Invertebrate and sediment characteristics of the Starrs Point lower intertidal region: final report of Federal Summer Job Corps project 16-01-003

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Investigations on the Ecology of the Bay of Fundy

INVERTEBRATE AND SEDIMENT CHARACTERISTICS OF THE STARRS POINT LOWER INTERTIDAL REGION

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Project 16-01-003

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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The advice, guidance and assistance so freely given by the above to the project leaders and students was responsible for the success of the program.

F. J. Simpson
Director, ARL/NRC

FINAL REPORT

of

FEDERAL SUMMER JOB CORPS PROJECT

#16-01-003

INVERTEBRATE AND SEDIMENT CHARACTERISTICS OF THE STARRS POINT LOWER INTERTIDAL REGION.

Submitted to

THE NATIONAL RESEARCH COUNCIL - ATLANTIC

REGIONAL LABORATORY

HALIFAX, N.S.

as prepared by

J. SHERMAN BOATES

DEPARTMENT OF BIOLOGY

ACADIA UNIVERSITY

WOLFVILLE, NOVA SCOTIA

OCTOBER, 1978

FORWARD

In the summer of 1977, the Biology Department of Acadia University supported by the Atlantic Regional Laboratory and the Federal Summer Job Corp Program undertook baseline studies to determine the distribution and abundance of the intertidal invertebrate fauna of the Minas Basin-Scots Bay area. The success of this endeavour made possible a larger, more comprehensive study in the form of three Federal Summer Job Corp Projects during the summer of 1978. Two of these projects centered around various aspects of the sediment and faunal regemes of the southwestern Minas Basin. This report deals primarily with the intertidal sediments and their respective invertebrate faunas whereas the second report concentrates on planktonic forms and sediment material suspended in the water column. Although they are presented separately it is hoped that they will be considered together, along with other complimentary studies,past and present, in light of attaining a better understanding of thisbiologically unique area.

J. Sherman Boates

J. SHERMAN BOATES

PROJECT LEADER

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The information presented in this report is, for the most part, the work of John Allen, Beth Parker and Brian Miller who were employed by the project. Their efforts in the "mud" and in the lab were greatly appreciated.

Lastly, thanks to Cathy for her understanding and inspiration.

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INTRODUCTION

In the past few years a number of studies have dealt with the intertidal invertebrates of the Minas Basin and surrounding area. This work is helping to narrow a previous gap in the information existing since the early preliminary studies by Bousfield and Leim (1958). Recent interest has developed for two primary reasons centering around the unique physical and biological features of the area and the feasibility of Fundy tidal power development. Most of the studies to date have dealt with seasonal trends in abundance and distribution of the invertebrates in the upper intertidal area. Gratto (1977, 1978) paying particular attention to *Corophium volutator* (Pallas) and Fuller and Trevors (1977) have studied invertebrate distribution over much of the southwestern Minas Basin. Similar work has been conducted by McCurdy (1977) in the Passamaquoddy Bay. Perhaps the most extensive work to date has been carried out in the Cobequid Bay area by Yeo (1978). His work deals more specifically with the invertebrate-substrate relationships in a number of communities present in the area.

The importance of the Starrs Point mudbar was first realized by Hicklin (pers. comm.) who recognized it as the preferred foraging habitat of thousands of migrant shorebirds (Charadrii)stopping over in the Minas Basin area. Fuller and Trevors (1977) found that the area supported the highest overall abundance of invertebrates of many transects sampled during July over the entire southwestern Minas Basin. Extremely high densities of *Corophium volutator* (Pallas) were also reported.

The present study was undertaken to describe the faunal and sediment characteristics of the lower intertidal region of the Starrs Point mudbar. Our objectives were as follows;

(i) to determine the numerical abundance and distribution of invertebrates present in a lower intertidal mudflat situation.

(ii) to investigate various aspects of the biology of the major food species, *Corophium volutator* (Pallas).

(iii) to describe both the coarse and fine sediment particle size distribution from the invertebrate sampling locations.

(iv) to determine the water and organic content of sediments at the same locations.

(v) to establish any obvious relationships between the invertebrates and sediments in the area.

A final aspect of this project deals with the breeding and foraging ecology of the Great Blue Heron (*Ardea herodias* L.) breeding in the southern Minas Basin. Although not directly related to the invertebrates and sediments of the region, this study further establishes the high productivity of the Minas Basin estuarine environment.

STUDY AREA

The study area was located at Starrs Point, Kings County, Nova Scotia (45°08'N, 64°22'W), 6 km north of Wolfville (Figure 1). Like the rest of the Bay of Fundy extremely high, semi diurnal tides are experienced in the Starrs Point area. Amplitudes range from around 7.5 m during neap tides to over 15 m on spring tides (Elliot, 1977). Of concern here, the tides expose a long triangular intertidal mudbar that originates at the base of the point and extends over 5 km to the north east. The mudbar bordered by the channels of the Cornwallis and Canard River composes a major portion of the mudflat in the south-western Minas Basin (Figure 2).

The general topography of the Starrs Point mudbar is shown in Figures 3, 4 and 5 which are aerial views of the upper, middle and lower regions of the bar respectively. The many intertidal creeks present in the photographs illustrates that drainage occurs away from the center of the mudbar. Elevation decreases in a northeast direction toward the end of the bar and toward the channels of the Cornwallis and Canard Rivers.

From the ground the study area is flat and extensive. Figure 6 shows the mudbar looking north to Kingsport, Figure 7, a view of transect C looking east and Figure 8 shows Starrs Point from transect A. Sediments ranging from fine sand to clay are soft and make walking difficult. Tracks remain visible in the mud for several months. Although currents are reported to be strong in the area small objects stayed on the surface of the flats for several weeks.

This study was restricted to four transects that cut across the lower intertidal mudbar as shown in Figure 9.

FIGURE 1 : MAP OF THE MINAS BASIN AREA SHOWING THE LOCATION OF STARRS POINT.

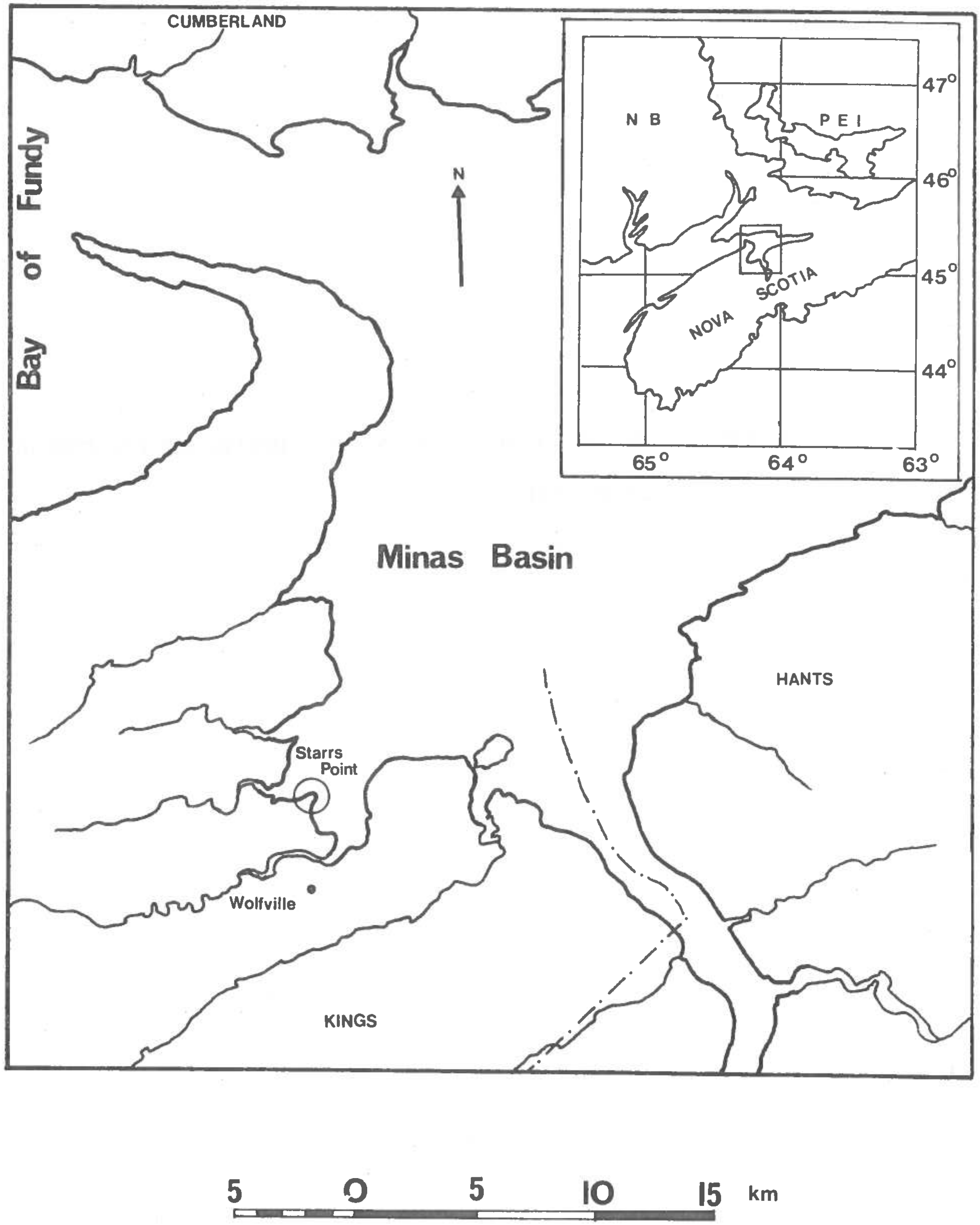
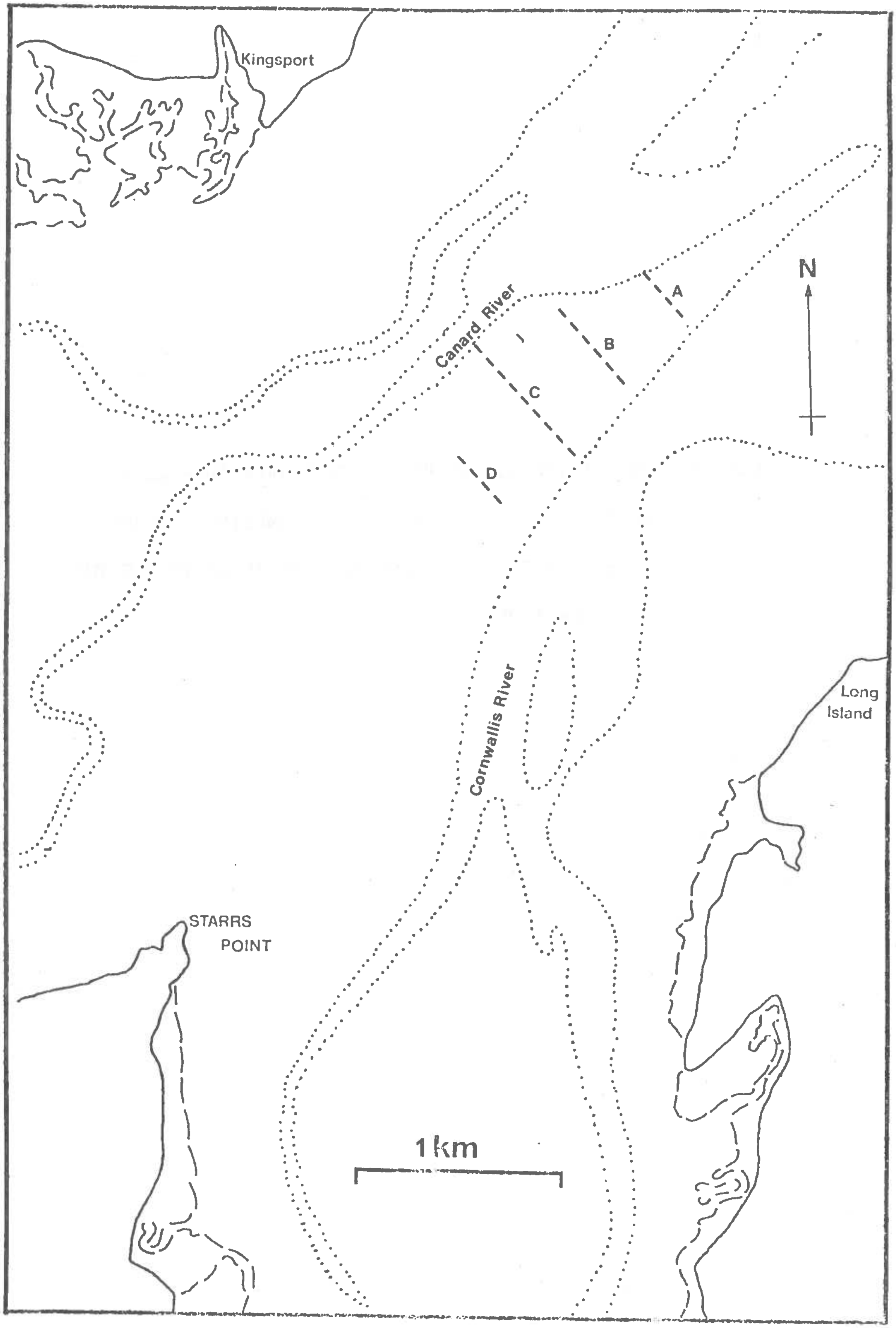

