POPULATION SIZE, DISTRIBUTION AND FISHWAY UTILIZATION OF JUVENILE ALOSINES IN THE ANNAPOLIS RIVER ESTUARY

1994 Final Report

to

Nova Scotia Power Inc.

prepared by

A. Jamie F. Gibson
and
Graham R. Daborn

Acadia Centre for Estuarine Research,
Acadia University, Wolfville, Nova Scotia BOP 1X0

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1.0 EXECUTIVE SUMMARY

During the summer and fall of 1994 a study of the seaward movement of young alosines (American shad, *Alosa sapidissima*, blueback herring, *A. aestivalis*, and alewife, *A. pseudoharengus*) was conducted in the Annapolis Estuary. During the first part of the study, fish surveys to determine the locations of young alosines were carried out using shore seines throughout the estuary between Bridgetown and Annapolis Royal. Alosines were present in the estuary at the beginning of the surveys (July 13), and only a small number were captured on the final day of the survey (Sept. 21), implying that most had moved seaward at least as far as the headpond by this date. While there was overlap in the areas occupied by the different species, there appeared to be some degree of spatial segregation between species. Initially larger fish were found further seaward in the estuary, but over time this trend broke down, presumably as relative age differences within the populations decreased. During the study more than 7000 alosines were marked with sub-cutaneous injections of dye and released at the point of capture. Based on ratios of the number of fish examined for marks, the number of recaptures and the number of marked-fish-at-large, the population size of young of the year alosines is estimated at 1,576,003 (95% confidence limits = 1,157,468 - 2,468,657) individuals, an estimate that is considerably higher than those from previous studies.

Fish passage at the Annapolis causeway was monitored on 77 tides between July 28 and November 16, an intensity that greatly exceeds that in other studies at that location. More than 40 % of the 2186 alosines captured came from the new fishway, suggesting that this may be a significant route to the sea. Only 9 alosines were captured in the old fishway, although both fishways appear to be important passages for some non-alosine species, such as Atlantic silversides. It appears that smaller alosines show a preference for the new fishway, an observation that is probably explained by behavioral differences between alosines of different size. The percent catch figures used for comparing the importance of different routes of passage may be misleading, as they do not take into consideration the differences in cross-sectional area of the different routes. Based on experiments to determine fish distribution within the fishways, it was calculated that between August 30 and November 4 about 4641 alosines passed through the new fishway while 850 alosines moved seaward through the old fishway.

1.1 Acknowledgments

This project would not have been possible without the hard work of a number of people. The field crew consisted of two full time members: Ken Meade and Steve Mockford, both of whom willingly worked long hours, often cold and wet, without complaint. Ms. Josée Parent of Nova Scotia Power Inc. supplied valuable input into the design of the project and was always available to discuss how the work was going. Josée, along with Brad MacLean, Donnie Burke, Frank Ryan, and Terry Toner, also assisted for many hours with the field work. Additional help with the field work came from Jim Holmes, Bonnie MacEwan, Chris Halliday, Robert MacEwan and William Harlow of the Bear River First Nation's Fish Ecology Group. Without their volunteer assistance the fish survey work could not have continued into September. Peggy DeMerchant, Trent Oldford and Greg Butler also assisted in the field on occasion.

2.0 INTRODUCTION

The Annapolis River estuary is a macrotidal estuary located at the head of the Annapolis Basin in south-western Nova Scotia. In 1960 a dam was built across the estuary near Annapolis Royal, which limited the tidal exchange upstream of the dam and created a headpond with an area of about 10.8 x 10^6 m^2 (Melvin et al. 1985). The Annapolis Tidal Generating Station was constructed at this location during 1980-84, which, together with the causeway, provides an obstacle for migrating anadromous fish which spawn in the Annapolis River system. This obstacle potentially affects both adults moving inland towards spawning grounds further upriver, and adults and juveniles leaving the estuary and returning to the sea. At present there are three main routes of passage downstream past the causeway. Access for post-spawning adult and young-of-the-year alosines is provided by an open slot fishway (the 'Old Fishway') installed beside the sluice gates at the southern end of the causeway and by an additional fishway (the 'New Fishway') which runs between the turbine forebay and the tailrace. The third route of passage is through the turbine tube.

Three species of alosines are known to breed successfully in the Annapolis River and Estuary: the American shad, *Alosa sapidissima*, the alewife, *Alosa pseudoharengus*, and the blueback herring, *Alosa aestivalis.* Adults spawn in the river during the spring and young-of-the-year (YOY) alosines move downstream in the late summer and early fall to winter at sea (Daborn et al. 1979, Williams and Daborn 1984, Williams et al. 1984, Baker and Daborn 1990, Stokesbury and Dadswell 1989). Although basic knowledge exists about the life history of these stocks, the sizes of the stocks and the environmental conditions that trigger their downstream movement are not known. Stokesbury (1985, 1986) concluded that a combination of precipitation and lunar cycle influences are responsible for triggering migration, whereas O'Leary and Kynard (1986) found that a decrease in water temperature initiated the downstream migration of American shad and blueback herring in the Connecticut River.

Previous studies have attempted to investigate the extent to which YOY alosines move seaward through either of the fishways or the turbine, however evidence is conflicting (Andrews and McKee 1991). Stokesbury and Dadswell (1991) reported that <2% of their alosine catch occurred in the fishways, implying that the fishways do not play an important role in YOY alosine migration to the sea. Ruggles and Stokesbury (1990) estimated that 5% used the old fishway, whereas acoustic observations by McKinley and Patrick (1988) suggested that larger accumulations of fish were to be found near the sluice gates and old fishway than in the turbine forebay. Assessing the relative importance of the different routes through the causeway is an important step toward determining the best practices for management and conservation of migratory fish stocks in the Annapolis River and Estuary.

During the late summer and early fall of 1993 a project was undertaken to monitor the migration of young-of-the year alosines in the Annapolis River between Bridgetown and Annapolis Royal. This study (Gibson and Daborn 1993), concluded that approximately 75 000 alosines were present in the estuary at the time of the study, but that due to the timing of the work, a portion of the migration may have been missed. The study also suggested that the importance of the fishways relative to the turbine for the downstream passage of alosines at the Annapolis causeway may have been underestimated during previous studies by Stokesbury and Dadswell (1989, 1991). It was therefore decided to repeat some of the activities of 1993 during the summer and fall of 1994 to investigate further the questions posed by the above work. Specifically, the objectives of the 1994 study were:

1. To estimate the population size of the 1994 year class of alosines in the Annapolis River and Estuary System.

2. To investigate the relative importance of the two fishways and the tidal turbine at the Annapolis causeway as passages for alosines moving to the sea.

3. To investigate the importance of tributaries below Bridgetown as nursery habitat for young alosines.

4. To document the downstream movements of YOY alosines, relating these to environmental parameters where feasible.

5. To obtain morphometric information for different schools of alosines during the downstream migration.

To meet these objectives it was proposed that fish surveys of the lower river and estuary from above Bridgetown to Annapolis Royal be conducted during July and August. When sufficient numbers of YOY alosines had gathered at the head of the estuary upstream of Bridgetown (expected to occur in late August), 5 000 to 10 000 individuals were to be marked using individually numbered Floy tags and released back into the estuary. Marking would occur in the vicinity of Bridgetown, where a barrier net would be installed to ensure large numbers of alosines could be marked in a short period of time. The progress of these fish as they migrated downstream would then be monitored through regular fish surveys with seine nets. The results of these surveys were expected to provide information about the rates of migration and the population size. When it appeared the fish were nearing the causeway, a period of intense monitoring of the fishways and the turbine tailrace would begin. This work would supply information about the routes of passage past the causeway and in addition, was expected to increase the number of recaptures thus improving the population estimate. This monitoring would continue until the majority of the alosines had passed through the Annapolis causeway.

3.0 METHODOLOGY

The project consisted of two overlapping phases. Fish surveys in the Annapolis estuary between Bridgetown and Annapolis Royal began on July 13, 1994 and were discontinued after the Sept. 21 survey when few alosines were found. These surveys mainly involved locating YOY alosines in the upper estuary, monitoring their passage downstream to the Annapolis causeway, and collecting data for the estimate of stock size.

The other phase of the project consisted of monitoring fish passage in the vicinity of the Annapolis Tidal Generating Station, with the emphasis on movements of YOY alosines. Monitoring began on July 28, 1994 and was concluded on Nov. 16.

Maps showing the location of the Annapolis river, the river between Bridgetown and Annapolis, and the area in the vicinity of the Annapolis Tidal Generating Station are given in Figure 1.

3.1 Fish Surveys

The initial fish surveys, designed to discover the locations of alosines between Bridgetown and Annapolis and then to monitor their progress downstream, were conducted using seine nets. Two seines, differing in size, were used: the smaller seine measured 10 m by 2 m, and the larger seine 25 m by 4.5 m. Both nets were 0.3 cm mesh. The larger seine, which was used when surveying the main branch of the estuary, was fished in two ways. The first method involved towing the seine parallel to the shore by deploying one or two people on land to walk one end of the seine along the shoreline, while two other people towed the other end of the seine parallel to the shoreline using a Zodiac. The seine was towed about 30 m to 50 m, after which it was closed off against the beach. The fish were then corralled to a pocket formed at one end of the seine, which allowed processing of the fish without removing them from the water for more than a few seconds at a time. Processing involved identifying, enumerating, sometimes marking and, with the exception of a small sample retained for morphometric purposes and for confirming identifications, releasing the fish. In order to keep handling time to a minimum (thus minimizing the stress imposed on the fish), the by-catch composition, and the total number of alosines if the catch was large, were estimated instead of being physically counted. This was necessary as the number of fish captured in a seine often exceeded 1000. The above seining technique was employed in the majority of cases. The second seining method involved towing the seine perpendicular to the shoreline

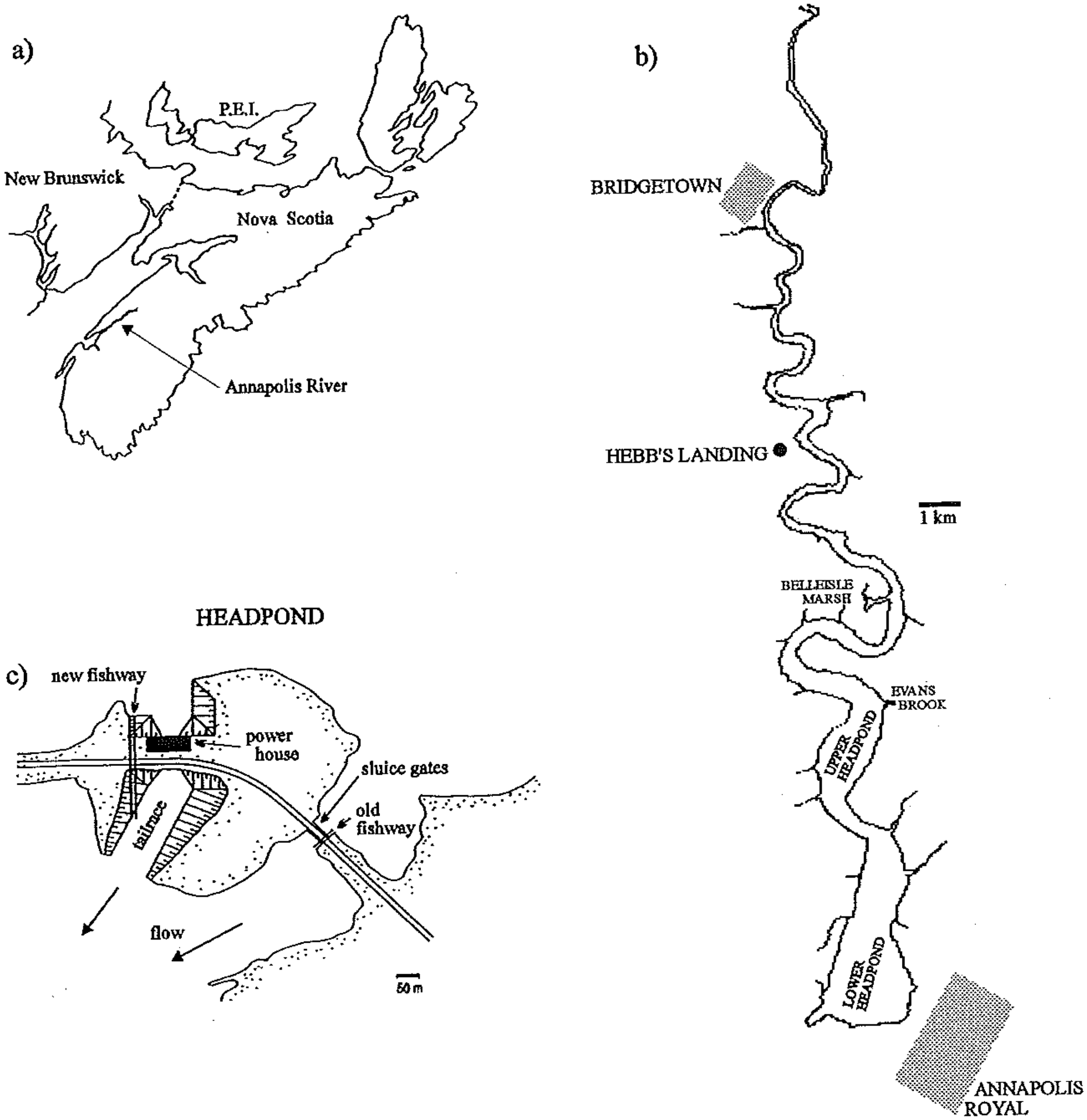


Figure 1. Maps showing: a) the location of the Annapolis River in Nova Scotia, b) the Annapolis River between Bridgetown and Annapolis, and c) the Annapolis Tidal Generating Station (Ruggles and Stokesbury, 1990).

using 2 Zodiacs, one at each end of the seine. The seine was then closed off against the beach and handled in a manner similar to the above. The smaller seine was used for surveying shallow tributaries and embayments. It was deployed and pulled by hand.

The location of each seine was recorded using a G.P.S. field navigator (Magellan™, model: 35001). Temperature and salinity profiles were recorded in the center of the estuary directly offshore from each seine location using an Applied Microsystems Ltd. environmental monitoring probe (model: Aquamate 1000).

3.2 Mark - Recapture Experiment for the Population Estimate

It was apparent from the results of the fish surveys conducted in July that large numbers of alosines were already present in the estuary downstream of Bridgetown and that waiting for large schools to form at the head of the estuary upstream of Bridgetown would mean missing a large proportion of the fish. Additionally, these fish were smaller than those expected to be found in late August and were too small to be marked with Floy tags. Therefore the entire mark - recapture portion of the study was redesigned.

Northwest Marine Technology Ltd. (Shaw Island, Wa.) had developed a marking system using a subcutaneous injection of a small quantity (app. 0.1 μl) of an elastopolymer containing fluorescent dye. While this system would not allow for individual recognition of marked fish, by using different colors of dye (4 were available) and different marking locations, distinct groups of fish could be identified. By dividing the study area and study period into separate partitions, and assigning a unique marking combination to each partition, it would be possible to tell approximately where and when a recaptured marked fish had been initially marked. This marking system was chosen for this study.

A mobile marking station was developed that allowed on-site marking of alosines wherever they were captured in the estuary. Fish were captured and corralled into a pocket at one end of the seine as described above. The fish were transferred to a 1.25 m x 0.5 m x 0.5 m holding pen which could be attached to the side of a Zodiac using elastic cords. The transfer was accomplished by holding one edge of the pen under water beside the seine and encouraging the fish to swim from the seine into the pen by slowly lifting the seine from the water. In this way the fish were transferred without removing them from the water. It was found that fish would swim quietly in the holding pen without showing signs of panic or stress. Fish were anesthetized using MS222 prior to marking. This was accomplished by dip-netting the fish (using a plastic spaghetti strainer) a few at a time, into a 20 L bucket containing the anesthetic solution. The anesthetized fish were removed from the solution, marked, and placed in another 20 L bucket containing estuary water for recovery, after which the fish were released.

The marks were injected using 3/8 inch 26 gauge tuberculin needles. Marks that were injected under scales were not very visible, but marks injected on the operculum just behind the eye were quite visible. All marks were placed in this location, giving three possible marking positions with each color: left side, right side, and both sides (two - color combinations were also possible using both sides). Fish less than 4 or 5 cm total length were considered too small to mark.

For the purposes of determining migration rates by comparing the time and location of marking with the time and location of recapture, the study period was divided into weeks and the study area partitioned into sections corresponding with those shown in Figures 3 - 6. A unique marking combination was assigned to each week and river section.

Handling mortality and mark retention experiments were conducted on three occasions. In each case approximately 30 fish were handled or marked, and placed in a 1.5 m x 1.0 m x .75 m holding box made of 5 mm Vexar screening which was sunk to the bottom in about 1.75 m of water. In each experiment the box was checked after about 2 weeks, at which time the fish were examined for ill effects from this treatment and for mark retention and released.

An estimate of stock size of the alosines was made using the modified Schnabel method described by Ricker (1975). Prior to employing this method, the number of fish marked from each seine was corrected for handling mortality and mark loss based upon the results of two mark retention experiments. Mark retention and survival were 79.4% on the first occasion and 100 % on the second (see results). Marking efficiency was presumed to have increased between these two occasions due to increased skill in applying marks as markers gained more experience. Experience was quantified as the total number of fish marked prior to each mark retention experiment, and these data were used to establish a linear relationship between marking efficiency and the number of fish marked prior to each seine:

$$\text{M.E. } (\%) = 0.00757 * N_m + 51.31 \qquad \text{eqn. 1}$$

where: M.E. = percent marking efficiency

N_m = number of fish marked prior to each seine

The marking efficiency was then calculated for each seine and the corrected number of fish successfully marked calculated by multiplying the marking efficiency by the actual number of fish marked. Using the corrected number of fish marked, the total number of alosines was calculated using the formula (Ricker 1975):

$$N_p = \Sigma(C_t * M_t)/(R+1) \qquad \text{eqn. 2}$$

where N_p = the size of the population

C_t = number of alosines examined from the seine t

M_t = the number of marked alosines at large at the time of seine t

R = the total number of recaptures

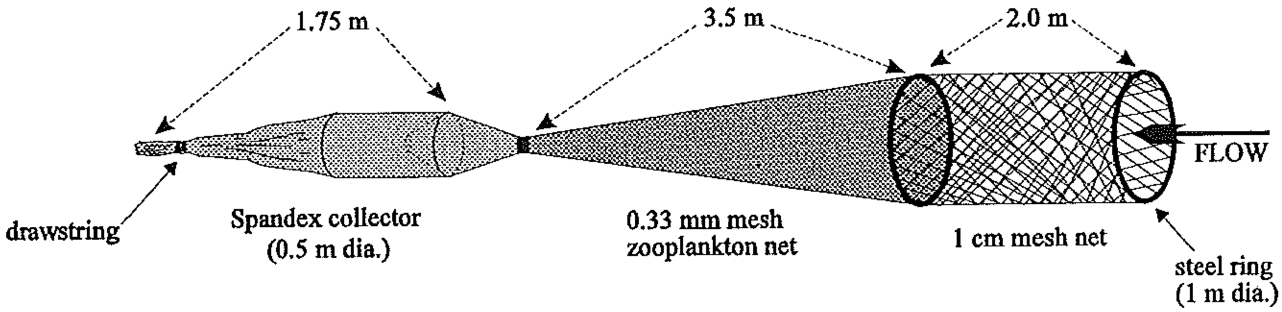
The variance of 1/N, which has an approximately normal distribution (Ricker 1975), was calculated as:

$$VAR(1/N) = (R+1)/(\Sigma(C_t * M_t))^2 \qquad \text{eqn. 3}$$

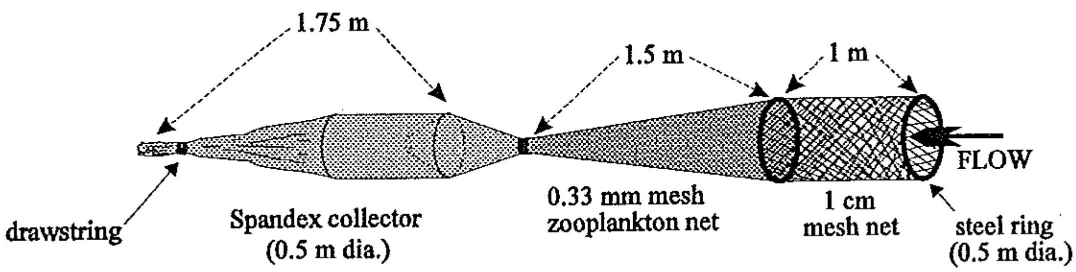
Confidence limits for 1/N were calculated using t-values for the normal curve. These limits were inverted to give limits of confidence for the population estimate. The relative proportions of fish of each alosine species retained for determination of stock characteristics was used as an estimate of the true relative abundances for these species which, along with the alosine population estimate was used to calculate population estimates for the 3 alosine species encountered in the river.

3.3 Monitoring Alosine Passage at the Annapolis Causeway

Monitoring alosine passage in the vicinity of the Annapolis Tidal Generating Station was accomplished by fishing modified zooplankton nets in the two fishways and in the tailrace below the turbine. Two types of nets were used for this work. Most of the monitoring was done using 1.0 m diameter nets. These nets were made up of three parts: a 2.0 m long section, cylindrical in shape, made of 1 cm mesh nylon netting; a section consisting of a 0.33 mm zooplankton net, approximately 3.5 m in length, which tapered conically from 1 m at the mouth to 17.8 cm at the cod end (the net used in the new fishway was cylindrical in shape for the first 2 m and tapered sharply during the final meter); and a final section, which was the collector. The collectors were 1.75 m long Spandex cylinders fitted over 0.5 m diameter cylinders (about 0.75 m in length). The collectors had funnel-shaped entrances designed to keep fish from escaping from the net. The tail ends of the collectors were designed so that they could be opened and closed with drawstrings allowing them to be emptied. The other type of net used was 0.5 m in a)



b)



c)

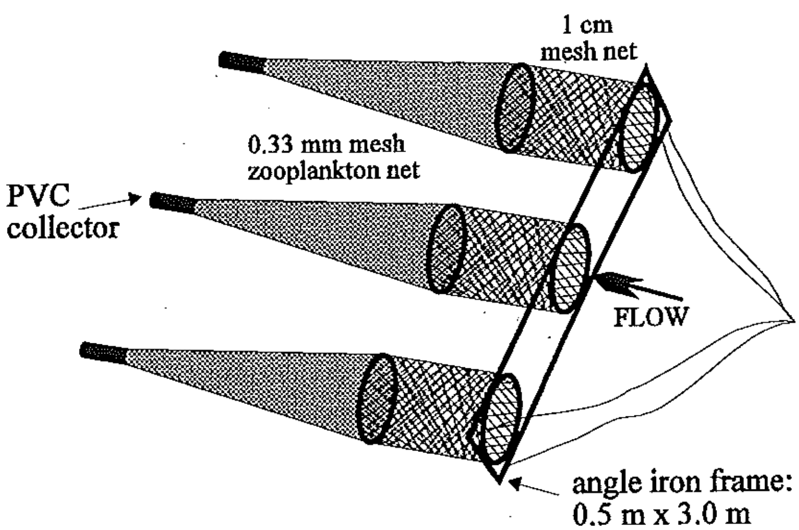


Figure 2. Diagrams of nets used to monitor fish passage at the Annapolis causeway: a) 1 m nets, b) 0.5 m nets used for routine monitoring, c) 0.5 m nets used when fishing three nets simultaneously in a fishway.

diameter, and was a scaled down version of the 1.0 m net. The first section of the net was 0.75 m in length and the zooplankton net 1.5 m in length. These nets were fitted with collectors similar to the above. Diagrams of these nets may be found in Figure 2.

A typical deployment consisted of setting a 1 m net in the new fishway as the tide began to ebb. A 1 m net was set in the old fishway immediately afterwards (the time lapse was usually about 10 minutes). A third 1 m net was suspended from the boom line in the tailrace below the turbine prior to the start of generation. The tailrace net was removed just prior to the end of generation and its catch identified, enumerated, and the live, non-alosines were released. The old fishway net was pulled and emptied in a similar manner shortly before the onset of the flood tide in the headpond, and the new fishway net removed at the beginning of the flood tide. This order of removing the nets had to be adhered to due to the difficulties of pulling these nets against the currents that exist in the fishways during the ebb tide.

The above protocol was followed for the majority of deployments with a few exceptions. During early September the by-catch of Atlantic silversides was too high in the fishways to warrant using the 1.0 m nets. So, until the silverside catch subsided later in September, 0.5 m nets were used to monitor the fishways. These smaller nets were also used as replacement nets on two occasions when 1.0 m nets were lost or destroyed by the currents until new 1.0 m nets could be made.

On three occasions a 0.5 m net was fished in the tailrace beside a 1.0 m net (both nets emptied hourly), to provide a database for comparing the fishing efficiency of the two nets. The comparison was made after multiplying the catch of the 0.5 m net by 3.9989, which is the ratio of the cross-sectional area that the two types of nets fished. When compared using a Wilcoxon signed-ranks test, the difference in catch of the two nets was not statistically significant ($p=.656$, d.f.$=10$). The catch of the 0.5 m net was therefore standardized by the above constant and included in the presentation and analysis of the fish passage data. All data presented in this report include this standardization.

On a number of occasions the tailrace net was emptied hourly throughout the deployment in order to provide data about the timing of fish movement through the turbine.

On four occasions in the new fishway, and two occasions in the old fishway, experiments were conducted to determine if the fish were homogeneously distributed across the fishway. Three 0.5 m nets were U- bolted to a 3 m x 0.5 m rectangular frame made of 1.5 inch angle iron. One net was fastened at each end of the frame and the third in the middle. The three nets were then deployed in a fishway so that one net fished in the middle of the fishway and one near each wall. A diagram of this apparatus is supplied as Figure 2 (c).

Water temperature and salinity were recorded in the mouth of the new fishway using an Applied Microsystems Ltd. environmental monitoring probe just prior to setting the nets on each tide that was monitored.

3.4 Size and Condition of Migratory Alosines

The timing of downstream migration may be determined by environmental factors but may also depend upon individual fish size or condition. For these reasons, subsamples of fish were retained for determination of fork length (measured to the nearest 0.1 millimeter) and weight (to tenths of a gram). From these values, the condition factors (Fulton's condition factor) of the alosines were calculated using the formula (Ricker 1975):

$$CF=(W / FL^3) * 100 \qquad \text{eqn. 4}$$

where CF = condition factor
W = weight in grams
FL = fork length in centimeters

Condition factors are a measure of the relationship between the length and the weight of a fish and are reported unitless, possibly to avoid confusion with density measurements. They are species, size and perhaps population dependent, and are therefore relative indices that can give some indication about the quality of environmental conditions. When comparing samples of fish of the same species, size and from the same population, an increase in condition factor indicates better conditions for growth.

4.0 RESULTS

4.1 Results: Fish Surveys

Seines were fished 211 times between July 13 and Sept. 21, 1994. The date, time, seining method, catch and fate of the fish captured for each of these seines is summarized in Appendix 1. The catch per unit effort (C.P.U.E.), of all alosine species combined, for one week periods spanning the sampling period is shown in Figure 3. The largest catches occurred at the upstream end of the estuary near Bridgetown during late July. Alosines were captured in this area until mid- September. Alosine numbers in the rest of the estuary remained relatively constant from the third week of July, when the C.P.U.E. first began to increase, until mid September, when numbers captured declined. Only 12 alosines were captured in 11 seines on September 21 and this was taken as an indication that most alosines had moved downstream at least as far as the headpond. As was the case in 1993, no alosines were caught in the uppermost portion of the study area, but fishing effort in this area was not as intense as further downstream.

