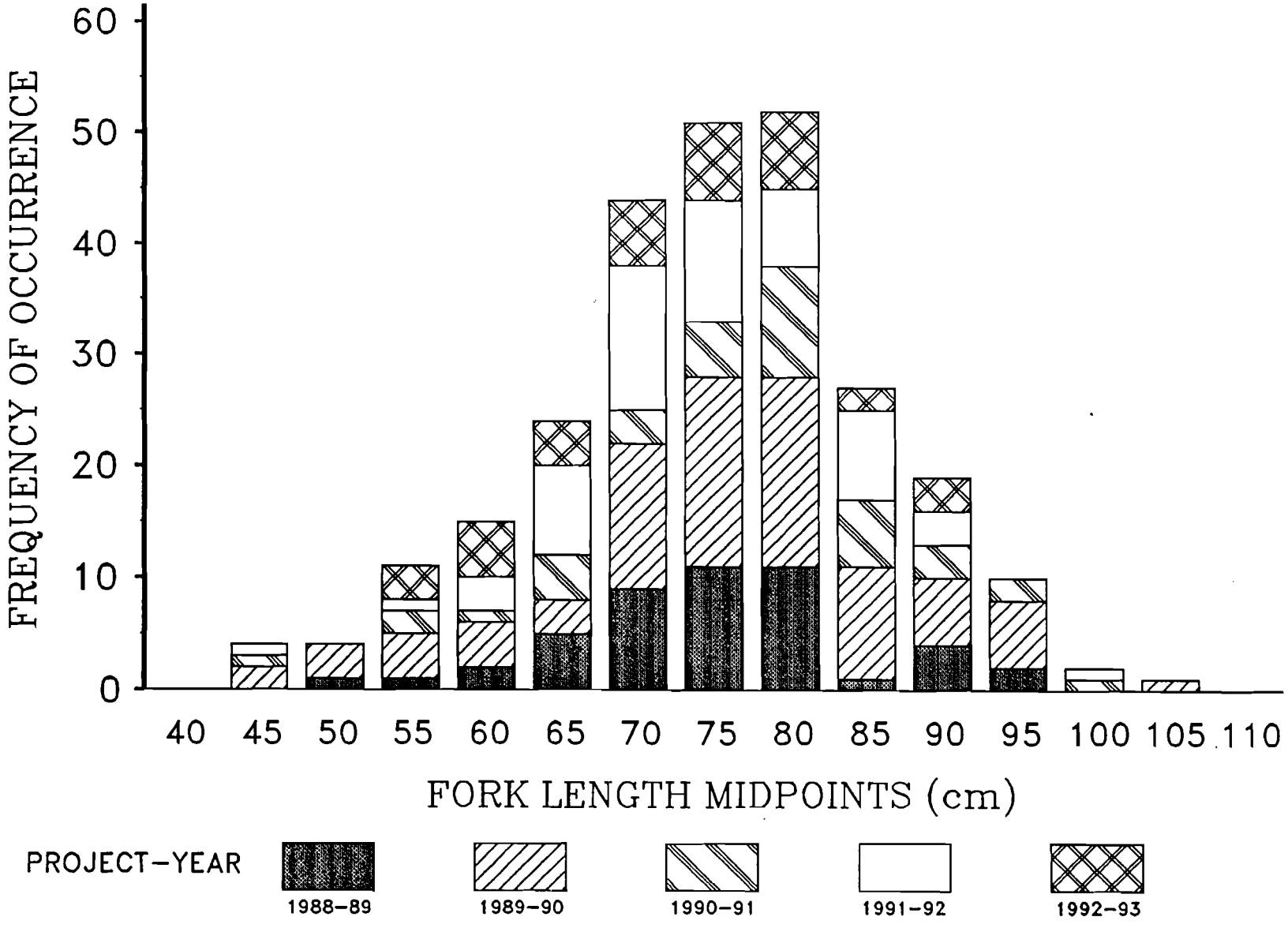


Figure 7. Length frequency distribution of shortnose sturgeon collected in the Connecticut River from 1988 - 1992 by project year.



Appendix 1. Field Sheet for angler survey.

Connecticut Department of Environmental Protection
Fisheries Division
1992 Connecticut River American shad sport fishery creel census

Date_____

Time_____

Location_____

Fishermen counted_____

Cars with trailers_____

Weather_____

Trip #_____

Location: Wilson
Power
Loomis
Barts
RiversEdge
91 West
91 East
Rte 140
Above Enfield Dam W
Below Enfield Dam W
Enfield Dam E
Enfield Rapids
Sanctuary
Breakneck

Method: S (shore)
B (boat)
Br (bridge)

	Time	# Creeled	# Released	Hours Fished	Comp/ Inc	Add. Hours	Method	# in Boat
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								

3 rec'd.