CUMBERLAND
Bay of Fundy
N
N B
P E I
NOVA SCOTIA
47°
46°
45°
44°
65°
64°
63°
Minas Basin
HANTS
Starrs Point
Wolfville
KINGS
5 0 5 10 15 km

FIGURE 9 : MAP OF THE STARRS POINT STUDY AREA SHOWING THE APPROXIMATE LOCATIONS OF THE SAMPLING TRANSECTS, A, B, C AND D. THE DOTTED LINE APPROXIMATES THE MEAN LOW TIDE MARK.


Kingsport
N
A
B
Canard River
C
D
Cornwallis River
Long Island
STARRS POINT
1km

METHODS

A. SAMPLING TRANSECTS

All samples were collected over low tide periods along the four parallel transects (A, B, C and D) shown in Figure 9. A 100 m graduated line and a compass were used to place colored survey stakes at 50 m intervals along the transects marking the position of sampling stations. The transects were 350 m apart and orientated parallel to the general direction of tidal flow. Table 1 shows the length and number of sampling stations on each transect. A diagram illustrating the sample grid layout and the numbering scheme of the sampling stations is presented in Figure 10. The dates samples were collected are summarized in Table 2.

On the 15 July observations were carried out over a complete high tide to high tide cycle at the 7 locations shown in Figure 11. The time a location was uncovered on the falling tide and first reached by the rising tide was recorded and the number of hours each location was exposed, calculated. Stations 5; A, B, C and D were used to represent their respective transects because they approximated the head of the tide and therefore the topographic high of the mudbar.

B. INVERTEBRATES

(i) Transect collections. The 56 invertebrate stations were sampled over a two day period in May, June and July on the dates given in Table 2. Every month, at each station, two adjacent 15 X 15 X 10 cm cores were collected with a sampler and shovel. Each core was placed in a bottomless bucket that had been fitted to a "Tyler"

TABLE 1 : LENGTH AND NUMBER OF SAMPLING STATIONS FOR EACH TRANSECT.

TRANSECT	length(m)	# of invertebrate sampling stations	# of sediment sampling stations
A	450	10	5
B	700	15	8
C	1050	22	11
D	500	9	5
	total	56	29

TABLE 2 : SUMMARY OF SAMPLING DATES DURING SUMMER 1978.

INVERTEBRATE COLLECTIONS	: 24-25-26 MAY
	27-28 JUNE
	28-29 JULY
SEDIMENT COLLECTIONS	: 25 MAY
	03 JULY (JUNE)
	01 AUGUST (JULY)
COROPHIUM VOLUTATOR COLLECTIONS	: 06 MAY
	08 JUNE
	15 JULY

FIGURE 10: A DIAGRAMATIC REPRESENTATION OF THE STARRS POINT SAMPLING GRID SHOWING THE FOUR TRANSECTS AND THE STATION NUMBERING SCHEME. INVERTEBRATES WERE COLLECTED FROM ALL THE STATIONS SHOWN. SEDIMENT SAMPLING STATIONS ARE INDICATED BY THE CLOSED CIRCLES. SAMPLING STATIONS ARE 50 m APART AND THE TRANSECTS ARE 350 m APART.

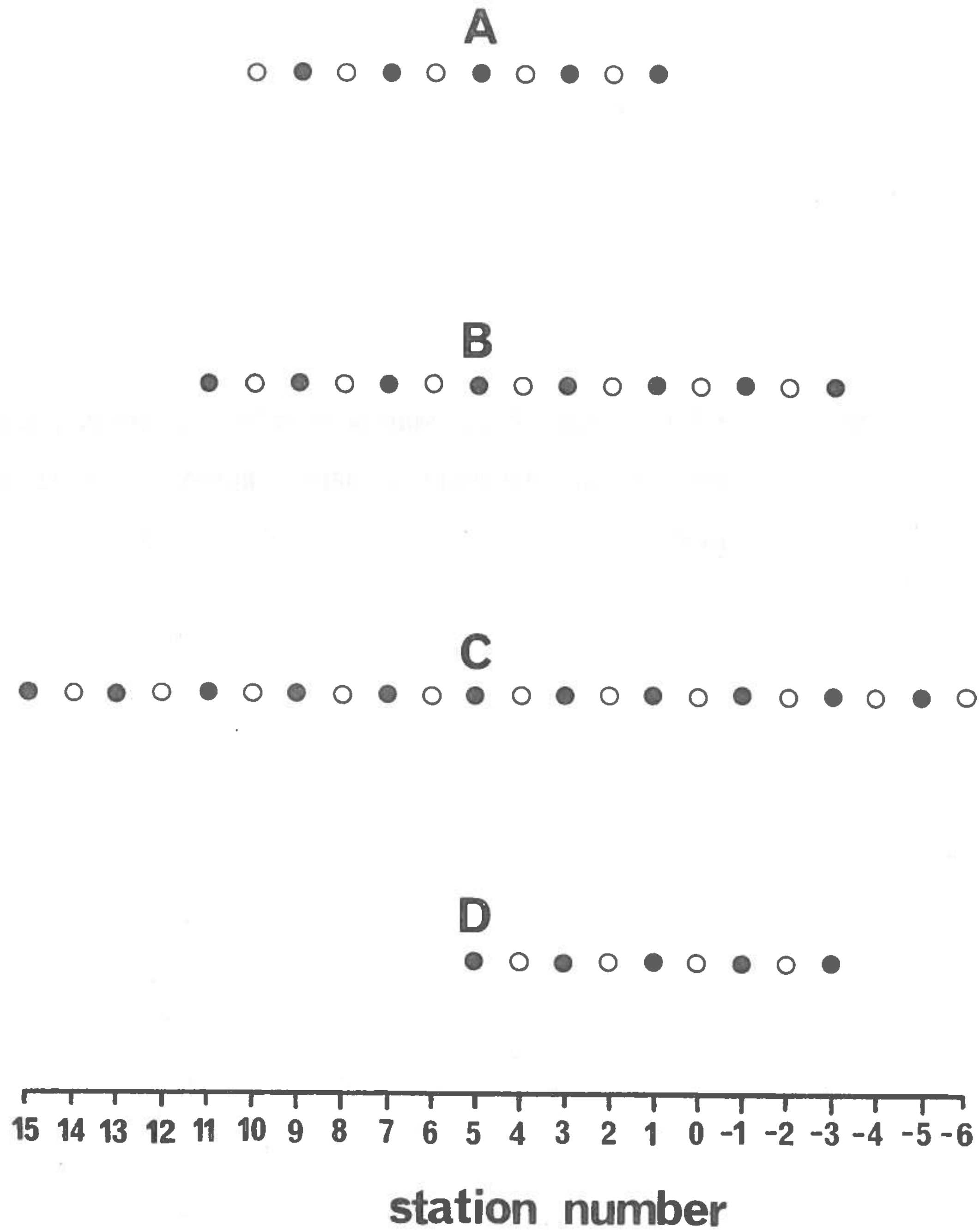
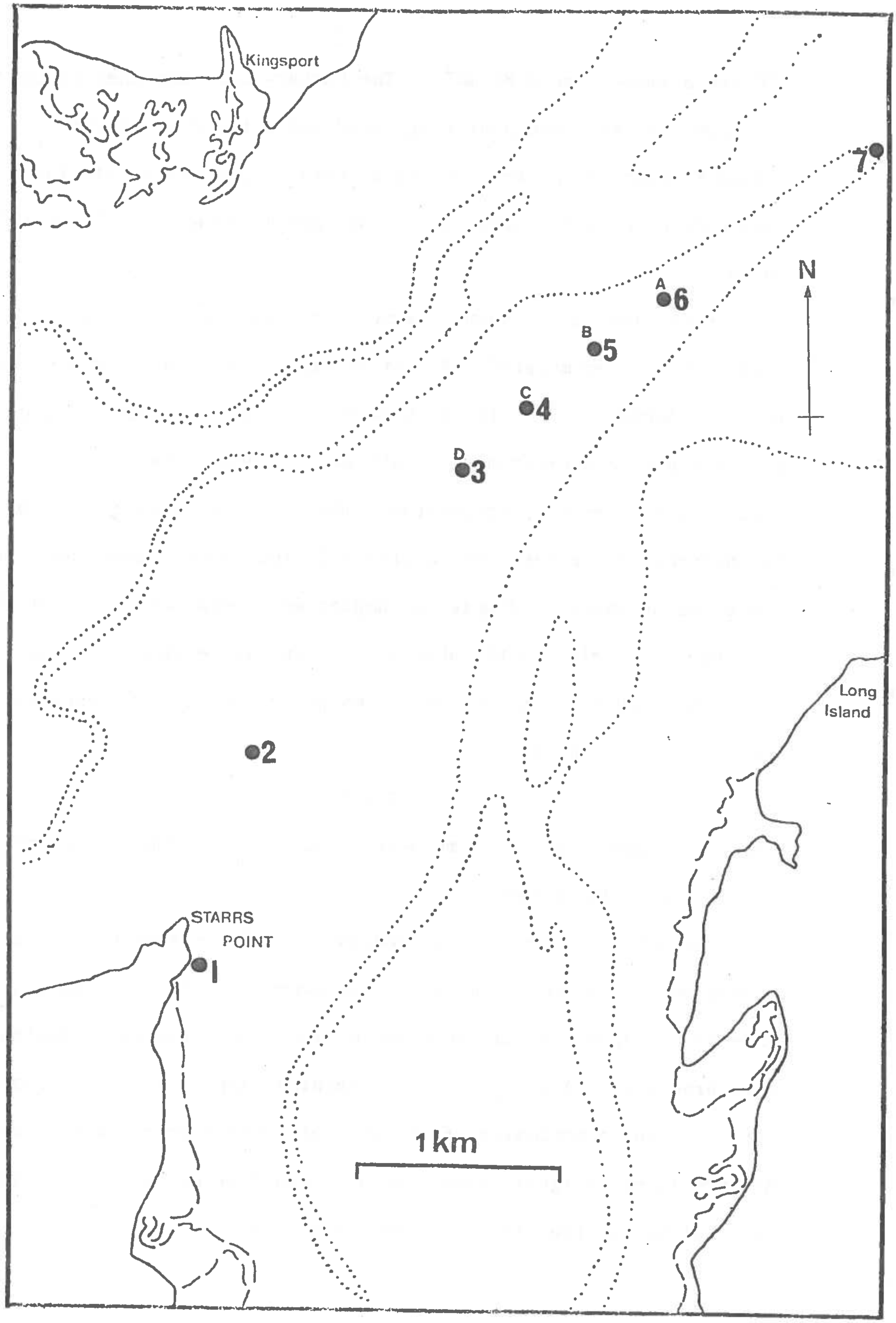

