DISTRIBUTION AND DOWNSTREAM MOVEMENT OF JUVENILE ALOSINES IN THE ANNAPOLIS RIVER ESTUARY

1993 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

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 from the end of August through October 1993, in two phases. During the first phase, young alosines were captured using shore seines at locations between Bridgetown and Annapolis. Attempts to locate and track fish using a portable fish finder were not successful. In early September the fish were most abundant at the head of the tide near Bridgetown, but by mid-September the largest catches occurred near Hebb's Landing. Seine collections in the latter part of the month were small, probably as a result of the inefficiency of the seining method for sampling in the headpond. More than 1200 alosines were marked by fin clipping and released at the point of capture, resulting in 9 recaptures. On the basis of these figures, the population size of young of the year alosines is estimated at 74022 (95% confidence limits = 43288 - 148045).

During the later part of September and October, fish movements through the causeway at Annapolis were monitored using ichthyoplankton nets. Only 202 alosines were captured among a total catch of about 4000 fish. Most (76.2%) were taken in the tailrace of the tidal generating station but catches were also good (23.3%) in the new fishway. Only 1 alosine was captured in the old fishway. The relative abundance of the alosine species was different from those in previous studies, the population consisting of about 68% American shad. Experiments with different net sizes and designs as well as with a submersible video camera were carried out to assess the best method for monitoring downstream movements of fishes. It is concluded that the ichthyoplankton nets used in this study are not suitable for collecting live alosines from this environment, nor are they suitable for the determination of the absolute number of fish using the fishways. They do, however, supply presence/absence and relative abundance data. Future studies should be designed around these limitations. Underwater photography may have some application in monitoring passage through the new fishway.

1.1 ACKNOWLEDGMENTS

This project was carried out with the help of several people. The field crew consisted of two full time members: Dale Murphy and Ken Meade. Tracy Horsman, Charlane Bishop, Dean Rose and Blair Macduff occasionally assisted with the seining during the first phase of the project. Thanks also go to John James and the crew at the Annapolis Tidal Generating Station for advice about working around the station and for providing head differential information for days when we were sampling around the causeway. Josée Parent and Mary-Beth Benedict of Nova Scotia Power both supplied input into the design of this project. Ms. Benedict also assisted in the field on two occasions. Dr. M. J. Dadswell of Acadia University helped with fish identification.

2.0 INTRODUCTION

Research on the Annapolis River and Estuary has shown that populations of alosines (chiefly the American shad, *Alosa sapidissima*, the alewife, *Alosa pseudoharengus*, and the blueback herring, *Alosa aestivalis*) successfully breed in the Annapolis system, moving 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.

Access to the sea requires transit through the causeway constructed near Annapolis in 1959-60. Prior to construction of the Annapolis Tidal Generating Station in 1980-84, access for post-spawning adult and young-of-the-year alosines was provided by an open slot fishway (the 'Old Fishway') constructed alongside the sluice gates at the southern end of the causeway. An additional fishway (the 'New Fishway') was incorporated into the design of the Annapolis Tidal Generating Station during construction. Thus, at the present time there are three major routes of access through the causeway for seaward migrating fish: the old fishway, the new fishway, and the turbine tube.

An important question therefore relates to the extent to which fish pass seaward through either of the fishways or the turbine. In previous studies, evidence has been 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 young-of-the-year (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 YOY alosines in the Annapolis River between Bridgetown and Annapolis Royal. The project was aimed at providing information on the stock size and migratory movements of these alosines within this estuary by attempting to meet the following objectives:

1. To determine the location(s) of schooling YOY alosines in the upper estuary of the Annapolis, prior to their seaward migration past the causeway.

2. To estimate the population size of the 1993 year class of alosines.

3. To document the downstream movement of any school(s) of YOY alosines, relating these movements to potentially important environmental factors.

4. To investigate the relative importance of different routes of passage in the vicinity of the Annapolis Tidal Generating Station.

5. To characterize the habitat(s) occupied by schooling YOY alosines in the upper estuary (i.e. below Bridgetown) prior to their final downstream movement to the sea.

6. To obtain information on stock characteristics (mean length, mean weight, condition factor, etc.) for the school(s) of migrating alosines.

3.0 METHODOLOGY

The project was conducted in two phases. The first phase, beginning on Aug. 27, 1993 involved determining the location(s) of YOY alosines in the upper estuary, and, after they were located, attempting to monitor their passage downstream to the Annapolis causeway. The second phase of the project began on Sept. 24, 1993 and consisted of monitoring fish passage in the vicinity of the Annapolis Tidal Generating Station with an emphasis on the movements of YOY alosines. 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 may be found in Figure 1.

3.1 METHODS EMPLOYED DURING PHASE 1

The emphasis during the first phase of the project was placed on locating and tracking YOY alosines in the upper estuary. To this end a couple of methods were employed. We attempted locating schools of YOY alosines using an Eagle™ Ultra II Fish Finder. We tested the fish finder throughout the upper estuary and in the headpond by scanning areas of shoreline with the fish finder and then seining over the same area in an effort to determine whether a particular signal indicated the presence or absence of fish.

Because we were unsuccessful locating and tracking fish with the fish finder, we depended upon locating alosines in the upper estuary using seines. 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. Two methods of seining were employed. 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. It was found that the steep banks and slippery shoreline limited the number of areas where this method could be employed so the technique was generally abandoned in favor of towing the seine perpendicular to the shoreline using 2 Zodiacs, one at each end of the net. This method proved much more practical and was employed during most of the first phase of the study.

The location of each seine was recorded using a G.P.S. field navigator (Magellan™, model 35001). Temperature and salinity were recorded in the vicinity of each seine using an Applied Microsystems Ltd. environmental monitoring probe (model EMP2000). Dissolved oxygen samples were collected in areas where it was felt oxygen could potentially be limiting.

The majority of fish captured in these seines were released except for a small number that were saved for confirming identifications. A small subsample of alosines (the size of the sample

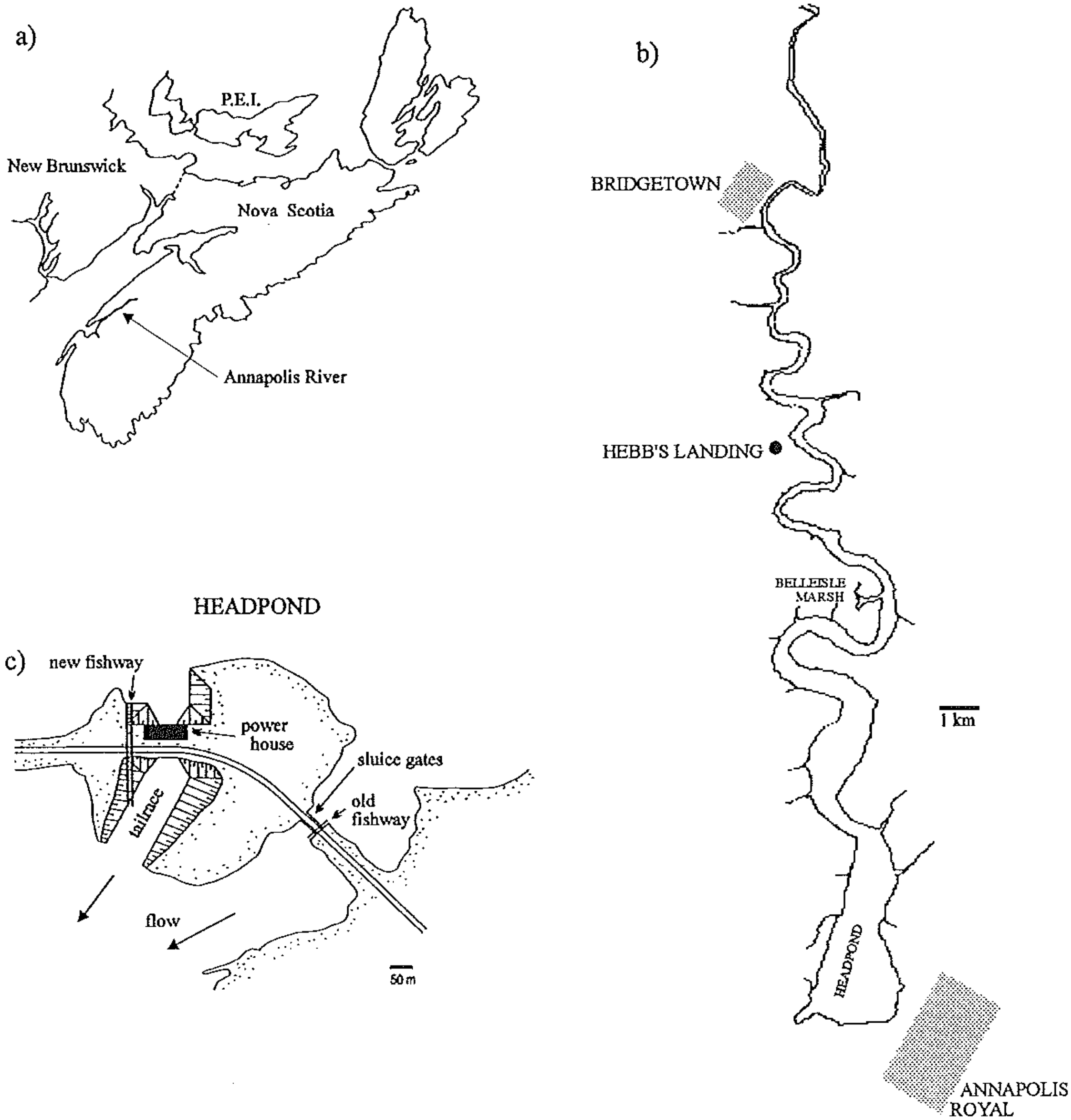

Figure 1. Maps showing: a) the location of the Annapolis River in Nova Scotia, b) the Annapolis River between Bridgetown and Annapolis, and c) the Annapolis Tidal Generating Station (Ruggles and Stokesbury, 1990).

was dependent upon the size of the catch) was taken from some of catches for the determination of stock characteristics (fork length, weight and condition factor). This number was kept to a minimum in order to maximize the number of marked alosines in the estuary. With the exception of this subsample, all alosines caught during this phase of the study were marked by fin clipping and released back into the river. After the fish were clipped, they were held in buckets on shore in order that any immediate mortality associated with the fish handling could be observed. If the fish appeared healthy after about twenty minutes, they were released back into the river.

An estimate of stock size of the alosines was made using the modified Schnabel method described by Ricker (1975). The total number of alosines was calculated using the formula:

$$N = \sum(C_t * M_t)/(R+1) \qquad \text{eqn. 1}$$

where N = the size of the population

C_t = number of alosines examined from the seine at time t

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

R = the total number of recaptures

Limits of confidence were calculated by treating R as a random variable with a Poisson distribution and using the table of confidence limits for such a variable found in Appendix II of Ricker (1975). 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.

3.2 METHODS EMPLOYED DURING PHASE 2

The second phase of the project, which began on Sept. 24, 1993, consisted of monitoring fish passage in the vicinity of the Annapolis Tidal Generating Station, with the emphasis placed on the movements of YOY alosines. Fish passage was monitored by fishing with modified ichthyoplankton nets in the two fishways and in the tailrace below the turbine. Five nets (3 different models) were used during this phase, and the design of these nets is shown in Figure 2. Three of these nets were 1 m in diameter, 1 was 0.5 m in diameter and the other net 0.3 m. The 1 m diameter nets consisted of three sections: a 2 m long cylinder, made of 1 cm mesh nylon netting; the second section was a 0.33 mm mesh 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 final section was a collector. The collectors were 1.75 m long Spandex cylinders fitted over 0.5 m diameter cylinders

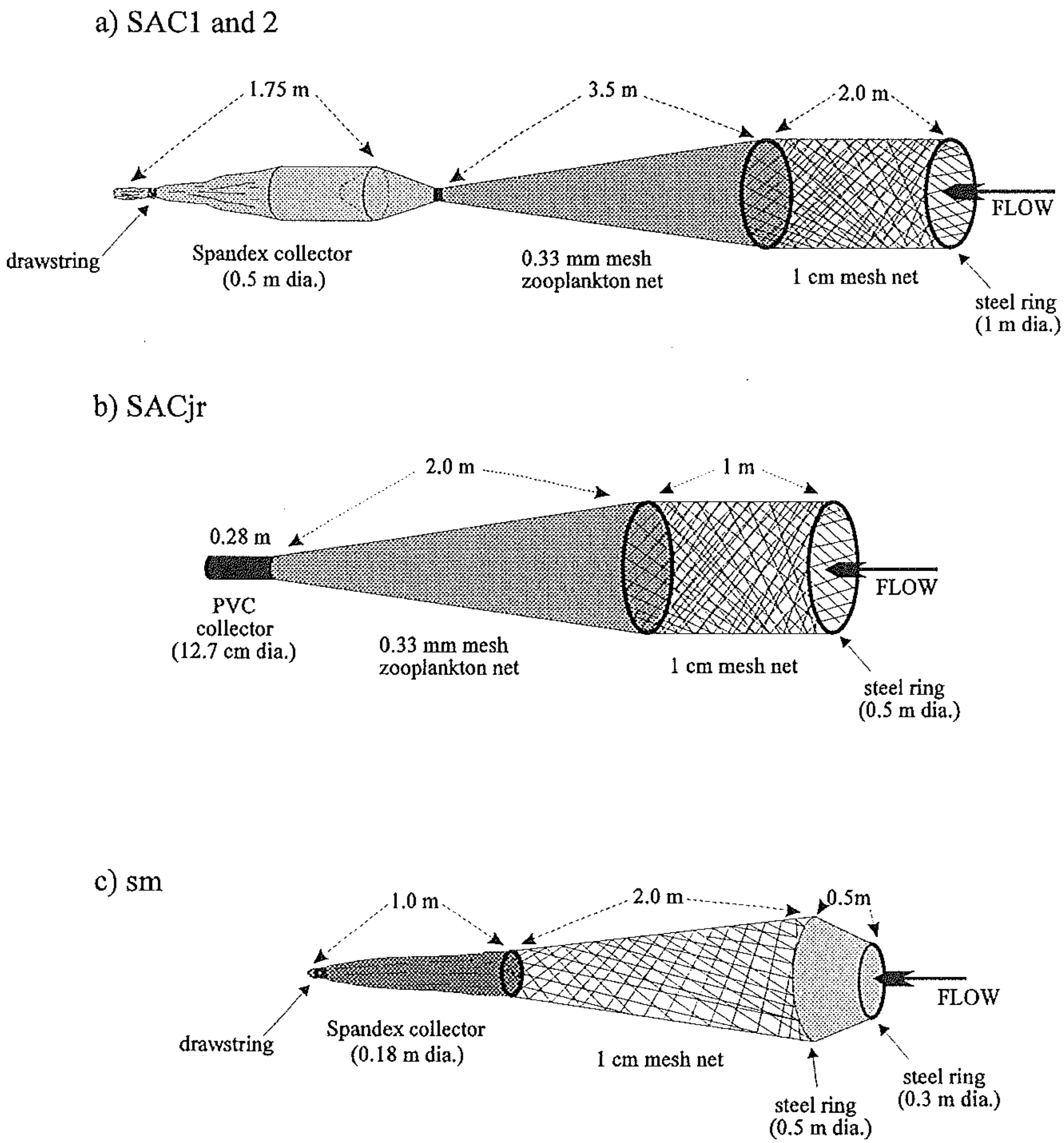

Figure 2. Nets used to monitor fish passage at the Annapolis causeway.