American shad numbers remained high in the vicinity of Bridgetown until early September (Figure 4). This is in contrast with the pattern shown by blueback herring and alewives which vacated the upper reaches of the estuary early in August (Figures 5 and 6, respectively). Distribution patterns for the three species of alosines in other parts of the estuary appeared more or less similar. The lower C.P.U.E.'s at the seaward end of the study area are probably a reflection of the size and depth of the river relative to the small area covered by each seine rather than an indication of the relative abundance of fish in different parts of the estuary.

Length - frequency distributions for American shad, blueback herring, and alewives, for different regions of the estuary during each week of the study are shown in Figures 7, 8 and 9. The trends appear similar for the three species. During the later part of July and the first three weeks of August, the smallest fish were found at the upstream limit of the estuary, while increasingly larger fish were found as one moved seaward. During late August and September length - frequency distributions appeared more homogenous throughout the estuary.

During late July and then periodically throughout the survey, 10 seines were conducted in Evans Brook. No alosines were captured in any of these seines. Seines were also conducted in July in a number of smaller tributaries for the purposes of assessing the stock size of alosines located downstream of Bridgetown, that would have been missed

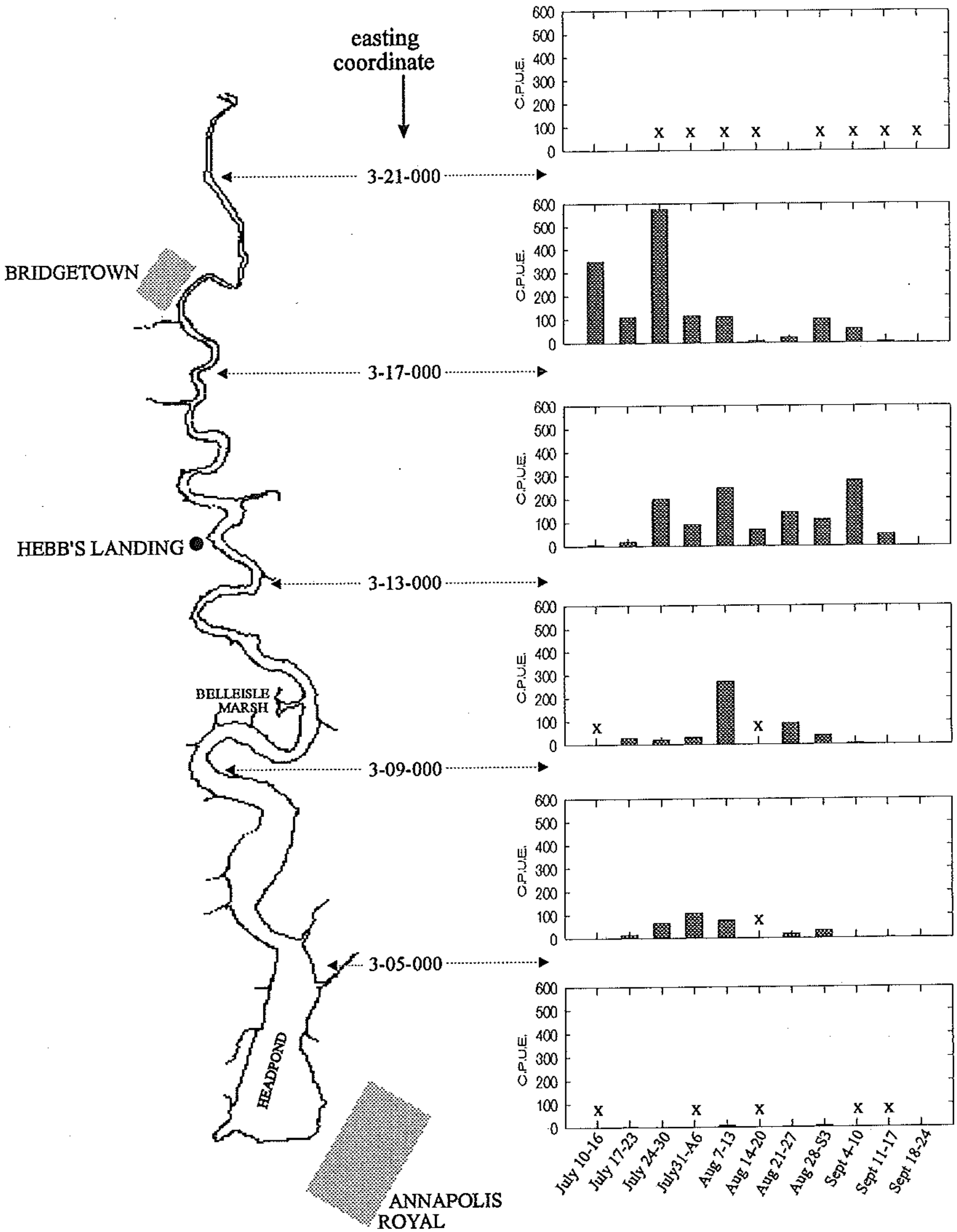


Figure 3. The time and location of alosine catches during the seining portion of the project summarized as catch per unit effort for 1week periods over 6 sections of the river. Easting coordinates refer to the U.T.M. easting coordinate at the intersection of the easting line and the river. X's mark periods that were not sampled.

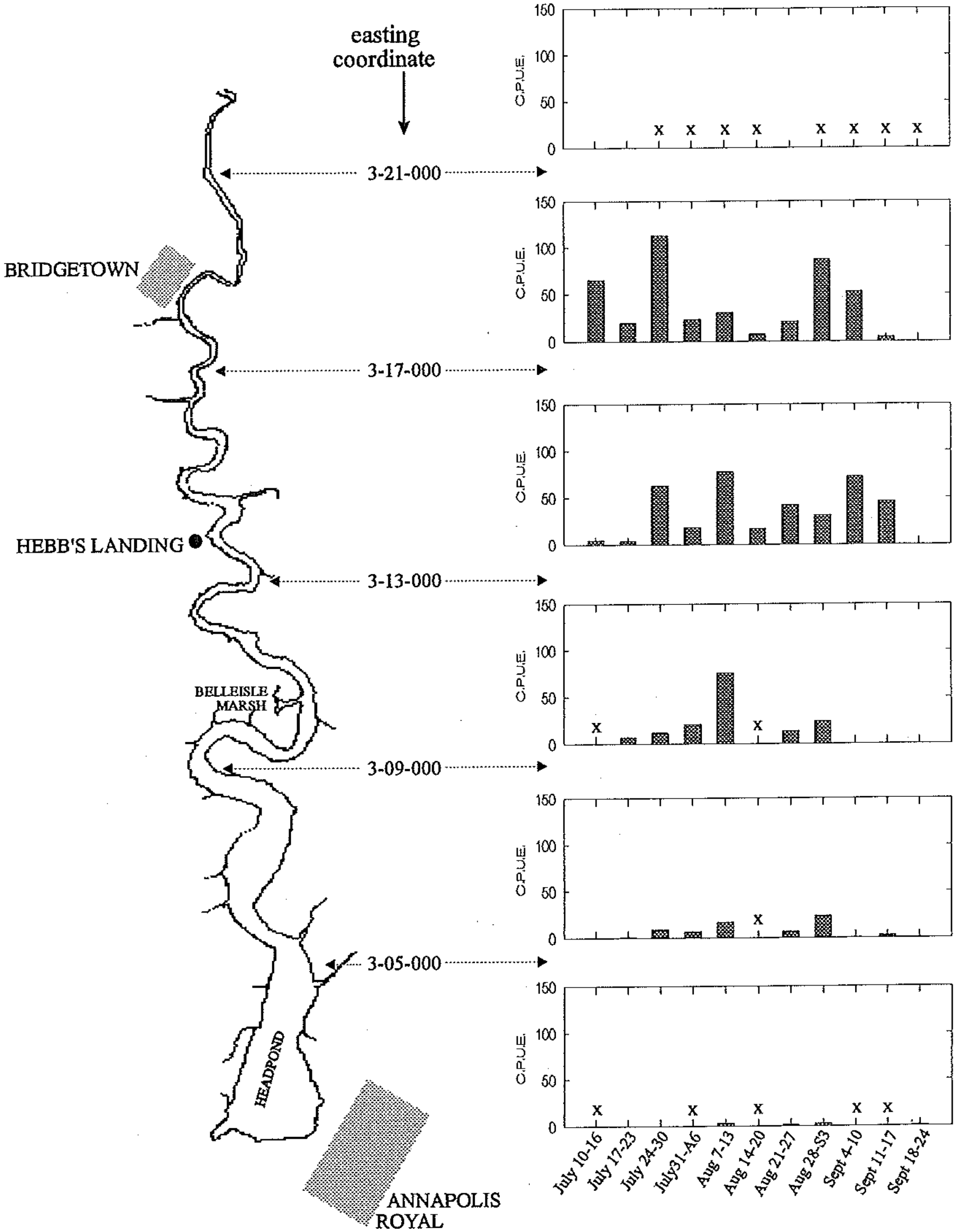


Figure 4. The time and location of Am. shad catches during the seining portion of the project summarized as catch per unit effort for 1 week periods over 6 sections of the river. Easting coordinates refer to the U.T.M. easting coordinate at the intersection of the easting line and the river. X's mark periods that were not sampled.

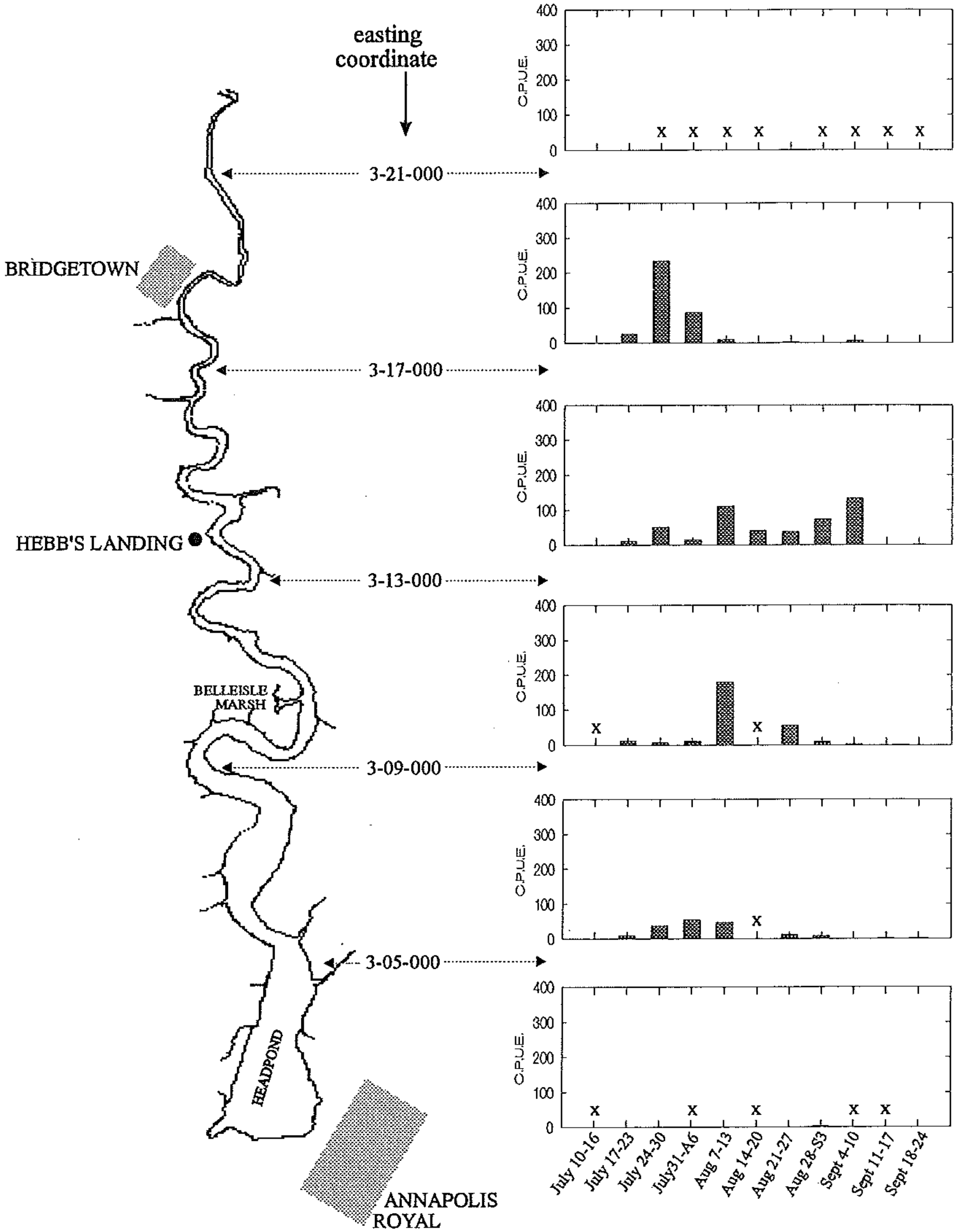


Figure 5. The time and location of blueback herring catches during the seining portion of the project summarized as catch per unit effort for 2 day periods over 6 sections of the river. Easting coordinates refer to the U.T.M. easting coordinate at the intersection of the easting line and the river. X's mark periods that were not sampled.

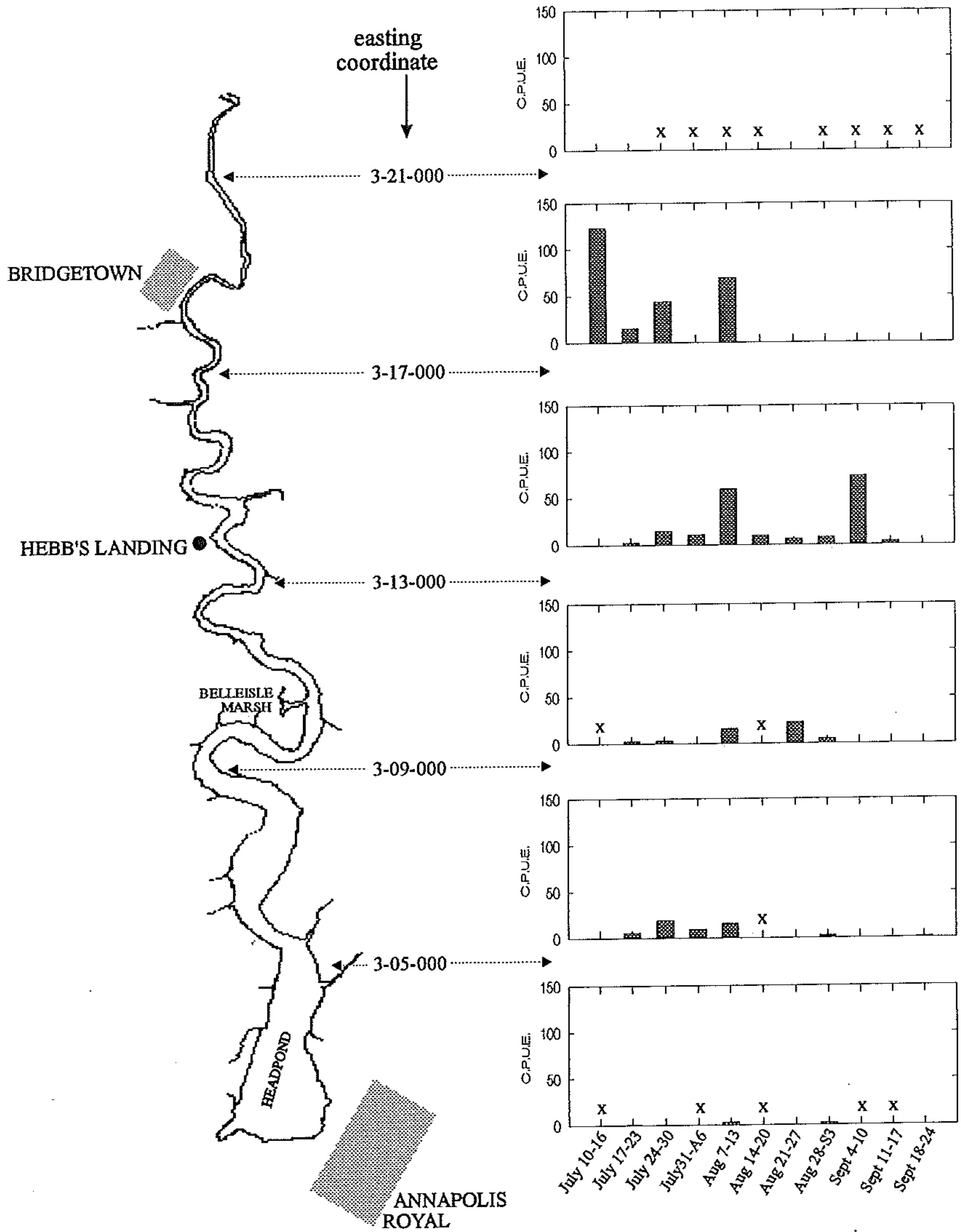


Figure 6. The time and location of alewife catches during the seining portion of the project summarized as catch per unit effort for 1week periods over 6 sections of the river. Easting coordinates refer to the U.T.M. easting coordinate at the intersection of the easting line and the river. X's mark periods that were not sampled.

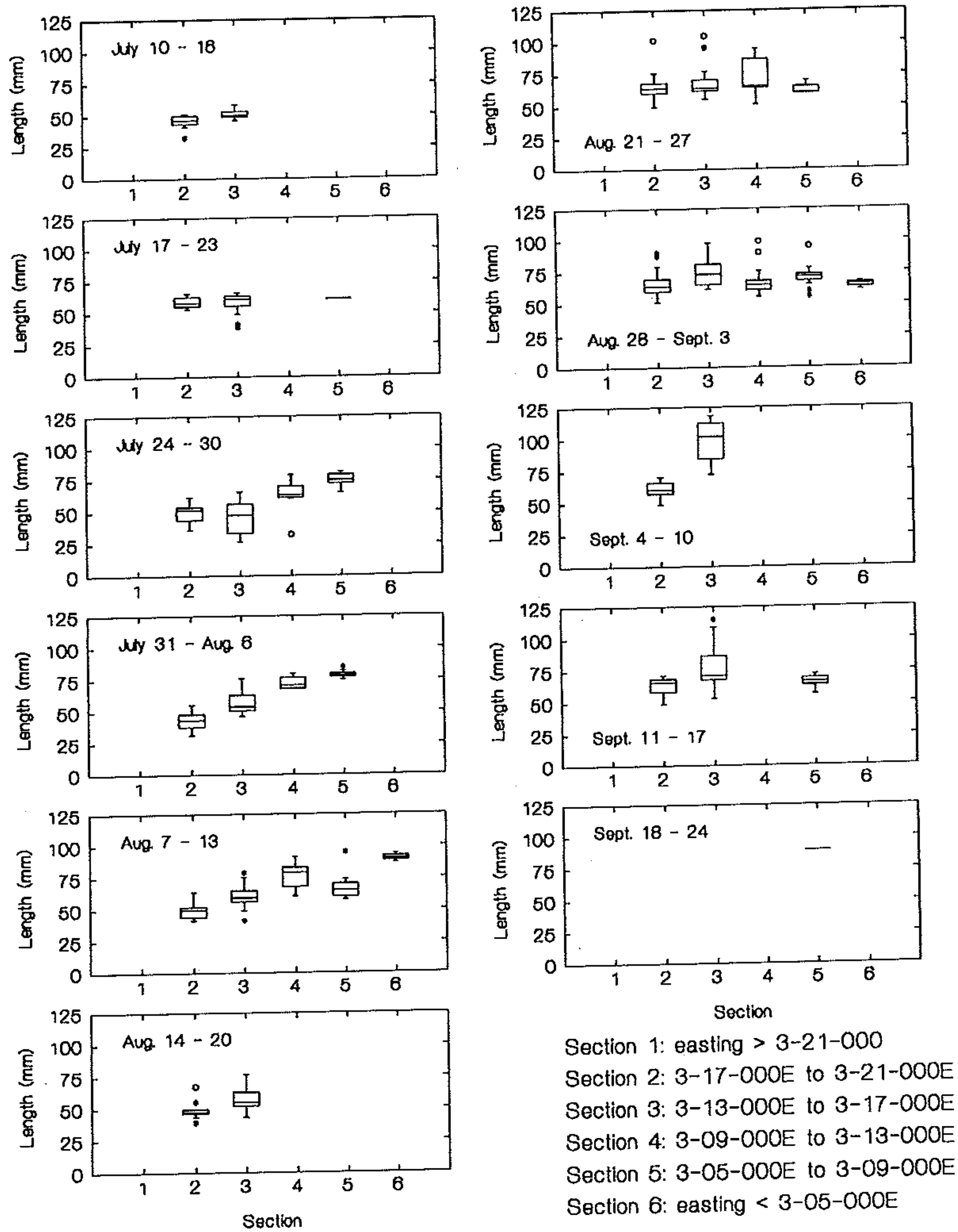


Figure 7. Length frequency distributions for American shad during each week of the fish survey. The sections indicated correspond with the graphs in Figures 3, 4, 5 and 6. Section 1 is upstream of Bridgetown and section 6 is near Annapolis Royal.

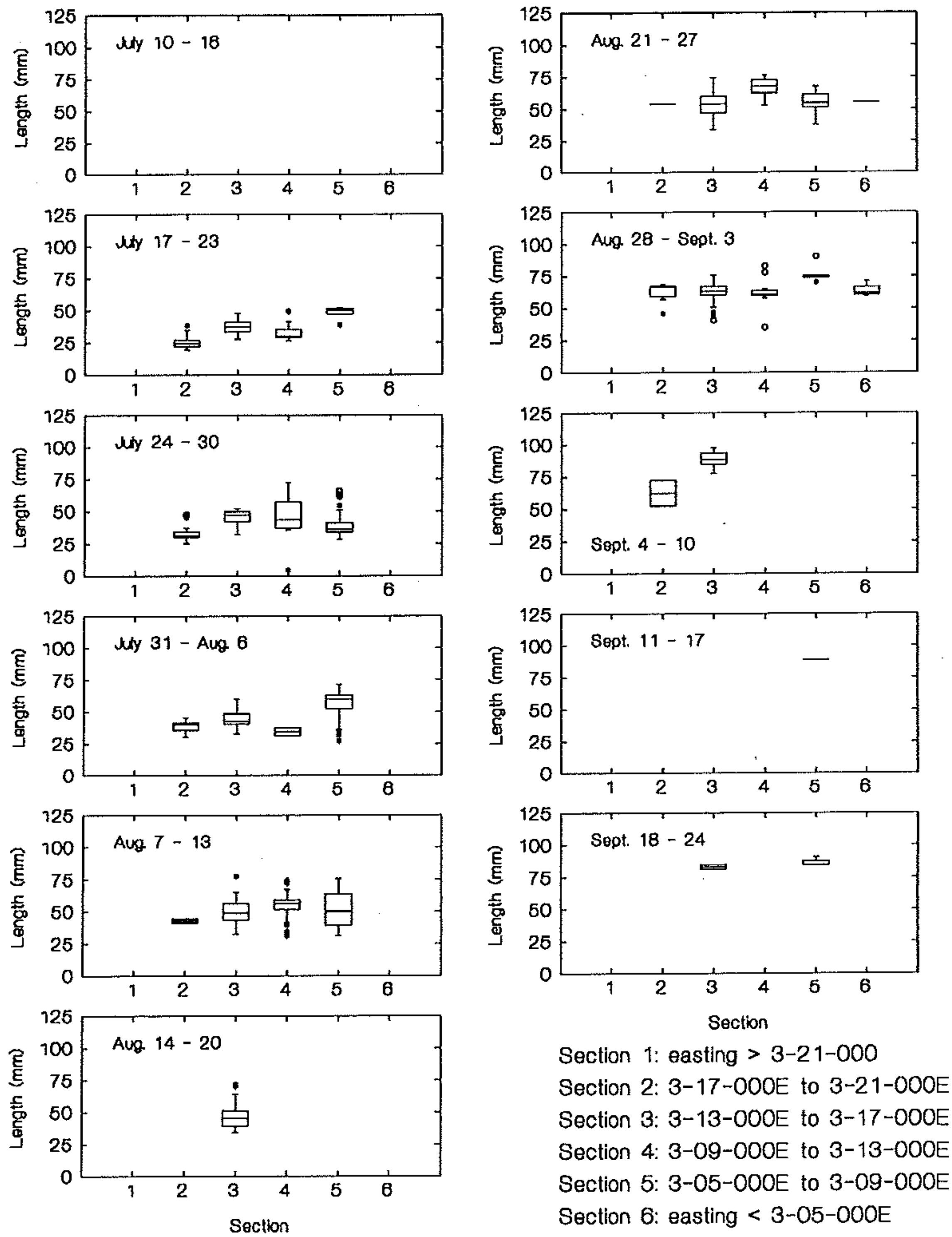


Figure 8. Length frequency distributions for blueback herring during each week of the fish survey. The sections indicated correspond with the graphs in Figures 3, 4, 5 and 6. Section 1 is upstream of Bridgetown and section 6 is near Annapolis Royal.

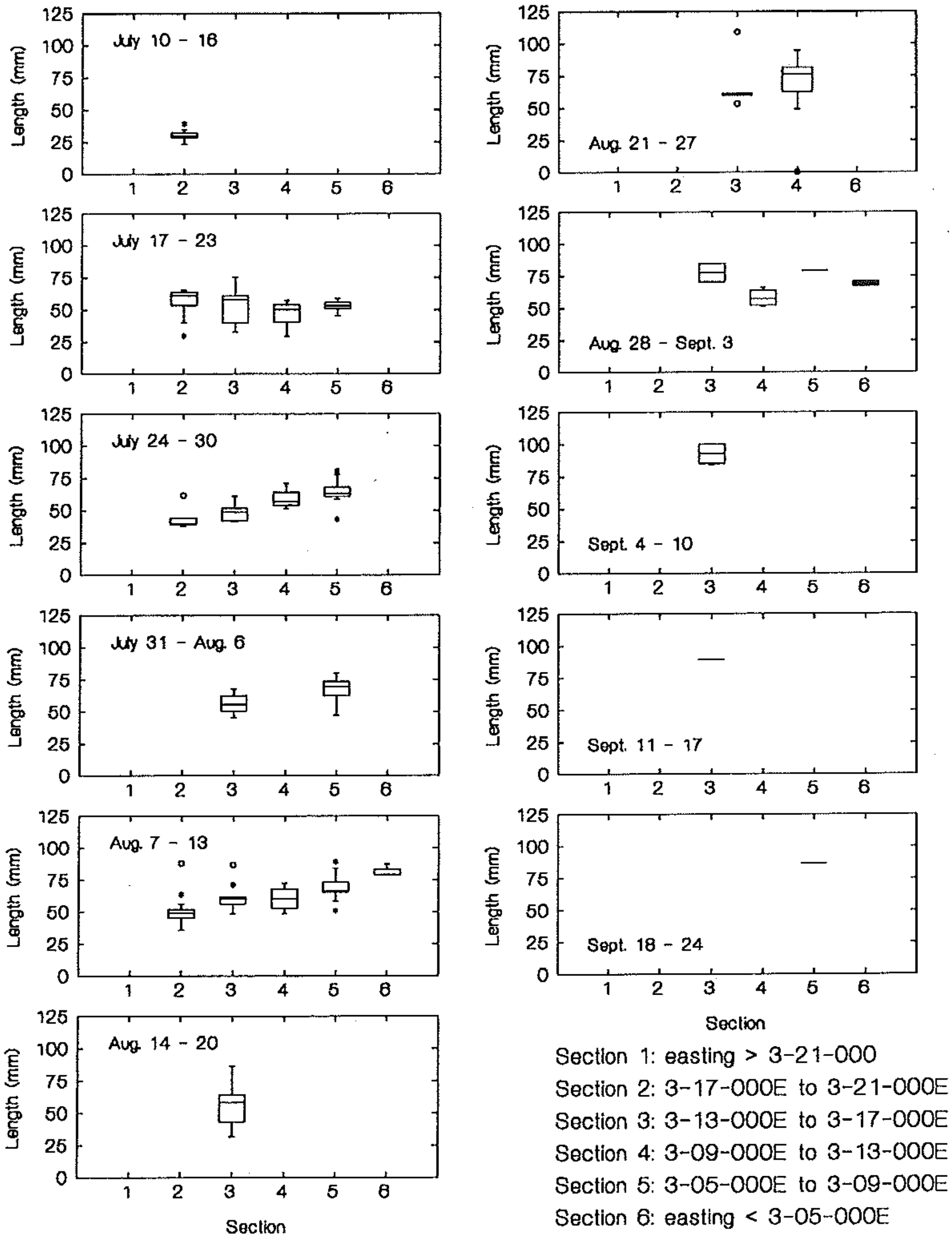


Figure 9. Length frequency distributions for alewives during each week of the fish survey. The sections indicated correspond with the graphs in Figures 3, 4, 5 and 6. Section 1 is upstream of Bridgetown and section 6 is near Annapolis Royal.

under the initial mark-recapture plan. As large numbers of alosines were already present in the main branch of the estuary below Bridgetown, the question was considered redundant and the seines in these areas discontinued.