A
B
C
D
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 -1 -2 -3 -4 -5 -6
station number

FIGURE 11 : MAP OF STARRS POINT MUDBAR SHOWING THE SEVEN LOCATIONS WHERE TIDAL OBSERVATIONS WERE CARRIED OUT ON 15 JULY 1978.


Kingsport
N
A
6
B
5
C
4
D
3
7
2
Long
Island
STARRS
POINT
1
1km

#20 sieve (mesh size 0.85 mm^2). The bucket-sieve was then placed in a pool or creek and gently agitated until the fine sediment passed through the sieve. The invertebrates and other material remaining were then placed in jars and preserved with 5-8% neutralized formalin.

In the laboratory samples were placed in trays, sorted, identified and enumerated. A list of keys useful for this area is found in Appendix 1. Only the head ends of animals were counted in order not to overestimate in situations when animals, particularly small polychaetes were fragmented. The tubes secreted by many of the polychaete species were carefully dissected to insure that they contained an animal. Completed samples were retained in 70% alcohol.

Data referring to the abundance of species encountered has been converted to number of organisms per $metre^2$ of substrate using the following formula:

$$N = 44.4 (X)$$

where N = number of $organisms/metre^2$ and X = the number of organisms per 15 X 15 X 10 cm sample.

Time did not permit us to analyse all of the samples collected. Of the May collection both cores from every station were completed. However, in June and July only one of the cores from each station were processed. Analysis of the remaining samples is in progress. For this reason estimates of invertebrate densities presented for May are likely slightly more accurate than June or July as they have been calculated from the mean density of two samples.

(ii) Corophium volutator collections. In May, June and July, as stated in Table 2, several hundred Corophium volutator were collected from an area just north of station 1B for length-weight and calorimetry studies. These specimens were collected with shovel and sieve (Tyler #20), and placed in jars of seawater. The jars were then returned to the lab and placed in a freezer (-10°C) within 2 hours of collection.

Later, the C. volutator samples were thawed and a number of animals removed for length and dry weight determinations. Care was taken to ensure that all the sizes present in the collection were represented in the sub-sample. These animals were sieved, checked for the presence of eggs, and measured to the nearest 0.1 mm (rostrum to telson) with Venier calipers. Next, specimens were put in numbered foiled pans and dried to constant weight (6 hr at 70°C) in a vacuum oven. Weights were determined to the nearest 0.001 mg with a "Cahn" electrobalance.

Corophium specimens remaining in the May and June samples were dried (24 hr at 70°C), pressed into pellets and ignited in a "Phillipson" oxygen microbomb calorimeter. In May, all specimens were lumped together, however, in June, 7 size classes were considered separately. Beforehand the calorimeter was calibrated with a benzoic acid standard (6.318 cals/mg). Four trials proved the machine to be relatively consistent yielding a mean value of 0.3042 calories/line (Table 3).

TABLE 3 : BENZOIC ACID CALIBRATION OF "PHILLIPSON" MICROBOMB CALORIMETER.

Pellet	Weight(mg)	Calories/line
1	8,478	0.307
2	11,005	0.305
3	12,947	0.301
4	9,873	0.304

mean = 0.3042
s.d. = 0.0025

Ash content was also determined for May and June specimens of Corophium volutator. Pellets were used in the May determinations whereas single animals were used in June. Regardless, dry weights were recorded, followed by a 12 hour exposure to 520°C in a muffle furnace. Specimens were then reweighed. The % ash (by weight) can then be calculated as follows:

$$\% \text{ ASH} = \frac{\text{weight after ignition at } 520°\text{C}}{\text{dry weight at } 70°\text{C.}} \times 100\%$$

C. SEDIMENTS

Sediments collections were made a few days after invertebrate samples were obtained in May, June and July (Table 1). Two samples were taken in undisturbed sediment as close to the invertebrate sample as possible. Only the 29 stations (100 m apart) shown in Figure 10 were sampled. One sample was used for particle size and analysis and one for H_2O and organic content.

(i) Sediment particle size distribution. Samples for particle size analysis were taken with a circular core, 9 cm deep X 6 cm in diameter which yielded samples ranging in weight from 100-250 gms. Samples were immediately returned to the laboratory and placed in cold storage where they were held for 1 or 2 days prior to processing.

Methods for the coarse sieve analysis of the sediments follows closely the methods outlined in Royse (1970). Samples were dried, weighed, placed in a graded series of sieves (8, 4, 2, 1, 1/2, 1/4, 1/8, 1/16 mm) and clamped to a sieve shaking apparatus for a constant time period. Sediment fractions retained by each sieve were subsequently weighed. Results are expressed as % of total sample weight in each Phi Ø size category. See table 4 for compraison of the millimetre, Phi and Wentworth grain size classifications.

Fifteen of the June fine sediment fractions (i.e. less than 4 Ø) were retained for fine particle size analysis using a "model T" Coulter Counter. General operating and calibration procedures follow the instruction manual provided with the machine. A 280 μ aperture and estuary water electrolyte were used throughout. Approximately 0.1 gram of the sample was added to 250 ml of electrolyte while it was constantly stirred. Results are presented as recorded by the Coulter counter interms of both % total volume of the sample and number of particles in each of the particle size classes.

(ii) Water and organic content of sediments. Samples for water and organic content analysis were collected adjacent the particle size sample by pressing a plastic vial (4.6 cm long, 2.3 cm diameter) into the substrate. The vial and sediment was removed and capped. Sample weight using this method ranged from 20-45 gm.

In the laboratory, the caps were removed and the wet weight of the vial and the sample recorded. Vials containing samples were then dried to a constant weight (2-4 days at 70°C) and reweighed. % water content of the sample was calculated by the formula:

$$\% \; H_2O = 1 - \frac{\text{dry weight}}{\text{wet weight}} \times 100\%$$

After this treatment, about 1 gram of dried sediment from each vial was weighed and placed in a muffle furnace at 520°C for

TABLE 4 : COMPARISON OF MILLIMETER, PHI AND WENTWORTH PARTICLE SIZE CLASSIFICATIONS.

mm	Phi(Ø)	Wentworth
8	-3	
		pebble gravel
4	-2	
		granule gravel
2	-1	
		very coarse sand
1	0	
		coarse sand
1/2	1	
		medium sand
1/4	2	
		fine sand
1/8	3	
		very fine sand
1/16	4	
		silt
1/256	8	
		clay
1/4096	12	

(adapted from Royse, 1970).

24 hours. Samples were then reweighed. The % organic matter present in the sample could then be determined as follows:

$$\% \text{ organic matter} = 1 - \frac{\text{weight after ignition at } 520^{\circ}\text{C}}{\text{dry weight}} \times 100\%$$

RESULTS

A. TIDAL OBSERVATIONS:

The results of the tidal observation conducted at the 7 locations in Figure 11 on 15 July are summarized in Table 5. Four hours before predicted low tide the first section of mudflat (1) in the area was exposed. About 3 hours before low tide station 5D(3) uncovered followed 12, 14 and 16 minutes later by stations 5C(4), 5B(5) and 5A(6) respectively. On the rising tide the 4 stations were covered 1 hr 49 min and 2 hr 26 min after low tide. Estimates of the time each station was exposed ranges from 4 hr 2 min at 5A to 5 hr 21 min at station 5D.

Because the tide encroaches the elevated center of the mudbar as well as the headland of the point, stations away from the center of the bar (stations 5A, B, C and D) have shorter periods of exposure. Variation in the period of exposure is dependent on the lunar cycle. Although the height of the tide varies seasonally, the time period in which the tide rises and falls remains constant. Therefore, on spring tides, exposure periods are shorter and during neaps the reverse is true. In the general area, over the period of study, tidal amplitude ranged from 0.1 to 2.1 m on low tides and from 6.6 to 8.6 m on high tides (Canadian Hydrographic Service, 1978). On 15 July tidal conditions were about average with respective low and high tide heights of 1.2 and 7.2 m.

TABLE 5 : OBSERVATIONS ON THE SEVEN LOCATIONS SHOWN IN FIGURE 11. THE OBSERVATIONS WERE DONE ON 15 JULY OVER A COMPLETE TIDAL CYCLE. HIGH TIDE AND LOW TIDE HEIGHTS WERE 7.2 m AND 1.2 m RESPECTIVELY. LOW TIDE OCCURRING AT 1455.

LOCATION	UNCOVERED ON FALLING TIDE (hours before low tide)	COVERED ON RISING TIDE (hours after low tide)	HOURS EXPOSED	COMMENT
1	4:00	-		first exposed mudflat
2	3:25	2:54	6:19	-
3	2:55	2:26	5:21	station 5D
4	2:43	2:15	4:58	station 5C
5	2:29	2:94	4:33	station 5B
6	2:13	1:49	4:02	station 5A
7	0:00	0:00	-	low tide mark

B. INVERTEBRATES

(i) General. Over the sampling period 27 species of invertebrates representing 5 phyla were identified from the transect samples. A list of these invertebrates is given in Table 6. Transect A, where 25 species were found (Table 7) had the highest number of species. Species diversity decreased toward the shore with 24, 20 and 14 species collected from transects B, C and D respectively. Low species diversity is a characteristic of high stress environments such as the intertidal mudflats of the Bay of Fundy. In the Passamaquoddy Bay, McCurdy (1977) reported 32 and 36 invertebrate species from two different beaches whereas Gratto (1977) working at Avonport, a mudflat environment similar to Starrs Point, found 23 species. Studies in the upper Bay of Fundy (Yeo, 1978) have shown that as few as 11 species occur there.