(about 0.75 m in length). The collectors had funnel-shaped entrances designed to keep fish from escaping back into the net. The tail ends of the collectors were designed so that they could be opened and closed with drawstrings to allow them to be emptied. One of these nets was named SAC1, another SAC2, and the third, which shredded irreparably on its first usage, was not named.

Because of the size of these nets, we were not able to retrieve them from the fishways during the ebb tide (the water flows are too strong), and they could only be pulled from the water as the tide turned and started to flood. In order to determine when the fish use the fishways relative to the generation period, two smaller nets were made. One of these nets (referred to as SACjr) was 0.5 m in diameter and was of similar design to the 1 m nets except that it was fitted with a standard zooplankton collector.The collector was a PVC cylinder open at one end, 28 cm in length, 12.7 cm in diameter, with a hole covered with screening in one side to allow water to drain out. The other net which had a 0.3 m mouth, was fitted with a Spandex zooplankton collector. This net (referred to in the results as 'sm') did not seem to fish effectively and was only used on two occasions.

The majority of fish caught during phase 2 were saved for identification and enumeration in the laboratory. The fish were transported to the laboratory on ice and were stored frozen until examination. The fork length and weight of all alosines caught were measured and notes were made on the physical condition of the fish (characterized as redeye, physical damage to the body or head such as bruises, abrasions or shearing, or tearing of the fish) when they were examined.

As an alternative to using nets to estimate fish passage in the fishways, we attempted to record fish moving in the fishways with a submersible video camera. A Sony Handycam in an Amphibico case was mounted on a 4 m steel rod which served as a handle for lowering the camera into the water. The video system was tested in the new fishway during an afternoon ebb tide, with the intention of determining the range of view such a system would have if employed in the fishway.

3.3 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 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):

$$CF=(W / FL^3) * 100 \qquad \text{eqn. 2}$$

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 dependant, 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.

Estimates of growth rates were derived from the differences of the mean fork lengths of the fish caught in the upper estuary during the first phase of the project and at the causeway during the second phase. The average daily growth rates were estimated by dividing these differences by the number of days between the median day of each phase.

4.0 RESULTS

A summary of field activities during both phases of the project is provided in Appendix 1. The summary contains a day by day description of the field work for this project as well as a listing of the time, location and catch of all fishing efforts that were made.

4.1 RESULTS: PHASE 1

A number of attempts were made to locate schools of YOY alosines using the fish finder throughout this phase. We tested the fish finder in both the upper estuary and the headpond. In near shore locations or areas characterized by shallow water we were unable to distinguish between fish and the bottom or shoreline. Tests were conducted by scanning areas of shoreline with the fish finder and then seining over the same area. In areas where we felt the fish finder was indicating a school of fish we were often unable to capture any fish and, conversely, in areas where we interpreted the signal as a statement that no fish were in the area we were able to catch fish with a seine. It is interesting to note that when large numbers of fish were present in the river above Bridgetown (this was known because large numbers of fish were seen jumping) we were able to adjust the signal to indicate the presence of fish, but without the knowledge that the fish were present we were unable to distinguish reliably between a school of fish and background interference. When testing the fish finder in the deeper water of the headpond, at no time did we pick up a signal that could be confidently interpreted as a school of fish. For these reasons, and also because the fish finder could not provide information on species' identity or body size, we concluded that this particular instrument was not suitable for our purposes.

Ninety-nine seines were conducted over 10 days in the field and a total of 1550 YOY alosines were captured, of which 1259 were marked and released back into the river. The location and time of these catches is summarized in Figure 3 as the catch per unit effort of two day periods spanning the sampling period. For presentation purposes the river is divided into 6 sections based on the intersection of the easting (U.T.M.) coordinates with the river. The majority of the fish were caught at the upper end of the estuary just above Bridgetown (easting app. 3-19-220) during the first 10 days of September. This area is the upper limit of the salt wedge which extends up the estuary, with salinities in the top 1 m of water ranging from 0.5 ppt to 2.9 ppt. No alosines were caught further upstream from this area, nor were alosines seen jumping above this point even at times when such activity was heavy at Bridgetown.

By Sept. 10, catches at Bridgetown had dropped substantially and the fishing effort shifted further downstream. On this day the majority of the fish were caught just upstream from Hebb's

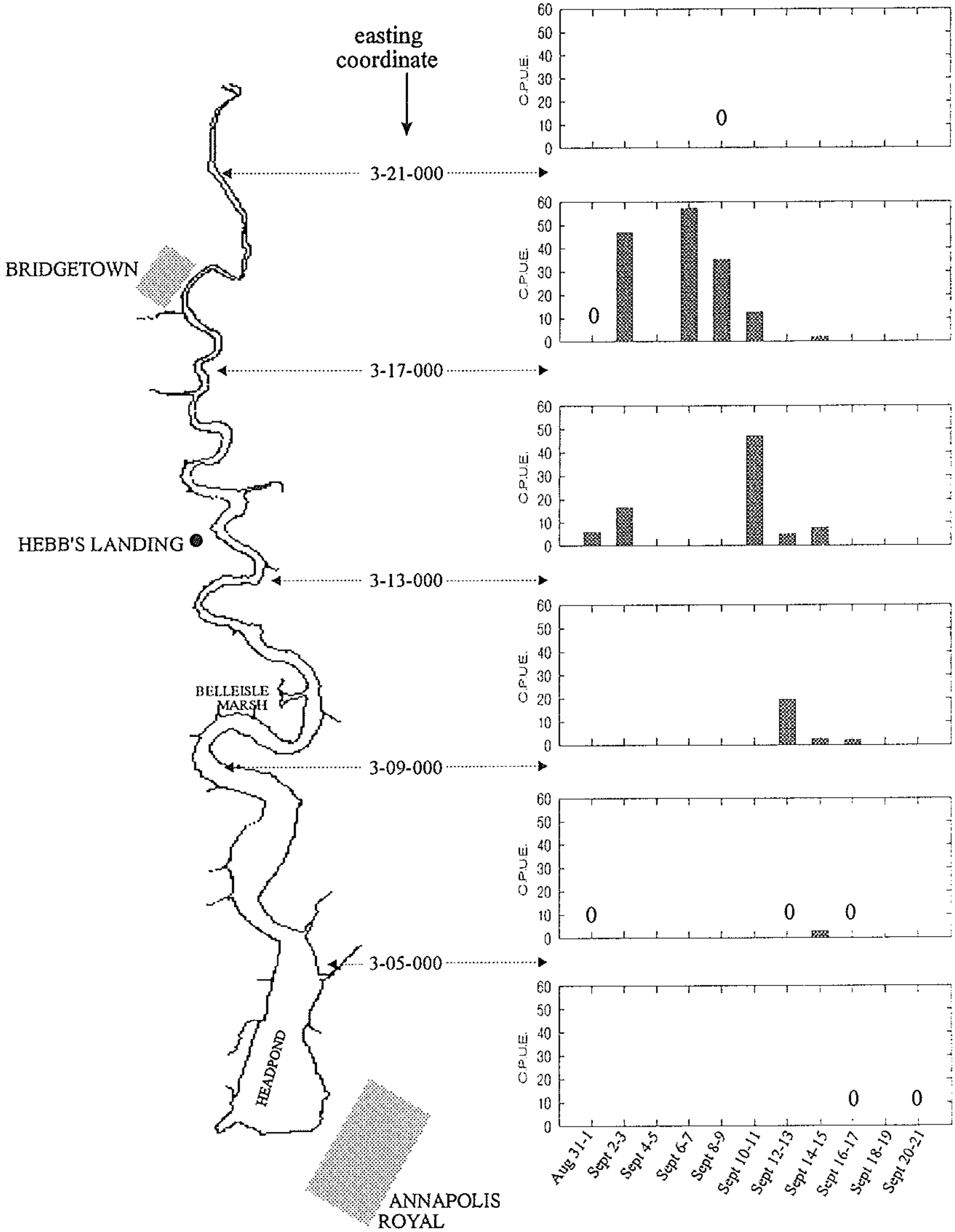

Figure 3. The time and location of alosine catches during the first phase of the project summarized as catch per unit effort for 2 day periods over 6 sections of the river. Easting coordinates refer to the U.T.M. easting coordinate at the intersection of the easting line and the river. Zeros mark periods where the C.P.U.E. was 0. Other periods were not sampled.

Landing (easting 3-14-200) where surface salinities ranged from 8.2 ppt to 14.6 ppt. While the catches in this area were only high for the one day, it is thought that fish were in the area for several days earlier while we were concentrating our efforts further upstream. Catches below this location were minimal, which is probably a reflection of the size and depth of the river in the lower estuary relative to the small area covered by each seine.

A total of 9 marked fish were recaptured during the seining. Using eqn. 1, an estimate of stock size of 'alosines' (not corrected for Atl. herring bi-catch) was calculated as 77026 individuals (95% C.I. are estimated as lower: 45044 individuals and upper: 154053 individuals). Of the fish retained for determination of stock characteristics during this phase, 65.0% were American shad, 23.3% were blueback herring, 7.8% were alewives and 3.9% were Atlantic herring. Using these relative abundances the population estimate was adjusted to numbers per species and the results are summarized in Table 1.

Table 1. Estimates of stock size of YOY alosines.

Species	Estimate of Stock Size		
	N	95% lower C.L.	95% upper C.L.
American Shad	50067	29279	100134
Blueback herring	17947	10495	35894
Alewives	6008	3513	12016
Total alosines	74022	43288	148045

Water temperatures were recorded throughout the field work. Figure 4 is an isopleth showing how the water temperature varied in the river over this three week period. Water temperature was relatively constant along the length of the river, although at the beginning of September the headpond was about 2 C cooler than the river (19-20 C versus 21-22 C). By the third week of September the water temperature for both the headpond and the river was around 17 C.

Salinities were also recorded and are summarized in Figure 5. The salinities ranged from 0.05 ppt above Bridgetown to 29.5 ppt in the headpond. The isopleth shows that there was some variability in the salinities over the three week period at any given point along the river.

Dissolved oxygen concentrations were also measured at different locations throughout the river. All D. O. concentrations were above 8.2 ppm, and thus were near saturation.

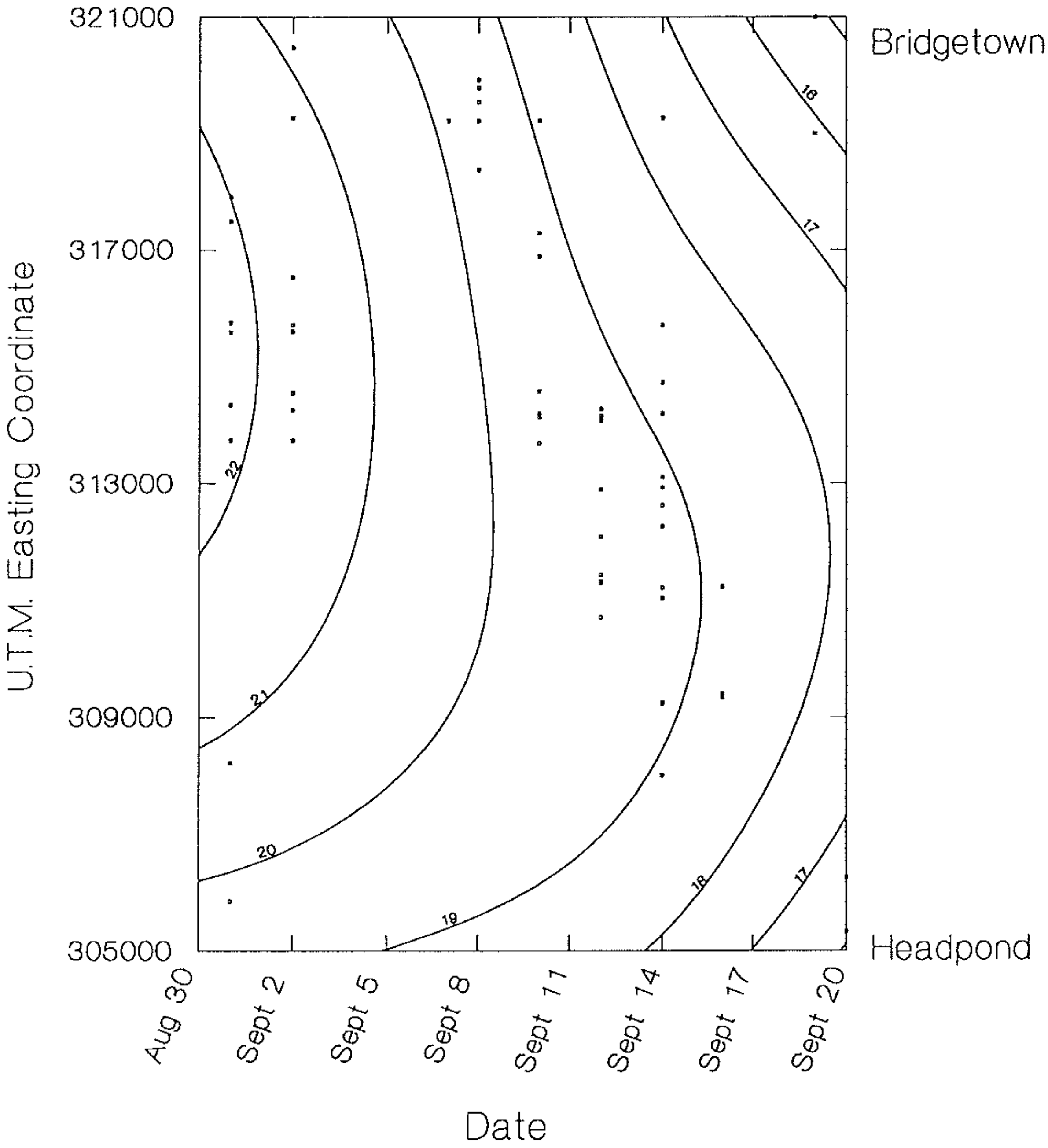

Figure 4. Variations in water temperature during the first phase of the project as a function of location (y-axis) and time (x-axis). The dots represent the sample locations.

