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Investigations on the Ecology of the Bay of Fundy

PLANKTON AND SUSPENDED SEDIMENTS IN THE SOUTHERN BIGHT OF MINAS BASIN

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Project 16-01-005

October 1978

A series of projects on the enumeration and interactions of the flora, fauna, chemistry hydrology and geology of the Bay of Fundy with an emphasis on the Minas Basin and Scots Bay. The projects were conducted under the Summer Job Corps Program supported by the Department of Manpower and Immigration, the Atlantic Regional Laboratory of the National Research Council, the Biology and Chemistry Departments of Acadia University, Atlantic Geoscience Centre - Bedford Institute of Oceanography and the Biology Department of the University of New Brunswick.

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F. J. Simpson
Director, ARL/NRC

PLANKTON AND SUSPENDED SEDIMENTS
IN THE SOUTHERN BIGHT
OF MINAS BASIN

FINAL REPORT OF CANADA SUMMER
JOB CORPS PROGRAM,
PROJECT 16-01-005.

CATHY PENNACHETTI

Introduction

The Minas Basin is a unique estuarine region having tidal ranges in excess of 12 m (Bousfield 1961). Such extreme tides result in thorough vertical mixing and high turbidity of the water column, while dynamically static circulation restricts exchange of tidal water with the Bay of Fundy proper (Bousfield 1961). This region has attracted relatively little attention from biologists until the advent of increasing interest in estuarine research and proposed tidal power development. The Summer Job Corps Program contracts, granted to Acadia University, have provided the financial support and manpower necessary for detailed study of many important aspects of this region.

This report presents physical and biological data about the water column and mudflats of the southwestern portion of the Minas Basin. A large proportion of this area consists of highly productive salt marshes and mudflats, and it is suspected that conditions may therefore be quite different from those in other portions of the Basin (Daborn, pers. comm). Some relevant biological studies of the Minas Basin include Bousfield (1961), Bousfield and Leim (1960), Jermolajev (1952), and Peterson and Peterson (MS 1976). Various other researchers have concentrated on particular aspects of the study region. These include Honours and Masters students from Acadia University and researchers from the Atlantic Regional Laboratory, National Research Council, Halifax. Past Job Corps Programs (*eg*. Fuller and Trevors 1977) also contributed baseline information concerning the distribution and abundance of benthic organisms at various locations throughout the Basin. Basic information about plankton in the study region was accumulated by Daborn (1977), and

Pennachetti (1977). A substantial amount of geological and hydrographic data for the Minas Basin, the Cobequid Bay region in particular, has been compiled during recent years (various authors in Amos 1978). However, the extensive and localized study presented in this report provides more detailed information.

The dynamics of suspended organic and inorganic particulate matter in the water column, and their physical and biological inter-relations with the underlying Basin, have been examined in considerable detail. Temporal (tidal, seasonal) and spatial patterns of the distribution and abundance of flora, fauna and sediments are presented. Interpretation of these data should help to increase our (man's) understanding of the ecology of this region, particularly features of the local hydrographic relationships. Various food chains and the biology of some of the dominant organisms were examined in greater detail in an attempt to analyze the effects of environmental conditions on the local biota. It was felt that a detailed study of this region would show a much higher level of primary and secondary productivity than would be anticipated from previous information.

Acknowledgements

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Dr. J. Bleakney and Mr. A. Colodey advised me throughout the summer. Miss Carolyn Byrd and Dr. C.C. Davis provided identification and confirmation of phytoplankton species. Amphipod and Polychaete identifications were aided by G. Gratto, P. McCurdy and B. Parker. Dr. C. C. Davis and Dr. D. Steele helped with various other fauna. Dr. W. Threlfall was most helpful with parasitic Crustacea. I am indebted to C. Calder, A. Davis, D. Imrie, H. Leslie, R. Milton, P. Reid and K. Strong for their dedication during preparation of final figures and calculations. Thanks also to I. Barthwick, Dr. C.C. Davis and N. Williams for their editorial assistance. B. Coldwell is to be commended for her co-operation and work on the typescript.

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Physical and Chemical Studies - Introduction.

The Minas Basin has received considerable attention with regard to the dynamics of sediments in macrotidal systems (Amos 1977, and various authors in Amos and Long 1978). This interest has recently been stimulated by the potential plans for tidal power development (Daborn 1977, Amos 1978). Amos and Long (1978), summarized these wide ranging site- and topic-specific data and undertook a study to incorporate the various data into a whole. Most of the detailed information was collected in the North and Eastern portions of the Minas Basin (eg Cobequid Bay); however little physical and chemical data are available for the south-western bight (see Bousfield and Leim 1958, Pennachetti 1977, unpublished). The present research was intended to consider spatial, tidal and seasonal patterns of some aspects of the physical and chemical nature of the south-western Minas Basin and is essential to the understanding of the regional dynamics of the water column. It is also of prime importance when considering the biology of the area and the Minas Basin system as a whole.

1. CORNWALLIS RIVER STUDIES.

Objectives (a). To examine the longitudinal distribution of suspended sediments and longitudinal stratification near the mouth of the River.

(b). To investigate the longitudinal movement of suspended particulate matter.

Methods

(a) On May 9, 1978, 15 points between Port Williams sewage ponds and the mouth of the Cornwallis River were sampled within a 1 1/2 hour time period (see fig 16). On June 21, 1978, 39 points, extending as far upstream as New Minas (see fig 21), were sampled. All sampling occurred within 1 1/2 hours of slack high tide, and where possible samples were taken at the surface and 1 m depths through the water column using a 2.1 Kemmerer sampler. Temperature was measured at various sites along the river, and the salinity of water samples was determined with a Y S I S-C-T meter immediately upon return to the laboratory. Samples were stored in a constant temperature room at 10°C until analysis. Subsamples were filtered through .45 μ Millipore (May 9) or Nuclepore (June 21) filters. The filters were dried at 50°C for 24 hours and the total weight of suspended sediments was measured on a Cahn 4100 electrobalance. Differences were based on the mean weight of 15 clean filters. Where possible these dried samples were examined under a Cambridge Scanning electron microscope and analyzed for particle size, composition, origin and angularity. Representative photographs were also taken.

Within 48 hours of collection 2-ml subsamples were analyzed for total particle count and size distribution using a Coulter Counter Model TA II equipped with a 280 μ aperture tube. Dilutions depended on individual samples, and the Electrolyte consisted of filtered seawater from Kingsport (0.45 μ Millipore filter). Background counts were deleted from final total counts, but size distribution graphs were left uncorrected.

(b). Two sample sites including Port Williams Bridge and the Mouth of the Cornwallis River were simultaneously visited for a 12 hour period on July 6, 1978 (see Figs 3 and 26). Surface water samples were taken at 1/2 hour intervals and analyzed for suspended particulate matter. Additional samples were collected at intervals throughout the day at the Port Williams site for BOD analysis. Where possible temperature and salinity were measured immediately upon collection using a Y S I S-C-T meter. Otherwise samples were cold-stored overnight and salinity measurements taken within 24 hours.

Suspended particulate matter samples were analyzed within 48 hours (see section (a)). B.O.D. samples were cold-stored and treated by personnel from the Environmental Protection Service.

Results and Discussion

(a). Results from 9 May samples are shown in figures 14(a-o) and 16-20. Figure 16 gives the salinity values at surface and 1 m depths at each of the 15 sample stations. Fig. 17 shows total suspended particle counts (per 2 ml. subsample) at the respective stations, and Fig. 18 is a graph illustrating the change in total mean particle count as a function of distance from the mouth of the river. Fig. 19 illustrates size distribution of suspended sediments from surface-waters at each station along the river. Fig. 20 shows scanning electron micrographs of the filtered surface-water sub-samples. The full size electron micrographs for both surface and 1 m depths are also presented in Figure 14 (see photograph album 1).

It should be noted that sites 2-15 were visited within 1 hour, while site 1 was visited afterwards. This time lapse introduces some error in the interpretation of results, since total particle counts and size distribution of suspended material are affected by tide time (see Tide-Depth studies and Cornwallis River Study (a)). This kind of error was unavoidable in view of manpower and equipment availability but was minimized by sampling as close to high-tide time as possible. Also, since tidal movements upstream lag somewhat behind those of the Basin proper (pers. obs.) visiting the stations in an upstream direction helped to restrict this error.

Although a "turbidity maximum" was not reached the results indicated that the river became progressively more turbid upstream (e.g. $\overline{X}_1 = 1.8 \times 10^5$ while $\overline{X}_{15} = 3.5 \times 10^5$ see Fig 18). The former count was notably lower since it was visited at high tide proper, however the basic trend was very clear. Some inconsistencies were noted but they were probably related to the topography of the river bed and to particular wind and wave conditions at the various stations. Thus the differences at stations 10 and 11 ($\overline{X}_{10} = 298,625$, $\overline{X}_{11} = 355,610$) may depend partly on calm vs. rough conditions that were noted in these respective sites.

Station 3 showed a region of extreme turbulence and mixing (pers. obs., see Cornwallis River Study (b)). It overlies the main River channel at the point where the latter swings around the saltmarsh and into the Basin proper (see Fig. 3). Fresher water from the river moved downstream just north of this region while tidal water moved in along the South Shore. Such flow patterns were observed along respective banks during flood tide. The slightly higher salinity values at the south shore stations (see Fig 16) and the occurrence of "tide lines" at the approximate boundaries of these somewhat distinct water bodies (see Fig 54) seemed to substantiate this view.

Vertical differences were also apparent. In most cases the 1 m depth shows higher concentrations of suspended particulate matter. This may be associated with the tendency for suspended material to settle out around slack tide (Amos 1978). Exceptions to this occurred at stations 12 and may be attributed to peculiar local hydrographic conditions.

Size distribution analysis of suspended material illustrates the increased predominance of smaller sized particles as one moves from station 15 to station 1 (see figs 19 and 20). In fig 19 this is apparent by the shift in peak population values from a relatively even spread in the 4-10 μ diam. range (upriver) to an increased 4-5 μ peak (downriver). These lower size range peaks are somewhat affected by electrolyte contributions, but since all samples were equally treated the basic trend is still apparent. Such changes are visually apparent by examining scanning electron micrographs in figs 14 and 20 (eg note 3 vs. 13, both of which are 500X magnifications). Size distribution trends such as these are probably ultimately associated with fresh water run-off and current speeds, but vary locally with particular hydrographic conditions.

Figure 16. Salinity[1] at 15 sample stations (surface of 1 m depths) for 9 May Cornwallis River Study.

[1] All Salinity values in $^{o}/oo$. This is true for all subsequent data.

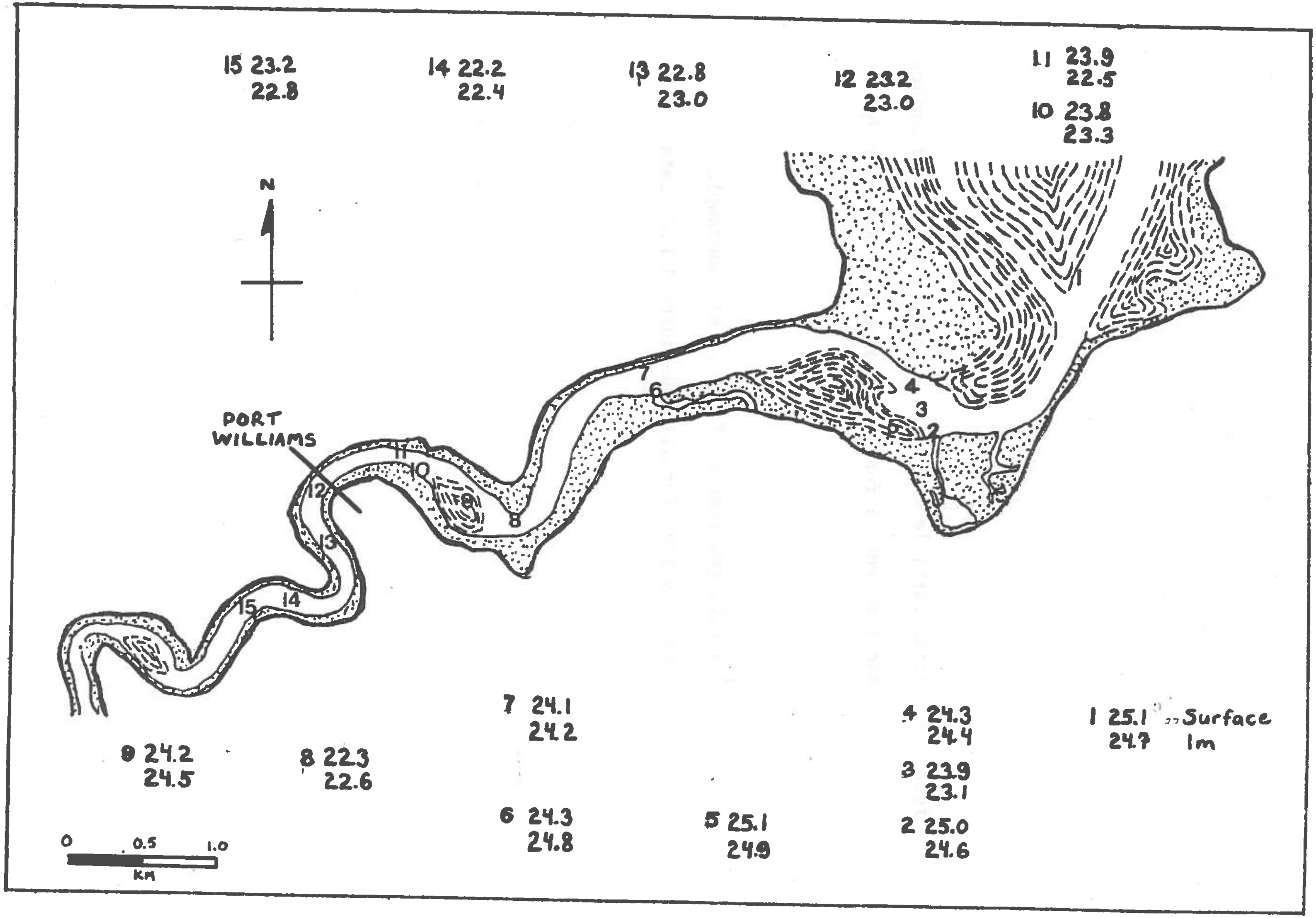

15 23.2
22.8
14 22.2
22.4
13 22.8
23.0
12 23.2
23.0
11 23.9
22.5
10 23.8
23.3
N
PORT
WILLIAMS
7 24.1
24.2
4 24.3
24.4
1 25.1 Surface
24.7 1m
9 24.2
24.5
8 22.3
22.6
3 23.9
23.1
6 24.3
24.8
5 25.1
24.9
2 25.0
24.6
0 0.5 1.0
KM

Figure 16

Figure 17. Total particle count[1] at 15 sample stations (surface and 1 m depths) for 9 May Cornwallis River Study.

[1] T.P.C. recorded as T.P.C./2 ml. subsample. This is true for all subsequent T.P.C. data.

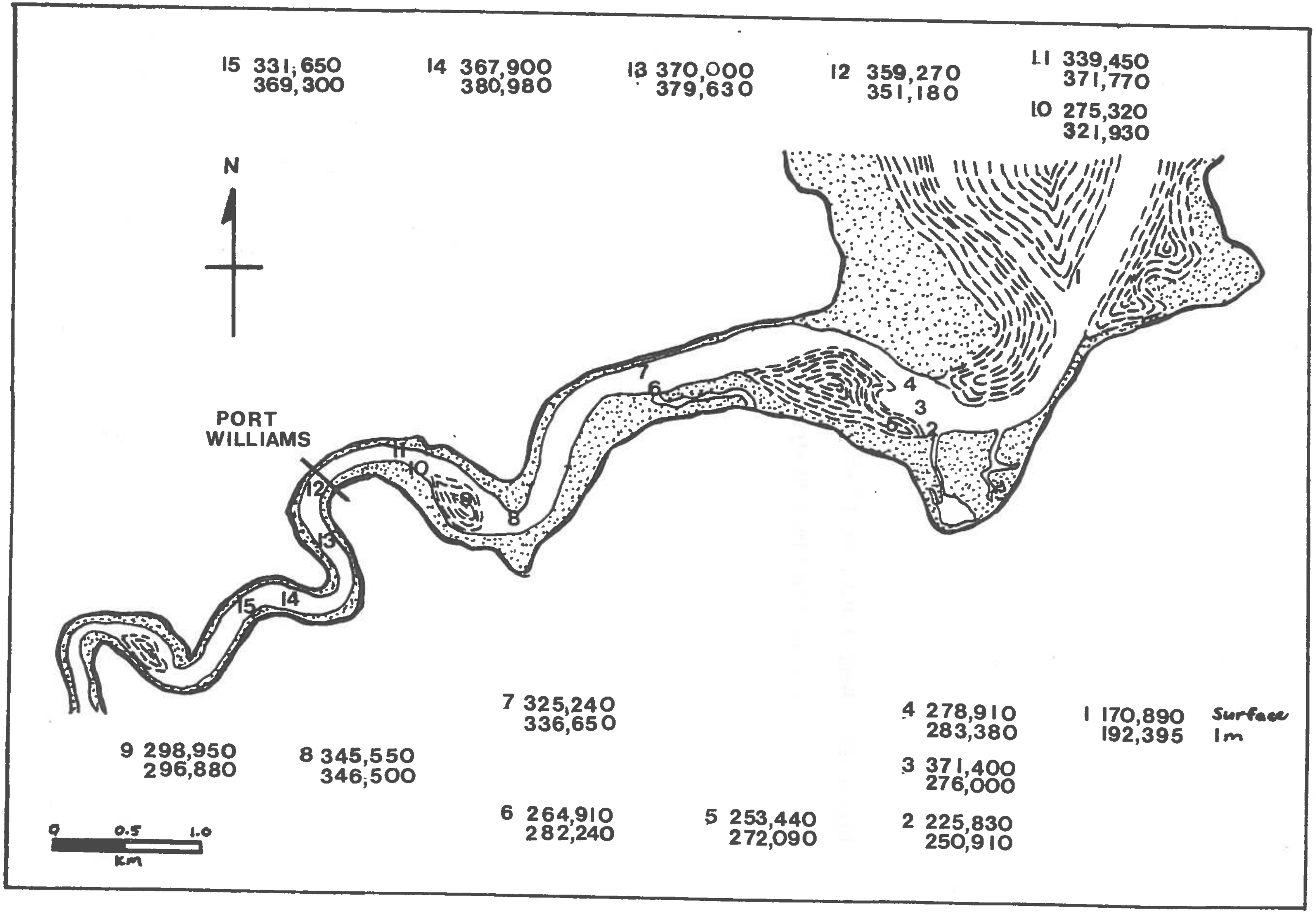

15 331,650 369,300
14 367,900 380,980
13 370,000 379,630
12 359,270 351,180
11 339,450 371,770
10 275,320 321,930
N
PORT WILLIAMS
7 325,240 336,650
4 278,910 283,380
1 170,890 192,395
Surface
1m
9 298,950 296,880
8 345,550 346,500
3 371,400 276,000
6 264,910 282,240
5 253,440 272,090
2 225,830 250,910
0 0.5 1.0
KM

Figure 17

Figure 18. Mean T.P.C. at 15 stations visited on 9 May, Cornwallis River Study.

Figure 18

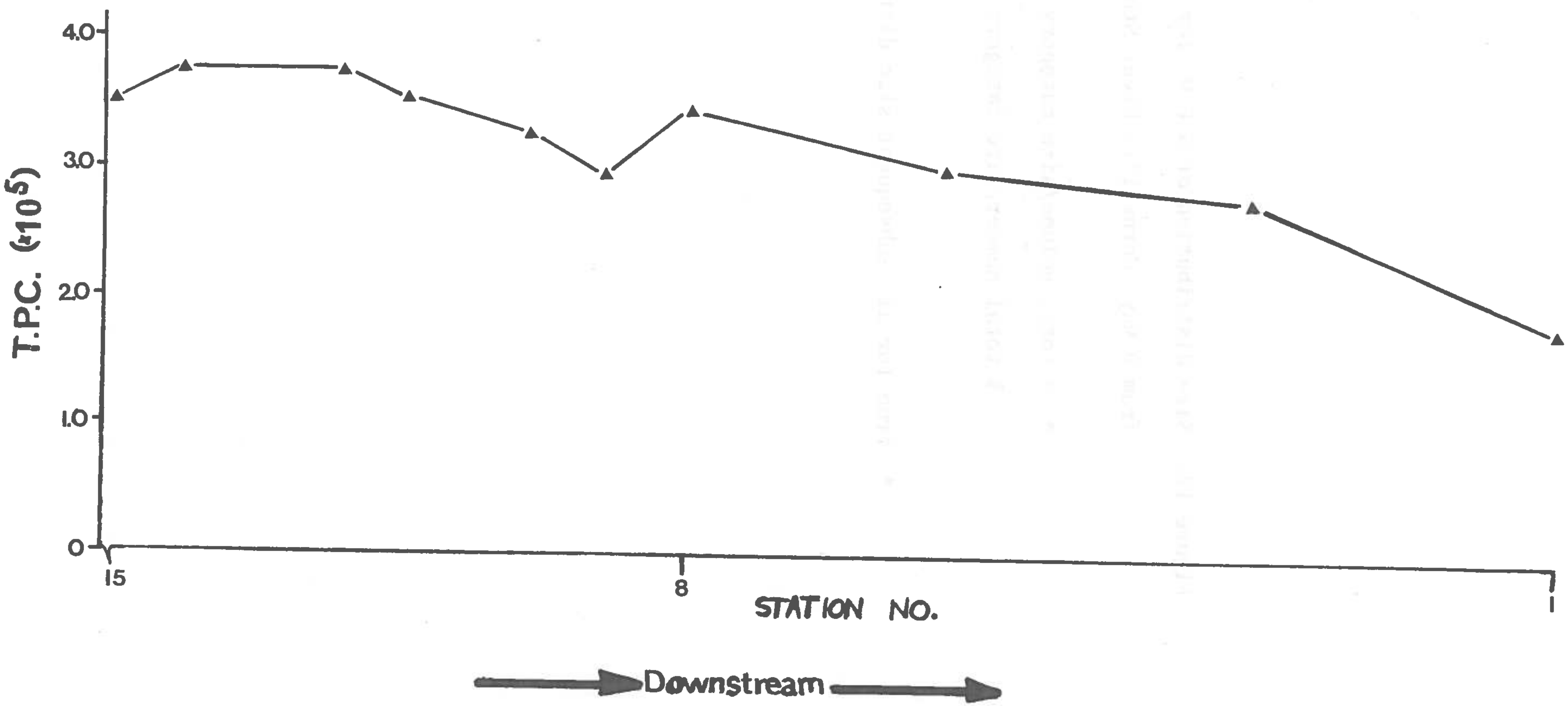


Figure 19. Size distribution of S.P.M. for 15 surface water samples from 9 May, Cornwallis River Study.

* % total volume/size category

* % total number/size category

* true for all subsequent size distribution data presented.

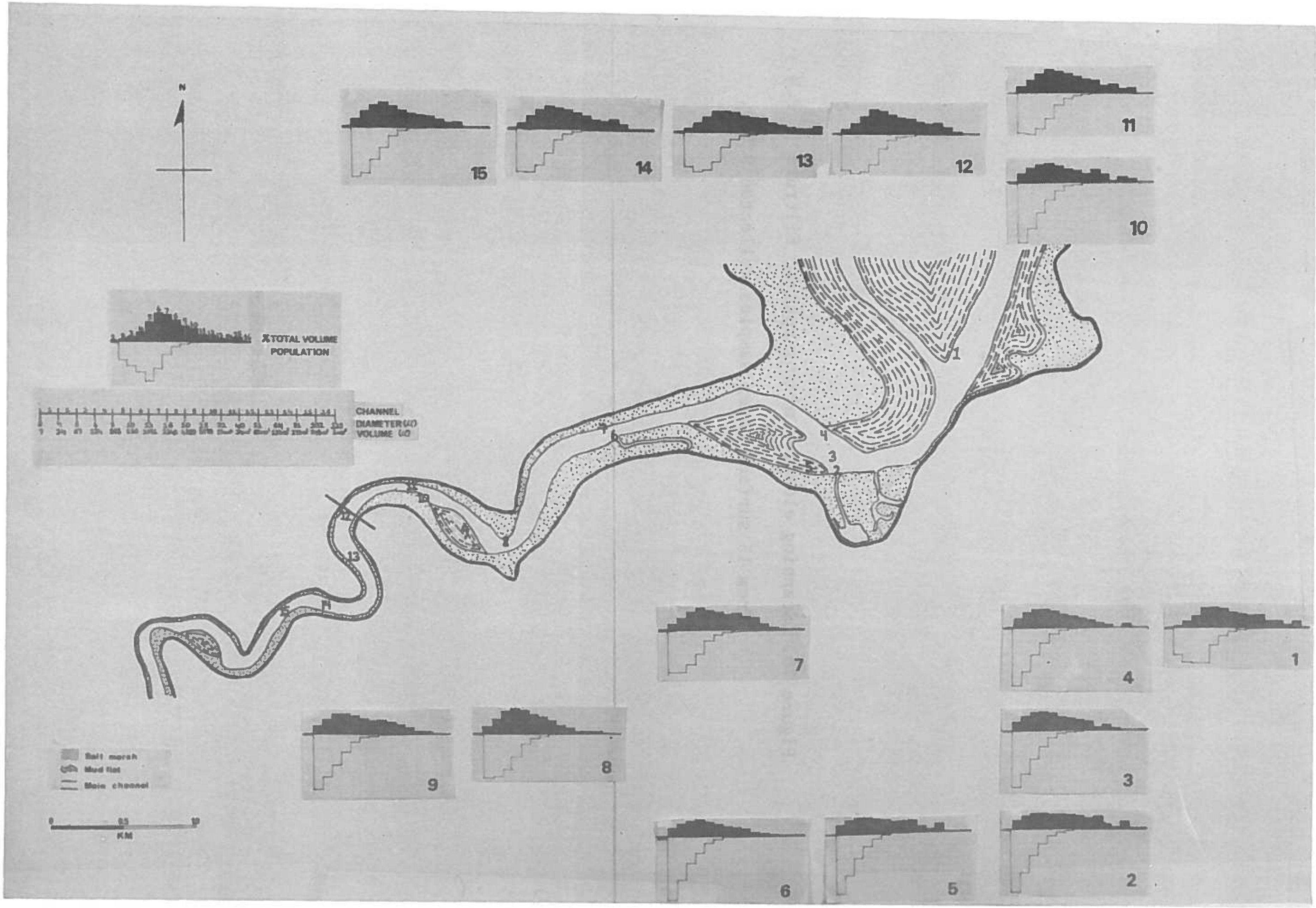
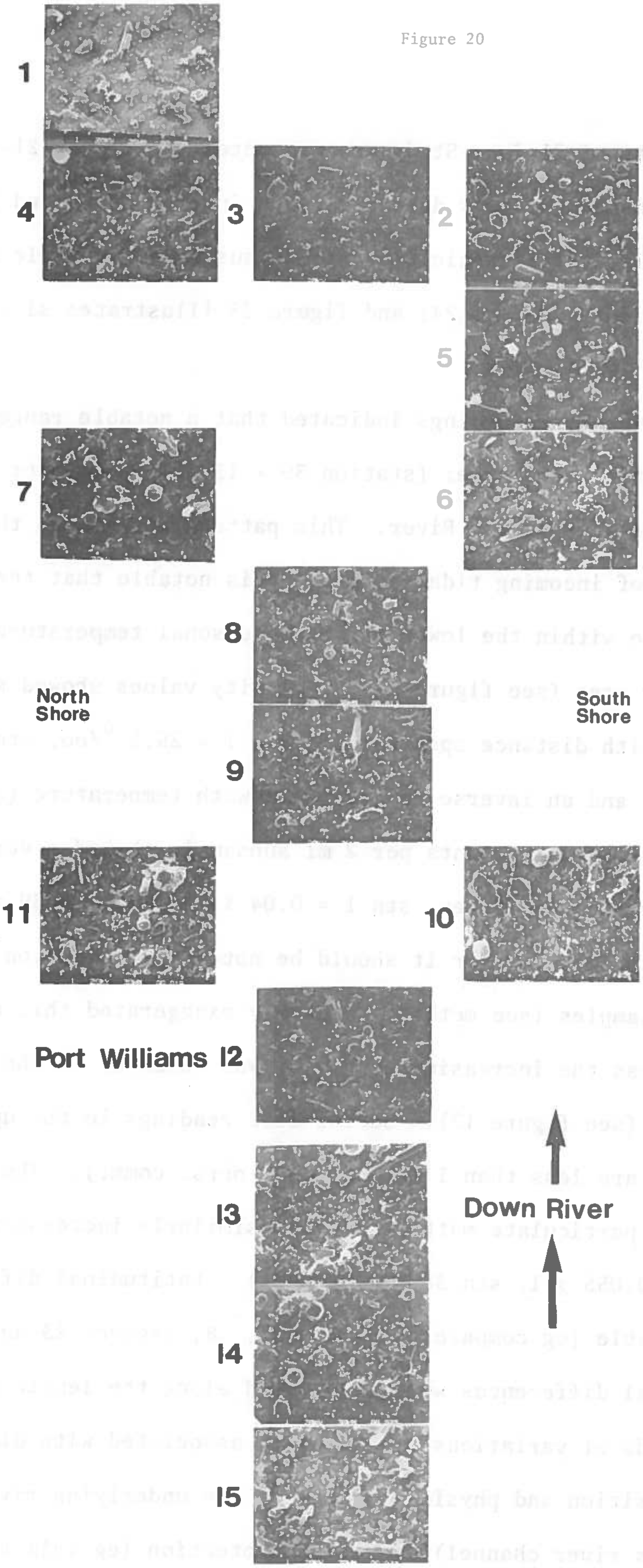

N
%TOTAL VOLUME
POPULATION
CHANNEL
DIAMETER(μ)
VOLUME (μ)
Salt marsh
Mud flat
Main channel
0
0.5
1.0
KM
15
14
13
12
11
10
7
4
1
9
8
3
6
5
2

Figure 19

Figure 20. Scanning electron micrographs of filtrate (S.P.M.) from 15 surface water samples collected 9 May.

Figure 20



1
4
3
2
5
6
7
8
North Shore
South Shore
9
11
10
Port Williams 12
Down River
13
14
15

Results of 21 June Study are presented in figures 21-25. Temperature and salinity data are given in figures 21 and 22 respectively; total particle count and suspended particle mass are shown in figures 23 and 24; and figure 25 illustrates size distribution analysis.

Temperature recordings indicated that a notable range (eg 0.8°C) existed between the upper (station 39 = 13.8°C) and lower (station 5 = 13.0°C) portions of the River. This pattern represents the cooling influence of incoming tidal water. It is notable that these temperatures were within the lower range of seasonal temperatures for the full study area (see figure 49). Salinity values showed significant decrease with distance upstream (eg stn 1 = 25.1 ^{o}/oo, stn. 39 = 20.1 ^{o}/oo) and an inverse relationship with temperature (as expected).

Total particle counts per 2 ml subsample showed a very significant change longitudinally (eg. stn 1 = 0.04 X 10^6 *vs.* stn 39 = 3.7 X 10^6/ 2 ml subsample), however it should be noted that dilution of the upstream samples (see methods) probably exaggerated this change. Nevertheless the increasing turbidity was observed in the upstream direction (see figure 12). Secchi disc readings in the upper part of the river are less than 1 cm (Haywood, pers. comm.). The mass of suspended particulate matter showed a similarly increasing trend (stn 3 = 0.055 g/1, stn 38 = 4.923 g/1). Latitudinal differences were found notable (eg compare sites 26, 27, 28, figures 23 and 24). Latitudinal differences were also noted along the length of the river. These kinds of variations are probably associated with differences in the composition and physical nature of the underlying river bed, (eg mudflat vs river channel) degree of protection (eg calm vs. windy conditions), and local run-off and fresh water input (eg from stream and saltmarsh channels). They may also be related to the dominance of incoming tidal water at various points along the river. In the latter regard it was noted that incoming tidal and outflowing river water were visible as distinct currents along opposite banks, and that the directions of flow alternated at different bends along the river. These kinds of patterns would account for some of the apparent inconsistencies noted.

The size distribution analysis indicated that a larger proportion of smaller particles were carried by upstream waters (see population graphs, figure 25). It must be noted however, that dilution of the upstream samples contributed significantly to total numbers in the first 2 particle size ranges (see methods). Size distribution graphs according to % total volume were not as notably affected by dilution factors (pers. obs.) and examination of these data clearly illustrated an increased proportion of larger sized particles upstream.

It should be emphasized that stations were sampled in a down-stream direction (eg. stn 39 - stn 1). Those near the mouth of the river were sampled around slack high-tide whereas upstream sites were sampled before slack water. This probably contributed somewhat to the increased turbidity upstream (see Time-Depth studies) however these kinds of time intervals are unavoidable (see previous discussion). A "turbidity maximum" was not reached during this sampling session and it is suspected that this maximum must occur at a considerable distance upstream (subsequent observations). It would appear that currents and turbidity continue to increase as incoming tidal water is forced into the narrow upstream portions of the river (pers. obs.).

Figure 21. Temperature[1] data at 5 locations along Cornwallis River, 21 June Study.

[1] All temperatures are in °C. This is true for all subsequent data.

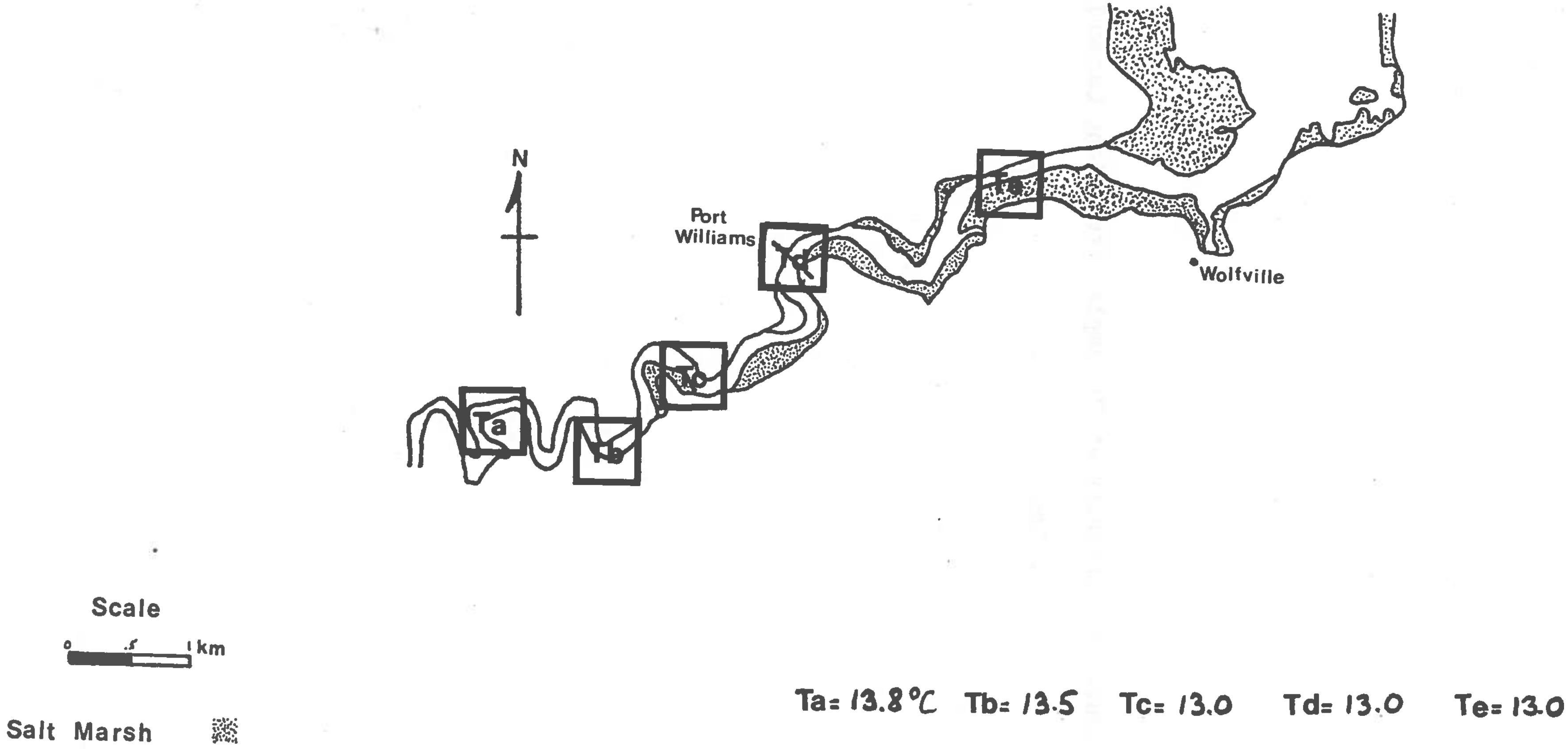

N
Port Williams
Wolfville
Ta
Tb
Tc
Td
Te
Scale
0 .5 1 km
Salt Marsh
Ta= 13.8°C Tb= 13.5 Tc= 13.0 Td= 13.0 Te= 13.0

Figure 21

Figure 22. Salinity at 39 sample sites along Cornwallis River, 21 June.

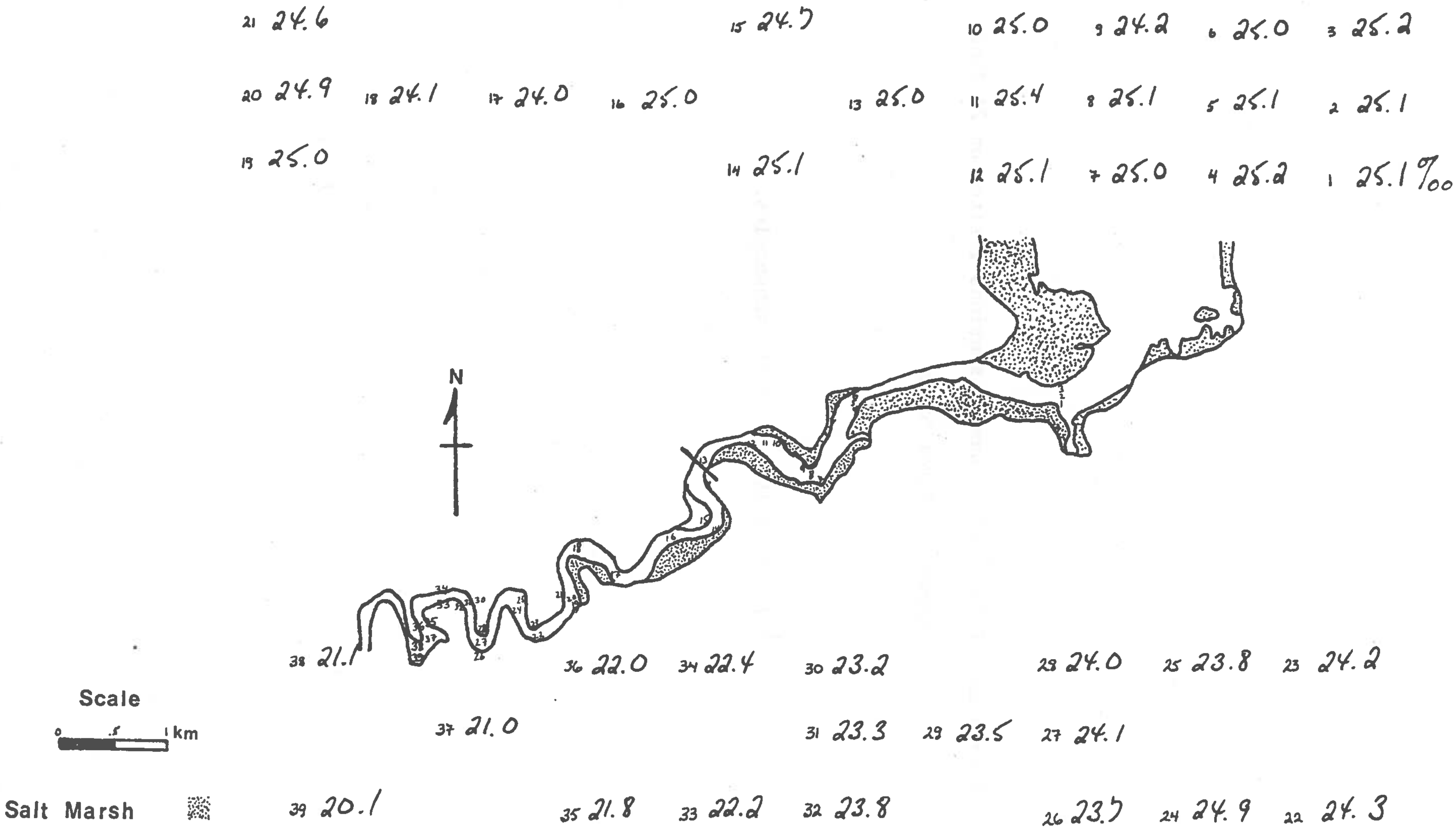

21 24.6
15 24.7
10 25.0
9 24.2
6 25.0
3 25.2
20 24.9
18 24.1
17 24.0
16 25.0
13 25.0
11 25.4
8 25.1
5 25.1
2 25.1
19 25.0
14 25.1
12 25.1
7 25.0
4 25.2
1 25.1‰
N
38 21.1
36 22.0
34 22.4
30 23.2
28 24.0
25 23.8
23 24.2
37 21.0
31 23.3
29 23.5
27 24.1
39 20.1
35 21.8
33 22.2
32 23.8
26 23.7
24 24.9
22 24.3
Scale
0 .5 1 km
Salt Marsh

Figure 22

Figure 23. T.P.C.[1] at 39 sample stations visited on 21 June, Cornwallis River Study.

[1] T.P.C. X 10^6 for 2 ml. subsamples.

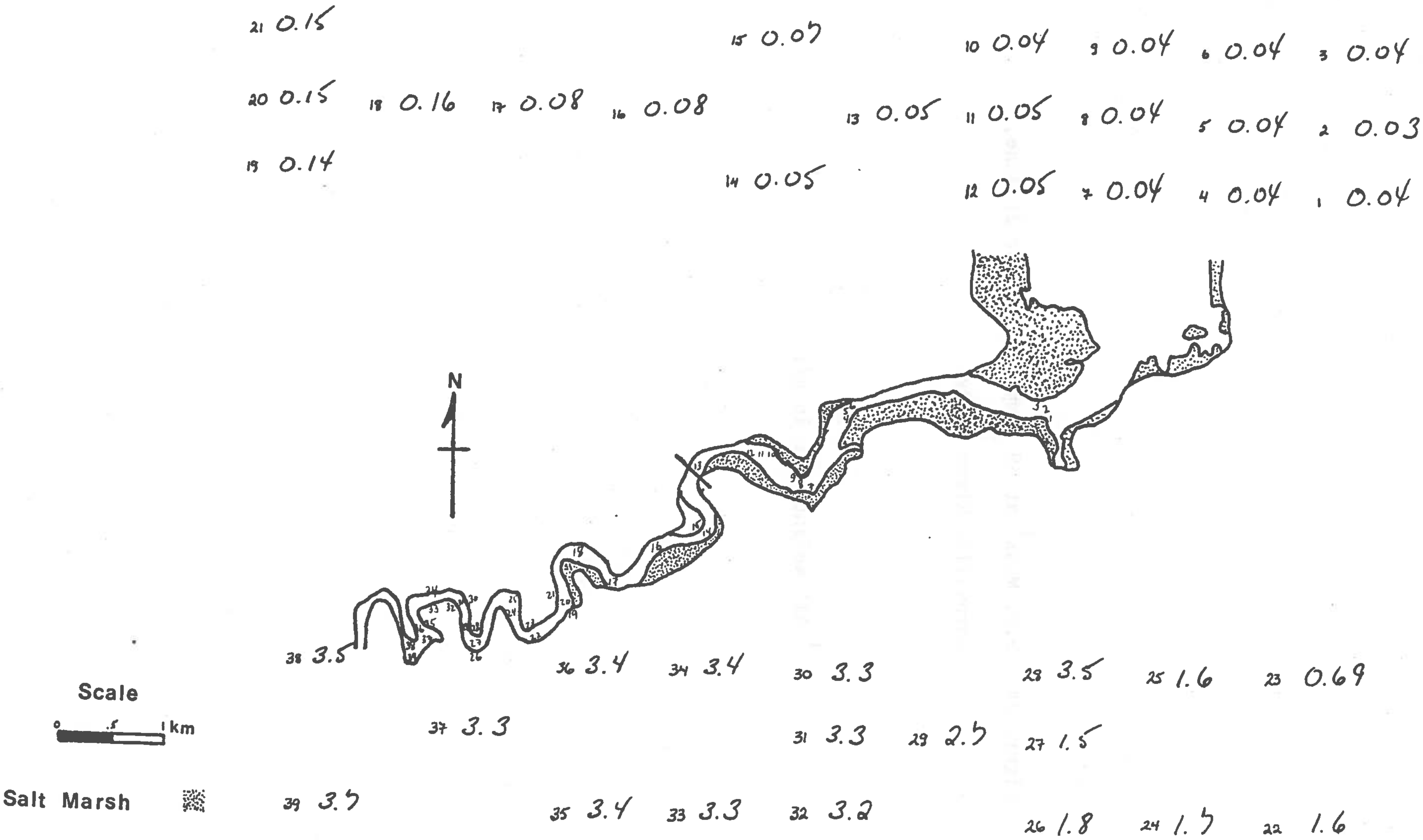

21 0.15
15 0.07
10 0.04
9 0.04
6 0.04
3 0.04
20 0.15
18 0.16
17 0.08
16 0.08
13 0.05
11 0.05
8 0.04
5 0.04
2 0.03
19 0.14
14 0.05
12 0.05
7 0.04
4 0.04
1 0.04
N
38 3.5
36 3.4
34 3.4
30 3.3
28 3.5
25 1.6
23 0.69
Scale
0 .5 1 km
37 3.3
31 3.3
29 2.7
27 1.5
Salt Marsh
39 3.7
35 3.4
33 3.3
32 3.2
26 1.8
24 1.7
22 1.6

Figure 23

Figure 24. S.P. Mass[1] at 39 sample sites for 21 June, Cornwallis River Study.

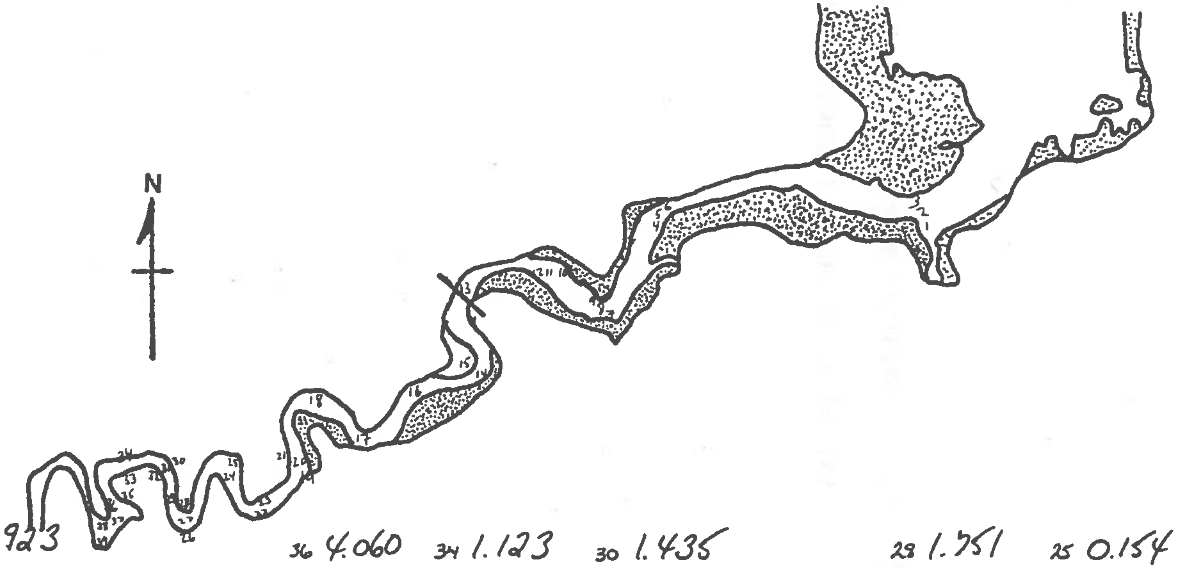
[1] All weights are in g/l.

780621
g/1

21 0.345 15 0.160 10 0.090 9 0.109 6 0.089 3 0.055

20 0.282 18 2.210 17 1.195 16 0.306 13 0.442 11 0.102 8 0.066 5 0.049 2 0.052

19 0.186 14 2.248 12 0.229 7 0.106 4 0.667 1 0.069



38 4.923 36 4.060 34 1.123 30 1.435 28 1.751 25 0.154 23 0.513

37 2.374 31 0.924 29 0.754 27 0.564

39 4.656 35 2.772 33 2.011 32 1.290 26 0.687 24 0.288 22 0.403

Scale

0 .5 1 km

Salt Marsh

Figure 24

Figure 25. Size distribution of S.P. Matter at 39 sample sites visited on 21 June, Cornwallis River Study.