Nematodes (Nematoda), too small to be sampled effectively, and chironomids (Insecta) obviously vagrants, occurred sporadically in small numbers but will not be discussed here.

(ii) Species abundance and distribution. Figure 12 establishes the importance of each invertebrate species with respect to its % occurrence over the entire sampling area. On this basis the species have been divided in 3 arbitrary categories as follows:

I ABUNDANT - species with % occurrence values greater than 70%,

II COMMON - species found in 30-60% of the samples, and

III UNCOMMON - species occurring in less than 25% of the samples.

Of the 27 species collected 5 are considered abundant, 6 common and 16 uncommon. In the section following the status of the 11 abundant and common species is discussed.

TABLE 6 : ANNOTATED LIST OF INVERTEBRATES COLLECTED AT STARRS POINT AND ABBREVIATIONS USED IN TEXT.

			Abbrev.	Status
PLATYHELMINTHES		Notoplana atomata (Müller)	N.a.	U
RHYNCHOCOELA		Cerebratulus lacteus (Leidy)	C.l.	U
MOLLUSCA	GASTROPODA	Turbonella elegantula	T.e.	U
		Hydrobia totteni	H.t.	U
		Lunatia heros (Say)	L.h.	U
		Nassarius obsoletus (Say)	N.o.	U
		Buccinium undatum Linnaeus	B.u.	U
	BIVALVIA	Encis directus (Conrad)	E.d.	U
		Gemma gemma (Totten)	G.g.	U
		Mya arenaria Linnaeus	M.a.	U
		Macoma balthica (Linnaeus)	M.b.	U
ANNELIDA	POLYCHAETA	Phyllodoce mucasa Oersted	P.m.	U
		Eteone heteropoda Hartman	E.h.	U
		Eteone longa (Fabricius)	E.l.	A
		Glycera dibranchiata Ehlers	G.d.	C
		Nephtys caeca (Fabricius)	N.c.	A
		Nereis virens Sars	N.v.	U
		Heteromastus filiformis (Claparede)	H.f.	A
		Clymenella torquata (Leidy)	C.t.	C
		Streblospio benidicti Webster	S.i.	C
		Pygospio elegans Claparede	P.e.	C
		Spiophanes bombyx	S.b.	A
		Scolopos armiger (Müller)	S.a.	U
		Chaetozone setosa Malmgren	C.s.	C
		Fabricia sabella Ehrenberg	F.s.	U
ARTHROPODA	CRUSTACEA	Oxyurostylis smithi Calman	O.s.	C
		Corophium volutatòr (Pallas)	C.v.	A

A = Abundant

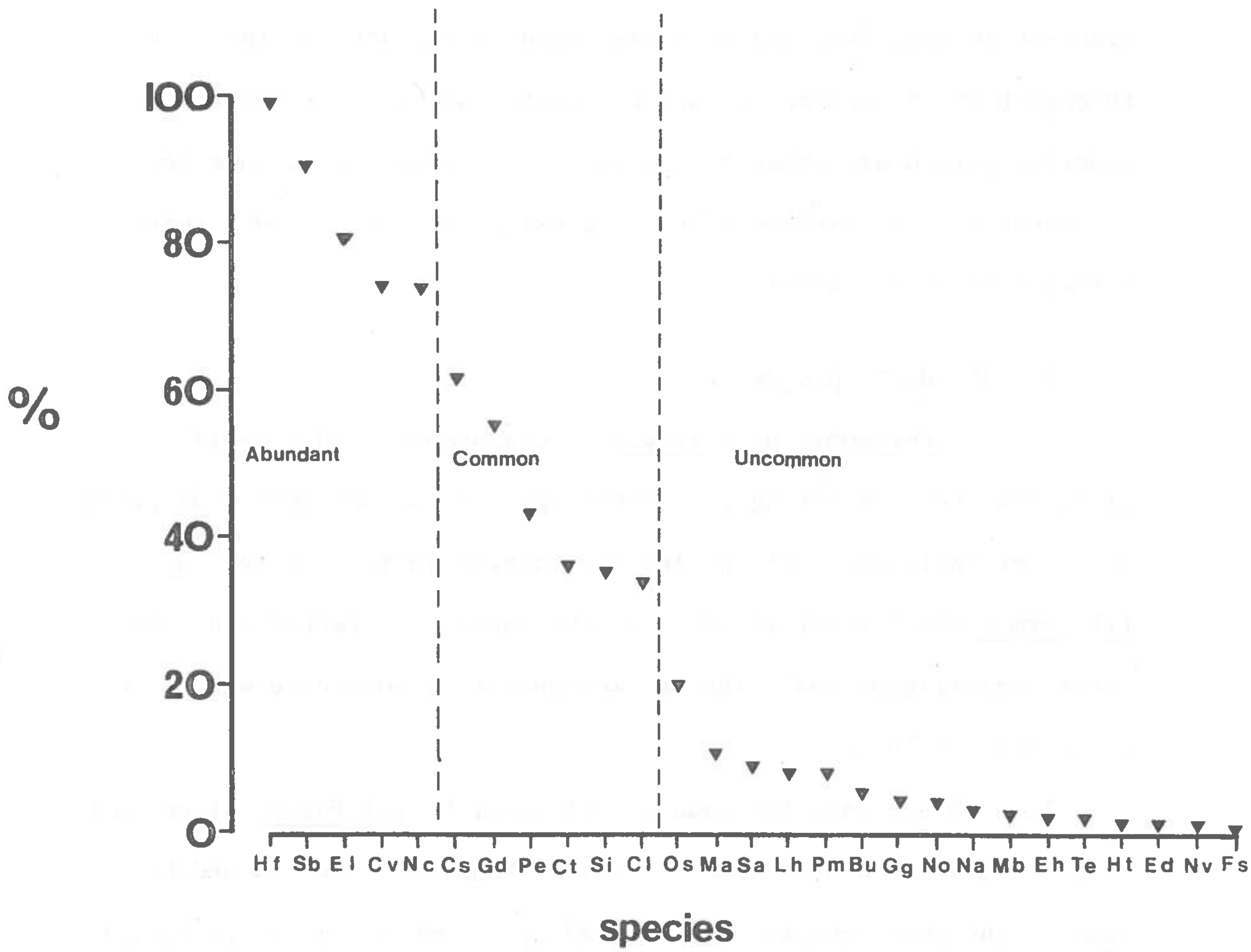
C = Common

U = Uncommon

TABLE 7 : % OCCURRENCE OF EACH INVERTEBRATE SPECIES AT EACH OF THE FOUR TRANSECTS A, B, C AND D.

Species	TRANSECT A	B	C	D	TOTAL
N.a.	3.3	2.2	4.8	0	3.3
C.l.	36.7	44.4	31.7	6.7	34.0
T.e.	6.7	2.2	0	0	2.0
H.t.	6.7	0	0	0	1.3
L.h.	16.7	8.9	4.8	6.7	8.5
N.o.	10	2.2	3.2	0	3.9
B.u.	20	6.7	1.6	0	6.5
E.d.	3.3	2.2	0	0	1.3
G.g.	16.7	4.4	0	0	4.6
M.a.	36.7	4.4	4.8	6.7	11.1
M.b.	13.3	0	0	0	2.6
P.m.	26.7	6.7	3.2	0	8.5
E.h.	3.3	4.4	0	0	2.0
E.l.	66.6	64.4	93.6	100	80.4
G.d.	23.3	53.3	74.6	46.7	55.6
N.c.	70.0	77.8	82.5	26.7	73.2
N.v.	0	2.2	0	6.7	1.3
H.f.	96.7	100	98.4	100	98.7
C.t.	66.7	29,9	31.7	13.3	36.0
S.i.	6.7	8.9	63.5	46.7	34.6
P.e.	50.0	40	33.3	80	43.1
S.b.	93.3	82.2	90.5	53.3	85.0
S.a.	10.0	4.4	14.3	0	9.1
C.s.	36.7	46.7	79.4	73.3	60.8
F.s.	0	0	1.6	0	0.7
O.s.	43.3	17.8	12.7	0	18.9
C.v.	86.7	66.7	71.4	80	73.9
No. of species	25	24	20	14	27

FIGURE 12 : % OCCURRENCE OF THE 27 INVERTEBRATE SPECIES FROM 204 SAMPLES COLLECTED AT THE 4 TRANSECTS DURING MAY, JUNE AND JULY. SPECIES ABBREVIATIONS ARE AS FOUND IN TABLE 6.


100
80
60
40
20
0
%
Abundant
Common
Uncommon
Hf Sb El Cv Nc Cs Gd Pe Ct Si Cl Os Ma Sa Lh Pm Bu Gg No Na Mb Eh Te Ht Ed Nv Fs
species

The results of the invertebrate sample analysis for each transect in May, June and July are found in Appendix B, tables B1 through B11. % occurrence data for each transect over the entire sampling period are presented in Table 7. Reference to numerical abundance or % occurrence in the following species accounts refers directly to these tables.

I. Abundant species.

1. Heteromastus filiformis (Claparede). This small, blood-red, tube-secreting polychaete species was the most widespread and numerically dominant species encountered in this study. H. filiformis was present in 98.7% of the samples collected over the entire sampling period. The maximum density encountered was 11,500/m^2 at station 1D in July.

Table 9 presents the mean densities of H. filiformis along each sample transect in May, June and July. Means were determined by summing the invertebrate densities along a transect in a particular month and dividing by the number of stations in the transect. Density decreased toward the end of the mudbar from a high of 5589/m^2 at transect D in July to 986/m^2 at A in July. No seasonal density trend is evident, densities remaining relatively constant May through July.

2. Spiophanes bombyx. The tube-building, spionid polychaete Spiophanes bombyx exhibited the second widest distribution of the species encountered (85% occurrence). Densities of 15,140/m^2 were observed at station -2B in July.

S. bombyx displayed a density gradient pattern opposite to the trend shown by Heteromastus filiformis (Table 8). The highest densities occurred at transect A and decreased sharply towards transect D where very low densities (34 and 82/m^2) were encountered. Seasonally, numbers built up through May and June and declined in July.

3. Eteone longa (Fabricius). Although not as numerically dominant as the previous two polychaete species, Eteone longa had a high occurrence value of 80.4%. Peak densities were found at station 2A in July (2575/m^2). The transect and monthly density averages for this species (Table 11) also show peaks in June and July at transect A.