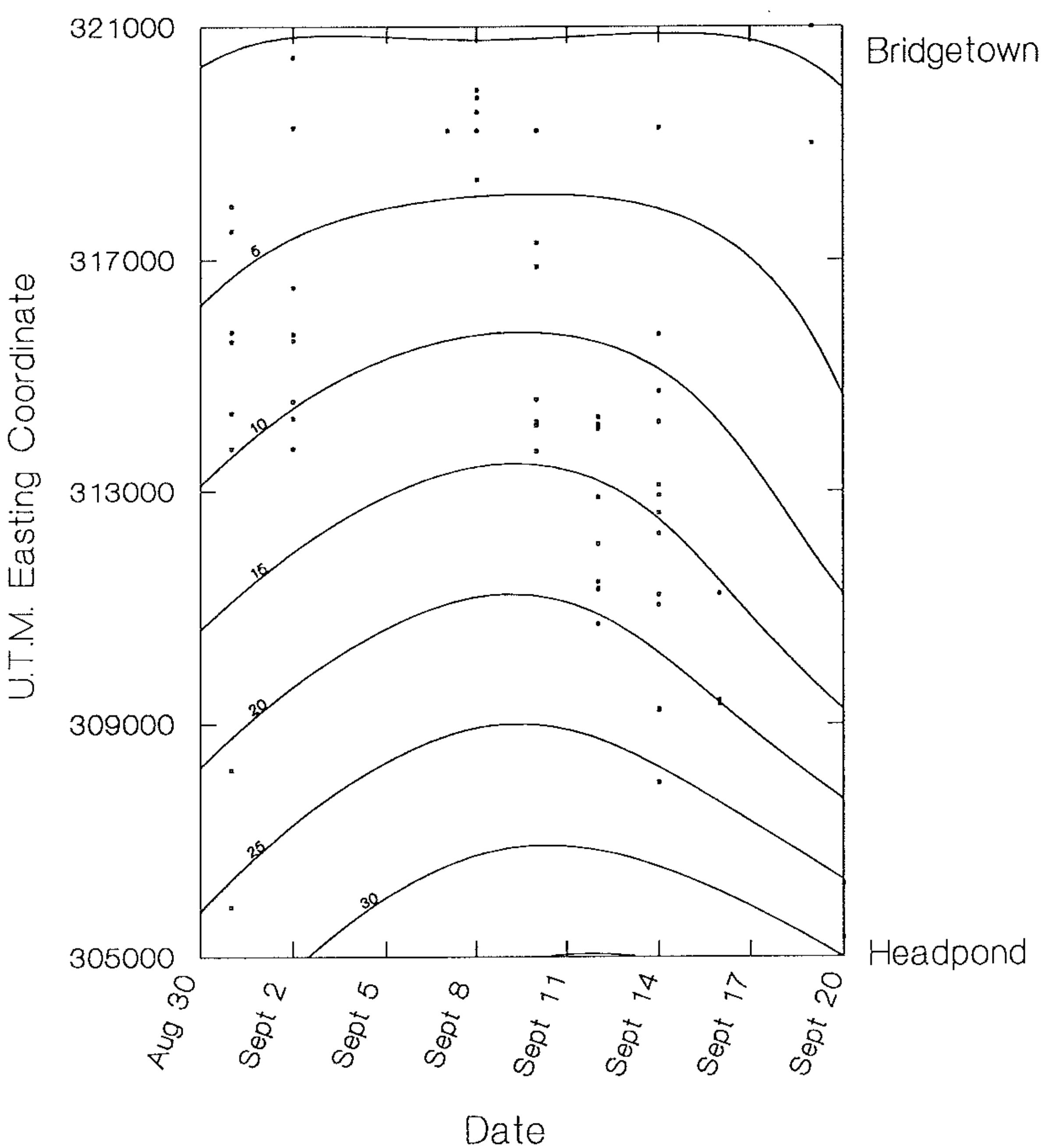

Figure 5. Variations in salinity in the Annapolis Estuary during the first phase of the project presented as a function of location (y-axis) and time (x-axis). The dots represent the sample locations.

4.2 RESULTS: PHASE 2

During the second phase of the project, 17 ebb tides were monitored during 11 trips to the causeway. Nets were deployed in the new fishway on 16 tides, in the old fishway on 13 tides, in the tailrace during 14 generation periods, and on the boom cable below the old fishway once. A summary of the species and the total number of fish caught in each location is presented in Table 2. A total of 4158 fish were captured, and of these, 26.2 % were captured in the tailrace below the turbine, 59.2 % were caught in the new fishway, and 14.6 % were caught in the old fishway. Of the 202 alosines that were captured, 76.2 % were caught in the tailrace, 23.3 % in the new fishway, and 0.5 % were captured in the old fishway.

Table 2. Total numbers and species of all fish caught in the two fishways and the tailrace during the second phase of the project.

SPECIES	TAILRACE	NEW FISHWAY	OLD FISHWAY	TOTAL
sea lamprey	1	4	31	36
American eel	2	76	5	83
blueback herring	52	9	0	61
alewife	11	9	1	21
American shad	91	29	0	120
Atlantic herring	658	1407	11	2076
rainbow smelt	9	1	0	10
tomcod	4	6	0	10
Atlantic silverside	185	776	531	1492
3-spine stickleback	30	102	3	135
pipefish	6	13	18	37
striped bass	0	1	1	2
cunner	1	0	0	1
Atlantic wolffish	0	0	1	1
American sand lance	0	1	0	1
butterfish	15	18	0	33
longhorn sculpin	0	1	0	1
lumpfish	0	1	3	4
smooth flounder	13	6	2	21
winter flounder	12	1	0	13
TOTAL	1090	2461	607	4158

The distribution of these catches over time is shown in Figure 6. For the purposes of presentation each of the 17 ebb tides sampled was given a number. The dates and times of each net deployment corresponding to these tide numbers may be found in Table 3. Figure 7 contains a similar presentation of the alosine catch for each tide. The downstream movement of all alosine species appeared to occur simultaneously, with the largest catch occurring on Oct. 14.

Several efforts were made to determine at which times during the ebb tide the fish move past the causeway. On one occasion (Oct. 26), a time series spanning the ebb tide was conducted in the tailrace and the new fishway simultaneously and the results of these efforts are presented in Figure 8. The catch data are standardized to number of fish/hr (most nets were fished for one hour intervals but changing tides and the onset and finish of generation necessitated fishing some nets for shorter intervals) and the time of day refers to the median time that the net was in the water (-0.3 refers to 2340h on Oct. 25). It appears from the graph that Atlantic herring move past the causeway at a more or less constant rate throughout the ebb tide while Atlantic silversides tend to move early in the tide cycle. The few American shad caught were caught during the first half of the generation period.

The salinity and temperature of the water were measured at the upstream entrance to the new fishway during each ebb tide that was sampled. Time series of salinity and temperature changes over a single ebb tide were conducted on the first two trips but no change was found in either parameter during these trials. After this time salinity and temperature were recorded only once per tide. Problems with the EMP2000 forced us to measure the temperature and salinity of the water with a YSI model 33 S.C.T. meter on tides 7, 8, 9, 12 and 15. This particular instrument is known to give low salinity readings so 2.5 ppt were added to each of the readings from the instrument to bring the values up to the correct level. Figure 9 shows the temperature and salinity of the water on each tide plotted with the total alosine catch in the three locations combined. There is no obvious relationship between either parameter and the alosine catch. Alosines were first captured on Oct. 5 when the water temperature had dropped to 12 °C, but only one alosine was caught during this tide. The first significant catch occurred in the new fishway on Oct 7-8 when the water temperature had dropped to 8 °C.

The majority of alosines captured were retained for identification, morphometric analysis, and examination at the laboratory. The purpose of the examination was to determine if the collection method was suitable for collecting live fish. The fish were stored frozen and thawed prior to examination. This method of preserving the fish proved unsatisfactory as the majority of the fish exhibited storage damage that rendered them unsuitable for determining damage that may be caused by the nets. However a number of the fish (those stored in smaller samples and perhaps were thus frozen more quickly) were considered suitable for this process, and the results are

Table 3. Date and times of fishing efforts corresponding to the tide numbers.

TIDE NUMBER	DATE	TAILRACE			NEW FISHWAY			OLD FISHWAY		
		net	time in	time out	net	time in	time out	net	time in	time out
1	Sept 24	-	-	-	SAC1	0910	1705	-	-	-
2	Sept 24-25	-	-	-	SAC1	2150	0600	-	-	-
3	Sept 29*	-	-	-	sm	1350	2115	sm	1505	1935
4	Oct 5*	SAC1	0525	0900	sm	0447	0735	sm	0559	0840
5	Oct 7-8	SACjr	2000	0030	SAC1	1847	0200	SAC2	1925	0055
6	Oct 9-10	SACjr	2045	0355	SAC1	2100	0440	SAC2	2055	0415
7	Oct 11-12	SACjr	2245	0555	SAC2	2245	0615	-	-	-
8	Oct 14	SAC2	0015	0745	SAC1	0045	0810	-	-	-
9	Oct 15	SAC1	1507	2045	SACjr	1413	2112	SAC2	1435	2135
10	Oct 16	SAC1	0325	0910	SACjr	0335	0955	-	-	-
11	Oct 16	SAC2	1545	2110	SAC1	1515	2200	SACjr	1527	2135
12	Oct 17	SAC2	0430	0930	SAC1	0344	1042	SACjr	0425	1030
13	Oct 17	SAC2	1620	2215	-	-	-	-	-	-
14	Oct 19-20	SAC2	1817	0005	-	-	-	SACjr	1800	0045
15	Oct 20	SAC2	0558	1225	SAC1	0621	1304	SACjr	0629	1247
16	Oct 22-23	SAC2	2044	0305	SAC1	2030	0410	SACjr	2103	0349
17	Oct 25-26	SAC1	0006	0554	SACjr	2315	0700	SAC2	2333	0643

* small net alternated at 1/2 hour intervals between the two fishways

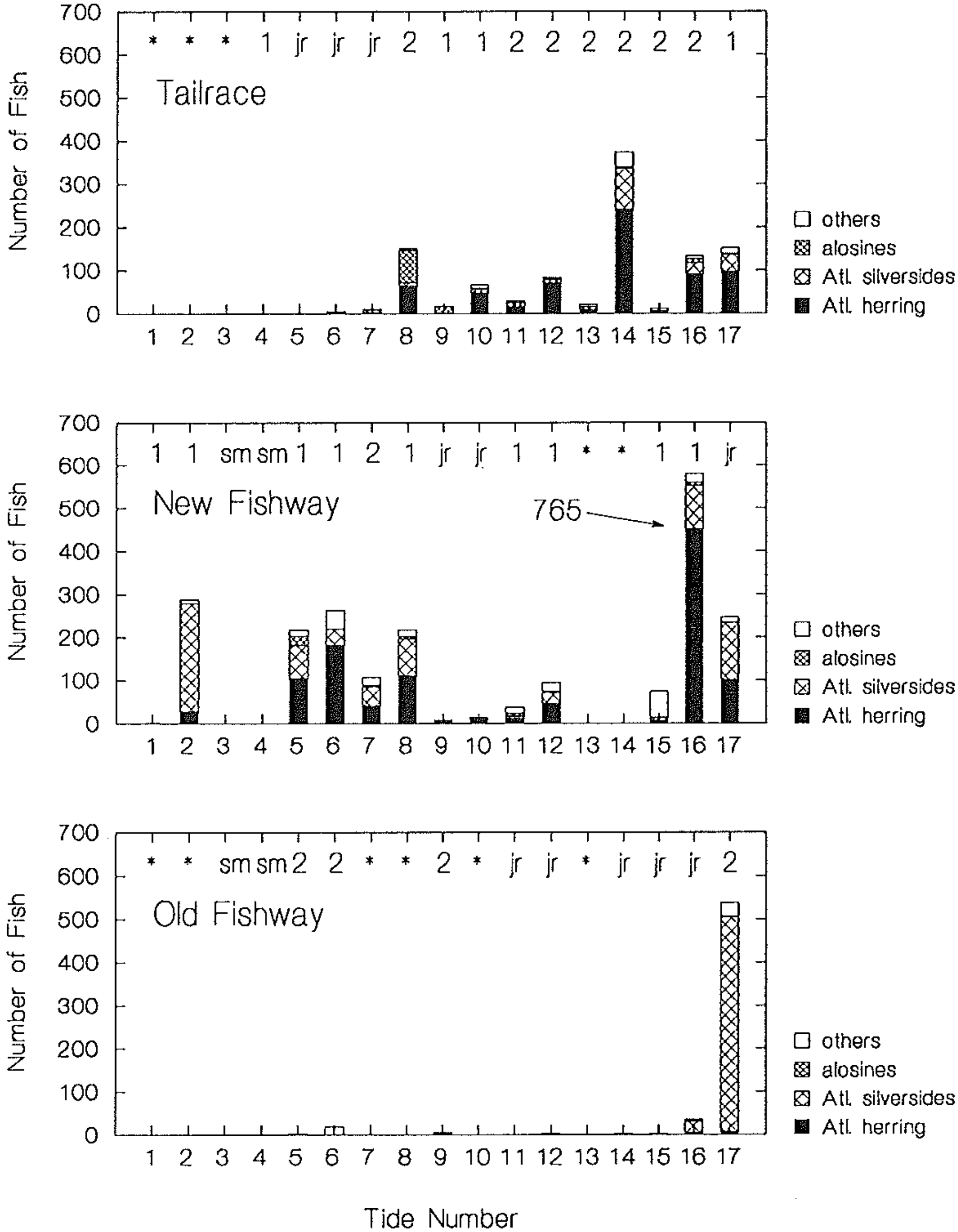

Figure 6. The number of fish of all species captured at each location per tide during the second phase of the project. The number at the top of the graph refers to the net used. A '*' indicates that a location was not sampled during that tide.