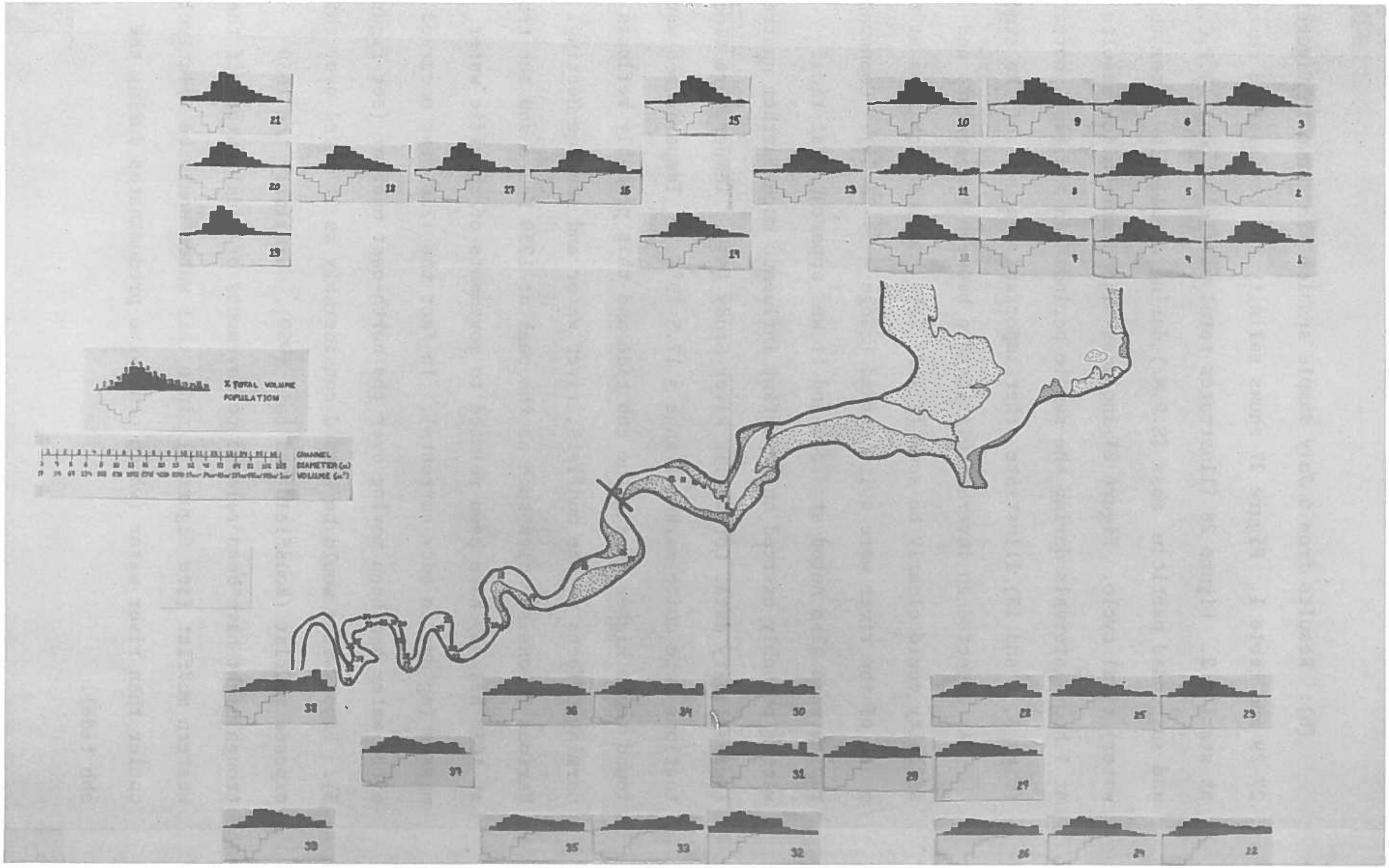


Figure 25

(b). Results from 6 July sample session are shown in figures 27-29 and table 1. Figure 27 shows salinity and temperature changes at station 2. Figure 28 illustrates total particle count (T.P.C.) and suspended particle mass (S.P.M.) during a full (low water to low water) tidal cycle. Figure 24 includes size distribution results at 1 hour intervals during the sample period. In addition photographs (figs 3, 8 and 13) illustrate other important features of the study.

As expected an inverse relationship between temperature and salinity could clearly be seen (figure 28). Salinity changes at the mouth of the river were quite marked (range = 14-23.5‰). Comparable ranges were also noted at stn 1 and it was apparent that tidal waters probably exerted an important influence much farther upstream (see salinity data, Cornwallis River Study (a)). Temperature fluctuations were quite marked (range = 17.5-19°C.). Temperatures were found to be higher during the ebb tide and this probably reflects the warming effects of the mudflats, river water and surface heating. Various inconsistencies such as the peak at 1230 hours and the trough at 1630 hrs may have been related to movements of specific water masses (eg due to eddy currents). In fact the 1230 peak occurred just after water had been moving over the north-east mudflat (see figure 3). Flood water would be warmed considerably as it moved over this exposed mudflat (Bousfield and Leim 1959). Similarly the 1630 trough might have been related to movements of tidal water off the western mudflat (see figure 3) since this water would be relatively cooler than river water (which otherwise predominates during the ebb tide).

Figure 26. Location of station 1 (O) and 2 (O), 6 July Cornwallis River Study.

Figure 26

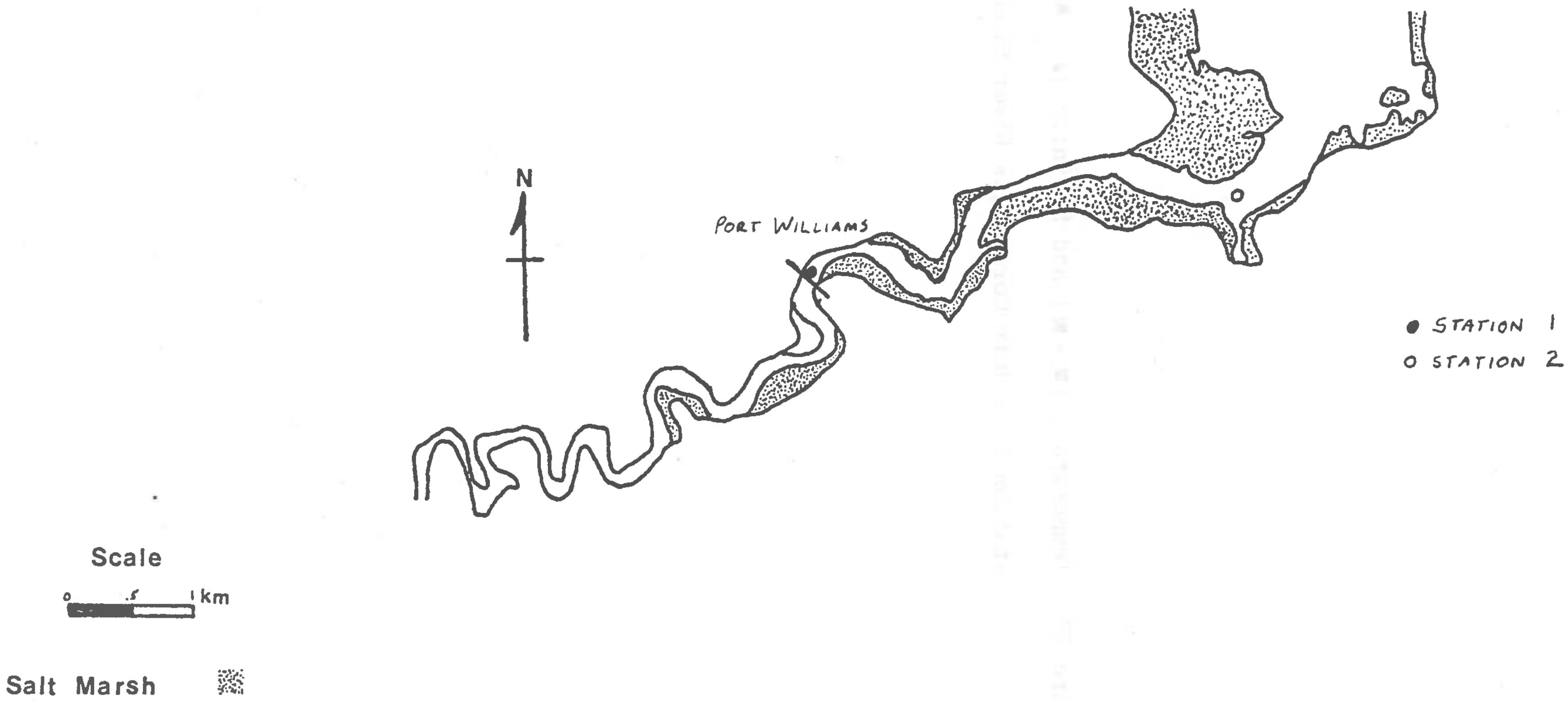
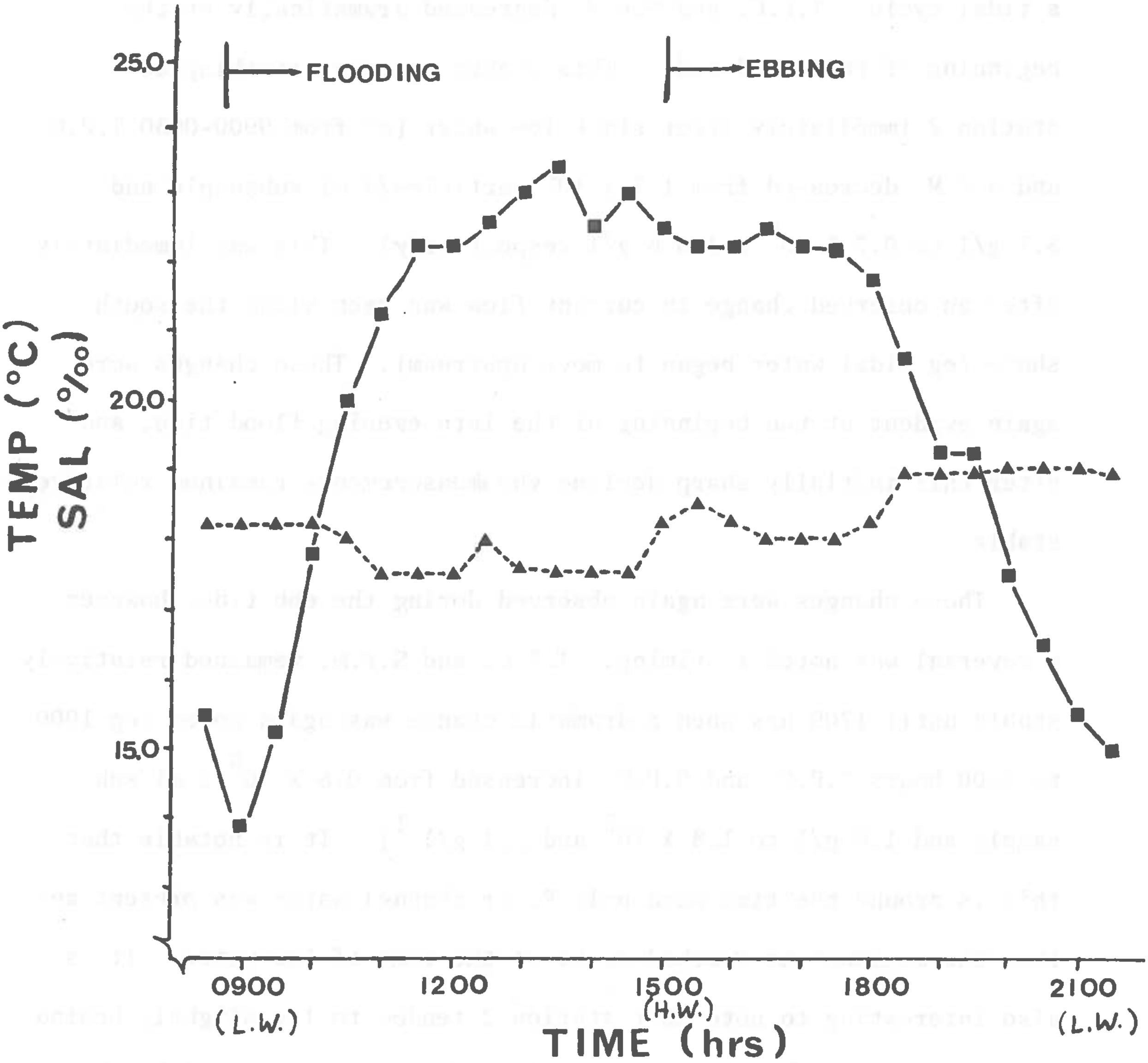


Figure 27. Temperature (■ - ■) and Salinity (▲ - ▲) results at station 2, 6 July Cornwallis River Study.

Figure 27



25.0
20.0
15.0
FLOODING
EBBING
TEMP (°C)
SAL (‰)
0900
(L.W.)
1200
1500
(H.W.)
1800
2100
(L.W.)
TIME (hrs)

Figure 28(a) and (b) clearly illustrate the relative influence of Basin and River water on the suspended particulate pattern during a tidal cycle. T.P.C. and S.P.M. decreased dramatically at the beginning of the flood tide. This change was very striking at station 2 immediately after slack low water (eg from 0900-0930 T.P.C. and S.P.M. decreased from 1.7 x 10^5 particles/2 ml subsample and 3.7 g/l to 0.7 X 10^5 and 0.6 g/l respectively). This was immediately after an observed change in current flow was seen along the south shore (eg tidal water began to move upstream). These changes were again evident at the beginning of the late evening flood tide, and after this initially sharp decline the measurements remained relatively stable.

These changes were again observed during the ebb tide, however a reversal was noted in timing. T.P.C. and S.P.M. remained relatively stable until 1700 hrs when a dramatic change was again noted.(eg 1900 to 2000 hours T.P.C. and S.P.M. increased from 0.8 X 10^5/2 ml subsample and 1.0 g/l to 1.8 X 10^5 and 3.1 g/1^{-1}). It is notable that this is around the time when only River channel water was present and that the maximum was reached right at the time of low water. It is also interesting to note that station 2 tended to lag slightly behind station 1 but followed the same basic patterns. T.P.C. and S.P.M. at station 1 were consistently higher than at station 2 during the time intervals between slack tides (see figures 13 and 28). These results indicate a longitudinal movement of suspended particulate matter downstream on ebb tide. It should be noted that inconsistencies in the basic trends noted (eg large trough at station 1, 1900 hours)

Figure 28. (a) T.P.C. at stations 1 (■ - ■)[1] and 2 (▲ - ▲)[1], 6 July Cornwallis River Study.

(b) S.P. Mass at stations 1 (■ - ■) and 2 (▲ - ▲), 6 July Cornwallis River Study.

Figure 28

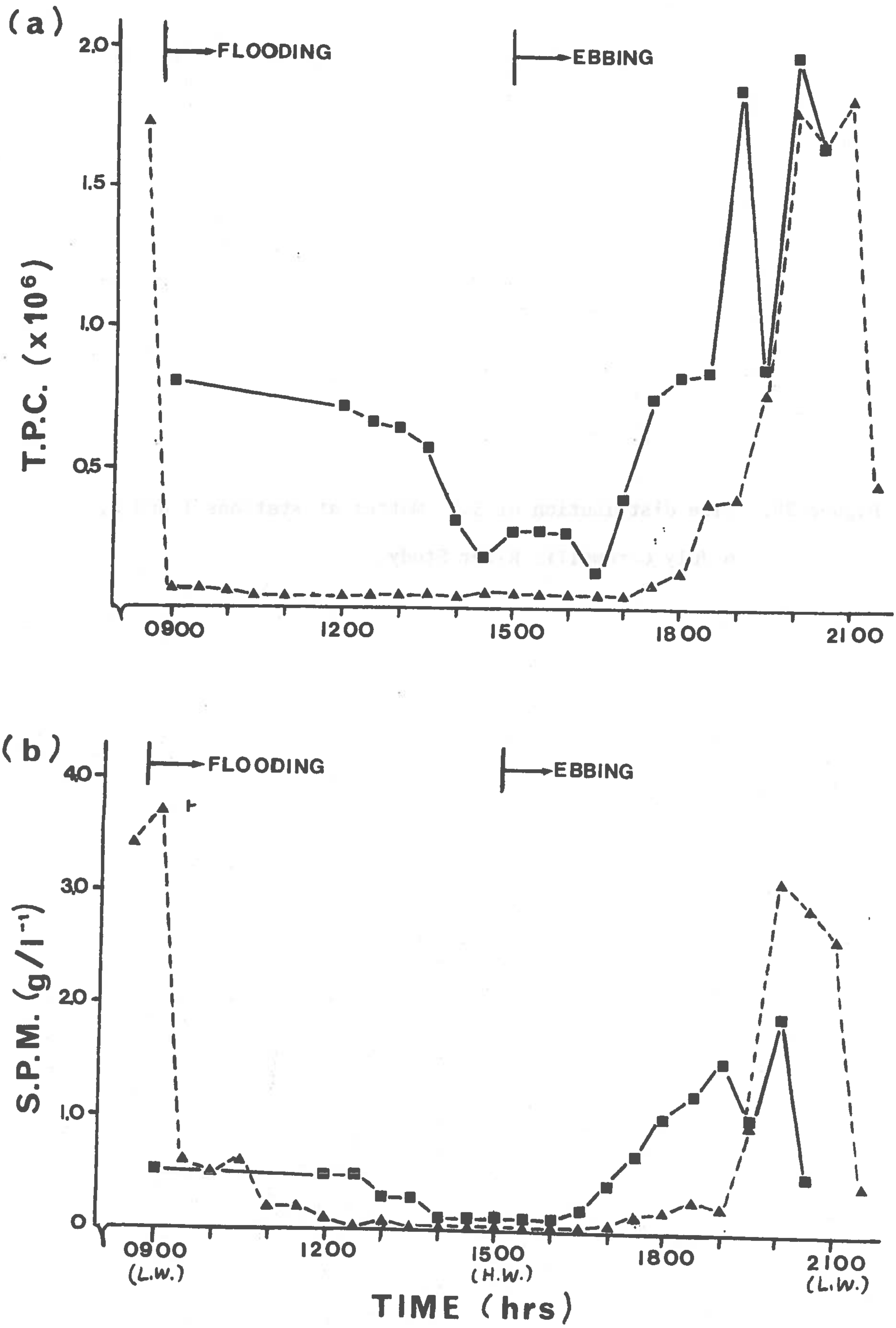
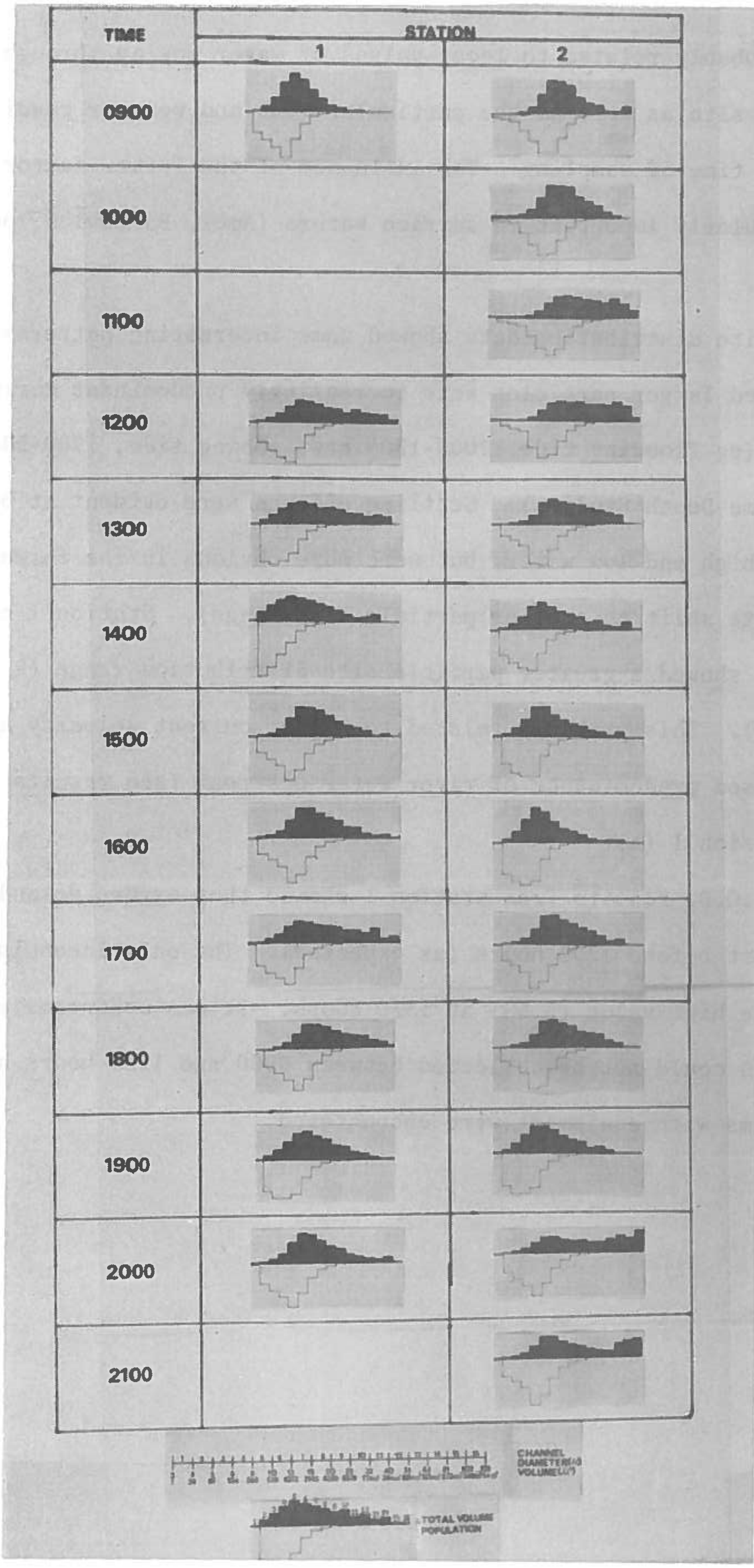

(a)
FLOODING
EBBING
T.P.C. (x10^6)
2.0
1.5
1.0
0.5
0900
1200
1500
1800
2100
(b)
FLOODING
EBBING
S.P.M. (g/l^-1)
4.0
3.0
2.0
1.0
0
0900
(L.W.)
1200
1500
(H.W.)
1800
2100
(L.W.)
TIME (hrs)

Figure 29. Size distribution of S.P. Matter at stations 1 and 2, 6 July Cornwallis River Study.

Figure 29


TIME
STATION
1
2
0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
CHANNEL
TOTAL VOLUME
POPULATION

are probably related to local pulses of water moving through the sample site as well as the particular wind and weather conditions at the time of sampling. The influence of the latter factor is particularly important in surface waters (Amos, Barthwich, pers. comm.).

Size distribution data showed some interesting patterns. As expected larger particles were increasingly predominant during mid tides (eg flooding tide, 1000-1300 hrs, ebbing tide, 1700-2000 hrs.; see Time-Depth Studies). Settling effects were evident at both slack high and low water, but were more obvious in the former case (eg note shift to smaller particle size range). Station 1 consistently showed a greater particle size-distribution range (% Total Volume). This probably related to higher current velocity and increased predominance of river water upstream (see results and discussion I (a).

B.O.D. results from station 1 showed that oxygen demands were greatest before 1200 hours (as expected). The only inconsistency was the high value (3.33) at 1330 hours. It was unfortunate that samples could not be collected between 0900 and 1200 hours however problems with equipment were encountered.

Table 1. B.O.D. Results for Station 1, Cornwallis River Study (6 July)*.

Time (Hrs)	B.O.D. (mg)
0900	2.065
1200	2.565
1230	<1.33
1300	1.93
1330	3.33
1400	<1.33
1430	1.33
1500	<1.33
1530	<1.33
1600	<1.33
1700	<1.77
1800	1.33
1900	<1.33
2000	1.33

* Sample analysis by Job Corps Program Employees of the Environmental Protection Services group.

2. TIME-DEPTH STUDIES.

Objectives - These studies were intended to examine various physical, chemical and biotic changes in the water column over a full tidal cycle. Three representative points in the south-western bight of the Minas Basin were considered (see figures 1, 2 and 7). Temperature; salinity; light penetration; total number; mass and size distribution of suspended sediments; current and wind speed and direction; and plankton were of primary interest. Daily patterns and overall trends were considered, and because of difficulties of access in this part of the Minas Basin the studies were started at one high tide and continued to the next.

Methods - Field - On May 29, June 16 and June 29, and July 13, 1978, sites at Wolfville Saltmarsh, Longspell Point, and Canard River estuary were sampled (see figures 1, 2 and 7). Sampling began within 1 1/2 hours of the early morning high tide and continued every hour for 12 hours. Personnel in boat A collected water samples at 1 m intervals using a 2.1 L Kenmerer water sampler. On July 13 a 1 L Knudsen sampler kindly loaned by the Atlantic Geo-Science Center (Bedford Institute of Oceanography) was used. Temperature and salinity were measured in situ with a Y.S.I. S-C-T meter. Plankton hauls were also taken (see Biological Studies II 1. (b)). Personnel in boat B measured light penetration at 0.5 m intervals with a Kahlsico Submarine Photometer and a secchi disc. Wind and current speeds were measured with a TSK flowmeter over 1 min periods.

Laboratory-Water samples were stored in a constant temperature cold room at 10°C immediately upon return to the laboratory. These were then analyzed for total suspended sediments and size distribution of suspended sediments within 48 hours of collection. A Coulter Counter Model TAII with a 280 μ aperture was used, stir-speeds and operator kept as constant as possible. If dilution was required it was dependent on the visual observation of concentration in individual samples, the dilutant used was filtrate from filtered samples (see below). Background counts were deleted from total counts, however size distribution graphs remain uncorrected.

Water samples from 29 May were filtered through .45 μ Millipore filters, whereas Nuclepore membranes were used for subsequent samples. (The actual volume filtered again depended on visual observation of concentration of suspended sediments). The filtrate was dried at 50°C for 24 hours and total weight was measured on a Cahn 4100 electro-balance. Actual weight was determined by subtraction of the mean weight of 15 clean filters. All filters were stored in disposable plastic 55 mm petri dishes. Those from 1 m depths on 29 May were sent to Bedford Institute of Oceanography (B.I.O.) for analysis using a Cambridge Scanning Electron Microscope (S.E.M.) and representative micrographs were obtained. All other filters were stored for future S.E.M. work at Acadia University.

Results and Discussion

Results from 29 May are shown in figures 15 and 30-36. Figures 30 and 31 show temperature and salinity values at 1 hour - 1 m intervals throughout the tidal cycle. Figure 32 illustrates the lines of 25 and 5% light penetration as well as secchi disc readings. Total particle counts (T.P.C.) and total weights of suspended particulate matter (S.P.M.) are shown in figures 33 and 34 respectively. Size distribution data and scanning electron micrographs from 1 m water samples are presented in figures 35 and 36. The full size micrographs are also included in figure 15. Graphs include depth measurements above chart datum and the predicted depth curve for the southwestern bight of the Minas Basin. The latter was determined based on the combined results of all Time-Depth studies.

No data were obtained from 1200-1500 hrs on 29 May when the area was exposed at low tide. Thus low water was actually 6 m above chart datum. Only a very small channel of water continued to flow in the region between the salt marsh sample site and the mid-Basin mudflat (see figures 1 and 2).

Vertical temperature and salinity data illustrated the well mixed nature of the Basin water in this region. Except for the 1100 hr measurements, temperature ranges never exceeded 1.5°C at any given time. Small vertical differences probably resulted from eddy generated mixing as noted at 1100 hours. The exception may be related to the output of an underground spring that was observed at the sample site as the region became exposed. These 'spring' outputs consisted of built-up sand mounds with a deep central core containing relatively large, dark sand particles and noticeably colder water. Otherwise there was a general trend towards increasing temperature with the incoming tide. It is suspected that this pattern related to the movement of tidal water over the exposed mud flats and to surface heating (see Cornwallis River Study (b)). Salinity results also demonstrated the well mixed nature of the water column. Slight decreases were noted near low, slack water (see figure 31).

Light penetration data indicated that the maximum depth to which 5% light penetration occurred was only about 1 m. This agreed with results determined in the light penetration study (see Phys. and Chem. Studies, I 3 (a)). As the tide ebbed this penetration depth decreased on the flooding tide. Turbidity decreased and so light penetrated to a greater depth. The maximum penetration occurred at high tide (0800 and 1930 hours). Flood tide currents are generally stronger than during the ebb tide and therefore able to maintain a greater number and size range of particles in suspension (Amos 1978). Thus, as current velocities fall at or near slack-high tide particles tend to settle out and light penetration increases. Data for total particle count (T.P.C.), suspended particle mass (S.P.M.) and size distribution substantiate this view (see below). Secchi disc (S.D.) readings showed a relationship with points of 5% light penetration during the tidal cycle, however a correlation was not determined since S.D. measurements were only estimated to the nearest 0.1 m.

Vertical T.P.C. and S.P.M. results also indicated a well mixed water column. An exception occurred at 1900 hours when a sudden decrease in T.P.C. from 5.8 to 4.4 X 10^6 occurred between 10 and 9 m above chart datum. This may have been an indication of the influence of the underlying channel water, a phenomenon that has recently been documented by other estuary researchers (Amos 1978). The fact that S.P.M. determinations do not show comparable change may reflect differences in particle origin or size distribution. The highest T.P.C. and SPM values occurred at 1600 hours (mid flood). This is characteristically the period of strongest current flow during a tidal cycle (Amos 1978) and relative current data presented in figure 35 showed that this was the case. TPC and SPM should increase as current speed increases; however it must be noted that the true maximum may not be included since no samples were taken from the shallow channel below the sample site from 1200-1500 hours. A complete set of data would probably have indicated a low tide maximum (see Cornwallis River Study (I) (b)). The basic patterns in T.P.C. results are illustrated in the Scanning Electron micrograph series (figures 15 and 36). These clearly demonstrate the increasing concentration of particles around low water. Note that the more highly concentrated filters were from smaller volumes of water.

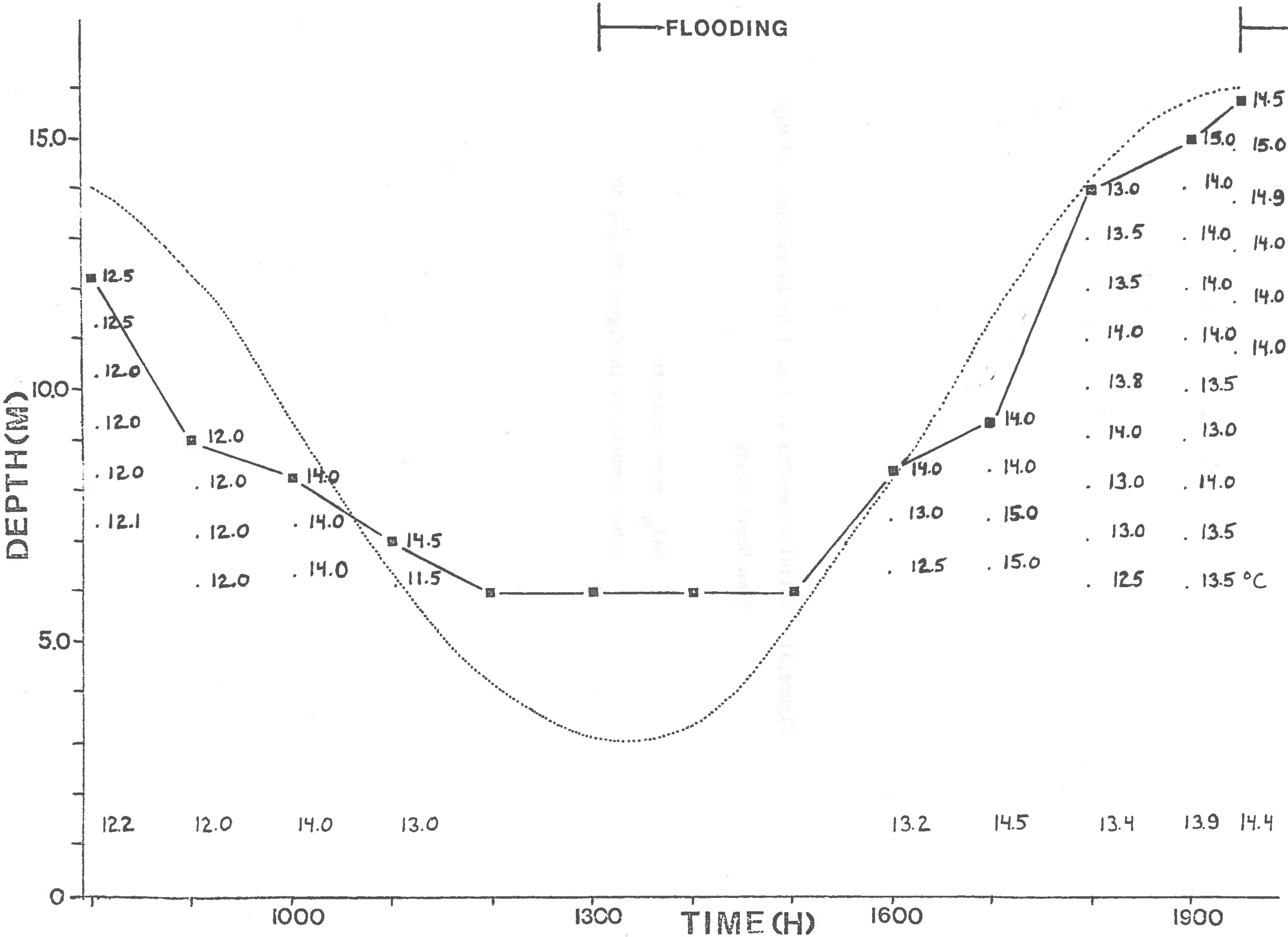
Although both TPC and SPM depend on current speed the size distribution of these particles depends upon both maximum, and residual currents (Amos, pers. comm.). Maximum current flow affects the larger particle size range whereas the distribution of smaller particles is determined primarily by residual currents. Such relationships may account for the seemingly perplexing size distribution results from this study. Limitations in equipment did not permit more accurate current data to be recorded however it is suspected that current patterns on this region are extremely complex (see Amos and Josie 1976). Current speeds were not measured as absolute values, however figure 35 gives relative data based on flowmeter readings. The vectors are unidirectional for the ebbing and flooding tides. As expected largest values were observed during mid ebb and mid flood tide and currents associated with flood tide were the most pronounced.

Figure 30. Temperature at 1 m, 1 hr time intervals, 29 May Time-Depth Study.

T_M mean temperature

\- Depth above chart datum

.... Calculated theoretical time-depth pattern for S.W. Minas Basin.



FLOODING
DEPTH (M)
TIME (H)
15.0
10.0
5.0
0
1000
1300
1600
1900
12.2 12.0 14.0 13.0 13.2 14.5 13.4 13.9 14.4 Tm
°C

Figure 30

Figure 31. Salinity results at 1 m, 1 hr intervals, 29 May Time-Depth Study.

Sal_m mean salinity

other symbols as in figure 29 and 30.

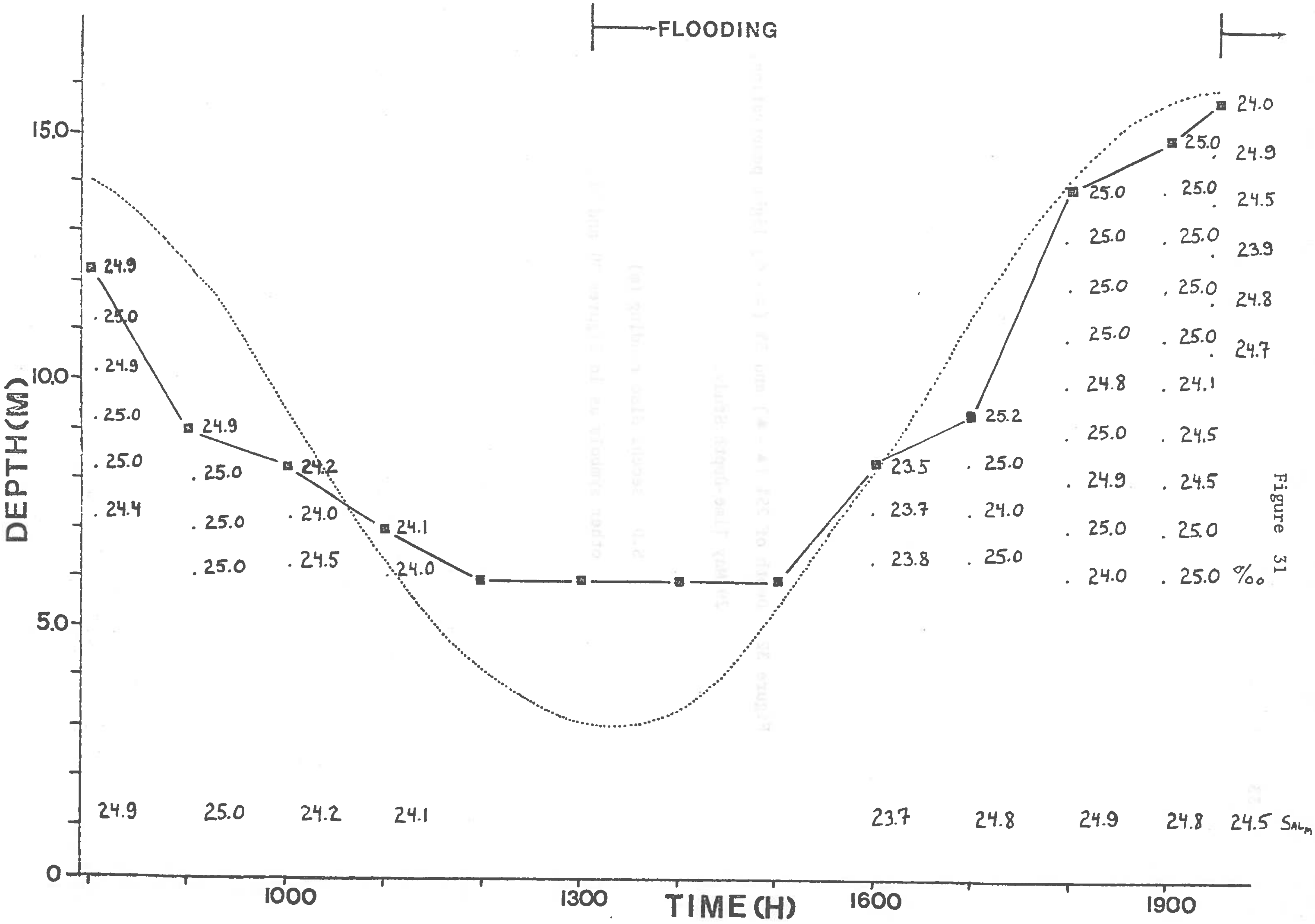

FLOODING
DEPTH(M)
TIME(H)
15.0
10.0
5.0
0
1000
1300
1600
1900
24.9
25.0
24.9
25.0
25.0
24.4
24.9
25.0
25.0
25.0
24.2
24.0
24.5
24.1
24.0
23.5
23.7
23.8
25.2
25.0
24.0
25.0
25.0
25.0
25.0
25.0
24.8
25.0
24.9
25.0
24.0
25.0
25.0
25.0
25.0
24.1
24.5
24.5
25.0
25.0
24.0
24.9
24.5
23.9
24.8
24.7
‰
24.9
25.0
24.2
24.1
23.7
24.8
24.9
24.8
24.5 Sal_m

Figure 31

Figure 32. Depth of 25% (▲ - ▲) and 5% (△ - △) light penetration, 29 May Time-Depth Study.

S.D. secchi disc reading (m)

other symbols as in figures 30 and 31.

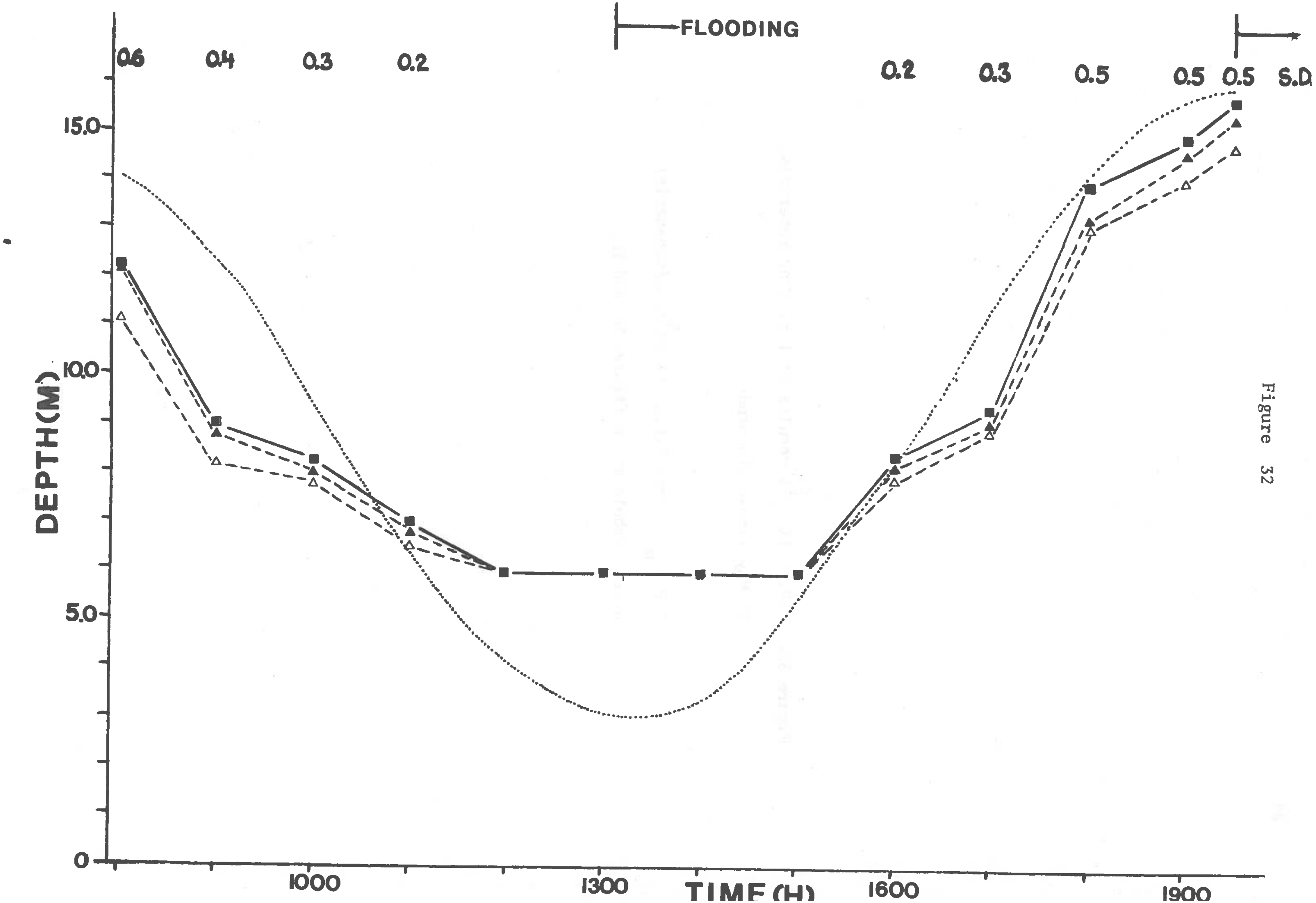

FLOODING
0.6
0.4
0.3
0.2
0.2
0.3
0.5
0.5
0.5
S.D
15.0
10.0
5.0
0
DEPTH(M)
1000
1300
1600
1900
TIME(H)

Figure 32

Figure 33. T.P.C. (X 10^5) results at 1 m, 1 hr intervals, 29 May Time-Depth Study.

T.P.C.$_m$ mean T.P.C. (X 10^5/2 m/subsample)
other symbols as in figures 30 and 31.

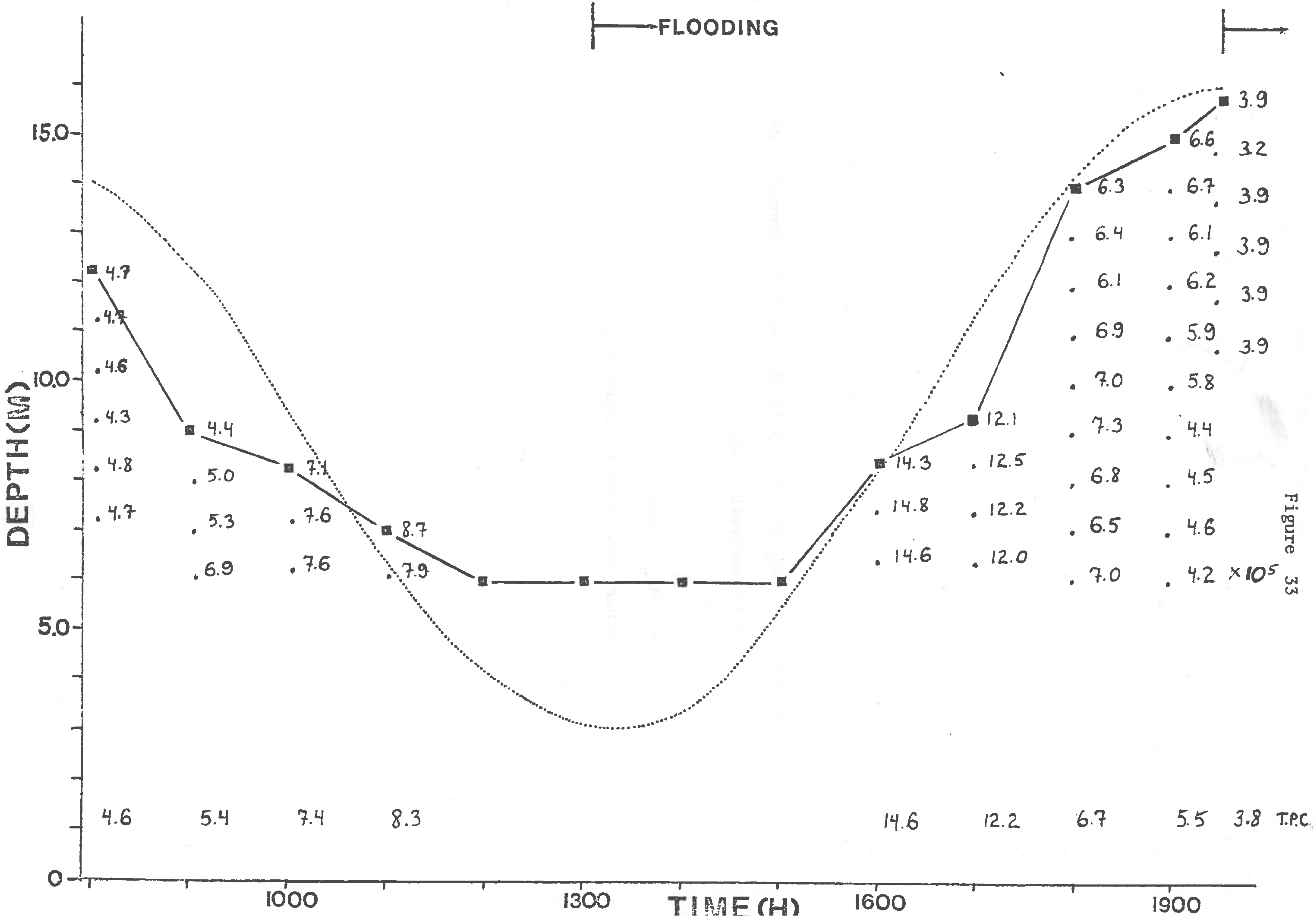

FLOODING
DEPTH(M)
15.0
10.0
5.0
0
TIME(H)
1000
1300
1600
1900
4.7
4.7
4.6
4.3
4.8
4.7
4.4
5.0
5.3
6.9
7.1
7.6
7.6
8.7
7.9
14.3
14.8
14.6
12.1
12.5
12.2
12.0
6.3
6.4
6.1
6.9
7.0
7.3
6.8
6.5
7.0
6.6
6.7
6.1
6.2
5.9
5.8
4.4
4.5
4.6
4.2
3.9
3.2
3.9
3.9
3.9
3.9
×10⁵
4.6
5.4
7.4
8.3
14.6
12.2
6.7
5.5
3.8
T.P.C.

Figure 33

Figure 34. S.P. Mass results (g/l) at 1 m, 1 hr intervals, 29 May Time-Depth Study.

$S.P.M._m$ mean S.P. Mass

other symbols as in figure 30 .