The results of the experiments to assess fish handling mortality and mark retention are summarized in Table 1. The purpose of the first experiment was to determine if fish handling or retention in the holding box had ill effects on the fish. The next two experiments also included effects of marking. In each case the fish were held about two weeks. All the fish survived the experiments without showing any obvious ill effects. During the first marking experiment, only 79.4 % of the fish retained their marks, however, in the second, mark retention was 100 %. This improvement was attributed to increased skill in applying marks as markers developed more experience. These data were used to adjust the marked-fish-at-large data used in the estimate of stock size (see methods).

Table 1. Results of the fish handling mortality and mark retention experiments.

Time Period	Experiment and Results
July 19 - July 31	40 alosines were placed in the holding box. All 40 survived to be released at the end on the time period.
Aug. 12 - Aug. 28	34 alosines were marked and placed in the holding box All the fish survived, however 7 had lost their marks by the end of the time period.
Aug. 28 - Sept. 9	30 alosines were marked and placed in the holding box. Examination of the fish at the end of the period revealed that all 30 fish had survived and retained their marks

Temperature and salinity measurements were recorded at the location of most seines during the fish survey. As a summary of these data, temperature and salinity profiles are shown in Figures 10, 11 and 12 for four locations in the estuary at time intervals of about 2 weeks.

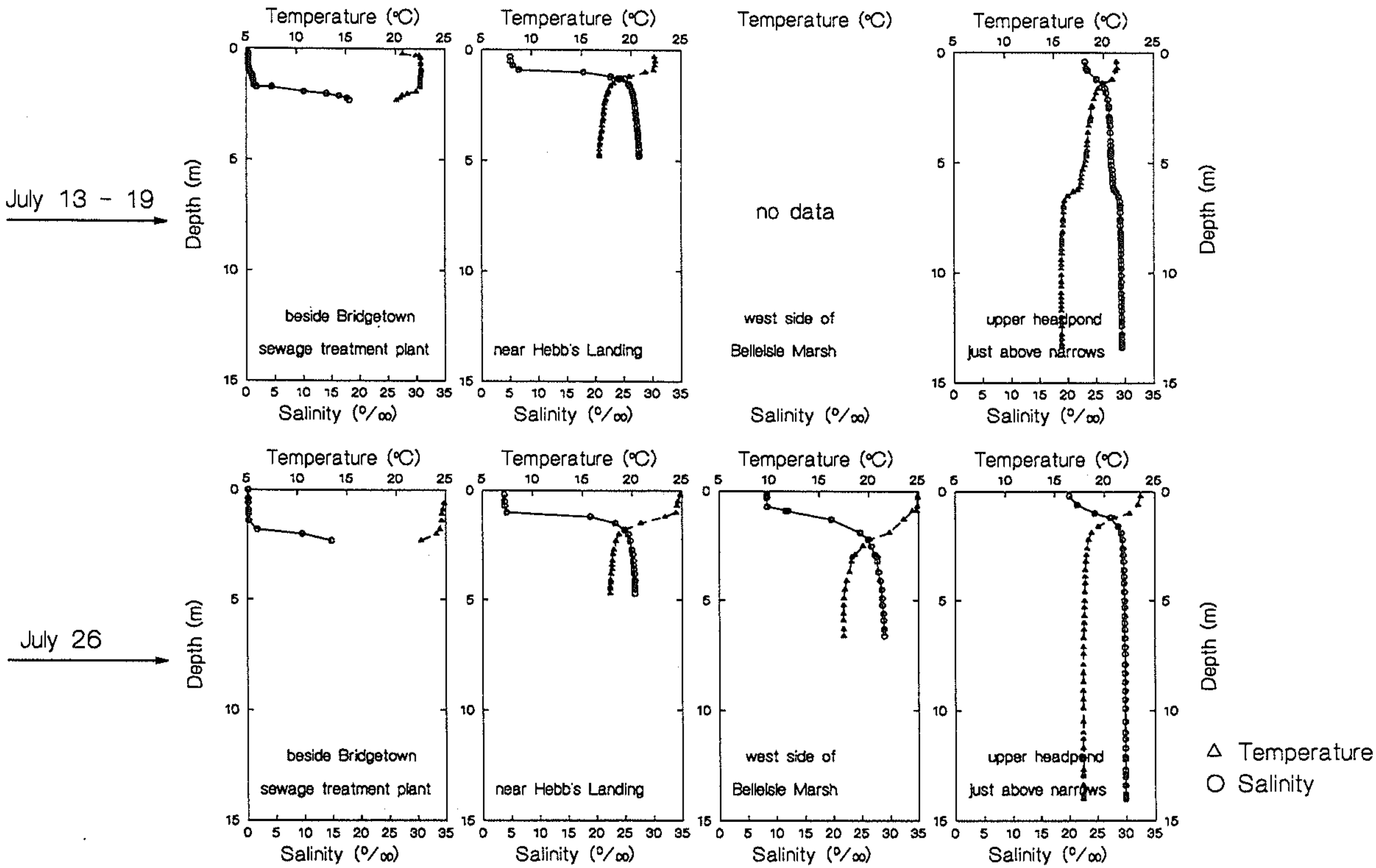


Figure 10. Temperature and salinity profiles at selected locations in the Annapolis Estuary during the fish survey.

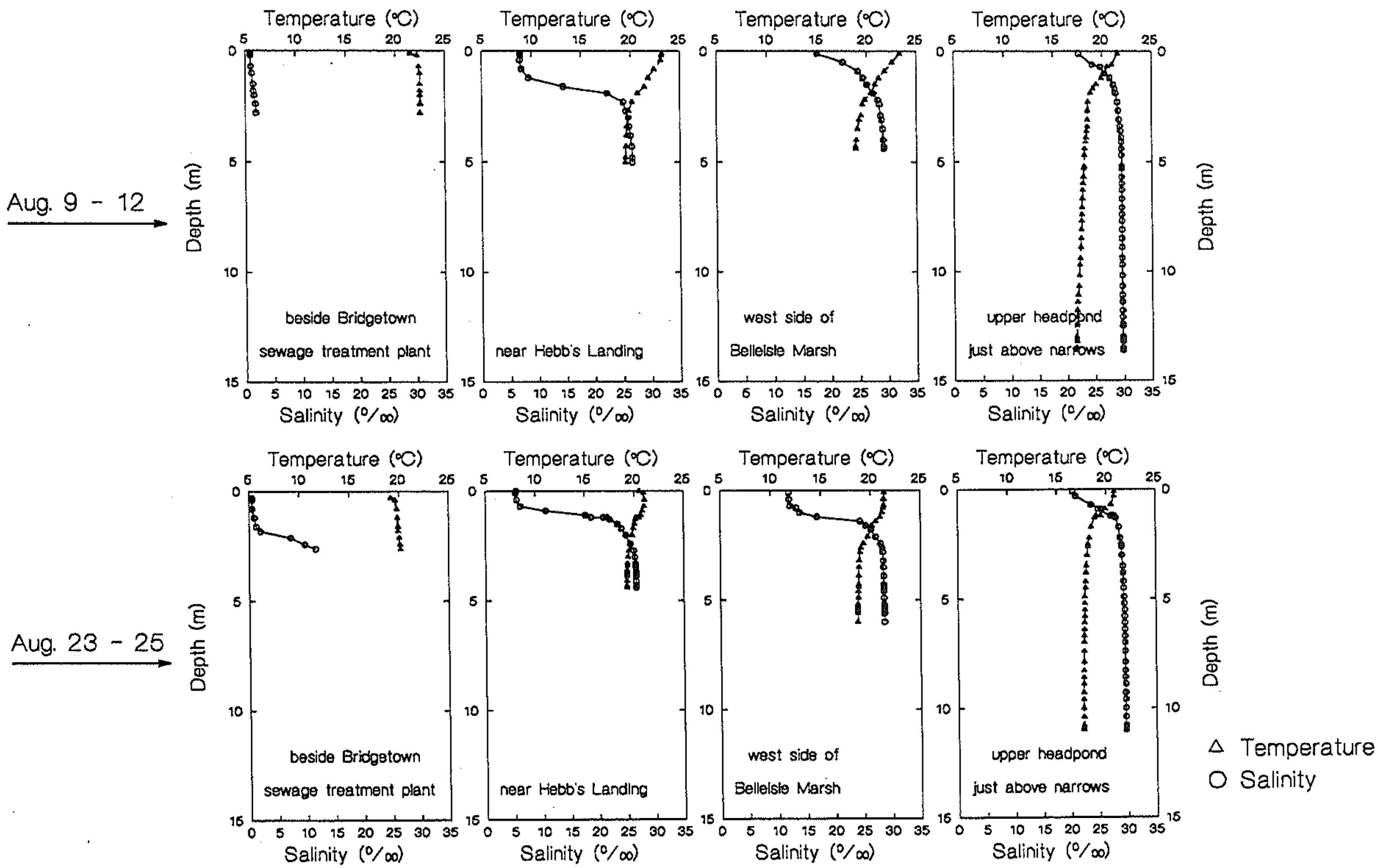


Figure 11. Temperature and salinity profiles at selected locations in the Annapolis Estuary during the fish survey.

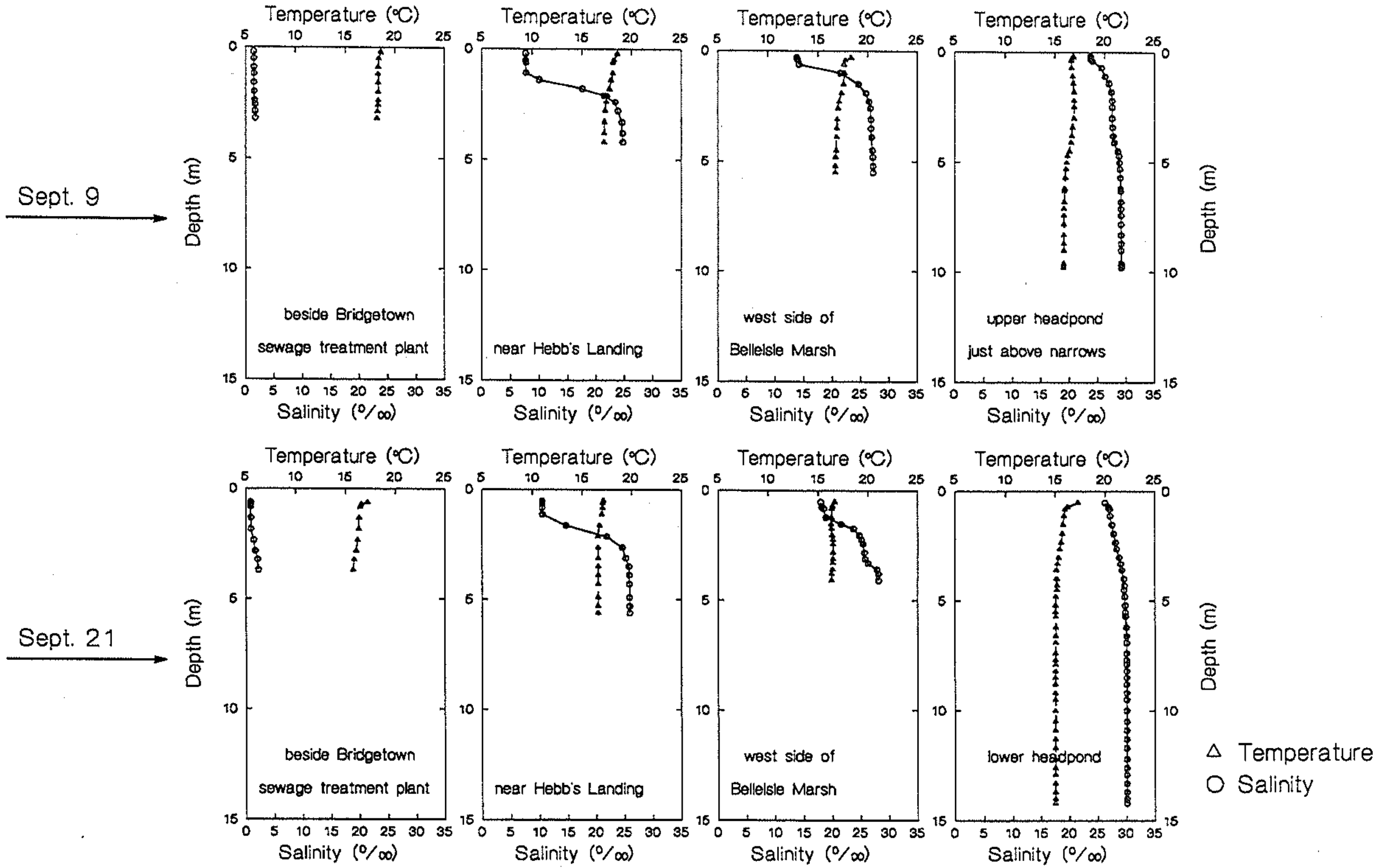


Figure 12. Temperature and salinity profiles at selected locations in the Annapolis Estuary during the fish survey.

Surface water salinity ranged from about 1.0 ppt. near Bridgetown to around 16.0 to 18.0 ppt. in the upper headpond. These salinities remained relatively constant throughout the sampling period. A prominent halocline was present between 1 and 2 meters depth. Salinities below the halocline were on the order of 30.0 ppt. in the upper headpond, 26.0 to 28.0 ppt. in the vicinity of Hebb's Landing, and varied from about 1.0 to 21.0 ppt. at Bridgetown, near which the upper limit of the salt wedge is located.

Surface water temperatures were high, just exceeding 25.0 ^{o}C in late July at all locations above the upper headpond. In the headpond itself, temperatures reached a maximum of 23.5 ^{o}C. Surface temperatures ranged from 15.2 ^{o}C to 16.5 ^{o}C on September 21, when few alosines were captured during the fish survey. Bottom water temperatures in the vicinity of Bridgetown also reached the low to mid twenties, and ranged from 15.0 ^{o}C to 19.5 ^{o}C in the rest of the estuary.

4.2 Results: Mark - Recapture Experiment for the Population Estimate

Between July 30 and August 28, 7107 alosines were captured, marked and released back into the estuary. The majority of alosines captured during this period and during the fish surveys in September were examined for marks, resulting in 20 recaptures. One additional recapture occurred during monitoring at the causeway, which was not used in the population estimate calculation. An estimate of stock size of alosines was calculated as 1,576,003 individuals (95% C.I. are estimated as lower: 1,157,468 individuals and upper: 2,468,657 individuals). Of the fish retained for determination of stock characteristics during this phase, 42.17% were American shad, 40.79% were blueback herring and 17.04% were alewives. Using these relative abundances the population estimate was adjusted to numbers per species and the results are summarized in Table 2.

The attempts to monitor fish migration by comparing marking time and location with recapture time and location, were not as successful as hoped. The time elapsed between marking and recapture varied from 1 to 5 weeks, however all recaptures occurred either in the zone in which marking took place or else one zone either up or downstream. Four recaptures occurred further up the estuary than where marking took place. The one recapture at the causeway occurred on September 26. This fish was marked in the vicinity of Hebb's landing between August 23 and 28.

Table 2. Estimates of stock size of YOY alosines.

Species	Estimate of Stock Size		
	N	95% lower C.L.	95% upper C.L.
American Shad	664,600	488,104	1,041,033
Blueback herring	642,852	472,131	1,006,965
Alewives	268,551	197,232	420,659
Total alosines	1,576,003	1,157,468	2,468,657

4.3 Results: Monitoring Alosine Passage at the Annapolis Causeway

Monitoring alosine passage in the vicinity of the Annapolis Tidal Generating Station began on July 27 and was continued until November 16. Fish passage was monitored by fishing with modified zooplankton nets in the two fishways and in the tailrace below the turbine. Nets were set on 1 tide in July, 9 tides in August, 23 tides in September, 31 tides in October and 8 tides during November. The locations, times, net types and catches for all net deployments at the causeway are listed in Appendix 2. A summary of the 26 species and the total number of fish caught in each location is presented in Table 3.

During the fish passage monitoring, nets were successfully set (excluding times with net failures) on 70 tides in the tailrace below the turbine, 66 tides in the old fishway and 64 tides in the new fishway. In total, 82,194 fish were captured, and the vast majority of these (76.6 %) were captured in the new fishway, while 18.8 % of the total catch came from the old fishway and only 4.6 % came from the tailrace. These percentages are skewed in favor of the fishways by the large numbers of Atlantic silversides captured in early September. Excluding Atlantic silversides, 31.7 % of the fish were captured in the tailrace, 40.7 % were caught in the new fishway, and 27.6 % were caught in the old fishway. Of the 2186 alosines that were captured, 48.0 % were caught in the tailrace, 51.5 % in the new fishway, and 0.5 % were captured in the old fishway. These percentages are also skewed in favor of the new fishway by a catch of 870 alewives at this location on July 28. If this catch is removed from the data the percentage of total alosine catches from each location are: 79.8 % for the tailrace, 19.4 % from the new fishway and 0.8 % from the old fishway.

Table 3. Total numbers and species of all fish caught in the two fishways and the tailrace during the monitoring of fish passage at the Annapolis causeway. Data from 0.5 m nets are standardized to the equivalent catch from a 1.0 m net. Data from the experiments to determine fish distribution in the fishways are not included in the table.

SPECIES	TAILRACE	NEW FISHWAY	OLD FISHWAY	TOTAL
sea lamprey	29	62	303	394
American eel	42	223	105	370
blueback herring	616	66	1	683
alewife	66	979	1	1046
American shad	368	80	9	457
Atlantic menhaden	0	2	1	3
Atlantic herring	77	113	0	190
rainbow smelt	131	64	51	246
hake sp.	7	9	4	20
tomcod	0	6	2	8
Atlantic silverside	2,005	60,944	14,115	77,064
stickleback sp.	120	109	537	766
pipefish	91	216	347	654
skate sp.	1	1	1	3
cunner	2	1	0	3
wrymouth	1	1	1	3
rock gunnel	0	6	4	10
American sand lance	3	10	2	15
butterfish	21	105	0	126
longhorn sculpin	2	0	0	2
lumpfish	4	4	21	29
smooth flounder	1	1	0	2
winter flounder	32	6	10	48
windowpane	13	19	11	43
mummichog	0	5	2	7
Atlantic mackerel	2	0	0	2
TOTAL	3,634	63,032	15,528	82,194

The distribution of the number of fish and the number of alosines caught over time is shown for the tailrace, new fishway and old fishway in Figures 13, 14 and 15 respectively (note scale differences between sites). The distribution of total catches appears to be similar at the three locations; the largest catches occurring during the first 10 days of September, the second week of October, and the first week of November. With the exception of the July 28 catch of 870 alewives in the new fishway (no alosines were captured in the tailrace or old fishway on this date), the temporal distribution of alosine catches appears similar between the tailrace and new fishway. The distribution appears bi-modal, with large catches during the first week of September and again early to mid October.

The temporal distribution of the American shad, blueback herring and alewife catches is shown for each of the three locations in Figures 16, 17 and 18. The distribution patterns for both American shad and blueback herring appear more or less similar to the pattern described above, although the largest numbers of American shad were captured during early September while the largest blueback herring catches occurred during the second week of October. The two largest catches of alewives occurred at the end of July and in early August. Catches after this time were small (less than 10 per tide per location) and more or less sporadically distributed.

Alosines using the new fishway may be smaller than those passing through the turbine, as shown by the length - frequency histograms in Figure 19. American shad captured in the new fishway were on average 12.2 mm shorter in fork length than those captured in the tailrace, alewives from the new fishway were 40.1 mm shorter than those from the tailrace and blueback herring from the new fishway were shorter than those from the tailrace by 4.2 mm. In all three cases the difference is statistically significant ($p<0.01$).

Time series of the catch for the tailrace, the new fishway and old fishways combined, for all alosines, American shad, blueback herring and alewives are shown overlaid against selected environmental parameters in Figures 20 - 23 respectively. Environmental parameters shown are water temperature, salinity, lunar phase and tidal range.

Salinity fluctuated throughout the study probably as a function primarily of precipitation and tidal excursion, however it does not appear to be correlated with the fluctuations in alosine catches. Minimum and maximum salinities recorded are 24.2 and 32.7 ppt.

Water temperature may serve as an environmental signal for alosines to move seaward, however during this study none of the high alosine catches appear correlated with a rapid drop in temperature. At the beginning of August, when the highest alewife catches occurred, the water temperature was around 18 C. The temperature had declined to about 16 C when the largest American shad movement occurred in early September,

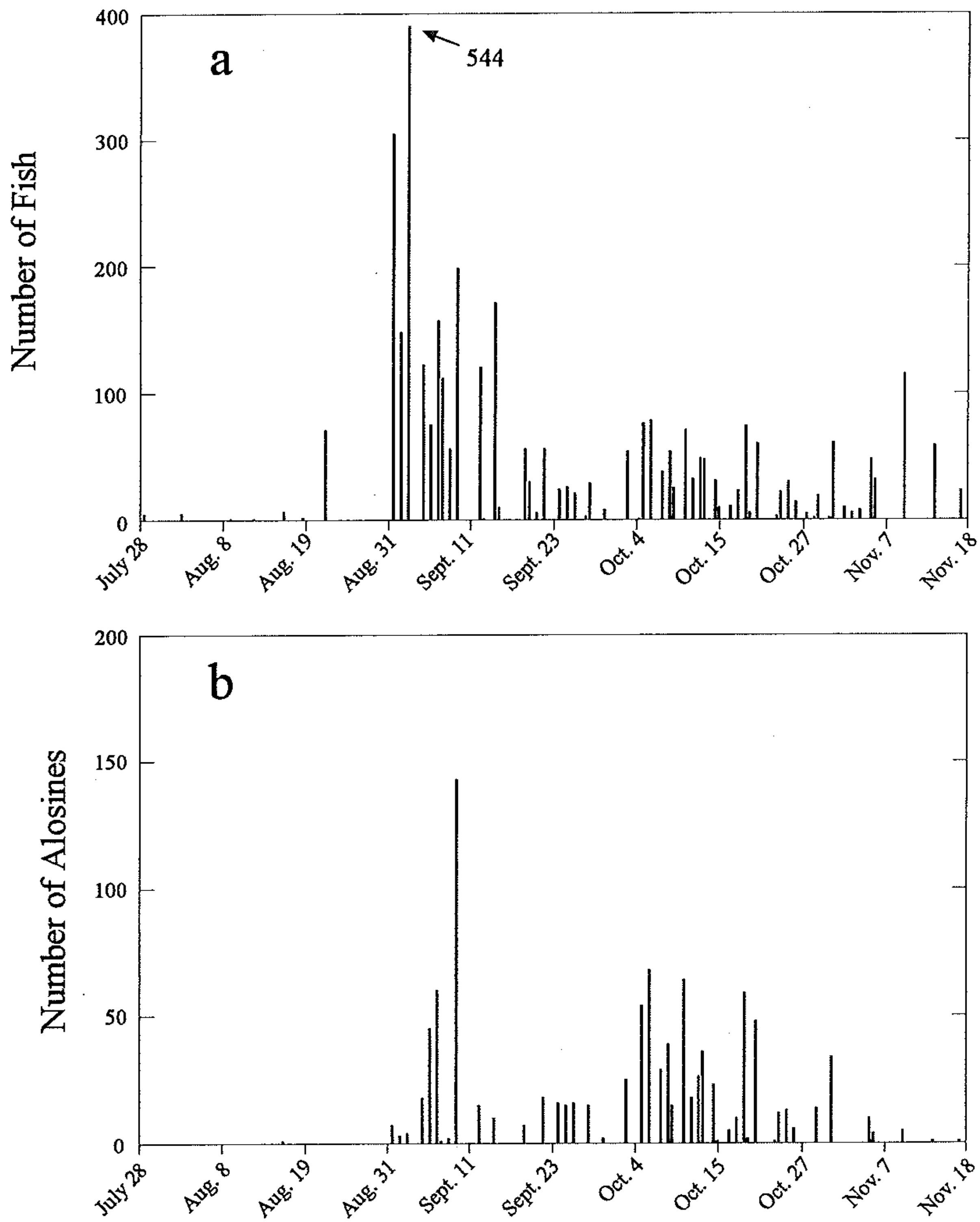


Figure 13. The number of fish of all species (a), and the number of alosines (b), captured in the tailrace. Data from 0.5 m nets are standardized to represent the equivalent catch from a 1.0 m net.

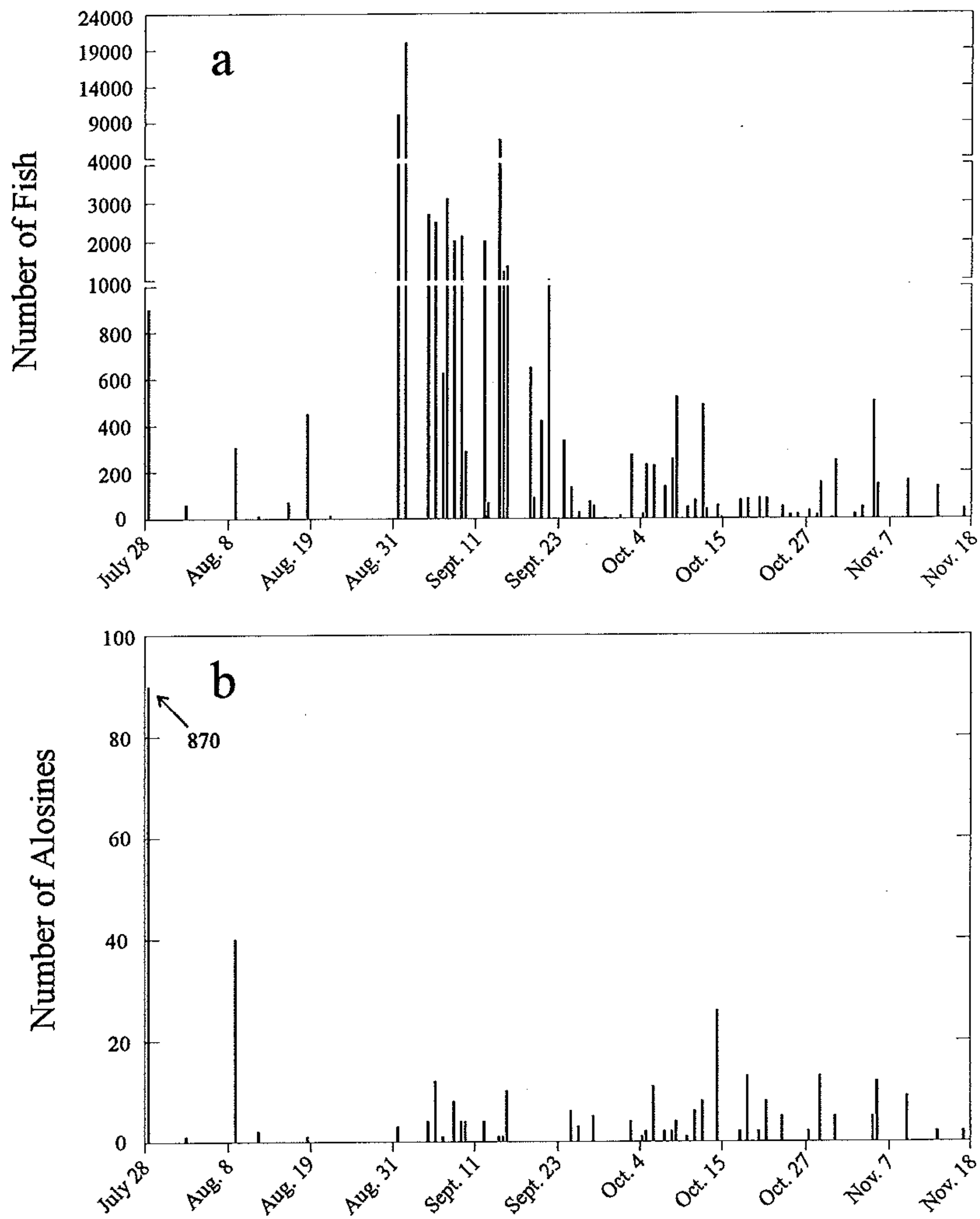


Figure 14. The number of fish of all species (a), and the number of alosines (b), captured in the new fishway. Data from 0.5 m nets are standardized to represent the equivalent catch from a 1.0 m net.