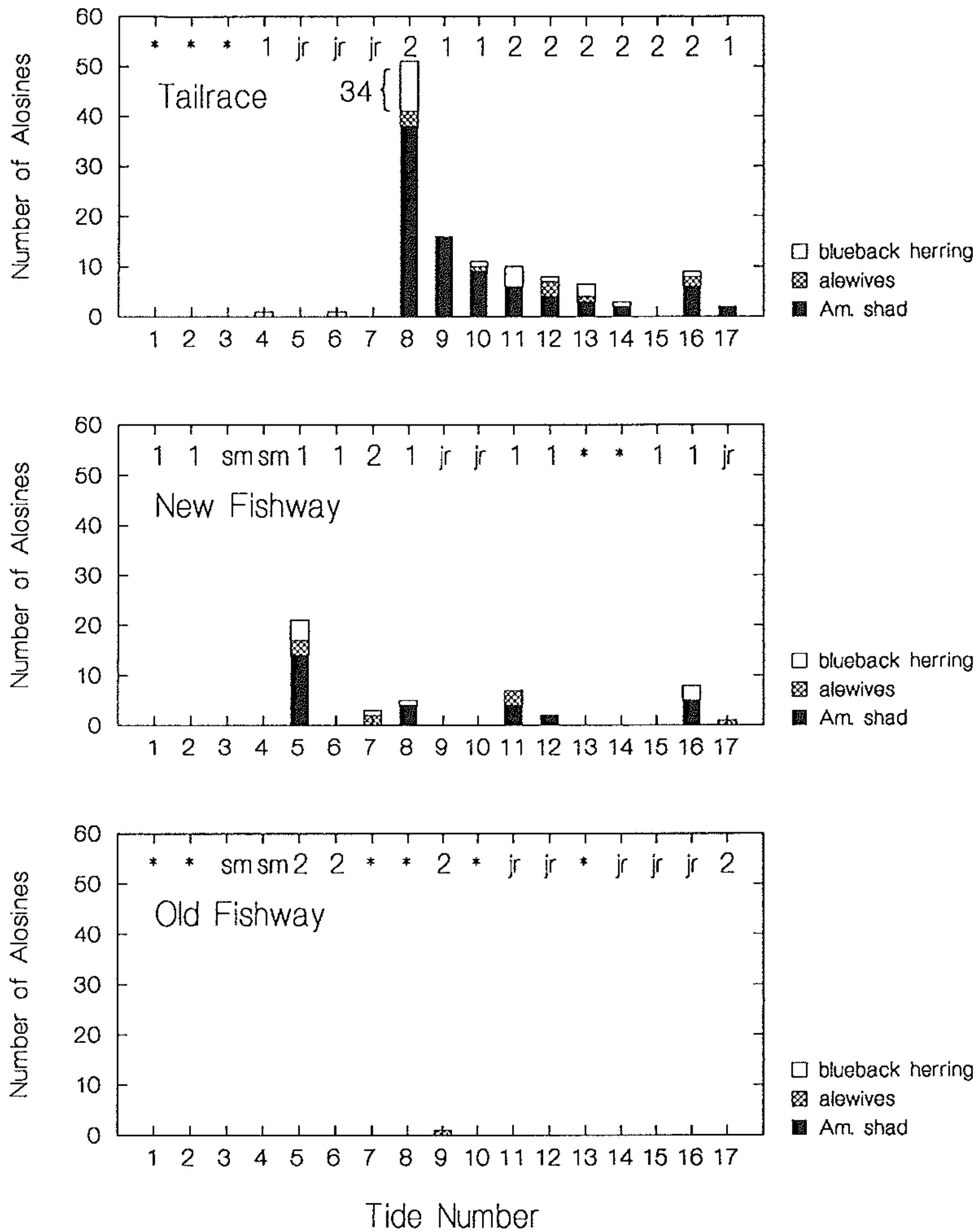

Figure 7. The total number of alosines captured at each location per tide during the second phase of the project. The number at the top of the graph refers to the net used. A '*' indicates that a location was not sampled during that tide.

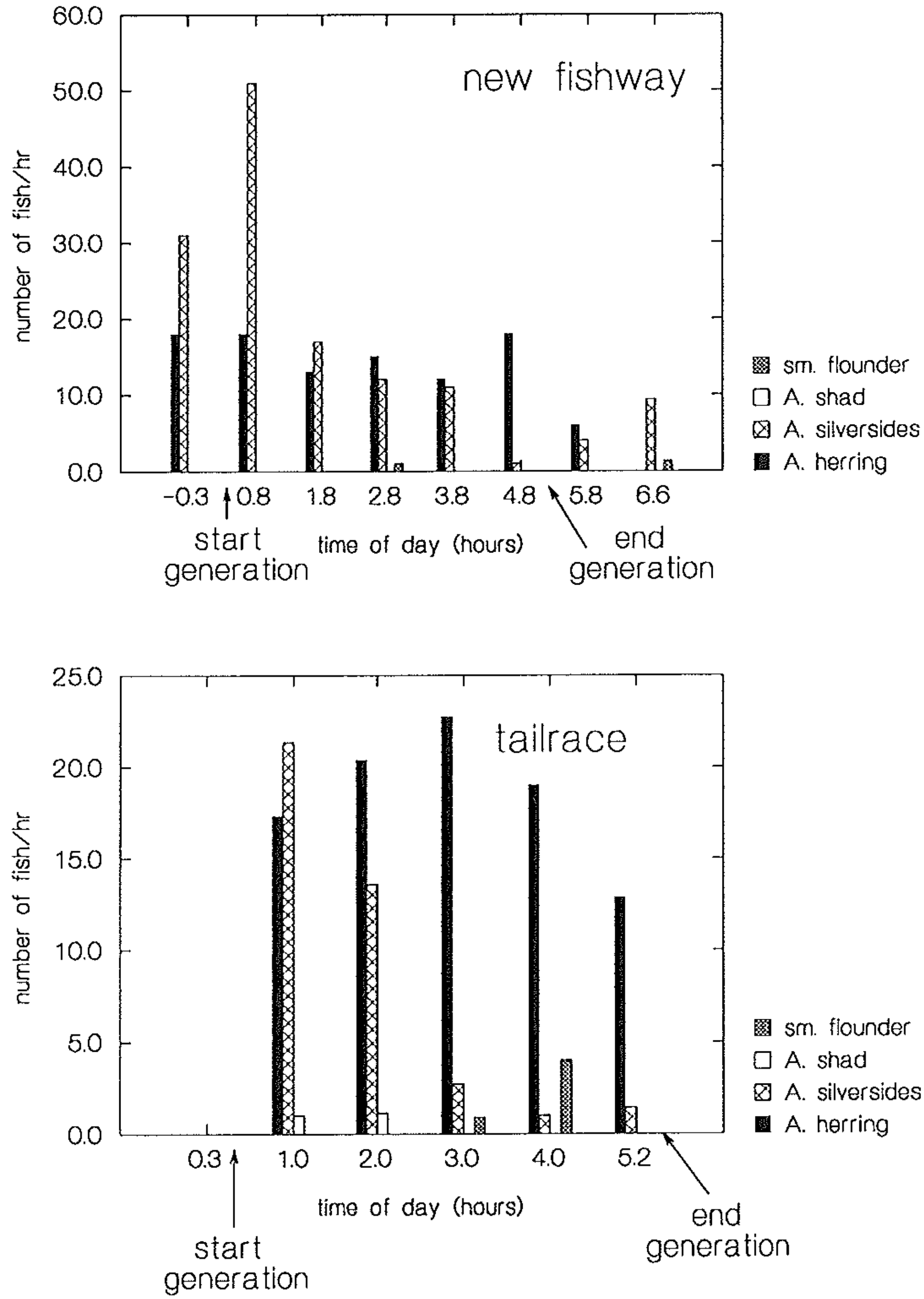

Figure 8. A time series showing the number of fish captured (standardized to catch/hour) in the new fishway and the tailrace over an early morning ebb tide.

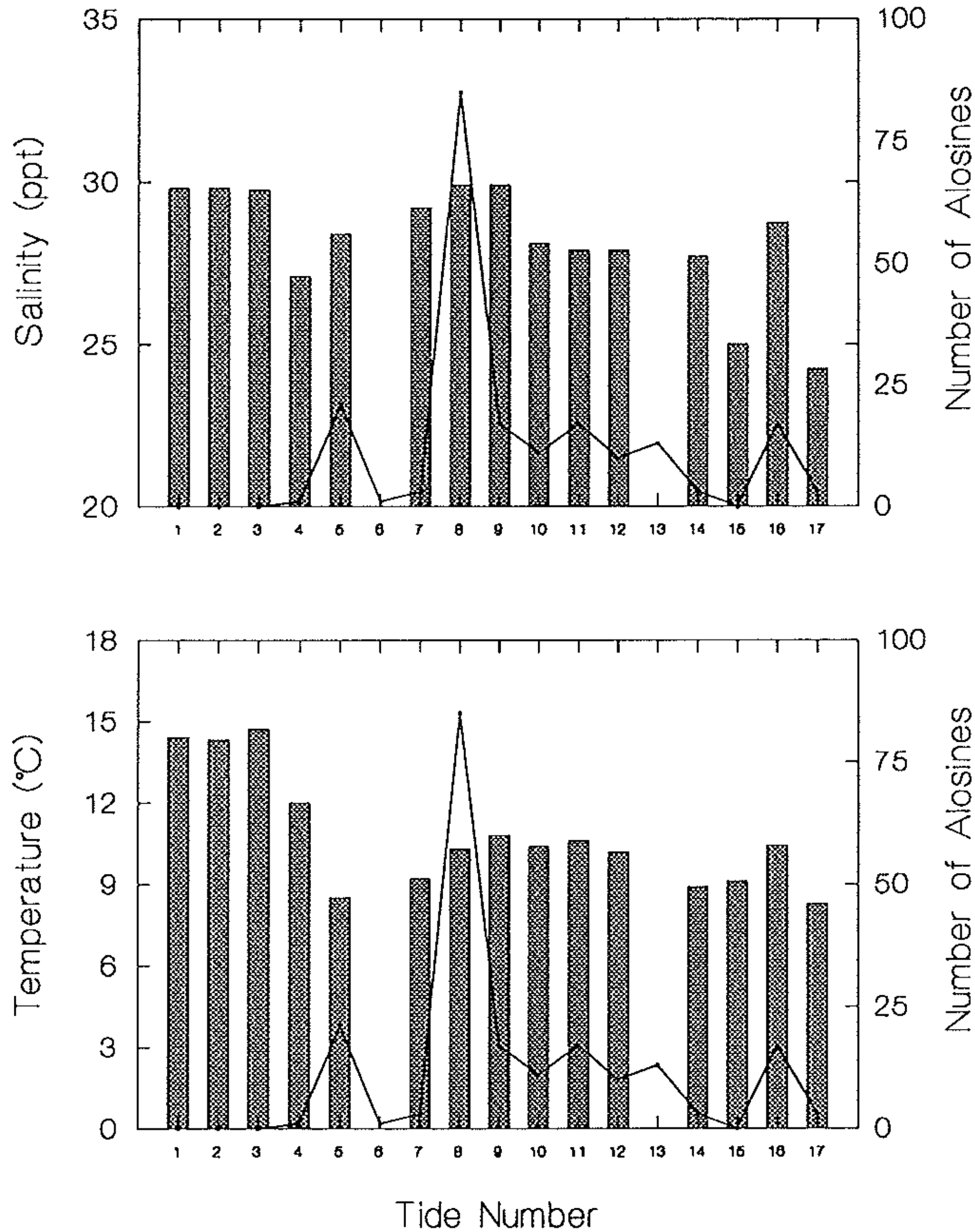

Figure 9. Temperature and salinity of the water (plotted as bars)at the upstream end of the new fishway during each tide sampled. The line represents the total number of alosines captured at all locations combined for each tide.

summarized in Table 4. Redeye is characterized by any hemorrhaging in the eyes or eye socket. Damage to the body includes cuts, abrasions or bruising on the body or head of the fish. Injuries were not broken into finer categories as fish showing one type of injury often showed other types of injuries.

Table 4. Summary of injuries to the alosines captured in the second phase of the project. N refers to the number of individuals examined, redeye to hemorrhaging in the eye, and B.D. (body damage) to cuts, abrasions, or bruises on the body or head of the fish.

Species	New Fishway			Tailrace		
	N	redeye (%)	B.D. (%)	N	redeye (%)	B.D. (%)
Am. Shad	17	82.4	64.7	70	88.6	11.4
bb herring	5	100	60.0	46	86.9	8.6
alewives	5	100	0	11	63.6	0
Atl. herring	290	35.2	65.2	200	36.5	35.5

On one occasion (tide number 10), SAC2 was set on the boom line below the old fishway with the intention of determining whether or not this would be a suitable place to sample the old fishway. The net captured 1 three-spine stickleback. On another occasion (tide number 13) we modified SAC1 to make it similar to the nets used by Stokesbury in 1985 and 1986 (similar to ours except without the cylindrical portion at the mouth of the net and fitted with a zooplankton collector instead of the fish trap type collector we used), and fished it in the tailrace 10m away from SAC2 to see if our nets were fishing with an efficiency that was comparable to his nets (This was necessary in order to compare our numbers to his). SAC1-modified captured 3 Am. shad, 2 blueback herring, 1 Atl. silverside, 1 rainbow smelt and 7 Atl. herring. SAC2 captured 3 Am. shad, 3 blueback herring, 2 alewives, 3 winter flounder, 10 Atlantic herring, 1 Atl. silverside, 1 tomcod, 1 butterfish, and 4 three-spine sticklebacks. Thus, in total SAC2 caught 1.6 times the number of alosines and 2 times the total number of fish than SAC1-modified. A similar comparison was made during tide number 8 between SAC2 and SACjr again by fishing them 10 m apart in the tailrace.

After standardizing the catches to the catches per one square meter fishing area, SAC2 had caught 5.1 times the number of alosines and 3.4 times the total number of fish as SACjr. From these comparisons it was decided that in both cases the fishing selectivities and efficiencies of the nets were different enough to exclude the possibility of comparing catches between the different nets.

When tested in the new fishway the submersible video camera was found to have a range of view between 1 and 1.5 meters using ambient light on a sunny afternoon. Turbidity and small air bubbles limit visibility. Fish were not observed during the test.

4.3 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. Length frequency distributions are presented for American shad, blueback herring, and alewives in Figures 10, 11, and 12 respectively, for those fish caught during each phase of the project. Mean fork lengths, weights, and condition factors of YOY alosines are summarized in Table 5. American shad and blueback herring of greater length than 170 mm, and alewives of greater length than 130 mm are considered 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	phase 1	63	72.8 (14.0)	4.9 (2.6)	1.14 (0.10)
	phase 2	102	104.0 (12.9)	12.4 (5.5)	1.04 (0.13)
bb. herring	phase 1	33	79.1 (16.5)	5.9 (3.0)	1.04 (0.15)
	phase 2	61	105.7 (12.1)	12.8 (5.3)	1.04 (0.19)
alewives	phase 1	6	66.8 (12.3)	3.9 (2.1)	1.19 (0.09)
	phase 2	8	106.5 (10.9)	12.3(2.9)	1.01 (0.09)

The median date of the first phase of the project was Sept. 6 and the median date of the second phase of the project Oct. 2. If one assumes from this a growth period of 26 days, growth rates for the YOY alosines can be calculated for this time period. The data indicate growth rates of 1.2 mm/day for American shad, 1.0 mm/day for blueback herring, and 1.5 mm/day for alewives.