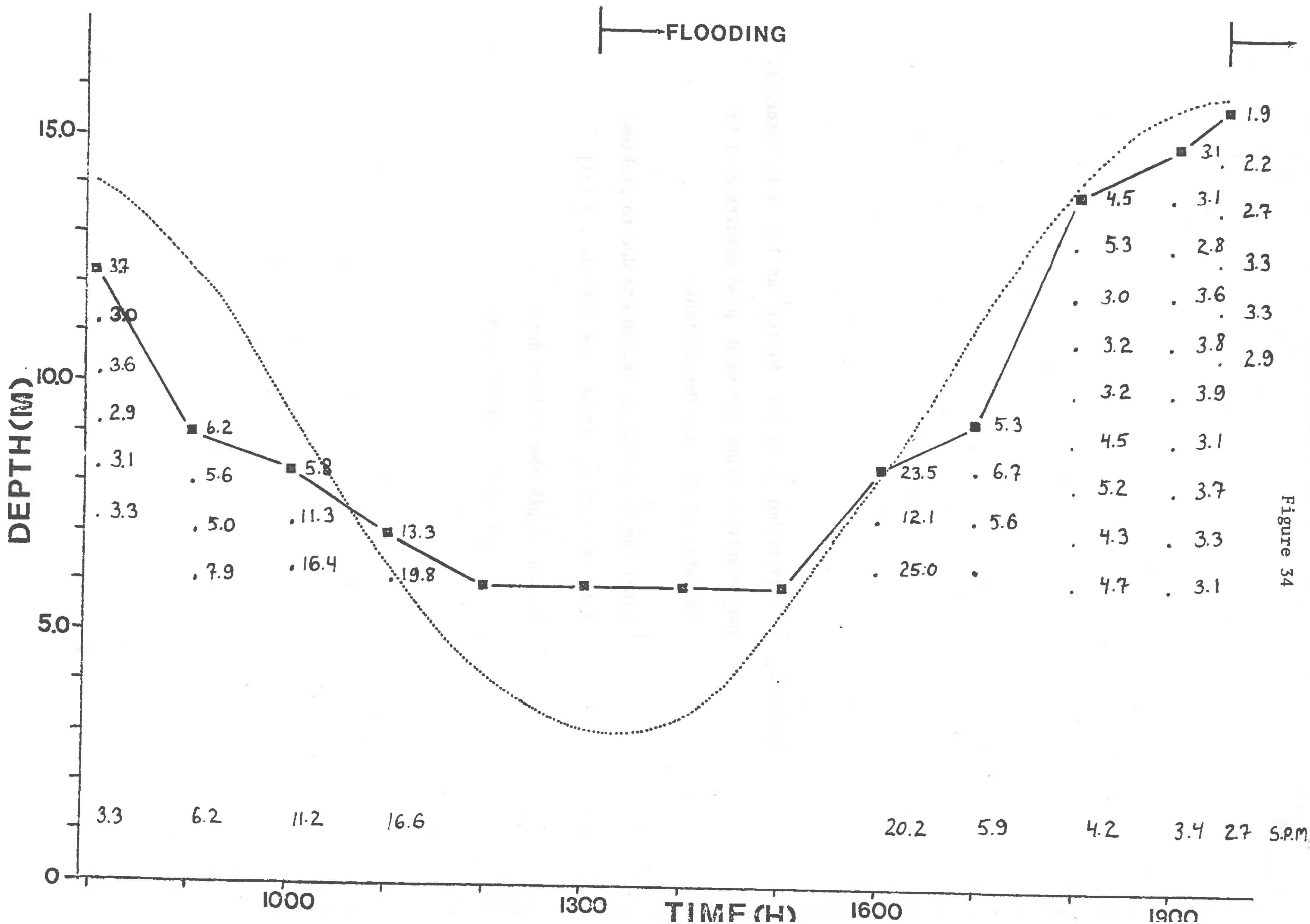

FLOODING
DEPTH(M)
TIME(H)
15.0
10.0
5.0
0
1000
1300
1600
1900
3.7
3.0
3.6
2.9
3.1
3.3
6.2
5.6
5.0
7.9
5.8
11.3
16.4
13.3
19.8
23.5
12.1
25.0
5.3
6.7
5.6
4.5
5.3
3.0
3.2
3.2
4.5
5.2
4.3
4.7
3.1
3.1
2.8
3.6
3.8
3.9
3.1
3.7
3.3
3.1
1.9
2.2
2.7
3.3
3.3
2.9
3.3
6.2
11.2
16.6
20.2
5.9
4.2
3.4
2.7
S.P.M

Figure 34

Figure 35. Size distribution of S.P. Matter[1] at 1 m, 1 hr intervals[1] and relative current and wind speed results at 1 hr intervals, 29 May Time-Depth Study.

[1] final sample series is incomplete due to problems with sampling equipment (see methods I 2 (a)).

o——o Depth above chart datum

relative current speed

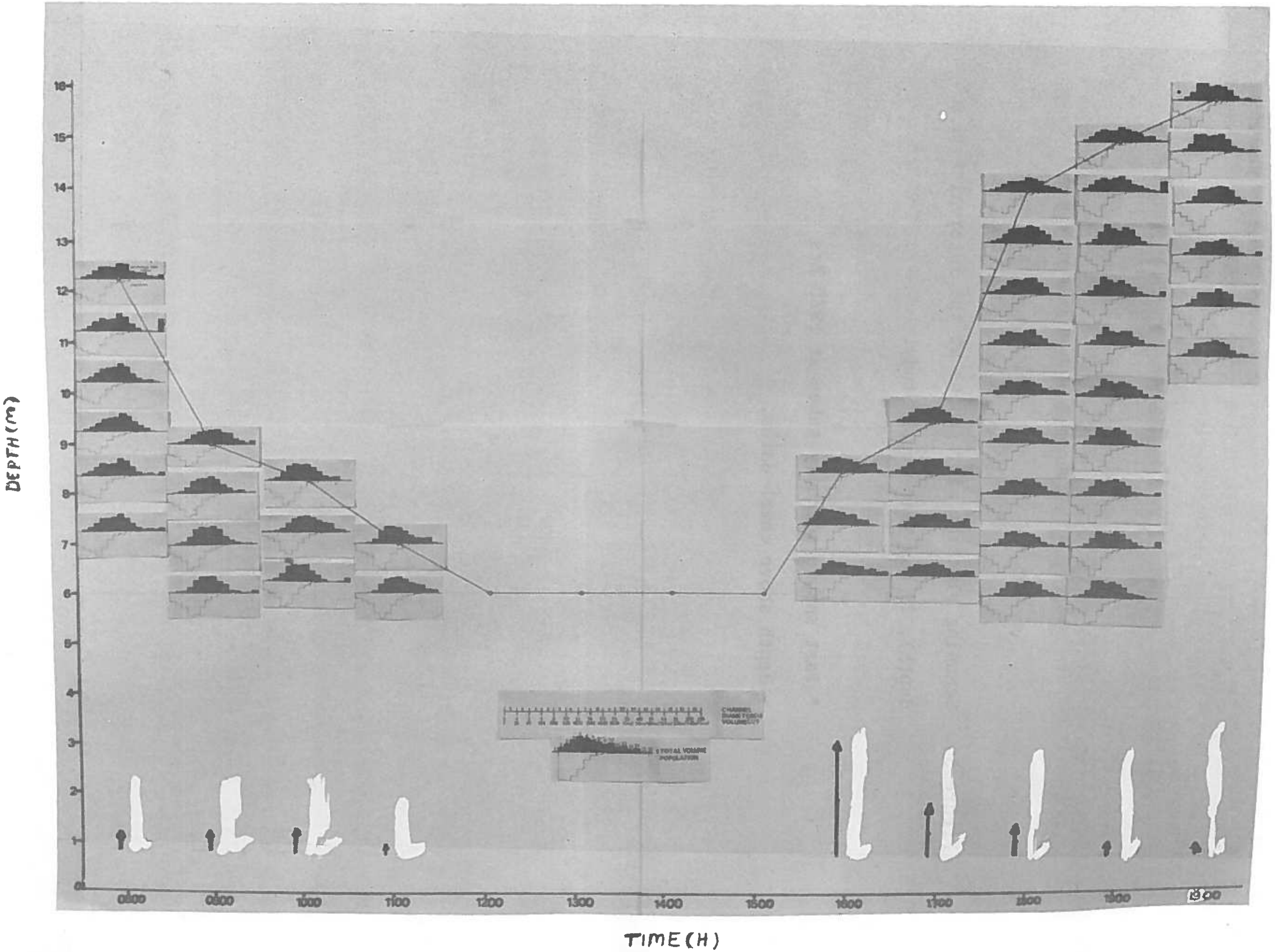

DEPTH (m)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0800
0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
TIME (H)

Figure 35

Figure 36. Scanning electron micrographs at the intervals* (1 m depth), 29 May Time-Depth Study.

* last sample actually taken at 1930 hrs depth above chart datum.

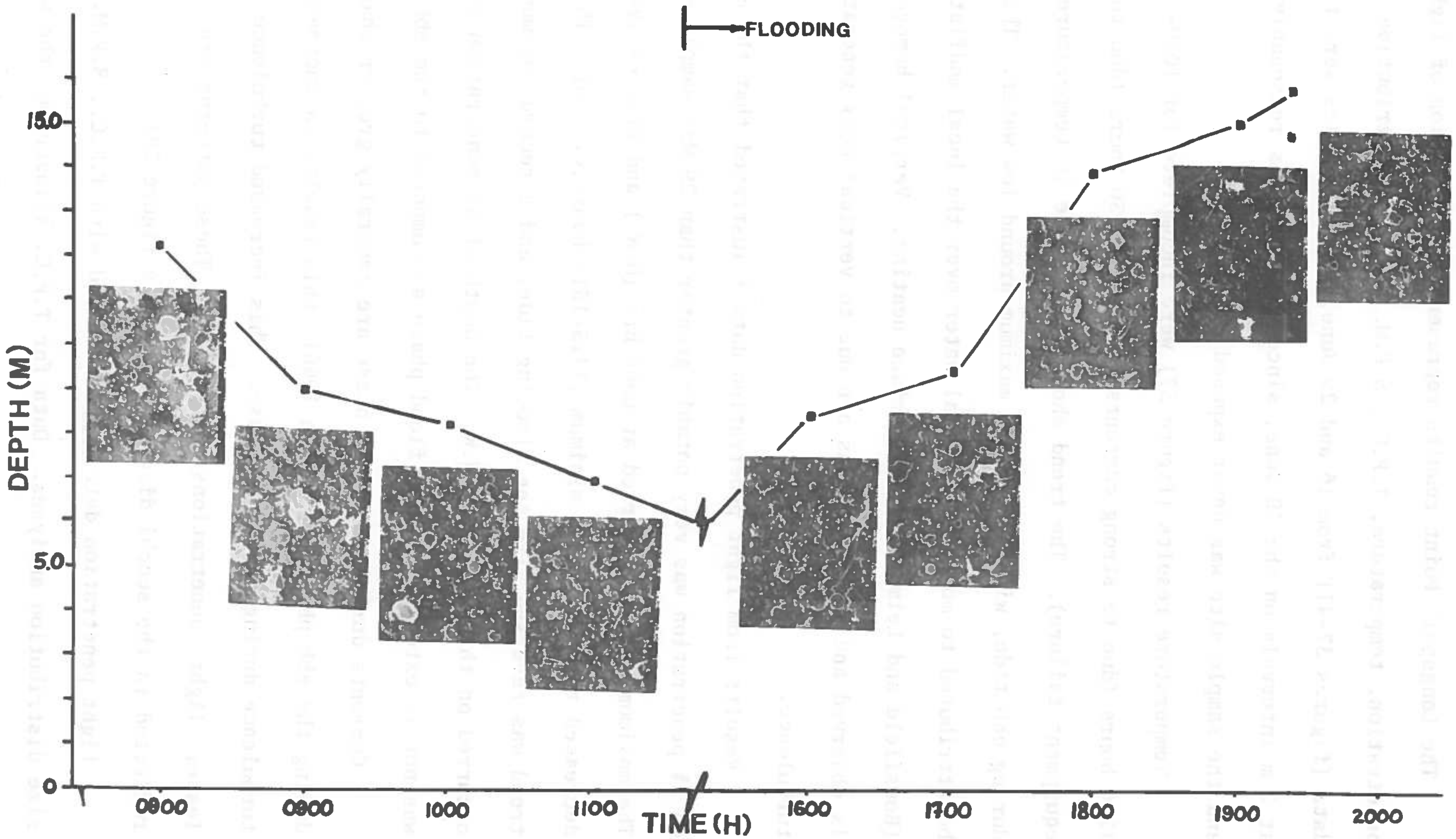

FLOODING
DEPTH (M)
15.0
5.0
0
0800
0900
1000
1100
1600
1700
1800
1900
2000
TIME (H)

Figure 36

The Longspell Point results represent a combination of light penetration, temperature, T.P.C., S.P.M. and size distribution data (figures 37-41) from 16 and 29 June. Water samples were taken at 2 m intervals on the 29 June, since the water was reasonably deep and the sample site was never exposed at low water.

Temperature results (figure 37) were incomplete for 1030-1230 hours (due to strong currents) and 1730-1930 hours (due to equipment failure). The trend shows an increase in temperature during ebb tide, with a probable maximum around low water. This can be attributed to movement of tidal water over the local mudflats (Bousfield and Leim 1959) and surface heating. Vertical homogeneity is observed and any variations are due to vertical eddy generated turbulence.

Results from light penetration data illustrated that the depth of 5% penetration was very notably greater than 29 May sample site. The maximum (c.6 m) occurred at 0900 hrs (H.W.) and progressively decreased to a low water minimum (1415-1515 hours,c. 2 m). This trend was reversed with the flooding tide, and a record maximum occurred on the subsequent H.W. The depth of 5% penetration however was not as extensive during flood phase as compared to the ebb phase.

Currents during the flood phase are generally greater than during the ebb phase (MacMillan 1966), this results in increased turbulence during the flood phase. This increased turbulence causes lesser light penetrations (Amos 1978). These patterns are reflected in the secchi disc readings (see figure 38).

Light penetration data were associated with T.P.C., S.P.M. and size distribution analyses. Data for T.P.C. illustrate the well mixed nature of the water column near Longspell Point during a tidal cycle. Values were lowest during the late evening high tide, while highest values were noted around low water. This was expected in consideration of gravity settling effects and the decreased volume of water during slack, low tide. River water and lateral movement of materials from the local mudflats undoubtedly contribute to this suspended material. Some inconsistencies are apparent, as in the bottom sample taken at 1630 hours. In this case the extremely high count resulted from the water sampler hitting the substrate (also see figure 41).

S.P.M. data (see figure 40) showed trends similar to those noted in the T.P.C. results. Total mass of suspended materials was greatest around low water, and least near the time of high tide. Values showed some increase during the mid flood phase. Again, inconsistencies such as the bottom depth value at 1930 hours suggest inclusion of substrate material.

Current datawere insufficient for more rigorous quantitative analysis. Personal observations clearly indicated that local currents here were markedly greater than at other sample sites, and that flow patterns are extremely complex (see figure 6).

Again current readings could only be expressed as relative values from a flowmeter. These are presented in figure 41 however surface values were not sufficient to illustrate the true extent of local currents. Wind speed data have not been recorded since tidal currents are the dominant force in this kind of estuary. It should be noted that the most pronounced currents were associated with a shift towards a larger particle size distribution range (8-10 μ, see figure 41, population graphs). Mid-flood observations also indicated an increased population of larger particle size, since maximum velocities would occur over this time. However at high tide (eg 1830-1930 hrs) smaller size ranges (3-4 μ) were dominant. This reflects gravity settling as tidal current velocities are reduced.

Figure 37. Temperature results at 2 m, 1 hr intervals, 29 June Time-Depth Study.

Symbols as in Figure 29 to 30.

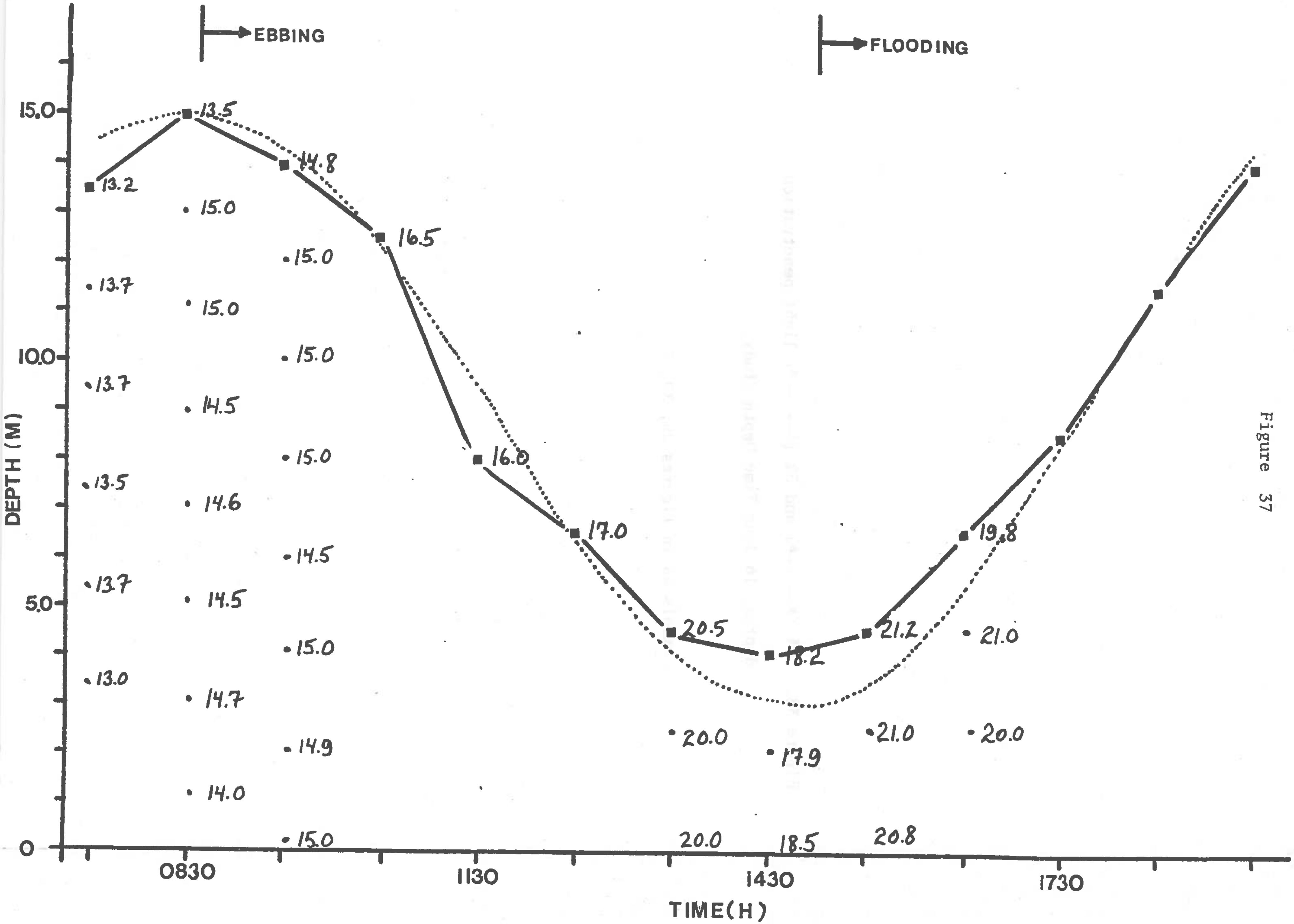

EBBING
FLOODING
DEPTH (M)
TIME(H)
15.0
10.0
5.0
0
0830
1130
1430
1730
13.2
13.5
14.8
16.5
16.0
17.0
20.5
18.2
21.2
19.8
13.7
13.7
13.5
13.7
13.0
15.0
15.0
14.5
14.6
14.5
14.7
14.0
15.0
15.0
15.0
14.5
15.0
14.9
15.0
21.0
20.0
17.9
21.0
20.0
20.0
18.5
20.8

Figure 37

Figure 38. 25% (▲-----▲) and 5% (△-----△) light penetration depths, 16 June Time-Depth Study.

symbols as in figures 29, 30, 31.

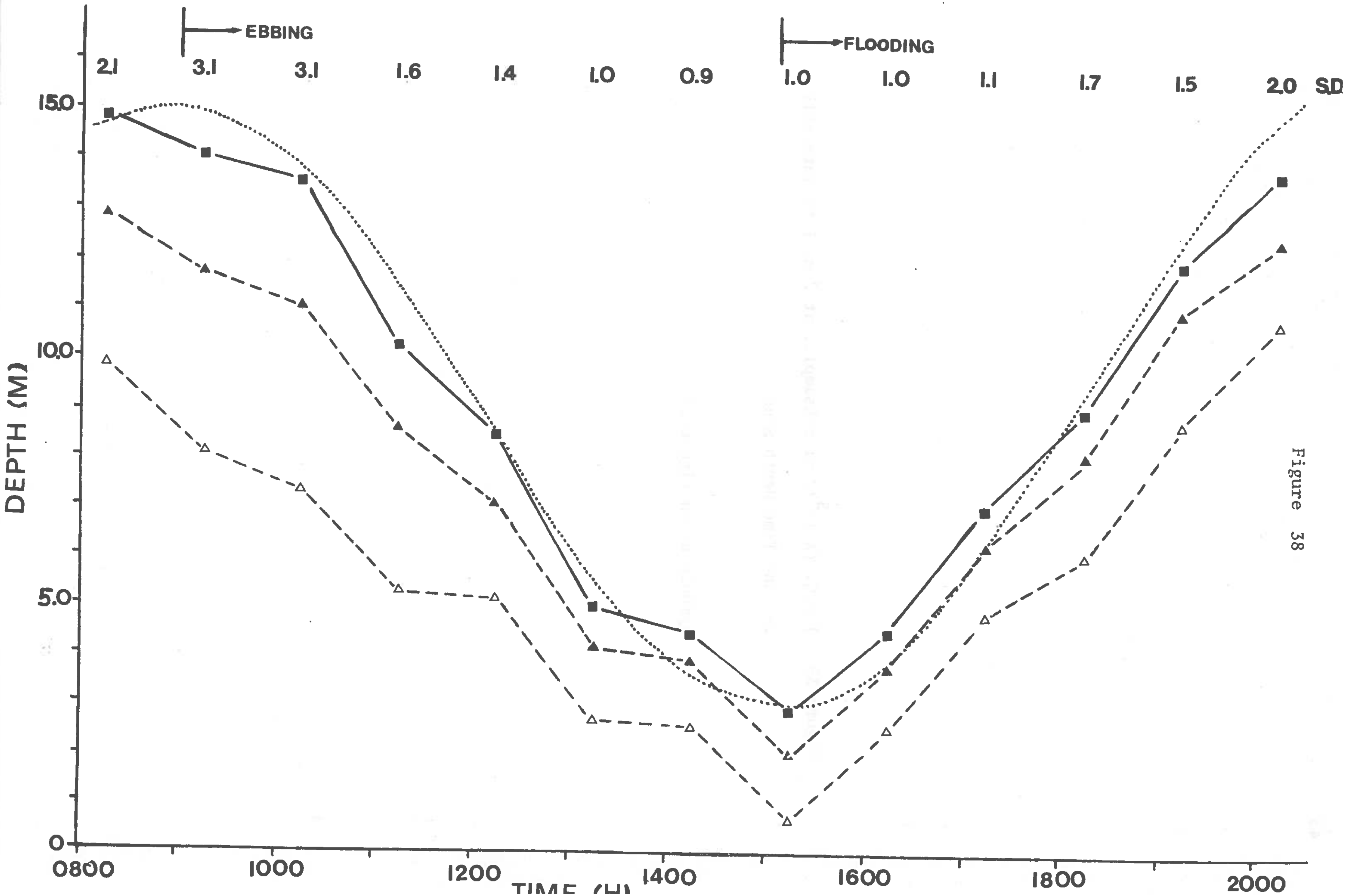
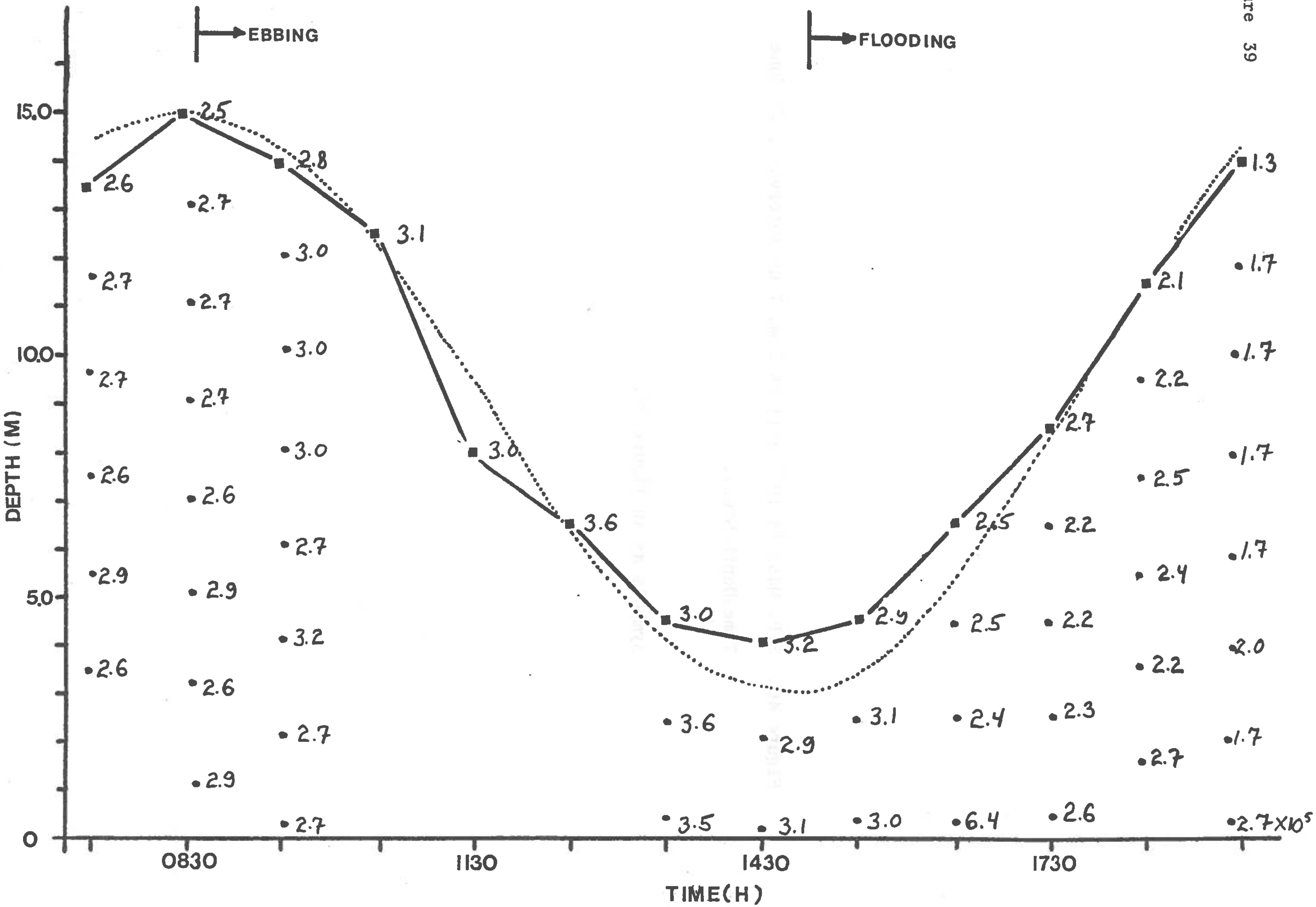

EBBING
FLOODING
2.1 3.1 3.1 1.6 1.4 1.0 0.9 1.0 1.0 1.1 1.7 1.5 2.0 SD
15.0
10.0
5.0
0
DEPTH (M)
0800 1000 1200 1400 1600 1800 2000
TIME (H)

Figure 38

Figure 39. T.P.C. (X 10^5/2 ml subsample) at 2 m, 1 hr intervals, 29 June Time-Depth Study.

symbols as in figure 29.



EBBING
FLOODING
15.0
10.0
5.0
0
DEPTH (M)
0830
1130
1430
1730
TIME(H)
2.6
2.7
2.7
2.6
2.9
2.6
2.5
2.7
2.7
2.7
2.6
2.9
2.6
2.9
2.8
3.0
3.0
3.0
2.7
3.2
2.7
2.7
3.1
3.0
3.6
3.0
3.6
3.5
3.2
2.9
3.1
2.9
3.1
3.0
2.5
2.5
2.4
6.4
2.7
2.2
2.2
2.3
2.6
2.1
2.2
2.5
2.4
2.2
2.7
1.3
1.7
1.7
1.7
1.7
2.0
1.7
2.7X10^5

Figure 39

Figure 40. S.P. Mass (X 10^{-2} g/l) at 2 m, 1 hr intervals, 29 June Time-Depth Study.

symbols as in figure 29.

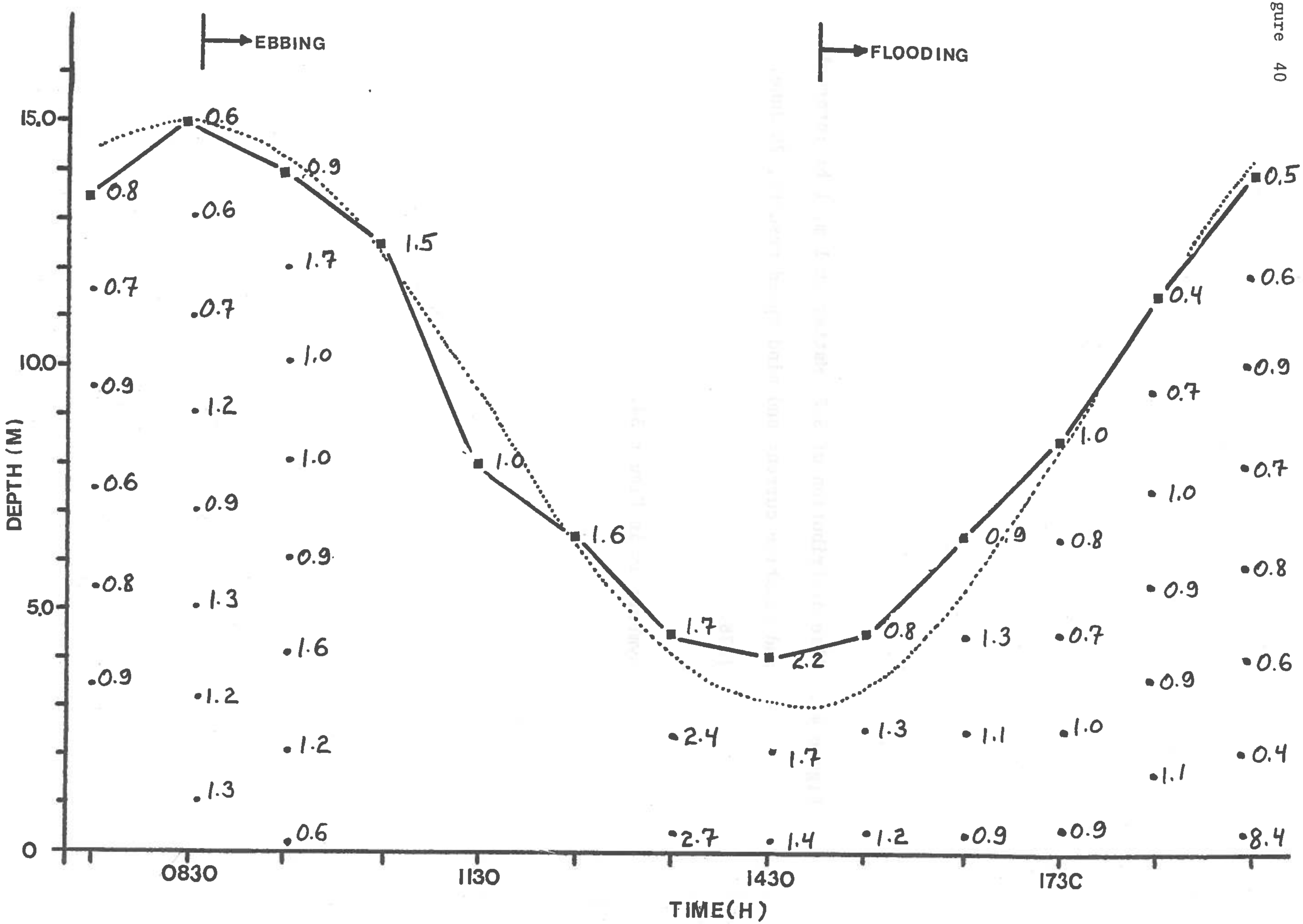

EBBING
FLOODING
DEPTH (M)
15.0
10.0
5.0
0
0830
1130
1430
173C
TIME(H)
0.6
0.8
0.6
0.9
0.7
0.7
1.7
1.5
1.0
0.9
1.2
1.0
1.0
0.6
0.9
1.6
0.9
0.8
1.3
1.6
0.9
1.2
1.2
1.3
0.6
1.7
2.2
0.8
0.9
1.0
0.4
0.5
0.6
0.9
0.7
0.7
1.0
0.8
0.8
0.9
1.3
0.7
0.6
0.9
2.4
1.7
1.3
1.1
1.0
0.4
1.1
2.7
1.4
1.2
0.9
0.9
8.4

Figure 40

Figure 41. Size distribution of S.P. Matter at 1 m, 1 hr intervals, and relative current and wind speed results, 29 June, 1978.

symbols as in Figure 34.

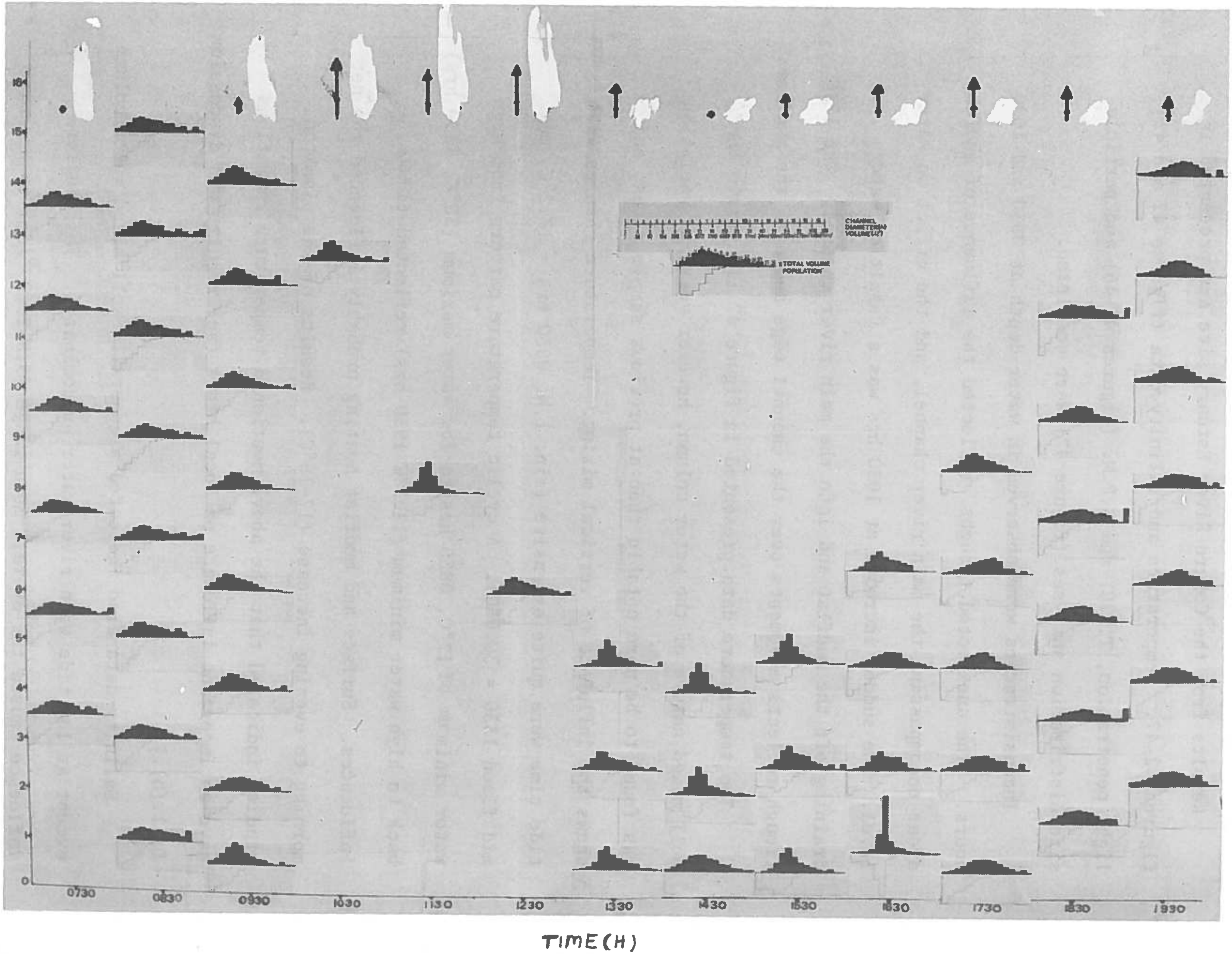

DEPTH(m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
0730
0830
0930
1030
1130
1230
1330
1430
1530
1630
1730
1830
1930
TIME(H)
CHANNEL
% TOTAL VOLUME
POPULATION

Figure 41

Results from the Canard River Estuary site are presented in figures 42-47. Temperature and salinity data (figures 42 and 43), light penetration, T.P.C. and S.P.M. (figures 44-46) and particle size distribution analyses (figure 47) were completed.

Inconsistencies were observed in water depth at 0930 and 1630 hours. The unexpected troughs reflected the influence of mudflat areas encompassing the main river channel, and the effect on water level. The sudden increase at 1030 hrs was a result of water draining off the mudflat and into the main river channel. The 1730 trough reflects movements over the channel edge and onto the mudflats.

The temperature data presented in figure 42 illustrate the well mixed nature of the water column, however vertical variation was found to be more notable than at previous sample sites, and shows the influence of vertical mixing. Temperature changes with tide time were quite extensive (min. L.W. 0830 hrs = 17.2°C, max. mid flood 1330 = 30.0°C). A cyclic temperature pattern from high water minimum of 17°C, 0830 hrs to low water maximum (30°C, 1330 hrs) back to high water minimum (18.3°C 1930 hrs) reflected tidal influences. Surface and mudflat heating probably influenced the net morning to evening increase (17-18°C). Results of the plankton studies indicated that the above mentioned temperature variations have an important influence on local biota (see results and discussion II 1.(b).).

Salinity data also indicated a generally well mixed water column except at low tide when river water predominated. This latter influence caused the overall mean range (9.8-26.9 $^{o}/oo$) to be quite extensive. Again vertical inconsistencies probably reflected current patterns and the generation of vertical eddy currents and associated turbulent pockets. As expected, the highest values were recorded at 1930 hrs (high, slack water). The vertical gradation toward decreased salinity (28-25 ^{o}/oo) at that time probably indicated the influence of the underlying river channel. Variations in mean salinity showed that maximum and minimum values occurred at high and low tides respectively.

Light penetration data is illustrated in figure 44. It was noted that penetration during the flooding tide was again lower than during the ebb tide (see Time-Depth Study for 16 June). The minimal depth of 5% penetration occurred around low tide. At this time the water was so turbid that secchi disc readings were not possible (eg. 1230-1330 hrs). Maximum penetration was recorded at 1930 and 2030 hours (high tide) and probably reflected the effects of gravity settling within a diminishing water volume to decreased current speeds. This maximum depth of 5% penetration was comparable to the value determined during the 20 June study (see Results and Discussion I.3.). The maximum secchi disc reading was also recorded at 2030 hours. A correlation between photometer measurements and secchi disc values was not determined, however the qualitative relationship is very clear.

Data for total particle count showed trends similar to those encountered in previous Time-Depth Studies (eg. max. low tide, 1330 hrs = 35.0×10^5, min. high tide 1930 hrs = 3.2×10^5). The extent of this range was probably exaggerated by the necessary dilution of low tide samples. The very high counts noted at low slack water show the importance of movements of suspended particulate matter from the River mudflats and saltmarshes to the Basin proper; these particles become very concentrated at low water as the depth and currents decrease. Although some vertical changes were noted the water column was generally well-mixed. The only exceptions were the surface and 1 m samples collected at 1530 hours, but these were probably due to wind action and surface stirring (see figure 47 (wind speeds and Cornwallis River Study (b)). The high values determined for low water were also reflected in light penetration results (see figure 44). It was also noted that T.P.C. during the ebb tide was less than that during flood tide. This was associated with the higher current velocities during flood tide.

Trends for suspended particulate mass were similar to those discussed for T.P.C. The maximum was encountered at 1330 hrs (16.7 X 10^{-2} g/l) while the minimum was at 2130 hrs (1.1 X 10^{-2} g/l). The very high values determined for some of the bottom samples (eg 0930 hrs, 2030 hrs) probably included substrate sediments (see previous discussions) and were not included in the calculation of mean (hourly) values. Vertical distribution of S.P.M. values prior to high tide (eg 1730 and 1830 hours) showed the effects of gravity settling; however the water column was quite well mixed around slack high tide (± 1 hour of high tide). The latter situation indicated complete settlement of larger particles.

Particle size distribution was difficult to interpret and probably reflected the diverse nature of the underlying substratum and surrounding region (eg mudflats, River channel, salt marshes see figure 4). Notable changes in the consistency of the mudflats were noted (eg mud to sand). Nevertheless the general trend towards smaller particle size ranges was evident in samples collected around slack (high) tide (eg 1830-2030 hours).

Figure 42. Temperature results at 1 m, 1 hr intervals, 13 July Time-Depth Study.

symbols as in figures 29 and 30.

Figure 42

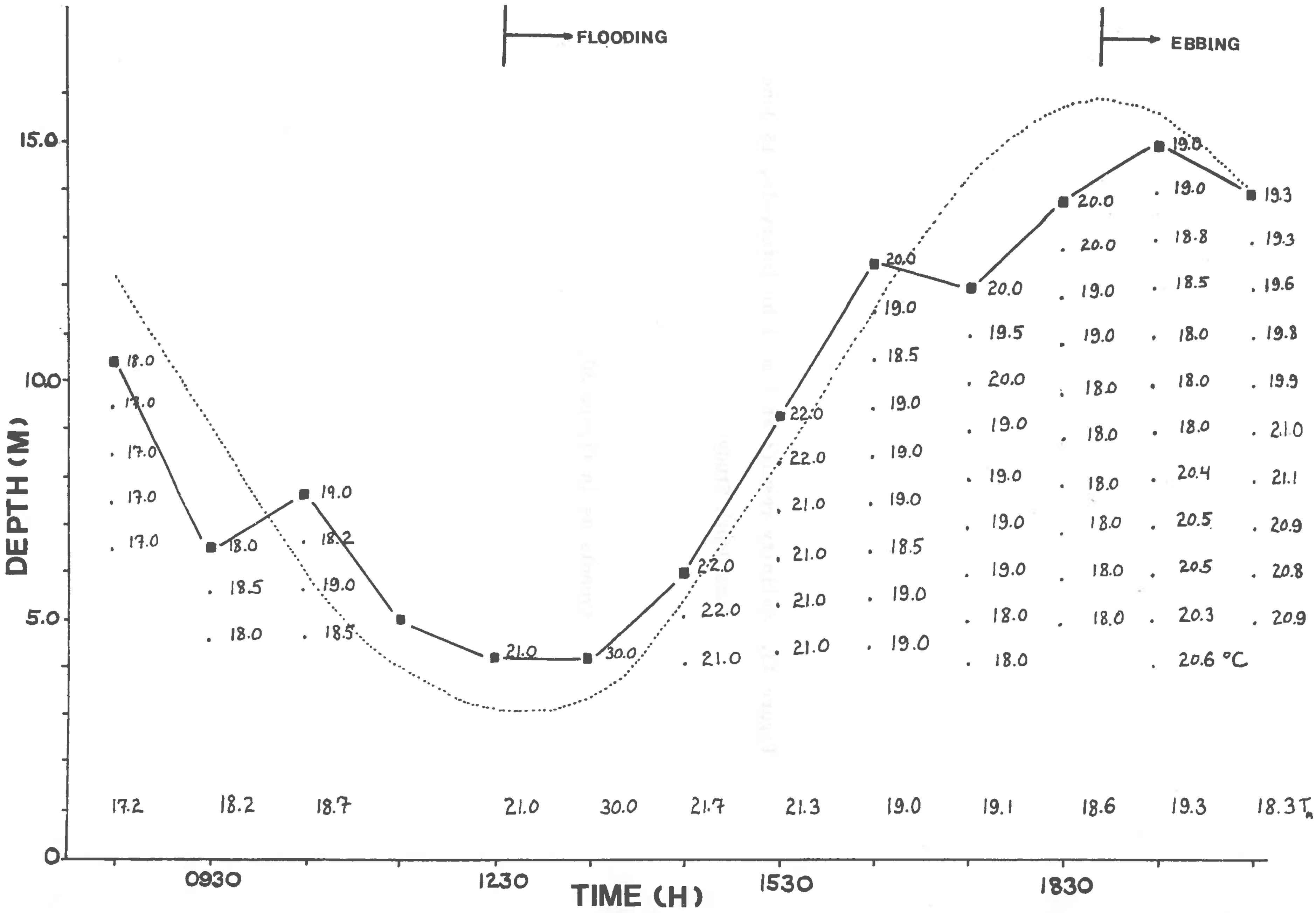

FLOODING
EBBING
DEPTH (M)
TIME (H)
15.0
10.0
5.0
0
0930
1230
1530
1830
17.2
18.2
18.7
21.0
30.0
21.7
21.3
19.0
19.1
18.6
19.3
18.3 T_n
20.6 °C

Figure 43. Salinity results at 1 m, 1 hr intervals, 13 June Time-Depth Study.

symbols as in figure 30.

Figure 43

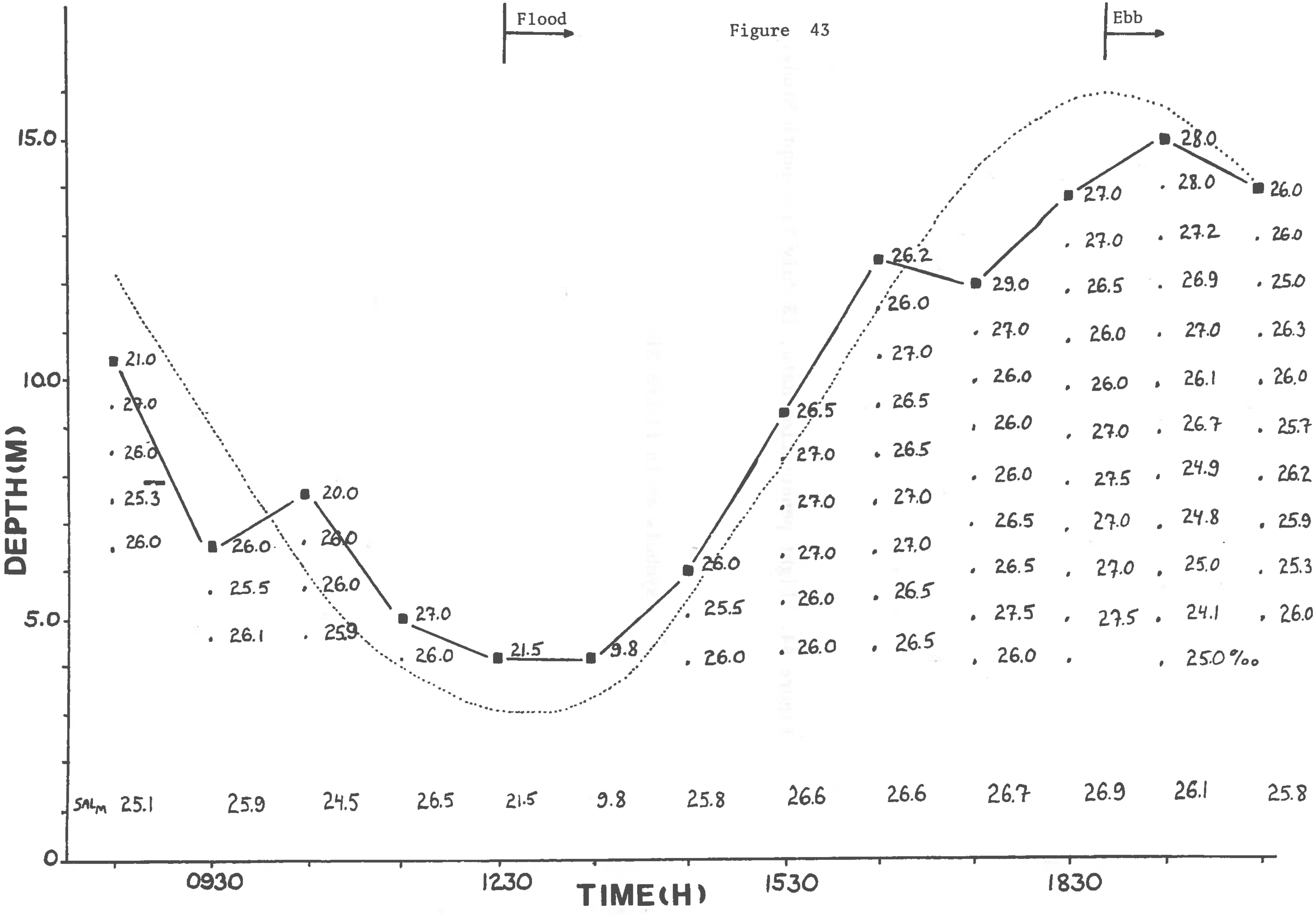

Flood
Ebb
DEPTH(M)
TIME(H)
15.0
10.0
5.0
0
0930
1230
1530
1830
SALm
25.1
25.9
24.5
26.5
21.5
9.8
25.8
26.6
26.6
26.7
26.9
26.1
25.8
25.0‰

Figure 44. Light penetration data, 13 July Time-Depth Study.

symbols as in figure 31.