4. Corophium volutator (Pallas). The burrowing amphipod, Corophium volutator was characterized by a more patchy distribution than the abundant polychaete species and numbers often fluctuated a great deal over a small area. This species was widespread, and was present in 74% of the samples. Single station densities were the highest recorded for any species in this study and values of greater than 20,000/m^2 were not uncommon. At station 9B, in June the density was estimated at 32,323/m^2 and in the same area in August densities exceeding 52,280/m^2 were discovered (Boates, pers. comm.)

Transect B supports the highest average density of C. volutator (Table 10). Numbers peaked in June and with the exception of transect A, dropped off sharply in July.

5. Nephtys caeca (Fabricius). Nephtys caeca was relatively widespread (70% occurrence value) but was not collected in high numbers. The highest density observed was 688/m^2 at station 6C in May.

Transect averages for this species (Table 12) were maximum at transect C during May. These averages generally declined from May to July.

II. Common Species.

6. Chaetozone setosa Malmgren. Present in 60.8% of the samples examined, Chaetozon setosa exhibited a noticeable fluctuation along sample transects. In July at transect D a peak density of $3019/m^2$ was observed.

A density gradient exists in terms of mean densities along the four transects (Table 14). High values as shown for transect C and numbers are reduced at B and again at A. Numbers increased throughout the sampling season at high densities (transect C) but seemed to remain stable at low densities.

7. Glycera dibranchiata Ehlers. Glycera dibranchiata is by far the largest polychaete present at Starrs Point. It was found regularly over the mudbar (55.6% occurrence) but in very low numbers (maximum density $268/m^2$ at station 6C in July).

Maximum average densities over transects was also at transect C and densities remained more or less stable over the sampling period (Table 13).

8. Pygospio elegans Claparede. Not a single specimen of Pygospio elegans was collected in May and as a result its occurrence value was low(43.1%). If we exclude May, this species was present in 87% of the samples analysed. Whether P. elegans was not present in May or whether it was too small to be effectively sampled cannot be determined.

In the June and July samples, P. elegans was so small and abundant it could not be counted, densities in any case were very high.

9. Clymenella torquata (Leidy). Clymenella torquata was most characteristic of transect A (Table 15) where the highest mean densities were recorded in May and June. The high values at transect A decreased in June and July and at lower densities present at transect C the reverse pattern was observed. The maximum density of this species was $2703/m^2$ at station 15C in July.

10. Streblospio benidicti (Webster). Transect C supported the greatest density of Streblospio benidicti ($2176/m^2$ at 14C in June). Transect mean densities (Table 16) further indicate that the transect C is the most important area for this species. Very low densities were determined at transects A and B.

11. Cerebratulus lacteus (Leidy). The average densities in which the only nemertine species, Cerebratulus lacteus, was encountered are presented in Table 17. Although this species occurred over most of the mudflat, numbers were low and never exceeded $244/m^2$ (8C, May and 4A June).

TABLE 8 : MEAN DENSITIES (#/m^2/station) OF *SPIOPHANES BOMBYX* FOR TRANSECTS A, B, C, AND D IN MAY, JUNE AND JULY.

TRANSECT	MAY	JUNE	JULY
A	4755	3485	1829
B	1915	2503	929
C	1706	2565	1587
D	--	82	160

TABLE 9 : MEAN DENSITIES (#/m^2/station) OF *HETEROMASTUS FILIFORMIS* FOR TRANSECTS A, B, C, AND D IN MAY, JUNE AND JULY.

TRANSECT	MAY	JUNE	JULY
A	1467	1276	986
B	3172	3542	2475
C	4799	5641	4238
D	--	4780	5589

TABLE 10 : MEAN *COROPHIUM VOLUTATOR* DENSITIES (#/m^2/station) FOR TRANSECTS A, B, C, AND D IN MAY, JUNE AND JULY.

TRANSECT	MAY	JUNE	JULY
A	699	2156	3168
B	986	9989	3941
C	643	4421	517
D	---	4307	688

TABLE 11 : MEAN DENSITIES (#/m^2/station) OF *ETEONE LONGA* FOR TRANSECTS A, B, C AND D IN MAY, JUNE AND JULY.

TRANSECT	MAY	JUNE	JULY
A	7	921	586
B	50	97	500
C	124	314	422
D		163	552

TABLE 12 : MEAN DENSITIES (#/m^2/station) OF _CHAETOZONE SETOSA_ FOR TRANSECTS A, B, C, AND D IN MAY, JUNE AND JULY.

TRANSECT	MAY	JUNE	JULY
A	13	40	44
B	132	127	92
C	460	928	1054
D	-	44	903

TABLE 13 : MEAN DENSITIES (#/m^2/station) OF _CLYMENELLA TORQUOTA_ FOR TRANSECTS A, B, C AND D IN MAY, JUNE AND JULY.

TRANSECT	MAY	JUNE	JULY
A	320	173	44
B	41	86	6
C	53	93	169
D	-	22	0

TABLE 14 : MEAN DENSITIES (#/m^2/station) OF *NEPHTYS CAECA* FOR TRANSECTS A, B, C AND D IN MAY, JUNE AND JULY.

TRANSECT	MAY	JUNE	JULY
A	82	42	40
B	148	49	77
C	176	118	82
D	-	0	30

TABLE 15 : MEAN DENSITIES (#/m^2/station) OF *GLYCERA DIBRANCHIATA* FOR TRANSECTS A, B, C, D IN MAY, JUNE AND JULY.

TRANSECT	MAY	JUNE	JULY
A	4	4	13
B	23	39	21
C	51	36	49
D	--	41	15

TABLE 16 : MEAN DENSITIES (#/m^2/station) OF *STREBLOSPEO BENEDICTI* FOR TRANSECTS A, B, C AND D IN MAY, JUNE AND JULY.

TRANSECT	MAY	JUNE	JULY
A	0	4	0
B	1	9	0
C	51	387	135
D	--	22	296

TABLE 17 : MEAN DENSITIES (#/m^2/station) OF *CEREBRATULUS LACTEUS* FOR TRANSECTS A, B, C AND D IN MAY, JUNE AND JULY.

TRANSECT	MAY	JUNE	JULY
A	22	38	9
B	20	9	22
C	37	6	11
D	--	9	0

(iii) Biology of *Corophium volutator* (Pallas). Studies dealing with *Corophium volutator* in this area have focused on its seasonal distribution and density. Gratto (1977) has done some work on the size class frequency distributions of this species. *C. volutator* is the most important food for shorebirds in the area (Hicklin, 1977) and forms a conspicuous part of the diet of ground feeding fishes (Imrie, pers. comm.). During this study work on length-weight relationships and calorific content of *C. volutator* was initiated.

I. Length-weight relationships.

Invertebrate growth and production are usually studied by observing changes in a linear dimension and converting these measurements into estimates of mass (Daborn, 1974). The length-weight relationships determined here will be used at a later date to make production estimates for this species over the summer period at the Starrs Point mudbar.

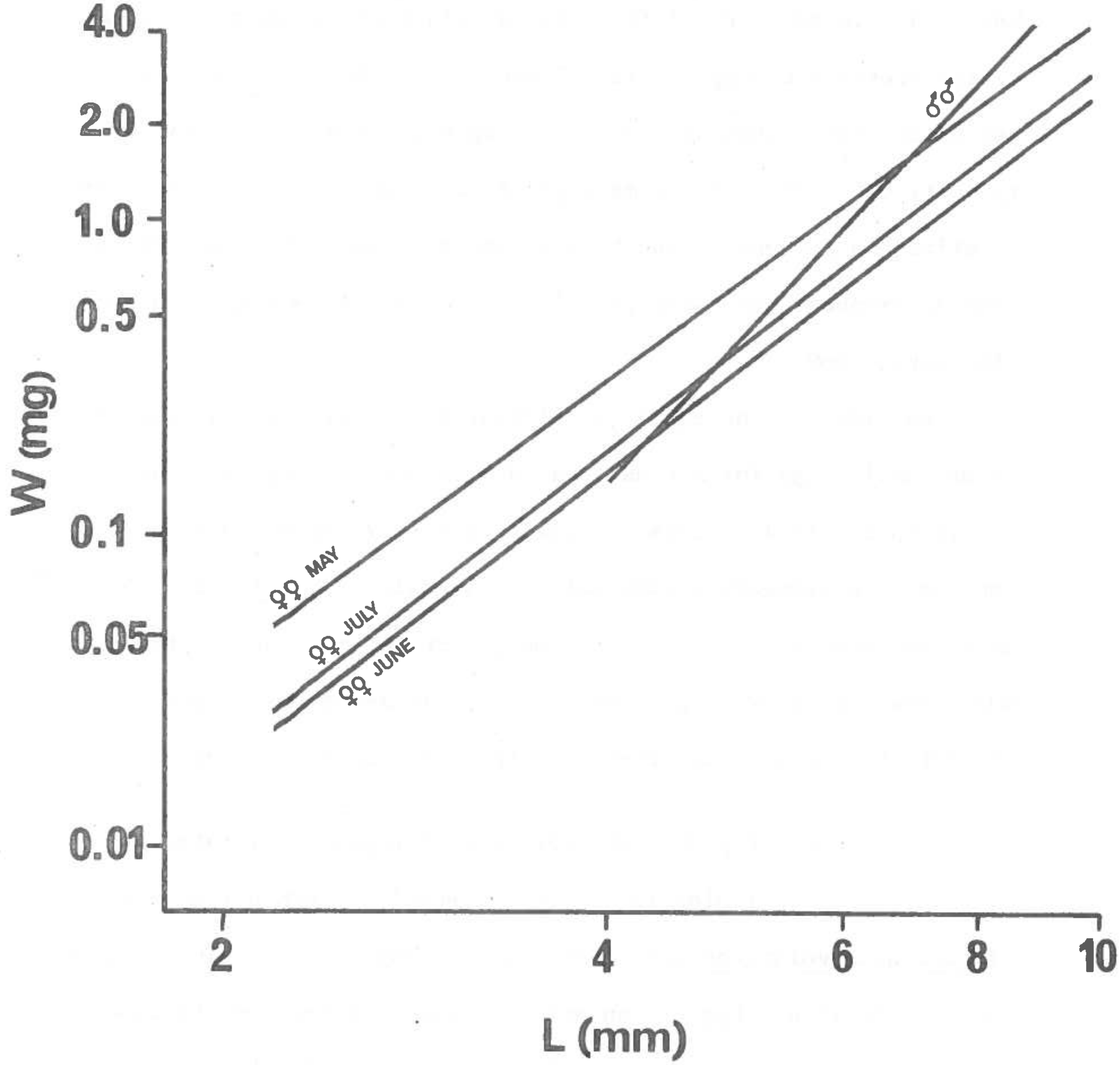
Data collected on the length and the dry weight of *C. volutator* are presented in Table C1 for females and in Table C2 for males. A strong logrithmic relationship ($r > 0.92$) exists between length and dry weight in all cases following the general equation.

$$W = qL^b$$

where W = weight, L = length, q is a constant and b the exponent, which for crustaceans, does not greatly differ from 3 (Winberg 1971) Equations for females in May, June and July and for males throughout the season are shown in Figure 13. May, June and July equations for females have similar values of b and as a result form three parallel lines (Figure 13). The constant (q) of the May equation is appreciably

FIGURE 13 : LENGTH WEIGHT RELATIONSHIPS FOR FEMALE *COROPHIUM VOLUTATOR* IN MAY, JUNE AND JULY AND FOR MALES OVER THE ENTIRE SAMPLING PERIOD.