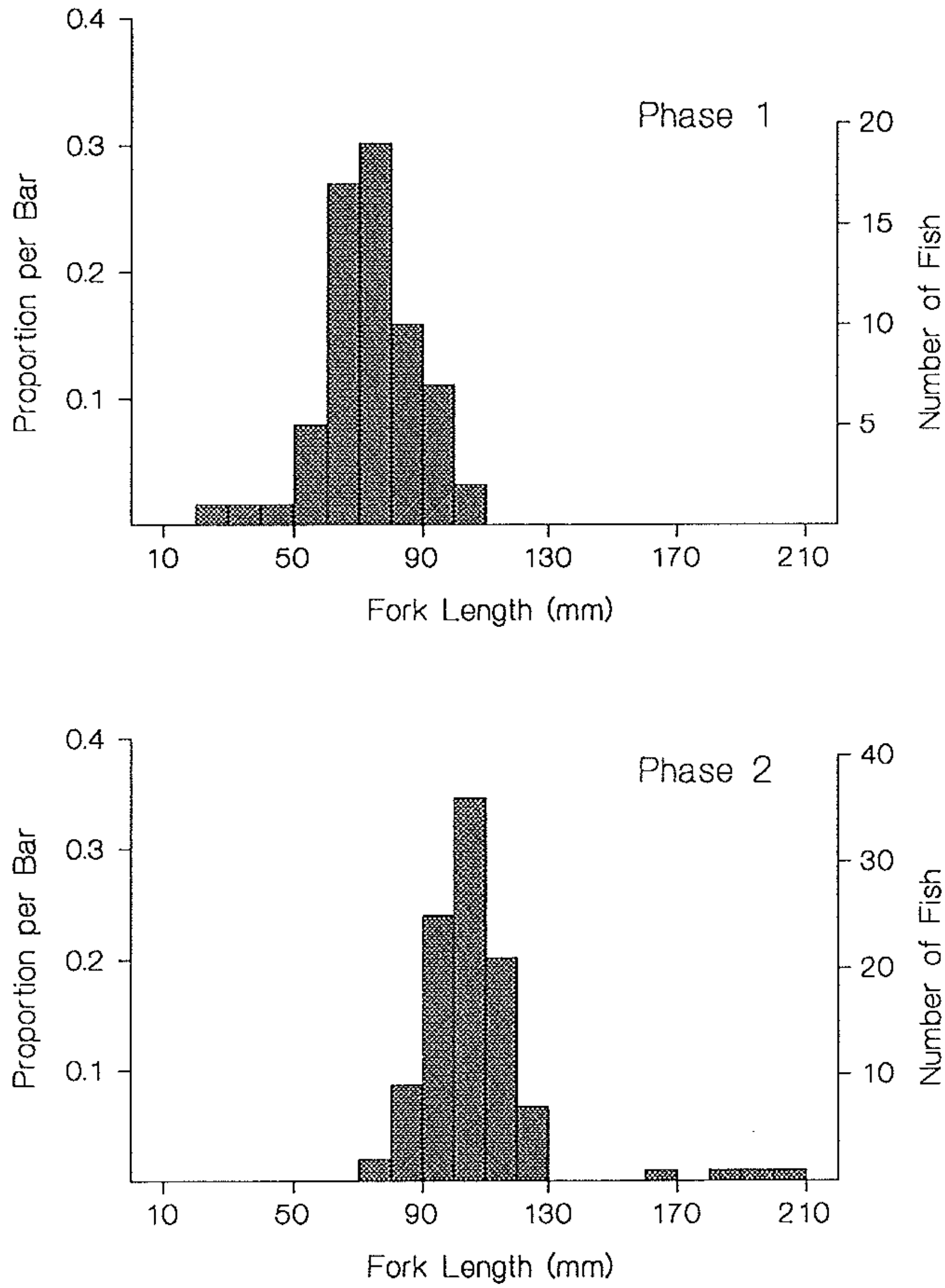

Figure 10. Length frequency distributions for the American shad captured during the two phases of the project.

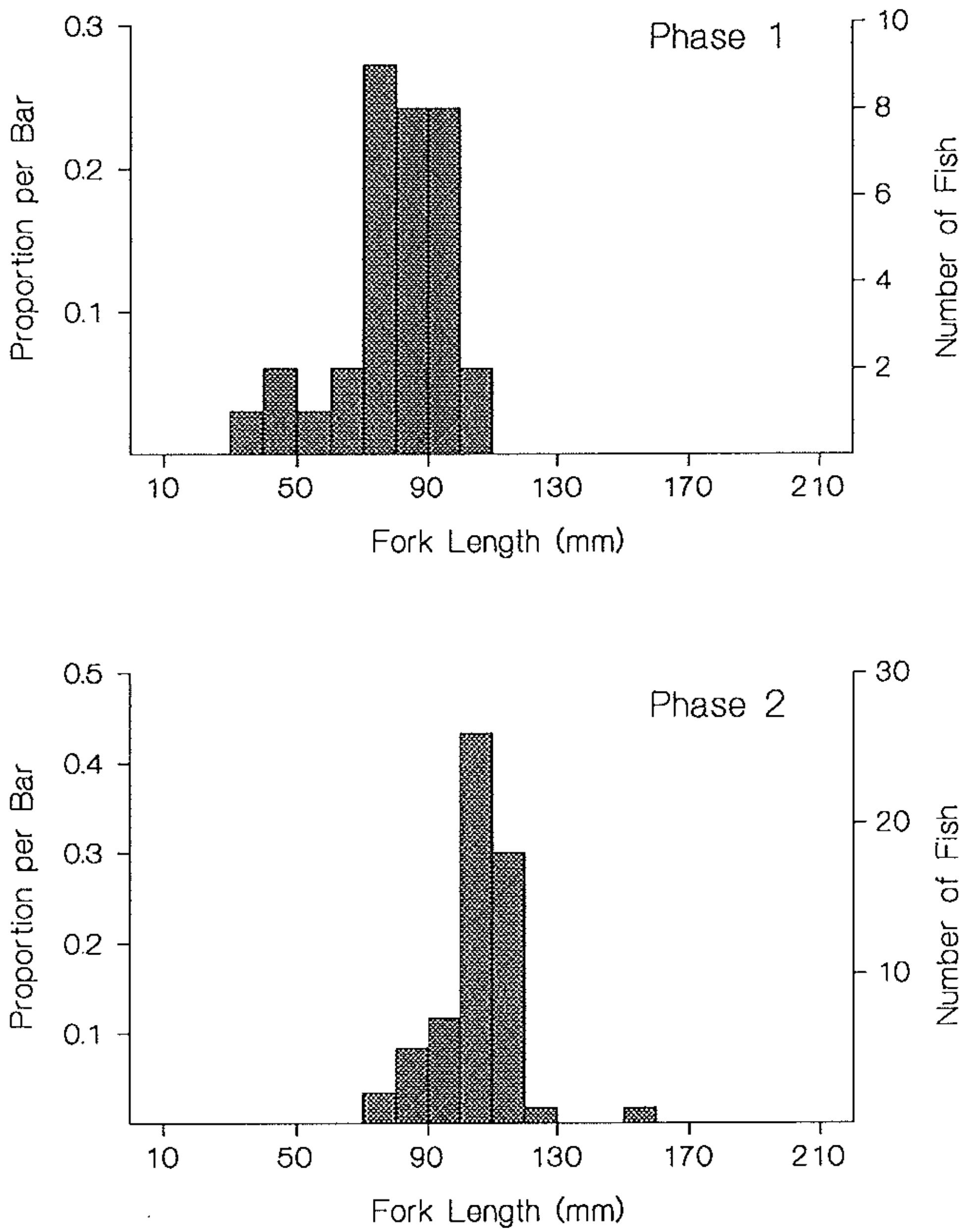

Figure 11. Length frequency distributions for the blueback herring captured during the two phases of the project.

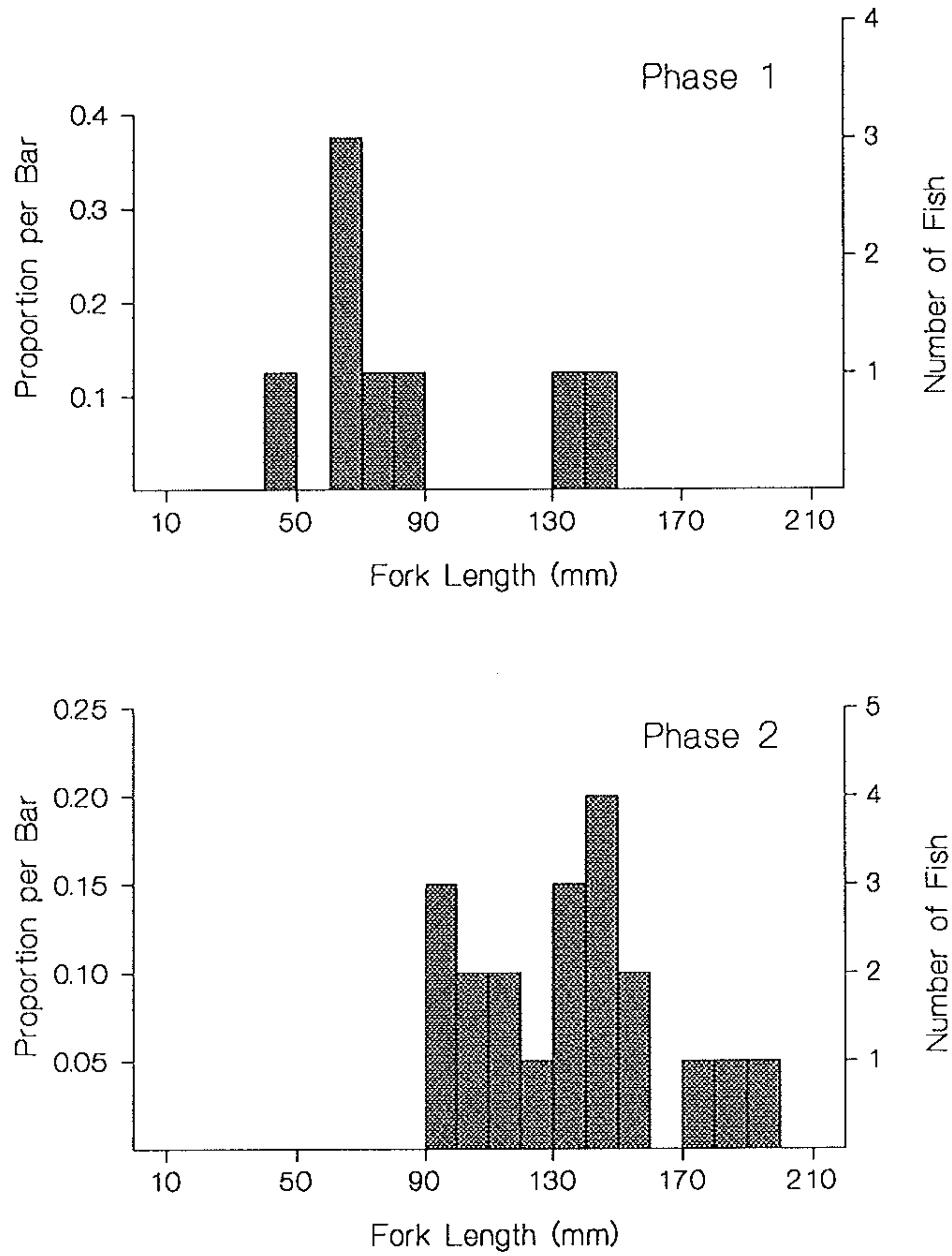

Figure 12. Length frequency distributions for the alewives captured during the two phases of the project.

long a period of time as is indicated in other studies. Stokesbury found that the decline in the seine catches in the estuary in 1985 occurred almost a month before a major movement of fish was recorded at the causeway (Stokesbury and Dadswell 1989). He concluded that schools of alosines may form in the deeper water of the headpond and remain there for some time before moving to sea. Since they were not captured by shore seines at this time, Stokesbury and Dadswell assumed they avoid shallow waters. O'Leary and Kynard (1986) also noted significant changes in behavior of alosines during seaward migration.

The drop in alosine catches during this study did coincide with the time at which the fish reached a larger and deeper body of water. This decline could be interpreted as a statement about the efficiency or suitability of the seining methods in this habitat rather than attributed to behavioral changes in 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 3.0-3.5 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, our seining method appears to be effective in the shallower waters of the river, however, it is not a reliable method for collecting a large number of alosines in the headpond.

Determining the rate of migration of YOY alosines (as well as a more precise estimate of stock size) could better be accomplished through an uncoupling of the capture-marking stage of the experiment from the recapture-tracking stage. A large number of fish could be marked with comparative ease (using spaghetti tags or some other method that allows individual recognition) by erecting a barrier net at a suitable location above Bridgetown and marking the fish before they reach the estuary. The fish could then be recaptured using a methodology similar to ours, thus providing information about the exact rate at which individuals move downstream, information about the population size, and perhaps settle the question as to how long fish remain in the headpond if recaptures also occurred at the causeway. That we were able to recapture 9 marked alosines with only 1260 marked throughout the entire study implies that such a methodology could easily be successful.

5.2 Mark and Recapture Studies. (Objective 2).

The initial intention to mark fish using the fluorescent dye technique adopted by Stokesbury (1987) was not carried out because, while the technique may be suitable for the mass marking of a large number of fish rapidly, the logistics of identifying marked fish in the field made the method appear unfeasible. The majority of the dye washes off the fish within a couple of days and in order to see the remaining dye the fish must be closely examined in the dark using ultraviolet light (Phinney et. al. 1967). So while the method may have increased marking rates, the problems associated with identifying marked fish rapidly in the field would have outweighed any of these benefits.

The use of 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. Both of these assumptions were violated in our experiment, the first because the population stratifies to some extent as it migrates, 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. Both of these violations would tend to increase the probability of underestimating the population size. A low number of recaptures will also increase the probability of underestimating the population, however Ricker (1975) suggests that this bias can be ignored when R is greater than 4.

The small number of recaptures (R=9) was a function of not marking enough fish in the river. Marking the fish before they reach the estuary through capturing the fish with a barrier net would allow one to greatly increase the number of marked fish in the river and at the same time allow one to randomize the recapture effort in the estuary thus removing some of the bias in the population estimate.

Our stock size estimate of 74022 alosines is within the range of Stokesbury's estimates of stock sizes in 1985 and 1986 of 115000 and 18000 alosines respectively (Stokesbury and Dadswell 1989). However relative abundances calculated from the numbers captured by seining reported in Table 1 of Stokesbury and Dadswell (1989) indicate that in 1985 YOY blueback herring were most abundant (70.3%), followed by alewives (16.1%) and YOY American shad (13.1%). In 1986 American shad were most abundant (54.2%), followed by blueback herring (37.9%) and alewives (7.9%). Adjusting the population estimates to reflect stocks of individual species yields estimates of 80845 and 6822 individuals for blueback herring in 1985 and 1986 respectively, estimates of 15065 and 9756 individuals for American shad, and 18515 and 1422 respectively for alewives. Hence the conclusion that YOY alosine numbers were much lower in 1986 relative to 1985 (the reduction in the population size was estimated at 90%) reported by Stokesbury and Dadswell (1989) might really have been a conclusion about the YOY blueback herring and alewife populations while the American shad YOY stocks remained in the same range. The point of this is that the total alosine stock is really made up of three distinct and separate subgroups whose populations fluctuate in different ways and probably respond to different stimuli. Treating the stock as a single group masks between-species variability that would be important in understanding how the populations behave. So while superficially our estimate of 74022 YOY alosines appears to be in the same range as Stokesbury's estimates of 1985 and 1986, in reality our YOY American shad population estimate of 50,067 individuals is on the order of 4 to 5 times larger than Stokesbury's estimate, our YOY blueback herring population estimate of 17947 is very low when compared to the 1985 estimate but still higher than the estimate in 1986, and our estimate of 6008 alewives falls in-between the estimates of the 1985 and 1986. It should be pointed out that while the absolute estimates of the population size may be criticized (Stokesbury's lack an error term), in all three years the relative abundances calculated from the data collected at the causeway more or less agree with the relative abundances calculated from the seine collections: the implication is that the changes in species relative abundance are real.