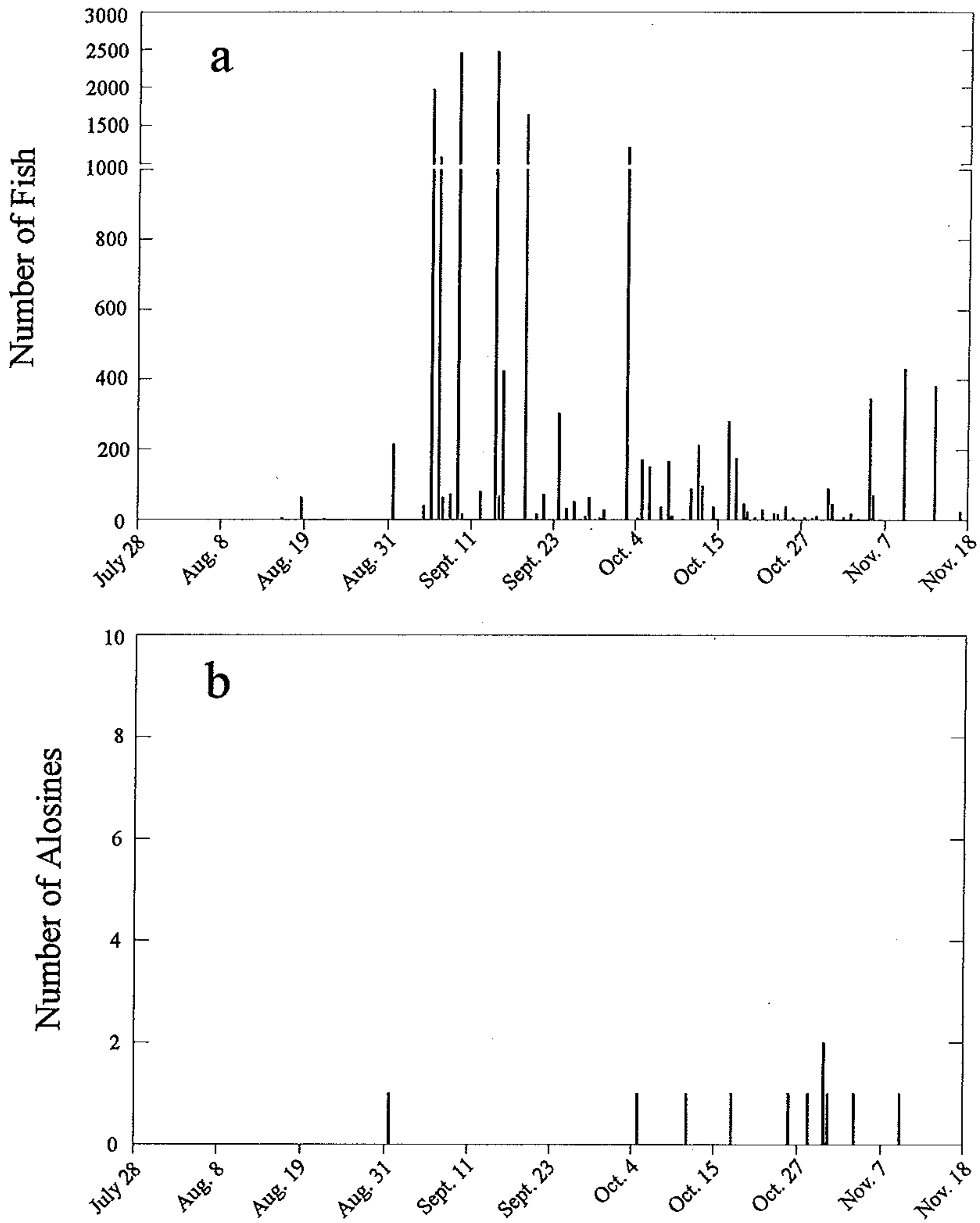


Figure 15. The number of fish of all species (a), and the number of alosines (b), captured in the old fishway. Data from 0.5 m nets are standardized to represent the equivalent catch from a 1.0 m net.

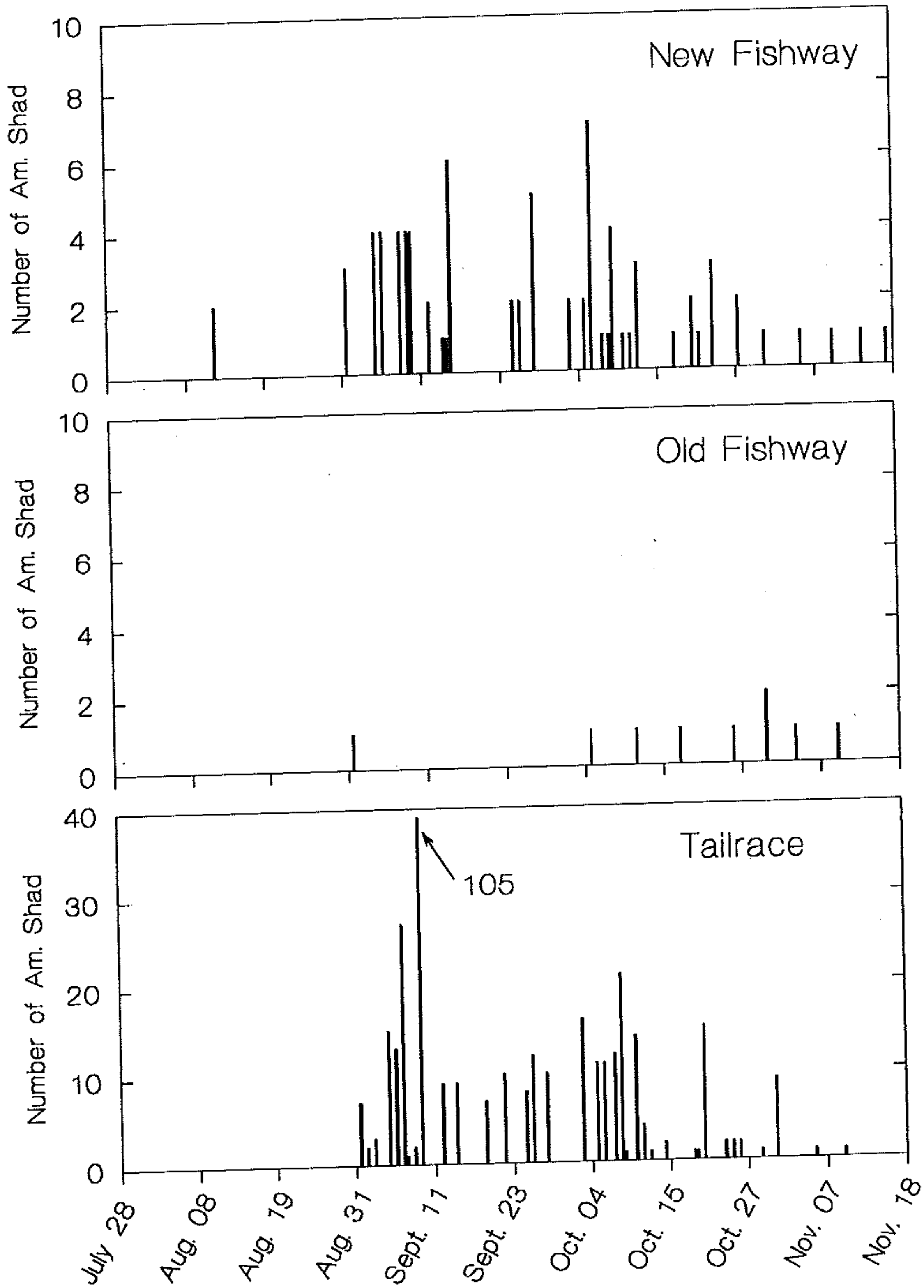


Figure 16. Time series showing the distribution and magnitude of the American shad catches from two fishways and the tailrace.

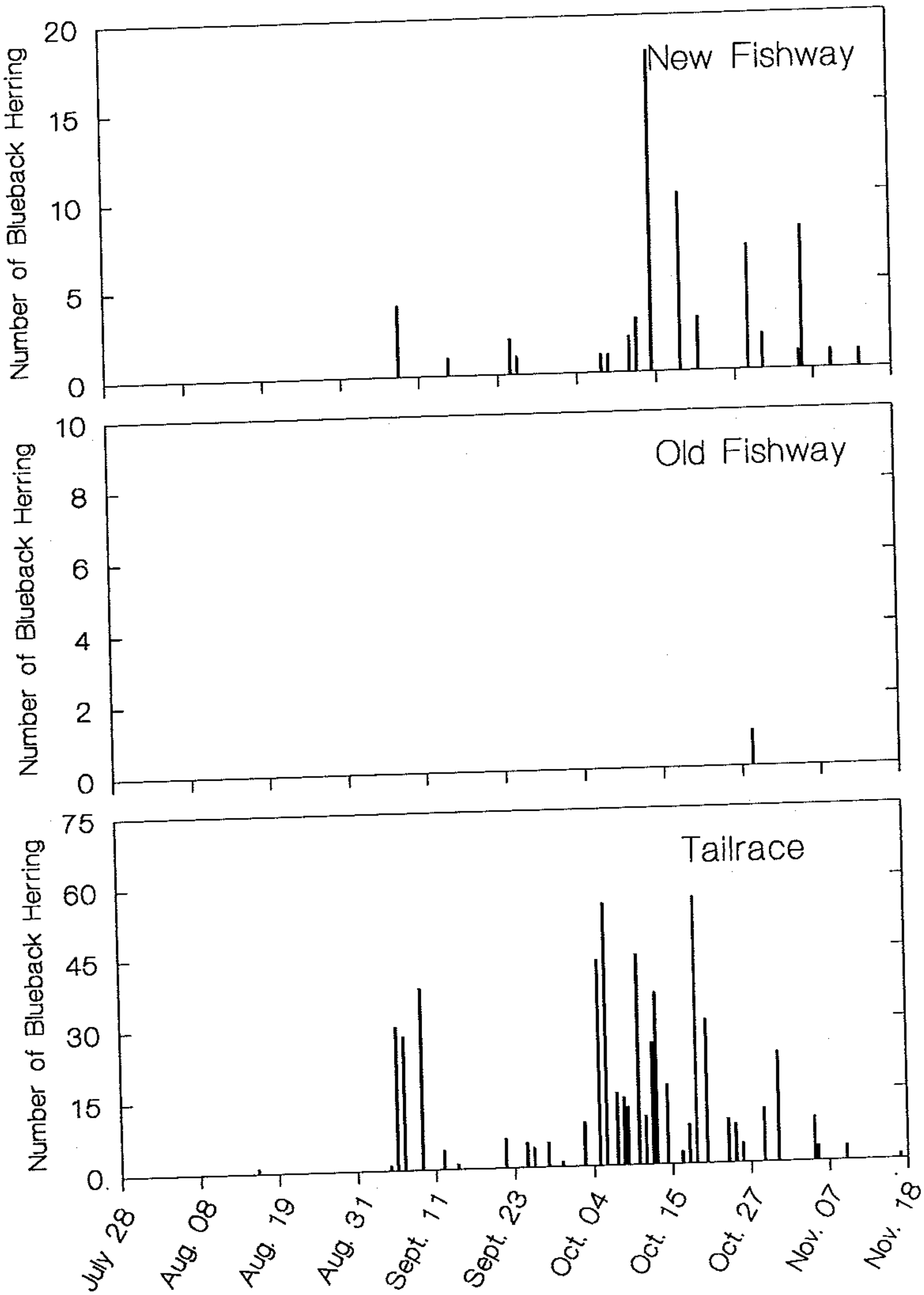


Figure 17. Time series showing the distribution and magnitude of the blueback herring catches from two fishways and the tailrace.

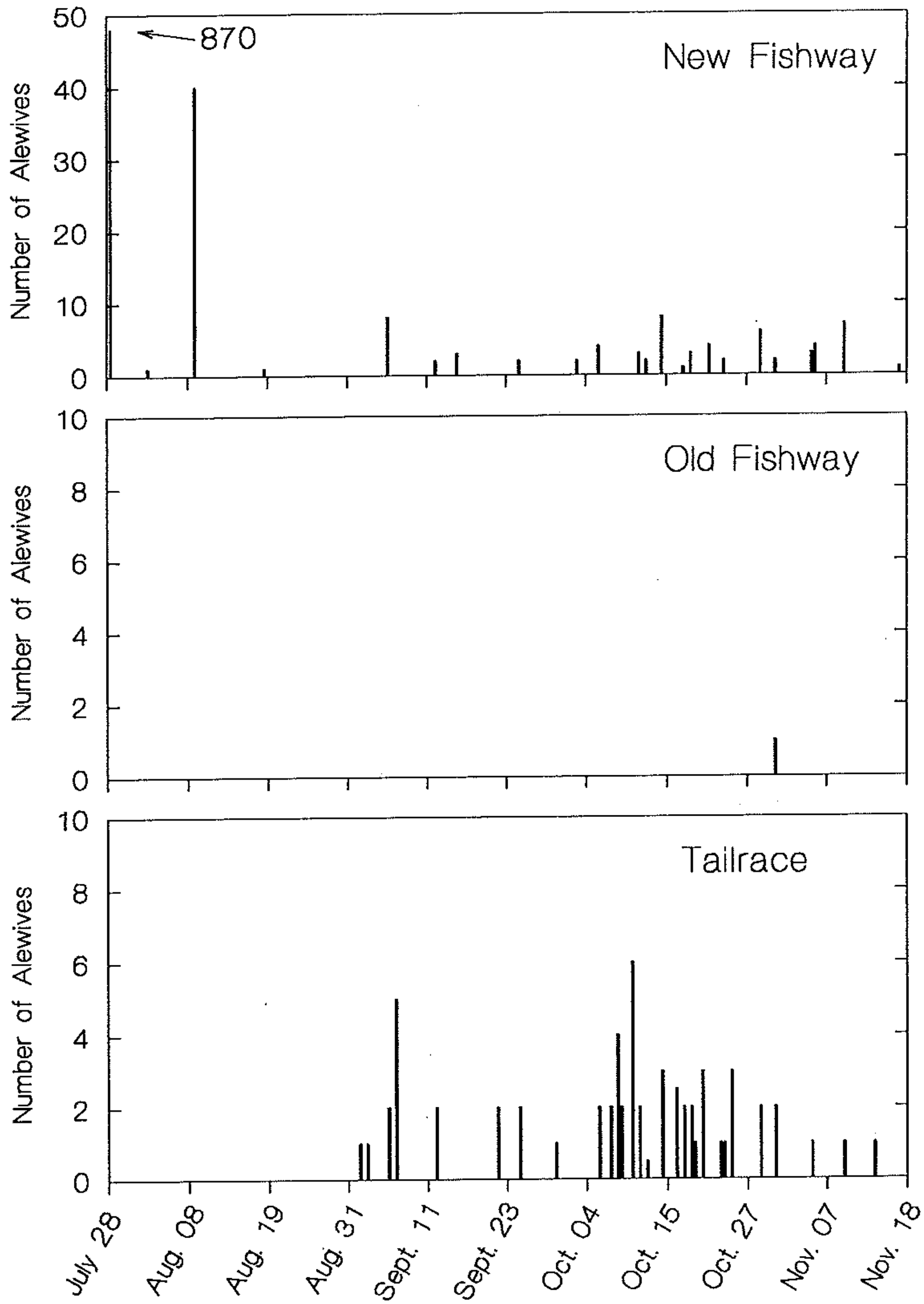


Figure 18. Time series showing the distribution and magnitude of the alewife catches from two fishways and the tailrace.

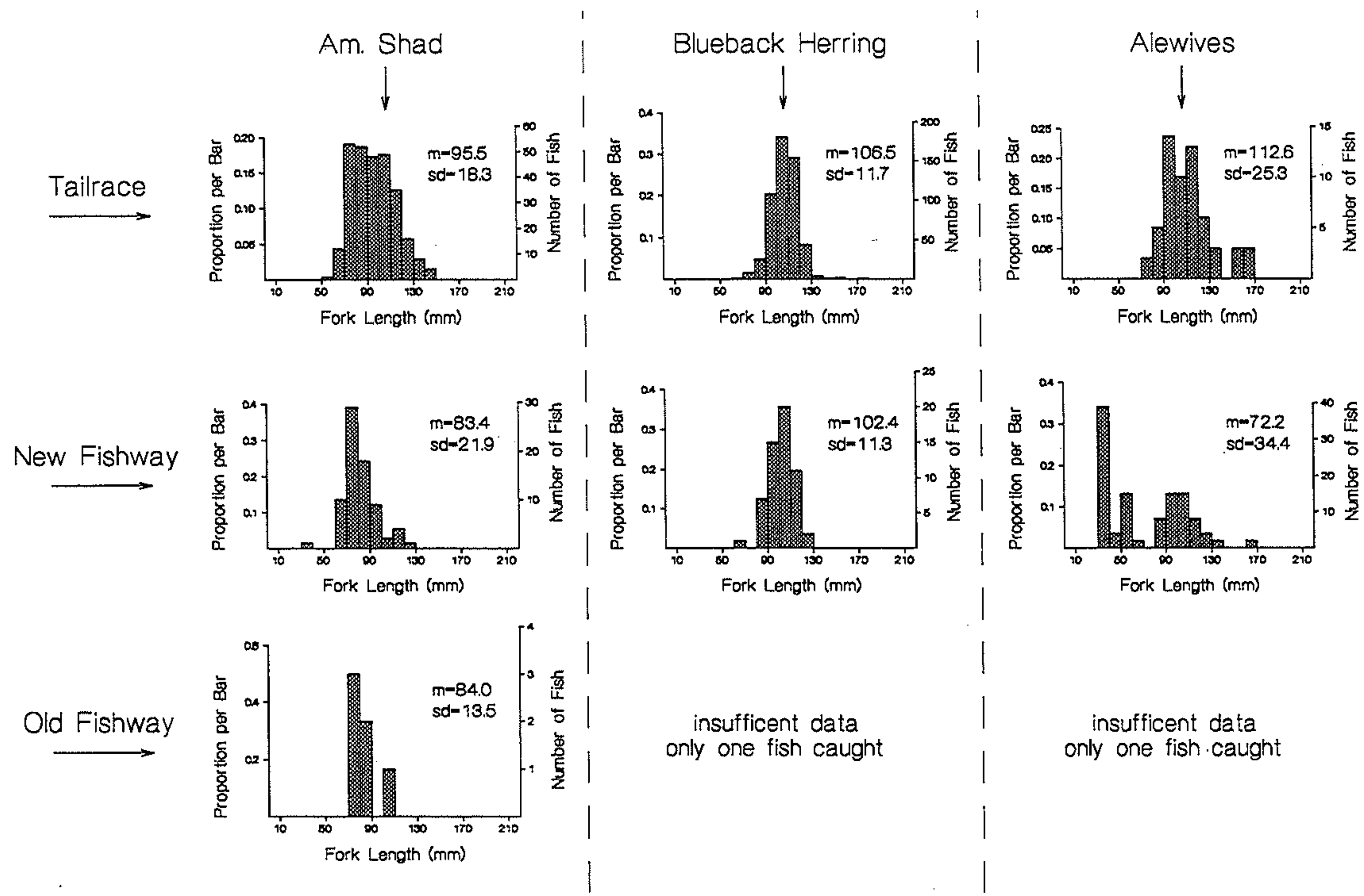


Figure 19. Length frequency distributions for American shad, blueback herring and alewives showing differences in size between fish captured in the tailrace, new fishway and old fishway (m=mean , sd=standard deviation).

and was in the range of 10 - 14 C in early October coinciding with the largest movements of blueback herring.

From Figures 20 - 23, it appears that alosine movements may be coupled with the lunar cycle, either directly, or through its effect on tidal range. Figure 24 contains scatter plots of the number of alosines captured in the three locations against phase of the moon (Fig. 24 a) and tidal range (Fig. 24 b). The largest numbers captured appear to fall between the new moon and first quarter (Fig. 24 a), and the magnitude of the largest catches appears to increase with increasing tidal range.

It appears from the results of the experiments fishing three nets simultaneously in the fishways that the fish are not evenly distributed across the fishways, as shown in Figure 25. Eddies exist on the north side of the fishway (in the vicinity where the nets were fished) for much of the ebb tide, which limit fish movement in more than 25 % of the fishway. The ratios of the area under the curves shown for each fishway in Figure 25 to the area under the curve expected if the fish were evenly distributed (below the horozontal line Y=1), yields correction factors that may be used to adjust extrapolations from the catch of a net to the total number of fish moving through a fishway while the net was fishing. Using pixel counts to determine the areas, the correction factors are calculated as 0.7365 and 0.7693 for the new and old fishways respectively. Assuming the nets sample at 100 % efficiency and that the fish are evenly distributed vertically within the fishway, an estimate of the number of alosines passing through a fishway during a given period may be calculated as follows:

$$N = A_f/A_n \times CF \times Alos \times Tides \qquad \text{eqn 4.}$$

where: N = total number of alosines passing through the fishway in the given time period

A_f/A_n = the ratio of the cross-sectional areas of the fishway to the net

CF = correction factor

Alos = mean number of alosines captured per tide

Tides = number of tides during the given time period

The values used for this calculation for the period between August 30 and November 4, when monitoring was most intense, are summarized in Table 4. It is estimated that 4641 alosines passed through the new fishway and 850 through the old fishway during this time.

Table 4. Summary of values used to estimate the number of alosines passing through the fishways between August 30 and November 4.

Location	Ratio of area of fishway to area of net	Mean number of captured alosines per tide (std. error)	Correction factor	Number of tides (Aug. 30 - Nov. 4)	Number of alosines that passed through the fishway (95 % C.I.)
New Fishway	13.14	3.70 (0.67)	0.74	129	4641 (2994 - 6288)
Old Fishway	50.35	0.17 (0.06)	0.77	129	850 (262 - 1438)

4.4 Results: Size and Condition of Migratory Alosines

Fork lengths, weights and condition factors were determined for all alosines retained during both phases of the project. These parameters are summarized in Table 5. Alosines longer than 170 mm fork length were considered to be second year fish and are not included in the calculations of the values in the table.

Table 5. Mean (standard deviation) of the fork length, weight, and condition factor of YOY alosines retained during both phases of this project.

SPECIES	PHASE	N	FORK LENGTH (mm)	WEIGHT (g)	CONDITION FACTOR
Am. shad	fish survey	682	62.66 (14.64)	3.23 (3.07)	1.10 (0.15)
	fish passage monitoring	362	92.43 (18.40)	8.95 (6.10)	0.99 (0.14)
bb. herring	fish survey	677	50.56 (4.96)	1.79 (1.66)	1.06 (0.17)
	fish passage monitoring	527	105.89 (11.68)	12.42 (4.72)	0.99 (0.12)
alewives	fish survey	293	55.13 (16.47)	2.65 (2.43)	1.18 (0.26)
	fish passage monitoring	173	86.33 (36.25)	10.06 (10.28)	1.03 (0.14)

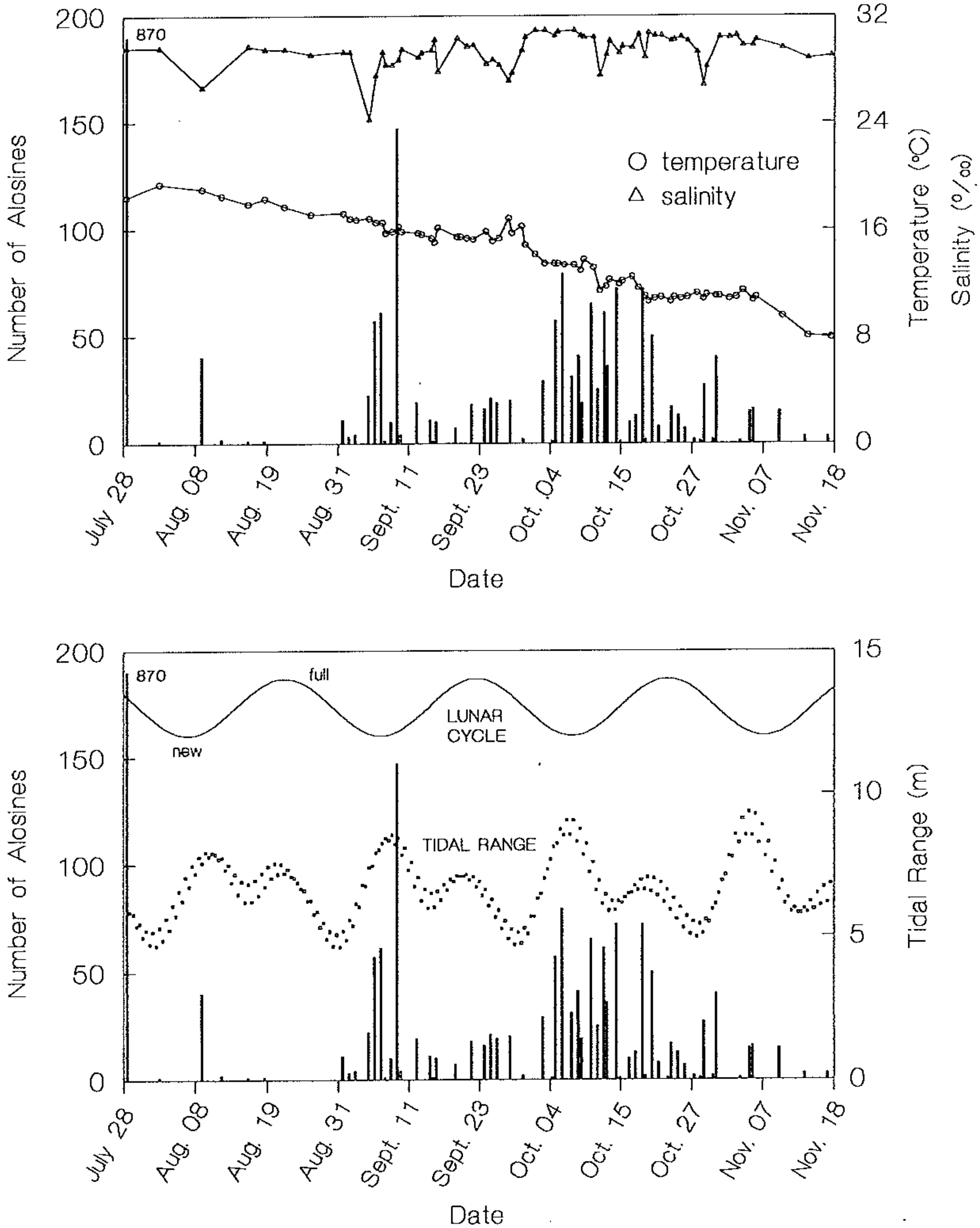


Figure 20. Time series of the alosine catch from the two fishways and tailrace combined overlaid against the corresponding temperatures and salinities (top) and the lunar and spring - neap cycles (bottom).