L = Length, W = Weight.



♀♀ May	$W = 0.0054\ L^{2.939}$	$r = 0.927$
♀♀ June	$W = 0.0021\ L^{3.089}$	$r = 0.979$
♀♀ July	$W = 0.0023\ L^{3.164}$	$r = 0.978$
♂♂	$W = 0.0004\ L^{4.321}$	$r = 0.958$

higher than the values for June and July and as a result the line for May is displaced to the left. This displacement seems to be related to the presence of eggs as 72, 17 and 22% of the specimens used to calculate these equations were carrying eggs in May, June and July respectively. The lines remain parallel because in crustaceans the relationship between fecundity and length is generally logarithmic with an exponent value similar to that which relates weight to length (Khmeleva, 1969).

The slope of the equation calculated for males was 4.321. This is unusually high for a crustacean and values are typically below 3.5 (Winberg, 1971). This deviation is easily explained if we consider the elongate second antennae of male C. volutator. These antennae, nearly as long as the body, were not included in the measurement of body length and therefore increase the weight but not the length of animal and result in the observed high slope value.

II. Calorimetry and Ash Content of Corophium volutator.

In Tables 18 and 19 the result of ash determinations of Corophium volutator are presented. In May, a mean value of 27.6% ash was attained. Regression analyses was performed on the June data but showed no relationship between length and ash content. Mean ash content was 27.5% in this sample period.

May samples, in which all size classes of animals were lumped yielded uncorrected calorific values ranging from 3.53 to 3.68 cal/mg with a mean of 3.63 cal/mg (Table 20). When these measurements were corrected for ash content the mean value rose to 5.01 cal/mg.

Calorific determinations for different size classes of *C. volutator* were very interesting. The results tabulated in Table 21 show a sharp drop in calorific value between the 4 and 5 mm size classes. Mean uncorrected calorific value for animals < 4.5 mm was 3.98 cal/mg compared to 3.60 cal/mg for animals > 4.5 mm. If the size frequency distribution of the 1458 specimens used in this experiment (Figure 14) is considered we see that the abrupt change in calorific value corresponds to the cut off point between young of the year and adult components of the population.

The fact that 94% of the egg carrying females were larger than 4.5 mm implies that only adults are reproducing. By June, the majority of adults (78%) have already released their embryos. The low calorific value of adult specimens may be associated with poor body conditioning following reproduction.

TABLE 18 : ASH CONTENT OF *COROPHIUM VOLUTATOR* IN MAY 1978.

PELLET	DRY WEIGHT(70°C)	WEIGHT AFTER IGNITION(520°C)	% ASH
1	10.07	2.70	26.8
2	13.39	3.76	28.1
3	8.91	2.49	27.9

mean = 27.6
s.d. = 0.70

TABLE 19 : ASH CONTENT OF <u>COROPHIUM</u> <u>VOLUTATOR</u> IN JUNE 1978.

TEST	LENGTH (mm)	DRY WEIGHT (70°C)	WEIGHT AFTER IGNITION (520°C)	% ASH
1	7.8	0.720	0.171	23.8
2	7.4	0.631	0.118	18.7
3	5.4	0.348	0.075	21.6
4	8.2	1.499	0.491	32.8
5	6.4	0.804	0.109	26.0
6	9.3	1.651	0.464	28.1
7	6.6	0.806	0.265	32.9
8	4.7	0.266	0.049	18.4
9	9.7	2.558	1.015	39.7
10	3.4	0.099	0.024	24.2
11	4.5	0.182	0.034	18.7
12	5.9	0.330	0.118	35.8
13	3.6	0.111	0.085	36.6

mean = 27.49
s.d. = 7.40

TABLE 20 : CALORIFIC DETERMINATIONS FOR <u>COROPHIUM VOLUTATOR</u> COLLECTED IN MAY 1978.

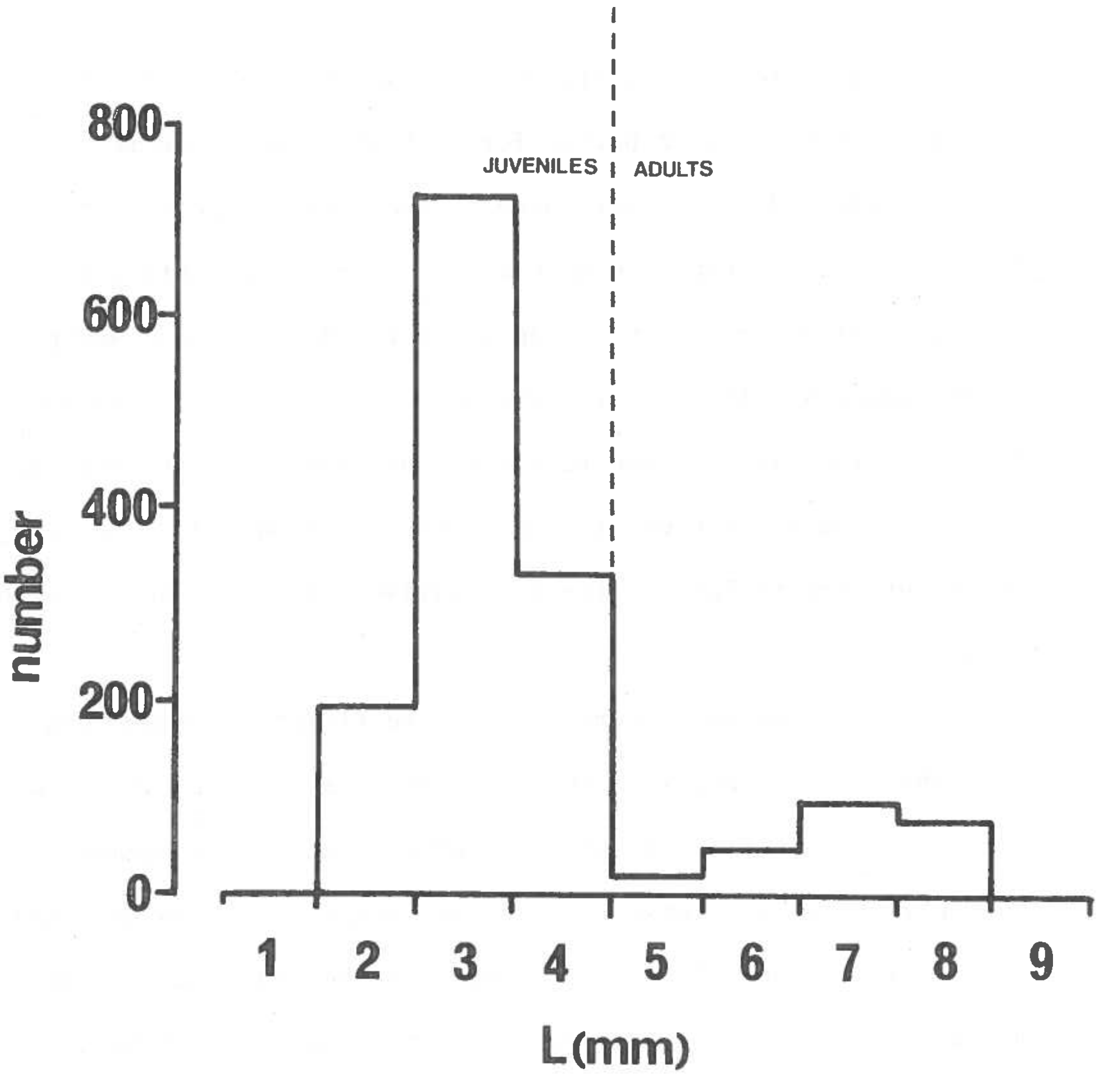
PELLET	PELLET WEIGHT(mg)	Calories/mg	Calories/mg(ash-free)
1	8.234	3.65	5.04
2	8.318	3.53	4.88
3	10.669	3.68	5.08
4	10.762	3.67	5.07
5	8.432	3.60	4.98
		mean = 3.63	5.01
		s.d. = 0.068	0.085

TABLE 21 : CALORIFIC VALUE OF COROPHIUM VOLUTATOR IN RELATION TO SIZE CLASS (JUNE).

SIZE CLASS (mm)	mg DRY WEIGHT (70°C)	CALORIES/mg (uncorrected)	CALORIES/mg ASH-FREE
1.5-2.4	7.439	3.32	4.56
	6.695	4.05	5.59
2.5-3.4	8.991	4.09	5.64
	7.626	4.01	5.53
3.5-4.4	7.315	4.05	5.59
	8.453	4.35	6.00
4.5-5.4	6.811	3.63	5.01
6.5-7.4	9.409	3.66	5.04
	8.191	3.60	4.97
	6.251	3.62	4.99
7.5-8.4	7.855	3.60	4.96
	9.163	3.51	4.84
	9.430	3.60	4.97
	7.326	3.56	4.91
8.5-9.4	10.518	3.63	5.01
	11.801	3.56	4.91
	9.427	3.61	4.98
	11.430	3.41	4.70
	11.466	3.72	5.13
	13.534	3.67	5.06

FIGURE 14 : SIZE CLASS DISTRIBUTION OF THE 1453 <u>COROPHIUM VOLUTATOR</u>

SPECIMENS USED IN THE CALORIMETRY EXPERIMENT.



800
600
400
200
0
number
JUVENILES
ADULTS
1
2
3
4
5
6
7
8
9
L(mm)

C. Sediments

(i) Particle size distribution: Figures 15, 16, 17 and 18 show the particle size distribution for each station of the four transects in May, June and July. Data used to construct these size frequency histograms can be found in Appendix C. For easier interpretation the % weight values have been averaged for the 3 phi, 4 phi and pan fractions of the samples collected at stations 9, 7, 5, 3 and 1 from each transect. These stations were common to all of the transects with the exception of D. This data is presented in Table 22, 23 and 24. The reader is again referred to Table 4 for a comparison of size classification terms.

From preliminary observation in the field, it seemed that there were observable changes in the substrate over the mudbar. Generally sediments were softest in the area of transect D and became more firm, northward until at transect A, the sediments were firm and sandy. Figures 19, 20 and 21 are photographs of the sediment at transects A, B and C respectively. Differences in the substrate along the transects were also noted. The substrate was definitely softest towards the ends of the transects and became more firm in the direction of the center of the mudbar (level of stations 5). Seasonally, there appeared to be sediment movement from the soft areas near the head of Starrs Point and the sediments in this area became easier to walk in as the sampling season progressed. On the other hand, in the area of transect A fine sediment seemed to accumulate over top of the firm sand during the summer. Many aspects of these observations were verified by the sediment sampling program.