5.3 Passage through the Annapolis Causeway. (Objective 4).

Ichthyoplankton nets set in the two fishways and the tailrace of the tidal generating station captured 202 alosines (120 shad, 61 blueback herring, and 21 alewives), together with nearly 4000 other fish. The number of alosines is small, but comparable with the 84 captured by Stokesbury in 1986 (Stokesbury 1987), and the 374 recorded by Ruggles and Stokesbury (1990), although far less than the 1253 alosines recorded by Stokesbury in 1985 (Stokesbury 1987). Interestingly, the total number of fish (4158) far exceeds the records for 1985 and 1986 (1883 and 938, respectively). Sampling effort varies between the studies: for example, in our study 1m diameter nets were used in the tailrace for a total of 64.5 net-hrs. (capturing 154 alosines). In 1985, 2 nets fishing in the tailrace fished a total of about 141 net-hrs. (capturing app. 1200 alosines), and in 1986, 1 m diameter nets were fished in the tailrace for a total of about 171 net-hrs. (capturing app. 80 alosines). Variation in sampling effort, therefore, does not explain the differences in the number of fish caught. The differences may be attributable to annual and seasonal variations in relative abundances of fish or serendipity with regard to the choice of sampling occasion (since downstream movement past the causeway appears to occur over very short periods). Differences may also be attributable in part to the use of different net designs. In addition it appears that susceptibility to capture in a net varies from species to species depending upon the time sampling was conducted during the ebb tide: Atlantic herring were captured at all stages of the ebb, whereas Atlantic silversides were taken primarily during the first part of the ebb tide, and less so thereafter. Too few alosines were captured during these time series to generalize about their behavior, although the few American shad that were captured in the tailrace during the time series trials were caught during the first half of the generation period (see Figure 8).

Sampling fish in strong flows using standard ichthyoplankton nets is a highly unsatisfactory technique. Comparison of catches using conical nets of different diameters (1.0, 0.5, 0.3 m) in this study showed that the efficiency of the nets decreased with a decrease in the net diameter. The smallest net did not catch any fish in the fishways over the two tides that it was used to attempt to collect time series data. However, on these occasions fish were not seen swimming in the new fishway, while they were observed on days when the catch was higher. Additionally, a 1m net set in the tailrace on the second of these tides captured only 1 blueback herring and 1 three-spine stickleback, the implication being that fish were not moving past the causeway during this time. At best, however, this net is really only suitable for the collection of presence/absence data. The 0.5 m net SACjr, captured fish, but generally far less than would be expected by its relative cross sectional area. This net may be suitable for the collection of relative proportion type data, such as could be used in time series data over the course of an ebb tide. It is possible that the reduced efficiency exhibited by this net was caused by its standard cod-end collector (which might make it possible for fish to escape from the net) more than by its reduced diameter. The smaller catch in SAC1 when it was fitted with a standard collector and fished beside SAC2 fitted with a fish trap type collector would support the hypothesis that water velocity alone is insufficient to ensure that fish do not escape from the net.

The ichthyoplankton nets also proved unsatisfactory for the collection of live, undamaged fish. The majority of the fish captured in the 1 m nets exhibited some form of damage (see Table 4). It is felt that the degree of damage sustained by the fish increases the longer the fish remain in the nets and also as the size of the catch grows. The greater degree of damage exhibited by the fish captured in the new fishway relative to the tailrace is probably caused by the higher water velocities encountered there. The majority of our net sets (and all of those used in these calculations) were for either the full ebb tide (in the new fishway) or the full generation period (in the tailrace), so that the fish in the new fishway spent more time in the net (approximately. 7 hrs. relative to approximately 5.5 hrs in the tailrace). This would account for the greater degree of damage to these fish. Observations of the condition of fish removed from the nets while conducting the time series showed that most of these fish, which had remained in the net for only one hour, were still in relatively good condition, and were released live. The conclusion is that if one wishes to collect fish in these locations using this type of net, one would need to design a sampling regime that would minimize the length of time the fish spent in the net. This could be accomplished in the tailrace if the net was used only to funnel the fish into a holding tank beside a boat. The tank could then be periodically emptied from the boat and the fish examined with minimal net damage.

Regardless of the selectivity and efficiency problems associated with the use of ichthyoplankton nets when sampling in this type of environment, we were able to catch fish in the new fishway. The fact that 59.2% of our total catch and 23.3% of our alosine catch came from the new fishway does not support the contention by Stokesbury (1987) that only a minuscule proportion of the alosines utilizes the fishways (reported as less than 0.2% of his catch by Stokesbury (1987), but as less than 2.0% of the alosine catch according to Stokesbury and Dadswell (1991)). However, only one alosine (0.5%) was captured in the old fishway and fishing success was poor in this location on all occasions except the final tide. While fishing effort with 1 m diameter nets was less in the old fishway than in the other locations, this alone is not adequate to explain the low catch. It appears that this fishway does not play as important a role in the downstream passage of fish as either the turbine or the new fishway.

It is questionable whether the submersible video camera would prove to be a suitable method for monitoring fish passage in the fishways. Visual observations in the new fishway suggest that at least at the upper end of the fishway fish are asymmetrically distributed with more fish moving with the higher flows in the center of the channel than near the sides. As the range of view of the camera is not adequate to span the entire channel, the placement of the camera would bias the number of fish counted in the field of view. Additionally, it is unknown if a lighting system can be designed that would have a minimal influence on the passage of the fish, allowing the use of the camera at night when the fish are moving. Attempting to use a camera in the old fishway would be further compounded by the apparent lack of a good mounting point. Further testing will be necessary to determine whether the use of a submersible camera to monitor fish passage would be feasible, however, at present, it appears inevitable that further work on the downstream movement and passage of fish through the causeway at Annapolis will have to be pursued using modified net collection techniques.

5.4 Determination of stock characteristics. (Objective 6).

Length and weight measurements suggest that YOY shad and blueback herring were on the whole larger than recorded by Stokesbury in 1985 and 1986 (Stokesbury and Dadswell 1989). There were too few alewives for meaningful comparisons. The crude growth rates for shad and bluebacks calculated by dividing the mean change in length by the number of days between median dates for the two phases of the study suggest that growth rates were similar to or higher than the 1985 year class. Stokesbury's catches in 1986 were very small, and suggested to Stokesbury and Dadswell (1989) that growth conditions were poor that year, and the rates reported are lower than our estimated growth rates for 1993. Annual variations in stock size for migratory alosines in Nova Scotia are well documented (e.g. O'Neil, 1980), and the differences between the size and growth reported by Stokesbury and Dadswell (1989) and those reported in this study are probably simply part of this variation.

6.0 SUMMARY

During the first phase of the project, 1550 alosines were captured in the Annapolis River between Bridgetown and the Annapolis causeway. Of these, 1259 were marked and released back into the river and of these, 9 were recaptured in subsequent seines. The population size of the alosines was estimated at 74,022 individuals, consisting of 50,067 American shad, 17,947 blueback herring, and 6008 alewives.

Efforts to track fish with a fish finder were unsuccessful and the data from the seine collections were not suitable for determining the rates at which the alosines move downstream. However, the migration from Bridgetown took place during a period of about 2 weeks between Sept. 2 and Sept. 16. Alosines were first encountered near Bridgetown at the river-estuary boundary. It was concluded that the acclimation rate of the fish to higher salinities may limit the rate at which they move downstream.

During the second phase of the project 202 alosines were captured at the Annapolis causeway along with about 4000 other fish. The majority of the alosines were caught in the tailrace (76.2%), but the numbers caught in the new fishway (23.3%) imply that the new fishway plays a much more important role in the passage of fish than previous studies have shown. Apparently other species also utilize the new fishway, as 59.2% of the total number of fish caught were captured in this location. The old fishway appears to play a less important role however, as only 14.6% of the total catch occurred there and most of that on one occasion.

Different species of fish appear to move past the causeway at different times during the ebb tide. Atlantic silversides show a preference for the early part of the tide, while Atlantic herring appear to move past at a constant rate throughout the generation cycle. The number of alosines caught during the time series experiment was too low to be conclusive, however the few that were captured were caught during the first half of the ebb tide.

The use of ichthyoplankton nets for sampling fish in these high water velocities presents several kinds of problems. Nets of different diameters and designs fish with different efficiencies, so it is not feasible to compare catches made with different types of nets. Nets fitted with fish trap type collectors appear to catch more fish, implying that fish may be able to escape out of the nets with standard cod ends. Because of the high water velocities it appears that the nets damage the fish, so this method is not suitable for the collection of live fish or fish that need to be collected in good condition. Besides water velocity, the length of time in the net and the size of the catch in the net are thought to influence the degree of damage the fish sustain.

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8.0 APPENDICES

8.1 APPENDIX 1. Summary of Field Activities.

Appendix 1. Summary of field activities.

Listed below is an account of the activities of each day spent in the field while working on this project. The location, time and number of fish caught in each seine during the first phase of this project is provided in Table 1.1. Similar data for each net set at the causeway during the second phase may be found in Table 1.2.

Aug. 27, 1993

Reconnaissance trip.

1. We explored the lower river (below Hebb's Landing) looking for places suitable for beach seining.
    - Located 5 places that could be beach seined at low tide.
2. We tested the fish finder attempting to find a suitable configuration for locating schools of small fish.
3. We attempted 5 test seines (did not record results) with the small seine (no alosids were captured).

Aug. 31, 1993

Reconnaissance trip.

1. We explored the upper river (above Hebb's Landing looking for places suitable for beach seining.
    - located 9 places that could be beach seined at low tide.
    - G.P.S. and C.T.D. readings were taken at these locations.
2. 5 seines were attempted and the results recorded.
    - alosids were captured in one of these seines and a subsample retained.
3. We concluded that conventional beach seining methods would not be suitable for locating alosids in the river and that another method would have to be found. We decided to attempt to fish with a larger seine that could be towed by two Zodiacs.
4. Further attempts to locate schools of fish using the fish finder were unsuccessful.

Sept. 2, 1993

Seining in the upper river.

1. Ten seines were conducted in the upper river using the large seine and towing it behind the two Zodiacs.
    - the method proved to be more successful than the beach seining techniques as larger areas could be covered, and the potential seining areas were not limited by the depth of the water.
    - G.P.S. and C.T.D. readings were taken at these locations.
    - alosids (ranging in number from 5 to 50) were found in 7 of these seines.
2. Large numbers of fish were seen jumping in the Bridgetown area around dusk. Attempts were made to determine the extent of the area occupied by these fish.

Sept. 7, 1993

Seining in the upper river.

1. It was decided to attempt to mark as many alosids as possible by fin clipping.
2. 3 seines were conducted at dusk in the area behind Bridgetown where the fish were seen jumping the previous trip.
    - C.T.D. readings and D.O. samples were taken at this location.
    - a seine at 1730h contained 5 alosids, a seine at 1815h was empty, and a seine at 1915h contained 167 alosids and many silversides and white perch. Four alosids died in the net, 23 were saved for identification and the other alosids were fin clipped and held in a bucket for 20 - 30 minutes to see if the handling caused any immediate mortality. None was observed. The other fish in the net were not counted as the fish were beginning to look stressed from the length of time they were in the net.
    - all alosids caught and released on this trip had the left pectoral fin clipped.
3. Thousands of fish were observed jumping at dusk in the area behind Bridgetown.
4. It was concluded that due to the steep and slippery banks in this area, and the amount of jumping in and out of the boats that is required by this seining method, that seining operations could not be conducted safely in the dark even with lights.

Sept. 8, 1993

Seining in the upper river.

1. Continued with a methodology similar to Sept. 7,1993, with a total of 9 seines conducted.
2. 317 alosids were released after having the left pectoral fin clipped on this trip with the best seining success occurring at dusk.
3. 4 C.T.D. readings and 5 D.O. samples were taken on this day.

Sept. 10, 1993

Seining in the upper river.

1. Began seining operations shortly after dawn in the area behind Bridgetown.
2. 37 alosids caught in 1 of 2 seines (all had the left pectoral clipped).
3. Due to the low fishing success and lack of jumping activity it was hypothesized that the fish had moved downstream.
4. 10 seines were conducted between Bridgetown and Hebbs Landing.
   - 462 alosids were released following clipping of the left pectoral fin.
5. 6 C.T.D. readings and 6 D.O. samples were taken on this day.

Sept. 12, 1993

Seining in lower river.

1. Seining operations continued with 18 seines conducted in the lower part of the river.
2. A total of 237 alosids were caught in 5 of these seines, with 130 caught in one seine. 21 of these were saved for identification purposes and the remainder had the right pectoral fin clipped and were released.
3. 11 C.T.D. readings and 7 D.O. samples were taken on this day.

Sept. 14, 1993

Seining along the whole river below Bridgetown.

1. 2 seines were conducted behind Bridgetown in the early morning.
   - One seine was empty and the other contained 2 alosids (both were clipped on the right pectoral fin and released).

- No jumping activity was observed in the area at this time.

2. 4 seines were then conducted in the area east of Hebbs Landing which had produced good catches on Sept. 10.
   - 53 alosids were caught in these seines (all were right pectoral clipped and released).
3. 19 seines were conducted in the lower river with the majority of the effort placed on fishing the upper headpond.
   - 43 alosids were caught in these seines (all were right pectoral clipped and released).
4. 9 C.T.D. readings and 3 D.O. samples were taken on this day.
5. Efforts to test the fish finder in deeper water were made on this day. An area was scanned with the fish finder, and if fish were located by the fish finder, the area was seined. This technique of locating and catching fish proved unsuccessful.

Sept. 16, 1993

Seining in the lower river.

1. Only 4 seines were conducted on this day due to an outboard motor failure.
   - 4 alosids were captured, right pectoral clipped and released.
2. 3 C.T.D. readings and 2 D.O. samples were taken.

Sept. 20, 1993

Seining in the upper headpond.

1. 7 seines were conducted in the late afternoon and evening in the upper headpond.
   - no alosids were found.
2. 3 C.T.D. readings and 1 D.O. reading were taken.
3. Efforts were made to locate fish in the area of the causeway using the fish finder. No signal was detected that could conclusively be interpreted as a school of small fish.

Sept. 24 - 25, 1993

This was our first day at the causeway. The intention this day was to set a 1m diameter net in each of the two fishways for two tidal cycles (one during the day and one at night).

1. The nets were set at 0910h and at 0950h in the new and old fishways respectively.
2. At 1140h the net in the old fishway tore apart.
3. The net in the new fishway remained intact and was removed from the water at 1705h.
    - the net contained 1 pipefish and one Atlantic silverside.
4. the net was reset in the new fishway at 2150h, left in place for the tidal cycle, and pulled out at 0600h Sept. 25, 1993.
    - the net contained a large number of fish, many of them dead or in poor condition, which were saved for identification and enumeration in the laboratory.
5. C.T.D. and current meter readings, and water depth measurements were taken in the new fishway each hour on the hour while the nets were in fishing.
6. Local fishermen commented that a large number of fish had moved downstream past the causeway the previous Saturday (Sept. 18).

Sept. 29, 1993

The question arose during the last trip as to the times during the tidal cycle that the fish use the fishway. Therefore a new net was built that was small enough (0.3m diameter) that it could be hauled from the fishway during the ebb tide. This net was fished for 1/2 hour intervals alternating between the new and old fishways. One ebb tide (afternoon and early evening) was sampled on this trip.