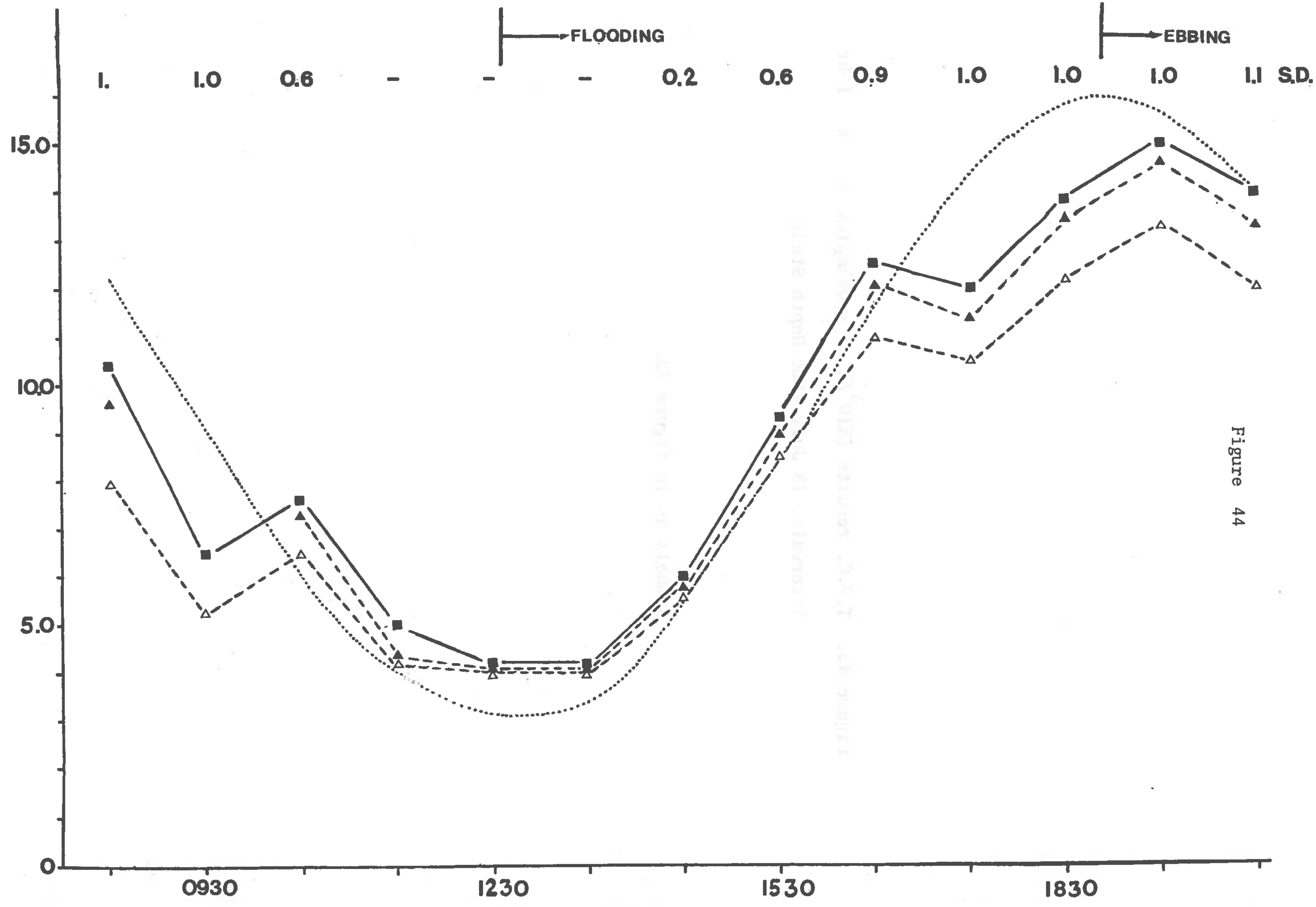
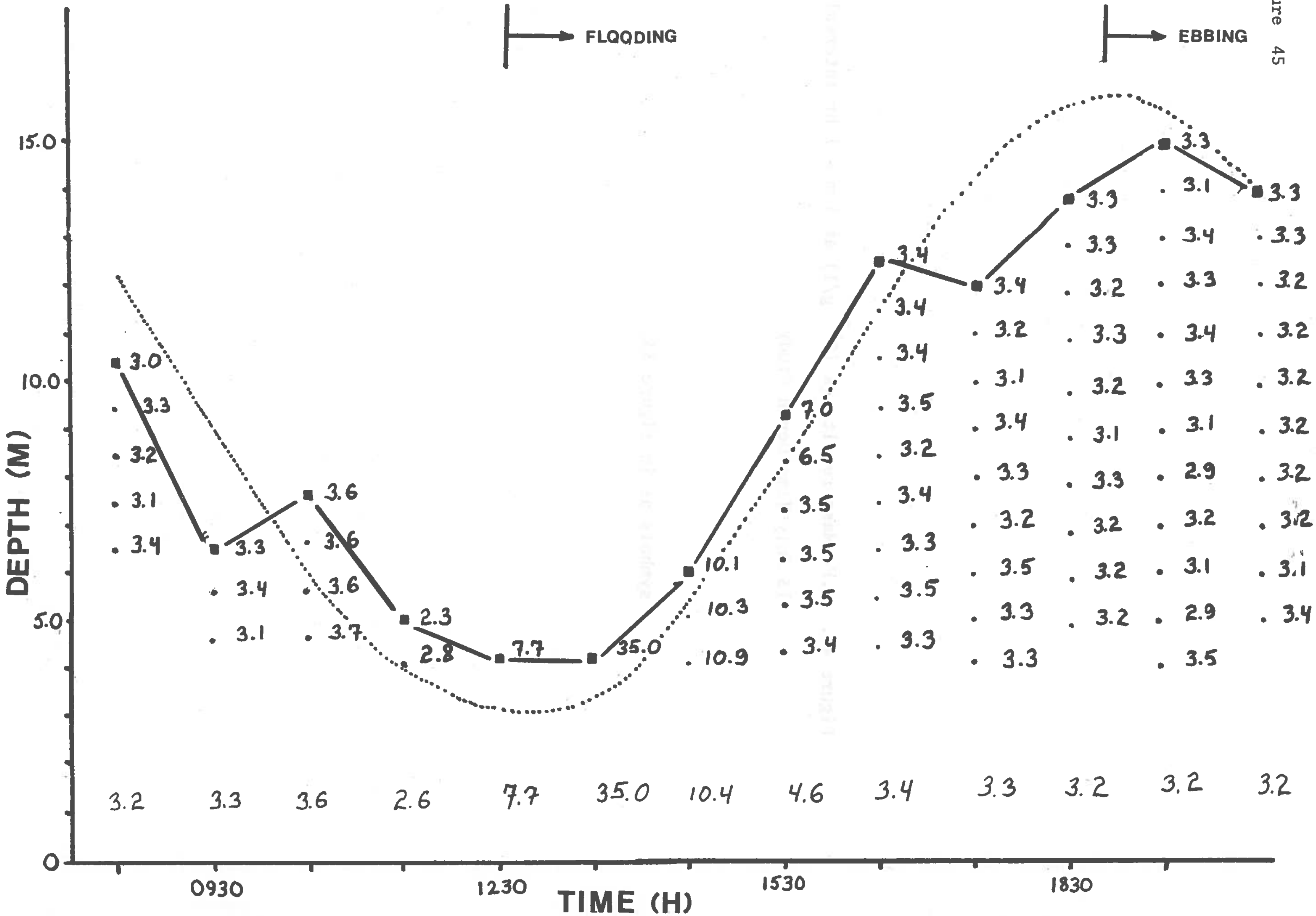

FLOODING
EBBING
1. 1.0 0.6 - - - 0.2 0.6 0.9 1.0 1.0 1.0 1.1 S.D.
15.0
10.0
5.0
0
0930
1230
1530
1830

Figure 44

Figure 45. T.P.C. results (X10^5/2 ml subsample) at 1 m - 1 hr intervals, 13 July Time-Depth Study.

symbols as in figure 32.



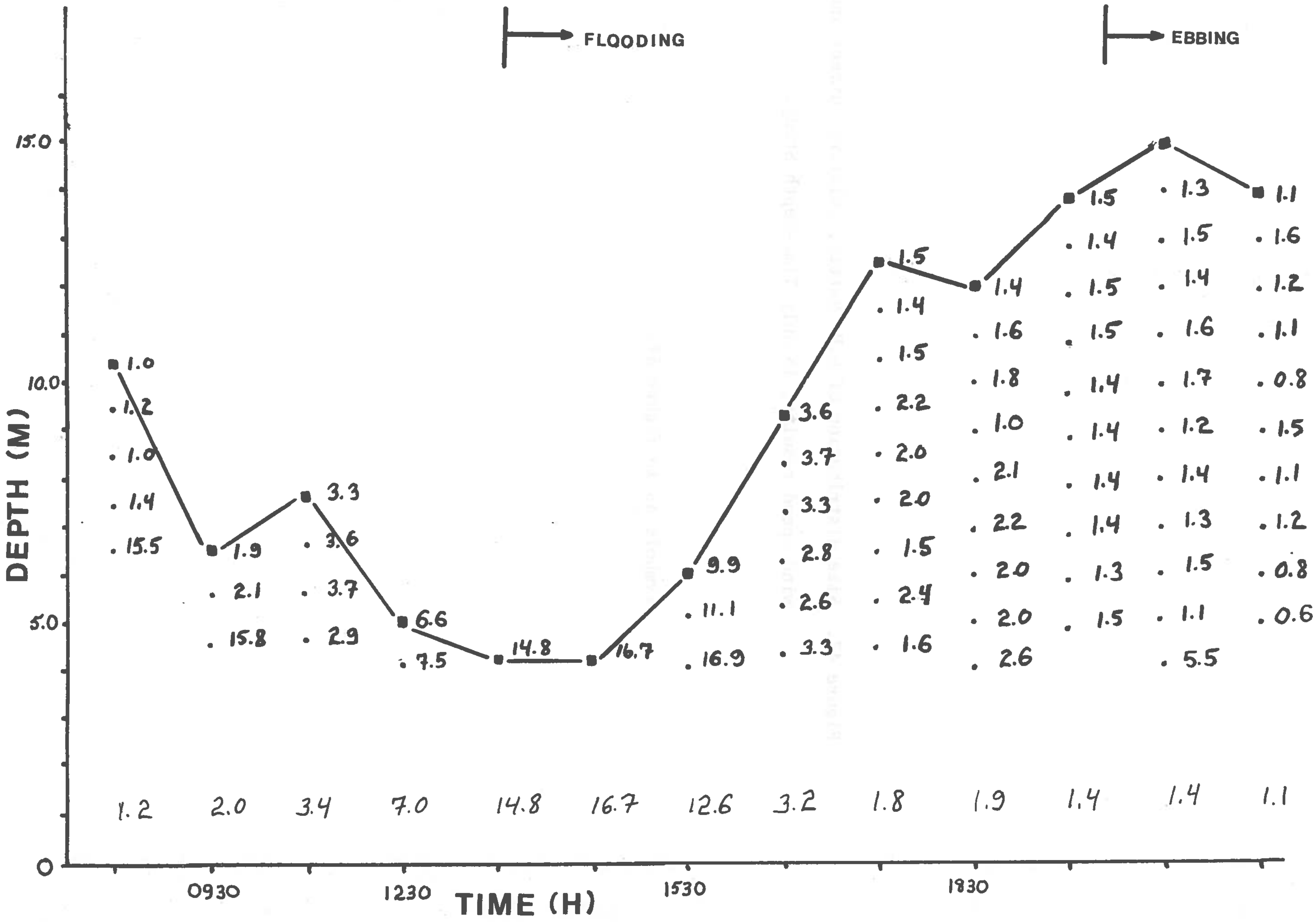
FLOODING
EBBING
DEPTH (M)
TIME (H)
15.0
10.0
5.0
0
0930
1230
1530
1830
3.0
3.3
3.2
3.1
3.4
3.3
3.4
3.1
3.6
3.6
3.6
3.7
2.3
2.8
7.7
35.0
10.1
10.3
10.9
7.0
6.5
3.5
3.5
3.5
3.4
3.4
3.4
3.4
3.5
3.2
3.4
3.3
3.5
3.3
3.4
3.2
3.1
3.4
3.3
3.2
3.5
3.3
3.3
3.3
3.3
3.2
3.3
3.2
3.1
3.3
3.2
3.2
3.2
3.3
3.1
3.4
3.3
3.4
3.3
3.1
2.9
3.2
3.1
2.9
3.5
3.3
3.3
3.2
3.2
3.2
3.2
3.2
3.2
3.1
3.4
3.2 3.3 3.6 2.6 7.7 35.0 10.4 4.6 3.4 3.3 3.2 3.2 3.2

Figure 45

Figure 46. S.P. Mass results (X 10^{-2} g/l) at 1 m - 1 hr intervals, 13 July Time-Depth Study.

symbols as in figure 33.

Figure 46



FLOODING
EBBING
DEPTH (M)
15.0
10.0
5.0
0
TIME (H)
0930
1230
1530
1830
1.2
2.0
3.4
7.0
14.8
16.7
12.6
3.2
1.8
1.9
1.4
1.4
1.1

Figure 47. Size distribution of S.P. Matter, relative current and wind speed results, 13 July Time-Depth Study.

symbols as in figure 34.

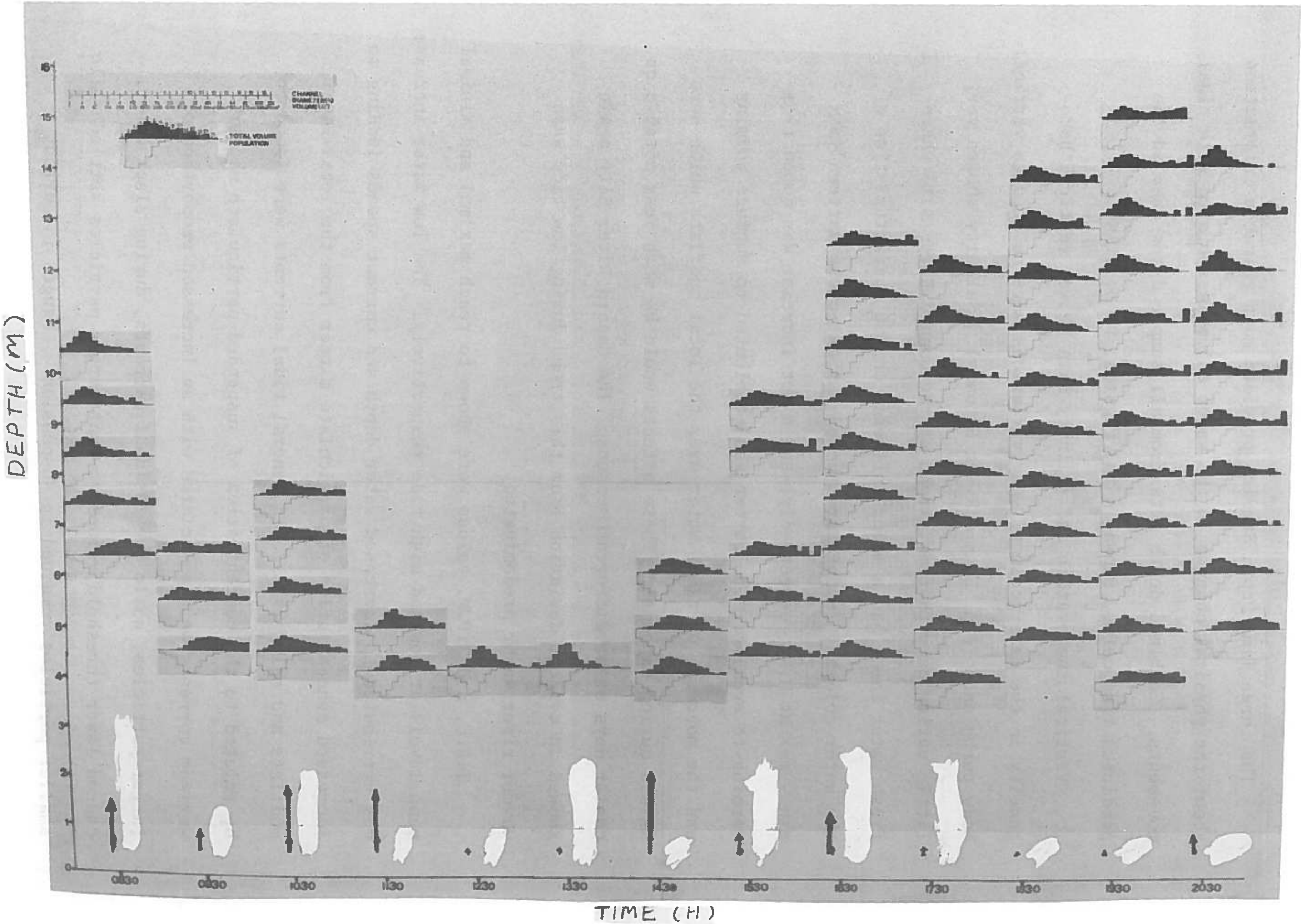

DEPTH (M)
TIME (H)
0830
0930
1030
1130
1230
1330
1430
1530
1630
1730
1830
1930
2030
TOTAL VOLUME
POPULATION

Figure 47

The three Time-Depth Studies provided much valuable information about the physical changes in the water column associated with tidal movements. Combined depth data from all sample dates enabled the predicted tide curve, shown in the figures, to be drawn.

Vertical temperature and salinity data showed vertical homogeneity in the water column. Any variations were related to vertical eddy turbulence (esp. Canard River Estuary). Salinity showed very little variation with time except at the Canard River site where fresh water input had a major influence on the characteristics of the water column. Temperature showed a tidal cycle pattern (max - min - max at H.W. respectively) and a net increase was noted from morning to evening. The latter was attributed to surface warming and the movement of tidal water over the local mudflats which were warmed during exposure. These effects would be much less notable on cooler days or at different seasons. The Canard River Site again showed an evident deviation from this trend during low tide when warmer river water predominated.

T.P.C. and S.P.M. values were shown to reach maximal and minimal mean levels at low and high tide respectively. The low water increase was attributed to decreased water depth and current speeds leading to increased concentration of particulate matter from the local River, mudflats and saltmarshes. In general tidal currents were found to be related to the concentration of suspended particulate matter. Maximum currents were associated with an increased proportion of larger particles, while the residual currents, during slack water, caused lower threshold values so that larger particles settled while smaller particles remained in suspension. Changes in current velocities were associated with the changes in particle size distribution, lower current velocity being associated with lower threshold velocity and gravity settling. Those sample series collected near the Cornwallis and Canard River mouths exhibited a much greater range than the Longspell Point sample site. Electromicrographs and Coulter Counter analysis used here successfully to illustrate changes in particle size distribution and concentration.

This study indicated that various localities in the S.W. bight of the Minas Basin can be identified according to characteristic patterns of physical and chemical properties associated with the tidal cycle. Results from this study suggest that some regions are River dominated (eg Canard River Estuary), and show marked ranges in various physical and chemical parameters; other tidally dominated regions tend to show much less variation and adhere more closely to predicted values; while regions such as the Wolfville salt marsh site are somewhat intermediate between these two extremes.

Although the data presented is not complete they have provided very interesting baseline information upon which future studies may be developed. Future work should include more precise current data from different locations, depths, tide states and seasons. Thermograph data such as that accumulated during the summer (see section I. 3.) should be analyzed and this kind of information should be gathered over extended time periods. This kind of physical and chemical information is critical to the understanding of the ecology and biology of this unique region.

3. GENERAL PHYSICAL AND CHEMICAL FEATURES OF THE SOUTH-WESTERN BIGHT OF THE MINAS BASIN.

Objectives. (a) The aim of this study was to examine some physical and chemical features of the South-western Minas Basin. Local and seasonal aspects of depth, temperature, salinity, light attenuation and suspended particulate matter were considered.

(b) This study was intended to examine light penetration patterns in the Habitant, Canard, and Cornwallis River estuaries. Overall trends in this region were reviewed.

Methods. (a) Field. Twenty sites in the Southwestern bight of the Minas Basin were sampled between 17 May and 3 August 1978 (see figures 1, 2 and 49). All samples and measurements were taken within 1 1/2 hours of high tide. Time and depth were recorded at each station, a 1L water sample was collected, and where possible temperature and salinity were measured immediately with a Y S I S-C-T meter. Temperature was also recorded on a Ryan Model J thermograph left at Station B from June to 30 August, 1978. Water samples from mid and bottom depths were collected with a 2.1 L Kemmerer or 1L Knudsen sampler at a few randomly selected stations. Secchi disc readings were also recorded. Water samples were stored in a constant temperature cold room at 10°C and analyses were carried out within 48 hours. Subsamples were analyzed for total particle count (T.P.C.) and particle size distribution using the Coulter Counter Model TA II (see Cornwallis River and Time-Depth Studies). With few exceptions the subsamples were left undiluted.

Water samples were filtered through Nuclepore membranes using Millipore (T.M.) apparatus. The volumes filtered depended on visual concentration of suspended material, and filters were dried, weighed and stored as in the Cornwallis River and Time-Depth Studies.

On June 20, twelve sites in the Habitant and Canard River estuaries were sampled, and sixteen in the Cornwallis River estuary were sampled on 25 July (see figure 52). A Kahlsico submarine photometer was used to measure light penetration at .5 m intervals at each station. All visits took place within 1 1/2 hours of high tide and readings were taken by the same person. Secchi disc readings were recorded for the 20 June session and depth was measured at each site. The latter was corrected to a high tide value based on the normal depth curve determined by the Time-Depth studies.

(b) Physical and chemical parameters of various sites from Delhaven to the Minas Channel were also studied (see figure 54), but these sites were not visited on a regular basis. A 36' fishing vessel operated by Mr. Glen Travis was rented for this purpose through NRC Operating Grant 9697. Samples and measurements were performed as in the main study region (see above).

Results. (a) Results for the main study area (figure 1) are presented in tables 2 and 3 and figures 49-51 and 53. Table 2 shows depth (uncorrected), temperature, salinity, total numbers and weights of suspended particulate matter, and secchi disc readings on the different sample dates throughout the season. Table 3 presents similar data according to location. Sample time relative to high tide is also indicated. Figure 49 is a graph illustrating the mean temperature changes throughout the sample season. Figure 40 includes mean secchi disc readings at 14 of the sample stations. Figure 51 shows particle size distribution graphs for 21-VII sample sites. Penetration data is presented in figure 53.

Tables 1 and 2 illustrate both local and seasonal variations in the physical and chemical parameters considered. Temperature increased considerably during the sample season (see figure 49) and showed noticeable variation between sample sites (table 3). Variations with tide time were also recorded at station B where the thermograph operated constantly for two months. Thermograph records have not yet been analysed.

Salinity showed some seasonal variations, however local differences were more notable. The Cornwallis River estuary sites (especially A and B) were most notably influenced by fresh water input, other stations also showed decreased salinities at times (eg. stations I, J, L and Q). The latter stations show the influence of the Habitant and Canard Rivers.

Suspended particulate matter showed considerable variation, particularly at station A where total counts/2 ml subsample were consistently greater than 100,000. This was not unexpected since S.P.M. was found to increase upstream (see Cornwallis River Study), however dilution of the water samples may have exaggerated these results (eg. 3:1 dilutions were used for analysis of station A samples while most other samples were undiluted). Ranges in T.P.C. at different locations during the sample season were not extensive. Although they appeared to show a tendency to increase over the sample season, inconsistencies were frequent and imply that local hydrographic and weather conditions were very important. This is especially true for surface samples (see Cornwallis River Study (b)). Vertical distribution of suspended particles was examined at some of the stations and results indicated that Basin water is quite well mixed. Little variation in the T.P.C.

was noted between surface, mid and bottom depth samples from particular sites (see table 2, sites A,B,D,I,L,Q). This was expected in view of the results of Time-Depth Studies. The data for total suspended particle mass are not complete, however these data showed more marked variation than those for T.P.C. This was expected since total weights depend on the size distribution (vs total number) of particles and since the volume of water filtered varied from sample to sample.

Particle size distribtuion data are presented in figure 49. These represent samples collected at 10 sample sites on 21 June. Station 0 is the only deep water station which is predominantly influenced by tidal water. The size distribution graph (population per size channel) clearly illustrates the predominance of smaller size range of particles (peak in channel 2 : 3-5μ). Stations I, L and B which are predominantly river influenced showed a notable shift to larger particle size peaks (eg. channels 4 and 5, 6-10μ). Some vertical variations were noted (stations I, R) however these were not as marked as locational variation. Data such as these illustrated the well mixed nature of Basin water, as well as the importance of River input to the physical and chemical characteristics of the study area.

Figure 48. Location of 20 sample sites in main study region, May-August 1978.

salt marsh

dyke land

main river channel

Figure 48

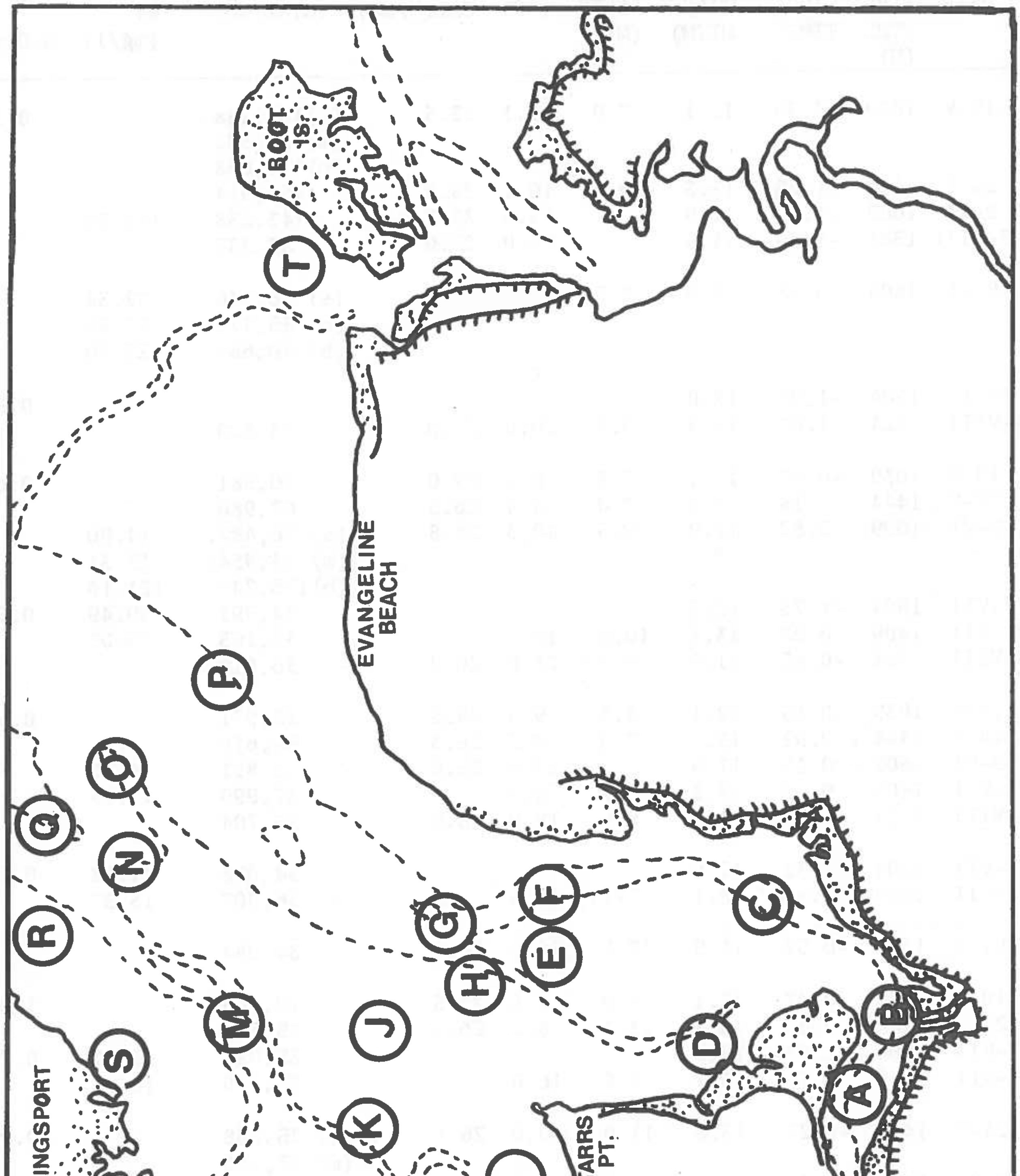

BOOT IS.
EVANGELINE BEACH
KINGSPORT
STARRS PT.
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T

Table 2. Physical and Chemical Results of Main Study area according to location.

SITE	DATE	TIDE TIME (H)	SAMPLE TIME	TIDE HT(M)	DEPTH (M)	(°C)	SAL(‰)	TOTAL NO.	WT (mg/l)	S.D.(M)
A	19-V	1039	-0.90	12.1	7.0	11.1	23.5	(s)107,238		0.3
								(m)101,522		
								(b)114,058		
	24-V	1444	-1.65	13.3	9.8	10.1	25.8	161,914		
	9-VI	1609	-1.15	11.9		15.5	23.2	143,538	109.56	
	3-VIII	1324	-1.40	11.9		20.0	25.0	33,387		
B	9-VI	1609	-0.95	11.9	8.5	13.5	24.8	(s) 36,046	32.38	
								(m) 35,472	77.96	
								(b) 40,685	25.70	
C	7-VII	1504	-1.07	12.0						0.8
	3-VIII	1324	-1.07	11.9	9.0	20.0	27.0	34,820		
D	19-V	1039	-0.40	12.1	7.5	9.0	29.0	20,981		0.6
	24-V	1444	-1.18	13.3	7.0	9.9	26.5	67,986		
	9-VI	1609	-0.82	11.9	9.5	12.3	26.8	(s) 36,484	14.90	
								(m) 34,954	15.31	
								(b)175,240	121.16	
	7-VII	1504	-1.73	12.0				34,991	30.49	0.6
	21-VII	1409	-0.23	13.1	10.0	16.5		35,105	13.05	
	3-VIII	1324	-0.85	11.9	9.5	21.0	26.2	35,016		
E	19-V	1039	-0.15	12.1	4.5	9.5	25.5	22,971		0.5
	24-V	1444	-0.92	13.3	7.3	9.3	26.3	55,616		
	9-VI	1609	-0.15	11.9		13.0	25.0	32,851	4.93	
	21-VII	1409	-0.57	13.1	5.9	16.0		37,999	17.65	
	3-VIII	1324	-0.73	11.9	9.0	18.0	28.0	33,704		
F	7-VII	1504	-1.32	12.0				34,638	41.88	0.6
	21-VII	1409	-0.82	13.1	17+(?)	16.5		36,007	15.37	
G	3-VIII	1324	-0.52	11.9	12.5	20.5	26.8	34,084		
H	19-V	1039	+0.27	12.1	8.0	8.6	25.5	19,945		1.0
	24-V	1444	-0.65	13.3	13.3	8.6	26.5	35,521		
	7-VII	1504	-2.07	12.0				35,054	22.07	0.7
	21-VII	1409	-1.15	13.1	5.9	16.0		32,495	10.81	
I	24-V	1444	+0.27	13.3	11.0	10.0	26.1	(s) 25,838		0.9
								(m) 27,156		
	9-VI	1609	-0.65	11.9	6.7			9.694	3.51	
	23-VI	1514	-1.10	13.2	6.2	16.5	23.1	34,133	83.02	0.7
	7-VII	1504	-1.58	12.0				33,784	17.62	
	21-VII	1409	-0.48	13.1	5.5	19.5	26.5	(s) 36,079	27.12	0.6
								(m) 37,310	22.19	
								(b) 34,302	24.68	
	3-VIII	1324	-0.82	11.9	5.5	18.6		32,256		0.9

Table 2 (continued).

SITE	DATE	TIDE TIME (H)	SAMPLE TIME	TIDE HT(M)	DEPTH (M)	(°C)	SAL(°/oo)	TOTAL NO.	WT (mg/l)	S.D.(M)
J	23-VI	1514	-1.57	13.2	7.0	15.0	23.8			1.0
	21-VII	1409	-0.65	13.1	5.5	18.0	26.7	32,998	16.08	
K	17-V	0859		11.7	4.5	10.0	26.1	25,091		0.8
	7-VII	1504	-1.82	12.0				30,851	12.42	
L	17-V	0859	-0.23	11.7	6.5	11.0	26.0	(s) 19,843		1.2
								(m) 20,846		
								(b) 22,339		
	24-V	1444	+0.60	13.3	8.8	9.5	26.3	25,838		-.6
								(s) 27,156		
	23-VI	1514	-0.62	13.2	5.2	18.0	24.1	(m) 34,311	124.9	0.9
	7-VII	1504	-1.88	12.0				31,264	15.22	
	21-VII	1409	-0.32	13.1	14.4	17.0		32,858	10.97	
	3-VIII	1324	-0.57	11.9	9.0	18.9		32,256		1.2
M	17-V	0859		11.7		9.5	26.0	18,201		1.2
	3-VIII	1324	-0.32	11.9	7.3	17.1		28,052		1.5
N	7-VII	1504	-0.82	12.0				22,869	7.53	
O	17-V	0859		11.7		8.2	26.5	15.407		
	21-VII	1409	-0.82	13.1	14.0	17.0	26.0	29,538	9.20	1.5
P	23-VI	1515	-0.03	13.2	14.0	12.0	26.0	20,106	8.48	1.6
Q	24-V	1444	-1.23	13.3	11.0	8.0	26.5	(s) 21,006		1.3
								(m) 24,934		
	9-VI	1609	+0.35	11.9	14.6			14,138	3.51	
	23-VI	1414	-0.32	13.2	15.0	12.2	21.1	28,603	21.4	1.6
	7-VII	1504	-1.07	12.0				22,034	8.52	
	21-VII	1409	-1.32	13.1	12.0	18.2	24.9	28,971	11.09	1.5
								30,934	11.89	
								30,866	16.9	
	3-VIII	1324	-1.15	11.9	11.5	17.0		24,215		
R	9-VI	1609	+0.60	11.9				15,139	1.77	
	3-VII	1324	-0.15	11.9	6+	17.1		15,992		1.5
S	9-VI	1609	-1.15	11.9	8.25			25,957	2.54	
T	24-V	1444	-0.73	13.3	7.0	9.5	26.3	(s) 26,853		0.8
								(m) 27,745		

(s) surface sample
(m) mid-depth sample
(b) bottom sample
S.D. Secchi Disc Depth

Table 3. Physical and Chemical Results of main study area according to date.

DATE	SITE	TIDE TIME (H)	SAMPLE TIME	TIDE HT(M)	DEPTH (M)	T(°C)	SAL (°/oo)	S.P.M. TOTAL NO.	S.P.M. WT(mg/l)	S.D.(M)
19-V	A	1039	-0.90	12.1	7	11.1	23.5	(s)107,238 (m)101,522 (b)114,058		0.3
	D		-0.40		7.5	9.1	29.0	20,981		0.6
	E		-0.15		4.5	9.5	25.5	22,971		0.5
	H		+0.27		8.0	8.6	25.5			1.0
17-V	K	0859	+0.18	11.7	4.5	10.0	26.1	25,091		0.8
	L		-0.23		6.5	11.0	26.0			1.2
	M		-0.73			9.5	26.0	18,201		1.2
	O		-1.40			8.2	26.5	15,407		
24-V	A	1444	-1.65	13.3	9.8	10.1	25.8	161,914		
	D		-1.18		7.0	9.9	26.5	67,986		
	E		-0.92		7.3	9.3	26.3	55,616		
	H		-0.65		13.3	8.6	26.5	35,521		
	I		+0.27		11.0	10.0	26.1	25,838		0.9
	L		+0.60		8.8	9.5	26.3	(s) 25,838 (m) 27,156		0.6
	Q		-1.23		11.0	8.0	26.5	(s) 21,006 (m) 24,934		1.3
	T		-0.73		7.0	9.5	26.3	(s) 26,853 (m) 27,745		0.8
9- VI	A	1609	-1.15	11.9		15.5	23.2	143,528	109.56	
	B		-0.95		8.5	13.5	24.8	(s) 36,046 (m) 35,927 (b) 37,529	32.38 77.96 48.08	
	D		-0.82		9.5	12.3	26.8	(s) 36,484 (m) 34,954 (b)175,240	14.90 15.31 121.16	
	E		-0.15			13.0	25.0	32,851	4.93	
	I		-0.65		6.7			9,694	3.51	
	Q		+0.35		14.6			14,138	3.51	
	R		+0.60					15,139	1.77	
	S		-1.15		8.25			25,957	2.54	
23-VI	I	1514	-1.10	13.2	6.2	16.5	23.1	34,133	83.02	0.7
	J		-1.57		7.0	15.0	23.8	24,801	7.45	1.0
	L		-0.68		5.2	18.0	24.1	34,311	124.9	0.9
	P		-0.03		14.0	12.0	26.0	20,106	8.48	1.6
	Q		-0.32		15.0	12.2	21.1	28,603	21.4	1.6
7-VII	C	1504	-1.07	12.0						0.8
	D		-1.73					34,991	30.49	0.6
	F		-1.32					34,638	41.88	0.6
	H		-2.07					35,054	22.07	0.7
	I		-1.58					33,784	17.62	

Table 3. (continued)

DATE	SITE	TIDE TIME (H)	SAMPLE TIME	TIDE HT(M)	DEPTH (M)	T(°C)	SAL (^{o}/oo)	TOTAL NO.	WT(mg/l)	S.D.(M)
7-VII (cont.)	K	1504	-1.82					30,851	12.47	
	L		-1.88					31,264	15.22	
	N		-0.82					22,869	7.53	
	Q		-1.07					22,034	8.52	
21-VII	B	1409	-0.02	13.1	14.4	17.0		40,685	25.70	
	D		-0.23		10.0	16.5		35,105	13.05	
	E		-0.57		5.9	16.0		37,999	17.65	
	F		-0.82		17+	16.5		36,007	15.37	
	H		-1.15		5.9	16.0		32,495	10.81	
	I		-0.48		5.6	19.5	26.5	(s) 36,079	27.12	0.6
								(m) 37,310	22.19	
								(b) 34,307	24.68	
	J		-0.65		5.5	18.0	26.7	32,998	16.08	1.1
	L		-0.32		14.4	17.0		32,858	10.47	
	O		-0.82		14.0	17.0	26.0	29,538	9.20	1.5
	R		-1.32		12.0	18.2	24.9	(s) 28,971	11.09	1.5
								(m) 30.934	11.89	
								(b) 30,886	16.9	
3-VIII	A	1324	-1.40	11.9	8.5	20.0	25.0	33,387		
	C		-1.07			20.0	27.0	34,820		
	D		-0.85		9.5	21.0	26.2	35,016		
	E		-0.73		9.0	18.0	28.0			
	G		-0.52		12 5	20.5	26.8	34,084		
	I		-0.82		5.5	18.6		32,256		0.9
	L		-0.57		9.0	18.9		32,256		1.2
	M		-0.32		7.3	17.1		28,052		1.5
	Q		-1.15		11.5	17.0		24,215		1.8
	R		-0.15		6+	17.1		25,992		1.5

Figure 49. Temperature data ($\overline{X}$, range) for sample dates 17 May-3 August 1978.

▲ mean

I range

Figure 49

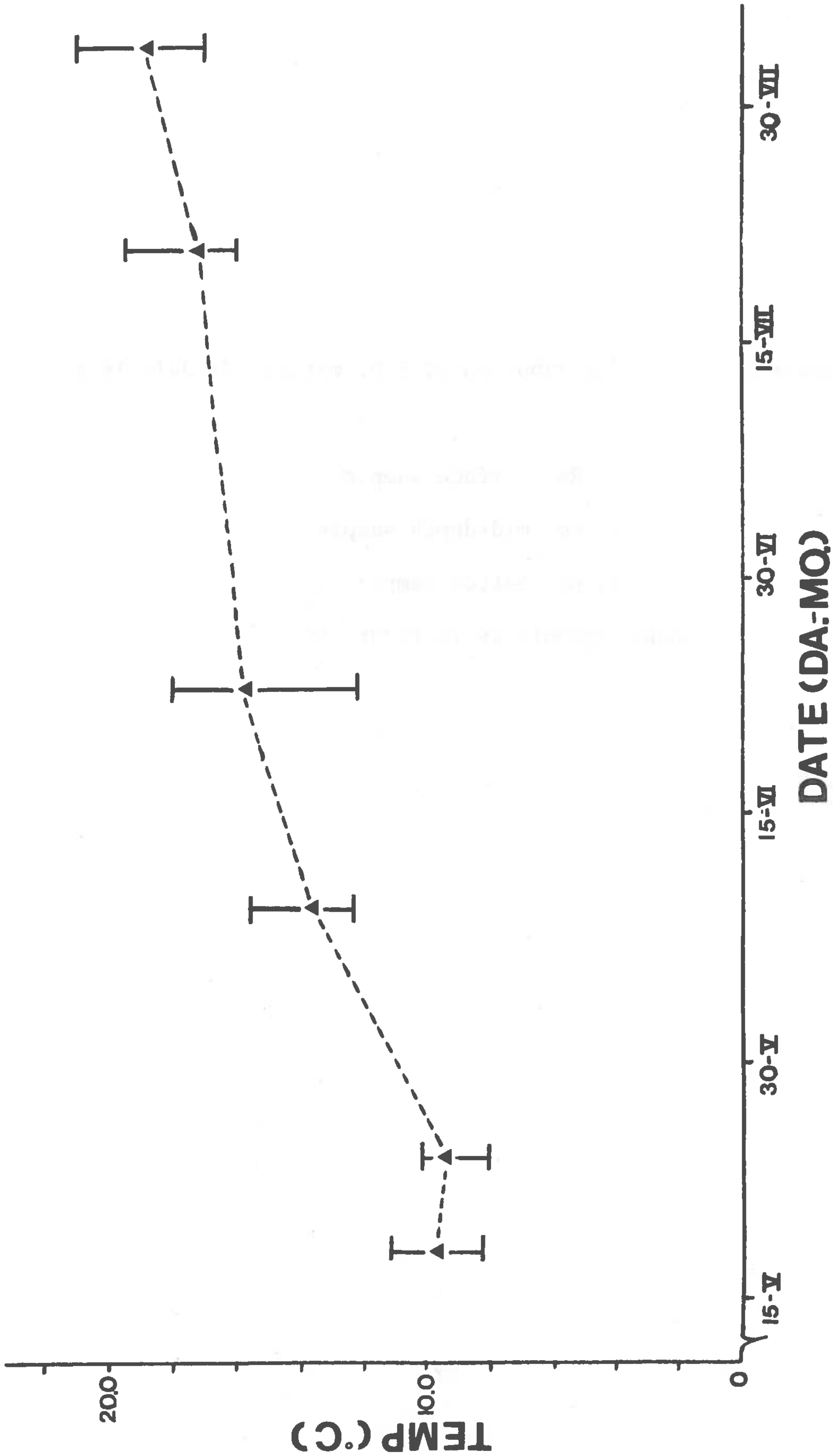


Figure 50. Size distribution of S.D. matter, 21 July 1978.

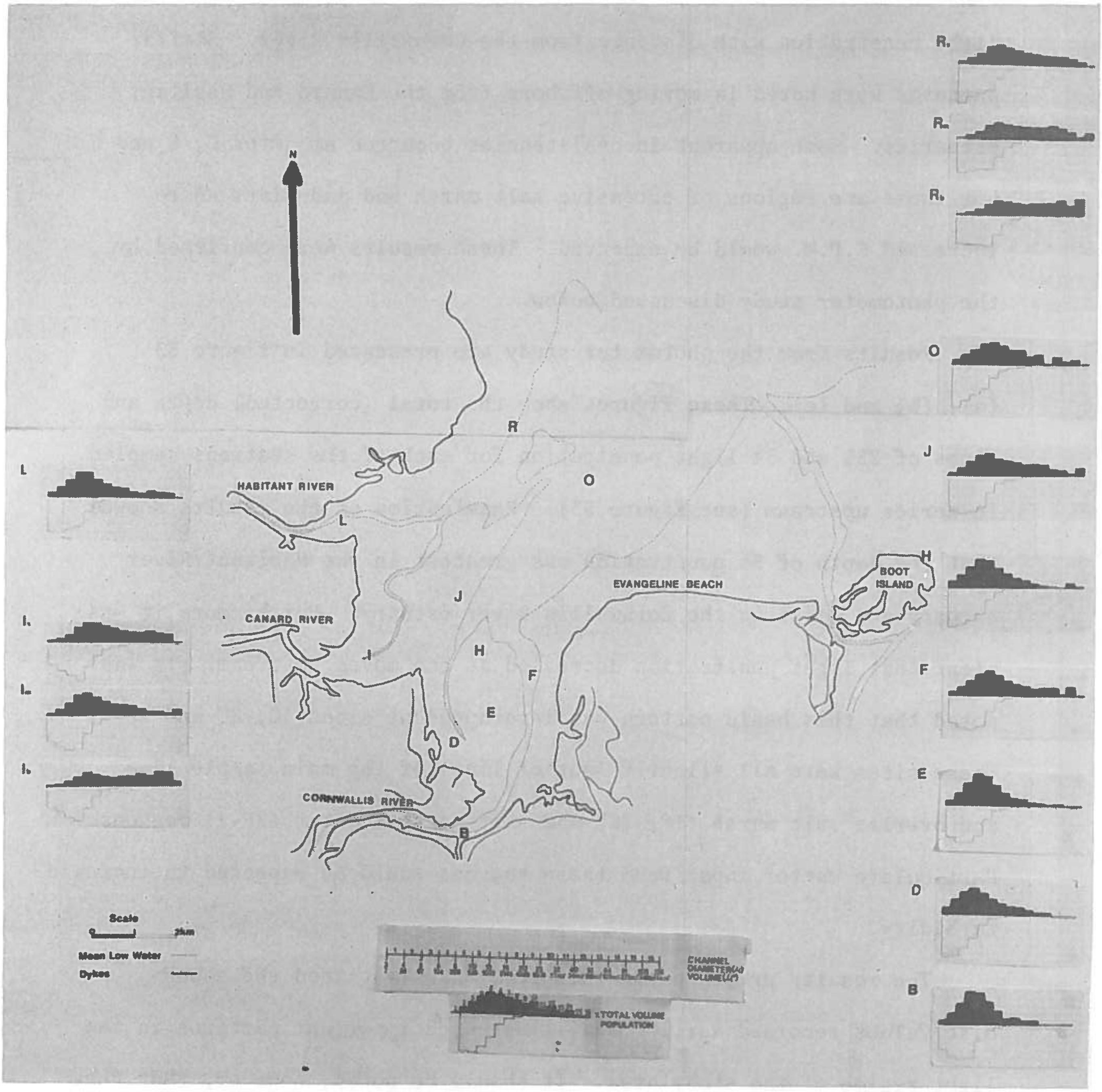
s, Rs surface sample

m, Rm mid-depth sample

b, Rm bottom sample.

other symbols as in figure 34.

Figure 50



N
HABITANT RIVER
CANARD RIVER
CORNWALLIS RIVER
EVANGELINE BEACH
BOOT ISLAND
R
O
L
J
H
F
E
D
B
Scale
0
2km
Mean Low Water
Dykes
CHANNEL DIAMETER
VOLUME
TOTAL VOLUME POPULATION

Secchi disc readings have been recorded in tables 2 and 3 and mean values for the stations visited more than once are indicated in figure 51. Figure 51 clearly illustrates the increase in depth of 5% light penetration with distance from the Cornwallis River. Similar patterns were noted in moving offshore from the Canard and Habitant estuaries. Some apparent inconsistencies occurred at sites D, E and F but these are regions of extensive salt marsh and mud flats where increased S.P.M. would be expected. These results were confirmed by the photometer study discussed below.