The sediments over much of the mudbar were well sorted and most particles were in the 3 and 4 phi size categories which describe fine sand, very fine sand and coarse silt (Table 4). Size categories other than 3 phi, 4 phi and the pan fraction rarely accounted for more than 4% of the sample weight.

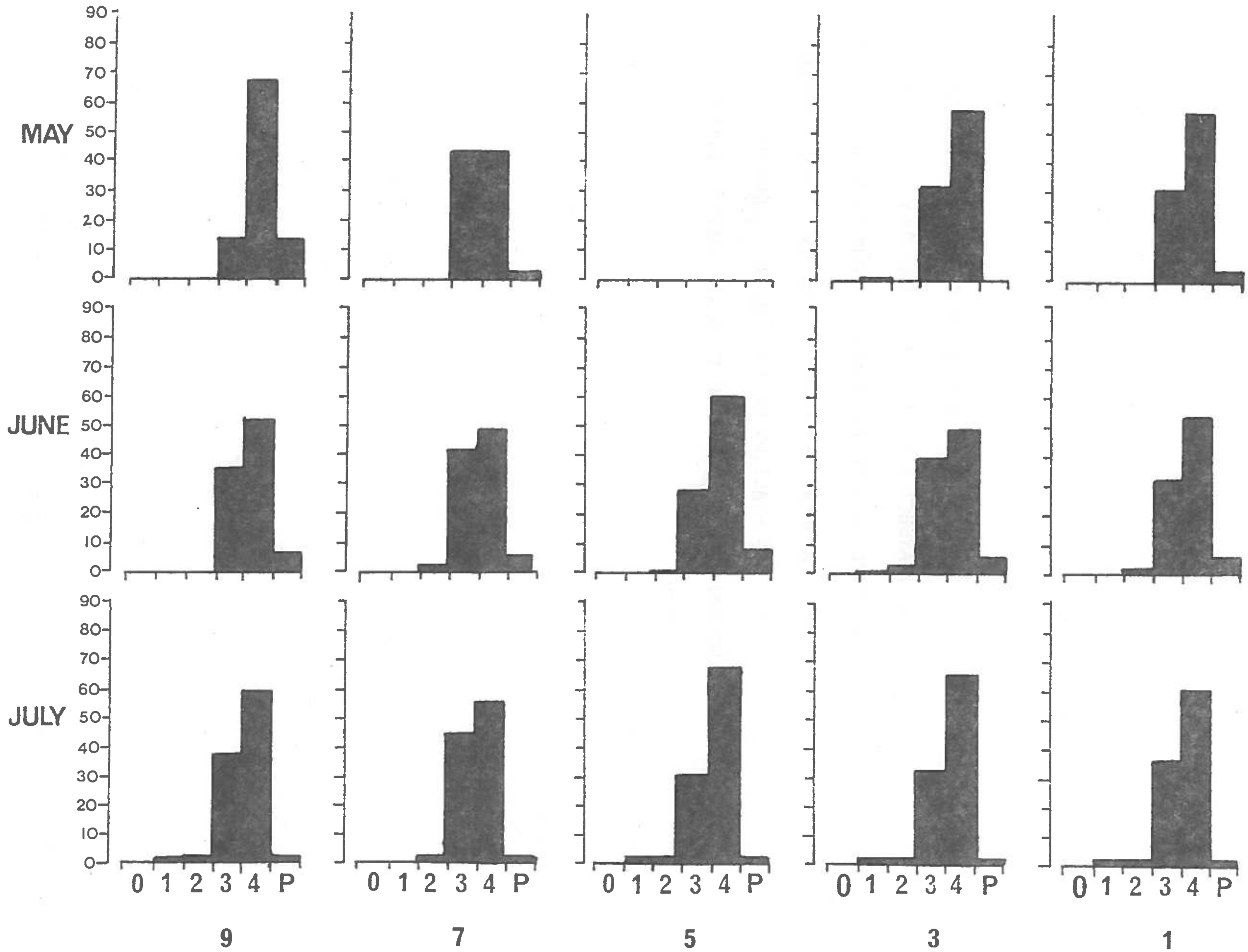
Transect A. Transect A was firm and relatively sandy. The largest mean 3 phi fraction and the smallest 4 phi fraction over the entire sampling periods were obtained there. Mean 3 phi fraction increased from 32% of sample weight in May to 45% in July. The 4 phi fraction mean exhibited an opposite trend decreasing from 59% in May to 52% in July. The mean pan fraction for A transect was generally small and dropped from just over 6% in May and June to 0.9% in July.

Transect B. This transect was characterized by fine soft sediment layers overtop of a firm, sandier base. The results show transect B to be intermediate between Transects A and C and the means shown for transect B for the 3 and 4 phi size classes fall between the values for these two transects. There is no apparent season trend in the particle size distribution of the transect, however in July an increase in the 3 phi fraction and a reciprocal drop in size class 4 phi occurred. The pan fraction decreased from 12.5% in May to 1.9% in July.

Transect C. The sediments along transect C were softer and stickier than either A or B and in fact the coarse fraction (3 phi) was less and the finer fraction (4 phi and pan) larger. The 4 phi fraction accounted for between 62 (May) and 73% (June) of the sample weight of the average stations. At transect C seasonal differences were most obvious between May and June when the mean size of the 3 phi and pan fraction decreased and the 4 phi fraction increased.

Transect D. D. transect had the softest and finest sediments of the 4 transects. This transect was only sampled in June and July. The largest 4 phi and the smallest 3 phi mean fractions were determined for this transect. As much as 89% of the sample (July) was composed of 4 phi sized particles.

FIGURE 15 : PARTICLE SIZE DISTRIBUTION OF SEDIMENTS COLLECTED ALONG TRANSECT A IN MAY, JUNE AND JULY. RESULTS ARE PRESENTED AS % OF THE SAMPLE WEIGHT IN EACH PHI SIZE CLASS. NUMBERS 0-4 REFER TO PHI UNITS AND P REFERS TO THE PAN FRACTION OF THE SAMPLE. NUMBERS AT THE BOTTOM EDGE OF THE PAGE INDICATE SAMPLE STATION NUMBERS.


MAY
JUNE
JULY
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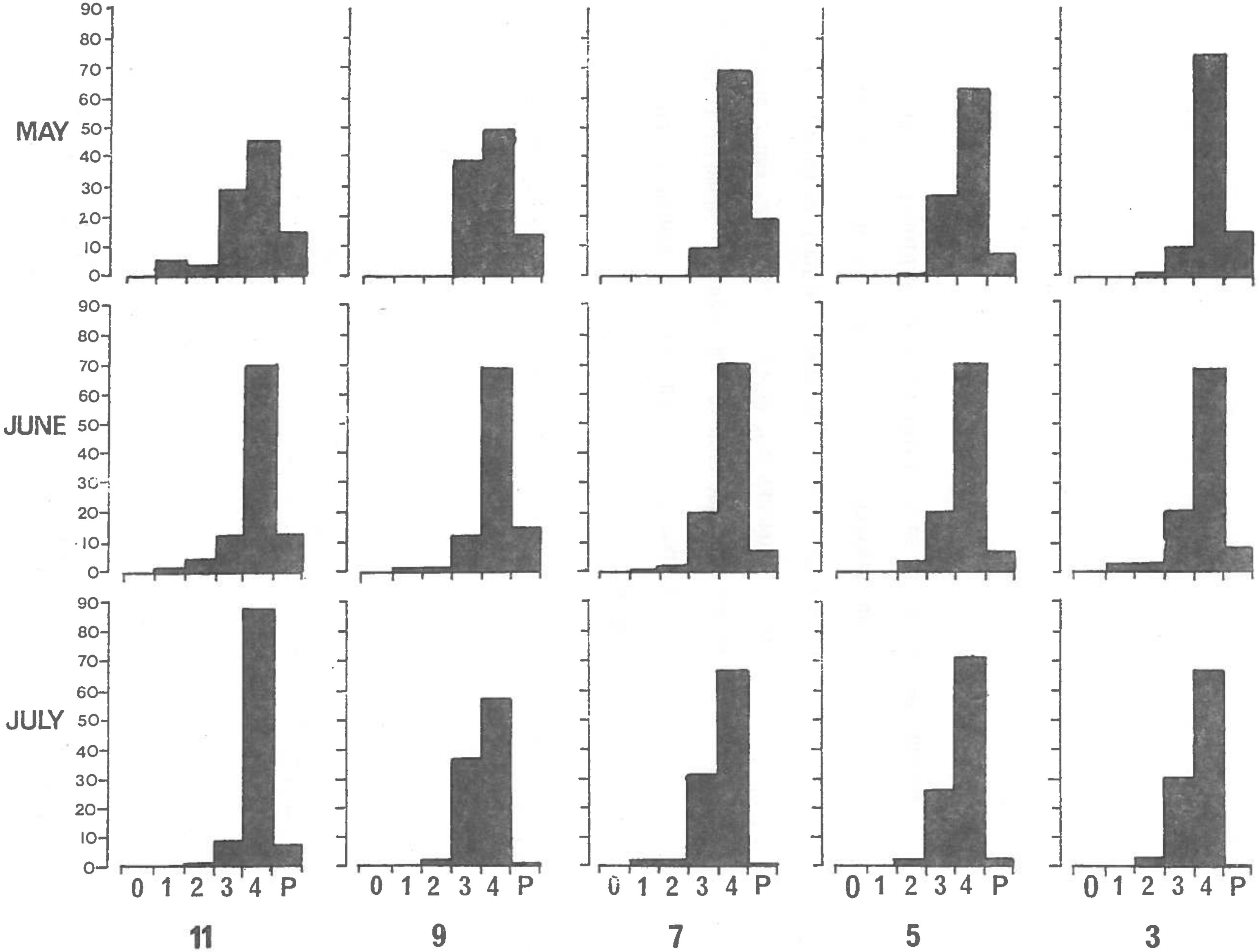
80
70
60
50
40
30
20
10
0
0 1 2 3 4 P
9
7
5
3
1

FIGURE 16 : PARTICLE SIZE DISTRIBUTION OF SEDIMENTS COLLECTED ALONG TRANSECT B IN MAY, JUNE AND JULY. RESULTS ARE PRESENTED AS % OF THE SAMPLE WEIGHT IN EACH PHI SIZE CLASS. NUMBERS 0-4 REFER TO PHI UNITS AND P REFERS TO THE PAN FRACTION OF THE SAMPLE. NUMBERS AT THE BOTTOM EDGE OF THE PAGE INDICATE SAMPLE STATION NUMBER.