1. The net was fished 5 times in the new fishway and 3 times in the old fishway.
    - no fish were caught in any of these sets although some fish activity was observed in the new fishway around dusk.
2. C.T.D. and current meter readings, and water depth measurements were recorded on the hour in the new fishway while the nets were fishing.

Oct. 5, 1993

While in hindsight it seems apparent that the net was not fishing effectively, at the time this had not been ascertained so we decided to repeat operations similar to those of Sept. 29, with the exception that we would fish an early morning ebb tide and additionally we would set SAC1 in the tailrace below the turbine to determine whether fish were moving downstream past the turbine on this tide.

1. The small net was fished 2 times in each fishway without catching any fish.
2. The tailrace net was fished from the start to the finish of generation and caught one alosid and one 3-spined stickleback.
3. C.T.D. and current meter readings, and water depth measurements were taken each hour on the hour during this ebb tide.

Oct. 7 - 8,1993

We decided to return to the method of fishing larger nets over the full ebb tide. We built a new net (SAC2) similar to SAC1 and also a 0.5m diameter net (SACjr) of similar design that we would fish in the tailrace. We chose to fish the nighttime ebb tide. We also found that the temperature and salinity were not changing during the tidal cycle and therefore began recording these parameters only once on each trip.

1. SAC1 was set in the new fishway as the water changed direction in the fishways.
2. SAC2 was set in the old fishway immediately afterwards.
3. SACjr was set in the tailrace at the start of generation.
4. SACjr was removed from the tailrace at the end of generation. It contained one Atlantic herring and one 3- spined stickleback.
5. SAC2 was pulled from the old fishway shortly before the water flow reversed direction. It contained 3 American eels and 5 crabs.
6. SAC1 was pulled from the new fishway as the water flow reversed direction. This net contained some alosids, and numerous other fish and the catch was saved for enumeration in the laboratory.

Oct. 9 - 10, 1993

We continued monitoring fish passage at the causeway by setting the nets in a manner similar to Oct. 7. One nighttime ebb tide was monitored.

1. SAC2 was set in the old fishway shortly after the tide began to ebb.
2. SAC1 was set in the new fishway immediately afterwards.
3. SACjr was set in the tailrace shortly before the start of generation.
4. SACjr was removed from the tailrace as generation stopped and contained 3 Atlantic herring, 1 blueback herring, and one Atlantic silverside.

5. SAC2 was removed from the old fishway and contained 17 Pipefish, 1 Striped bass (<12 cm total length), 1 smooth flounder and one crab.
6. SAC1 was pulled from the new fishway as the tide turned and contained numerous Atlantic herring and other fish. The catch was saved to be enumerated in the laboratory.

Oct. 11 - 12,1993

The intent on this trip was to continue in a manner similar to the previous two trips however SAC1 was found to be too badly torn to be used on this occasion so we decided to fish the tailrace and the new fishway only as catches in the old fishway had been poor at best. One nighttime ebb tide was monitored.

1. SAC2 was set in the new fishway shortly after the water flow reversed and began to flow down the fishway.
2. SACjr was set in the tailrace just prior to the start of generation.
3. SACjr was pulled from the tailrace at the end of generation and contained 3 Atlantic herring, 1 American eel, 7 Atlantic silversides, and 1 crab.
4. SAC2 was removed from the new fishway as the water began to flow up the fishway. It contained numerous fish, including 3 alosids, all of which were saved for enumeration in the laboratory.

Oct. 13 - 14, 1993

We continued monitoring fish passage at the causeway during nighttime ebb tides (again one tide on this trip). We decided to fish SAC2 and SACjr in the tailrace close together to attempt to determine whether they fished with the same efficiency. SAC1 was repaired prior to this trip and fished in the new fishway.

1. SAC1 was set in the new fishway as the water flow reversed direction and began to flow down the fishway.
2. SAC2 and SACjr were set in the tailrace 10m apart just prior to the onset of generation.
3. SAC2 and SACjr were removed from the tailrace at the end of generation. SAC2 contained 75 alosids plus numerous other fish and SACjr contained alosids and a few other fish.
4. SAC1 was pulled from the new fishway as the flow in the fishway reversed. It contained 6 alosids plus a number of other fish.

Oct. 15 - 17,1993

Oct. 15 was the new moon and was coupled with high tides so we decided that over the next few days we would monitor all ebb tides in the hope that these conditions would be conducive to an alosid migration. The procedure over these days was modified to test for different phenomena.

1. The first net set occurred late afternoon on Oct. 15. SAC2 was set in the old fishway and was left in position for the full ebb tide. SAC1 was set in the tailrace and was left in position for the full generation period. SACjr was fished in the new fishway and was retrieved and reset 2 times during this set. In total SACjr caught 6 Atlantic herring and one mummichog in the new fishway, SAC2 caught 1 alewife, 1 American eel, 1 Atlantic herring and 2 Atlantic silversides in the old fishway, and SAC1 caught 16 American shad and 1 Atlantic herring in the tailrace.
2. The next net set occurred during the early morning of Oct. 16. This time SAC2 was set on the boom below the old fishway to attempt to determine if more fish were using this fishway than our work was suggesting. The net was placed in position as the water flow turned to flow downstream in the fishway and was pulled as the flow turned back upstream. The net caught one three-spined stickleback. SAC1 was fished in the tailrace for the course of the generation period and caught numerous fish including 11 alosids. All these fish were saved. SACjr was fished in the new fishway for the most of the l ebb tide and caught 7 Atlantic herring, 2 Atlantic silversides, 3 sticklebacks and 2 tomcod.
3. The nets were reset mid afternoon on Oct. 16. SAC1 was set in the new fishway, SAC2 was set in the tailrace, and SACjr was set in the old fishway. SACjr did not catch any fish however the catches in both the new fishway and the tailrace were substantial and were saved for enumeration in the laboratory. The catch from the new fishway contained 7 alosids and the catch from the tailrace 10 alosids.
4. The nets were again set in the early morning of Oct. 17. The nets were positioned in the same locations as the previous set and again fished for the full time period (the full ebb tide in the fishways and the full generation period in the tailrace). The catch from the old fishway consisted of 2 Atlantic silversides and 1 three-spined stickleback. The catches from the new fishway and the tailrace were both larger and were saved to be examined later. The net in the new fishway caught 2 alosids on this set and the net in the tailrace caught 8.
5. During the final net set of this trip we decided to attempt to determine if our

number of other fish. The tailrace catch contained 9 alosids, numerous Atlantic herring, and several other fish. Both the tailrace and the new fishway catches were saved for examination in the laboratory.

Oct. 25-26,1993

This was our final trip to the causeway in our effort to monitor the juvenile alosid migration at Annapolis. On this trip we monitored one late night ebb tide,in a manner similar to the other trips with the exception that we pulled the nets in the tailraceand the new fishway hourly to attempt again to measure at which times relative to generation fishuse the fishway or go through the turbine. All fish caught on this trip were released.

1. SACjr was fished in the new fishway over the ebb tide and retrieved 8 times over this tide. The total catch was relatively large but only 1 alosid (a 1 year old? alewife) was caught.
2. SAC1 was fished in the tailrace for the generation period. It was emptied 6 times during which it too caught a number of fish but only 2 alosids.

3 SAC2 was fished in the old fishway and was left in place for the full ebb tide. Its catch consisted of over 500 Atlantic silversides as well as a few other fish.

Table 1.1 Location, time and catch of all seine collections. A location is given by its U.T.M. coordinates.

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Aug. 31	1655	3-15-584E 20 49-65-738N	small seine pulled by hand	no alosids; 2 Atl. silversides
Aug. 31	1700	3-15-735E 20 49-66-444N	small seine pulled by hand	12 alosids (4 saved for identification were all Am. shad); numerous Atl. silversides and mummichogs
Aug. 31	1757	3-17-916E 20 49-67-643N	small seine pulled by hand	no alosids; numerous mummichogs, silversides, sticklebacks, common suckers
Aug. 31	1945	3-08-207E 20 49-60-713N	small seine pulled by hand	no alosids; numerous silversides and sticklebacks
Aug. 31	2030	3-05-847E 20 49-60-503N	small seine pulled by hand	no alosids; app. 10 Am. eels, numerous silversides and stickle-backs, 1 rainbow smelt
Sept. 2	1405	3-13-461E 20 49-64-840N	large seine pulled by 2 boats	no alosids; app. 30 silversides and 1 smooth flounder
Sept. 2	1440	3-13-744E 20 49-64-729N	large seine pulled by 2 boats	15 alosids (6 saved for identification included 4 alewives and 2 blueback herring); hundreds of silversides and 1 mummichog
Sept. 2	1523	3-14-263E 20 49-65-082N	large seine pulled by 2 boats	no alosids; app. 200 silversides
Sept. 2	1558	3-14-263E 20 49-65-082N	large seine pulled by 2 boats	no alosids; app. 150 silversides and 3 sticklebacks
Sept. 2	1645	3-14-555E 20 49-66-009N	large seine pulled by 2 boats	5 alosids; 20 silversides

Table 1.1 (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Sept. 2	1721	3-15-603E 20 49-65-700N	large seine pulled up an inlet by one person on each side of the inlet	20 alosids (a sample of 7 saved for identification contained all Am. shad); app. 100 silversides and some sticklebacks
Sept. 2	1746	3-15-711E 20 49-66-367N	as above	40 alosids (a sample of 6 saved for identification contained 4 Am. shad and 2 alewives); 1000+ silversides, sticklebacks and mummichogs present
Sept. 2	1835	3-16-522E 20 49-66-647N	small seine pulled parallel to shore by boat and one person on shore	50 alosids (a sample of 6 saved for identification contained 3 blueback herring and 3 Am. shad); app. 50 silversides, sticklebacks and mummichogs
Sept. 2	1915	3-16-990E 20 49-66-696N	large seine fished as above	20 alosids; app. 10 silversides
Sept. 2	1957	3-19-269E 20 49-66-894N	large seine pulled by 2 boats	47 alosids; (a sample of 10 saved for identification contained all Am. shad); no other fish
Sept. 7	1730	3-19-220E 20 49-6-916N (south bank)	large seine pulled by 2 boats	5 alosids (fin clipped and released); no other fish
Sept. 7	1815	3-19-220E 20 49-6-916N (north bank)	large seine pulled by 2 boats	no alosids; app. 5 silversides and 3 sticklebacks

Table 1.1 (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Sept. 7	1840	3-19-220E 20 49-66-916N (south bank)	large seine pulled by 2 boats	167 alosids (4 died in the net, 23 were saved for identification, and 140 were fin clipped and released. The sample contained 2 alewives, 5 blueback herring and 16 Am. shad.); numerous white perch, Am. eels, silversides, mummichogs and sticklebacks)
Sept. 8	1530	3-19-220E 20 49-66-916N (south bank)	large seine pulled by 2 boats	4 alosids (fin clipped and released); no other fish
Sept. 8	1545	3-19-075E 20 49-66-899N	large seine pulled by 2 boats	79 alosids (fin clipped and released); 1 stickleback, 1 eel and one silverside
Sept. 8	1610	3-19-539E 20 49-66-989N	large seine pulled by 2 boats	no fish
Sept. 8	1710	3-18-377E 20 49-67-818N	large seine pulled by 2 boats	24 alosids (fin clipped and released); 2 sticklebacks, 1 pipefish and app. 6 silversides
Sept. 8	1740	3-19-782E 20 49-67-442N	large seine pulled by 2 boats	7 alosids (fin clipped and released); no other fish
Sept. 8	1810	3-19-914E 20 49-67-095N	large seine pulled by 2 boats	14 alosids (fin clipped and released); no other fish
Sept. 8	1840	3-19-220E 20 49-66-916N (south bank)	large seine pulled by 2 boats	11 alosids (fin clipped and released); a few silversides
Sept. 8	1933	3-19-215E 20 49-67-950N	large seine pulled by 2 boats	80 alosids (fin clipped and released); numerous silversides and sticklebacks

Table 1.1 (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Sept. 8	2000	3-19-220E 20 49-66-916N	large seine pulled by 2 boats	98 alosids (fin clipped and released); no other fish recorded
Sept. 10	0710	3-19-220E 20 49-66-916N	large seine pulled by 2 boats	37 alosids (fin clipped and released); 39 silversides
Sept. 10	0725	3-19-220E 20 49-66-916N	large seine pulled by 2 boats	no fish
Sept. 10	0740	3-17-658E 20 49-67-431N	large seine pulled parallel to shore by 1 person on shore and by 1 boat	1 alosid (fin clipped and released); 1 stickleback and 1 silverside
Sept. 10	0755	3-17-286E 20 49-66-572N	large seine pulled by 2 boats	no fish
Sept. 10	0815	3-16-885E 20 49-66-628N	large seine pulled by 2 boats up the mouth of a tributary	no alosids; 1 Am. eel
Sept. 10	0827	3-16-885E 20 49-66-628N	large seine pulled further up tributary by 1 person on shore and one boat	no fish
Sept. 10	1030	3-13-692E 20 49-64-783N	large seine pulled by 2 boats	20 alosids (a sample of 4 saved for identification were all Am. shad; the other 16 were fin clipped and released); no other fish
Sept. 10	1100	3-14-138E 20 49-65-146N	large seine pulled by 2 boats	no alosids; 3 silversides

Table 1.1 (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Sept. 10	1140	3-14-200E 20 49-65-921N	large seine pulled by 2 boats	191 alosids (a sample of 17 fish saved for identification contained 8 Am. shad, 7 blueback herring and 2 Atl. herring; the remainder were fin clipped and released); more than 500 silversides, numerous sticklebacks
Sept. 10	1217	3-14-380E 20 49-66-079N	large seine pulled by 2 boats	1 alosid (fin clipped and released); a few silversides, 1 pipefish and some sticklebacks
Sept. 10	1240	3-14-586E 20 49-65-791N	large seine pulled by 2 boats	no alosids; app. 30 silversides
Sept. 10	1300	3-14-250E 20 49-65-902N	large seine pulled by 2 boats	194 alosids (a sample of 8 fish saved for identification were all blueback herring; one fish had been previously clipped; the remaining 185 alosids were fin clipped and released); more than 300 silversides, some mummichogs
Sept. 10	1320	3-14-345E 20 49-65-890N	large seine pulled by 2 boats	65 alosids (5 had been previously clipped; the remaining 60 were fin clipped and released); more than 200 silversides
Sept. 12	1130	3-14-200E 20 49-65-921N	large seine pulled by 2 boats	20 alosids (fin clipped and released); app. 300 silversides
Sept. 12	1148	3-14-154E 20 49-65-901N	large seine pulled by 2 boats	no alosids; app. 75 silversides and 1 smooth flounder
Sept. 12	1200	3-14-109E 20 49-65-533	large seine pulled by 2 boats	no alosids; 4 silversides and 6 6 sticklebacks