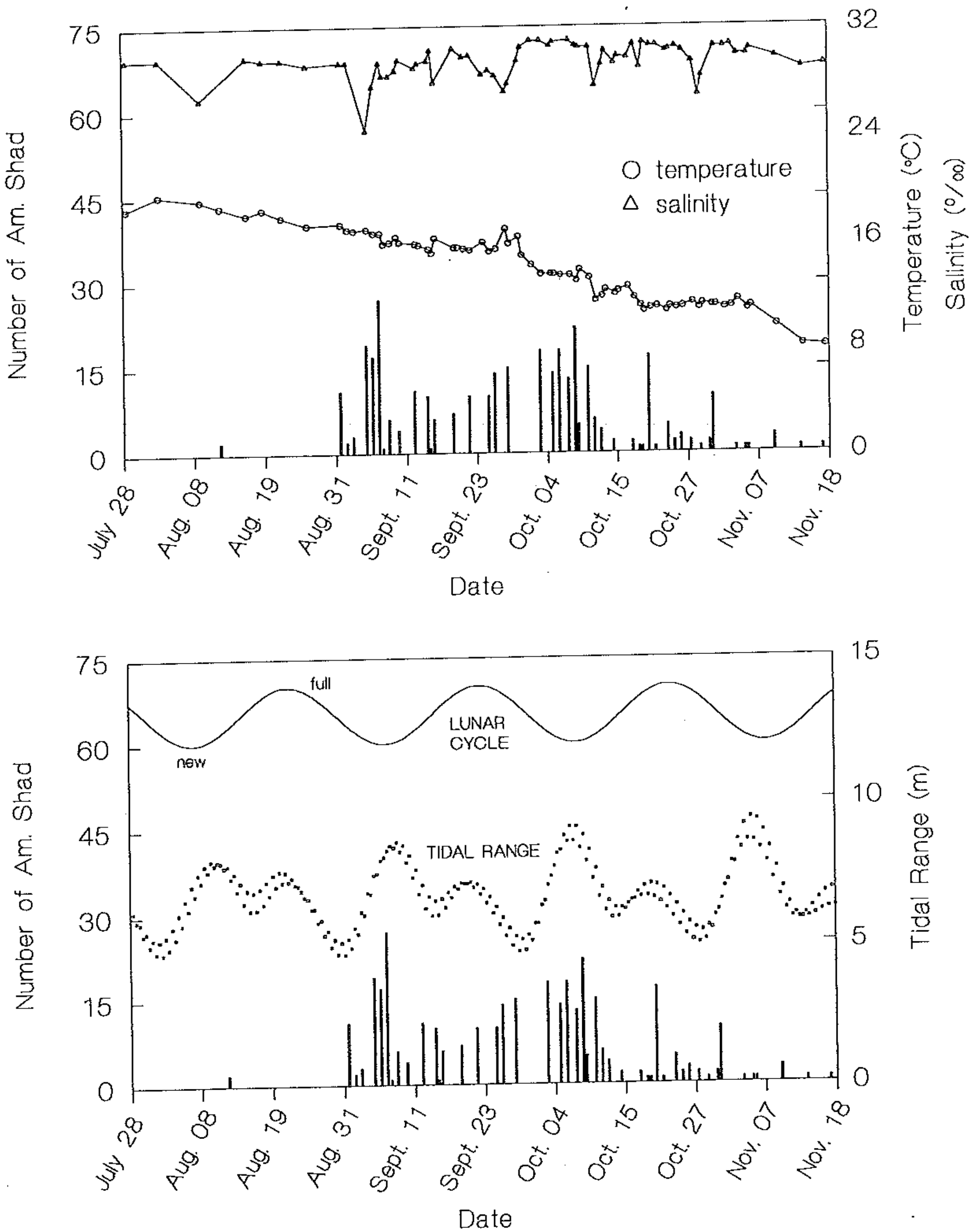
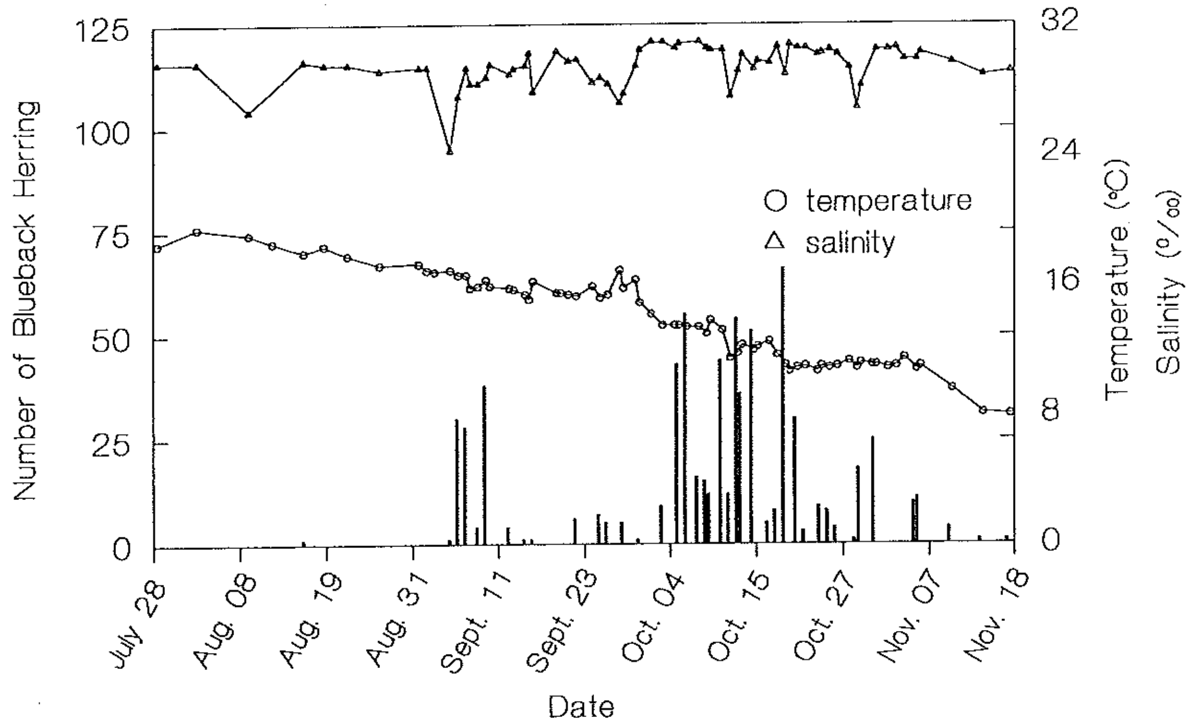


Figure 21. Time series of the American shad catch from the two fishways and tailrace combined overlaid against the corresponding temperatures and salinities (top) and the lunar and spring - neap cycles (bottom).



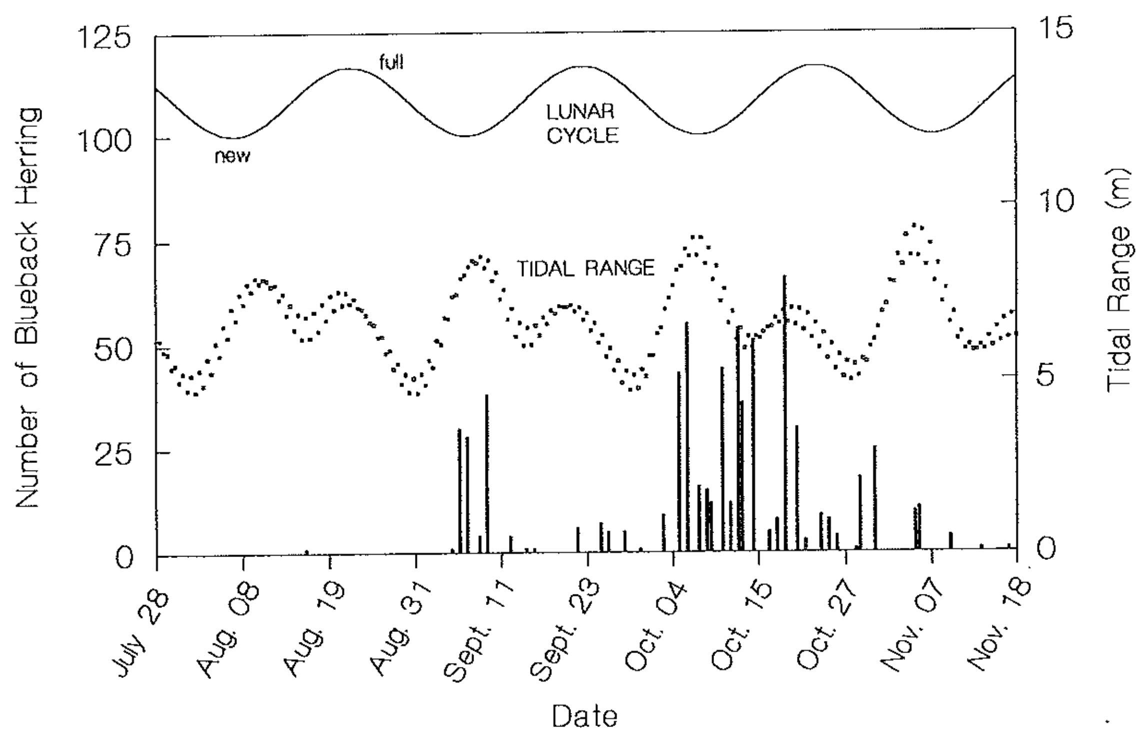


Figure 22. Time series of the blueback herring catch from the two fishways and tailrace combined overlaid against the corresponding temperatures and salinities (top) and the lunar and spring - neap cycles (bottom).

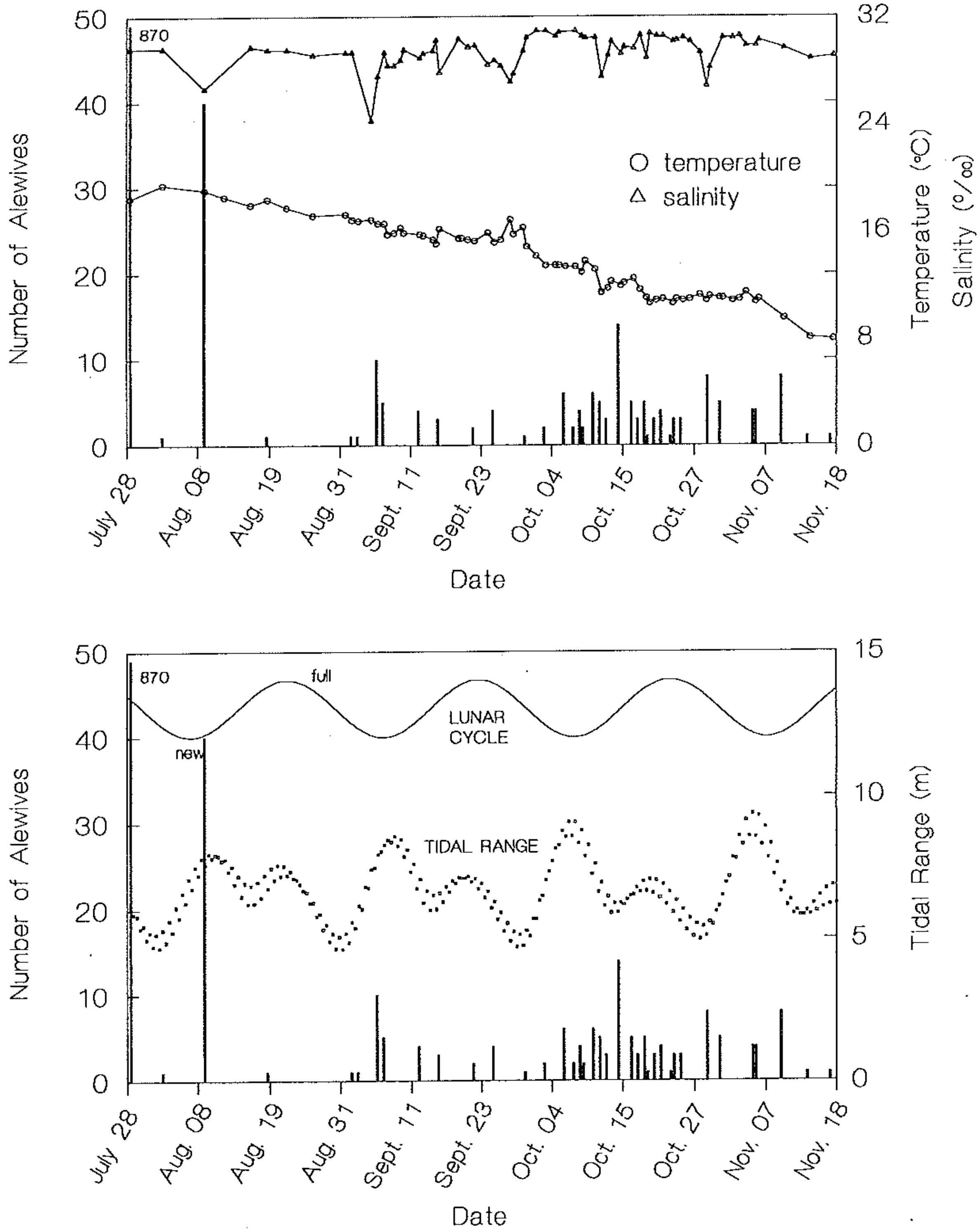


Figure 23. Time series of the alewife catch from the two fishways and tailrace combined overlaid against the corresponding temperatures and salinities (top) and the lunar and spring - neap cycles (bottom).

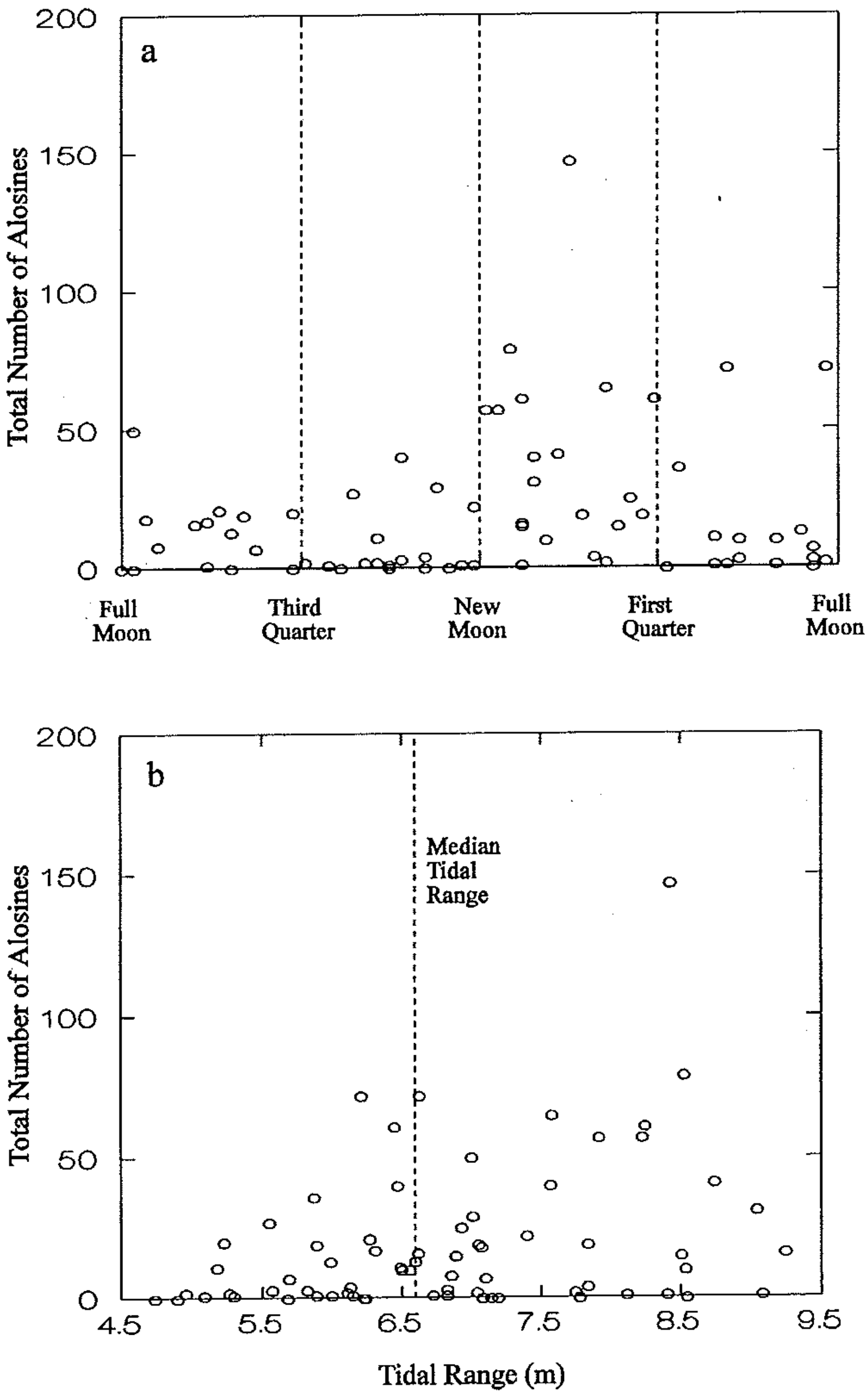
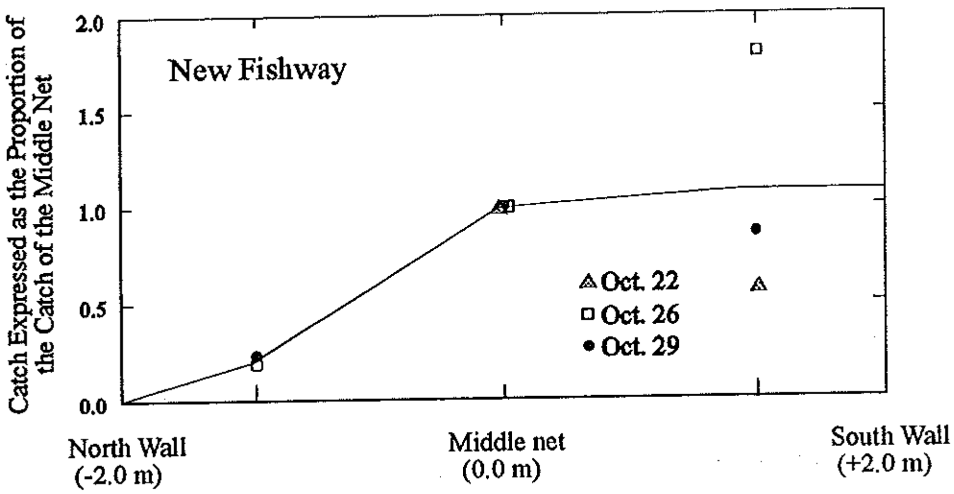


Figure 24. The number of alosines caught in the tailrace and the fishways combined ploted against the phase of the moon (a) and tidal range (b).



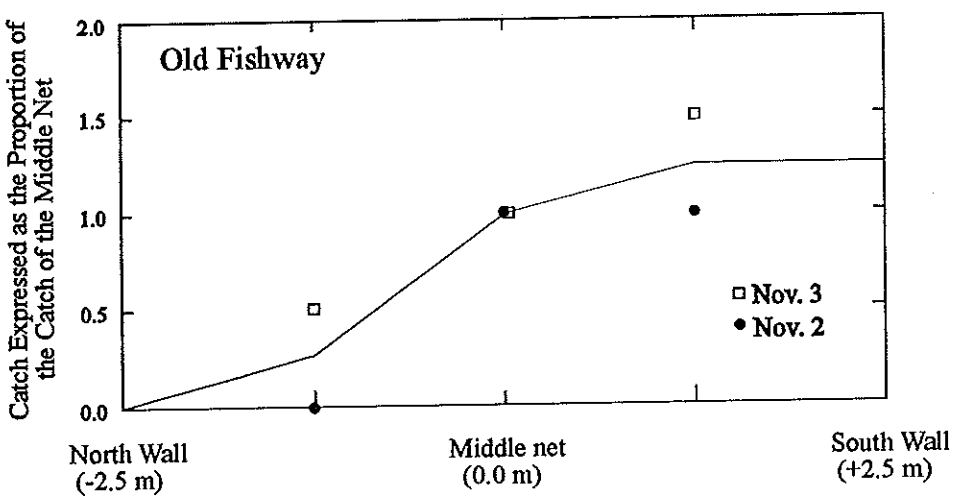


Figure 25. Distribution of catches, expressed as a proportion of the catch of the middle net when fishing three nets similtaneously in the new fishway (top) and the old fishway (bottom).

5.0 DISCUSSION

5.1 Location and Downstream Movement of YOY Alosines (Objectives 3,4 and 5)

Repeating an observation from 1993 work (Gibson and Daborn 1993), declining C.P.U.E.'s as one moves seaward in the estuary should be interpreted as a statement about the efficiency or suitability of the seining methods in different habitats rather than attributed to behavioral changes, or changes in abundance of the fish. While the technique seemed quite effective in the river where the seine can reach close to the bottom and cover a large portion of the available habitat, the same is not the case in the headpond, where fishing success with the seine appears to be more a matter of chance. The net only fishes the top 3.0 m , and if the fish are any deeper than that they would not be caught by the net. The method is also only useful along a shoreline onto which the net can be beached, and a large portion of the shoreline of the headpond is characterized by dead falls and rocks that snag the net, making that portion of the shoreline unsuitable for seining. In summary, the seining method appears to be effective in the shallower waters of the upper estuary, however, it is not a reliable method for collecting a large number of alosines in the headpond. For these reasons, the C.P.U.E. data presented in Figures 3 - 6 should be interpreted as relative abundance over time at a particular location in the estuary, but not used for comparisons between locations at a particular point in time.

Based on the results of the 1993 study (Gibson and Daborn 1993), we anticipated that the initial surveys in July would turn up few if any YOY alosines in the estuary at that time and that congregations of YOY alosines would form in mid to late August in the vicinity of Bridgetown. These congregations were expected to move downstream during late August and early September. This proved not to be the case, as YOY alosines were found congregating at the upper end of the estuary in July and were present throughout the estuary by the beginning of August. Based upon this result, the estuary functions not merely as a passage from nursery areas at the river-estuary boundary to the sea as suggested in Gibson and Daborn (1993), but as a nursery area itself. Larval or juvenile alosines move into the upstream end of estuary and then gradually work their way seaward. This results in a population that is stratified with smaller fish being more abundant at the head of the estuary and larger fish downstream. This stratification breaks down over time, probably because the age structure of the population becomes more uniform over time. Additionally, one would expect larger fish to be more mobile, thereby covering a larger range and increasing the amount of mixing in the population.

While all three alosine species showed distribution patterns similar to that described above, there do appear to be some spatial and temporal differences in the way American shad, blueback herring, and alewives utilize the estuary. The largest alewife C.P.U.E.'s in the vicinity of Bridgetown occurred during the first week of the study in mid-July. No alewives were captured in this area after August 13 and catches in the remainder of the estuary above Bridgetown were more or less constant (albeit 'patchy') during the rest of the project. Large numbers of alewives were also captured at the Annapolis causeway on July 28 (870 alewives) and on August 8 (40 alewives) implying that at least a portion of the population had moved well downstream by this time. It is not known whether these fish continued to move seaward to the Bay of Fundy. However the presence of alewives above the causeway into September suggests that during the survey period, YOY alewives occupied an area that extended from above Hebb's Landing to some point seaward of the Annapolis causeway.

American shad were also captured in the vicinity of Bridgetown during the middle of July and, in contrast with the distribution pattern for alewives, they were present in the area until the September 21 survey date. Two American shad were captured at the causeway on August 10, but these were the only ones captured before August 30. It appears therefore, that during the survey period, YOY American shad in the Annapolis occupied a range that, while overlapping with that of alewives, was generally located further up the estuary.

Blueback herring occupied an area that appeared intermediate to those occupied by alewives and American shad. Only very small numbers of blueback herring were captured in the vicinity of Bridgetown after August 6 and, with the exception of 1 blueback herring captured on August 15, bluebacks were not captured at the Annapolis causeway until the first week of September.

While the above observations contrast markedly with the conclusions of the 1993 study (specifically that alosines were not present in the estuary until early September and that the entire migration took place in about two weeks), the data themselves are not so conflicting. C.P.U.E.'s in the vicinity of Bridgetown during early September are similar (approx. 50 to 70 alosines per seine), and the alosines appeared to vacate the upper reaches of the estuary during the second week of September during both years. The data therefore imply that the previous conclusions about the pattern of alosine movement in 1993 are erroneous, probably due to the timing of the fish survey work carried out during that year.

Surface water temperatures and salinities appear more or less similar during September for the two years. For example, the surface water temperature in the vicinity of

Hebb's Landing on September 9, 1994 was 18 °C, whereas it was around 19 °C at this date in 1993 (Figure 4, Gibson and Daborn 1993). Surface salinity was also similar, around 9 to 10 ppt. at this time both years.

A prominent halocline was present throughout the upper reaches of the estuary, between one and two meters depth. It is not known what, if any, effect this has on the alosines, but because they are regularly seen jumping, they either reside in the top 1 to 2 meters of water, or move freely back and forth across the halocline. Intuitively, the latter appears more likely. Given that bottom water salinities were around 27 ppt. near Hebb's Landing, and sometimes as high as 21 ppt. near Bridgetown, acclimation to higher salinities may not be an important factor limiting the rates of alosine migration as suggested in the 1993 report. Chittenden (1972) found that young blueback herring could survive transfer from water with 0 ppt. salinity to water with 29 ppt. salinity.

Despite a number of attempts to locate alosines in Evan's Brook, no alosines were captured at this location. Local fishermen, however, report that alewives (or blueback herring ?) do run in that river. Attempts to locate nursery areas in the numerous small tributaries that enter into the Annapolis Estuary were quickly considered redundant when it was discovered that large numbers of fish were already present in the main branch of the estuary in the vicinity of these tributaries.

5.2 Mark - Recapture Studies (Objective 1)

Because large numbers of alosines were discovered downstream of Bridgetown during late August, the initial plans, to mark large numbers of fish in the vicinity of Bridgetown and then monitor their movement downstream, were abandoned. Consequently, a mobile marking station was developed and alosines were marked where ever they could be found.

Because the alosines were smaller than anticipated from last year's study (marking took place about a month earlier than anticipated) the use of Floy tags to mark fish was abandoned in favor of marking using sub-cutaneous injections of an elastopolymer containing fluorescent dye. In hindsight, this system appeared quite suitable for our purposes, although user skill in applying the marks seems to play an important role in mark retention or at least in applying marks that are visible to the naked eye. Because of the fluorescent dye, marks are more visible when stimulated with ultraviolet light (the marking kit comes with the light) which would make weaker markers, or marks that are too deep, more visible. The use of the light was not practical in this study due to the increase in handling time involved in looking for marks and the problems of using the light under bright sunlight.