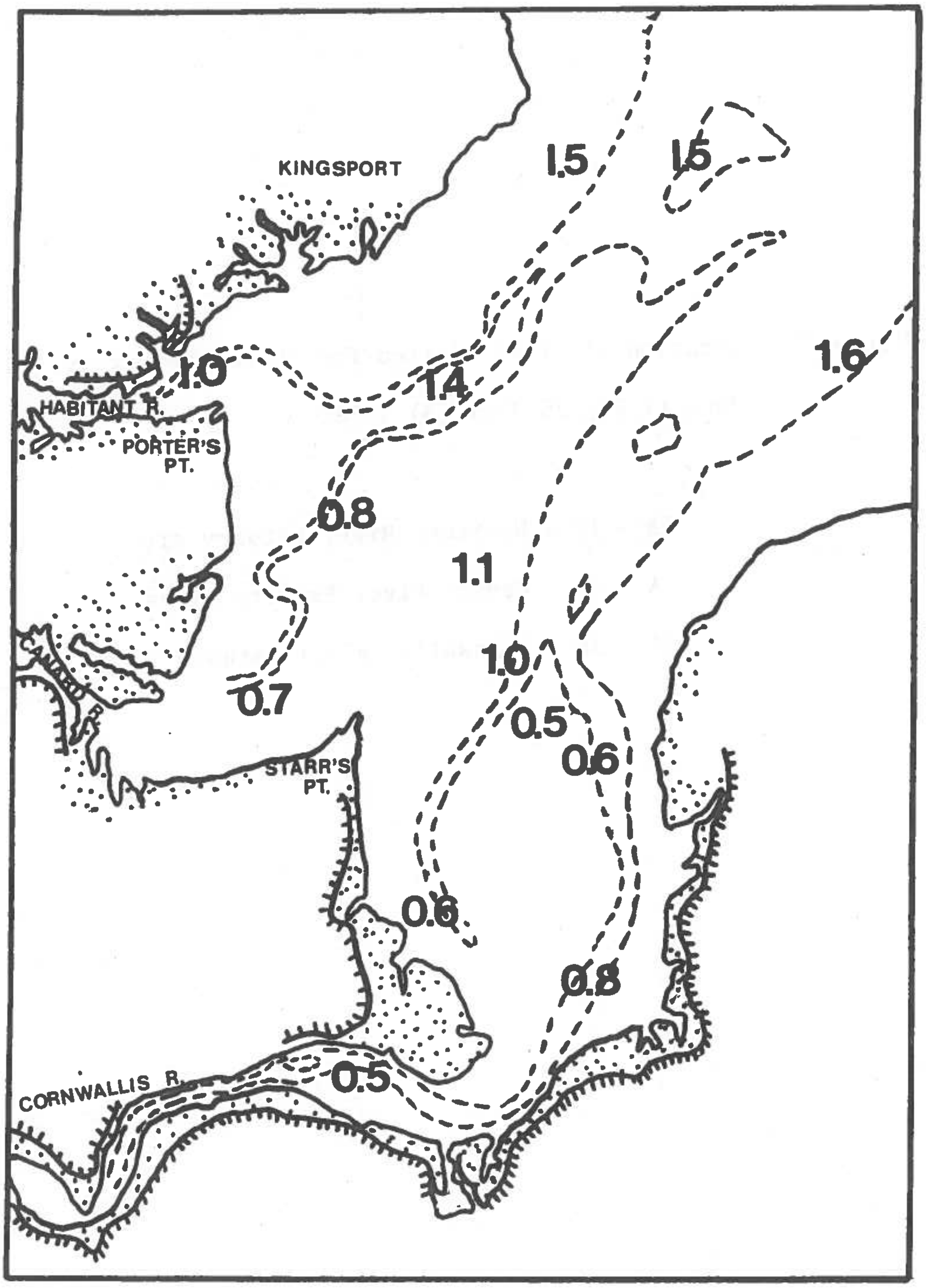
Results from the photometer study are presented in figure 53 (a), (b) and (c). These figures show the total (corrected) depth and lines of 25% and 5% light penetration for each of the stations sampled. in series upstream (see figure 53). Examination of the results showed that the depth of 5% penetration was greatest in the Habitant River estuary and least in the Cornwallis River estuary. Furthermore it was clear that light penetration decreased as one moved upstream. It was noted that this basic pattern was interupted at sites 1C, 2C and 3E-I. These sites were all slightly 'out of line' of the main sample line and overlie salt marsh (1C, 2C) and salt-marsh-mudflat (2E-I) regions. Particulate matter input from these sources would be expected to increase turbidity.

The results presented in this study substantiated the secchi disc values recorded earlier and illustrated important patterns in the light regime of the study area. It should be noted, however, that the long time span between sample dates imposed some restrictions on the interpretation of the data.

Figure 51. Mean secchi disc values at 14 stations in main study area.

other symbols as in figure 47.

Figure 51



KINGSPORT
1.5
1.5
1.0
1.4
1.6
HABITANT R.
PORTER'S PT.
0.8
1.1
1.0
0.7
0.5
0.6
STARR'S PT.
0.6
0.8
0.5
CORNWALLIS R.

Figure 52. Location of sites visited for photometer study, 20 June (1,2), 25 July (3) 1978.

1A - 1F - Habitant River Estuary sites.

2A - 2F - Canard River Estuary sites.

3A - 3P - Cornwallis River Estuary sites.

Figure 52

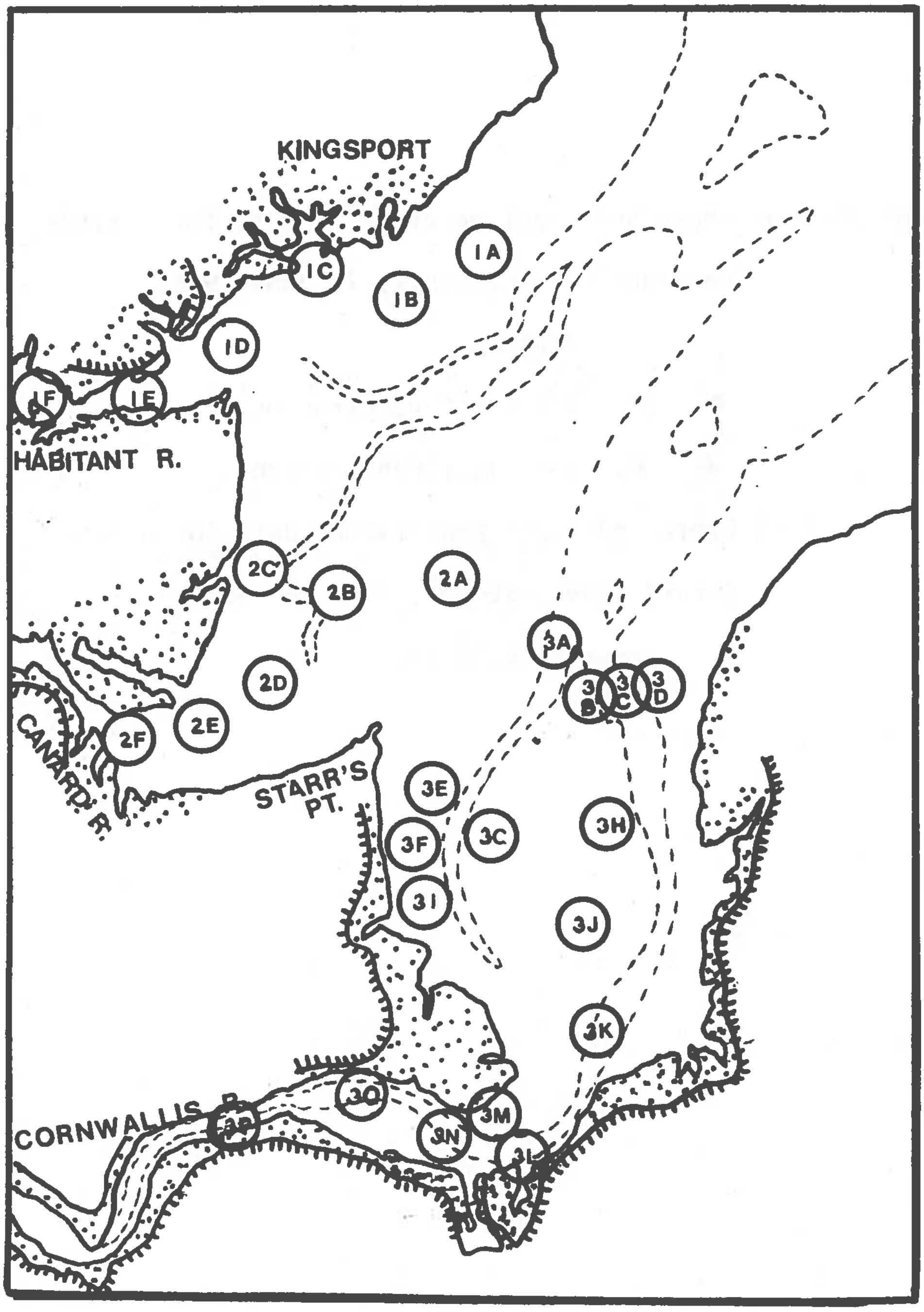

KINGSPORT
IA
IB
IC
ID
IE
IF
HABITANT R.
2A
2B
2C
2D
2E
2F
CANARD R.
STARR'S PT.
3A
3B
3C
3D
3E
3F
3C
3H
3I
3J
3K
3L
3M
3N
3O
3P
CORNWALLIS R.

Figure 53. (a) Depth and light penetration data for 6 sites, Habitant River estuary, 20 June 1978.

depth

■ · ■ 25% light penetration

▲ · ▲ 5% light penetration

(b) Depth and light penetration data for 6 sites, Canard River estuary, 20 June 1978.

symbols as in (a)

Figure 53

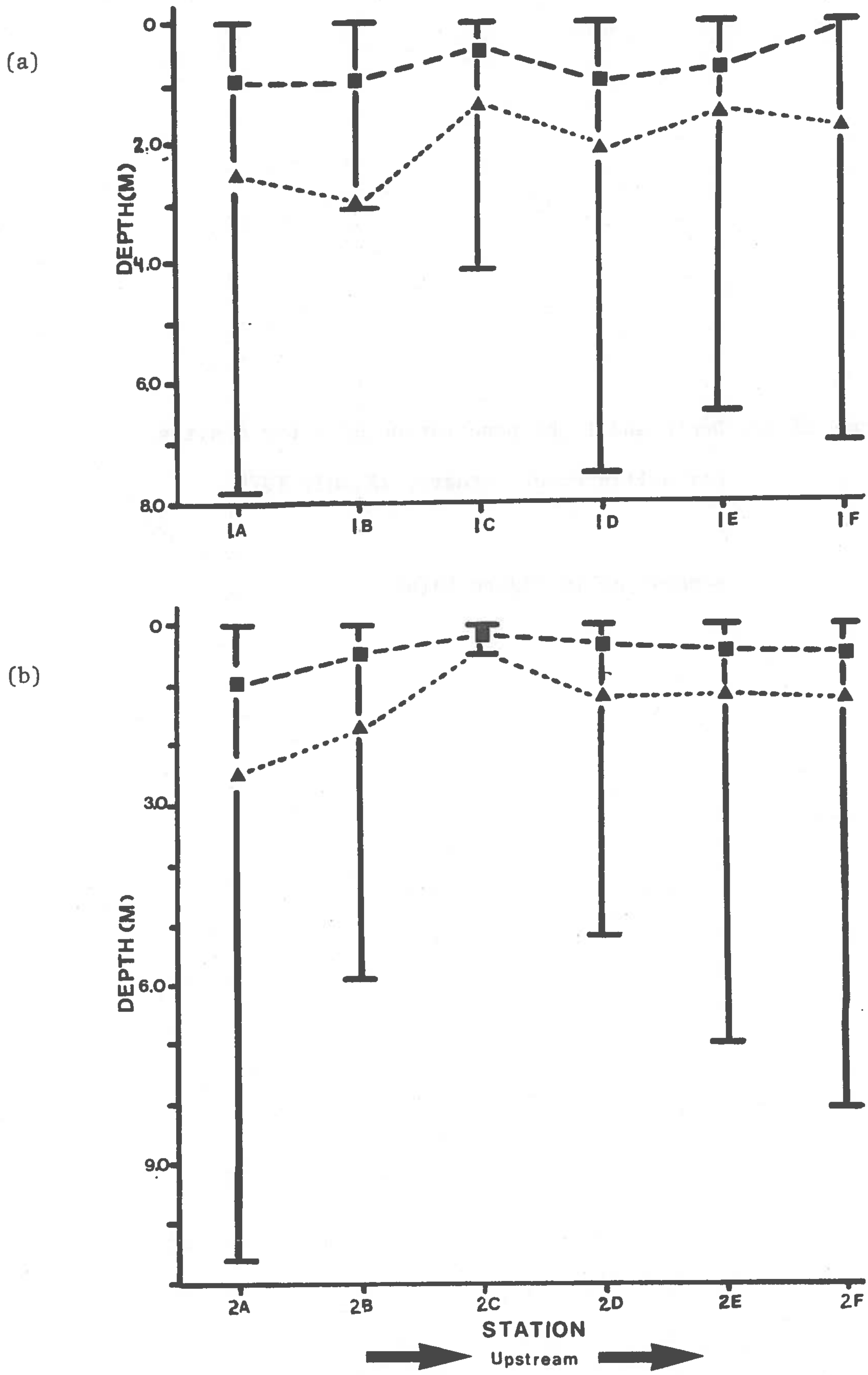
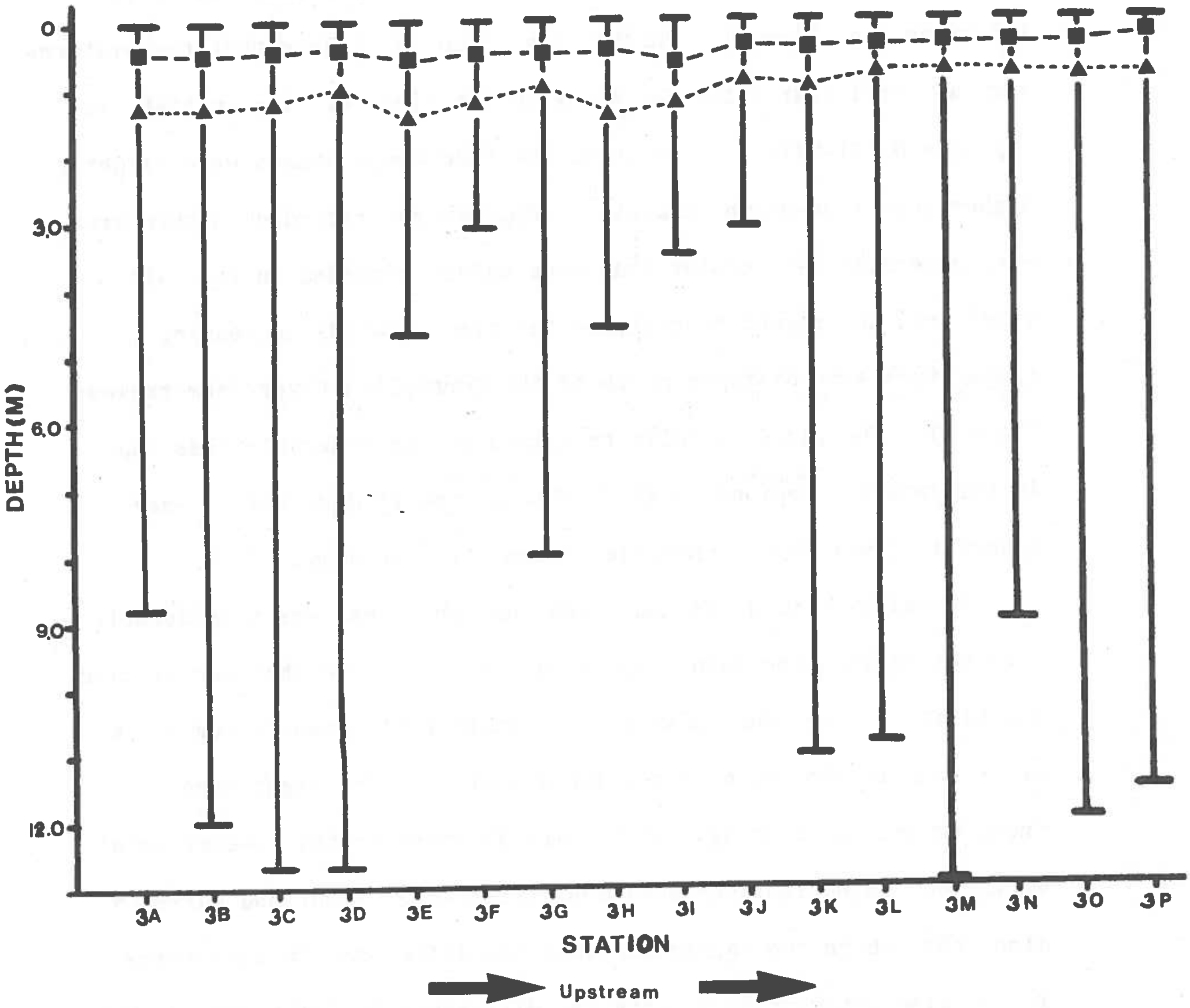

(a)
0
2.0
4.0
6.0
8.0
DEPTH(M)
1A
1B
1C
1D
1E
1F
(b)
0
3.0
6.0
9.0
DEPTH (M)
2A
2B
2C
2D
2E
2F
STATION
Upstream

Figure 53 (c) Depth and light penetration data for 6 sites,
Cornwallis River estuary, 25 July 1978.

symbols as in figure 53(a).

Figure 53

(c)



0
3.0
6.0
9.0
12.0
DEPTH (M)
3A
3B
3C
3D
3E
3F
3G
3H
3I
3J
3K
3L
3M
3N
3O
3P
STATION
Upstream

Results from the sample sites north of Delhaven are presented in table 4. Temperature values indicated that notable seasonal changes do occur. Although sampling in this region covered only a one-month range increases of as much as 5.9°C were noted at certain locations (eg. site D). Furthermore it could be seen that temperatures vary at particular sites depending on the time relative to high tide (eg site D, 31-VII). As expected low tide temperatures were slightly higher (see Time-Depth studies). Temperatures recorded in this area were generally 2-4° cooler than mean values recorded in the main study area and seemed to continue the trend towards decreasing temperature with distance north of the Cornwallis River (see tables 2 and 3). The range of salinity values was considerably less than in the interior regions of the bight and the 21 June values were generally lower than comparable values for late July.

Secchi disc readings indicated that this area was considerably less turbid than the main study area. It was noted that secchi disc visibility in the Minas Channel was considerably greater (eg 4.5 m at G) than in the Basin proper (eg 4 m at F). One might expect a trend towards increasing clarity with distance north; however local variations in bottom configuration, fresh water input and currents along this shoreline caused considerable difference in turbulence. It was also interesting to note the difference in light penetration with tide time (eg site D, 31 VII; site E 27 and 31 VII).

Depth readings for the Minas Channel and north of lower Blomidon varied quite dramatically within a short distance of the shore. A good example of the kinds of changes encountered was observed on 27

July. At 1218 a tide line was noted about 75 m offshore (see figure 54). The fishing vessel travelled across the tideline taking depth soundings and recorded changes from 30 to 18 to 9 m from the channel to the shore side of the tideline. We were informed that the region shoreward of the tide line is a large back-eddy area in which the currents and wave action characteristic of the Channel proper are less pronounced (Travis pers. comm.). Two other back eddy areas occur in the regions of the sample sites C and E. Tide lines were commonly encountered just offshore and parallel with the coastline and have often been known to contain large trees and other organic material (eg. *Chalina oculata, Flustra foliosa, Ascophyllum nodosum*). It would appear that offshore and nearshore waters in this region do not mix completely.

Water samples were analyzed for total particle count of suspended materials. T.P.C. were variable however it would appear that 22 June samples were somewhat less turbid than the late July samples. The variations at single sample sites within short time intervals probably reflect an interaction of influences including tide times (eg. site A, 27 and 31-VII), and local physical, hydrographic and weather conditions. Suspended particle mass was only determined for the 22-VI samples and in this series variations were quite marked. The very high value from site A can be related to the noticeable abundance of larger size particles shown by the size distribtuion analysis. Size distribution indicated the extremely low value for site B is erroneous (eg human error). Weight determinations were not completed for the 27 and 31-VII sample sessions.

Although the results of this study were not as complete as the data accumulated in the main sample area, they illustrated some important characteristics of this region. More extensive studies in the northern portions of the Basin are planned for the coming year and it is hoped that Economy Point and Walton areas will be surveyed. More extensive studies of these areas should help increase our understanding of the dynamics of the Minas Basin waters.

Figure 54. Location of 7 sample sites north of Longspell Point visited 22 June, 27 July and 31 July 1978.

approximate location of tide lines noted throughout May - August 1978.

Figure 54

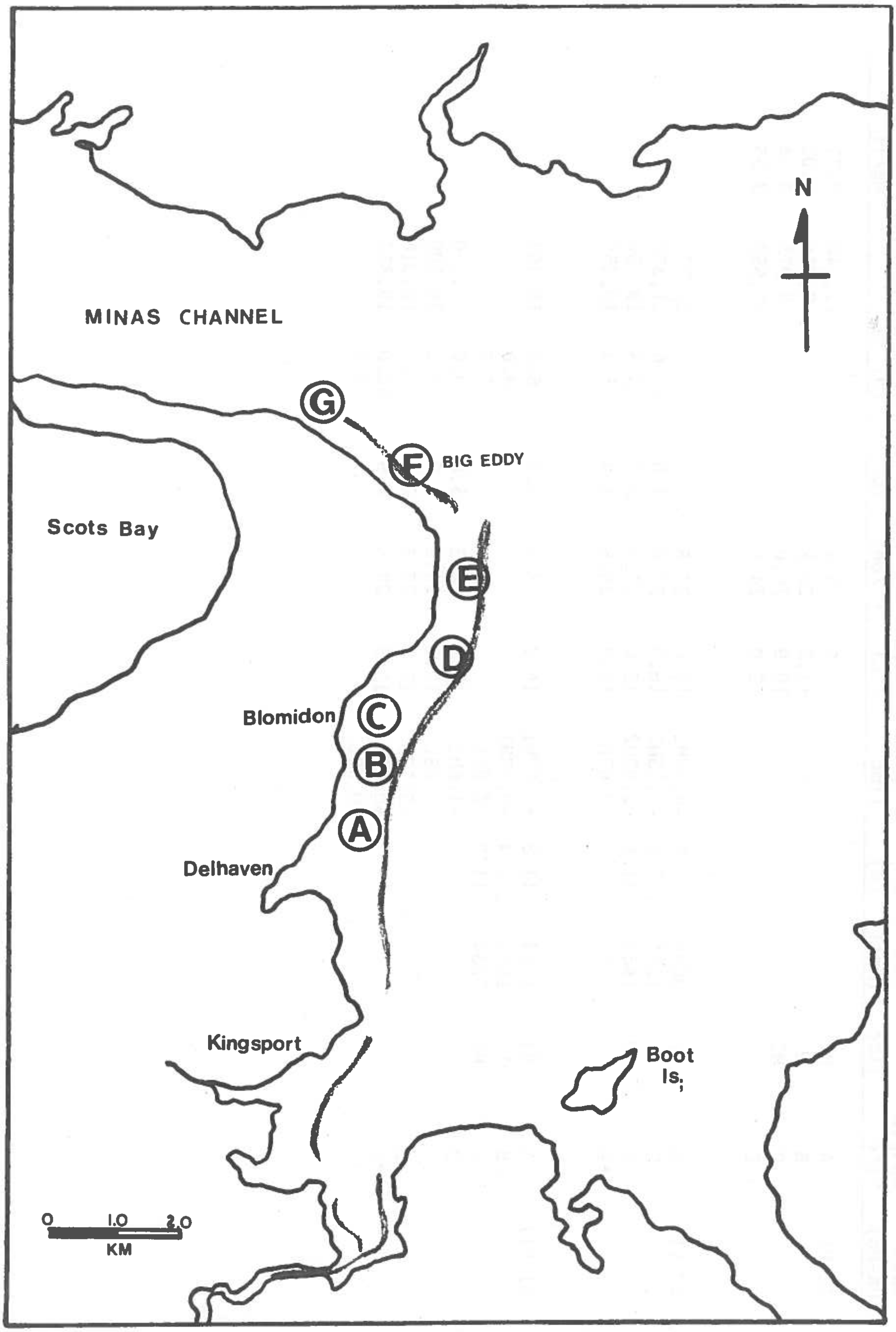

MINAS CHANNEL
N
G
F
BIG EDDY
Scots Bay
E
D
Blomidon
C
B
A
Delhaven
Kingsport
Boot
Is;
0
1.0
2.0
KM

Table 4. Physical and Chemical Results of Sample areas north of Longspell Point.

Date (Da-Mo)	Sample Site	Tide	Time (Hrs)	Ht (m)	Sample* Time	Temp (°C)	Sal (°/oo)	S.D. (m)	Depth (m)	T.P.C.	S.P.M. (mg/l)
22 VI	A	H1				11.8	25.8			11,446	7.77
	B	L				11.3	25.5			9,546	0.02
	D	H2				10.9	26.0			9,075	3.64
	E					12.0	24.6			13,558	3.55
27 VII	A	H1	0609	11.7	-0.58H2	16.0	27.5			22,273	
	C	L	1211	2.0	-1.15H2	16.0	27.0	3.0	12.6	21,378	
	E	H2	1844	11.8	-2.93H2	15.0	27.3	3.5	15.3	19,156	
	**F				-0.67L	15.0	26.5	3.4	23.4	19,250	
31 VII	A	H1	1014	11.5	+1.07H1	16.9	28.0	3.8	6.0	15,203	
	B	L	1611	2.4	+0.53H1				9.0		
	C	H2	2234	11.9	+2.01L				5.3		
	D				+1.6H1	16.2	28.3	3.8	9.0	17,530	
					-1.68L	17.2	28.8	2.0	4.2	20,190	
	E				+0.52L	17.9	27.3	2.8	7.2	16,016	
	**G				+0.53L	15.5	28.5	4.5	36.0	19,833	
					+0.88L				3.6		

(4) SATELLITE CALIBRATION STUDY[1]

Objectives. The purpose of this study was to determine the correlation between suspended sediment concentration (SSC) values obtained from satellite images of Chignecto Bay, and SSC values determined from filtered water samples from that area. Comparisons of particulate composition of samples collected in the Chignecto-Shepody Bay area with those of the Minas Basin were also to be made.

Methods. One litre surface water samples were taken from 25 sample sites in Shepody Bay (see figure 55) and ten sites in Baie Verte on 5 and 27 May, 1978. Collections took place when Landsat II passed over this area. All samples were immediately poisoned with 1 ml NaN_3 and subsamples were later treated as follows:

(a) Approximately 500 ml were saved as a reference sample.

(b) 250-500 mls were filtered through pre-weighed 0.4 μm Nuclepore filters using a Millipore (T.M.) filtering apparatus. Filters were dried at 60°C and re-weighed to determine suspended particulate matter (SPM) concentration in mg/1.

(c) 50 ml from each sample were filtered through Whatman GF/C filters and prepared for chlorophyll analysis with the Turner Fluorometer. It should be noted that SSC for the June 5 samples were so high that subsamples had to be centrifuged and dried before SPM could be determined. The wet, drained sediment subsample was used for Chlorophyll analysis.

[1] Material for this study was prepared by H. Leslie at Bedford Institute of Oceanography.

(d) Samples were prepared for the S.E.M. by filtering a small volume of each through a 0.4μm Nuclepore filter. A representative area of each filter was photographed and particles were counted, sized (using the Wentworth scale) and identified as organic or inorganic. A similar procedure was followed for filters used in previous satellite calibration studies of the Avon River Estuary in 1975 and 1976 respectively (see figures 56 and 57).

(e) Several filtrate samples were analyzed for the presence of colouring agents such as dissolved humus. For this purpose a Beckman spectrophotometer was used with a reference sample of 30% NaCl at wavelengths ranging from 400-800 μm.

Results and Discussion. Results are indicated in tables 5 to 8 and figure 58. Tables 5 and 6 present SSC and Chlorophyll data for Shepody Landsat samples while table 7 shows comparable data for Baie Verte samples. Table 8 represents various parameters of the particulate matter as indicated by analysis of Scanning Electron Micrographs. Figure 58 shows a graph of the spectra of samples (from Shepody Bay).

As indicated by tables 5 and 6 the method of processing samples affected results quite dramatically. Those with a high SPM were found to occlude the Millipore filter and had to be centrifuged. This process required repeated transfers and resulted in decreased accuracy of S.P.M. calculations (see table 6). However several important trends were revealed in these sets of data. For instance, the expected tendency for S.P.M. to decrease from the Pedicodiac River to Shepody Bay proper was very clear. Furthermore, the inverse relationship of S.P.M. with Chlorophyll A was evident by the general increase in Chlorophyll A values from the River to the Bay. This was to be expected as one moved to clearer waters. S.C.C. and Chlorophyll measurements varied with sample site, tide time, weather conditions and other factors that affect turbidity. Thus the general trends noted showed some inconsistencies and served to indicate the complex nature of sediment distribution.

Other important observations were made by comparing the data in table 5 and 7. Results indicate that S.P.M. concentrations were much higher in Shepody Bay than in Baie Verte. It followed that percentage Chlorophyll A should be higher in the latter case, and indeed results indicated that this is the case.

Scanning Electron Micrograph studies revealed that the majority of particles in the samples were greater than 4 μm in diameter. At present only the micrographs from the 1978 study have been analyzed, but preliminary observations seemed to show that the particle size and organic content of the Shepody Bay and Avon River Estuary samples were somewhat similar. This phenomenon has already been mentioned in relation to previous discussion of particle size distribution on the Minas Basin (see Time-Depth Study). It was suspected that these kinds of differences in the nature of S.P.M. of the two regions may be related to such factors as origin of particles (eg. shale vs sandstone), basin topography and water movements (Amos pers. comm.).

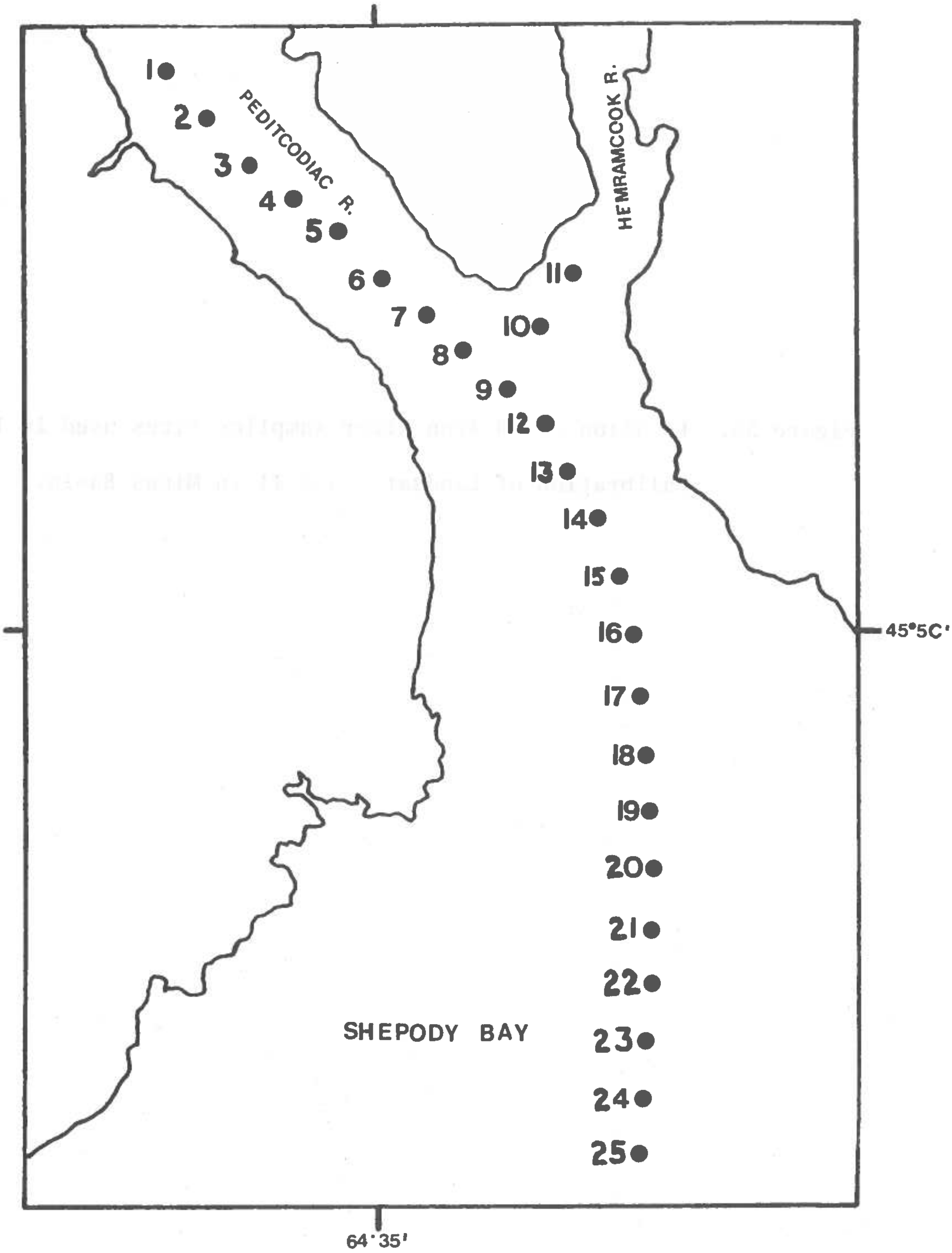
Spectral analysis of filtrates from several samples revealed little water discolouration. This indicated that dissolved humus was either absent or present in undetectable concentrations. It followed that most of the colour detected on the satellite image was due to other organic and inorganic particles. The inorganic particle size, origin, and distribution have already been discussed (see above). Table 8 also provides a checklist of the kinds of organic particles that occur in water samples. The checklist clearly indicated the abundance of diatoms, various eggs, and fecal matter in the water column of the study areas.

Conclusions and Future Work. The 1975 and 1976 investigations in the Minas Basin revealed a very high correlation between S.P.M. values calculated from satellite photographs and those determined from filtered water samples. Comparison of data from the 1978 study of Chignecto-Shepody Bay with those obtained from satellite images of that region will help to determine the usefulness of satellite imagery in the calculation of SPM in the area.

Comparisons of the concentrations and types of suspended sediments in the Minas Basin and Shepody Bay should reveal interesting similarities and differences between the two systems. This may also provide a very important basis to the understanding of the biology of these unique hydrographic regions.

Figure 55. Location of 25 Shepody Bay sampling sites used in 1978 calibration of Landsat II in Chignecto Bay.

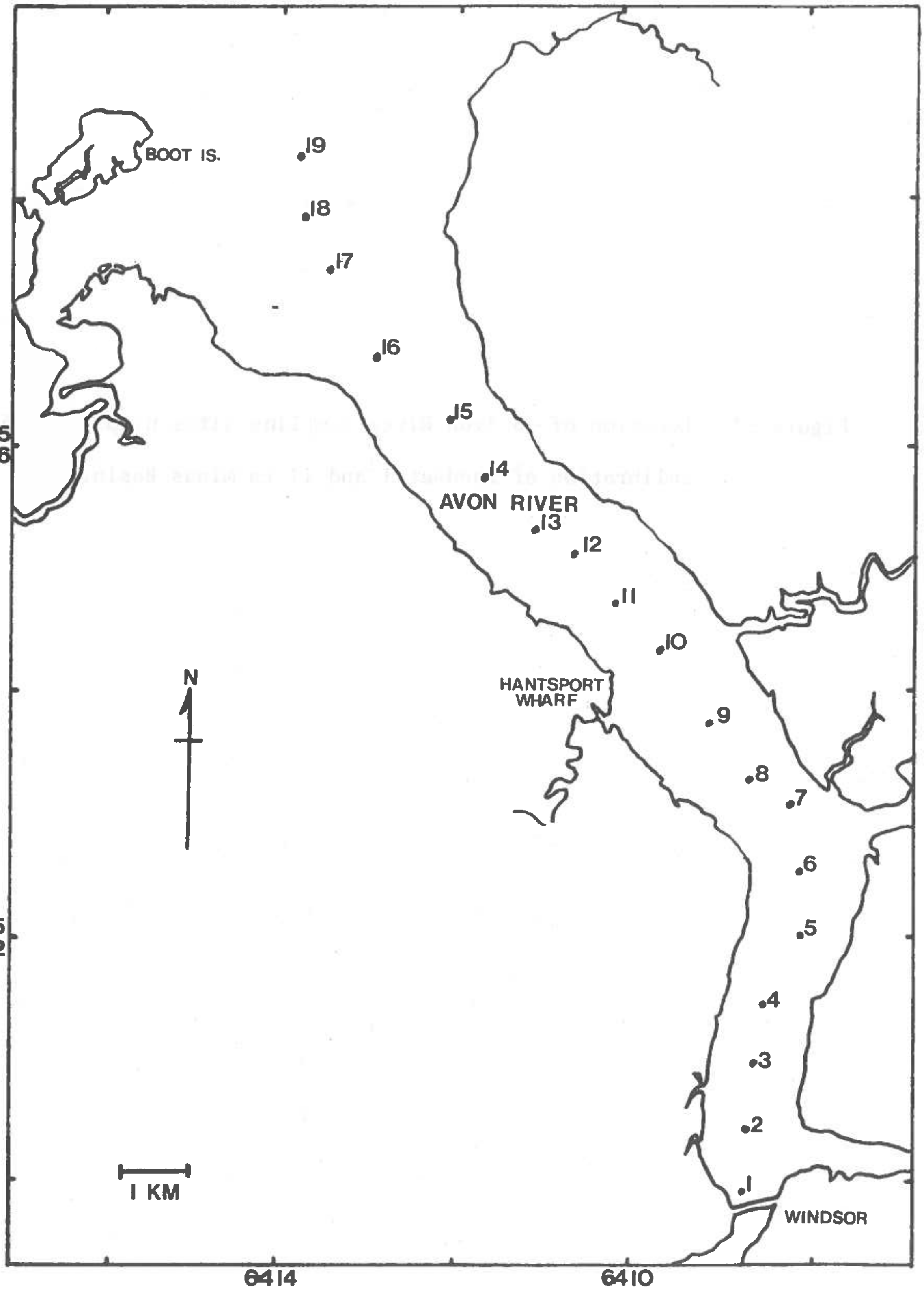
Figure 55



PEDITCODIAC R.
HEMRAMCOOK R.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
SHEPODY BAY
45°5C'
64'35'

Figure 56. Location of 19 Avon River sampling sites used in 1975 calibration of Landsat I and II in Minas Basin.

Figure 56



BOOT IS.
19
18
17
16
15
14
AVON RIVER
13
12
11
10
HANTSPORT
WHARF
9
8
7
6
5
4
3
2
1
WINDSOR
N
1 KM
45 06
45 02
6414
6410

Figure 57. Location of 13 Avon River sampling sites used in 1976 calibration of Landsat I and II in Minas Basin.

Figure 57

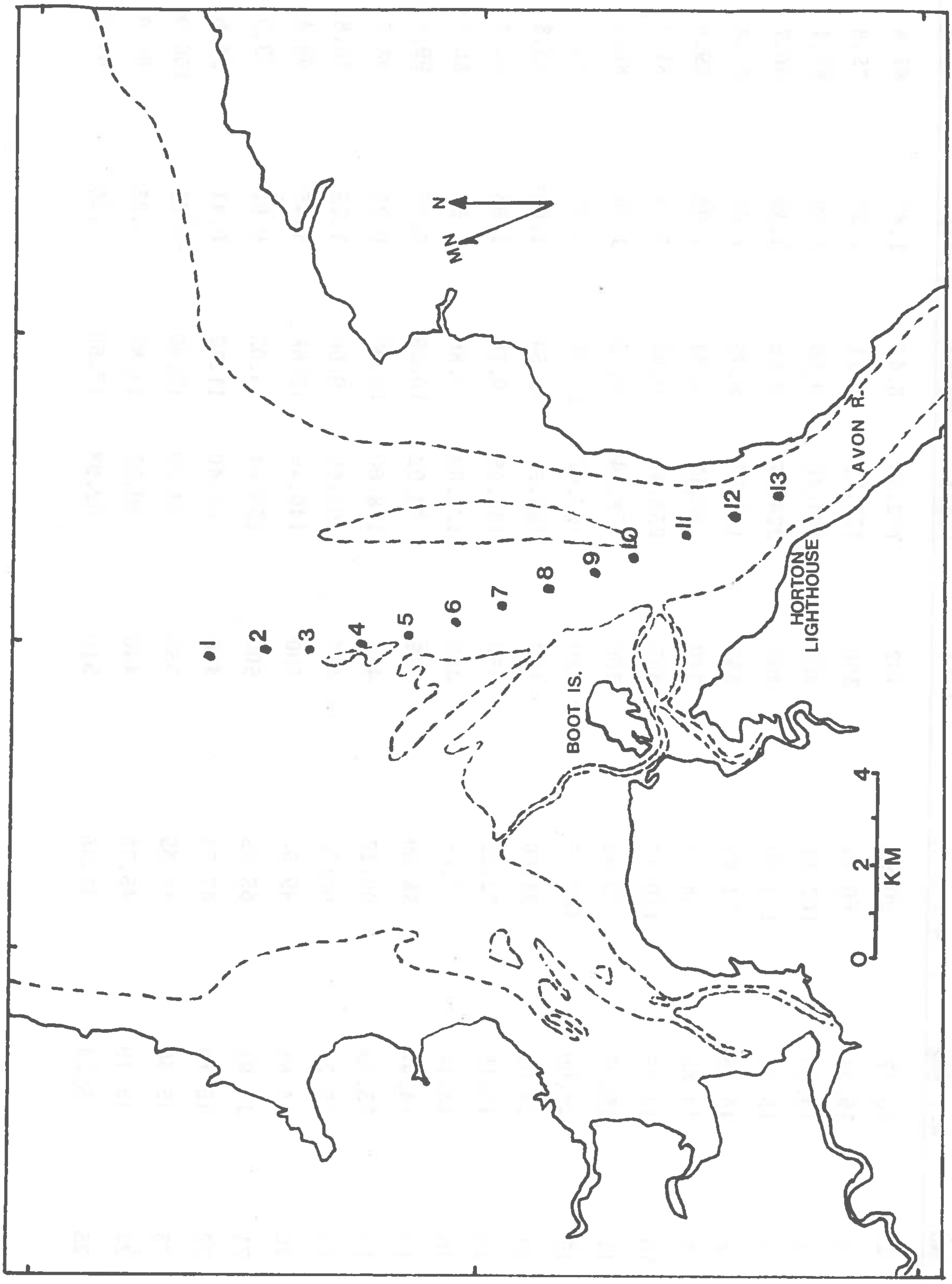

N
MN
1
2
3
4
5
6
7
8
9
10
11
12
13
AVON R.
HORTON LIGHTHOUSE
BOOT IS.
0
2
4
KM

Table 5. Suspended sediment concentration and chlorophyll content of filtered 1978 Landsat samples from Shepody Bay.

Sample No.	Pre-filtered wt. (mg)	Post-filtered wt. (mg)	Amt. filtered (ml)	S.P.M. (mg/l)	Chl. A (mg/m^3)	Phaeophytion (m/m^3)	% Chl. A
2	15.47	90.54	492	152.58	8.43	1.87	81.8
3	15.35	60.75	350	129.71	7.11	2.27	75.8
4	14.95	102.43	450	194.40	9.08	1.59	85.1
5	15.06	121.39	465	228.67	9.96	2.38	80.7
6	16.18	81.49	355	183.97	8.43	1.93	81.4
7	14.88	58.12	240	180.17	9.08	1.06	89.6
10	14.75	130.32	495	233.47	9.08	2.13	81.0
11	15.05	79.92	360	178.44	8.75	1.38	86.4
12	15.00	107.17	480	192.02	11.60	0.85	93.2
14	15.02	94.80	480	166.21	8.54	1.66	83.8
15	15.15	72.22	450	142.68	9.19	1.96	82.4
16	15.14	72.68	460	125.09	8.86	1.38	86.5
17	14.97	58.00	435	98.92	10.29	0.07	99.4
18	15.33	99.27	470	178.60	13.68	0.21	98.5
19	15.24	60.78	435	104.69	9.96	1.25	88.8
20	14.84	89.57	500	149.46	13.68	1.45	90.4
21	14.93	65.25	500	150.64	13.02	0.01	99.9
22	15.19	47.34	470	68.40	11.82	0.41	96.6
23	15.38	48.35	350	94.20	13.90	<0.01	100.0
24	15.19	45.79	440	69.55	11.82	0.25	97.9
25	15.24	47.36	510	62.98	17.60	0.26	97.9

Table 6. Suspended sediment concentration and chlorophyll content of centrifuged 1978 Landsat samples from Shepody Bay.

Sample No.	Pre-Centrifuged Weight (g)	Post-Centrifuged Weight (g)	Amount (ml) Centrifuged	S.P.M. (mg/l)	Chl. A. (mg/m^3)	Phaeophytin (mg/m^3)	% Chl. A.
1	20.21019	26.39233	530	11,664.42	8.82	17.35	33.7
2	20.27591	26.55801	406	11,179.09	10.02	26.76	27.3
3	21.40189	25.47820	495	8,234.94	7.04	16.23	30.2
4	21.43376	22.56445	510	2,217.04	1.90	4.35	30.4
5	20.16673	21.49372	520	2,551.90	1.88	6.97	21.3
6	20.13924	21.95470	490	3,705.02	2.61	11.07	19.1
7	20.14405	23.08009	510	5,756.94	5.30	15.97	24.9
9	21.77489	22.81447	380	2,735.74	3.46	10.48	24.8
12	21.77463	23.34286	515	3,045.11	5.02	11.56	30.3
14	20.84841	21.91213	375	2,836.59	4.08	9.19	30.8
15	20.56717	21.59306	477	2,146.52	4.13	7.10	36.7
16	20.90351	21.50833	523	1,156.44	2.73	4.34	38.6
17	20.32374	21.15673	480	1,735.40	3.20	4.82	39.3
18	20.15909	20.60721	525	853.56	2.54	2.76	47.9
19	20.83897	21.33978	412	1,215.56	3.24	6.14	34.6
20	21.75200	22.14923	410	968.85	4.10	5.79	41.5
21	20.26504	20.55990	505	583.88	5.00	3.17	61.2
22	20.19146	20.51603	510	634.41	3.19	1.54	67.5
23	21.38264	21.67788	437	675.61	1.84	2.46	42.7
24	21.39787	21.61883	440	502.18	1.14	1.39	44.9
25	20.14352	20.53243	470	827.37	3.21	0.86	78.8

Table 7. Suspended Sediment concentration of chlorophyll content of filtered Baie Verte Landsat samples (1978).

Sample No.	Pre-Filtered Wt. (mg)	Post-Filtered Wt. (mg)	Amount (ml) Filtered	S.P.M. (mg/l)	Chl. A. (mg/m^3)	Phaeophytin (mg/m^3)	Chl. A %
1	15.00	16.15	515	2.19	1.98	0.01	99.3
2	15.14	16.18	510	2.04	3.03	<0.01	100.0
3	15.09	15.86	495	1.56	3.09	<0.01	100.0
4	15.09	15.74	448	1.45	1.56	0.39	80.2
5	15.06	16.11	530	1.78	2.22	<0.01	100.0
6	14.94	15.96	490	2.08	2.13	0.36	85.6
7	15.40	16.44	480	2.17	2.71	<0.01	100.0
8	15.31	16.28	560	1.73	1.99	0.04	98.0
9	15.46	16.10	365	1.75	1.51	0.28	84.3
10	15.48	16.20	480	1.50	1.92	<0.01	150.0

Figure 58. Spectrum of Shepody Bay sample #1 vs 30% NaCl (% absorption vs wavelength).

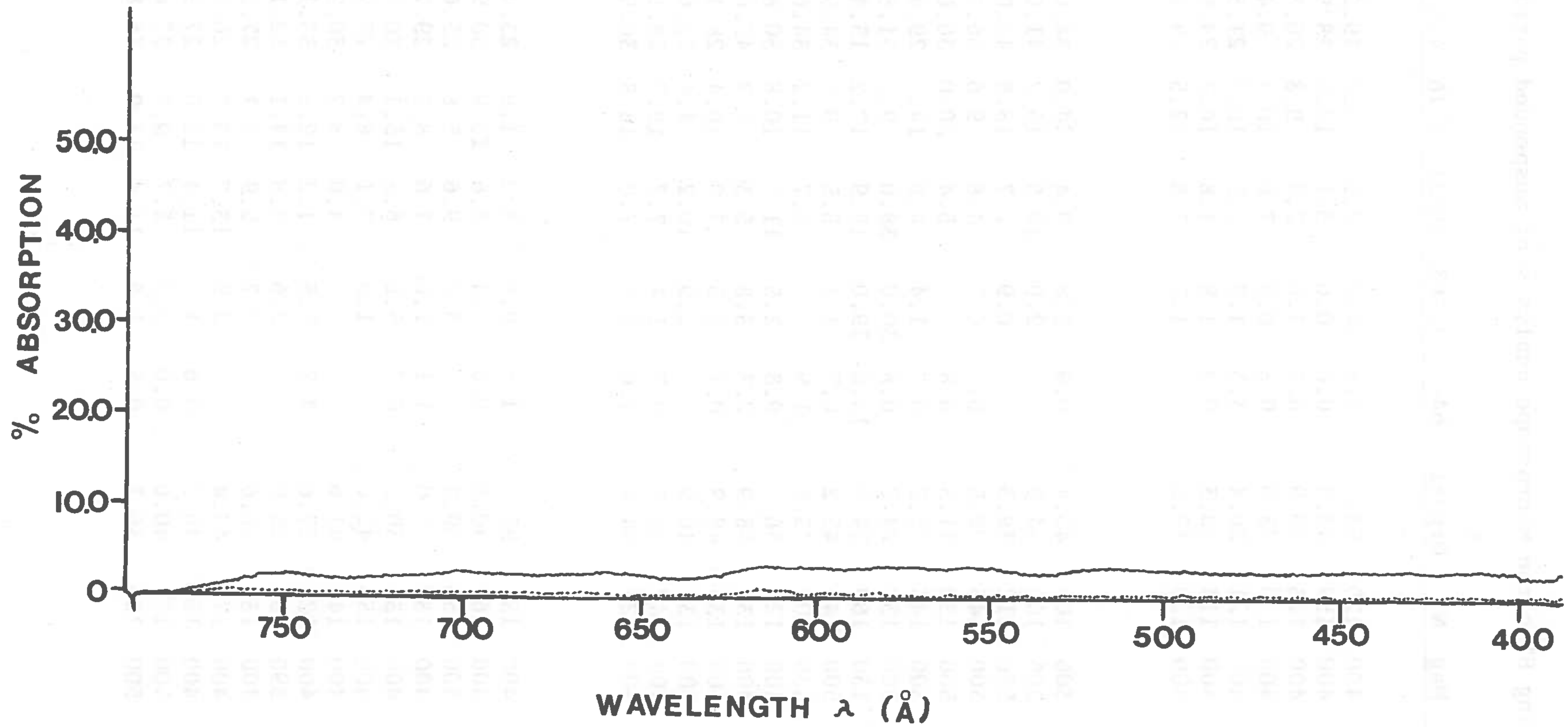

% ABSORPTION
50.0
40.0
30.0
20.0
10.0
0
750
700
650
600
550
500
450
400
WAVELENGTH λ (Å)

Figure 58

Table 8a. Scanning Electron Microscope analysis of suspended particulate matter.