Table 1.1 (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Sept. 12	1215	3-14-075E 20 49-65-006N	large seine pulled by 2 boats	no alosids; app. 100 silversides and 2 sticklebacks
Sept. 12	1230	3-14-278E 20 49-65-125N	large seine pulled by 2 boats	5 alosids (fin clipped and released); 3 mummichogs
Sept. 12	1428	3-12-893E 20 49-63-842N	large seine pulled by 2 boats	68 alosids (a sample of 10 saved for identification contained 7 Am. shad, and 4 blueback herring; 58 alosids were fin clipped and released); app. 50 rainbow smelt, 100 silver-sides and 3 sticklebacks
Sept. 12	1435	3-12-956E 20 49-63-830N	large seine pulled by 2 boats	no alosids; app. 50 silversides and 3 sticklebacks
Sept. 12	1450	3-12-800E 20 49-63-859N	large seine pulled by 2 boats	no alosids; app. 75 silversides
Sept. 12	1512	3-12-092E 20 49-64-276N	large seine pulled by 2 boats	1 alosid (fin clipped and released); app. 50 silversides and one smooth flounder
Sept. 12	1526	3-11-437E 20 49-64-177N	large seine pulled by 2 boats	no alosids; app. 10 silversides
Sept. 12	1545	3-11-327E 20 49-63-511N	large seine pulled by 2 boats	16 alosids (fin clipped and released); over 1000 silversides
Sept. 12	1610	3-11-307E 20 49-63-000N	large seine pulled by 2 boats	130 alosids (2 had been previously clipped, a sample of 11 saved for identification contained 4 Am. shad, 5 blueback herring, and 2 Atl. herring; the remainder were fin clipped and released); no other fish

Table 1.1 (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Sept. 12	1625	3-11-500E 20 49-63-010N	large seine pulled by 2 boats	no alosids; 12 silversides
Sept. 12	1642	3-11-376E 20 49-62-998N	large seine pulled by 2 boats	no alosids; app. 100 silversides and 2 mummichogs
Sept. 12	1715	3-10-714E 20 49-61-402N	large seine pulled by 2 boats	1 alosid (fin clipped and released); app. 75 silversides
Sept. 12	1743	3-10-613E 20 49-61-719N	large seine pulled by 2 boats	no alosids; app. 100 silversides and 2 smooth flounder
Sept. 12	1800	3-09-316E 20 49-61-169N	large seine pulled by 2 boats	no alosids; app. 100 silversides and 1 rainbow smelt
Sept. 12	1830	3-09-316E 20 49-61-169N	large seine pulled parallel to shore by one person on shore and one boat	no alosids; app. 100 silversides
Sept. 14	0800	3-19-269E 20 40-66-894N	large seine pulled by 2 boats	2 alosids (fin clipped and released); no other fish
Sept. 14	0830	3-14-200E 20 49-65-921N (south bank)	large seine pulled by 2 boats	3 alosids (fin clipped and released); app. 50 silversides, 10 mummichogs, 10 sticklebacks and 2 eels
Sept. 14	0850	3-14-200E 20 49-65-921N (north bank)	large seine pulled by 2 boats	no alosids; app. 400 silversides and 20 mummichogs
Sept. 14	0900	3-14-089E 20 49-65-946N	large seine pulled by 2 boats	19 alosids (fin clipped and released); app. 150 silversides, some eels, mummichogs and pipefish

Table 1.1 (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Sept. 14	0915	100 m west of previous seine	large seine pulled parallel to shore by one person on shore and one boat	33 alosids (one had been previously fin clipped; 32 were fin clipped and released); app. 200 silversides, some eels and mummichogs
Sept. 14	0940	3-14-732E 20 49-65-556N	large seine pulled by 2 boats	no alosids; 2 silversides and 1 stickleback
Sept. 14	1000	3-15-704E 20 49-66-407N	large seine pulled parallel to shore by one person on shore and one boat	no alosids; app. 200 silversides and a few mummichogs
Sept. 14	1030	3-13-461E 20 49-64-840N	as above	no alosids; app. 50 silversides
Sept. 14	1130	3-13-106E 20 49-64-275N	large seine pulled by 2 boats	no alosids; 1 stickleback
Sept. 14	1215	3-12-929E 20 49-63-825N	large seine pulled by 2 boats	no fish
Sept. 14	1232	3-12-622E 20 49-63-591N	large seine pulled by 2 boats	19 alosids (fin clipped and released); app. 700 silversides and 300 rainbow smelt
Sept. 14	1250	100 m east of previous seine	large seine pulled by 2 boats	no alosids; app. 300 silversides and 100 rainbow smelt
Sept. 14	1314	3-12-263E 20 49-64-069N	large seine pulled by 2 boats	2 alosids (fin clipped and released); app. 2000 silversides
Sept. 14	1320	3-11-218E 20 49-62-782N	large seine pulled by 2 boats	no alosids; 1 mummichog

Table 1.1 (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Sept. 14	1330	100 m west of previous seine	large seine pulled by 2 boats	no alosids; app. 75 silversides
Sept. 14	1345	3-11-040E 20 49-62-366N	large seine pulled by 2 boats	no alosids; app. 1000 silversides, 1 smooth flounder, and a few rainbow smelt
Sept. 14	1410	3-09-407E 20 49-61-388N	large seine pulled by 2 boats	17 alosids (fin clipped and released); app. 50 silversides
Sept. 14	1430	3-09-234E 20 49-61-189N	large seine pulled parallel to shore by one person on shore and one boat	no alosids; app. 200 silversides
Sept. 14	1445	as above	as above	no alosids; app. 50 silversides
Sept. 14	1508	3-09-254E 20 49-62-620N	large seine pulled by 2 boats	no alosids; app. 250 silversides and a few eels
Sept. 14	1520	50 m east of previous seine	large seine pulled parallel to shore by one person on shore and one boat	no alosids; 1 stickleback
Sept. 14	1535	3-08-003E 20 49-62-006N	large seine pulled by 2 boats	3 alosids; (fin clipped and released); app. 300 silversides
Sept. 14	1600	3-08-231E 20 49-60-671N	large seine pulled by 2 boats	no alosids; app. 750 silversides and a few smelt
Sept. 16	1625	3-11-234E 20 49-62-400N	large seine pulled by 2 boats	4 alosids (fin clipped and released); no other fish

Table 1.1 (con't).

DATE	TIME	LOCATION	SEINING METHOD	RESULTS
Sept. 16	1650	3-11-263E 20 49-62-333N	large seine pulled by 2 boats	no fish
Sept. 16	1702	3-09-403E 20 49-61-313N	large seine pulled by 2 boats	no fish
Sept. 16	1725	3-09-348E 20 49-61-164N	large seine pulled by 2 boats	no fish (outboard motor failure)
Sept. 20	1640	3-05-875E 20 49-60-551N	large seine pulled by 2 boats	no alosids; app. 75 silversides and 1 eel
Sept. 20	1700	3-06-016E 20 49-60-498N	large seine pulled by 2 boats	no alosids; app. 700 silversides
Sept. 20	1720	3-06-253E 20 49-60-596N	large seine pulled by 2 boats	no alosids; app. 700 silversides
Sept. 20	1900	3-05-875E 20 49-60-551N	large seine pulled by 2 boats	no alosids; app. 15 silversides
Sept. 20	1930	3-05-333E 20 49-59-318N	large seine pulled by 2 boats	no alosids; app. 50 silversides and 1 rainbow smelt
Sept. 20	1950	3-05-875E 20 49-60-551N	large seine pulled by 2 boats	no alosids; app. 750 silversides 1 skate and a few shrimp
Sept. 20	2010	3-05-875E 20 49-60-551N	large seine pulled by 2 boats	no alosids; app. 200 silversides and 10 rainbow smelt

Table 1.2. The time, location and catch of all nets set in the fishways and tailrace at the Annapolis causeway.

DATE	TIME in	TIME out	LOCATION	NET	ALOSIDS no. and species	OTHER FISH no. and species
Sept. 24	0910	1705	new fishway	SAC1	0	1 pipefish 1 Atl. silverside
Sept. 24	0950	-	old fishway	similar to SAC1	the net was distroyed by the water flow	
Sept. 24-25	2150	0600	new fishway	SAC1	0	5 butterfish 1 3-sp. stickleback 28 Atl. herring 251 Atl. silversides 1 longhorn sculpin 1 Am. eel 1 smooth flounder
Sept. 29	1350	1420	new fishway	sm. net	0	0
Sept. 29	1505	1535	old fishway	sm. net	0	0
Sept. 29	1605	1635	new fishway	sm. net	0	0
Sept. 29	1705	1735	old fishway	sm. net	0	0
Sept. 29	1805	1835	new fishway	sm. net	0	0
Sept. 29	1905	1935	old fishway	sm. net	0	0
Sept. 29	2005	2035	new fishway	sm. net	0	0
Sept. 29	2045	2115	new fishway	sm. net	0	0
Oct. 5	0447	0520	new fishway	sm. net	0	0
Oct. 5	0559	0630	old fishway	sm. net	0	0
Oct. 5	0650	0735	new fishway	sm. net	0	0
Oct. 5	0800	0840	old fishway	sm. net	0	0

Table 1.2 (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSIDS no. and species	OTHER FISH no. and species
Oct. 5	0525	0900	tailrace	SAC1	1 blueback herring	1 3-sp. stickleback
Oct. 7 - 8	1847	0200	new fishway	SAC1	14 Am. shad 3 alewives 4 blueback herring	1 Am. eel 1 pipefish 78 Atl. silversides 1 rainbow smelt 4 butterfish 6 3-sp. sticklebacks 1 tomcod 104 Atl. herring
Oct. 7 - 8	1925	0055	old fishway	SAC2	0	3 Am. eels
Oct. 7 - 8	2000	0030	tailrace	SACjr	0	1 Atl. herring 1 3-sp. stickleback
Oct. 9 - 10	2055	0415	old fishway	SAC2	0	17 pipefish 1 striped bass 1 smooth flounder
Oct. 9 - 10	2100	0440	new fishway	SAC1	0	15 Am. eels 2 smooth flounder 1 winter flounder 182 Atl. herring 1 lumpfish 4 pipefish 4 butterfish 16 3-sp. sticklebacks 38 Atl. silversides
Oct. 9 - 10	2045	0355	tailrace	SACjr	1 blueback herring	3 Atl. herring 1 Atl. silverside
Oct. 11 - 12	2245	0615	new fishway	SAC2	1 blueback herring 2 alewives	45 Atl. silversides 11 Am. eels 1 Am. sand lance 1 pipefish 3 tomcod 41 Atl. herring 3 3-sp. sticklebacks 2 butterfish

Table 1.2 (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSIDS no. and species	OTHER FISH no. and species
Oct. 11 - 12	2245	0555	tailrace	SACjr	0	3 Atl. herring 1 Am. eel 7 Atl. silversides
Oct. 14	0015	0745	tailrace	SACjr	2 Am. shad 3 blueback herring	2 Atl. silversides 6 Atl. herring
Oct. 14	0015	0745	tailrace	SAC2	34 blueback herring 38 Am. shad 3 alewives	4 smooth flounder 9 Atl. silversides 63 Atl. herring
Oct. 14	0045	0810	new fishway	SAC1	5 Am. shad 1 blueback herring	87 Atl. silversides 2 tomcod 110 Atl. herring 1 3-sp. stickleback 9 Am. eel 3 pipefish
Oct. 15	1435	2135	old fishway	SAC2	1 alewife	2 Atl. silversides 1 Atl. herring 1 Am. eel
Oct. 15	1507	2045	tailrace	SAC1	16 Am. shad	1 Atl. herring
Oct. 15	1413	1650	new fishway	SACjr	0	0
Oct. 15	1655	2112	new fishway	SACjr	0	6 Atl. herring 1 mummichog
Oct. 16	0320	0920	boom below old fishway	SAC2	0	1 3-sp. stickleback
Oct. 16	0325	0910	tailrace	SAC1	9 Am. shad 1 blueback herring 1 alewife	4 smooth flounder 1 winter flounder 2 pipefish 47 Atl. herring 1 3-sp. stickleback

Table 1.2 (con't).

DATE	TIME in	TIME out	LOCATION	NET	ALOSIDS no. and species	OTHER FISH no. and species
Oct. 22 - 23	2044	0305	tailrace	SAC2	2 alewives 6 Am. shad 1 blueback herring	2 winter flounder 90 Atl. herring 27 Atl. silversides 5 3-sp. sticklebacks
Oct. 22 - 23	2103	0349	old fishway	SACjr	0	27 Atl. silversides 1 sea lamprey 3 lumpfish 4 Atl. herring
Oct. 25 - 26	2333	0643	old fishway	SAC2	0	30+ sea lamprey 6 Atl. herring 500+ Atl. silversides 1 smooth flounder 1 Atl. wolffish
Oct. 25 - 26	0006	0031	tailrace	SAC1	0	0
Oct. 25 - 26	0031	0130	tailrace	SAC1	1 Am. shad	17 Atl. herring 21 Atl. silversides
Oct. 25 - 26	0131	0224	tailrace	SAC1	1 Am. shad	12 Atl. silversides 18 Atl. herring 4 3-sp. sticklebacks
Oct. 25 - 26	0224	0330	tailrace	SAC1	0	25 Atl. herring 3 Atl. silversides 1 3-sp. stickleback 1 pipefish 1 smooth flounder
Oct. 25 - 26	0330	0430	tailrace	SAC1	0	19 Atl. herring 4 smooth flounders 1 3-sp. stickleback 1 sea lamprey 1 Atl. silverside
Oct. 25 - 26	0430	0554	tailrace	SAC1	0	18 Atl. herring 2 Atl. silversides 1 3-sp. stickleback

Table 1.2 (con't).

DATE	TIME in	out	LOCATION	NET	ALOSIDS no. and species	OTHER FISH no. and species
Oct. 25 - 26	2315	0015	new fishway	SACjr	0	31 Atl. silversides 18 Atl. herring 1 sea lamprey 1 3-sp. stickleback
Oct. 25 - 26	0015	0115	new fishway	SACjr	0	51 Atl. silversides 1 sea lamprey 18 Atl. herring 2 3-sp. sticklebacks
Oct. 25 - 26	0115	0215	new fishway	SACjr	0	17 Atl. silversides 13 Atl. herring
Oct. 25 - 26	0215	0315	new fishway	SACjr	0 1 alewife	15 Atl. herring 12 Atl. silversides 1 smooth flounder 1 Am. eel
Oct. 25 - 26	0315	0415	new fishway	SACjr	0	12 Atl. herring 11 Atl. silversides
Oct. 25 - 26	0415	0515	new fishway	SACjr	0	18 Atl. herring 1 sea lamprey 1 Atl. silverside 1 3-sp. stickleback
Oct. 25 - 26	0515	0615	new fishway	SACjr	0	4 Atl. silversides 6 Atl. herring
Oct. 25 - 26	0615	0700	new fishway	SACjr	0	7 Atl. silversides 1 sea lamprey 1 smooth flounder

8.2 APPENDIX 2. Scientific names of species referred to in this report.

Appendix 2. 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*
tomcod	*Microgadus tomcod*
Atlantic silverside	*Menidia menidia*
3-spine stickleback	*Gasterosteus aculeatus*
pipefish	*Syngnathus fuscus*
white perch	*Morone americana*
striped bass	*Morone saxatilis*
cunner	*Tautogolabrus adspersus*
Atlantic wolffish	*Anarhichas lupus*
American sand lance	*Ammodytes americanus*
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.