The Schnabel method for estimating stock size from a multiple mark-recapture experiment requires at least two assumptions: there must be random mixing of marked fish within the population, and either the marking effort or the recapture effort must be randomly distributed throughout the population (Ricker 1975). Both of these assumptions were violated in our experiment, the first because the population appeared stratified to some extent, and the second because the fishing effort was concentrated where the fishing success was greatest in an effort to maximize the number of marked fish in the river (although approximately once a week the entire study area was surveyed to help reduce this bias). Both of these violations tend to increase the probability of underestimating the population size. Additionally, a Schnabel estimate is not strictly appropriate for open populations (populations undergoing immigration or emigration) as is the case here. Emigration from the population over the course of the study would tend to increase the ratio of marked to unmarked fish in the population over time which would also increase the probability of underestimating the population. For the above reasons the stock size estimates should if anything be considered to be biased low.

The estimates of stock size given in Table 2 are estimates of the number of YOY alosines in the estuary between Bridgetown and Annapolis Royal during the time of the study, and therefore are not necessarily indicative of the total reproductive success of the alosines within this system this year. This is especially true in the case of alewives as the largest catch of alewives at the Annapolis causeway (July 28) occurred before fish marking commenced in the estuary and the second largest catch (August 8) occurred just after its commencement. The estimate of the stock size of juvenile alewives presented in Table 2 is therefore probably a gross under-estimation of the reproductive success of alewives in the Annapolis River system during 1994, as large numbers of YOY alewives had moved out of the study area before marking began.

While the estimates of stock size within the estuary (1,576,003 alosines) may be biased low, they are more than an order of magnitude higher than the estimates of stock size in the 1993 study (74,022 alosines), or the Stokesbury and Dadswell (1989) estimates of the numbers of alosines passing the causeway in 1985 (115,000 alosines) and in 1986 (18,000 alosines). These differences could possibly be due to real differences in YOY alosine abundance, but are more likely due to differences in methodology and timing between the studies. The 1993 estimate was based on mark-recapture work conducted during September, which is the time the alosines are moving into the headpond and past the causeway. The estimate may be indicative of the number of alosines in the estuary during the study, but it is probably not indicative of the total number of YOY alosines produced by the Annapolis River system that year.

The estimates of Stokesbury and Dadswell of the number of alosines moving past the causeway may have been biased in a number of ways. The calculations are based on the assumptions that the net fishes at 100 percent efficiency and that flows across the tailrace are homogenous. Neither of these is true. Gibson and Daborn (1993) showed that nets of a design similar to those used by Stokesbury and Dadswell fish at a lower efficiency than the nets used in the 1993 and 1994 studies, although the true efficiency of either net is unknown. Nor are the flow velocities homogenous across the tailrace. While the flow has not been characterized in this area, it is obvious that a large eddy exists on the north side of the tailrace during most of the generation period where the velocity seaward is negative. Another bias occurred in the choice of fishing times which was based on attempts to maximize the catch (Stokesbury and Dadswell (1989) probably to improve the mortality estimates. The catch was then treated as the mean of a random sample for calculating the population estimate (Stokesbury, 1987). This would tend to increase the probability of over-estimating the population, but only if one was successful in maximizing the catch. In the present study, 7 of the 10 largest alosine catches occurred while fishing tides that extended to at least 0300h and often through dawn (although the two largest catches occurred on tides that ended around midnight). During the 1986 season Stokesbury did not fish any tides that extended beyond 0130h (Stokesbury 1987), and indeed fished only 4 tides throughout September, the month during which 59.6 % of the American shad were caught during this study (albeit only 19.2 % of the blueback herring).

5.3 Alosine Passage at the Annapolis Causeway (Objective 2)

The monitoring intensity during this study vastly exceeds the efforts in the three previous studies: 77 tides were monitored this year versus 17 in 1993 (Gibson and Daborn 1993), 28 in 1985 and 29 in 1986 (Stokesbury 1987). Many of the latter were only monitored for part of the generation period. As a result of this effort, the total catch (82,194 fish) and the number of alosines captured (2186) also greatly exceed the numbers for previous years (the total number of fish captured in the 1993 study was 4,158 and the number of alosines caught was 202) allowing for some interesting conclusions.

In 1993, 59.3 % of the total fish and 23.3 % of the alosines caughted were captured in the new fishway. This is in contrast with the results of Stokesbury (1987) who determined in 1985 (based on the fact that less than 2 % of his alosine catch came from the new fishway) that so few alosines were captured the new fishway that it was not worth monitoring in 1986. In this study, even after excluding from the data the new fishway catch of 870 alewives on July 28, 19.4 % of the alosines captured came from this location. Additionally, the new fishway appeared to play an important role in the passage of non-alosine species (particularly Atlantic silversides), as is evidenced by the fact that 76.6 % of the total catch came from that location (versus 4.6 % from the tailrace). The differences between the studies of Stokesbury and the 1993 and 1994 work are probably due to the use of more efficient nets during the later studies.

The old fishway, however, does not appear to play as important a role in the passage of alosines. Only 11 were captured there during the course of the study. Other species (again Atlantic silversides) appear to use this passage as is evidenced by the fact that 18.8 % of the total number of fish captured were caught in the old fishway. This observation is in agreement with the acoustic observations of McKinley and Patrick (1988) who found large congregations of fish near the sluice gates.

McKinley and Patrick (1988) did not detect large congregations of fish near the turbine forebay or near the new fishway, however schools of several thousand fish (most likely Atlantic silversides) were regularly observed by eye during this study, closely hugging the bank north of the turbine and extending (still close to shore) into the embayment to the north of the Annapolis Tidal Generating Station. Because of their proximity to the shoreline, these fish may be difficult to detect acoustically. When the tide ebbs, these fish can be seen moving into the turbine forebay, still hugging the north bank as they move with the current in a direction that takes them towards and down the new fishway. A similar behavior was noticed in 1993 with regard to small Atlantic herring which were basically absent from the area during 1994.

The above observations may also help to explain the phenomenon that alosines captured in the new fishway tend to be smaller than those captured in the tailrace, as shown in Figure 19. If smaller individuals have a preference for shallower, near shore water, they may tend to end up in the new fishway in the above manner rather than following the dominant deeper water flow and passing through the turbine.

The percent catch figures presented above are misleading in that they do not take into account the cross sectional area fished by a net relative to the cross sectional area of the passage. The estimates of 4641 alosines passing through the new fishway and 860 alosines moving seaward through the old fishway between August 30 and November 4 may be a more valid indicator of the true value of these routes of passage. It is important to note that these estimates are based on the assumptions that the nets fish at 100 % efficiency and that the alosines are evenly distributed vertically within the fishway. Neither of these assumptions would likely hold true if tested. Violating the assumption that the net fishes at 100 % efficiency would lead to an underestimation of the true number of fish passing through the fishway, while violating the assumption about the vertical distribution could lead to either too high or too low an estimate depending upon the nature of the distribution.

Stokesbury and Dadswell (1989) reported that the seaward migration of YOY alosines occurred primarily during a ten day period from October 15 - 25 (with a small secondary peak around October 25) in 1985, but that alosines moved seaward between mid August and mid November during 1986 (with a slight peak occurring with the new moon in early October). The pattern in 1994 appears more complex, probably due to the increased sampling intensity during this study. The largest numbers of alewives were captured at the end of July and in early August and after this time catches were small and somewhat sporadic. American shad and blueback herring catches increased rapidly in early September and then declined until a second peak during the second week of October, although alosines were captured more or less constantly in between. The largest catches of American shad occurred during the September peak while the largest blueback herring catches coincided with the October peak. All three alosine species were still present in the vicinity of the Annapolis Tidal Generating Station when monitoring ceased in mid November. These observations are consistent with the results of the 1993 study, where peak alosine movements occurred during the second and third weeks of October. Monitoring that year did not begin until September 24 so it is unknown whether fish moved earlier in the month, although observations of local fishermen suggest it is likely. The above results seem to suggest that alosine movement past the causeway is not a rapid event, but that YOY alosines remain in the vicinity of the causeway for a period of time as part of a passive migration towards the Bay of Fundy. This conclusion is consistent with the finding of O'Leary and Kynard (1986) who found the migration of American shad lasted 41 days in 1981 and 52 days in 1982 in the Connecticut River.

Stokesbury and Dadswell (1989) reported that alosine movements past the causeway appeared to be coupled with the lunar cycle, specifically that the alosines move between the new moon and first quarter. Some of the largest alosine catches in this study also occurred during this period (Figure 24), however, a few relatively large catches occurred during other phases of the moon as well. The coupling with the spring - neap tidal cycle appears slightly better, as no large catches coincided with the lowest tidal ranges, but it would be an oversimplification to conclude that either of these factors alone triggers alosine movements.

5.4 Determination of Stock Characteristics (Objective 5)

Some variation exists between the size of alosines collected during monitoring of fish passage in this study and those collected in the previous year (Gibson ad Daborn 1993). Blueback herring were approximately the same size in both years (mean fork lengths of 105.7 mm and 105.9 mm in 1993 and 1994 respectively). American shad collected in 1994 averaged 12.4 mm shorter than in 1993 (104.0 mm and 92.4 mm fork length respectively) and alewifes were also smaller (106.5 mm F.L. in 1993 and 86.33 mm in 1994). These differences could be attributable to annual variation in stock size such as those documented by O'Neill (1984), but are more likely attributable to the timing of collection. The majority of blueback herring were captured in mid October in both years and fish from these two groups are about the same size. The majority of alewives, however, were captured 2 months earlier in 1994 than 1993 and in 1994 large numbers of American shad were captured more than one month earlier than in 1993. For this reason these numbers are not really comparable.

6.0 CONCLUSIONS

While an adequate database for comparing the reproductive success of alosines in the Annapolis Estuary is lacking, intuitively it appears that 1994 was at least a reasonable year as is evidenced by an estimated YOY stock size of about 1.6 million alosines. This estimate vastly exceeds previous estimates, but due to problems with methodology and timing, previous studies may not have reflected the total YOY stock size.

It appears from this study that the Annapolis Estuary plays an important role as a nursery area for young alosines and that these fish may remain in the system for more than 3 months. YOY alosines may also be found in the vicinity of the Annapolis Tidal Generating Station for a period of more than three months, although there appears to be a change in species composition over this time. The alosine migration during this year was not the short 10 day or 2 week event suggested by other studies, but a slow gradual process as the fish passively made their way seaward. Spring tides appear to coincide with some of the larger alosine movements.

The relative catch from the two fishways and the tailrace suggest that large numbers of alosines may use the new fishway, but that the old fishway does not play an important role in passing alosines to the sea. Both fishways appear to play an important role in the passage of some other species. It also appears that alosines passing through the new fishway are smaller than those passing through the turbine tube, and this difference is probably attributable to behavioral differences between different sized fish. While use of relative catches for comparing between these locations provides some insight into the relative importance of the passages, it may be misleading due to the differences in cross-sectional area of the passages under comparison.

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Appendix 1. Location, time and catch of all seine collections.

Appendix 1. Location, time and catch of all seine collections.

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
July 13	1616	3-05-404E 20 49-59-389N	small seine pulled by hand (type 1)	0 alosines; 6 Atl. silversides ,1 Am. eel, 1 stickleback
July 13	1700	3-05-764E 20 49-60-472N	large seine pulled parallel to shore by boat and personnel on shore (type 2)	0 alosines; c. 50 Atl. silversides, 2. Am. eels, 25 sticklebacks
July 13	1713	3-05-918E 20 49-60-885N	type 2	0 alosines; c. 750 Atl. silversides, 10 sticklebacks
July 13	1828	3-09-463E 20 49-60-844N	type 1	0 alosines; c. 20 Am. eels, 1 Atl. silverside, 7 sticklebacks
July 13	2052	3-19-329E 20 49-66-922N	type 2	c. 600 alosines (all released)
July 14	1530	3- 19-279E 20 49-66-758N	type 2	13 alosines (all saved for identification and morphometrics)
July 14	1625	3-14-280E 20 49-65-989N	type 1	0 alosines; c. 10 mummichogs, 1000 Atl. silversides, 25 sticklebacks
July 14	1646	3 -15 -199E 20 49 -65 -569N	type 2	1 blueback herring; c. 1500 Atl. silversides, 3 sticklebacks
July 14	1709	3-15-425E 20 49-66-034N	type 2	0 alosines; c. 1000 Atl. silversides, 20 sticklebacks, 1 white perch
July 14	1739	3-15-744E 20 49-66-433N	type 2	1 alosine, c. 4000 Atl. silversides, 50 mummichogs
July 14	1819	3-17-513E 20 49-66-831N	type 2	22 alosines (21 saved for identification and morphometrics); c. 1000 Atl. silversides, 20 sticklebacks

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
July 14	2020	3-19-271E 20 49-66-758N	type 2	c. 1700 alosines (94 saved for identification and morphometrics, remainder released); 5 white perch,
July 14	2042	3-20-240E 20 29-67-341N	type 2	c. 100 alosines (18 saved for identification and morphometrics, remainder released)
July 19	1530	3-17-636E 20 49-67-270N	type 2	c. 100 alosines (24 saved for identification and morphometrics, 40 placed in holding box, remainder released); c. 300 Atl. silversides, 20 sticklebacks
July 19	1623	3-16-962E 20 49-66-680N	type 2	11 alosines (6 saved for identification and morphometrics, 5 released); c. 200 Atl. silversides
July 19	1645	3-15-667E 20 49-66-459N	type 2	93 alosines (22 saved for identification and morphometrics, 71 released): c. 200 Atl. silversides, 10 Am. eels, 16 sticklebacks
July 19	1700	3-14-967E 20 49-65-534N	type 2	13 alosines (5 saved for identification and morphometrics, 8 released); c. 7 Am. eels, 25 Atl. silversides
July 19	1730	3-13-597E 20 49-64-773N	type 2	20 alosines (all saved for identification and morphometrics); c. 50 Atl. silversides, 3 mummichogs, 3 Am. eels
July 19	1759	3-12-171E 20 49-64-222N	type 2	39 alosines (23 saved for identification and morphometrics 16 released); c. 75 Atl. silversides, 5 sticklebacks, 1 Am. eel
July 19	1827	3-11-079E 20 49-62-108N	type 2	8 alosines (all saved for identification and morphometrics); c. 150 Atl. silversides, 5 sticklebacks

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
July 19	1905	3-14-337E 20 49-65-992N	type 2	4 alosines (all released); c. 50 Atl. silversides, 1 white perch
July 22	1046	3-06-142E 20 49-60-531N	type 2	1 alewife (released); c. 50 Atl. silversides,
July 22	1117	3-08-810E 20 49-62-780N	type 2	51 alosines (17 saved for identification and morphometrics, 9 died in net, 25 released); c. 400 Atl. silversides
July 22	1145	3-09-019E 20 49-61-775N	type 2	8 alosines (released); c. 400 Atl. silversides, 5 Atl. menhaden
July 22	1210	3-11-105E 20 49-62-056N	type 2	8 Am. shad (released); 1 winter flounder
July 22	1250	3-11-727E 20 49-64-443N	type 2	59 alosines (13 saved for identification and morphometrics, 43 released); c. 40 Atl. silversides
July 22	1320	3-13-487E 20 49-64-876N	type 2	10 alosines (all saved for identification and morphometrics); 20 Atl. silversides, 1 Am. eel
July 22	1343	3-14-044E 20 49-65-133N	type 2	11 alosines (all saved for identification and morphometrics); 15 Atl. silversides
July 22	1400	3-14-404E 20 49-66-005N	type 2	3 alosines (released); c. 15 Atl. silversides, 1 Am. eel
July 22	1420	3-14-980E 20 49-65-624N	type 2	3 alosines (all saved for identification and morphometrics); 12 Atl. silversides
July 22	1521	3-15-819E 20 49-68-486N	type 2	3 Am. shad (all saved for identification and morphometrics); 10 Atl. silversides
July 22	1542	3-17-040E 20 49-66-564N	type 2	25 alosines (all saved for identification and morphometrics); c. 100 Atl. silversides

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
July 26	1044	3-20-050E 20 49-67-346N	type 2	c. 1200 alosines (23 saved for identification and morphometrics, remainder released)
July 26	1105	3-19-243E 20 49-66-914N	type 2	c. 120 alosines (15 saved for identification and morphometrics, remainder released)
July 26	1216	3-15-444E 20 49-66-311N	type 2	c. 400 alosines (25 saved for identification and morphometrics, remainder released); c. 75 Atl. silversides, 4 mummichogs
July 26	1236	3-14-095E 20 49-65-791N	type 2	c. 120 alosines (29 saved for identification and morphometrics, remainder released); c. 75 Atl. silversides, 4 sticklebacks
July 26	1256	3-13-359E 20 49-64-754N	type 2	c. 150 alosines (22 saved for identification and morphometrics, remainder released); c. 50 Atl. silversides
July 26	1316	3-12-397E 20 49-63-708N	type 2	8 alosines (all saved for identification and morphometrics); c. 100 Atl. silversides, 30 sticklebacks
July 26	1342	3-11-202E 20 49-67-370N	type 2	c. 30 alosines (14 saved for identification and morphometrics, remainder released); c. 30 Atl. silversides, 10 sticklebacks, 1 Am. eel
July 26	1358	3-11-018E 20 49-61-983N	type 2	25 Am. shad (9 saved for identification and morphometrics, 16 released); 50 Atl. silversides, 4 sticklebacks

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
July 26	1421	3-09-223E 20 49-61-225N	type 2	c. 125 alosines (13 saved for identification and morphometrics, remainder released); c. 300 Atl. silversides, 20 sticklebacks
July 26	1444	3-08-439E 20 49-62-599N	type 2	c. 175 alosines (16 saved for identification and morphometrics, remainder released); c. 400 Atl. silversides, 4 sticklebacks, 1 Am. eel
July 26	1507	3-08-138E 20 49-60-664N	type 2	c. 175 alosines (31 saved for identification and morphometrics, remainder released); c. 1000 Atl. silversides, 1 pipefish, 20 sticklebacks, 2 windowpane
July 30	1115	3-09-019E 20 49-61-775N	type 2	93 alosines (attempts to mark by dorsal fin were unsuccessful and abandoned, 13 saved for identification and morphometrics, 80 released); c. 250 Atl. silversides and 3 Atl. menhaden
July 30	1340	3-09-019E 20 49-61-775N	type 2	0 alosines; c. 750 Atl. silversides, 10 sticklebacks
July 30	1400	3-08-999E 20 49-61-775N	type 2	45 alosines (30 marked -left cheek orange- and released, 15 saved for identification and morphometrics); c. 200 Atl. silversides
July 30	1450	3-08-501E 20 49-62-787N	type 2	6 Am. shad (all marked -left cheek orange- and released); c. 400 Atl. silversides

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
July 30	1515	3-08-207E 20 49-60-774	type 2	66 alosines (46 marked -left cheek orange- and released, 12 saved for identification and morphometrics, 8 released unmarked); c. 350 Atl. silversides
July 30	1645	3-08-350E 20 49-61-748N	type 2	75 alosines (64 marked -left cheek orange- and released, 11 saved for identification and morphometrics); c. 225 Atl. silversides
July 30	1750	3-08-501E 20 49-62-787N	type 2	3 alosines (all released unmarked); c. 400 Atl. silversides
July 31	1440	3-19-271E 20 49-66-758N	type 2	12 alosines (all released unmarked); 1 white perch
July 31	1525	3-20-082E 20 49-67-227N	type 2	13 alosines (7 released unmarked, 6 saved for identification and morphometrics); 1 Am. eel
July 31	1615	3-17-641E 20 49-67-183N	type 2	c. 400 alosines (49 marked -right cheek orange- and released, 8 died during marking, 31 saved for identification and morphometrics, remainder released);
July 31	1820	3-13-555E 20 49-64-815N	type 2	58 alosines (42 marked -right cheek orange- and released, 10 released unmarked, 6 saved for identification and morphometrics); c. 25 Atl. silversides, 3 sticklebacks, 3 Am. eels
July 31	1855	3-12-381E 20 49-63-683N	type 2	31 alosines (17 marked - right cheek orange- and released, 8 released unmarked, 6 saved for identification and morphometrics); c. 200 Atl. silversides, 8 sticklebacks, 10 mummichogs, 1 white perch, 3 Am. eels

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
July 31	1930	3-09-018E 20 49-61-696N	type 2	0 alosines; c. 200 Atl. silversides
July 31	1955	3-09-392E 20 49-61-151N	type 2	7 alosines (4 saved for identification and morphometrics, 3 released unmarked); c. 400 Atl. silversides, 5 Am. eels
July 31	2012	3-09-392E 20 49-61-151N	type 2	0 alosines; c. 400 Atl. silversides
July 31	2040	3-08-207E 20 49-60-774N	type 2	32 alosines (20 marked - right cheek orange- and released, 3 released unmarked, 9 saved for identification and morphometrics); c. 75 Atl. silversides
Aug. 3	1515	3-05-701E 20 49-60-544N	type 2	0 alosines; c. 100 Atl. silversides, 1 Am. eel, 20 sticklebacks
Aug. 3	1550	3-08-222E 20 49-60-719N	type 2	0 alosines; c. 15 sticklebacks, 50 Atl. silversides, 2 Am. eels, 1 winter flounder
Aug. 3	1630	3-09-070E 20 49-62-745N	type 2	19 alosines (15 marked -right cheek red- and released, 4 saved for identification and morphometrics); c. 100 Atl. silversides, 12 sticklebacks, 1 Am. eel
Aug. 5	1615	3-13-473E 20 49-64-844N	type 2	109 alosines (93 marked -both cheeks orange- and released, 5 released unmarked, 11 saved for identification and morphometrics); c. 40 Atl. silversides

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Aug. 5	1710	3-13-812E 20 49-64-688N	type 2	110 alosines (99 marked -both cheeks orange- and released, 1 released unmarked, 10 saved for identification and morphometrics); c. 20 Atl. silversides, 1 Am. eel, 1 white perch, 1 pipefish
Aug. 5	1800	3-14-147E 20 49-64-648N	type 2	47 alosines (35 marked -both cheeks orange- and released, 7 released unmarked, 5 saved for identification and morphometrics); 4 white perch, 1 pipefish
Aug. 5	1830	3-14-102E 20 49-65-057N	type 2	182 alosines (118 marked -both cheeks orange- and released, 28 released unmarked, 24 saved for identification and morphometrics, 12 1+ yr. alewives released unmarked); c. 30 Atl. silversides, 1 pipefish
Aug. 5	1930	3-14-104E 20 49-65-801N	type 2.	c. 100 alosines (23 saved for identification and morphometrics, remainder released unmarked);
Aug. 5	2015	3-19-271E 20 49-66-758N	type 2	34 alosines (19 saved for identification and morphometrics, 15 released unmarked); 1 common sucker)
Aug. 9	1155	3-05-217E 20 49-59-170N	type 2	6 alosines (all saved for identification and morphometrics); c. 250 Atl. silversides, 3 sticklebacks
Aug. 9	1230	3-05-910E 20 49-60-567N	type 2	4 alosines (all saved for identification and morphometrics); c. 150 Atl. silversides, 8 sticklebacks, 1 pipefish

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Aug. 9	1630	3-09-347E 20 49-61-403N	type 2	21 alosines (8 released unmarked, 13 saved for identification and morphometrics); c. 1000 Atl. silversides, 7 sticklebacks
Aug. 9	1710	3-09-019E 20 49-61-775N	type 2	0 alosines; c. 300 Atl. silversides, 8 sticklebacks
Aug. 9	1745	3-09-918E 20 49-61-321N	type 2	45 alosines (27 marked -right cheek red- and released, 10 released unmarked, 8 saved for identification and morphometrics); c. 300 Atl. silversides
Aug. 9	1830	3-11-204E 20 49-62-754N	type 2	463 alosines (442 marked -right cheek red- and released, 3 died during marking, 17 saved for identification and morphometrics, 1 previously marked); c. 75 Atl. silversides, 10 sticklebacks
Aug. 11	1242	3-11-062E 20 49-62-057N	type 2	c. 306 alosines (233 marked -left cheek red- and released, c. 50 released unmarked, 23 saved for identification and morphometrics); c. 400 Atl. silversides, 2 mummichogs, 8 sticklebacks
Aug. 11	1310	3-11-128E 20 49-63-067N	type 2	53 alosines (43 marked -left cheek red- and released, 10 released unmarked); c. 400 Atl. silversides, 2 white perch, 2 mummichogs, 1 windowpane, 10 sticklebacks
Aug. 11	1350	3-11-325E 20 49-63-697N	type 2	854 alosines (790 marked -left cheek red- and released, 15 died during marking, 30 released unmarked, 19 saved for identification and morphometrics); c. 50 Atl. silversides, 12 sticklebacks

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Aug. 12	1130	3-11-347E 20 49-63-457N	type 2	34 alosines (all marked -right cheek red- and released, and placed in holding box)
Aug. 12	1400	3-13-414E 20 49-64-780N	type 2	254 alosines (193 marked -both cheeks red- and released, 41 released unmarked, 20 saved for identification and morphometrics); c. 15 Atl. silversides
Aug. 12	1530	3-14-131E 20 49-64-946N	type 2	113 alosines (97 marked -both cheeks red- and released, 12 saved for identification and morphometrics, 4 released unmarked); c. 10 Atl. silversides, 3 sticklebacks
Aug. 12	1600	3-14-276E 20 49-65-939N	type 2	473 alosines (388 marked -both cheeks red- and released, 30 released unmarked, 21 died during marking, 34 saved for identification and morphometrics); c. 20 Atl. silversides, 5 sticklebacks
Aug. 12	1810	3-15-694E 20 49-66-430N	type 2	c. 150 alosines (7 saved for identification and morphometrics, the remainder released unmarked)
Aug. 12	1840	3-17-663E 20 49-67-355N	type 2	c. 125 alosines (12 saved for identification and morphometrics, the remainder released unmarked); 3 Am. eels
Aug. 12	1915	3-19-181E 20 49-66-963N	type 2	c. 125 alosines (19 saved for identification and morphometrics, the remainder released unmarked)
Aug. 12	2000	3-19-735E 20 49-67-124N	type 2	c. 75 alosines (32 saved for identification and morphometrics, the remainder released unmarked)

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Aug. 16	1345	3-17-765E 20 49-67-455N	type 2	3 Am. shad (all released); 2 Am. eels, 5 sticklebacks
Aug. 16	1410	3-17-483E 20 49-66-963N	type 2	1 Am. shad (released); 6 Am. eels, 10 sticklebacks
Aug. 16	1620	3-15-488E 20 49-65-807N	type 2	28 alosines (23 marked -left cheek green- and released, 5 saved for identification and morphometrics); c. 10 Atl. silversides, 4 sticklebacks, 1 Am. eel
Aug. 16	1645	3-15-048E 20 49-65-547N	type 2	33 alosines (26 marked -left cheek green- and released, 4 released unmarked, 7 saved for identification and morphometrics); c. 30 Atl. silversides, 4 sticklebacks, 1 Am. eel, 1 white perch
Aug. 16	1715	3-14-577E 20 49-65-734N	type 2	50 alosines (41 marked -right cheek green- and released, 9 saved for identification and morphometrics); c. 25 Atl. silversides, 6 sticklebacks, 1 Am. eel, 1 white perch
Aug. 16	1750	3-14-308E 20 49-65-947N	type 2	26 alosines (22 marked -right cheek green- and released, 4 saved for identification and morphometrics); c. 50 Atl. silversides, 1 white perch
Aug. 16	1820	3-14-150E 20 49-65-835N	type 2	72 alosines (60 marked -right cheek green- and released, 4 released unmarked, 12 saved for identification and morphometrics); c. 40 silversides, 1 stickleback
Aug. 16	1850	3-14-095E 20 49-64-000N	type 2	7 Am. shad (all released unmarked); c. 10 Atl. silversides, 2 pipefish