Stn.	No.	Mag	N	% Organic	64-	31-63	16-31	8-16	4-8	4	Degree of Floculation
Avon 1975											
2	64-1	400	120	54.2	0.8	4.2	2.5	4.2	19.2	69.2	3
4	23-1	400	159	45.9	0.6	0.6	3.1	12.6	28.9	54.1	3
5	2-1	400	123	30.9	0.8	1.6	2.4	9.8	20.3	65.0	4
6	35-1	400	129	38.0	0.8	0.8	7.0	10.1	19.4	62.0	2
7	49-1	400	121	36.4	3.3	1.7	2.5	10.7	21.5	60.3	3
8	62-1	400	114	39.3	0.9	1.8	1.8	16.7	24.6	54.4	4
9	3-1	400	120	32.5		1.7	7.5	22.5	19.2	49.2	1
Avon 1976											
1	2316-2	306	106	43.4	0.9	3.8	9.4	24.0	34.0	32.1	
2	2317-1	306	105	34.3		2.9	10.5	15.2	41.0	30.5	2
3	2318-1	530	112	39.3		0.9	2.7	18.8	42.0	35.7	1
4	2464-1	500	146	29.5	0.7	0.7	4.8	9.6	36.3	47.9	2
4	2465-1	500	130	31.5	0.8		5.4	20.0	30.0	43.8	2
4	2466-1	500	143	25.2	0.7	1.4	4.9	14.7	29.4	49.0	2
4	2467-1	500	132	24.2	0.8	30.0	38.0	9.1	31.8	51.5	2
5	2393-1	150	169	24.9	13.6	29.0	18.9	17.2	15.4	5.9	1
5	2392-1	500	146	45.2	0.7	1.4	5.5	9.6	34.9	47.9	4
6	2321-1	530	107	33.6	1.9		3.7	11.2	34.6	48.6	3
7	2322-1	400	120	36.7	0.8	2.5	11.7	10.8	30.8	43.3	3
8	2323-1	400	131	38.9	2.3	3.8	5.3	9.2	42.0	37.4	3
9	2324-1	400	135	48.9	0.7	1.5	3.0	10.4	28.1	56.3	3
10	2325-1	400	137	40.9		2.9	10.2	4.4	22.6	59.9	3
11	2326-1	400	142	38.7	0.7	1.4	7.7	19.7	28.9	41.5	4
12	2327-1	500	128	34.4	1.6	5.5	7.0	18.8	30.5	26.7	3
Shepody 1978											
	77001-1	400	154	52.6	1.3	0.6	3.2	1.9	23.4	69.5	3
	77002-1	400	165	40.6	0.6	2.4	3.6	13.9	30.9	40.5	2
	77003-1	400	156	39.4		3.2	9.6	5.8	25.6	55.8	2
	77006-2	400	182	33.0	1.1	1.6	1.6	8.2	29.7	57.7	2
	77007-1	400	139	30.2	0.7	5.8	6.5	15.1	20.9	51.1	2
	770010-1	400	155	42.6		1.9	7.1	8.4	27.7	54.8	3
	770011-1	400	149	41.6			4.0	8.7	30.2	57.0	3
	770012-1	400	127	27.6	4.7	5.5	1.2	12.6	33.1	29.9	1
	77013-2	390	156	35.9		2.6	5.8	14.1	32.1	45.5	3
	77014-1	400	136	45.6		0.7	5.9	8.1	27.2	58.1	2
	78637-1	400	175	43.4		2.9	13.7	13.7	26.9	42.9	1
	78638-1	400	158	46.2	0.6	1.3	11.4	12.0	27.2	42.5	2
	78639-1	500	175	40.6	0.6	2.3	5.7	9.7	32.6	49.1	1
	78640-1	500	193	36.3	0.5	1.6	11.4	11.9	36.8	37.8	1

Table 8b. Scanning Electron Microscope analysis of suspended particulate matter.

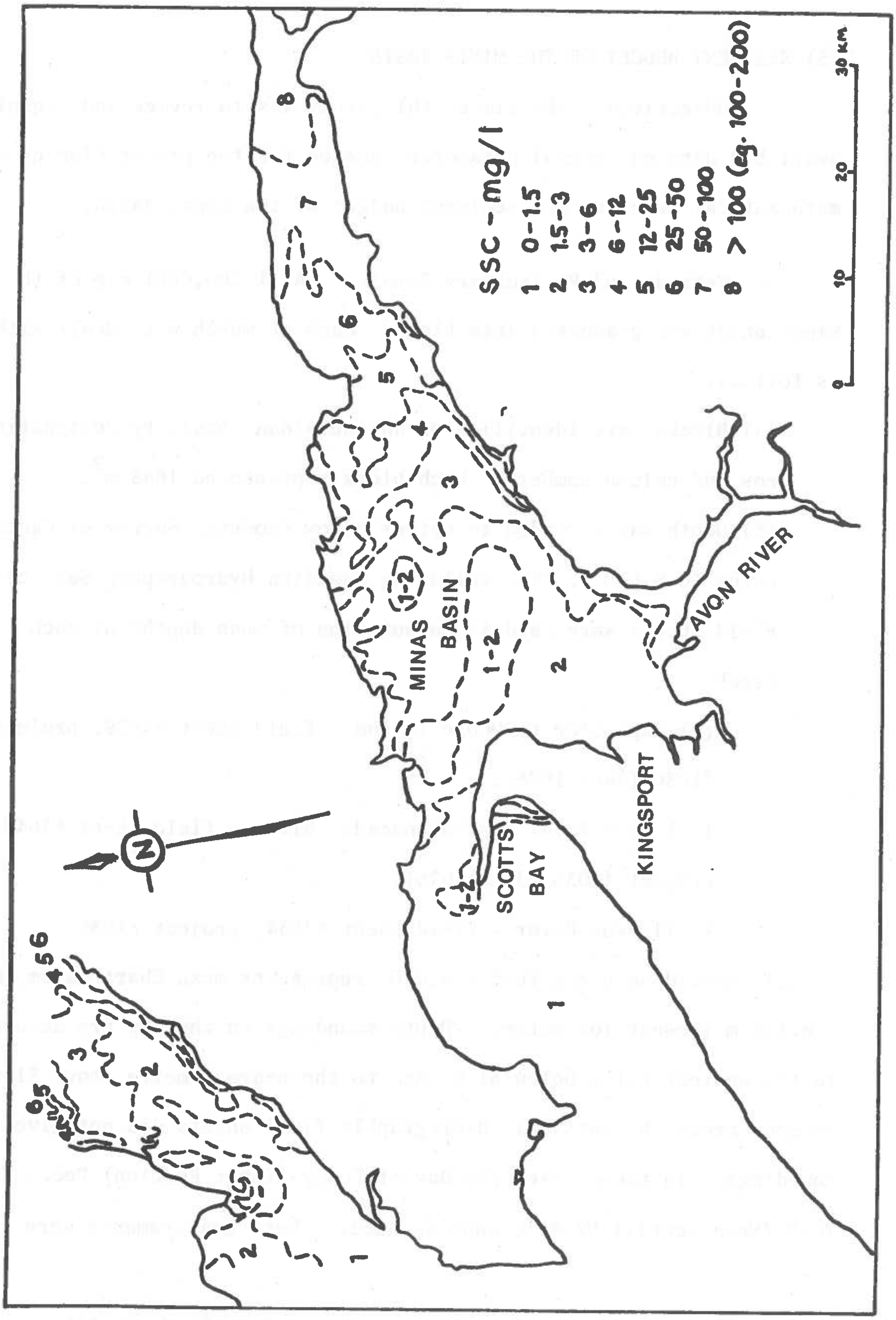
Stn.	No.	1* Dia.	2 Egg	3 Faec.	4 Spi.	5 Bry.	6 Rad.	7 Cil.	8 For.	9 Pol.	10 Lig.
Avon 1975											
2	64-1	+	+	+	+			+		+	
4	23-1	+	+								
5	2-1	+	+								
6	35-1	+			+						
7	49-1	+	+								
8	62-1	+	+								
9	3-1	+			+						
Avon 1976											
1	2316-2	+	+		+						
2	2317-1	+	+								
3	2318-1	+	+		+						
4	2464-1	+		+	+						
4	2465-1	+									
4	2466-1	+	+		+						
4	2467-1	+	+	+	+						
5	2393-1				+						
5	2392-1	+	+		+						
6	2321-1	+	+		+						
7	2322-1	+	+	+	+						
8	2323-1	+	+	+	+		+	+			
9	2324-1	+	+	+	+						
10	2325-1	+									
11	2326-1	+	+								
12	2327-1	+	+		+					+	
Shepody 1978											
	77001-1	+	+			+					
	77002-1	+	+								
	77003-1	+	+	+							
	77006-2	+	+	+	+						
	77007-1	+			+						
	770010-1	+									
	770011-1	+	+								
	770012-1	+							+		
	77013-2	+									
	77014-1	+	+								
	78637-1	+			+						
	78638-1	+	+	+		+					
	78639-1	+	+	?	?						
	78640-1	+			?	+					

* Dia.- Diatoms
Egg - Egg sacs
Faec.- Faecal material
Spi.-Spicules
Bry.-Bryozoan Fragments
Rad.-Radiolarians
Cil.-Ciliophorans
For.-Foraminiferans
Pol.-Pollen grains
Lig.-Lignaceous material

Figure 59. Suspended sediment concentrations (mg/l) data, Minas Basin (and Chignecto Bay).

(after Amos and Joyce 1977)

Figure 59


SSC - mg/l
1 0-1.5
2 1.5-3
3 3-6
4 6-12
5 12-25
6 25-50
7 50-100
8 > 100 (eg. 100-200)
0 10 20 30 KM
MINAS BASIN
AVON RIVER
SCOTTS BAY
KINGSPORT
N

[2](5) SEDIMENT BUDGET OF THE MINAS BASIN.

Objectives: The aim of this study was to review and organise available data on several parameters needed for the preparation of a mathematical model of the sediment budget of the Minas Basin.

Methods and Preliminary Results: A (1:200,000) map of the Minas Basin was graduated into blocks, each of which were dealt with as follows:

(a) Blocks were identified on an individual basis by designating row and column numbers. Each block represented 1648 m^2.

(b) Depth was recorded in metres below Geodetic Survey of Canada Datum (G.S.C.D.). The following Canadian Hydrographic Service Field Sheets were used in computation of mean depths of each block:

(i) Cape D'Or to Moose Island - field sheet #4639, project #1036 (June 1976).

(ii) Avon River to Shubenacadie River - field sheet #4640, project #1036 (June 1976).

(iii) Avon River - field sheet #4654, project #1036.

It should be noted that G.S.C.D. represents mean Chart Datum (MCD) + 8.126 m (lowest low water). Depth soundings on the map are accurate to the nearest 0.1 m below 31 m, and to the nearest metre above 31 m. In some areas the available hydrographic field sheets did not give soundings. In these cases the Bay of Fundy (Inner Portion) Decca Chain 7C/V (Nova Scotia) D7-4010 map was used. These measurements were

[2] Preparation of material for this report was done by J. MacRae.

converted from fathoms to metres by multiplying by 1.821. It should be noted that on this map soundings east of a line in Chedabucto Bay are on a datum that is 3 fa. higher than North America 1927 datum.

(c) High-tide suspended sediment concentration (S.S.C.) was recorded correct to .1 mg/1. Figure 59 shows S.S.C. contours 30 min. after high tide as determined in a macrotidal system using Landsat images (Amos and Alfoldi 1977). Using a scale of 1:200,000 these were transferred to the original grid map of the Minas Basin. An average value for each concentration range was determined and used in recording S.S.C. values for the individual blocks. For blocks which lay on a countour boundary a 'mean' value of the contours within the block was used.

(d) A Bed Load Thickness value of .5 m was applied to the entire Basin area (Amos pers. comm.).

(e) Bed Load Grain Size (in μ) was determined for each block by enlarging to a scale of 1:200,000. The appropriate values were transferred to the grid map by taking an average for each block. 'ϕ' units were ultimately converted to μ using the formula $mm = 2^{-\phi}$.

(f) Cliff input (m^3/year) considers a number of parameters including cliff height (m), recession period (y), recession (m), recession rate (m/yr), length of cliff, total input volume (m^3/year) and corrected total volume inputs (m^3/year). Cliff heights were taken from Amos and Josie (1977) but averages were taken where necessary (eg if more than 1 cliff height determination had been presented). Recessions and recession period information has likewise been taken from Amos and Josie (1977). Values for each block were determined and transferred to the grid map.

Length of cliff line (m) information was calculated for each block based on the graduated (1:200,000) map. Total volume input was then found using the following formula:

Total Vol. input = recession rate x Length x Height.

The total value came to 2.9 x 10^6 m^3/yr and was slightly lower than that determined by Amos and Josie (1977). Thus a correction factor was used in order to make the input data comparable.

$$\text{eg. } \frac{3.1 \times 10^6 \text{ m}^3/\text{yr}}{2.9 \times 10^6 \text{ m}^3/\text{yr}} = 1.1$$

Only corrected values were recorded.

It should be noted that in cases where a cliff height measurement was not available a zero value was assigned to the block. This was the case when blocks were G.S.C. data.

(f) Differential grain size (μ) was determined by sieve analysis. The weight of each size interval was measured and cumulative percentages then determined and graphed for each sample. Mean gram size (MZ) was determined according to the following formula.

$$MZ = (\phi 16 + \phi 50 \times \phi 84)/3$$

Mean values (converted to μ) were then assigned to individual blocks. The sample locations have been marked on a bathymetric map of the Minas Basin but are not available for the present report.

The geological map of N.S. (Dept. of Mines, N.S. 1965) was used to show geological formations and rock types along the Minas Basin coasts.

(g) River Input (m^3/tidal cycle) was examined for 25 rivers flowing into the Minas Basin. These were selected on the basis of their large catchment area. Only 2 (the Salmon and Shubenacadie) were chosen as representative of small and large river systems respectively. River input was determined to be 52 and 59 m^3/tidal cycle for large and small rivers. It should be mentioned that river input applies only to the block(s) that the river discharges into. These have been recorded on the grid map.

(h) River grain-size was recorded as 5 μ for each of the 25 blocks into which the rivers flow (Amos, pers. comm.).

(i) Finally, offshore input (m^3/tidal cycle) was determined from the data of Amos and Josie (1977, p. 171) using stations 13 and 14 as reference points. The given values were converted from g/m/tide x 10^6 to m^3/tide as illustrated below:

1249

1.8 30m^3/tide (stn 13)N block 1249-1.8 x $10^{-2}m^3$/tide 1648 = 30m^3/tide 1349 2.0 33 "

2.1 35 " (stn 14) 5 block 1449-2.1 x $10^{-2}m^3$/ tide x 1648 m = 35m^3/tide 1449.

Although the complete data sheets are not yet available, the preceding outline gives an indication of the kinds of data collections and accumulations necessary in the preparation of mathematical models. Baseline data such as these are presently being transferred to Fortran computer sheets for subsequent compilation and analysis. This kind of information is essential to present and future studies of the hydrographic features of the Minas Basin.

General Conclusions - Physical and Chemical Studies

Physical and Chemical data were collected from the south western portion of the Minas Basin and analyzed during May-August 1978. The Cornwallis River Study showed that tidal water exerts an influence at least 5 miles upstream. River water contributes significantly to the water of the south-western bight of the Minas Basin.

Temperature and salinity varied markedly during the tidal cycle. Although the pattern of temperature fluctuations was less consistent it showed notable changes between low tide maximum to high tide minimum values (eg 19°C at 2100 hrs (H.W.), 17.5°C at 1500 hrs (L.W.) at station 2, 6 July). Salinity changes are very marked and varied inversely with temperature, as expected (eg 14 ^{o}/oo, L.W. to 23 ^{o}/oo H.W., Stn. 2, 6 July). T.P.C. and S.P. C. analyses indicate that turbulence increases upriver and reaches extremely high values (eg 3.7×10^{6} particles/ 2 ml subsample and 4.9 g/l at upper stations, 21 June); however a 'maximum turbidity' was not determined. Tidal water affected the turbidity of river water greatly and leads to marked decreases in total suspended particulate matter (eg decrease from 1.7 $\times 10^{5}$ parts/2 ml subsample and 0.6 g/l between 0900 and 0930 on 6 July, stn. 2).

The Time-Depth Studies showed that the Cornwallis, Canard and Habitant Rivers, and local mudflats and saltmarshes contribute greatly to the suspended particulate matter in the water column.(eg. see scanning electron micrographs). Temperature shows cyclic variation between high tide mean minima to low tide minima (eg 20°C and 14°C on 29 June), however a slight net increase from the early morning to late evening high tide is usually evident (eg 17°C-18°C, 13 July). These changes are related to tidal water input and mudflat and surface water heating effects. The latter factors would not be as marked on a cloudy day or during another season. T.P.C. and S.P.M. values show maximum low tide and minimum high tide values (eg. 35.0 x 10^5 parts/2 ml subsample and 16.7 g/l, and 3.2 x 10^5 parts/2 ml subsample and 1.1 g/l at about low and high tides (respectively) for 6 July). The low tide maxima are related to concentration of materials within a decreasing volume of water, gravity settling and decreased current velocities. The high tide minima are related to gravity settling and decreased current velocities within a greatly increased volume of water. Particle size distribution data also show these kinds of effects as larger particles increase noticeably during mid-flood and mid ebb tides (eg see population distribution graph, 1030 and 1730 hrs, 29 June). Residual currents dominate when velocity drops to less than threshold values so larger particles begin to settle close to the time of slack tide (eg particle size distribution graphs for Time-Depth Studies). It was determined that current velocity is extremely important to the movement of suspended particulate matter in the southern portion of the Minas Basin, however only gross data were accumulated. Flowmeter readings indicated maximum velocities during mid-ebb and mid-flood tide, with decrease to Oo at slack tide (eg 29 June). Data about wind velocities was not considered important since it was obvious that tidal effects dominate the generation of currents in this area.

The waters of the south-western bight of the Minas Basin were found to be extremely turbid but showed a trend toward decreasing turbidity to the north and east (eg S.D. at site A = 0.5, I = 0.7, L = 1.0, Q = 1.5, Minas Channel = 4.5). This was confirmed by the Photometer study which indicated that light attenuation increased upriver in each of the 3 main rivers, and that the depths of 5% light penetration at Habitant River and Canard River were greater than that at the Cornwallis River. The water column was found to be very well mixed in terms of suspended particulate matter, temperature and salinity, and any variations were attributed to eddy generated turbulence.

Seasonal temperature changes were noted in the sample areas (eg $\overline{X}$ = 10°C and 19°C on 15 May and 30 August respectively), however it was found that considerable variation could be noted among different locations from the same sample time and date (eg 12.0°C and 16.5°C at sites P and I, 23 July). High tide salinity measurements did not show a seasonal trend however the range in values at different sites and dates was notable (eg 21.1 $^{o}/oo$ and 26.5 $^{o}/oo$ at site Q, 24 May and 23 June, 21.1 and 26.0 $^{o}/oo$ at Q and P, 23 June).

The satellite calibration study revealed that a high correlation exists between S.P.M. values calculated from satellite imagery and those from filtered water samples. These kinds of data indicate that satellite imagery may be very useful in future studies of this kind. Electron Micrographs also contributed greatly to the study of similarities and differences between Minas Basin and Shepody Bay suspended matter. These kinds of approaches should contribute greatly to our understanding of the dynamics of these systems.

The review of various parameters of the Minas Basin served to tie together many different aspects of a wide ranging field. These will be used for the preparation of a mathematical model for the prediction of the sediment budget of the Minas Basin. This kind of baseline data accumulation is essential to present and future studies of hydrographic conditions of the Minas Basin.

References (Physical and Chemical Studies)

Amos, C.L. 1978. Sedimentation Resulting from Fundy Tidal Power. Colston Symposium[1] MS No. 007-10-11 pt. Unpublished.

Amos, C.L. and G.H.C. Josie. 1977. The Sediment Budget of the Minas Basin, Bay of Fundy, N.S. Bedford Institute of Oceanography, Oceanographic Series BII-D-77-3.

Amos, C.L. and B.F.N. Long. 1978. The Sedimentary Character of the Minas Basin, Bay of Fundy. Unpublished Manuscript.

Bousfield, E.L. and A.H. Leim. 1958. The Fauna of the Minas Basin and Minas Channel. Nat. Mus. Canada.Bull. No. 166 pp. 30.

Daborn, G.R. (ed.). 1977. Fundy Tidal Power and the Environment. The Acadia University Institute, Publication #28, pp. 304.

MacMillan, D.H. 1966. Tides. C.R. Books Limited, London.

Pennachetti, C.A. 1977. Zooplankton of the Minas Basin of Nova Scotia with special reference to the Planktonic Copepod *Eurytemora herdmani*. Unpublished.

[1] Other participants in the symposium have been noted (see Introduction to Physical and Chemical Studies).

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Biological Studies - Introduction

Various aspects of the biology of the Bay of Fundy have been studies in considerable detail (eg Bigelow 1926, Huntsman 1952, Bousfield 1961, Bousfield and Leim 1959, Jermogejev 1958, Peterson and Peterson 1976, several authors from Daborn 1976). Inhabitants of the water column of the Minas Basin, however, have not received as much attention. Jermolajev (1958) analyzed the most complete set of plankton collections from the Bay of Fundy. Although these collections were taken from a wide range of areas they were restricted (in time) to the months of July and August and included only a few tows from the Minas Basin. This necessarily excluded seasonally and spatially restricted plankters. Peterson and Peterson (1976) examined littoral Hydrozoa and Polychaeta from the Nova Scotian part of the Bay of Fundy, but excluded many plankters from consideration. Although the present study was largely restricted to the south-western bight of the Minas Basin it represents the most intensive and extensive study of plankton in the Basin. Local flora and fauna of this region were considered from spatial, seasonal and tidal perspectives. The last consideration represents a unique but important study.

Different species of *Eurytemora* have been studied in considerable detail. Both laboratory (Grice 1971, Katona 1972) and field (Jeffries 1967, Kratz 1965) populations have received attention. The biology of *Eurytemora herdmani;* however, is not as well known and especially in an extremely tidally influenced region such as the Minas Basin. It was hoped that more detailed examination of age composition, length and weight, and female clutch size variation would aid the understanding of *Eurytemora herdmani* in this area.

Until recently primary production on the Minas Basin received very little attention. The turbidity and extensive tidal movements of the Basin water appeared to preclude primary phytoplankton production. However the extensive salt marsh and mudflat areas indicate more significant production than anticipated. An initial overview of larger phytoplankters was accomplished in 1977 (Daborn and Pennachetti unpublished). A more extensive survey was undertaken in the present study to illustrate the potential production for this region. The information should provide the stimulus for more detailed analyses of primary production in this unique region.

Some information is presented here about the composition of the fish populations in the Minas Basin. However little is known about the dynamics of the system. The study of larval and young fish feeding relations was intended to provide a basis for future studies of the role of planktonic organisms in the trophic support of fish in headwaters of the Bay of Fundy system.

(A) PLANKTON.

Objectives. The aims of this study were 2-fold:

1. To study species diversity and abundance in the south-western portion of the Minas Basin. Daily, seasonal and tidal patterns were considered.

2. To undertake a detailed study of a dominant plankter, *Eurytemora herdmani* (Crustacea:Copepoda) in terms of the relative abundance of different life stages in relation to locality and tidal cycle. Length and weight measurements of copepodid stages, and the relationship between length and clutch size of mature females was examined.

Materials and Methods.

1. Field. (i) Twenty sites in the south-western portion of the Minas Basin were visited between 17 May and 3 August, 1978 (see fig 48 , Phys. & Chemc. studies 3(a). When possible three vertical hauls from the bottom were taken at each station. A variety of nets including a #20 Wisconson type, a #20 conical, and a Hensen egg net (with 15, 30 and 30 cm apertures and 80, 64 and 64 μ mesh sites respectively) were used. These were weighted to aid in vertical submersion. On some occasions a Clarke-Bumpus net (32 cm aperture, 64 μ mesh size) fixed to a wooden frame was hauled at the surface for five minute periods. Samples were usually kept live until return to the laboratory.

(ii) Three different sites were visited on 29 May, 16 and 29 June, and 13 July (see Time-Depth Studies). Three vertical hauls from the bottom were taken at 1 hr intervals over a full (high to high) tidal cycle. When currents were too strong oblique hauls were accepted. The Hensen egg net was used for all except the 29 May session when the Wisconson type was used. Samples were fixed in neutral formalin immediately upon collection.

(iii) Various sites north of Delhaven and in the Minas Channel were visited on 22 June, and 27 and 31 July, 1978. Samples were collected from a 36' fishing vessel operated by Mr. Glen Travis. The Clarke-Bumpus apparatus and a 1 m aperture conical net (1800 μ mesh size) were hauled off the stern for 10-15 min periods. These were taken at various times during the ebbing and flooding tide. All samples were fixed immediately.

Laboratory (i) - (iii). Live samples were examined under a Zeiss dissecting microscope and general notes regarding species composition were recorded. Representative organisms were sometimes separated, relaxed and fixed accordingly. Samples were then fixed and stored for more detailed examination.

After thoroughly mixing the samples, random 1-ml subsamples were drawn into a 1 ml sterile plastic syringe. These were examined in a Sedgewick Rafter Counting chamber under an Olympus microscope (100X magnification). Two subsamples of each sample were analyzed by different people and relative percentages of various zooplankters and phytoplankters recorded. Representative photographs of many of the plankters were taken with either a Wild photomicrographic apparatus (larger organisms) or a Cambridge Scanning Electron Microscope (smaller species). Subsamples were returned to their respective sample jars after analysis.

2. Laboratory. After analysis (as in section 1) samples were remixed and a random 10-ml subsample was drawn through a glass pipette. Naupliar and copepodid stages of *Eurytemora herdmani* were separated and counted to determine relative abundances. The metasomal length of individuals of the copepodid stages was measured under an Olympus microscope (100X magnification with travelling stage micrometer). A sufficient number of each was retained for weight determinations. The latter were dried at 60°C for 24 hours and weighed on a Cahn 4100 electrobalance. Mean weights for each copepodid stage were determined. A number of mature females with fully intact egg cases were also removed from the subsamples. Egg cases were separated from the body and teased apart. The number of eggs in each case was counted and recorded along with the metasomal length of the respective individuals. Metasomal length-clutch size data were analyzed for correlation coefficients using the Acadia University computer and the Michigan State Stat Pack.

Results and Discussion (A)1. (i)

Results of the General Zooplankton survey are presented in tables 7 to 18 and figures 1 to 52. Table 7 is a faunal list that includes all organisms encountered during the study. These have been identified to the generic level (specific level where possible) but it should be noted that some are unconfirmed (eg. *Microstomum* sp., *Euplana gracilis*). Table 8 includes all other taxa that could not be identified. It should be noted that not all organisms included in the species list are planktonic. For instance various tubiferous Polychaeta, insects, shrimps, isopods, hydroids, gastropods and harpacticoid copepods probably represent accidental inclusions (eg. tychoplankton). It is interesting to note that several of the taxa listed have not apparently been documented for this region before (eg. *Pleurobrachia pileus*, *Microstomum* sp., *Autolytus* sp., *Calanus fimmarchicus* and *Podon leuckarti*). The presence of *Bougainvillea* sp. is also notable since it is suggested that this species is endemic to the Minas Basin (Peterson and Peterson, 1976). Photographs of many of the zooplankters are presented in figures 1 to 52 (see photograph album).

Appendix 2 shows weather conditions and collecting methods for the different sample dates. Accounts of species composition of zooplankton subsamples for the high tide sample sessions (main study area) are given in tables 9 to 15. Larger zooplankters are eliminated from analyses (see methods) so these have been listed in Appendix 3. Table 9 shows the combined results from 17 and 19 May (see methods). All other tables include single sample date analyses.

In Table 9 it is notable that *Eurytemora herdmani* (copepodid stages) was the dominant plankter at all sample sites except M and Q. At the latter stations the samples were dominated by cypris larvae of *Balanus* sp. A few days later the rocks at Longspell Point were covered in newly settled barnacles. It is interesting that cypris larvae from additional samples collected from this region settled on the bottom of sample jars while stored in a constant temperature cold room at 10°C. Post-trochophore larvae represented a substantial proportion of plankters at site E. This is the vicinity of a large mudflat in which polychaetes are very abundant (Boates, pers. comm.)

On 24 May copepodid stages of *Eurytemora herdmani* were again the dominant forms in the plankton. *Balanus* sp. (nauplii and cypris) were numerous at some sites eg. Q, H and I) but their relative importance had diminished substantially since the previous sample dates. As expected their occurrence at stations H and I preceeded the appearance of newly settled barnacles on scattered rocks and transect stakes near Starr's Point (Boates, pers. comm., pers obs.). However the numbers in this area never approached those at Kingsport. Post-trochophore larvae were particularly important in the vicinity of Starr's Point (station 1). Results suggested that the reproductive periods of sedentary polychaetes and barnacles are very restricted and larvae are released during short intervals only. The sample from site T was noticeably depauperate and *Eurytemora herdmani* was much less abundant. Foraminifera comprised a large portion of this sample.

Results from 6 June are very interesting in a number of ways. In these samples there were very large numbers of the polychaete *Autolytus* sp. Both adults and free swimming larvae were present however the female form carrying an egg sac was most abundant. Although these were too large for inclusion in subsamples it is notable that Polychaete embryos and post-trochophore larvae occurred in increased proportions during June. This was especially true at sites B, D and H. A patchy distribution of larval Polychaeta was evident in sample site differences. This particular kind of worm typically reproduces during a very short time interval when the otherwise benthic adults became temporarily pelagic (Meglitsch 1972). This polychaete did not occur in any other plankton sample (1977 or 1978), suggesting an extremely limited reproductive period. It would appear that some of the trochophore larvae encountered later belong to this worm. *Eurytemora herdmani* was still dominant in subsamples; however naupliar stages far outnumbered copepodids on this date. Apparently a new cohort was initiated during late May-early June (eg. compare tables 10 and 11). *Balanus* sp. comprised an insignificant percentage of populations at most sample sites except station 1 (see previous discussion). Tintinnoidea occurred in relatively large numbers at site H.

On 23 June a noticeable shift from the prominence of *Eurytemora herdmani* to *Acartia* sp. took place. When *Acartia* sp. began to occur, specific identification of *Eurytemora herdmani* copepodids was only accomplished from the C5 stage. The long caudal rami were often used as the basis of distinction (see figures 23, 24). At these times we had to assume that N1-C4 stages occurred in proportion to the occurrence of adults of the two species. This leaves room for doubt because of the variable reproductive strategies of the two copepods (Daborn pers. comm.). The biology of these species in this area has not yet been studied so more detailed treatment of data was not undertaken. However it is notable that numerous researchers have studied copepod succession in estuaries (Jeffries 1967, Kratz 1965) and shown definite seasonal changes such as those presently noted. It is interesting to notice the decline in polychaete larvae on 23 June. For the first time Nematoda occupied a significant proportion of the population at each sample site. Tintinnoidea were very common at sites P and Q and Rotifera were fairly numerous at I, L and Q. Numbers of *Balanus* sp. larvae were insignificant except at station P. These may be the remnants of the spring reproductive phase. Mysidacea occurred over the Starr's Point mud-flat (site J) but the small proportion recorded probably reflect their exclusion from subsamples due to large size rather than infrequent occurrence (see Appendix 3).

Table 13 shows results from 9 sites visited on 7 July. *Acartia* sp. were more numerous than *Eurytemora herdmani* except at station N. *Acartia* was only outnumbered (by Nematoda) at stations south of Starr's Point (eg C and E-F). Nematodes were notable at most sample sites on this date; however their relative importance seemed to decrease farther north. At all stations except A, *Balanus* nauplii and cypris larvae showed increased numbers compared to 23 June. However relative abundance approached previous levels only at station Q. Perhaps some of these larvae were carried from Blomidon Point (see results II 1.(a) (iii)) where it was noted that barnacles settled at a later date than those at Kingsport. It is probable that lower water temperatures in the Blomidon region result in some-what later onset of reproduction in barnacles of that area. The relative abundance of *Balanus* sp. larvae declined progressively at sites further away from the main channel. On 7 July veliger larvae began to occur in significant numbers at most stations. This was especially notable at sites H and K. Both are near saltmarsh-mudflat areas where *Nassarius obsoleta* and other molluscs occur in exceptionally large numbers (Bousfield and Leim 1959; also see Fuller and Trevors 1977). Egg cases of *Nassarius obsoleta* were encountered (see photo-graph album, figure 11) but the identity of other veliger larvae could not be ascertained. Nematoda were again very common (especially in stations of the southern bight). Appendix 3 shows that *Microstomum* sp. and hydroid medusae were present in most samples, however these were too large for subsample analysis.

On 21 July (see table 14) *Acartia* sp. dominated most samples except station O, where *Eurytemora herdmani* was most abundant, and F, where Nematoda dominated. *Balanus* sp. were infrequent. However polychaete embryos and post-trochophore larvae consistently comprised more than 5% of total subsample populations near Kingsport. Nematodes and veliger larvae were quite important at all sites, the former at more southerly stations and the latter particularly at A and L.

Table 15 (3 August) indicates that Nematodes comprised a large percentage of the populations at various sites, however *Acartia* sp. was still dominant at most stations. The occurrence of *Eurytemora herdmani* became very limited. Similar results were determined in the 1977 survey (Pennachetti, unpublished). Polychaete larvae were present in relatively large proportions at stations G and M, both of which are in the vicinity of the Starr's Point mudflat. It is interesting that the occurrence and distribution of larval polychaetes was so patchy on 21 July and 3 August. Reproductive phases of different species from various locations may be involved. The harpacticoid copepod *Halithalestris croni* comprised quite a large proportion of the subsample from site D. Its occurrence was less frequent but notable at other stations. Site D overlies an extensive saltmarsh and this is probably the normal habitat of *H. croni*. The semipelagic habits of this species (Wilson, 1932) probably account for its notable but patchy abundance in samples. General notes (see Appendix 3) show that *Microstomum* sp. and hydroid medusae occur quite consistently at the various sample sites visited.

The General notes presented in Appendix 3 are important since they illustrate the diversity of larger plankters present at the different sites. Only those observations which subsample analysis failed to indicate have been included. These results showed that hydroid medusae and Mysidacea larvae occur quite regularly throughout the 1978 season. The scattered occurrence of larger and/or less frequently encountered plankters such as fish larvae, *Pleurobrachia pileus*, young *Corophium volutator* and *Calanus finmarchicus* are indicated.

Although the results of this study are not quantitative they served to illustrate many important features of both local and seasonal variations in zooplankton composition of the S.W. bight of the Minas Basin. This kind of information will provide valuable baseline data for future studies.

TABLE 7 : Faunal list of organisms collected from the south-west Minas Basin.

PROTOZOA	
DINOFLAGELLIDA	**Ceratium* sp.
TINTINNOIDEA	*Tintinnopsis* sp.
CNIDARIA	
HYDROZOA	**Bougainvillea* sp.[1]
ANTHOZOA	*Nemapsis bachei* L. Agassiz
	Nematostella vectensis Stephanson, 1935
CTENOPHORA	
TENTACULATA	**Pleurobrachia pileus*
PLATYHELMINTHES	
RHABDOCOELA	**Microstomum* sp.(?)
POLYCLADIDA	*Euplana gracilis* (?)
ASCHELMINTHES	
ROTIFERA	**Asplanchna* sp.[3] (?)
MOLLUSCA	
GASTROPODA	*Nassarius obsoleta*(Say) - egg cases
ANNELIDA	
POLYCHAETA	*Tharyx acutus* Webster and Benedict
	Autolytus sp. (prob. *A. coronatus*)
	Streblospio sp.
	Pygospio sp.
ARTHROPODA	
CRUSTACEA	
CLADOCERA	**Podon leuckarti*
COPEPODA	**Eurytemora herdmani* Thompson and Scott 1898
	**Centropages* sp.
	**Acartia* sp.
	**Pseudodiaptomus* sp. (probably *P. coronatus* Williams)
	**Calanus finmarchicus* (Gunner)
	**Halithalestris croni* (Krøyer) 1845
ISOPODA	*Idothea baltica* Pallas
AMPHIPODA	*Amphithoe rubricata* Mont.
	Corophium volutator
	Caprella linearis (Linnaeus)
CIRREPEDIA	**Balanus* spp. (nauplii and cypris)
MALCOSTRACA	
MYSIDACEA	**Neomysis americana* (S.I. Smith) - larvae
HEMICHORDATA	
CHAETOGNATHA	**Sagitta elegans*

OSTEICHTHYES[2] (larvae)	*Alosa pseudoharengus* (Wilson) 1811 *Alosa sapidissima* *Gasterosteus wheatlandi* Putman 1867 *Osmerus mordax* (Mitchell) 1815 *Anguilla rostrata* (Le Sueur) 1817 *Microgadus tomcod* (Walbaum) *Urophysis tenuis* (Mitchell) 1815 *Cottunculus thompsoni* (Gunther) 1882 *Pseudopleuronectes americanus* (Walbaum) 1792 *Liopsetta putnami*

1 described as *B. minas* by Peterson & Peterson (1976)

* planktonic in at least part of life cycle

2 see Section (B) Biological Studies

? unconfirmed

3 accidental - originated in fresh water

TABLE 8. Unidentified Taxa from the South West Minas Basin.

PROTOZOA	*Tintinnidea *Foraminifera *Ciliophora
PORIFERA	Spongillidae - spicules
CNIDARIA	Hydrozoa - hydroid colonies, medusae *Scyphozoa - ephyra
NEMATODA	
NEMERTINA	
MOLLUSCA	*Gastropoda - veliger and post veliger larvae[3] *Lamellibranchia - larvae
HIRUDINEA	Piscicolidae- 2 distinct species
POLYCHAETA	*trochophore and post-trochophore larvae
ARTHROPODA	Copepoda - Harpacticoida and Caligoida Amphipoda Gammaridae Hyperiidae *Decapoda - zoea, megalopa, calyptopsis larvae Caridea Cumacea *Euphauscacea
	Insecta[4] Acarina - mite
OSTEICHTHYTES	eggs

* planktonic in at least part of life cycle

[3] probably of *Nassarius obsoleta* and other gastropods found on Starr's Point mudflat (see section 7).

[4] mostly incidental in surface waters (especially in tide lines)

TABLE 9 % Composition of Zooplankton at 6 Sample Sites 17&19 MAY

	D	E	K	L	M	Q
Post-trochophores	4.9**	41.5**	1.6*	4.4*	3.9**	0.3*
E.herdmani	92.2***	52.6***	39.8***	50.1***	2.8*	24.7**
C6♀ with eggs		3.1	0.4			
C6♀ without eggs	4.7		0.4	1.3		
C6♂	2.9		2.2	2.5	0.4	1.1
C5♀	2.9		1.0	0.6	0.4	2.9
C5♂	3.9	3.1	0.2	5.8		2.5
C4	31.3	10.5	5.0	18.7	0.4	1.4
C3	38.9	26.8	10.7	17.3	1.6	10.7
C2	7.6	9.1	8.8	3.3		6.1
C1			11.1			
N1-N6				0.6		
Balanus sp.	2.9*	5.9*	8.7**	44.9**	93.2***	75.0***
nauplii	1.0		1.1			11.0
cypris	1.9	5.9	7.6	44.9	93.2	64.0

TABLE 10 %Composition of Zooplankton at 7 Sample Sites 24 MAY

	A	D	H	I	L	Q	T
Foraminifera	0.4**			5.9			76.9***
Post-trochophores		1.1**		29.4**			
H.croni					22.2**		
E.herdmani	99.5***	99.0***	80.4***	53.0*	77.6***	70.6***	7.7*
C ♀	6.7	3.3		5.9			
C ♀	8.9	13.0	6.5			29.4	
C ♂	11.2	18.5	27.8		4.4	5.9	
C5♀	11.2	14.1	6.5	5.9	22.2		
C5♂	3.4	7.6	2.2		8.9		
C4	14.5	20.7	14.1	5.9		11.8	
C3	26.8	19.6	21.1		8.9	5.9	7.7
C2	15.7	2.2	2.2	5.9	4.4	17.6	
C1	1.1				4.4		
NI-N				29.4	24.4		
Balanus sp.			21.1**	11.8*		29.4**	15.4**
nauplii				5.9		5.9	15.4
cypris			21.1	5.9		23.5	

TABLE 11 %Composition of Zooplankton at 7 Sample Sites 9 JUNE

	A	B	D	E	H	I	S
TINTINNOIDEA		1.9	2.7	1.4	9.6 *		
Ceratium sp.	0.3	1.3			0.3		
FORAMINIFERA		3.1	0.7		0.3		
Microstomum sp.		3.8	0.2				
NEMATODA	3.8	5.0*	16.5*	1.8	5.4		
ROTIFERA			0.7	18.8*	11.1		
POLYCHAETA	19.0**	61.3***	35.6**	23.8**	48.5***		2.9**
Embryos		7.5	24.7	9.5	5.5		1.0
Trochophores					1.8		
Post-trochophores	19.0	53.8	10.9	14.3	41.2		1.9
H.croni	2.4*	4.4	1.7	0.2	0.1		2.9**
E.herdmani	73.9***	17.5**	40.7***	53.9***	24.5**	84.1***	94.2***
C6♀ with eggs						1.7	10.2
C6♀							3.7
C6♂	1.0		0.2	0.2	0.3	10.6	16.6
C5♀	1.4	1.3		0.8	0.3	8.8	7.4
C5♂				0.8	0.1	5.2	3.7
C4	0.3	0.6	1.5	0.8	0.7	19.3	14.6
C3	7.3	4.4	1.7	3.1	4.9	31.6	29.2
C2	2.4	5.0	1.5	2.1	3.9	5.2	8.8
CI		3.1		1.0	0.5	1.7	
NI-N6	61.5	3.1	35.8	45.1	13.8		
Balanus sp.		1.9	0.9	0.2		15.8**	
Nauplii		1.3	0.7	0.2			
Cypris		0.6	0.2			15.8	
MYSIDACEA					0.1		

TABLE 12 Composition of Zooplankton at 5 Sample Sites 23 JUNE

	I	J	L	P	Q
TINTINOIDEA	2.8	4.9	1.2	5.4	11.8 *
Ceratium sp.	0.2		0.5	0.2	0.2
FORAMINIFERA	1.5	2.6	0.9	1.2	1.4
NEMATODA	13.0 **	14.4 **	17.6 **	11.2 *	15.3 **
ROTIFERA	11.5 *	2.1	10.8	1.2	9.1
VELIGER LARVAE			0.9		
POLYCHAETA	6.9	9.5 *	9.4	4.6	3.2
Embryos	6.3	7.4	7.8	4.0	2.9
Trochophore larvae					
Post-trochophore larvae	0.6	2.1	1.6	0.6	0.3
H. croni	0.9	0.7		0.2	0.6
other HARPACTICOIDA	1.2	1.4	0.2		0.2
Acartia sp.	2.3 ***	0.2 ***	3.2 ***	0.3	0.5
E. herdmani	0.5	0.2 ***	0.9 *	2.7 ***	2.1 ***
C6♀				0.3	0.6
C6♀			0.2	0.2	0.3
C6♂	0.5	0.2	0.7	1.2	1.0
C5♀				0.8	0.2
C5♂				0.2	
C4		0.5	0.5	0.2	1.0
C3	1.1		2.1	2.6	2.7
C	1.4	2.0	6.5	2.3	2.9
CI	2.8	3.5	2.1	4.2	3.0
NI-N6	53.6	56.6	39.6	51.6	41.7
Balanus sp.	0.4	0.2	0.9	12.1 **	4.2
Nauplii	0.2		0.7	11.8	4.2
Cypris	0.2	0.2	0.2	0.3	
Zoea larvae					0.2
MYSIDACEA		0.2			

TABLE 13 %Composition of Zooplankton at 9 Sample Sites 7 JULY

	C	D	E-F	H	I	K	L	N	Q
TINTINNOIDEA				1.6	1.1	0.8	1.6		1.7
Ceratium sp.	3.4	3.2	4.8		0.5		0.5	0.6	
FORAMINIFERA	0.9	1.6	2.4	15.9*	0.8	3.0	1.6	1.3	
NEMATODA	56.0***	25.8**	40.5***	11.1	21.4**	18.2*	17.6***	9.7**	8.7*
ROTIFERA					1.1	0.8	1.0		
VELIGER LARVAE	6.0	1.6	7.1	28.6**	2.5	22.0**	2.1		1.7
POST-TROCHOPHORE LARVAE	3.4				3.3	1.5	2.6	0.6	3.4
H. croni	0.9				0.3	3.0	0.5		1.7
other HARPACTICOIDA	0.9			1.6	1.1	0.5	3.0	0.6	
Acartia sp.	16.4**	48.4***	26.2**	23.8***	22.5***	12.9***	44.0***		13.9***
E. herdmani	4.3*		7.2		5.4*	0.8	1.0	66.0***	0.9
C6♀	2.6		2.4		1.9			1.3	
C6♀			4.8		0.5			0.6	
C6♂	1.7				3.0	0.8	1.0	10.4	0.9
C5♀									
C5♂					0.3			0.6	
C4				1.6	2.5	3.0	1.0	12.3	7.0
C3	3.4	8.1		1.6	4.4	2.3	1.0	15.6	5.2
C2	1.7	1.6		6.3	6.3	5.3	1.0	7.1	7.0
C1	0.9		2.4	1.6	3.6	2.3		1.9	3.5
N1-N6	1.7	3.2		1.6	20.6	17.4	18.1	16.2	14.8
Balanus sp.		6.4*	9.5*	4.8	1.9	6.0	3.6*	3.9*	30.5**
Nauplii		4.8		1.6	1.1	1.5		3.9	15.7
Cypris		1.6	9.5	3.2	0.8	4.5	3.6		14.8
MYSIDACEA					0.3				

TABLE 14 Composition of Zooplankton at 9 Sample Sites 21 JULY

	B	D	F	H	I	J	L	O	R
TINTINNOIDEA							0.4	1.2	1.1
FORAMINIFERA			5.7		1.2	0.7		1.2	1.1
NEMATODA	27.0**	37.5**	27.3***	7.8	12.0*	18.7**	2.3	5.8	11.1
ROTIFERA					3.1	0.7	10.0	1.2	2.1
VELIGER LARVAE	19.0*	2.1	9.1	9.8*			17.7**	7.0	2.1
POLYCHAETA	0.9	4.2*	9.1	5.9	6.2	7.4	16.1*	11.6**	13.7*
Embryos	0.6		1.1		3.5	3.7	1.5	8.1*	3.7
Post-trochophore larvae	0.3	4.2	8.0	5.9	2.7	3.7	14.6	3.5	10.0
H. croni					1.9	0.7	1.9	1.2	1.6
other HARPACTICOIDA					0.8				
Acartia sp.	40.1***	47.9***	23.9**	41.2***	6.9***	4.5***	12.7***		13.8***
E. herdmani	10.4	2.1	18.1*	11.7**	2.0**	0.7*	2.7	3.5***	8.6**
c6			1.1				0.4		1.1
c6	2.1		1.1	3.9	0.4				1.1
c6	6.8	2.1	12.5	7.8	0.8	0.7	2.3	1.2	4.8
c5	0.9		3.4		0.8			2.3	1.6
c5	0.6								0.5
c4		2.1	2.3	5.9	1.2	0.7	1.9		2.1
c3	1.8		1.1	3.9	2.7	3.7	1.5	2.3	7.4
c2		2.1	2.3	3.9	1.2	3.7	1.5	3.5	3.7
c1				2.0	1.9	1.5	2.3	8.1	2.6
N1-N6	0.9	4.2		7.8	59.1	56.7	32.7	53.5	27.0
Balanus sp.				1.1			1.2		
Nauplius				1.1					
Cypris							1.2		
	B	D	F	H	I	J	L	O	R

TABLE 15 %Composition of Zooplankton at 8 Sample Sites 3 AUGUST

	A	D	E	G	I	M	Q	R
Ceratium sp.							0.5	
FORAMINIFERA	12.8*	2.0		2.2			1.5	0.3
NEMATODA	46.2***	20.0*	36.6**	8.7	1.8	4.2	2.0	3.2*
ROTIFERA		23.0**	2.4	26.1**	20.8**	37.5***	28.9**	67.0***
VELIGER LARVAE		1.0	4.9*		1.8	5.2		0.5
POLYCHAETA		1.0		19.6*	4.2*	13.5*	13.1	3.0
Embryos		1.0		2.2	1.8	3.1	7.1	1.7
Post-trochophore larvae				17.4	2.4	10.4'	6.1	1.3
H.croni	2.6	8.0	2.4	2.2	2.4	1.0	1.0	0.7
other HARPACTICOIDA					1.8			
Acartia sp.	2.6**	5.0***	12.2***	4.3***	4.2***	9.4**	10.2***	3.9**
E. herdmani				2.2		1.0	3.0*	
C6 with eggs							0.5	
C6								
C6				2.2			1.0	
C5							1.5	
C5						1.0		
C4							2.0	
C3						3.1	1.0	0.4
C2			4.9	2.2	1.2	3.1	0.5	0.9
C1	5.1	2.0	4.9		2.4	1.0		2.4
N1-N6	30.8	38.0	31.7	32.6	57.1	20.8	35.0	17.7
Balanus sp. cypris							1.0	

Results and Discussion.

I(A) 1.(a)(ii). The data from Time-Depth Studies of zooplankton were extensive and time limitations prevented an equally extensive presentation and interpretation. A more detailed analysis of results is planned for the near future. However several observations will be discussed in this report.

Composition of the zooplankton for the 29 May tidal study is presented in table 16. The 1200-1500 time interval was not included since samples were not taken at this time (see Methods). As might be expected *Eurytemora herdmani* was the dominant plankter on this date (see Results (A)(a)(i)). It is interesting that naupliar stages were numerically predominant and that the degree of predominance tended to decrease during the flood tide (eg. 90-50% from low to high tide). At the same time the percentage composition of copepodid stages increased. The overall abundance of *Eurytemora herdmani* decreased during this time. This apparent decrease was probably related to the increase in polychaeta (larval stages) which was very noticeable during the flood tide (eg. 1-34% from 1600-1930 hrs). This reflects the same kinds of larval distribution patterns discussed previously ((A)(a)(i)) and indicates that tidal movements play an important role in polychaete distribution in the S.W. Minas Basin. Nematodes were noticeably abundant throughout the tidal cycle, but their occurrence appeared to be quite patchy. *Balanus* cypris larvae occurred in small numbers during the ebb tide and comprised a maximum of 4.7% of the total population sampled at 1930 hrs. The release of *Balanus* larval stages is probably also related to tide time. Mysidacea larvae were only present in subsamples from 0900 hours. They may have been present at all times but generally excluded from subsamples because of their large size.

Protozoan plankters were only represented in large numbers at 1700 hrs when the Foraminifera comprised 5% of the total population in subsamples. Harpacticoida showed patchy distribution patterns with a maximum before low tide (≤2 hrs). Their occurrence was generally low and scattered.

Results from 16 June are presented in table 17 and *Eurytemora herdmani* was consistently a dominant species. Note however that *Acartia* sp. occurred in small proportions at various times (esp. 1915 hrs). A mixture of naupliar and copepodid stages was evident and it was notable that the former showed marked increases around low tide (eg. >50% from 1415-1715 hrs). The apparent decrease in relative dominance at 0815, 1315 and 2015 probably reflects increased proportions of other plankters (Tintinnoidea, Nematoda) rather than real decreases. Nematoda were prominent plankters throughout the sample period however no real pattern was evident. Freshwater rotifers showed a tendency to increase around low tide time and this probably reflects the increasingly significant influence of the Habitant River channel. Polychaete larvae occurred in notable numbers throughout the day and increased slightly at the beginning of the flood tide. The distinct pattern evident on 29 May was not repeated on 16 June. *Balanus* larvae did not occur frequently in low water subsamples but as expected were relatively more abundant during the flooding and ebbing tides (see previous discussions).

Table 18 shows results from the 13 July sample session. This was the first Time-Depth Study in which *Acartia* sp. constituted a large proportion of the samples. Again *Eurytemora herdmani* could only be distinguished at the C5 and C6 stages (see Results II(A)(a)(i)). According to these data *Acartia* sp. and *Eurytemora herdmani* alternate in dominance throughout the tidal cycle. It would appear that ultimate dominance was associated with temperature since *Eurytemora herdmani* was more abundant only when the mean temperature was less than 20°C. This may be an important consideration in the interpretation of seasonal changes of zooplankton in the Minas Basin (see previous discussion (A)(a)(i)). Similar temperature related changes have been documented by other estuary researchers (Jeffries 1967). Nematoda showed patchy occurrence as did various protozoan plankters. *H. croni* and other harpacticoids occurred more frequently than in previous Time-Depth studies but showed no apparent patterns. Veliger larvae were also present for the first time in the series of Time-Depth Studies and peak occurrence was evident at 1930 hours (very near high tide time). The abundance of polychaete larvae showed some relationship with tide time but this was not as evident as in previous sessions. *Balanus* larvae did not occur in significant numbers and Mysidacea were only apparent in the 1530 subsamples (+2 hrs from low water).

Although data from the Time-Depth zooplankton studies have not been analyzed in detail, various important trends have been indicated in this account. In particular, the patchy distribution of zooplankton associations noted in the general surveys of the southern bight will also be reflected in the notable changes in species composition during a tidal cycle. Much of this patchiness is probably attributable to the generation and separation of eddy currents as the tidal water moves over the mudflats (Borthwick pers. comm.). It is apparent that there is great hetereogeneity in the zooplankton of this region. This kind of information should provide an important basis for future studies regarding the occurrence and distribution of zooplankters in this unique tidally influenced estuary.

TABLE 16 Time-Depth Zooplankton (%) Composition 29 MAY

	0800	0900	1000	1100	1600	1700	1800	1900	1930
SILICOFLAGELLATE	1.1								
TINTINNOIDEA								2.3	
Ceratium sp.			1.3	2.2 *			2.2	1.6	0.7
FORAMINIFERA			1.3		0.4	5.0 *	2.2	1.4	3.2
Microstomum sp								0.5	
NEMATODA	3.3 *	1.8 **	2.4 *	1.0	2.6 **	1.4	2.4 *	7.2 *	4.7 *
LAMELLIBRANCH LARVAE							0.5	1.2	
POLYCHAETA	4.3 **	0.6	3.8 **	1.0	0.9 *	11.1 **	23.4 **	27.6 **	34.3 **
Embryos									4.7
Post-trochophore larvae	4.3	0.6	3.8	1.0	0.9	11.1	23.4	27.6	29.6
HARPACTICOIDA			1.8	5.4 **		0.7	1.7		
E. herdmani	90.1 ***	96.2 ***	88.8 ***	89.0 ***	96.4 ***	79.9 ***	68.7 ***	54.2 ***	52.1 ***
C6 with eggs		0.6			0.2			0.5	
C6					0.2	0.7		0.5	1.4
C6	1.1	0.6	0.4		1.5	1.4	1.2		
C5					0.2	0.7			0.7
C5					0.2				
C4							0.5		
C3		3.0	0.4		1.1	2.1	2.2		
C2							1.7		
C1			0.7				0.5	2.4	1.4
N1-N6	89.0	92.0	87.3	89.0	93.0	75.5	61.6	50.8	48.6
Balanus sp.	1.1	1.2 *	0.4	1.0					4.7 *
cypris	1.1	1.2	0.4	1.0					4.7
SHRIMP LARVAE —		0.6							

TABLE 17 Time-Depth Zooplankton(%)Composition 16 JUNE

	0815	0915	1015	1115	1215	1315	1415	1515	1615	1715	1815	1915	2015
Py							0.4						
TINTINNOIDEA	50.0***	26.6**		31.0**	8.4*	6.2	3.1	1.3	4.5	7.0	8.6	21.2**	36.2***
Ceratium sp.	5.7	0.6	0.3	0.4	0.6				0.3				0.4
FORAMINIFERA	5.7	7.8	0.6	2.6	7.0	6.2	0.4	0.7	0.7	0.5	1.2	1.2	1.0
NEMATODA	14.2*	13.1*	13.7**	15.0*	33.2**	41.4***	12.6**	12.8*	11.1*	19.3**	14.1*	18.1*	33.5**
ROTIFERA	2.8	0.9		0.4	4.7	4.8	5.8	9.6	21.4**	6.5	1.2	5.9	
LAMELLIBRANCH LARVAE				0.4							0.3		
POLYCHAETA	6.3	7.2	0.6	5.0	5.8	8.2*	8.5*	16.4**	8.2	16.1*	24.6**	2.2	
Embryos		4.7		3.9		6.2	7.4	9.6	6.6	4.1	6.6	1.9	
Trochophore larvae					2.2								
Post-trochophore larvae	6.3	2.5	0.6	1.1	3.6	2.0	1.1	6.8	1.6	12.0	18.0	0.3	
HARPACTICOIDA							1.6			0.9		9.3	0.6
Acartia sp.			0.3	0.4									
E.herdmani	30.8**	29.1***	79.6***	38.0***	36.5***	32.8**	66.2***	59.0***	53.7***	49.4***	47.3***	45.5***	22.0*
C6 with eggs	0.6	0.9	2.0	1.1			1.1				1.2	1.6	2.2
C6	0.6	0.6	2.3	0.4	0.6						1.2		0.4
C6	3.4	2.8	11.0	1.7		1.3	1.1	0.4			6.6		4.6
C5	0.6	1.3	3.2	1.3	0.6						2.0		0.4
C5		0.3	2.6		0.6								
C4	2.3	2.8	14.2	2.4	1.1	1.3	1.1	0.4			2.0	0.6	2.6
C3	2.8	3.8	13.7	10.4	5.9	2.0	1.1	0.4	1.0	2.4	5.9	0.3	5.3
C2	1.2	1.3	4.1	2.6	2.2	2.0	7.4	2.3	0.7	3.2	5.0	1.9	1.0
C1		0.3		0.7	0.6		0.4	0.4		1.9			
N1-N6	19.3	17.8	26.5	17.4	24.9	26.2	54.0	55.1	52.0	41.9	23.4	41.1	5.5
Balanus sp.	2.4	5.6	4.4*	5.7	2.8		1.1			0.5	2.9	5.6	5.4
nauplius	1.8	5.3	0.3	5.0	1.7		1.1				2.9	5.6	5.4
cypris	0.6	0.3	4.1	0.7	1.1					0.5			0.4

TABLE 18 Time-Depth Zooplankton(%)Composition 13 JULY

	0830	0930	1030	1130	1430	1530	1630	1730	1830	1930	2030
TINTINNOIDEA			0.6		1.5			1.8	0.7	0.6	
Ceratium sp.				1.6	1.5	0.9	0.3			0.6	2.7*
FORAMINIFERA			3.0	1.6	1.5	0.4	0.8	1.4	1.3	1.8	1.4
B.minas							0.4	0.5			1.4
NEMATODA	3.2	4.5*	8.3*	15.6**	50.7***	27.9**	9.1*	19.1**	22.0**	16.8*	2.7*
ROTIFERA			0.4			0.4	2.1		0.7	1.2	1.4
VELIGER LARVAE	2.9		1.1		1.5	0.4	0.3	0.5	0.7	6.0	
POLYCHAETA	4.0*		1.1	0.5	1.5	1.3	1.6	3.2	3.3	2.4	
Embryos	0.4		0.2	0.5	1.5	0.9	1.3	1.4		1.8	
Post-trochophore larvae	3.6		0.9			0.4	0.3	1.8	3.3	0.6	
Acartia sp.	26.1**	61.4***	53.4***	68.8***	35.8**	40.7***	48.7***	12.7*	14.0*	39.5***	50.7***
H.croni	2.5		2.6	0.5		0.9	1.3	0.9	0.7	3.6	2.7
other HARPACTICOIDA		0.8	2.2	1.6	1.5	6.2	7.2	3.2	2.0	3.6	5.5
E.herdmani	60.1***	31.9**	27.0**	9.1*	3.0*	18.9*	27.9**	54.5***	53.9***	22.8**	31.5**
C6 with eggs			1.1					0.9	3.3		1.4
C6	0.4		1.7		1.5		0.3	1.4		0.6	
C6	6.4	2.3	2.6				0.5	6.4	5.3		2.7
C5	0.4	0.8	1.3				0.3	2.7	5.3		
C5	1.4		0.2					0.9			
C4	6.4	1.5				0.4	0.8	2.7	2.7		
C3	11.1	3.8	1.3			0.4	0.8	4.5	3.3	0.6	1.4
C2	7.9	1.5	1.3		1.5			4.1	5.3		
C1	6.8		0.4	0.5			0.3	3.6	4.0		
N1-N6	19.3	22.0	17.1	8.6		18.1	24.6	27.3	24.7	21.6	26.0
Balanus sp.	1.4	1.5	0.4	0.5	1.5	0.4	1.1	2.3	0.7	1.2	
nauplius										1.2	
cypris	1.4	1.5	0.4	0.5	1.5	0.4	1.1	2.3	0.7		
MYSIDACEA						0.9					

Results and Discussion (II)(A) 1.(a)(iii).

Time did not permit analyses of all plankton collections from the study region north of Delhaven. The 22 June samples were not analyzed, however general notes about collection of and organisms in these samples have been presented in Appendix 5. Subsamples from most of the 27 July collections have been examined and results are presented in table 19. Appendix 5 records conditions and methods of collection of those samples. Biological data from 31 July have not yet been examined.

Notes about 27 July session show that collection methods were comparable to those of the main study area at site A (eg. 64 µ mesh Clarke Bumpus net). Here, even when the Clarke-Bumpus apparatus was not functioning correctly a marked abundance of young copepodid stages was noted. It was very interesting that another collection in this area (with the 1800m mesh, 1 m conical net) had an abundance of *Eurytemora herdmani* females with egg sacs. This is very valuable information when considered in relation to the main study region. As previously discussed the numbers of *Eurytemora herdmani* had substantially declined in the southern bight (see (A)(a)(i)). Time-Depth Studies suggested that these seasonal changes were temperature related (see (A)(a)(ii)). Present data suggest that *Eurytemora herdmani* probably moves to cooler waters (see Phys. and Chem. results I(3)(b)) north of Delhaven. *Calanus finmarchicus* was noted in quite large numbers at sample site B. This species is the dominant form in the Gulf of Maine throughout the year (Bigelow, 1926) but apparently only a few move far up the Bay (Jermolajev, 1958). Jermolajev indicated that this species did not enter the Minas Basin, however present results indicated that individuals are occasionally carried into the Basin proper. In fact on one occasion live individuals were collected as far south as the Cornwallis River estuary (see results II(A) 1.(a)).

Most samples contained large amounts of detrital material, however this was not surprising since collections often passed through tide lines (see Phys. and Chem. studies I(3)(b)).

Zooplankton from 27 July was analyzed as in A(A) and it was noted that samples were depauperate relative to those of the main study area. Results are presented in table 19. Sites C, C^1, E, F, F^2 and F^3, were sampled with a 64 µ Clarke-Bumpus net and frame (see Appendix 5, and figure), however F^2 and F^3 were done during the flood (*vs* ebb) tide (see Appendix 1). *Eurytemora herdmani* (mixed stages) were dominant at C, C^1 and E and *Balanus* sp. larvae also comprised a large proportion of the populations from these sites. The latter is to be expected in view of the large numbers of newly settled *Balanus* sp. on shoreline rocks (pers. obs.). Sample F was somewhat depauperate in comparison to C, C^1 and E. This probably reflects differences to location (eg. Minas Channel vs. Basin proper) (see Jermolajev, 1958) and improper function of Clarke-Bumpus firing mechanism (see Appendix 5). Samples F^2 and F^3 also showed different results and these were probably related to tide time (see previous discussion and Appendix 5). *Eurytemora herdmani* occurred in relatively (much) lower proportions, while polychaete larvae were present in increased numbers. These results are similar to those indicated by Time-Depth studies (section II(A)(a)(ii) and once again illustrate the influence of tidal movements on the biology of local fauna. The decrease of *Eurytemora herdmani* in the Minas Channel is also a reflection of its typical estuarine habits.

Sites C^1, C^3, E^1 and F were all sampled with a 1 m conical net (see Appendix 5) and results are therefore comparable. Density and diversity in these samples were markedly decreased. However this is due to exclusion of most small plankters (large mesh size). Although larger species were collected these were mostly excluded from subsamples. Time did not permit general examination of these samples, but subsample results indicate shifting dominance and patchy distribution of organisms. This agrees with results from the main study area.

Although the results of plankton studies north of Delhaven are incomplete the data examined yielded some important information, particularly in relation to *Eurytemora herdmani* (see previous discussion). Results suggest that the dominant local plankters *Eurytemora herdmani* and *Acartia* sp. are temperature sensitive. It is hoped that future studies will yield more information about the temperature tolerances and movements of the local populations of these copepods. A more detailed survey of the region north of Delhaven is planned for the coming year. This kind of information will greatly improve our understanding of the biology of this unique region.

TABLE 19 %Composition of Zooplankton at 10 Sample Sites 27 JULY

	C	C²	E	F	C'	C³	E'	F'	F²	F³
TINTINNOIDEA	5.0				100.0***					
FORAMINIFERA								33.3***	5.1	
HYDROZOA	5.0	13.6*	16.2*			60.0***		33.3***	12.8	15.0*
Hydra	5.0	13.6*	13.0					33.3	12.8	15.0*
Medusae			3.2							
NEMATODA	2.1		3.2				40.0**			3.1
VELIGER LARVAE	14.3*		9.7						30.8**	14.4
POLYCHAETA	7.1	9.1	12.9			20.0**		33.3***	20.6*	15.7**
Embryos	5.0	6.8	9.7					33.3	18.0	13.8
Post-trochophore larvae	2.1	2.3	3.2			20.0			2.6	1.9
H.croni										0.6
other HARPACTICOIDA										1.9
C.finmarchicus	2.1		6.5							2.5
Acartia sp.	9.2	4.5	9.7	50.0***						
E.herdmani	33.4***	61.3***	20.5***						2.6	6.2
C6 with eggs	5.0		3.2							
C6		4.5							2.6	0.6
C6	12.1	4.5								0.6
C5	2.1									0.6
C5										
C4 COPEPOD	7.1	15.9	3.2							1.3
C3	5.0	34.1**	16.1							0.6
C2	2.1	2.3								1.3
C1										0.6
N1-N6										0.6
Balanus sp.	19.3**	11.4	19.4**	50.0***			60.0***		28.2**	40.0***
nauplius	14.3	11.4	6.5	50.0***			20.0		20.5	24.4
cypris	5.0		12.9				40.0		7.7	15.6
MYSIDACEA						20.0**				0.6
INSECTA	2.1									

Results - Phytoplankton - II(A)I.(a)(i)

Composition of the phytoplankton has been reported in tables 20 to 27 and in figures 54 to 69. Table 20 is a floral list for the 1978 study regions. Photographs of many common representatives are provided in figures 54 to 69 (see photograph album). Tables 21 to 27 include the relative composition of the phytoplankton on each sample date except for 17 and 19 May when results were combined (see zooplankton results (A)(a)(i)).

The floral list includes all net phytoplankters encountered during the sample season. Only those large enough to be distinguished under 100X magnification were identified. This undoubtedly excludes many smaller Bacillariophyceae and all nannoplankton. Many smaller species of phytoplankters (64 μ - largest diameter) are also eliminated from collection and analysis due to the sampling techniques employed (see Methods (A)(a)(i)). In view of these difficulties the results from individual sample dates will not be discussed in detail; however several observations should be noted.

The difficulties already discussed probably account for the high proportion of centric diatoms enumerated throughout the 1978 season. Results are further complicated by the depth of collection: (eg. on 24 May, in 3 vertical hauls (80μ mesh) *Coscinodiscus* dominates, whereas in a 5 min surface tow (64 μ mesh) *Rhizosolenia* dominates). These kinds of data suggest that phytoplankton composition as recorded in tables 21 to 27 is largely related to collecting methods. Nonetheless, constant collecting methods at different sites on a particular sample date do show local variations (eg. 6 June, 7 July, 8 August). These data indicate considerable patchiness in the composition of larger phytoplankters.

Although no quantitative data could be obtained it is interesting to note that an extensive phytoplankton "bloom" was observed on 1 September when sample stations north of Starr's Point were visited. Time did not permit detailed analyses of these samples but a general examination of samples indicated that *Biddulphia* spp. and *Rhizosolenia* spp. comprised the bulk of this bloom. No comparable blooms were noted during the main study season although relative abundance of phytoplankters increased slightly in late June-early July.

Although no conclusive quantitative statements can be made about the composition of the phytoplankton, several points should be emphasised. It appears that *Coscinodiscus* spp., *Rhizosolenia* spp. and *Biddulphia* spp. were the most abundant of the larger centric diatoms in the study area. *Gyrosigma* spp. and various Naviculoidea seem to comprise the bulk of the larger pennate varieties. It is suspected that smaller diatoms and nannoplankton are probably very abundant. The apparent diversity and abundance of phytoplankton is somewhat surprising in view of past accounts (Huntsman 1934, Bousfield and Leim 1960). It is hoped that more detailed and quantitative studies of local phytoplankton composition and abundance will be accomplished in the near future.

TABLE 20. Floral List from the South West Minas Basin[1]

CHLOROPHYTA	**Ulothrix* spp.
	**Spirogyra* spp.
	**Enteromorpha* spp.
BACILLARIOPHYCEAE	
CENTRALES	*Coscinodiscus centralis* Ehrenb.
	Coscinodiscus concinnus W. Sm.(?)
	Coscinodiscus eccentricus Ehrenb. var. *fasciculata* Husted t.
	Coscinodiscus gigas Ehrenb.
	other *Coscinodiscus* spp.
	Rhizoselenia setigera Brightwell
	other *Rhizoselenia* spp.
	Biddulphia regia (M. Schultze) Ostenfeld.
	other *Biddulphia* spp.
	Ditylum brightwelli (T. West) (Grunow et van Heurk)
	other *Ditylum* spp.
	Nitzschia closterium (Ehrenb.) W. Sm.
	other *Nitzchia* spp.
	Bellarochia spp.(?)
	Chaetoceros spp.
	Skeletonema spp.
PENNALES	*Navicula* spp.(?)
	Diploneis spp.
	Asterionella bleakeleyi W. Sm. var. *bleakeleyi*
	other *Asterionella* spp.
	Tubellaria spp.
	Thalassiothrix spp.
	Pinnularia spp.
	Gyrosigma spp.

[1] This list is by no means exhaustive. Numerous unidentified centric and pennate diatoms have not been included. Specific identifications and confirmations were provided by Carolyn Bird (NRC).

* accidentals

TABLE 21 %Composition of Phytoplankton at 6 Sample Sites 17&19 MAY

	D	E	K	L	M	Q
Pennate diatoms	9.0**	6.0**				
Coscinodiscus sp.	87.9***	94.0***	100.0***	100.0***	96.3***	100.0***
Biddulphia sp.	3.1*					
Rhizosolenia sp.					3.7**	

TABLE 22 Composition of Phytoplankton at 7 Sample Sites 24 MAY

	A	D	H	I	L	Q	T
Pennate diatoms	45.5			17.3	9.5	5.1	15.3
Coscinodiscus sp.	54.5	100.0	100.0	15.3	28.4	5.1	19.4
Biddulphia sp.				6.1	5.3	5.1	3.1
Rhizosolenia sp.				26.5	40.0	46.9	37.8
Centric diatoms				34.7	16.8	37.8	24.5

TABLE 23 %Composition of Phytoplankton at 7 Sample Sites 9 JUNE

	A	B	D	E	H	I	S
Gyrosigma spp.	5.8	1.6	3.4	2.7	0.7		
Naviculoidea	0.9		3.4		0.8		12.3**
Ditylum spp.	0.2	0.5					
Pennate diatoms	12.2	1.6	4.4	9.7*	1.7		
Coscinodiscus spp.	16.6*	7.3*	13.3*	11.0	1.7	80.2***	75.3***
Biddulphia spp.	5.5	6.0	4.4	5.9	5.5*		
Rhizosolenia spp.	21.9**	34.6**	35.7**	49.2***	53.9***		
Thalassiothrix spp.	0.5	1.6	1.2	0.8	9.1		
Tabellaria spp.				0.3			
Centric diatoms	36.6***	44.1***	36.3***	20.4**	27.2**	19.8**	12.3**

TABLE 24 % Composition of Phytoplankton at 5 Sample Sites 23 JUNE

	I	J	L	P	Q
CHLOROPHYTA		0.2			
Gyrosigma spp.	3.4	10.2	2.1		1.5
NAVICULOIDEA	5.1	3.1	4.1	5.0	3.0
PENNATE DIATOMS	0.4	37.6***	0.7		
Coscinodiscus spp.	30.9**	12.3	24.1*	3.6	25.9**
Biddulphia spp.	31.4***	9.6	26.2**	19.0**	23.8*
Rhizosolenia spp.	28.0*	14.0**	35.9***	52.0***	37.2***
CENTRIC DIATOMS	0.8	12.9*	6.9	10.0*	8.0

TABLE 25 %Composition of Phytoplankton at 9 Sample Sites 7 JULY

	C	D	E-F	H	I	K	L	N	Q
Gyrosigma spp.	2.3	3.0		20.3**	2.3	9.5*	5.1		2.5
NAVICULOIDEA	11.4*	3.0	21.4**	10.2	8.6		15.4*	4.0	10.0*
PENNATE DIATOMS				11.9*	1.0	7.4	7.7		
Coscinodiscus spp.	25.0**	10.6**		1.7	15.3*	7.4	20.5**	32.0**	17.5**
Biddulphia spp.	2.3	10.6**	14.3*	1.7	19.1**	37.9***	48.7***	8.0	10.0*
Rhizosolenia spp.	52.3***	68.2***	21.4**	44.1***	48.8***	34.7**	2.6	44.0***	60.0***
CENTRIC DIATOMS	6.8	4.5*	42.9***	10.2	4.8	2.1		12.0*	

TABLE 26 %Composition of Phytoplankton at 9 Sample Sites 21 JULY

	B	D	F	H	I	J	L	O	R
Gyrosigma spp.	2.0			8.3 *	24.6 ***	3.4	4.7	3.4	1.6
NAVICULOIDEA	8.9 *	3.4	32.0 ***	25.0 ***	4.2	17.9 **	13.1 *	5.4 *	5.4
PENNATE DIATOMS					2.5	2.8	0.7	0.5	
Coscinodiscus spp.	6.9	6.9 *	24.0 **	16.7 **	3.3	14.5 *	9.9	4.4	9.7 *
Biddulphia spp.	37.6 **	44.8 ***	16.0 *	25.0 ***	13.1 **	13.1	28.5 **	9.9 **	26.5 **
Rhizosolenia spp.	42.6 ***	41.4 **	24.0 **	25.0 ***	12.8 *	46.2 ***	40.5 ***	75.4 ***	54.6 ***
CENTRIC DIATOMS	2.0	3.4	4.0		1.6	2.1	2.6	1.1	1.6

TABLE 274 Composition of Phytoplankton at 8 Sample Sites 3 AUGUST

	A	D	E	G	I	M	Q	R
Gyrosigma spp.		3.3	3.8	0.8	27.1	19.2	0.8	2.5
Naviculoidea	25.0	13.3	7.7	19.4	9.3	3.0	0.8	7.6
Pennate diatoms			1.9		0.8	3.0		
Coscinodiscus spp.	35.7	6.7	7.7	0.3	3.1	2.0	4.9	6.7
Biddulphia spp.	10.7	53.3	50.0	1.0	45.7	48.5	34.6	36.1
Rhizosolenia spp.	28.6	23.3	26.9	78.5	11.6	23.2	57.6	45.4
Centric diatoms					2.3	1.0		

Results and Discussion - Phytoplankton II(A) 1.(a)(ii).

The composition of the phytoplankton from the three time-depth study areas are presented in tables 28 to 30. For reasons previously discussed these will not be interpretated in detail. However several observations are notable.

Results from 29 May and 16 June sample sites (see figures 28 and 29) almost invariably show that the larger diatoms were dominated by *Coscinodiscus* sp., *Rhizosolenia* sp. and other centric diatoms. Relative percentage values indicated a patchy distribution of these phytoplankters during the tidal cycle. It is interesting that Naviculoidea were especially abundant just prior to low tide on both dates. It is possible that naviculoid diatoms are more often associated with the mud-water interface (Daborn, pers. comm.) since they appeared to be more abundant at lower tidal levels. However such results may simply be an indication of lateral movements and patchy distribution (eg. due to eddy currents).

Results from the 7 July location showed somewhat less diversity of phytoplankters even though collecting methods were comparable with previous studies (see Appendix 2). On 7 July Naviculoidea consistently comprised a notable proportion of the phytoplankters, especially during late ebb and early flood tide. It was found that *Rhizosolenia* sp. was considerably more abundant that *Coscinodiscus* sp. These kinds of data suggest differences in specific relative percentage composition of phytoplankters at different areas and at different stages of the tide. The wide variations in relative composition of these various species emphasises the influence of tidal movements on the biology of the area. Although the data are incomplete and non-quantitative the relatively (and unexpectedly) high occurrence of larger phytoplankters in the area has been demonstrated. Hopefully future studies will examine various aspects of primary production more closely. Chlorophyll analysis of local water samples would probably provide much valuable information. In this regard it should be noted that water samples for this purpose were collected on the 13 July session, however these have not yet been analyzed or interpreted. This shall be done in the near future.

Table 28 Time-Depth Phytoplankton (%) Composition (29 May)

	0800	0900	1000	1100	1600	1700	1800	1900	1930
Spirogyra spp.			0.4						
Gyrosigma spp.	7.4	9.6	0.4	0.5	11.0	3.8	3.6	2.5	4.8
Naviculoidea	4.3	3.2	6.1	3.5	0.6				0.6
Ditylum spp.	0.4	0.5							
Pennate diatoms	2.3	10.3*	4.5	1.2	8.2	2.3	0.4	3.6	5.4
Coscinodiscus spp.	13.6*	9.3	22.9**	48.2***	35.6***	35.7**	25.0**	36.9***	27.5**
Biddulphia spp.	4.7	0.7	9.0	2.4	6.3	3.0	12.5	8.0	16.1
Rhizosolenia spp.	33.2***	31.3**	47.2***	14.9*	17.0*	37.2***	39.1***	30.8**	22.2*
Thalassiothrix spp.	1.6	0.5			0.3	0.8	0.6	0.3	
Asterionella spp.					0.6		0.6	0.7	
Centric diatoms	32.4**	34.7***	9.6*	29.2**	20.2**	17.3*	18.2*	17.2*	23.4**

Table 29 Time-Depth Phytoplankton(%)Composition (16 June)

	0815	0915	1015	1115	1215	1315	1415	1515	1615	1715	1815	1915	2015
Spirogyra spp								1.2					
Gyrosigma spp.	0.2	1.3	0.4	0.9	3.6	1.0	3.3	7.9	6.2	1.0	3.2		
Naviculoidea	4.0	1.5		4.2	9.7*	11.4**	7.2	3.7	5.8	2.9	7.5	0.5	1.6
Ditylum spp.	0.6							1.2					
Pennate diatoms	0.2	0.1	0.2	1.8	1.1	0.4	1.2	1.2	1.2	1.0	1.9		
Coscinodiscus spp.	4.6*	6.8*	21.5**	15.1*	14.5	3.9	16.2*	16.5	24.3**	24.3**	14.2*	3.7*	24.1*
Biddulphia spp.	2.3	2.5	7.3*	8.0	9.4	2.5	10.5	20.7*	18.1	17.6*	13.1	3.0	9.0
Rhizosolenia spp.	69.3***	71.1***	71.8***	34.0**	16.2**	5.7*	19.6**	24.4***	18.9*	24.3**	24.3**	57.9***	33.7***
Thalassiothrix spp.	0.6	0.7			0.8								0.4
Asterionella spp.	0.6												
Centric diatoms	17.8**	15.9**	0.4	36.0***	44.7***	75.0***	42.0***	23.1**	25.5***	29.1***	35.8***	35.0**	31.2**

Table 30 Time-Depth Phytoplankton(%)Composition (13 July)

	0830	0930	1030	1130	1430	1530	1630	1730	1830	1930	2030
Chlororophyta										0.5	
Gyrosigma spp.	2.4	8.9	3.3	11.0**	9.3**	5.2	4.1	6.0	1.8	2.3	
Naviculoidea	4.8*	12.2*	65.0***	80.3***	78.4***	52.6***	24.9*	10.0*	19.0**	17.0*	3.4
Pennate diatoms	1.2	1.1	1.3		1.0						
Coscinodiscus spp.	4.8*	11.8	8.5*	3.3	6.5*	11.7	13.7	11.3	8.1	15.1	9.1*
Biddulphia spp.	41.7**	17.8**	12.6**	3.9*	3.4	12.0*	25.7**	26.0**	15.1*	22.9**	14.8**
Rhizosolenia spp.	44.0***	46.7***	5.4	1.2	1.4	17.4**	30.3***	43.3***	50.6***	39.0***	71.6***
Centric diatoms	0.6	2.2	3.9	0.3		1.0	1.2	3.3	5.6	3.2	1.1

Results - Phytoplankton II(A)(iii).

Composition of the phytoplankton was studied for 27 July sub-samples (see table 35). Although *Coscinodiscus* sp., *Rhizosolena* sp. and "other" centric diatoms still dominated most samples (also see results II(A)(a)(ii)) it is interesting that Chlorophyta and Rhodophyta (eg. *Entermorpha*) were quite abundant at times. This is mainly attributable to passage through tide lines, however, and most of these species were 'accidental' inclusions. It is interesting that samples C^1, C^3, E^1 and F^1 show surprising abundances of various diatoms in spite of the large mesh size (1800 μ - see Appendix 5). This may be associated with the floating Chlorophyta and Rhodophyta collected. Results indicated that comparable collecting methods show various diversities and abundances of phytoplankters. This once again substantiates the observation that phytoplankton in the Basin has a very 'patchy' distribution.

TABLE 31 %Composition of Phytoplankton at Sample Sites 27 JULY

	C	C2	E	F	C'	C3	E'	F'	F2	F3
Chlorophyta	12.5*		25.0**					0.1	6.3	22.7**
Rhodophyta	3.8	14.3**								4.5
Gyrosigma spp.	3.8						1.6	0.1		
Naviculoidea					30.4**		1.3	0.3*		
Ditylum spp.					0.2			0.1		4.5
Pennate diatoms	3.8		8.3		58.8***		57.3***	1.0		
Coscinodiscus spp.		85.7***	33.3***		1.5	3.6		0.1	31.3**	40.9***
Biddulphia spp.	8.8					3.6	0.3		6.3	13.6*
Rhizosolenia spp.	37.5***		16.7*	1.1**	0.2	14.5***	26.6**	3.1**	12.5*	
Asterionella spp.	8.8				0.5	5.5*				
Centric diatoms	21.3**		16.7*	98.9***	8.3*	12.7**	12.5*	95.3***	43.8***	13.6*

Results and Discussion II(A) 2.

Results of the study of *Eurytemora herdmani* (composition, length and weight data for various age classes) have been presented in tables 32 to 39. Table 32 shows data for length measurements of copepodid stages from 17, 19 and 29 May and 9 June. The mean (overall) length and total sample size has also been included along with respective mean weight values. More detailed weight information has been given in table 33. Tables 34 to 39 show the relative numerical composition (%) of each stage (nauplii, C1-C6). Relative mass representation of stages C2-C6 have also been included in these tables. Information for different sample sites (17, 19, 29 May; 9 June) and sample times during a tidal cycle (29 May, 16 June) have been indicated.

Except for the C1 stage length data for the copepodid stages is quite extensive. The relatively small numbers of C1 stages was mainly attributable to the dates of collection since nauplii and young copepodids were not abundant at this time (see results II 1. (a)(i) and tables 34 to 37). The variation between sample dates and sites for particular stages was apparently not large; however this observation has not yet been statistically tested. The size differences between various stages are readily apparent and the trend towards decreasing mean length ($\bar{X}_L$) from C6 to C1 is clear (eg. range 1.33 mm max (C6♀ 19-V) to 0.11 mm min (C1 29-V)). As expected from previous observations (Pennachetti 1977) female C6 and C5's were noticeably larger than males (eg. 0.94 C6♀ *vs* 0.82 C6♂; 0.83 C5♀ *vs* 0.74 C6♂). It is interesting that younger females (C5) were found to have a greater mean length than older C6 males. This kind of overlap would cause problems in the prediction of age class or sex on mean length (eg. note also the small difference between $\bar{X}$ for C5♂ and C4). Although the data have not yet been rigorously analyzed, this will be accomplished in the near future and should provide much valuable and interesting information.

Weight measurements were found to be complementary with length data and again illustrated the size class and sex differentation. The data in table 32 and 33 suggest that the mean weight for C6♀♀ was substantially less than that of C5♀♀ however this is related to the exclusion of egg cases from the former measurements (see table 33).

This kind of study was time consuming and detailed but much valuable information was gained. Although time did not permit such intensive study of the C1 and naupliar stages, C2 to C6 stages were well studied. The data accumulated will certainly contribute to an understanding of the local population of this species. This was further substantiated by the analysis of relative numerical composition (%) and mass abundance of different stages.

Data were insufficient to permit the interpretation of seasonal trends however several obwervations are notable. On the 17 and 19 May no C1 or naupliar stages were encountered, but beginning on 24 May changes became obvious. By 29 May N1-N6 were extremely abundant (numerically) (see also results II 1.(a)(i)). It should be emphasized, however, that the biomass of the few older copepodid stages was probably comparable with the many younger stages. These kinds of trends are expected and emphasize the importance of biomass *vs* numbers in such populations. The increases in younger copepodids and nauplii were associated with a marked decrease or absence of adults. This suggests adult mortality after egg production and coincides with similar trends noted in the general zooplankton survey (see results II 1.(a)(i)). It is unfortunate that time did not permit more detailed analysis of naupliar stages and a larger range of sample dates. Those kinds of data would have provided a good overview of the local population. It should be noted that tables 32 and 33 show age composition (% and mass) during time-depth studies. Results emphasize the importance of tidal movements to local planktonic populations.

TABLE 32. Results of *Eurytemora herdmani* study - lengths data in mm.

STAGE	PARAMETER	DATE 17-V	19-V A	19-V D	24-V A	24-V D	24-V H	29-V	9-VI
C6♀	n	6	25	21	47	32	9	51	23
	$\overline{X}$	0.96	0.95	0.99	0.93	0.93	0.88	0.95	0.92
	SD	0.04	0.09	0.06	0.04	0.07	0.03	0.05	0.07
	Range	0.10	0.38	0.23	0.18	0.35	0.10	0.20	0.28
C6♂	n	49	21	24	47	50	18	52	50
	$\overline{X}$	0.84	0.82	0.88	0.82	0.84	0.78	0.83	0.79
	SD	0.05	0.05	0.04	0.04	0.04	0.03	0.11	0.03
	Range	0.23	0.20	0.08	0.20	0.33	0.10	0.85	0.10
C5♀	n	48	8		35	41	7	23	50
	$\overline{X}$	0.79	0.84		0.87	0.83	0.81	0.92	0.82
	SD	0.14	0.08		0.07	0.05	0.03	0.06	0.06
	Range	0.45	0.25		0.30	0.28	0.10	0.30	0.33
C5♂	n	51	8	26	34	12	6	34	50
	$\overline{X}$	0.73	0.74	0.77	0.77	0.71	0.60	0.80	0.69
	SD	0.09	0.10	0.05	0.05	0.06	0.09	0.07	0.03
	Range	0.35	0.28	0.20	0.33	0.23	0.25	0.30	0.13
C4	n	47	48	52	47	53	6	17	50
	$\overline{X}$	0.69	0.71	0.68	0.73	0.73	0.67	0.76	0.66
	SD	0.09	0.07	0.06	0.06	0.10	0.09	0.11	0.07
	Range	0.43	0.33	0.28	0.23	0.43	0.23	0.35	0.28
C3	n	50	36	50	47	50	11	35	47
	$\overline{X}$	0.67	0.60	0.62	0.65	0.67	0.68	0.64	0.56
	SD	0.07	0.06	0.07	0.08	0.08	0.04	0.10	0.05
	Range	0.30	0.23	0.30	0.25	0.38	0.13	0.43	0.23
C2	n	5		22	2	11		11	50
	$\overline{X}$	0.58		0.55	0.58	0.61		0.47	0.45
	SD	0.05		0.06	0	0.08	0	0.06	0.04
	Range	0.13		0.28	0	0.28		0.20	0.25
C1	n							11	49
	$\overline{X}$							0.36	0.38
	SD							0.10	0.04
	Range							0.25	0.20

STAGE	n	$\overline{X}_L$	$\overline{X}_W$*	
C6♀	214	0.94	0.0099	(without eggs)
C6♂	311	0.92	0.0082	
C5♀	212	0.83	0.0126	
C5♂	221	0.74	0.0049	
C 4	320	0.70	0.0046	
C 3	226	0.63	0.0035	
C 2	101	0.50	0.0029	
C 1	60	0.38	N/A	

TABLE 33

STAGE	17-V	19-V A	19-V B	24-V A	24-V B	$\bar{X}$*
**C6♀	0.0070	0.0113	0.0083		0.0133	0.0099
C6♂	0.0050	0.0066	0.0068	0.0034		0.0082
C5♀	0.0075	0.0062	0.0056	0.0144	0.0101	0.0126
C5♂	0.0027		0.0049	0.0070		0.0049
C 4	0.0030	0.0036	0.0035	0.0059	0.0072	0.0046
C 3	0.0020	0.0020		0.0045	0.0055	0.0035
C 2		0.0040	0.0018		0.0028	0.0024

* overall mean value for each stage

** Female adults used for weight measurements did not include egg sacs. The egg sacs were either not present (natural or due to handling) or were removed if present. The following data regarding weight differences between individuals without an egg sac, and with egg sac present but removed should be noted:

	$\bar{X}$	n
C6♀ without egg sac	0.0158	28
C6♀ with egg sac removed	0.0146	100
$\bar{X}$ egg sac weight added after X_W determination		
Egg sac alone	0.0083	100

These were the weight measurements used for calculation of total mass per subsample in tables 34 to 39.

Table 34

Age Composition of Eurytemora herdmani at 4 Sample Sites (17 May)

E. herdmani	O %	O Mass	M %	M Mass	L %	L Mass	K %	K Mass
C6 with eggs							0.2	0.0146
C6					0.7	0.0158	0.7	0.0632
C6	13.6	0.1722	21.3	0.0820	4.7	0.0574	9.8	0.0438
C5	5.2	0.1008	4.3	0.0252	5.4	0.1008	4.6	0.3528
C5	2.6	0.0196	4.3	0.0098	2.0	0.0147	6.3	0.1862
C4	32.5	0.2300	6.4	0.0138	14.9	0.1012	31.5	0.8740
C3	43.5	0.2345	29.8	0.0490	51.4	0.2660	44.6	0.9415
C2	2.6	0.0116	31.9	0.0435	20.9	0.0899	2.2	0.0377
C1			2.1				0.2	
N1-N6								

Table 35

Age Composition of Eurytemora herdmani at 3 Sample Sites (19 May)

E. herdmani	A %	A Mass	D %	D Mass	E %	E Mass
C6 with eggs	3.8	0.1022	0.9	0.0438		
C6	9.7	0.2844	5.9	0.3160	3.0	0.0292
C6	10.3	0.1558	7.1	0.1968	3.0	0.0164
C5	5.4	0.1260	3.8	0.1638	4.5	0.0378
C5	4.3	0.0392	7.9	0.1323	13.6	0.0441
C4	34.1	0.2898	29.1	0.4554	37.9	0.1150
C3	31.9	0.2065	38.5	0.4585		0.0840
C2	0.5	0.0029	6.8	0.0667	1.5	0.0029
CI						
N1-N6						

Table 36

Age Composition of Eurytemora herdmani at 7 Sample Sites (24 May)

	A		D		H		Q		T		I		L	
E. herdmani	%	Mass	%	Mass	%	Mass	%	Mass	%	Mass	%	Mass	%	Mass
C6 with eggs	8.0	0.3796	0.8	0.0584									3.6	0.0292
C6	6.5	0.3318	9.2	0.7110	15.5	0.1422							1.8	0.0158
C6	18.2	0.4838	14.2	0.5658	31.0	0.1476	9.7	0.0246	14.3	0.0082	10.5	0.0328	9.1	0.0410
C5	13.0	0.5292	8.6	0.2058	13.8	0.1008	25.8	0.1008			21.1	0.1008	9.1	0.0630
C5	9.0	0.1470	7.8	0.1862	10.3	0.0294	3.2	0.0049			15.8	0.0294	18.2	0.0490
C4	25.9	0.3864	19.5	0.4370	8.6	0.0230	12.9	0.0184	14.3	0.0046	15.8	0.0276	20.0	0.0506
C3	18.5	0.2100	34.7	0.5915	17.2	0.0350	9.7	0.0105	14.3	0.0035	13.2	0.0175	20.0	0.0385
C2	0.6	0.0058	4.9	0.0696	3.4	0.0058	9.7	0.0087	14.3	0.0029	10.5	0.0116	7.3	0.0464
CI							9.7		28.6		10.5		9.1	
N1-N6							19.3		14.3		2.6		1.8	

Table 37

Age Composition of Eurytemora herdmani at 7 Sample Sites (9 June)

	A		B		D		E		H		S		I	
E. herdmani	%	Mass	%	Mass	%	Mass	%	Mass	%	Mass	%	Mass	%	Mass
C6 with eggs	1.1	0.0292									1.5	0.1314	1.2	0.0438
C6	0.6	0.0158	0.8	0.0316					0.5	0.0316	1.4	0.1264	5.0	0.1896
C6	2.2	0.0328	2.3	0.0492			1.3	0.0328	1.5	0.0492	35.1	1.6728	22.3	0.4428
C5	3.9	0.0882	1.9	0.0630			1.3	0.0504	2.9	0.1512	12.9	0.9450	19.4	0.5922
C5	0.6	0.0049	1.1	0.0147			1.6	0.0245	5.1	0.1029	9.8	0.2793	10.7	0.1274
C4	7.7	0.0644	1.9	0.0230	1.8	0.0184	1.6	0.0230	10.4	0.1978	29.9	0.8004	31.8	0.3542
C3	6.1	0.0385	3.0	0.0280	4.0	0.0315	5.7	0.0630	19.6	0.2835	9.3	0.1890	9.5	0.0805
C2	10.5	0.0561	5.7	0.0435	4.9	0.0319	8.3	0.0754	21.8	0.2610				
C1	10.5		4.2		11.1		7.9		13.1					
N1-N6	56.9		78.2		78.2		72.4		25.2					

Table 38

Age Composition of E.herdmani (29 May)

	0800		0900		1000		1100		1600		1700		1800		1900		1930	
E.herdmani	%	Mass	%	Mass	%	Mass	%	Mass	%	Mass	%	Mass	%	Mass	%	Mass	%	Mass
C6 with eggs			1.6	0.0292	0.5	0.0292			1.8	0.0584	0.7	0.0146	2.5	0.1168	1.7	0.0438	3.0	0.0292
C6	1.0	0.0158	0.8	0.0158					1.8	0.0632	0.7	0.0158	5.1	0.2528	3.3	0.0948		
C6	7.9	0.0656	3.2	0.0328	0.8	0.0246			6.4	0.1148	1.5	0.0164	14.9	0.3854	9.4	0.1394	6.0	0.0328
C5	2.0	0.0252			0.3	0.0126			1.8	0.0504			2.9	0.1134	2.2	0.0504	1.5	0.0126
C5	3.0	0.0147			1.0	0.0196			2.3	0.0245			6.3	0.0980	1.1	0.0098	1.5	0.0049
C4	1.0	0.0046							1.8	0.0184			2.9	0.0414	1.7	0.0138		
C3	5.0	0.0175	4.0	0.0175	1.0	0.0140	0.7	0.0035	3.2	0.0245	1.5	0.0070	4.8	0.0525	2.8	0.0175		
C2	3.0	0.0087	1.6	0.0058	0.3	0.0029			1.4	0.0087	1.5	0.0058	0.6	0.0058	2.2	0.0116	3.0	0.0058
C1			1.6		0.8						0.7		1.9		3.3		4.5	
N1-N6	77.2		87.1		95.5		99.3		79.5		93.3		58.1		72.4		80.6	

Table 39

Age Composition of E.herdmani (16 June)

E.herdmani	0900		1000		1100		1200		1300		1400		1500	
	%	Mass	%	Mass	%	Mass	%	Mass	%	Mass	%	Mass	%	Mass
C6 with eggs	1.8	0.1022	2.6	0.1606	1.3	0.0438	2.7	0.0438	1.5	0.0146	0.4	0.0146		
C6	3.9	0.2370	1.0	0.0632	4.4	0.1580	3.6	0.0632	1.5	0.0158	0.4	0.0158	0.3	0.0158
C6	11.2	0.3526	19.2	0.6642	16.2	0.3034	10.9	0.0984	1.5	0.0082	3.9	0.0738	1.5	0.0410
C5	8.1	0.3906	9.0	0.4788	3.9	0.1134	3.6	0.0504	1.5	0.0126	0.4	0.0126	0.6	0.0252
C5	4.7	0.0882	10.5	0.2156	3.1	0.0343					0.4	0.0049		
C4	16.4	0.2898	24.7	0.4784	14.4	0.1518	36	0.0184			0.4	0.0046	0.6	0.0092
C3	13.5	0.1820	15.4	0.2275	17.0	0.1365	9.1	0.0350	4.4	0.0105	0.9	0.0070		
C2	6.3	0.0696	1.9	0.0232	11.8	0.0783	5.5	0.0174	13.2	0.0261	3.0	0.0203	2.1	0.0203
C1	3.6		3.8		9.3		12.7		7.4		3.9		3.6	
N1-N6	30.5		11.9		19.6		48.2		69.1		86.3		91.3	

Results and Discussion II(A) 2. (continued).

Figure 129 shows the relationship between metasomal length and clutch size of female *Eurytemora herdmani* collected between 3 May and 9 June 1978. Results indicated that clutch size varies considerably (range = 32-130) in the size range studied (0.85-1.05 mm) (see figure 129 and Appendix 7). Although the correlation coefficient was not very high (r = 0.48) the very low probability value (<0.001) showed that the relationship between metasomal length and clutch size is real. Low r values have been documented for other marine copepods (eg. *Euchaeta norvegica*, see Hopkins 1977) and it appears that a number of factors influence the given relationship. Results of a similar study (Pennachetti 1977, unpublished - see Appendix 6) showed that seasonal changes affect length-clutch size correlations (eg. r (16-V -14-VI, 1977) = 0.48, r(28-VI-30-VII 1977) = 0.65, r(1 and 2) = 0.83). The 1977 correlation value was determined on the basis of log transformations. This was not done for the 1978 season since the size range was so small (Strong, pers. comm). It is suspected that the 1978 r value would increase if females from the full sample season were included. Unfortunately time did not permit analysis of all data.