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Aug. 16	1915	3-13-977E 20 49-65-254N	type 2	17 alosines (10 released unmarked, 7 saved for identification and morphometrics); 1 Am. eel, 19 Atl. silversides
Aug. 19	1110	3-20-301E 20 49-67-406N	type 2	2 Am. shad (both released unmarked)
Aug. 19	1130	3-19-366E 20 49-66-990N	type 2	4 Am. shad (all released unmarked); 2 sticklebacks, 1 Am. eel
Aug. 23	1150	3-13-662E 20 49-64-794N	type 2	139 alosines (114 marked -left cheek blue- and released, 7 died during marking, 8 released unmarked, 10 saved for identification and morphometrics); c. 300 Atl. silversides, 10 sticklebacks
Aug. 23	1220	3-13-001E 20 49-63-748N	type 2	73 alosines (63 marked -left cheek blue- and released, 1 released unmarked, 9 saved for identification and morphometrics); c. 300 Atl. silversides
Aug. 23	1330	3-12-265E 20 49-64-460N	type 2	266 alosines (240 marked -right cheek blue- and released, 1 died during marking, 24 saved for identification and morphometrics, 1 previously marked); c. 200 Atl. silversides, 1 Atl. menhaden
Aug. 23	1430	3-11-294E 20 49-62-898N	type 2	3 alosines (all saved for identification and morphometrics); c. 200 Atl. silversides
Aug. 23	1440	3-10-770E 20 49-61-709N	type 2	24 alosines (19 marked -right cheek blue- and released, 5 saved for identification and morphometrics); c. 300 Atl. silversides

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Aug. 23	1515	3-09-411E 20 49-61-762N	type 2	50 alosines (41 marked -right cheek blue- and released, 9 saved for identification and morphometrics); c. 500 Atl. silversides
Aug. 23	1600	3-09-030E 20 49-61-713N	type 2	11 alosines (all released unmarked); c. 30 Atl. silversides
Aug. 23	1615	3-08-431E 20 49-62-690N	type 2	5 alosines (all saved for identification and morphometrics); c. 1000 Atl. silversides
Aug. 23	1646	3-07-994E 20 49-60-592N	type 2	0 alosines; c. 40 Atl. silversides
Aug. 23	1710	3-05-109E 20 49-59-034N	type 2	1 alosine (saved for identification and morphometrics); c. 350 Atl. silversides
Aug. 25	0900	3-19-321E 20 49-66-899N	type 2	0 alosines; 6 Am eels, 2 sticklebacks
Aug. 25	0920	3-19-321E 20 49-66-899N	type 2	4 Am. shad (all released unmarked); 5 sticklebacks
Aug. 25	0920	3-19-807E 20 49-67-129N	type 2	0 fish
Aug. 25	1030	3-17-688E 20 49-67-259N	type 2	86 alosines (74 marked -both cheeks blue- and released, 12 saved for identification and morphometrics); c. 20 Atl. silversides, 2 white perch, 10 sticklebacks
Aug. 25	1150	3-17-455E 20 49-66-757N	type 2	65 alosines (54 marked -both cheeks blue- and released, 4 saved for identification and morphometrics, 7 released unmarked); c. 10 Atl. silversides, 5 sticklebacks

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Aug. 25	1230	3-16-891E 20 49-66-731N	type 2	194 alosines (154 marked -left cheek blue- and released, 18 released unmarked, 22 saved for identification and morphometrics); 1 white perch, c. 6 sticklebacks, 6 silversides
Aug. 25	1310	3-16-427E 20 49-66-588N	type 2	144 alosines (131 marked -left cheek blue- and released, 13 saved for identification and morphometrics); c. 15 Atl. silversides
Aug. 25	1400	3-15-978E 20 49-66-287N	type 2	54 alosines (45 marked -left cheek blue- and released, 9 saved for identification and morphometrics); 3 Atl. silversides
Aug. 25	1445	3-16-961E 20 49-66-764N	type 2	128 alosines (99 marked -left cheek blue- and released, 29 saved for identification and morphometrics); c. 5 Atl. silversides
Aug. 28	1200	3-14-086E 20 49-65-024N	type 2	26 alosines (23 marked -left cheek blue- and released, 3 saved for identification and morphometrics); c. 20 Atl. silversides
Aug. 28	1425	3-11-319E 20 49-63-534N	type 2	25 alosines (24 marked -right cheek blue- and placed in holding box, 1 died during marking); c. 100 Atl. silversides, 1 Am. eel
Aug. 28	1440	3-11-319E 20 49-63-534N	type 2	6 alosines (all marked -right cheek blue- and and placed in holding box with the above fish); c. 50 Atl. silversides

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Aug. 28	1530	3-11-973E 20 49-64-385N	type 2	38 alosines (28 marked -right cheek blue- and released, 2 released unmarked, 8 saved for identification and morphometrics); c. 150 Atl. silversides, 15 sticklebacks, 6 Am. eels
Aug. 28	1600	3-14-107E 20 49-64-592N	type 2	52 alosines (46 marked -left cheek blue- and released, 6 saved for identification and morphometrics); c. 400 Atl. silversides, 15 sticklebacks, 3 Am. eels
Aug. 28	1640	3-14-241E 20 49-65-933N	type 2	165 alosines (150 marked -left cheek blue- and released, 15 saved for identification and morphometrics); c. 50 Atl. silversides
Aug. 28	1730	3-15-528E 20 49-65-738N	type 2	14 alosines (all marked -left cheek blue); c. 30 Atl. silversides
Aug. 28	1750	3-15-466E 20 49-66-311N	type 2	173 alosines (155 marked -left cheek blue- and released, 1 previously marked, 2 released unmarked, 15 saved for identification and morphometrics); c. 40 Atl. silversides
Aug. 28	2000	3-19-321E 20 49-66-899N	type 2	c. 232 alosines (75 marked -both cheeks blue- and released, c. 150 released unmarked (not examined for marks), 7 saved for identification and morphometrics); c. 25 white perch
Sept. 1	1040	3-08-967E 20 49-62-697N	type 2	74 alosines (63 examined -found to be unmarked- and released, 11 saved for identification and morphometrics); c. 15 Atl. silversides, 2 pipefish, 6 sticklebacks

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Sept. 1	1045	3-05-240E 20 49-59-293N	type 2	6 alosines (all saved for identification and morphometrics); c. 100 Atl. silversides
Sept. 1	1130	3-02-461E 20 49-58-100N	type 2	5 alosines (2 examined -found to be unmarked- and released, 3 saved for identification and morphometrics); c. 650 Atl. silversides, 6 sticklebacks
Sept. 1	1223	3-08-210E 20 49-60-628N	type 2	16 alosines (4 examined -found to be unmarked- and released, 12 saved for identification and morphometrics); c. 75 Atl. silversides, 7 sticklebacks
Sept. 1	1305	3-09-365E 20 49-61-426N	type 2	9 alosines (all saved for identification and morphometrics); c. 150 Atl. silversides,
Sept. 1	1330	3-10-907E 20 49-61-664N	type 2	8 alosines (all saved for identification and morphometrics); c. 60 Atl. silversides
Sept. 1	1400	3-11-388E 20 49-65-552N	type 2	23 alosines (all examined -found to be unmarked- and released); c. 100 Atl. silversides
Sept. 1	1430	3-11-790E 20 49-64-407N	type 2	17 alosines (all saved for identification and morphometrics); c. 10 sticklebacks, 1 Atl. menhaden, 1 winter flounder, 1 pipefish
Sept. 1	1630	3-17-636E 20 49-67-270	type 2	26 alosines (16 examined -found to be unmarked- and released, 10 saved for identification and morphometrics); 8 Atl. silversides, 8 sticklebacks

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Sept. 1	1645	3-19-243E 20 49-66-914N	type 2	21 alosines (6 examined -found to be unmarked- and released, 15 saved for identification and morphometrics); 3 Atl. silversides
Sept. 9	1015	3-05-664E 20 49-60-471N	type 2	0 alosines; 40 Atl. silversides, 3 smooth flounder, 2 rainbow smelt, 1 Am. eel
Sept. 9	1045	3-08-466E 20 49-62-734N	type 2	0 alosines; c. 100 Atl. silversides, 1 mummichog
Sept. 9	1225	3-11-161E 20 49-64-329N	type 2	2 blueback herring, 1 Am. shad (examined -found to be unmarked- and released); c. 25 Atl. silversides, 2 Am. eels, 16 sticklebacks
Sept. 9	1255	3-13-473E 20 49-64-844N	type 2	2 blueback herring (examined -found to be unmarked- and released); c. 40 Atl. silversides, 8 sticklebacks, 1 Am. eel
Sept. 13	1206	3-08-501E 20 49-62-787N	type 2	6 alosines (all saved for identification and morphometrics); c. 50 Atl silversides, 1 winter flounder
Sept. 13	1220	3-09-347E 20 49-61-403N	type 2	4 alosines (all saved for identification and morphometrics); c. 35 Atl. silversides, 4 winter flounder, 1 Am. eel, 1 pipefish
Sept. 13	1240	3-11-018E 20 49-61-983N	type 2	0 alosines; 1 Atl. silverside, 1 stickleback
Sept. 13	1305	3-11-793E 20 49-64-370N	type 2	0 alosines; c. 25 Atl. silversides, 3 sticklebacks, 1 pipefish
Sept. 13	1325	3-13-472E 20 49-64-837N	type 2	1 alosine (examined -found to be unmarked- and released); c. 45 Atl. silversides, 10 sticklebacks,

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Sept. 13	1345	3-14-144E 20 49-65-854N	type 2	0 alosines, 15 Atl. silversides, 6 sticklebacks, 1 pipefish
Sept. 13	1405	3-15-466E 20 49-66-311N	type 2	162 alosines (141 examined -found to be unmarked- and released, 21 saved for identification and morphometrics); c. 80 Atl. silversides, 1 Am. eel, 15 sticklebacks
Sept. 13	1420	3-15-978E 20 49-66-287N	type 2	68 alosines (54 examined -found to be unmarked- and released, 13 saved for identification and morphometrics, 1 found to have been previously marked); c. 35 Atl. silversides
Sept. 13	1455	3-16-???E 20 49-66-???N	type 2	15 alosines (8 examined -found to be unmarked- and released, 7 saved for identification and morphometrics); c. 20 Atl. silversides
Sept. 21	1120	3-01-026E 20 49-58-900N	type 2	1 Am. shad (examined -found to be unmarked- and released); c. 200 Atl. silversides, 1 Atl. herring, 1 pipefish
Sept. 21	1305	3-11-793E 20 49-64-370N	type 2	0 alosines; 2 sticklebacks, 1 rainbow smelt
Sept. 21	1315	3-13-473E 20 49-64-844N	type 2	6 alosines (saved for identification and morphometrics); c. 20 Atl. silversides, 1 stickleback
Sept. 21	1340	3-14-144E 20 49-65-854N	type 2	0 alosines; c. 25 Atl. silversides, 3 pipefish, 7 sticklebacks
Sept. 21	1415	3-15-978E 20 49-66-287N	type 2	0 alosines; c. 75 Atl. silversides, 8 sticklebacks

Appendix 1. (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Sept. 21	1505	3-17-636E 20 49-67-270N	type 2	0 alosines; 3 sticklebacks, 2 Atl. silversides
Sept. 21	1540	3-19-770E 20 49-66-751N	type 2	0 fish

Appendix 2. Time, location and catch of all nets set in the fishways and tailrace at the Annapolis causeway.

Appendix 2. Time, location and catch of all nets set in the fishways and tailrace at the Annapolis causeway.

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
July 27 -28	1745	0150	new fishway	1 m	870 alewives	3 Am. eels 22 butterfish 1 rainbow smelt 2 Atl. herring 2 sticklebacks
July 27 - 28	1810	0045	old fishway	0.5 m	0	0
July 27 - 28	1833	2020	tailrace	1 m	0	1 longhorn sculpin 2 sticklebacks
July 27 - 28	2020	2120	tailrace	1 m	0	0
July 27 - 28	2120	2220	tailrace	1 m	0	0
July 27 - 28	2220	2320	tailrace	1 m	0	0
July 27 - 28	2320	2415	tailrace	1 m	0	1 Atl. silverside 1 stickleback
Aug. 1 - 2	2120	0603	new fishway	1 m	1 alewife	22 Am. eels 27 butterfish 4 Atl. herring 5 rainbow smelt
Aug. 1 - 2	2200		old fishway	0.5 m	net destroyed by currents: no data	
Aug. 1 - 2	2230	0450	tailrace	1 m	0	1 butterfish 3 rainbow smelt 1 stickleback
Aug. 8	1515	1055	new fishway	1 m	40 alewives	211 Atl. silversides 26 sticklebacks 3 butterfish 2 mummichog 2 rainbow smelt 2 windowpane

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Aug. 8	1550	1800	tailrace	1 m	0	1 Atl. silverside
Aug. 8	1800	1915	tailrace	1 m	0	0
Aug. 8	1915	2015	tailrace	1 m	0	0
Aug. 8	2015	2115	tailrace	1 m	net failure: no data	
Aug. 10 - 11	1615	0030	new fishway	1 m	2 Am. shad	2 Am. eels 3 butterfish 1 Atl. silverside 2 sticklebacks
Aug. 10 - 11	1650	0020	old fishway	1 m	net failure: no data	
Aug. 10 - 11	1715	1900	tailrace	1 m	0	0
Aug. 10 - 11	2000	2100	tailrace	1 m	0	0
Aug. 10 - 11	2100	2200	tailrace	1 m	0	0
Aug. 10 - 11	2200	2300	tailrace	1 m	0	1 rainbow smelt
Aug. 14 - 15	2015	0400	new fishway	1 m	0	37 Atl. silversides 18 rainbow smelt 3 Am. eels 2 butterfish 1 tomcod 4 pipefish 2 Atl. herring 1 stickleback
Aug. 14 - 15	2030	0300	old fishway	1 m	0	2 tomcod 1 Atl. silverside 1 skate

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Aug. 14 - 15	2112	2245	tailrace	1 m	0	0
Aug. 14 - 15	2245	2345	tailrace	1 m	0	1 Atl. silverside
Aug. 14 - 15	2345	0045	tailrace	1 m	0	2 Atl. silversides 1 Atl. herring
Aug. 14 - 15	0045	0145	tailrace	1 m	1 blueback herring	1 rainbow smelt
Aug. 14 - 15	0145	0230	tailrace	1 m	0	1 rainbow smelt
Aug. 18	1210	1950	new fishway	1m	1 alewife	387 Atl. silversides 57 sticklebacks 5 rainbow smelt 1 pipefish
Aug. 18	1220	1935	old fishway	1 m	0	30 sticklebacks 30 rainbow smelt 2 pipefish 1 winter flounder 1 Atl. silverside
Aug. 18	1250	1410	tailrace	1 m	0	1 Atl. silverside
Aug. 18	1410	1510	tailrace	1 m	0	0
Aug. 18	1510	1610	tailrace	1 m	0	1 Atl. silverside
Aug. 18	1610	1710	tailrace	1 m	0	0
Aug. 21	1515	2205	new fishway	1 m	0	1 pipefish 11 rainbow smelt
Aug. 21	1535	2150	old fishway	1 m	0	2 rainbow smelt
Aug. 21	1550	1655	tailrace	1 m	0	0

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Aug. 21	1655	1805	tailrace	1 m	0	5 Atl. silversides 20 rainbow smelt
Aug. 21	1805	1900	tailrace	1 m	0	32 rainbow smelt
Aug. 21	1900	2000	tailrace	1 m	0	8 rainbow smelt
Aug. 21	2000	2100	tailrace	1 m	0	6 rainbow smelt
Aug. 25 - 26	1717	?	new fishway	1 m	0	?
Aug. 25 - 26	1730	?	old fishway	1 m	0	?
Aug. 25- 26	1750	?	tailrace	1 m	0	?
Aug. 30 - 31	2100	0510	new fishway	1 m	3 Am. shad	approx. 10,000 Atl. silversides 4 tomcod 6 pipefish
Aug. 30 - 31	2135	0430	old fishway	1 m	1 Am. shad	204 Atl. silversides 9 pipefish 2 rainbow smelt
Aug. 30 - 31	2210	2345	tailrace	1 m	4 Am. shad	148 Atl. silversides 2 rainbow smelt
Aug. 30 - 31	2345	0045	tailrace	1 m	1 Am. shad	1 wrymouth 1 windowpane 2 pipefish 3 rainbow smelt 89 Atl. silversides
Aug. 30 - 31	0045	0145	tailrace	1 m	0	13 Atl. silversides 1 pipefish

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Aug. 30 - 31	0145	0245	tailrace	1 m	2 Am. shad	1 rainbow smelt 19 Atl. silversides
Aug. 30 - 31	0245	0355	tailrace	1 m	0	17 Atl. silversides 1 Atl. herring
Aug. 31- Sept. 1	2200	0615	new fishway	1 m	0	app. 20,000 Atl. silversides 4 pipefish 8 Am. eels
Aug. 31 - Sept. 1	2233	0530	old fishway	1 m	net failure: no data	
Aug. 31 - Sept. 1	2255	0050	tailrace	1 m	2 Am. shad 1 alewife	1 hake 88 Atl. silversides 3 rainbow smelt 1 pipefish
Aug. 31 - Sept. 1	0050	0150	tailrace	1 m	0	32 Atl. silversides
Aug. 31 - Sept. 1	0150	0250	tailrace	1 m	0	4 Atl. silversides 1 rainbow smelt
Aug. 31- Sept. 1	0250	0350	tailrace	1 m	0	3 Atl. silversides 1 windowpane 1 Atl. herring
Aug. 31 - Sept. 1	0350	0450	tailrace	1 m	0	5 Atl. silversides 5 rainbow smelt
Sept. 2	0010	0150	tailrace (n)	1 m	1 Am. shad	163 Atl. silversides 4 pipefish
Sept. 2	0010	0155	tailrace (s)	1 m	0	1 Atl. silverside

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Sept. 2	0150	0245	tailrace (n)	1 m	0	114 Atl. silversides 6 pipefish 5 rainbow smelt 2 windowpane
Sept. 2	0155	0255	tailrace (s)	1 m	0	0
Sept. 2	0250	0350	tailrace (n)	1 m	1 Am. shad 1 alewife	84 Atl. silversides 6 pipefish 1 smelt
Sept. 2	0255	0355	tailrace (s)	1 m	net clogged with seaweed: no data	
Sept. 2	0350	0455	tailrace (n)	1 m	1 Am. shad	103 Atl. silversides 3 pipefish 1 Atl. herring 1 windowpane 1 rainbow smelt
Sept. 2	0355	0500	tailrace (s)	1 m	0	0
Sept. 2	0455	0600	tailrace (n)	1 m	0	43 silversides 1 butterfish 2 pipefish
Sept. 2	0500	0610	tailrace (s)	1 m	1 blueback herring 2 Am. shad	212 Atl. silversides 3 windowpane 2 smelt 2 pipefish
Sept. 4	0045	0815	new fishway	0.5 m	1 Am. shad	673 Atl. silversides 1 stickleback
Sept. 4	0130	0750	old fishway	0.5 m	0	9 pipefish 1 stickleback

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Sept. 4	0130	0720	tailrace	1 m	1 blueback herring 15 Am. shad 2 unid. alosines	95 Atl. silversides 5 pipefish 3 rainbow smelt 1 Atl. herring
Sept. 5	0140	0805	new fishway	0.5 m	2 alewives 1 Am. shad	602 Atl. silversides 4 Am. eels 12 pipefish 3 sticklebacks
Sept. 5	0155	0755	old fishway	0.5 m	0	480 Atl. silversides 3 Am. eels 2 sticklebacks 9 pipefish
Sept. 5	0210	0830	tailrace	1 m	2 alewives 30 blueback herring 13 Am. shad	23 Atl. silversides 3 pipefish 3 sticklebacks 1 butterfish
Sept. 6	0225	0915	new fishway	1 m	1 alosine	595 Atl. silversides 4 rainbow smelt 1 Am. eel 14 pipefish 1 butterfish 6 sticklebacks
Sept. 6	0246	0900	old fishway	0.5 m	0	252 Atl. silversides 17 pipefish 3 sticklebacks
Sept. 6	0300	0840	tailrace	1 m	5 Alewives 27 Am. shad 28 blueback herring	73 Atl. silversides 17 pipefish 4 rainbow smelt 1 butterfish 1 Am. eel 1 windowpane

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Sept. 6	1455	2215	new fishway	0.5 m	0	772 Atl. silversides 1 pipefish
Sept. 6	1530	2200	old fishway	0.5 m	0	14 Atl. silversides 1 pipefish 1 stickleback
Sept. 6	1555	2000	tailrace	1 m	1 Am. shad	21 Atl. silversides 4 pipefish 1 stickleback
Sept. 6	2000	2135	tailrace	1 m	0	82 Atl. silversides 2 pipefish 1 stickleback
Sept. 7	1545	2312	new fishway	0.5 m	1 blueback herring 1 Am. shad	500 Atl. silversides 1 pipefish
Sept. 7	1600	2225	old fishway	0.5 m	0	18 Atl. silversides
Sept. 7	1625	2150	tailrace	1 m	2 Am. shad	53 Atl. silversides 1 windowpane
Sept. 9 - 10	1725	0040	new fishway	0.5 m	1 Am. shad	525 Atl. silversides 5 sticklebacks
Sept. 9 - 10	1735	0015	old fishway	0.5 m	0	604 Atl. silversides 9 pipefish 1 stickleback
Sept. 9 - 10	1805	2335	tailrace	1 m	143 alosines subsample contained: 8 blueback herring 22 Am. shad	1 windowpane 1 butterfish 1 stickleback 2 pipefish 50 Atl. silversides
Sept. 10	0535	1250	new fishway	0.5 m	1 Am. shad	71 Atl. silversides

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Sept. 10	0550	1220	old fishway	0.5 m	0	2 Atl. silversides 1 pipefish 1 stickleback
Sept. 11 - 12	1905	0245	new fishway	1 m	2 alewives 2 Am. shad	app. 2000 Atl. silversides 1 butterfish 2 pipefish
Sept. 11 - 12	1915	0200	old fishway	0.5 m	0	19 Atl. silversides 1 stickleback
Sept. 11 - 12	1925	2115	tailrace	1 m	1 blueback herring 1 Am. shad	57 Atl. silversides 1 butterfish
Sept. 11 - 12	2115	2215	tailrace	1 m	1 Am. shad	22 Atl. silversides 1 pipefish 3 rainbow smelt
Sept. 11 - 12	2215	2315	tailrace	1 m	2 blueback herring 2 Am. shad	7 Atl. silversides 1 rainbow smelt
Sept. 11 - 12	2315	0015	tailrace	1 m	3 Am. shad	3 rainbow smelt 6 Atl. silversides
Sept. 11 - 12	0015	0115	tailrace	1 m	2 alewives 1 blueback herring 2 Am. shad	3 Atl. silversides 1 rainbow smelt
Sept. 12	0730	1500	new fishway	1 m	0	65 Atl. silversides 1 Atl. herring
Sept. 12	0740	1445	old fishway	0.5 m	0	0
Sept. 12	0805	0955	tailrace	1 m	0	1 stickleback
Sept. 12	0955	1055	tailrace	1 m	0	0
Sept. 12	1055	1155	tailrace	1 m	0	0
Sept. 12	1155	1255	tailrace	1 m	0	0

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Sept. 12	1255	1355	tailrace	1 m	0	0
Sept. 13 - 14	2105	0455	new fishway	1 m	1 Am. shad	app. 6500 Atl. silversides
Sept. 13 - 14	2120	0410	old fishway	0.5 m	0	617 Atl. silversides 1 pipefish 1 stickleback
Sept. 13 - 14	2145	0330	tailrace	1 m	1 blueback herring 1 menhaden 9 Am. shad	154 Atl. silversides 4 pipefish 2 butterfish 1 Atl. herring
Sept. 14	0940	1705	new fishway	1 m	1 Am. shad 2 Atl. menhaden	1153 Atl. silversides 1 pipefish 79 sticklebacks
Sept. 14	1000	1625	old fishway	0.5 m	0	16 sticklebacks 1 pipefish
Sept. 14	1015	1605	tailrace	1 m	0	8 Atl. silversides 1 pipefish 1 stickleback
Sept. 14 -15	2215	0600	new fishway	1 m	3 alewives 1 blueback herring 6 Am. shad	1328 Atl. silversides 2 pipefish 2 butterfish 1 rainbow smelt 1 mummichog 5 sticklebacks
Sept. 14 - 15	2235	0535	old fishway	0.5 m	0	104 Atl. silversides 1 pipefish 1 stickleback
Sept. 18	0105	0800	new fishway	0.5 m	0	162 Atl. silversides

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Sept. 18	0125	0745	old fishway	0.5 m	0	409 Atl. silversides 1 stickleback 1 hake
Sept. 18	0145	0730	tailrace	1 m	7 Am. shad	42 Atl. silversides 3 sticklebacks 3 rainbow smelt 1 pipefish
Sept. 18	1350	2245	new fishway	0.5 m	0	22 Atl. silversides
Sept. 18	1340	2030	old fishway	0.5 m	0	0
Sept. 18	1415	2005	tailrace	1 m	0	25 silversides 5 sticklebacks
Sept. 19	1410	1645	new fishway	0.5 m	0	17 Atl. silversides
Sept. 19	1645	1740	new fishway	0.5 m	0	1 Atl. silverside
Sept. 19	1740	2120	new fishway	0.5 m	0	87 Atl. silversides
Sept. 19	1440	2140	old fishway	0.5 m	0	3 Atl. silversides 1 pipefish
Sept. 19	1455	1625	tailrace	1 m	0	3 Atl. silversides 2 sticklebacks 1 pipefish
Sept. 19	1625	1725	tailrace	1 m	net failure no data	
Sept. 20	1500	2207	new fishway	0.5 m	0	252 Atl. silversides
Sept. 20	1520	2155	old fishway	0.5 m	0	17 Atl. silversides 1 pipefish

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Sept. 20	1545	2120	tailrace	1 m	2 alewives 6 blueback herring 10 Am. shad	36 Atl. silversides 2 sticklebacks
Sept. 22	1630	2355	new fishway	1 m	0	312 Atl. silversides 11 sticklebacks 7 pipefish 2 butterfish 1 mummichog 1 Atl. herring
Sept. 22	1653	2250	old fishway	0.5 m	0	58 Atl. silversides 18 sticklebacks
Sept. 22	1715	1815	tailrace	1 m	0	2 Atl. silversides 2 sticklebacks
Sept. 22	1815	1915	tailrace	1 m	0	1 stickleback
Sept. 22	1915	2015	tailrace	1 m	6 alosines*	0
Sept. 22	2015	2115	tailrace	1 m	8 alosines*	1 stickleback
Sept. 22	2115	2225	tailrace	1 m	2 alosines*	2 Atl. silversides
*the combined tailrace catch for Sept. 22 contained: 2 alewives, 8 blueback herring and 6 Am. shad						
Sept. 23 - 24	1640	0030	new fishway	1 m	2 alewives 2 blueback herring 2 Am. shad	98 Atl. silversides 15 sticklebacks 11 pipefish 1 mummichog 1 Atl. herring 1 windowpane
Sept. 23 - 24	1700	2340	old fishway	1 m	0	21 silversides 9 sticklebacks 2 pipefish