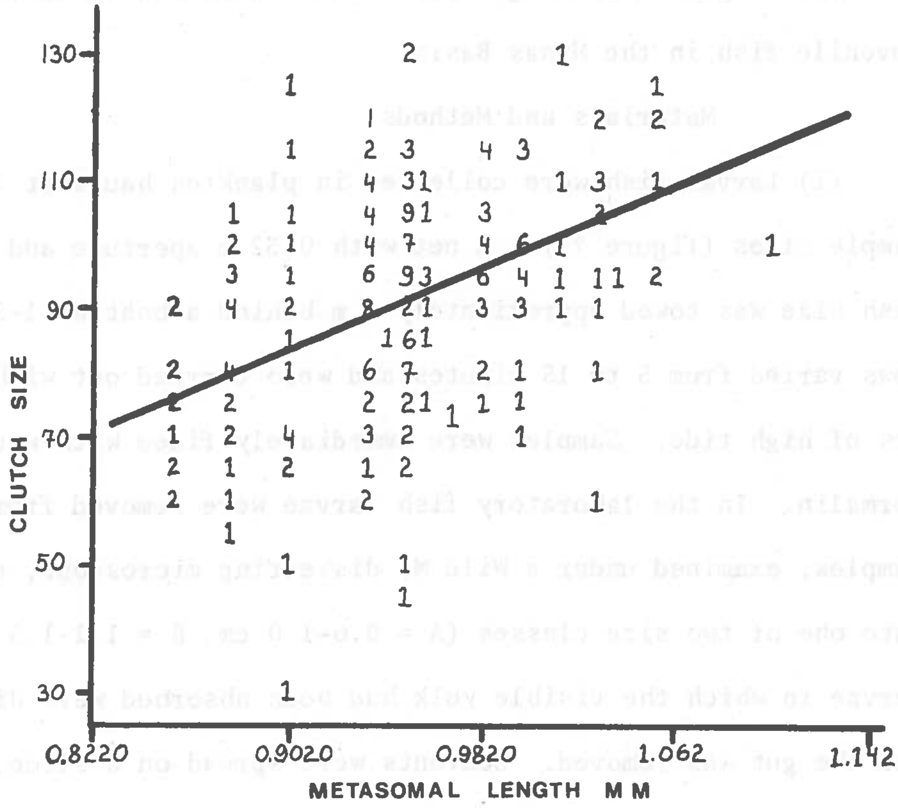
Results from both 1977 and 1978 indicated that a number of factors mask the relationship between length and clutch size. It is suspected that temperature and food (various authors, from Hopkins 1977) are responsible for the variations noted in the present study. This is understandable in view of the physically, chemically and biologically variable environment of the study area (see previous results, I & II).

In summary it appears that the clutch size of *E. herdmani* is related to metasomal length but is highly variable. This variation is probably related to environmental conditions. It is hoped that future studies will determine the nature of the factors involved.

Figure 129. Relationship between Length and Clutch size in *Eurytemora herdmani* 1978.

Numbers 1-9 refer to number of *Eurytemora* females of given length and clutch size.

Figure 129



Var	Mean	Std. Dev.	Variance	Range
L_{MET}	0.95	0.49	0.24×10^{-2}	0.85-1.05
Clutch size	92.16	16.76	281.05	32-130

$$y = 164.78X - 64.04$$

$n = 253$
$r = 0.48$
$F = 76.17$
Prob = <0.001

II (B) Larval and Young Fish[1]

Objectives. The purpose of this study was to examine the role of planktonic organisms in the nutrition of larval and juvenile fish in the Minas Basin.

Materials and Methods.

(i) Larval fish were collected in plankton hauls at four sample sites (figure 71). A net with 0.32 m aperture and 64 μ mesh size was towed approximately 3 m behind a boat at 1-2 knots. Tows varied from 5 to 15 minutes and were carried out within 1 1/2 hrs of high tide. Samples were immediately fixed with neutral formalin. In the laboratory fish larvae were removed from the samples, examined under a Wild M5 dissecting microscope, and placed into one of two size classes (A = 0.6-1.0 cm, B = 1.1-1.5 cm). Larvae in which the visible yolk had been absorbed were dissected and the gut was removed. Contents were spread on a slide, mounted in polyvinyl alcohol (PVA) stained with lignin pink and examined under an Olympus microscope (100X magnification).

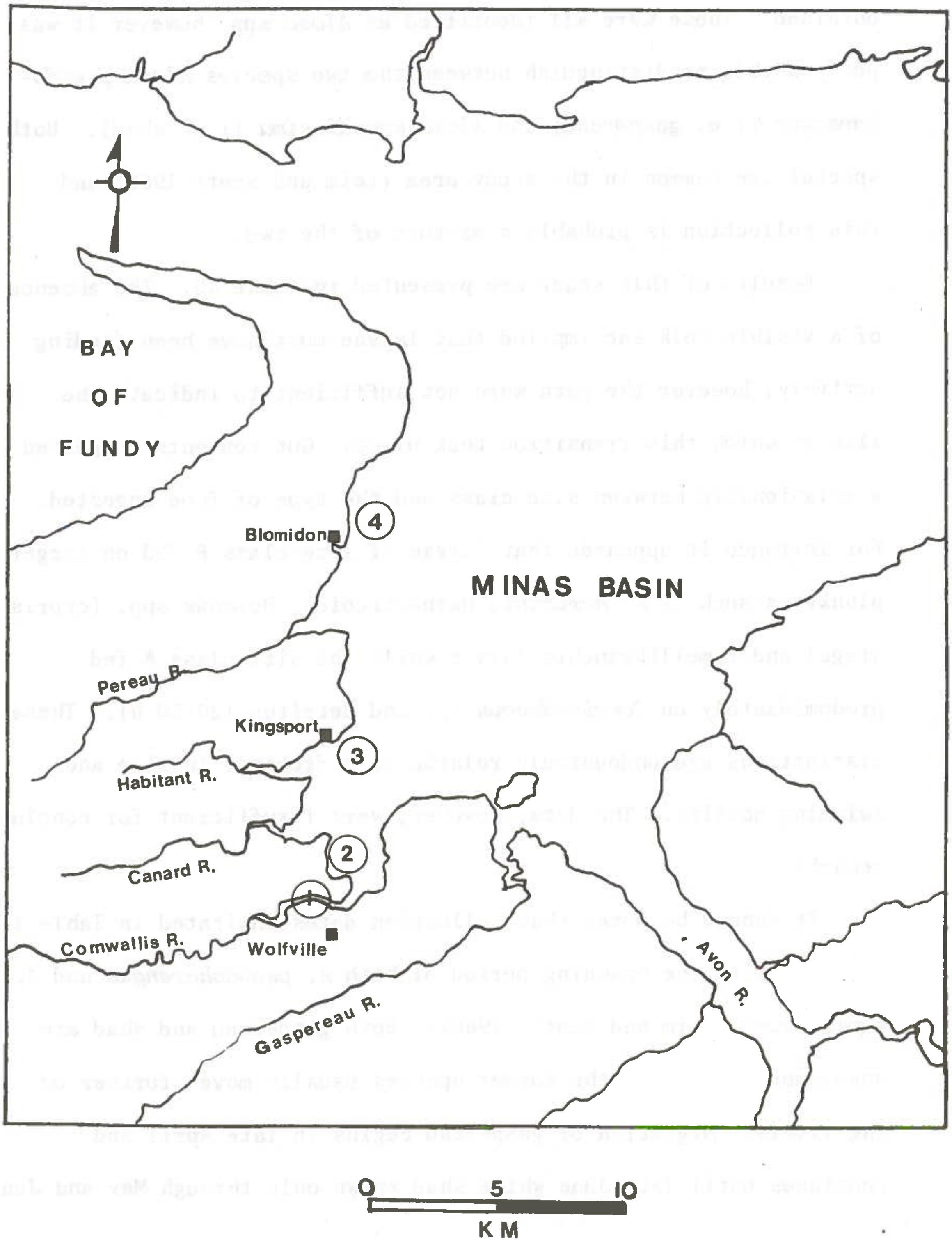
(ii) Juvenile fish were collected from sample sites 3 and 4 (figure 71). A 10 m beach seine with 1/4 in^2 mesh was hauled perpendicular to the shore by two people for approximately five minutes. The fish were immediately fixed with neutral formalin. Some juvenile

[1] This study was carried out by Diana Imrie and further analysis will be conducted and presented as an Honour's B.Sc. thesis.

fish were also collected from tidal pools at site 4 (figure 71) using a small dip net with 1 mm^2 mesh. In the laboratory the fish were identified and standard length (tip to final caudal flexure) was measured with vernier calipers. Gut contents were removed and spread in sea-water in a petri dish for close examination. When guts were apparently empty, slides were prepared and examined under the microscope. All other materials were fixed in neutral formalin and stored for later use.

Figure 71. Collecting locations for Fish Study.

Figure 71


BAY
OF
FUNDY
MINAS BASIN
Blomidon
4
Pereau R.
Kingsport
3
Habitant R.
2
Canard R.
Cornwallis R.
Wolfville
Avon R.
Gaspereau R.
0
5
10
KM

Results and Discussion. II (B) (ii)

In the course of plankton collections 25 larval fish were obtained. These were all identified as *Alosa* spp. however it was not possible to distinguish between the two species *Alosa pseudoharengus* (i.e. gaspereau) and *Alosa sapidissima* (i.e. shad). Both species are common in the study area (Leim and Scott 1966) and this collection is probably a mixture of the two.

Results of this study are presented in table 40. The absence of a visible yolk sac implied that larvae must have been feeding actively; however the data were not sufficient to indicate the size at which this transition took place. Gut contents suggested a relationship between size class and the type of food ingested. For instance it appeared that larvae of size class B fed on larger plankters such as *E. herdmani*, Harpacticoida, *Balanus* spp. (cypris stage) and Lamellibranchia larvae while the size class A fed predominantely on *Coscinodiscus* sp. and detritus (20-50 μ). These distinctions are undoubtedly related to difference in size and swimming ability. The data, however, were insufficient for conclusive remarks.

It should be noted that collection dates indicated in Table 1 coincide with the spawning period of both *A. pseudoharengus* and *A. sapidissima* (Leim and Scott, 1966). Both gaspereau and shad are anadromous, although the former species usually moves further up the rivers. Migration of gaspereau begins in late April and continues until late June while shad spawn only through May and June.

The apparent paucity of larvae in the Basin may be related to the fact that the majority of fry remain upstream during this period. Thus one should expect only accidental drifters to be caught in plankton tows in the Basin proper.

Conclusions and Future Studies.

The present study indicated that *Alosa* spp. are planktivorous following absorption of their yolk sac. There was no conclusive evidence to show them to be selective in their feeding habits. It is hoped that future studies will provide more detailed information about the role of different planktonic organisms in the nutrition of larval fish in the Minas Basin.

TABLE 40. Results of Larval fish study.

DATE DA MO	TIDE HEIGHT (M)	TIDE TIME (LOW)	*SAMPLE AREA	**SIZE RANGE	VISIBLE YOLK SAC	GUT CONTENTS
13 V	11.8 M	1144	3	A	-	*Coscinodiscus* sp., detritus
19 V	12.0 M	0944	4	A	V	*Coscinodiscus* sp.
19 V	12.1 M	1039	1	A	V	
			1	A	-	
			1	A	V	
			2	B	-	*Eurytemora herdmani*
24 V	12.4 M	0829	1	B	-	*Coscinodiscus* sp.
			1	A	+	
			1	B	+	
			1	B	+	
			1	A	+	
			1	A	+	
			1	A	+	
			1	B	-	*Balanus* sp. (cypris), *Coscinodiscus* sp.
26 V	13.3 M	1004	4	B	+	
			4	B	-	Lamellibranchia; *Coscinodiscus* sp.
9 V	12.3 M	1809	4	A	+	
			4	A	+	
			4	B	-	No visible contents
			4	B	-	No visible contents
10 VI	11.9 M	0419	3	A	+	
			3	A	+	
			3	B	+	
22 VI	13.2 M	1514	4	B	-	*Eurytemora herdmani*, *Balanus* sp. (cypris)

* see figure 71
** see Materials and Methods

(ii) Eleven species of juvenile fish were obtained from seine net collections. These included *Liopsetta putnami* (smooth flounder), *Gasterosteus wheatlandi* (black-spotted stickleback), *Urophycis tenuis* (white hake), *Osmerus mordax* (American smelt), *Alosa* spp. (shad and gaspereau), *Anguilla rostrata* (American eel), *Careproctus longipinnis* (longfin seasnail), *Cottonculus thompsoni* (pallid sculpin), *Microgadus tomcod* (tomcod), and *Raja erinacea* (little skate). The gut contents of 65 individuals were examined and standard body lengths measured. These are presented in table 41. Figure 130 illustrates the percentage of individuals in which various food items were found in three of the commonly encountered species (smooth flounder, black-spotted stickleback and white hake).

Thirty-one specimens of smooth flounder were examined and it was found that benthic Mysidacea and Harpacticoida were the primary food items. The presence of fecal pellets in some individuals also seemed to suggest bottom feeding habits. Although *Eurytemora herdmani* was occasionally encountered these were probably accidentally injested (Daborn, pers. comm.). It is notable that all individuals of 20-30 mm contained Digenetic trematodes.

Although the black-spotted stickleback is predominantly a fresh-water fish it is known to penetrate into brackish waters (Leim and Scott 1966). In this study, eight individuals were collected and examined. Results (see table 41) indicated that polychaete eggs and larvae, *E. herdmani* and harpacticoid copepods were regular food items. This suggests a semipelagic feeding habit.

Results for the seven specimens of white hake (Table 41 and figure 130) illustrated a more notable diversity of food items. It can be seen that *Corophium volutator* constantly occurred in gut contents and that Mysidacea and Isopoda are also very important food items. Although no previous data are available for this species, Leim and Scott (1966) indicated that Euphausiacea, Amphipoda, *Microgadus* sp. and *Alosa* spp. are regularly taken by *U. tenuis*. The former two were noted in this study. These kinds of food items strongly suggest a benthic feeding habit.

The eight American smelt examined contained a surprising variety of insects, one of which (Delphidacea) is native to the local salt marshes. *Eurytemora herdmani*, Harpacticoida and Mysidacea occurred much less frequently. These results suggested a tendency toward littoral feeding habits and illustrated the important role of local salt marshes in the ecology of the study area.

Six other species were looked at in small numbers and results have been included at the end of table 41. The sample sizes were so small no conclusions could be made. It was notable that *Calanus finmarchicus*, decapod larvae and fish larvae found in the pallid sculpin had not otherwise been encountered. Such food items are indicative of pelagic feeding habits.

Results of the present study suggested that juvenile *Liopsetta putnami* and *Urophycis tenuis* are benthic feeders while *Gasterosteus wheatlandi* is probably semi-pelagic. Copepoda (*E. herdmani* and Hapacticoida), Mysidacea and Amphipoda appeared to be very important food items of the juvenile fish. It should be emphasized, however, that the short sample period and inadequacies of sampling techniques imposed restrictions which hindered more conclusive results. A more intensive and regular study program is presently underway and will continue as long as possible. It is hoped that future results will yield more detailed information about the feeding habits and ecology of juvenile fishes in the Minas Basin.

Figure 130. Gut contents of fish from Minas Basin, 1978.

a) *Liopsetta putnami* - smooth flounder

b) *Gasterosteus wheatlandi* - black-spotted stickleback

c) *Urophycis tenuis* - white hake

Co -*Coscinodiscus*.

Pol-Polychaetes

Eur-*Eurytemora herdmani*

Cla-*Calanus*

Bal-*Balanus* sp. nauplii and cypris larvae

Eup-Euphausiacea

Chi-Chironomidae

Pol-Polychaete larvae

Lam-Lamellibranch larvae

Har-Harpacticoida

Iso-Isopoda

Cor-Corophium

Amp-Amphipoda

Mys-Mysidacea

Car-Caridea larvae

Bra-Brachyura

Fec-fecal pellets

Par-parasites

Figure 130

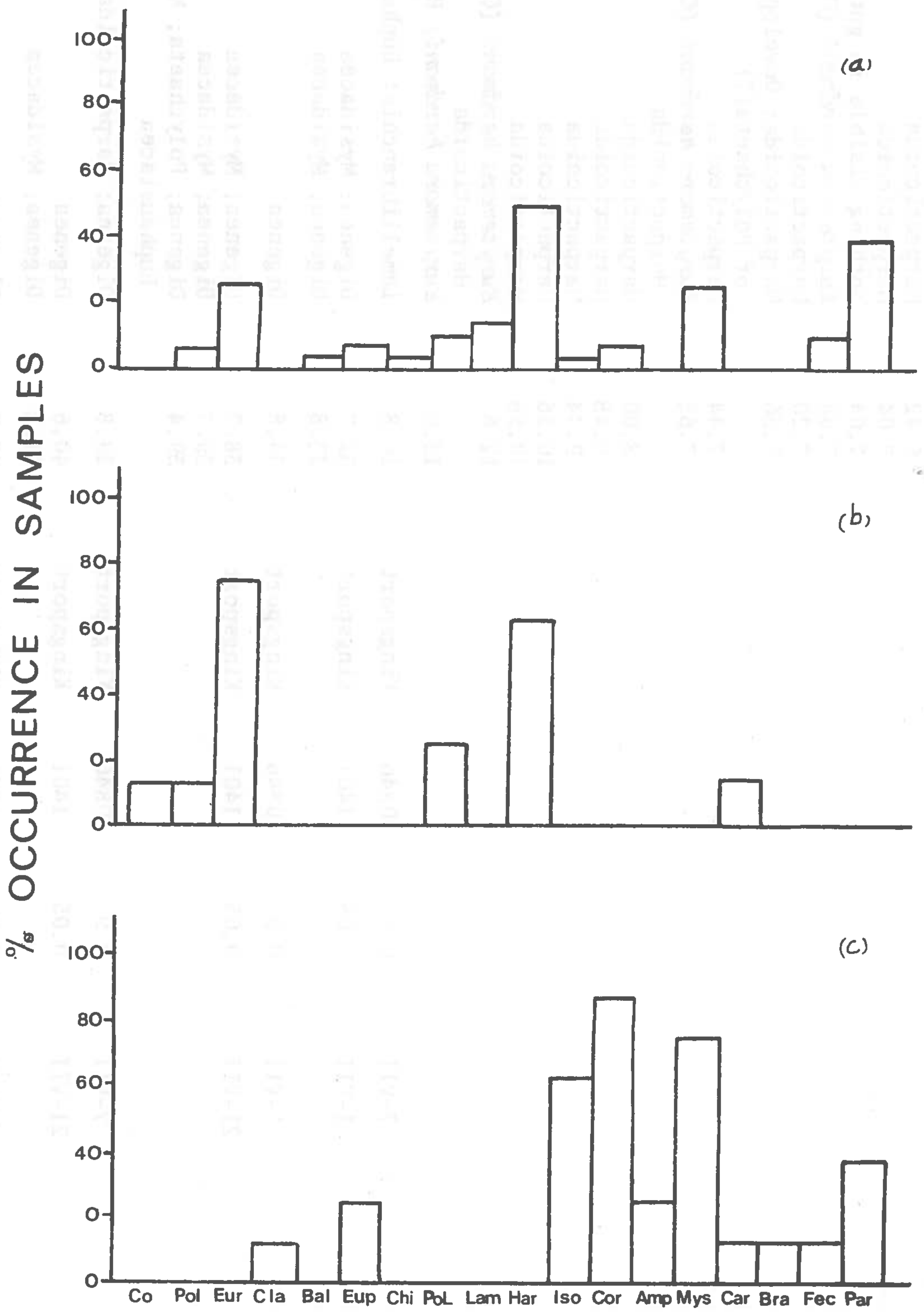

% OCCURRENCE IN SAMPLES
(a)
(b)
(c)
100
80
60
40
0
Co Pol Eur Cla Bal Eup Chi PoL Lam Har Iso Cor Amp Mys Car Bra Fec Par

TABLE 41. Results of Young Fish Study.

Species	Date Collected	Tide Ht. (m)	Low Tide Time(hrs)	Sample Site	Standard Body Length (mm)	Gut Contents
Liopsetta putnami	7-VII	0.9	0846	Blomidon	6.64	Harpacticoida
					6.42	Harpacticoida
					7.04	Harpacticoida
					7.04	Nothing visible in gut
					7.04	*Eurytemora herdmani* (C6♀)
					7.20	Harpacticoida
					7.36	Harpacticoida; Developing embryo of Polychaeta(?)
					7.44	Harpacticoida
					7.68	*Eurytemora herdmani* (C6♀ with eggs); Harpacticoida
					8.00	Harpacticoida
					8.48	Harpacticoida
					9.44	Harpacticoida
					10.56	Harpacticoida
					10.56	Harpacticoida
					12.6	*Eurytemora herdmani* (C6)); Harpacticoida
					13.6	*Eurytemora herdmani;* Harpacticoida
	7-VII	0.9	0846	Kingsport	16.8	Lamellibranchia: Euphausiacea
	21-VII	0.08	1401	Kingsport	32.7	Digenea; Mysidacea
					33.8	Digenea; Mysidacea
	7-VII	0.9	0846	Kingsport	34.8	Digenea
	21-VII	0.05	1401	Kingsport	38.7	Digenea; Mysidacea
					39.3	Digenea; Mysidacea
					39.4	Digenea; Polychaeta; Mysidacea; Euphausiacea
	7-VII	0.9	0846	Kingsport	39.8	Digenea; Harpacticoida
	21-VII	0.05	1401	Kingsport	40.6	Digenea
					41.2	Digenea; Mysidacea
	7-VII	0.9	0846	Kingsport	43.7	Digenea
	21-VII	0.05	1401	Kingsport	46.1	Digenea; Mysidacea

Table 41 (continued)

Species	Date Collected	Tide Ht. (m)	Low Tide Time (hrs)	Sample Site	Standard Body Length (mm)	Gut Contents
Liopsetta putnami	7-VII	0.9	0846	Kingsport	67.0	*Balanus* sp(cypris); *Corophium volutator*.
					69.5	Lamellibranchia;Chironomidae larvae
					74.7	Digenea; Lamellibranchia; Isopoda; fecal pellets
Gasterosteus wheatlandi	21-VII	0.05	1401	Kingsport	17.7	Polychaeta larvae; C6♀ *Eurytemora herdmani*.
					18.9	Harpacticoida; *Eurytemora herdmani*
					19.6	Harpacticoida; C6♀ *Eurytemora herdmani*
					21.7	Harpacticoida; C6♀ (with eggs) *Eurytemora herdmani*
					27.7	Harpacticoida; C6♀ *Eurytemora herdmani*.
	7-VII	0.9	0846	Kingsport	35.7	Polychaeta(embryo); Harpacticoida; C6♀ *Eurytemora herdmani*; Caridea larvae; developing embryo
					36.9	*Coscinodiscus* sp.
Urophycis tenuis	7-VII	0.9	0846	Kingsport	56.6	Nematoda; Isopoda; *Corophium volutator*; Mysidacea
					60.1	Digenea; Polychaeta; *Edotea montosa*; *Corophium volutator*; Euphausiacaea Caridea
					65.6	*Edotea monotosa*; *Corophium volutator*; *Neomysis americana*; Euphausiacaea
					69.7	*Corophium volutator*; Amphipoda; Mysidacea
					71.3	Brachiura; *Corophium volutator*; Mysidacea
					74.2	*Corophium volutator*; Mysidacea; fecal pellets
					92.7	*Daphnia* (ephippia); Isopoda; Amphipoda; Mysidacea; Euphausiacaea

Table 41 (continued)

Species	Date Collected	Tide Ht. (m)	Low Tide Time (hrs)	Sample Site	Standard Body Length (mm)	Gut Contents
Osmerus mordax	21-VII	0.05	1401	Kingsport	26.4	*Eurytemora herdmani*; Harpacticoida; developing embryo of Polychaeta
					31.6	Mysidacea
	7-VII	0.9	0846		35.5	
	21-VII	0.05	1401	Kingsport	7.13	Delphacidae; Dolicopodidae; Brachycerous; Diptera; cast skins of nymphs
					78.7	Cicodellidae; Lepidoptera; Diptera
					82.3	Insecta pieces
					86.3	*Eurytemora herdmani*; Mysidacea
					95.6	Lycosidae; Cicadillidae; Delphacidae; Diptera; Dolichopodidae
Alosa sp.	7-VII	0.9	0846	Kingsport	55.0	Mysidacea; fecal pellets
Anguilla rostrata	22-VI	0.05	0801	Blomidon	N/A	Dinoflagellida
Caraproctus longippinis	22-VI	0.05	0801	Blomidon	N/A	*Coscinodiscus* sp.
					N/A	Harpacticoida
Cottunculus thompsoni	7-VI	0.05	0846	Blomidon	94.4	Harpacticoida
					100.8	Harpacticoida; *Calanus finmarchicus*; Isopoda
	22-VI	0.05	0801	Blomidon	N/A	Harpacticoida, *Calanus finmarchicus*
					N/A	Isopoda; Amphipoda, Decapoda(larvae); fish larvae
Microgodus tomcod	7-VII	0.9	0846	Kingsport	70.7	*Corophium volutator*; Mysidacea
					83.1	Nematoda; *Corophium volutator*; Mysidacea; Palaemonidae
Raja erinacea	7-VII	0.9	0846	Kingsport	116.2	Mysidacea; Ruphausicae

Appendix 1. Tide times and heights for sample dates, May to August 1978[1]

SAMPLE SESSION	DATE (Da-Mo)	Tide Time (hrs)	Tide Ht. (m)
CORNWALLIS RIVER STUDIES	9 V	1504	12.1
	21 VI	1329	13.2
	6 VII	0806	1.6
		1419	12.0
		2021	2.0
TIDE-DEPTH STUDIES	29 V	0654	12.1
		1306	1.8
		1929	12.0
	16 VI	0859	11.9
		1506	1.9
		2124	12.4
	29 VI	0839	11.7
		1456	2.1
		2109	11.9
	13 VII	0634	11.8
		1241	1.8
		1854	12.1
LIGHT PENETRATION STUDIES	20 VI	1244	13.2
	25 VII	1739	12.2
PLANKTON STUDIES			
(A) SOUTH OF LONGSPELL POINT	17 V	0859	11.7
	19 V	1039	12.1
	24 V	1444	13.3
	9 VI	1609	11.9
	23 VI	1514	13.2
	7 VII	1504	12.0
	21 VII	1409	13.1
	3 VIII	1324	11.9
(B) NORTH OF LONGSPELL POINT	22 VI	0609	11.7
	27 VII	1211	2.0
		1844	11.8
	31 VII	1014	11.5
		1611	2.4
		2234	11.9

[1] Values have been taken from the 1978 Tide and Current Tables for the Atlantic Coast. The given values are based on St. John, N.B. readings and corrected according to the tidal differences for Cape Blomidon since this information is not available for the study area (Bleakney, pers. comm). It must be noted that the given values are not absolute. Locality, basin configuration and weather conditions influence exact times and heights considerably (Bleakney 1977, pers. obs).

Appendix 2. Sampling Conditions for 1978 high tide plankton sample sessions in main study area.

Date (Da Mo)	Weather Cloud Cover (1-10 scale)	Wind (km)	Waves (m)	Sites Visited	Collecting Method
17 V	10 fog	10	1	L,M,Q	5 min surface tow (CB)
19 V	1	5	.1	D,E,K	5 min surface tow (CB)
29 V	1	--	--	A,D,H,I L,Q,T	Wisconson type 5 min surface tow
9 VI	10 fog	10	.5	A,B,D,E, H,I,S	Wisconson type 5 min surface tow (CB)
23 VI				I,J,L,P,Q	Hensen egg net #20 conical
7 VII	10	--	.5	C,O,E,F,H, I,J,L,O,R	#20 conical, Hensen egg net
3 VIII	10 fog (cumulonimbus)	--	.2	A,D,E,G, I,M,Q,R	#20 conical

Appendix 3. General notes on some of the high tide plankton samples collected in 1978 (*no subsample analyzed).

DATE (Da Mo)	SAMPLE SITE	NOTES
19 V	D	Parasitic copepod associated with fish larvae (probably *Caligus* sp. (chalimus stage)
24 V	I	*Pleurobrachia pileus;* zoea larvae; fish larvae
	L	fish larvae with yolk sac
	Q	*Microstomum* sp.; *Balanus* sp. nauplii (very abundant - one observed holding *Coscinodiscus* sp. in mouth parts for a short period while moving); *Sagita elegans*, *Rhizosolenia* spp. and *Coscinodiscus* (very abundant)
7 VII	C	Hydroid medusae; *Calanus finmarchicus* (4 individuals); Mysidacea
	D	*Microstomum* sp.; (very few) early Polychaeta larvae; a few *Halothalestris croni;* mixture of larval copepod stages.
	E-F	Hydroid medusae; *Microstomum* sp.; *Corophium volutator* (antennae); Mysidacea larvae
	H	*Microstomum* sp.; Mysidacea larvae; various Insecta
	I	*Euplana gracilis;* (abundant) veliger larvae; (abundant) *H. croni*
	K	large specimen of Piscidolidae
	L	*Microstomum* sp.; Hydroid medusae (one noted injesting *H. croni* and with adult and larval copepods in tentacles); small specimens of *Pleurobrachia pileus*
	N	Hydroid (theca and small medusae); *P. pileus* (one large, one small) larger with copepodid in tentacles).
	Q	Hydroid medusa (noted injesting *H. croni* and with adult copepods in tentacles)
21 VIII	B	A few hydroid medusae; Mysidacea larvae; fish larvae
	D	Hydroid medusae; veliger larvae; Nematoda; *H. croni* with eggs; *Balanus* sp.(cypris); female *E. herdmani* with egg cases relatively abundant; large Mysidacea
	*E	veligers and post veligers; a few female *E. herdmani* with egg cases; Mysidacea larvae; *Corophium volutator* (a few very young specimens); fecal pellets (very abundant)
	F	*Balanus* sp.(cypris); Mysidacea larvae; fish eggs
	H	*Centropages* (?): Mysidacea larvae
3 VIII	A	Hydroid medusae; veliger larvae; Polychaeta; a few *Eurytemora herdmani;* Mysidacea larvae
	*C	abundant Hydroid medusae; Nematoda; veliger larvae; Trochophore larvae; *Calanus finmarchicus;* Mysidacea; *C. volutator*
	D	*Tintinnoidea; Microstomum* sp.; a few *E. herdmani*, *Balanus* sp. (cypris); *C. volutator*

Appendix 3. (continued)

DATE (Da Mo)	SAMPLE SITE	NOTES
3 VIII	E	Hydroid medusae; *Microstomum* sp.; Polychaeta; some *Eurytemora herdmani; C. volutator*
	G	Hydroid medusae; veliger larvae; various Insecta
	I	Hydroid medusae (noted eating nauplius and rotifer, also with adult copepod caught in tentacles); Hydroid theca; *Nematostella vectensis; Microstomum* sp.; *Euplana gracilis;* some *Eurytemora herdmani*
	*L	veliger and post veliger larvae; larger polychaete larvae; Harpacticoida; Mysidacea
	M	*Pygiospio* larvae (?); some female *E. herdmani* with egg cases; Mysidacea larvae.
	Q	Tintinnoidea; Hydroid thecae; *Microstomum* sp.; veliger and post veliger larvae; lamellibranch larvae; polychaete larvae; Mysidacea larvae
	R	*Microstomum* sp.; some *E. herdmani;* Mysidacea larvae
6 VI	Q	Hydroid medusae with copepods caught in tentacles; Polychaeta; Hyperidae; *Amphithae rubricata*

Appendix 4. General notes on some of the samples collected during 16 June Time-Depth Study.

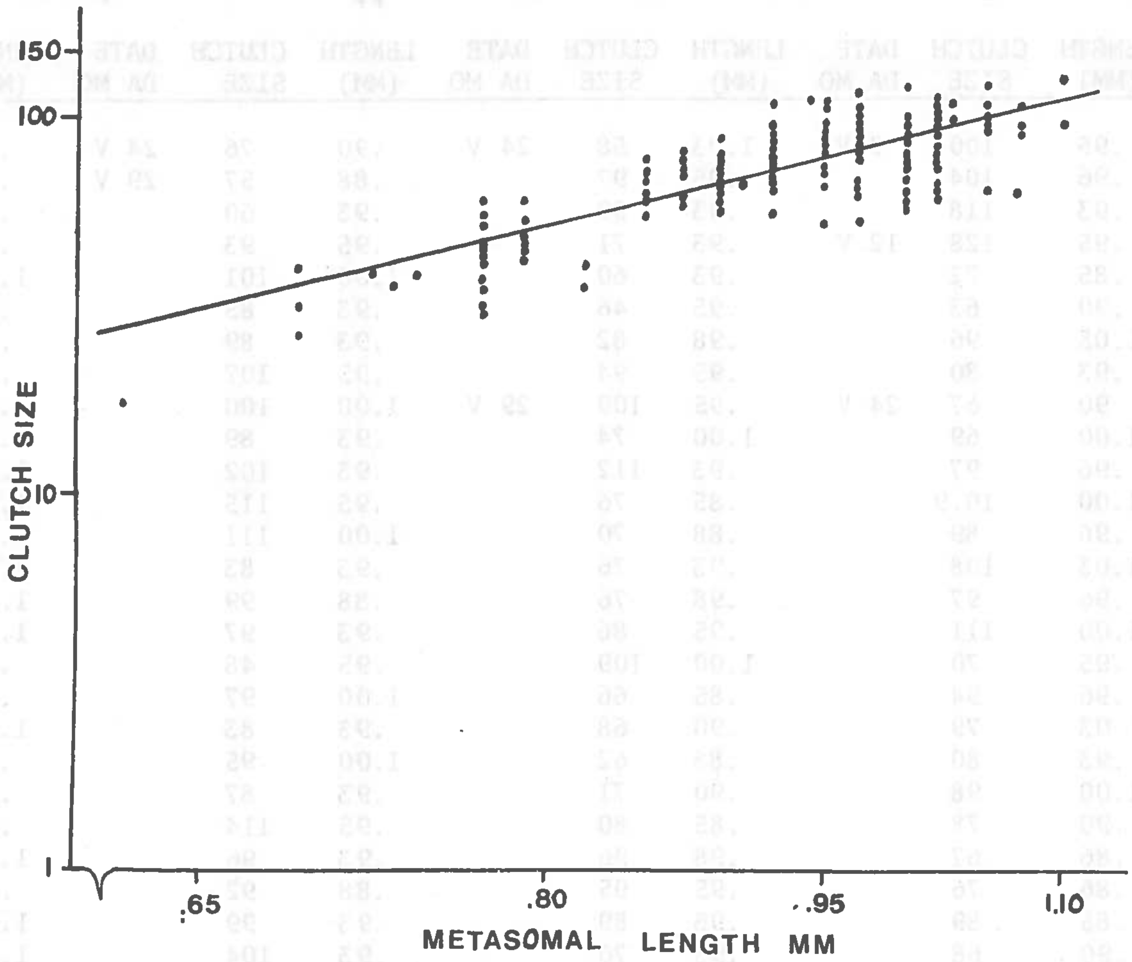
SAMPLE	TIME (hrs)	NOTES
A	0815	Hydroid medusae; abundant C6♀* with egg cases; zoea larvae; fish eggs.
B	0915	abundant C6♀ with egg cases; fish eggs
C	1015	Hydroid medusae; C6♀ with egg cases (extremely abundant); shrimp larvae; zoea larvae; abundant fish eggs
D	1115	Hydroid theca and Scyphozoan ephyra; *Caprella linearis;* zoea larvae; *Sagitta elegans*
E	1215	Hydroid theca; Harpacticoida
F	1315	very abundant fecal material
I	1615	Harpacticoida; filamentous Chlorophyta
J	1715	Hydroid thecae; Mysidacea larvae
K	1815	Hydroid thecae; abundant C6♀ with eggs; fish larvae
L	1915	Zoea larva, filamentous, Chlorophyta (very abundant)
M	2015	Hydroid thecae *Nematostella vectensis;* abundant C6♀ with eggs, shrimp larvae

* refers to *E. herdmani*

Appendix 5. Sampling time, method and general notes from sample sites north of Longspell Point.

DATE Da Mo	SITE	REF*	TIME	NET USED	NOTES
22 VI	A		1327-1332	1-m conical	Hydroid medusae; *Eurytemora herdmani* females with egg cases (abundant); Shrimp larvae; abundant zoea larvae; large amounts of debris and macrophytes.
	A^1		1344-1349	Clarke-Bumpus (revs 1645-1649 - improper functioning)	Quite an abundance of smaller plank-ters (mostly copepods) very few copepods with egg cases; at least one barnacle nauplius noted
	B		1350-1358	1-m conical (3 kmt speed)	Many *Calanus finmarchicus*; one *Caligus* sp.(?) noted; zoea larvae quite abundant; large numbers of Diptera; spiders, etc.; many fish eggs; a large amount of debris and algae noted
	D		1422-1427	1-m conical	A few *Corophium volutator;* one large shrimp(?) moltskin; large amounts of debris (<u>not</u> passed through tide line during tow).
	E		1439-1444	1-m conical	Nematoda observed; great abundance of ciliates (unidentified); abundant dipterans and 1 Tipulidae; 1 June bug; large amounts of *Fucus* (bladders) *Equisetum, Juncus, Entermorpha, monostroma*; other detrital material
27 VI	A_1	Kq	1804-1814	Clarke-Bumpus	(26.9 revs - 2 m deep).
	A	L	1804-1814	1-m conical	surface
	C_1	G	1711-1718	Clarke-Bumpus	(26.2 revs - 2 m deep
	C_2	H	1711-1718	1-m conical	
	C_3	I	1727-1737	Clarke-Bumpus	16.9 revs - 2 m deep
	C	J	1727-1737	1-m conical	
	E_1	E	1543-1553	Clarke-Bumpus	25.7 revs - 6-7 m deep
	E	F	1543-1553	1-m conical	surface
	F	A	1030-1040	Clarke-Bumpus	fired early - 5 min with tide, 5 min with back eddy
	F_1	B	1109-1114	1-m conical	surface-sample included Hydroid medusa and much algal debris
	F_2	C	1300-1310	Clarke-Bumpus	60.7 revs, 1 m deep
	F_3	D	1310-1320	Clarke-Bumpus	61.1 revs

Appendix 6



DATE	VAR.	MEAN	RANGE	n	r
16/5/77-14/6/77	LMET	0.96	0.89-1.07	153	0.42
	CL. SIZE	84.15	52-126		
28/6/77-30/8/77	LMET	0.76	0.69-0.85	44	0.65
	CL. SIZE	42.41	18-54		

$r_{16/5/77-30/8/77} = 0.83$

$$E = 89.5(L)^{2.5}$$

Appendix 7. Length and Clutch size measurements of C6♀♀ on various sample dates, 1978

DATE DA MO	LENGTH (MM)	CLUTCH SIZE	DATE DA MO	LENGTH (MM)	CLUTCH SIZE	DATE DA MO	LENGTH (MM)	CLUTCH SIZE	DATE DA MO	LENGTH (MM)	CLUTCH SIZE
3 V	.95	100	9 V	1.03	58	24 V	.90	76	24 V	.93	86
	.96	104		.95	97		.88	57	29 V	.98	[illegible]
	.93	118		.93	90		.93	60		.93	[illegible]
	.95	128	12 V	.93	71		.95	93		.95	85
	.85	72		.93	60		1.00	101		1.00	[illegible]
	.90	63		.95	46		.93	85		.93	[illegible]
	1.05	96		.98	82		.93	89		.98	97
	.93	80		.95	94		.95	102		.95	86
	.90	67	24 V	.95	109	29 V	1.00	100		1.03	[illegible]
	1.00	69		1.00	74		.93	89		.95	[illegible]
	.96	97		.93	112		.93	102		1.00	80
	1.00	10.9		.85	76		.95	115		1.05	[illegible]
	.96	89		.88	70		1.00	111		.95	[illegible]
	1.03	108		.93	76		.93	83		1.00	117
	.96	97		.98	76		.88	99		1.03	118
	1.00	111		.95	86		.93	97		1.01	[illegible]
	.95	70		1.00	109		.95	48		.83	[illegible]
	.96	94		.85	66		1.00	97		.98	116
	1.03	79		.90	68		.93	83		1.04	[illegible]
	.93	80		.88	62		1.00	95		.98	[illegible]
	1.00	98		.90	71		.93	87		.98	91
	.90	78		.85	80		.95	114		.96	[illegible]
	.86	67		.98	96		.93	96		1.01	[illegible]
	.86	76		.95	95		.88	92		.94	85
	.85	89		.93	89		.93	99		1.00	101
	.90	68		.93	70		.93	104		1.00	[illegible]
	.90	32		.93	89		.88	76		.95	[illegible]
	.90	72		.93	94		1.00	114		.93	88
	.93	82		.93	82		1.10	99		.95	[illegible]
	.96	86		.95	75		.95	80		.98	[illegible]
	.93	76		.88	67		.90	51		.98	94
	.93	84		.95	65		.93	86		.95	[illegible]
	.95	80		.95	85		.98	79		.93	[illegible]
	.90	127		.85	62		1.03	109		.90	92
	.96	75		.93	65		.98	117		.93	103
29 V	.98	92	29 V	.95	113	9 VI	1.00			.95	[illegible]
	1.00	111		.86	69		.95	101	9 VI	.93	[illegible]
29 V	.88	105		.95	75		.93	117		.95	89
	.95	80		.95	128		.95	100		.95	[illegible]
	.85	62		1.00	89		.90	97		.93	[illegible]
	.98	93		.85	89		.88	79		1.03	104
	1.05	118		1.00	88		.98	102		.93	[illegible]
	1.04	115	9 VI	.90	83		.88	79		.85	[illegible]
	.95	106		.98	98		.88	94			
	1.03	104		.93	110		.85	77			
	1.05	95		.95	109		.95	103			
	.95	101		.95	85		.98	117			
	.95	97		.88	81		.98	108			

Appendix 7. (continued)

DATE DA MO	LENGTH (MM)	CLUTCH SIZE	DATE DA MO	LENGTH (MM)	CLUTCH SIZE	DATE DA MO	LENGTH (MM)	CLUTCH SIZE	DATE DA MO	LENGTH (MM)	CLUTCH SIZE
29 V	1.01	91	9 VI	.98	103	9 VI	1.05	126			
	1.00	93		1.03	92		.88	91			
	1.01	130		.98	95		.95	82			
	.86	63		1.00	110		.88	70			
	1.03	121		1.05	110		.98	90			
	1.00	109		.88	89		.95	85			
	1.01	109		.95	95		.93	96			
	.98	112		1.00	115		.88	73			
	.95	102		.93	109		.98	104			
	.88	81		.93	117		.88	91			
	.95	107		.95	105		.95	103			
	.90	106		.98	110		1.00	109			
	.93	105		.93	98		.95	95			
	.93	80		.93	105		.95	104			
	.98	113		.95	72		.93	97			
	.95	107		.98	101		.90	90			
	.93	85		.88	94		.93	90			
	.90	115		.88	94		1.00	99			
	.93	87		1.03	110		1.00	102			
	.95	91		.93	91		.85	79			
	.88	98		.95	96		.95	81			
	.90	99		.98	99		1.00	108			

Biological Studies - Conclusions.

Much valuable information was gathered concerning the plankton of the Minas Basin study area. Some previously undocumented zooplankters were recorded for the Basin (eg. *Calanus finmarchicus*, *Autolytus* sp., *Podon leuckarti*). Many locational and seasonal variations in zooplankton composition and abundance were noted (eg. North *vs* South, shallow *vs* deep). These were attributed to reproductive biology of benthic fauna (esp Polychaeta, Mollusca and Cirrepedia) and to tidal movements (diurnal and seasonal). Larger net phytoplankters were found to be relatively abundant (esp. late August *Biddulphia* spp. bloom) and it is suspected the study area is considerably more productive than previously anticipated. *Coscinodiscus* and *Biddulphia* were the most commonly encountered phytoplankters however pennate diatoms (esp. Naviculoidea) were abundant on occasion.

Eurytemora herdmani showed changes in age composition and seasonal abundance. It is suspected that this species is successful at lower temperatures (eg. <20^{o}C) while *Acartia* sp. becomes dominant at higher temperatures (>20^{o}C). Copepodid stages of *E. herdmani* were found to differ in mean length and weight. Sexual differences (eg. C6 and C5 individuals) introduce some overlap which make egg prediction based on size difficult. It was found that C6 females carry a variable number of eggs. The actual number os clearly related to metasomal length. However other factors appear to mesh the relationship within a small length range. It would appear that temperature plays a very important role

Studies of larval fish indicated that *Alosa* spp. are planktiverous following absorption of the yolk sac, however selective feeding habits could not be shown conclusively. Gut contents of juvenile fish suggested that *Eurytemora herdmani*, Harpacticoida, Mysidacea and Amphipida are important food items. Young smooth flounder and white hake seemed to be benthic feeders while the black-spotted stickleback showed semi-pelagic habits. Continued study is underway and should yield more conclusive data regarding feeding relations in this area.

References cited in Biological Studies.

Bigelow, H.B. 1926. Plankton of the offshore waters of the Gulf of Maine, Bull. U.S. Bur. Fish. 40: 1-509.

Bousfield, E.L. 1961. Studies on littoral marine Arthropods from the Bay of Fundy region. Nat. Mus. Canada. Bull. 183, 42-62.

Bousfield, E.L. and A.H. Leim. 1959. The fauna of Minas Basin and Minas channel. Nat. Mus. Canada Bulletin 166, pp. 30.

Daborn, G.R. 1977. (ed) Fundy Tidal Power and the Environment. Acadia University Institute No. 28 pp. 304.

Hopkins, C.C.E. 1977. The relationships between maternal body size and clutch size, development time and egg mortality in *Euchaeta norvegica* (Copepoda:Calonoida) from Loch Etive, Scotland. J. Mar. Biol. Assoc. U.K. 57: 723-733.

Huntsman, A.G. 1934. Herring and water movements. In James Johnstone Memorial Volume, Liverpool Press.

Huntsman, A.G. 1952. The production of life in the Bay of Fundy. Trans. Roy. Soc. Canada, 46, III(5): 15-38.

Jeffries, H.P. 1967. Saturation of estuarine zooplankton by congeneric associates. In Lauft, G.(ed) Estuaries. Am. Soc. Adr. Sci. Wash. pp. 1-757.

Jermolajev, E.G. 1958. Zooplankton of the Inner Bay of Fundy, J. Fish. Res. Bd. Canada, 15(6): 1219-1228.

Kratz, G. 1965. Succession of Copepod Species in a Middle Atlantic Estuary. Chesapeake Sci.

Meglitsche, P.A. 1972. Invertebrate Zoology. Oxford University Press, U.S.A. pp. 834.

Pennachetti, C.A. 1977. Zooplankton of the Minas Basin of Nova Scotia with special reference to *Eurytemora herdmani* (Copepoda: Calanoida).

Peterson, K.W. and M.E. Peterson. 1976. Hydrozoa and Polychaeta from the littoral zone in the Nova Scotian part of the Bay of Fundy. Unpublished. 15 pp.

Trevors, J. and J. Fuller. 1977. The Minas Basin - Scots Bay Faunal Survey. Unpublished Report, Project 03D-002 and 03D-003. National Research Council of Canada Summer Job Corps Programme. 99 pp.

References used for the identifications in Biological Studies.

Gosner, K.L. 1971. Guide to the identification of Marine and Estuarine Invertebrates, Cape Hatteras to the Bay of Fundy. John Wiley & Sons Inc., U.S.A. pp. 693.

Grice, G.D. 1971. The developmental stages of *Eurytemora americana* Williams, 1906 and *Eurytemora herdmani* Thompson and Scott, 1897. (Copepoda:Calanoida). Crustaceana 20(2): 145-158.

Katona, S.K. 1972. The developmental stages of *Eurytemora affinis* (Poppe, 1880) (Copepoda:Calanoida) raised in laboratory cultures, including a comparison with the larvae of *Eurytemora americana* Williams, 1906, and *Eurytemora herdmani* Thompson & Scott, 1897. Crustaceana 21(1): 5-20.

Leim, A.H. and W.B. Scott. 1966. Fishes of the Atlantic Coast of Canada. Bull. 155. Fish. Res. Bd. Canada. pp. 485.

Linkletter, L.E. 1977. Illustrated key, marine annelids of the lower Bay of Fundy. Huntsman Marine Laboratory, St. Andrews, N.B. Unpublished MS. 69 pp.

Newell, G.E. and R.C. Newell. 1963. Marine Plankton - A Practical Guide. Hutchinson Educational Monograph. Anchor Press Ltd. Great Britain.

Scott, T., and A. Scott. 1968. The British Parasitic Copepoda. Johnson Reprint Corporation. U.S.A.

Edmondson, W.T. 1959. Fresh water biology. 2nd Edition. Wiley & Sons, N.Y. 1248.

Wilson, C.B. 1932. Copepods of the Woods Hole Region. Smithsonian Institution. U.S. Museum Bulletin 158, U.S. Printing Office.

Yamaguti, S. 1963. Parasitic Copepoda and Branchiura of Fishes. John Wiley & Sons Inc. U.S.A.