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Sept. 23 - 24	1735	2315	tailrace	1 m	2 alewives 5 blueback herring 8 Am. shad	8 Atl. silversides 1 hake 1 pipefish 1 winter flounder
Sept. 24 - 25	1710	0105	new fishway	1 m	1 blueback herring 2 Am. shad	13 Atl. silversides 2 pipefish 2 Am. eels 1 Atl. herring 6 sticklebacks
Sept. 24 - 25	1730	0025	old fishway	0.5m	0	8 sticklebacks 4 Atl. silversides 1 pipefish
Sept. 24 - 25	1748	0005	tailrace	1 m	4 blueback herring 12 Am. shad	2 Atl. silversides 1 stickleback 1 Am. eel 1 rainbow smelt
Sept. 26	0625	1415	new fishway	1 m	0	39 sticklebacks 32 Atl. silversides 1 skate 1 rainbow smelt
Sept. 26	0640	1320	old fishway	0.5 m	0	2 sticklebacks
Sept. 26	0710	1305	tailrace	1 m	0	2 sticklebacks 1 winter flounder
Sept. 26 - 27	1535	0245	new fishway	1 m	5 Am. shad	5 windowpane 22 Atl. silversides 4 Am. eels 5 butterfish 9 pipefish 5 sticklebacks 1 Atl. herring

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Sept. 26 - 27	1850	0125	old fishway	0.5 m	0	6 sticklebacks 6 pipefish 3 silversides 1 winter flounder
Sept. 26 - 27	1910	2055	tailrace	1 m	0	1 stickleback
Sept. 26 - 27	2055	2155	tailrace	1 m	0	1 winter flounder 2 Atl. silversides 2 pipefish
Sept. 26 - 27	2155	2255	tailrace	1 m	3 blueback herring 4 Am.shad	1 windowpane 1 butterfish 2 Am. eels
Sept. 26 - 27	2255	2355	tailrace	1 m	1 blueback herring 5 Am. shad	1 skate 1 cunner
Sept. 26 - 27	2355	0055	tailrace	1 m	1 blueback herring 1 Am. shad	1 windowpane 1 butterfish
Sept. 28	0810	1545	new fishway	1 m	0	3 sticklebacks
Sept. 28	0830	1515	old fishway	0.5 m	0	1 stickleback
Sept. 28 - 29	2055	0400	new fishway	1 m	net failure no data	
Sept. 28 - 29	2125	0330	old fishway	1 m	0	23 Atl. silversides 5 pipefish
Sept. 28 - 29	2215	2315	tailrace	1 m	1 alewife	1 rainbow smelt
Sept. 28 - 29	2315	0015	tailrace	1 m	0	1 pipefish
Sept. 28 - 29	0015	0115	tailrace	1 m	0	1 Am. eel

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Sept. 28 - 29	0115	0215	tailrace	1 m	1 blueback herring	1 Atl. herring 1 windowpane 1 pipefish
Sept. 28 - 29	0215	0315	tailrace	1 m	0	0
Sept. 30	0950	1716	new fishway	1 m	0	14 Atl. silversides
Sept. 30	1010	1650	old fishway	1 m	0	0
Sept. 30	1035	1635	tailrace	1 m	0	0
Oct. 1 - 2	2330	0705	new fishway	1 m	2 alewives 2 Am. shad	253 Atl. silversides 9 Am. eels 1 rainbow smelt 2 pipefish 1 stickleback 2 hake 1 rock gunnel
Oct. 1 - 2	2340	0640	old fishway	1 m	0	1214 Atl. silversides 1 rock gunnel 2 Am. eels 1 windowpane
Oct. 1 - 2	2355	0620	tailrace	1 m	9 blueback herring 16 Am. shad	19 Atl. silversides 4 winter flounder 2 Atl. herring 1 hake 2 Am. eels 1 rainbow smelt
Oct. 3	1305	2025	new fishway	1 m	1 unid alosine	13 Atl. silversides 2 winter flounder 1 pipefish 1 Atl. herring

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Oct. 3	1305	1955	old fishway	1 m	0	1 pipefish 1 stickleback 1 Atl. silverside
Oct. 3	1320	1935	tailrace	1 m	0	1 Atl. silverside
Oct. 4	0115	0845	new fishway	1 m	4 Am. shad	217 Atl. silversides 3 Am. eels 4 butterfish 2 Atl. herring 3 pipefish
Oct. 4	0130	0815	old fishway	1 m	1 Am. shad	161 Atl. silversides 7 pipefish 1 Am. eel 1 rock gunnel
Oct. 4	0150	0325	tailrace	1 m	3 blueback herring 2 Am. shad	6 Atl. silversides 1 hake 1 Am. eel
Oct. 4	0325	0425	tailrace	1 m	5 Blueback herring 4 Am. shad	3 Atl. silversides 2 pipefish
Oct. 4	0425	0525	tailrace	1 m	2 Am. shad 7 blueback herring	1 Am. eel 1 Atl. silverside
Oct. 4	0525	0625	tailrace	1 m	2 Am. shad 6 blueback herring	1 winter flounder 1 Atl. silverside
Oct. 4	0625	0740	tailrace	1 m	1 Am. shad 22 blueback herring	3 Atl. silversides 1 rainbow smelt 1 pipefish
Oct. 5	0225	0845	old fishway	1 m	0	123 Atl. silversides 21 pipefish 5 sticklebacks 1 wrymouth

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Oct. 5	0205	0920	new fishway	1 m	4 alewives 7 Am. shad 1 Atl. menhaden	183 Atl. silversides 14 pipefish 14 Am. eels 2 Atl. herring 2 sticklebacks 1 rainbow smelt
Oct. 5	0145	0825	tailrace	1 m	55 blueback herring 11 Am. shad 2 alewives	5 Atl. silversides 2 pipefish 1 butterfish 1 Atl. herring 1 stickleback
Oct. 6	1520	2250	new fishway	1 m	1 blueback herring 1 Am. shad	126 Atl. silversides 1 wrymouth 1 rainbow smelt 3 Am. eels 1 butterfish 1 windowpane
Oct. 6	1535	2225	old fishway	1 m	0	33 Atl. silversides 3 pipefish 1 Am. eel
Oct. 6	1545	2155	tailrace	1 m	2 alewives 15 blueback herring 12 Am. shad	6 Atl. silversides 2 sticklebacks 1 Atl. herring
Oct. 7	1610	2345	new fishway	1 m	1 blueback herring 1 Am. shad	241 Atl. silversides 2 Am. eels 2 Am. sand lance 1 mumichog 4 Atl. herring 1 butterfish 1 smooth flounder 1 pipefish 2 hake

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Oct. 7	1620	2320	old fishway	1 m	0	164 Atl. silversides 2 Am. eels 1 pipefish
Oct. 7	1635	2245	tailrace	1 m	4 alewives 14 blueback herring 21 Am. shad	8 Atl. silversides 3 Atl. herring 2 Am. eels 1 hake 1 cunner
Oct. 8	0435	1130	new fishway	1 m	4 Am. shad	484 Atl. silversides 28 sticklebacks 1 lumpfish 3 pipefish 3 Am. eels 1 rock gunnel
Oct. 8	0506	1115	old fishway	1 m	0	5 Atl. silversides 3 sticklebacks 2 pipefish 1 rainbow smelt
Oct. 8	0520	1100	tailrace	1 m	2 alewives 12 blueback herring 1 Am. shad	4 Atl. silversides 3 sticklebacks 2 pipefish 1 rainbow smelt
Oct. 9 - 10	1755	0120	new fishway	1 m	1 Am. shad	28 Atl. silversides 9 Am. eels 5 sticklebacks 3 pipefish 1 lumpfish 1 rock gunnel
Oct. 9 - 10	1810	0100	old fishway	1 m	0	1 pipefish

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Oct. 9 - 10	1830	0030	tailrace	1 m	6 alewives 44 blueback herring 14 Am. shad	3 Atl. herring 2 sticklebacks 1 pipefish 1 butterfish
Oct. 10 - 11	1842	0210	new fishway	1 m	3 alewives 1 blueback herring 2 Am. shad	52 Atl. silversides 3 Am. eels 4 Atl. herring 2 butterfish 3 windowpane 2 rainbow smelt 1 cunner 3 pipefish 1 stickleback
Oct. 10 - 11	1848	0150	old fishway	1 m	1 Am. shad	75 Atl. silversides 6 eels 3 pipefish 2 sticklebacks 1 mummichog
Oct. 10 - 11	1910	0125	tailrace	1 m	2 alewives 10 blueback herring 4 Am. shad 2 unid. alosines	8 Atl. silversides 2 Am. eels 1 Atl. herring 2 winter flounder 1 pipefish
Oct. 11 - 12	1945	0350	new fishway	1 m	2 alewives 3 blueback herring 3 Am. shad	428 Atl. silversides 14 Am. eels 8 sticklebacks 18 pipefish 5 butterfish 1 Am. sand lance 1 rock gunnel 1 windowpane 5 Atl. herring

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Oct. 11 - 12	2000	0240	old fishway	1 m	0	187 Atl. silversides 13 Am. eels 3 sticklebacks 3 windowpane 1 rock gunnel 5 pipefish
Oct. 11 - 12	2030	2215	tailrace	1 m	1 Am. shad	1 butterfish 1 Atl. herring 2 Atl. silversides
Oct. 11 - 12	2035	2215	tailrace	0.5 m	0	1 Atl. silverside
Oct. 11 - 12	2215	2315	tailrace	1 m	1 alewife 6 blueback herring	4 Atl. silversides 1 Atl. herring 1 pipefish 1 windowpane
Oct. 11 - 12	2215	2315	tailrace	0.5 m	3 blueback herring	2 Atl. herring 1 Atl. silverside
Oct. 11 - 12	2315	0015	tailrace	1 m	1 blueback herring	1 Atl. silverside
Oct. 11 - 12	2315	0015	tailrace	0.5 m	6 blueback herring	1 Atl. silverside 1 Atl. herring 1 butterfish
Oct. 11 - 12	0015	0115	tailrace	1 m	0	0
Oct. 11 - 12	0015	0115	tailrace	0.5 m	2 blueback herring	1 winter flounder
Oct. 11 - 12	0115	0240	tailrace	1 m	0	0
Oct. 11 - 12	0115	0240	tailrace	0.5 m	0	0

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Oct. 12	0805	1530	new fishway	1 m	0	34 Atl. sticklebacks 2 Am. sand lance 5 Atl. silversides 1 winter flounder 1 windowpane
Oct. 12	0820	1505	old fishway	1 m	0	92 sticklebacks 3 Atl. silversides 1 winter flounder
Oct. 12	0840	1445	tailrace	1 m	36 blueback herring	5 Atl. herring 5 Atl. silversides 1 winter flounder 1 butterfish
Oct. 13 - 14	2145	0545	new fishway	1 m	8 alewives 18 blueback herring	18 Atl. silversides 3 Atl. herring 2 Am. eels 1 windowpane 2 sticklebacks 4 pipefish
Oct. 13 - 14	2205	0450	old fishway	1 m	0	24 Atl. silversides 6 sticklebacks 1 pipefish 3 lumpfish 1 Am. eel 1 winter flounder
Oct. 13 - 14	2240	0015	tailrace	1 m	2 alewives 11 blueback herring	3 Atl. silversides 1 pipefish 1 Am. eel 1 winter flounder
Oct. 13 - 14	2240	0015	tailrace	0.5 m	0	0
Oct. 13 - 14	0015	0115	tailrace	0.5 m	1 alewife	0

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Oct. 13 - 14	0015	0115	tailrace	1 m	2 blueback herring 1 Am. shad	1 butterfish 1 windowpane 1 winter flounder
Oct. 13 - 14	0115	0215	tailrace	1 m	16 blueback herring	1 butterfish 1 Atl. herring 1 winter flounder 1 rainbow smelt 2 Atl. silversides
Oct. 13 - 14	0115	0215	tailrace	0.5 m	1 unid alosine	0
Oct. 13 - 14	0215	0315	tailrace	1 m	4 blueback herring 1 Am. shad	0
Oct. 13 - 14	0215	0315	tailrace	0.5 m	net not fishing properly: no data	
Oct. 13 - 14	0315	0415	tailrace	1 m	1 unid. alosine	1 Atl. herring
Oct. 13 - 14	0315	0415	tailrace	0.5 m	0	0
Oct. 14	1030	1805	new fishway	1 m	0	1 windowpane 4 sticklebacks 1 Atl. herring
Oct. 14	1045	1730	old fishway	1 m	0	2 sticklebacks
Oct. 14	1100	1700	tailrace	1 m	1 unid. alosine	7 Atl. silversides 2 sticklebacks
Oct. 15 - 16	2350	0720	new fishway	1m	net failure: no data	
Oct. 15 - 16	0001	0645	old fishway	1 m	0	256 Atl. silversides 13 pipefish 7 sticklebacks 5 Am. eels

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Oct. 15 - 16	0045	0215	tailrace	1 m	0	0
Oct. 15 - 16	0045	0215	tailrace	0.5 m	0	0
Oct. 15 - 16	0215	0315	tailrace	1 m	2 blueback herring 2 Alewives	4 Atl. silversides
Oct. 15 - 16	0215	0315	tailrace	0.5 m	0	0
Oct. 15 - 16	0315	0415	tailrace	1 m	2 alewives 2 blueback herring	1 Atl. silverside 1 winter flounder
Oct. 15 - 16	0315	0415	tailrace	0.5 m	net not fishing properly due to current : no data	
Oct. 15 - 16	0415	0515	tailrace	1 m	1 alewife 1 blueback herring	0
Oct. 15 - 16	0415	0515	tailrace	0.5 m	0	1 Atl. silverside
Oct. 15 - 16	0515	0615	tailrace	1 m	0	1 butterfish 1 Atl. silverside
Oct. 15 - 16	0515	0615	tailrace	0.5 m	0	0
Oct. 17	0055	0810	new fishway	1 m	1 Am. shad 1 alewife	56 Atl. silversides 5 Am. eels 1 butterfish 1 rainbow smelt 11 sticklebacks 2 Atl. herring
Oct. 17	0107	0750	old fishway	1 m	2 Atl. menhaden 1 Am. shad	156 Atl. silversides 6 Am. eels 4 sticklebacks 1 rock gunnel 7 pipefish

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Oct. 17	0123	0720	tailrace	1 m	8 blueback herring 2 alewives	7 Atl. silversides 5 sticklebacks 1 longhorn sculpin
Oct. 18	0130	0900	new fishway	1 m	3 alewives 10 blueback herring	47 Atl. silversides 4 Atl. herring 2 windowpane 7 sticklebacks 5 Am. eels 5 pipefish
Oct. 18	0145	0825	old fishway	1 m	0	28 Atl. silversides 6 windowpane 5 Am. eels 2 lumpfish 2 pipefish 2 sticklebacks 1 Atl. menhaden
Oct. 18	0205	0825	tailrace	1 m	2 alewives 56 blueback herring 1 Am. shad	7 Atl. herring 2 sticklebacks 2 winter flounder 2 pipefish 2 Atl. silversides 1 windowpane 1 hake
Oct. 18	1400	2035	old fishway	1 m	0	21 Atl. silversides 3 sticklebacks
Oct. 18	1420	2010	tailrace	1 m	1 alewife 1 Am. shad	1 smooth flounder 2 Atl. silversides 1 pipefish
Oct. 19	1430	2115	new fishway	1m	2 Am. shad	76 Atl. silversides 1 Am. eel 4 Atl. herring 2 sticklebacks

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Oct. 19	1450	2045	old fishway	1 m	0	3 Atl. silversides 2 sticklebacks 1 pipefish
Oct. 19	1530	2020	tailrace	1 m	3 alewives 30 blueback herring 15 Am. shad	5 Atl. silversides 3 Atl. herring 1 stickleback 2 winter flounder 1 hake
Oct. 20	1505	2245	new fishway	1 m	4 alewives 3 blueback herring 1 alewives	71 Atl. silversides 1 Atl. herring 1 Am. eel 1 hake 2 sticklebacks
Oct. 20	1525	2155	old fishway	1 m	0	19 Atl. silversides 8 pipefish 2 sticklebacks
Oct. 20	1540	2125	tailrace	1 m	net failure: no data	
Oct. 21	1545	2320	new fishway (north net)	0.5 m	0	18 Atl. silversides 3 Am. eels 4 sticklebacks 4 Atl. herring
Oct. 21	1545	2320	new fishway (middle net)	0.5 m	net failure: no data	
Oct. 21	1545	2320	new fishway (south net)	0.5 m	net failure: no data	
Oct. 22	0400	1050	new fishway (north net)	0.5 m	0	1 Atl. silverside 1 stickleback

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Oct. 22	1635	2340	new fishway	1 m	2 alewives 3 Am. shad	24 Atl. silversides 7 Am. eels 6 sticklebacks 5 Atl. herring 2 hake 1 pipefish 1 lumpfish
Oct. 22	1645	2320	old fishway	1 m	0	8 Atl. silversides 2 pipefish 2 Am. eels 3 sticklebacks 1 lumpfish
Oct. 22	1705	2300	tailrace	1 m	1 alewife 9 blueback herring 2 Am. shad	1 Atl. herring 4 Atl. silversides 2 winter flounder 2 sticklebacks 1 Am. eel
Oct. 22	0400	1050	new fishway (middle net)	0.5 m	0	1 Atl. silverside 1 Am. eel 1 stickleback
Oct. 22	0400	1050	new fishway (south net)	0.5 m	net failure: no data	
Oct. 22	0415	1030	old fishway	1 m	0	6 Atl. silversides 5 sticklebacks 3 pipefish 2 lumpfish 1 Am. eel
Oct. 22	0435	1005	tailrace	1 m	1 alewife	1 lumpfish 1 Am. eel

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Oct. 23	1655	2359	new fishway	1 m	0	8 Am. eels 4 Atl. herring 2 Atl. silversides 1 pipefish
Oct. 23	1710	2335	old fishway	1 m	0	21 Atl. silversides 10 Am. eels 3 pipefish 2 lumpfish
Oct. 23	1725	2320	tailrace	1 m	3 alewives 8 blueback herring 2 Am. shad	11 Atl. herring 1 pipefish 2 sticklebacks 3 Atl. silversides
Oct. 24 - 25	1745	0110	new fishway	1 m	0	8 Am. eels 1 hake 4 Atl. herring 4 Atl. silversides 1 stickleback
Oct. 24 - 25	1800	0025	old fishway	1 m	1 Am. shad	2 Am. eels 2 Atl. silversides 1 stickleback
Oct. 24 - 25	1820	0005	tailrace	1 m	4 blueback herring 2 Am. shad	5 Atl. herring 1 pipefish 1 stickleback 1 Am. eel
Oct. 25 - 26	1800	0200	new fishway (north net)	0.5 m	0	5 Am. eels 3 Atl. silversides 1 Atl. herring
Oct. 25 - 26	1800	0200	new fishway (middle net)	0.5 m	0	3 Atl. silversides 1 hake 1 Atl. stickleback

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Oct. 25 - 26	1800	0200	new fishway (south net)	0.5 m	1 alewife	0
Oct. 26	0615	1420	new fishway	1 m	2 Am. shad	24 sticklebacks 4 Atl. silversides 2 pipefish
Oct. 26	0630	1320	old fishway	1 m	0	3 Atl. silversides 2 sticklebacks 1 pipefish
Oct. 26	0650	1315	tailrace	1 m	0	5 sticklebacks
Oct. 27	0721	1511	new fishway	1 m	0	13 sticklebacks 2 Atl. silversides
Oct. 27	0734	1422	old fishway	1 m	1 blueback herring	1 stickleback 1 pipefish 1 Atl. silverside
Oct. 27	0755	1405	tailrace	1 m	0	1 Am. eel 1 stickleback
Oct. 27 - 28	2020	0335	new fishway	1 m	6 alewives 7 Am. shad 1 Atl. menhaden	99 Atl. silversides 14 Atl. herring 18 Am. eels 4 pipefish 2 winter flounder 1 rainbow smelt 1 stickleback
Oct. 27 - 28	2044	0255	old fishway	1 m	0	8 Am. eels 2 pipefish
Oct. 27 - 28	2100	0230	tailrace	1 m	2 alewives 11 blueback herring 1 Am. shad	2 Am. eels 1 winter flounder 1 Atl. silverside 1 rainbow smelt

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Oct. 28 - 29	2100	0345	new fishway (north net)	0.5 m	0	14 Atl. silversides 2 Am. eels 1 Atl. herring 1 pipefish 1 Am. sand lance
Oct. 28 - 29	2100	0345	new fishway (middle net)	0.5 m	0	20 Atl. silversides 1 Atl. herring 1 Am. eel
Oct. 28 - 29	2100	0345	new fishway (south net)	0.5 m	0	2 Atl. silversides 1 Am. eel 1 stickleback 1 rainbow smelt
Oct. 29	0908	1650	new fishway	1 m	0	3 sticklebacks
Oct. 29	0923	1630	old fishway	1 m	2 Am. shad	63 Atl. silversides 1 sea lamprey 7 Am. eels 6 sticklebacks 2 lumpfish 5 pipefish 1 windowpane 2 winter flounder
Oct. 29	0935	1610	tailrace	1 m	0	2 sticklebacks
Oct. 29 - 30	2139	0520	new fishway	1 m	2 alewives 2 blueback herring 1 shad 3 Atl. menhaden	209 Atl. silversides 22 Am. eels 6 pipefish 3 Atl. herring 1 tomcod 1 stickleback 1 rock gunnel

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Oct. 29 - 30	2155	0455	old fishway	1 m	1 alewife	32 Atl. silversides 7 Am. eels 3 lumpfish 2 sticklebacks
Oct. 29 - 30	2220	0440	tailrace	1 m	9 Am. shad 23 blueback herring 2 alewives	14 Atl. silversides 7 Am. eels 1 Am. sand lance 2 Atl. herring 1 stickleback 2 pipefish
Oct. 31	1020	1745	new fishway	1 m	net failure: no data	
Oct. 31	1035	1720	old fishway	1 m	1 Atl. menhaden	5 Atl. silversides 2 sticklebacks
Oct. 31	1045	1700	tailrace	1 m	0	8 sticklebacks 1 Atl. silverside 1 lumpfish
Nov. 1	1120	1825	new fishway	1 m	0	16 Atl. silversides 4 sticklebacks 1 Am. sand lance
Nov. 1	1140	1803	old fishway	1 m	0	6 Atl. silversides 11 sticklebacks
Nov. 1	1145	1825	tailrace	1 m	0	6 sticklebacks
Nov. 2	0015	0710	old fishway (north net)	0.5 m	0	0
Nov. 2	0015	0710	old fishway (middle net)	0.5 m	0	3 Atl. silversides 2 sticklebacks

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Nov. 2	0015	0710	old fishway (south net)	0.5 m	0	2 Atl. silversides 3 sticklebacks
Nov. 2	1226	1920	new fishway	1 m	0	31 Atl. silversides 13 sticklebacks 2 Am. sand lance 1 Atl. menhaden 1 Am. eel
Nov. 2	1236	1900	old fishway	1 m	1 Am. shad	1 lumpfish
Nov. 2	1246	1840	tailrace	1 m	0	3 sticklebacks 2 Atl. silversides 1 winter flounder 1 Am. sand lance 1 Am. eel
Nov. 3	0120	0820	old fishway (north net)	0.5 m	0	1 Atl. silverside
Nov. 3	0120	0820	old fishway (middle net)	0.5 m	0	2 Atl. silversides
Nov. 3	0120	0820	old fishway (south net)	0.5 m	0	2 Atl. silversides
Nov. 4	0200	0845	new fishway	1 m	3 alewife 1 blueback herring 1 Am. shad 1 Atl. menhaden	458 Atl. silversides 21 sticklebacks 6 Am. eels 5 rainbow smelt 5 Atl. herring 3 pipefish 2 sea lampreys

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Nov. 4	0208	0818	old fishway	1 m	0	314 Atl. silversides 1 mumichog 17 sticklebacks 4 Am. eels 2 pipefish 7 sea lampreys
Nov. 4	0218	0800	tailrace	1 m	1 alewife 9 blueback herring	4 Atl. herring 4 Am. eels 27 Atl. silversides 2 rainbow smelt 1 winter flounder
Nov. 4	1405	2100	new fishway	1 m	4 alewife 8 blueback herring	119 Atl. silversides 7 Am. eels 3 sticklebacks 3 pipefish 2 rainbow smelt 1 windowpane 1 Atl. herring
Nov. 4	1425	2035	old fishway	1 m	0	62 Atl. silversides 1 Am. eel 1 lumpfish 7 sticklebacks
Nov. 4	1435	2015	tailrace	1 m	3 blueback herring 1 shad	17 Atl. silversides 1 lumpfish 4 rainbow smelt 1 Am. eel 3 sticklebacks 2 Atl. herring

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Nov. 8 - 9	1735	0040	new fishway	1 m	7 alewives 1 Am. shad 1 Atl. menhaden 1 blueback herring	96 Atl. silversides 24 sea lampreys 10 Am. eels 10 pipefish 8 Atl. herring 2 windowpane 1 winter flounder 1 lumpfish 1 hake 1 rock gunnel 1 stickleback 1 rainbow smelt
Nov. 8 - 9	1735	0020	old fishway	1 m	1 Am. shad	56 sea lampreys 9 Am. eels 334 Atl. silversides 1 lumpfish 16 rainbow smelt 15 sticklebacks
Nov. 8 - 9	1810	2345	tailrace	1 m	3 blueback herring 1 Am. shad 1 alewife	67 Atl. silversides 12 sticklebacks 12 sea lampreys 2 mackerel 1 lumpfish 7 Am. eels 1 Am. sand lance 2 winter flounder 6 rainbow smelt
Nov. 12 - 13	2210	0520	new fishway	1 m	1 Am. shad 1 blueback herring	34 sea lampreys 64 Atl. silversides 14 Atl. herring 13 sticklebacks 1 Am. sand lance 7 pipefish 1 Am. eel

Appendix 2. (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSINES no. and species	OTHER FISH no. and species
Nov. 12 - 13	2225	0440	old fishway	1 m	0	228 sea lampreys 111 Atl. silversides 35 sticklebacks 1 winter flounder 1 Am. sand lance 3 lumpfish 4 pipefish
Nov. 12 - 13	2240	0410	tailrace	1 m	1 alewife	21 Atl. silversides 17 sea lampreys 2 Am. eels 3 winter flounder 10 sticklebacks 2 pipefish 3 Atl. herring
Nov. 16	1227	1915	new fishway	1 m	1 alewife 1 Am. shad	19 Atl. silversides 2 sea lampreys 9 Atl. herring 5 sticklebacks 2 pipefish 1 Am. sand lance 1 rainbow smelt 1 mummichog
Nov. 16	1238	1900	old fishway	1 m	0	11 Atl. silversides 11 sea lampreys 1 Am. sand lance 1 stickleback
Nov. 16	1250	1845	tailrace	1 m	1 blueback herring	16 sticklebacks 6 Atl. silversides

Appendix 3. Scientific names of species referred to in this report.

Appendix 3. Scientific names of species referred to in this report.

Common Name	Scientific Name*
sea lamprey	*Petromyzon marinus*
skate	*Raja sp.*
American eel	*Anguilla rostrata*
blueback herring	*Alosa aestivalis*
alewife	*Alosa pseudoharengus*
American shad	*Alosa sapidissima*
Atlantic herring	*Clupea harengus harengus*
rainbow smelt	*Osmerus mordax*
common sucker	*Catostomus commersoni*
hake	*Urophycis sp.*
tomcod	*Microgadus tomcod*
Atlantic silverside	*Menidia menidia*
stickleback	*Gasterosteus sp.*
pipefish	*Syngnathus fuscus*
white perch	*Morone americana*
cunner	*Tautogolabrus adspersus*
rock gunnel	*Pholis gunnelis*
wrymouth	*Cryptacanthodes maculatus*
American sand lance	*Ammodytes americanus*
Atlantic mackerel	*Scomber scombrus*
butterfish	*Peprilus triacanthus*
longhorn sculpin	*Myoxocephalus scorpioides*
lumpfish	*Cyclopterus lumpus*
windowpane	*Scophthalmus aquosus*
smooth flounder	*Liopsetta putnami*
winter flounder	*Pseudopleuronectes americanus*

*from: Scott, W. B., and M. G. Scott. 1988 .Atlantic Fishes of Canada Can. Bull. Fish. Aquat. Sci. 219: 731 p.