MAY
JUNE
JULY
0
10
20
30
40
50
60
70
80
90
0 1 2 3 4 P
11
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7
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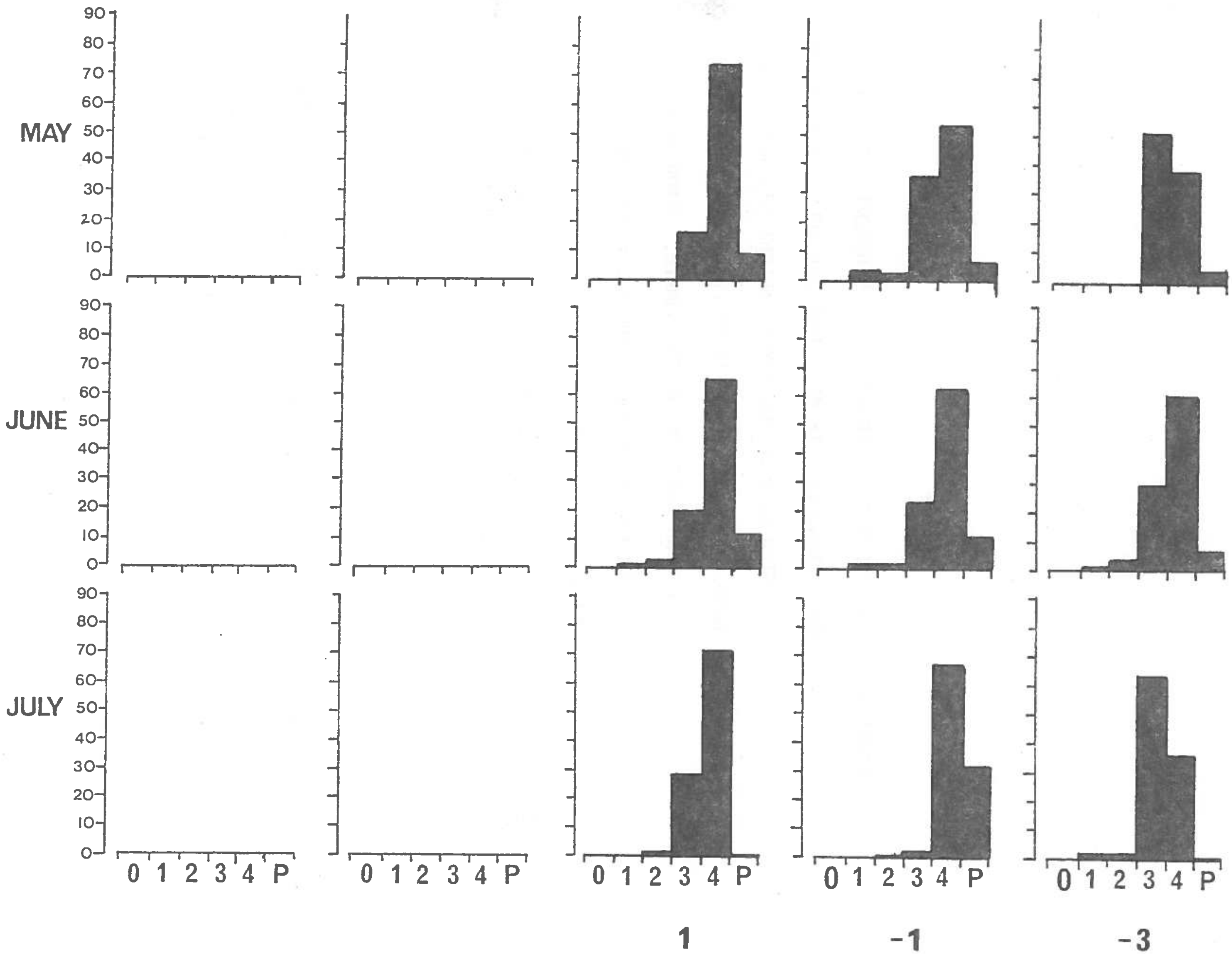
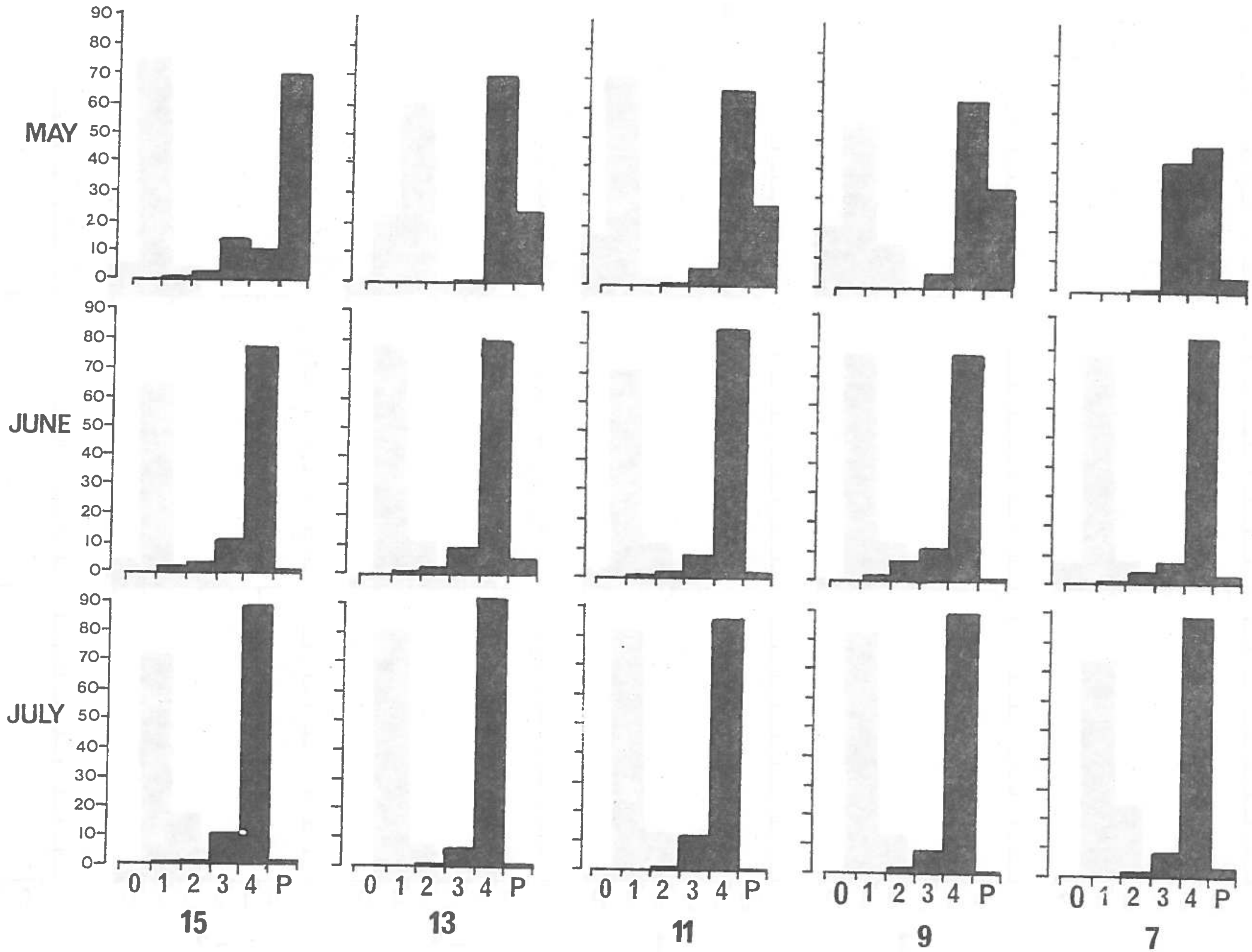
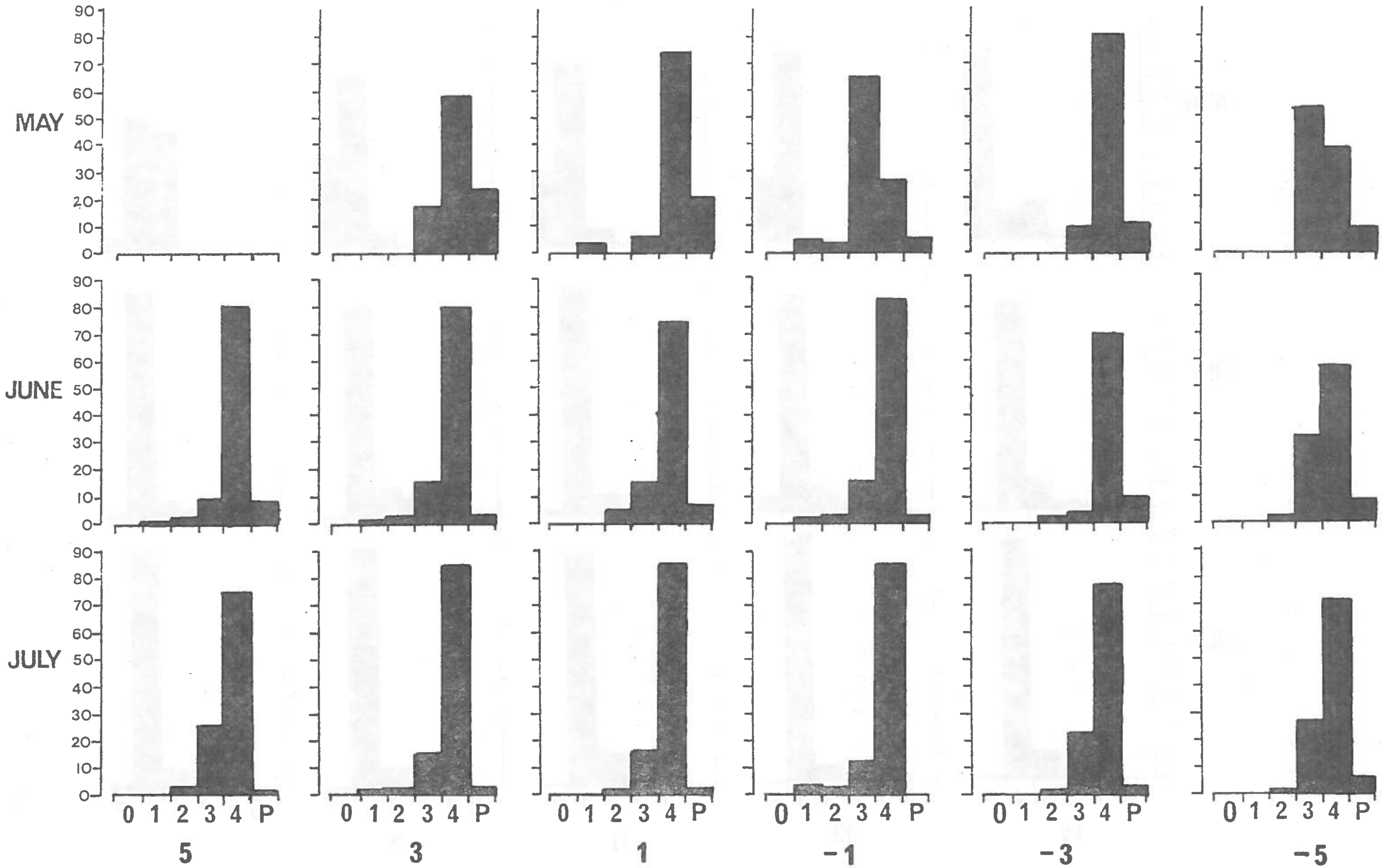
3



MAY
JUNE
JULY
90
80
70
60
50
40
30
20
10
0
0 1 2 3 4 P
1
-1
-3

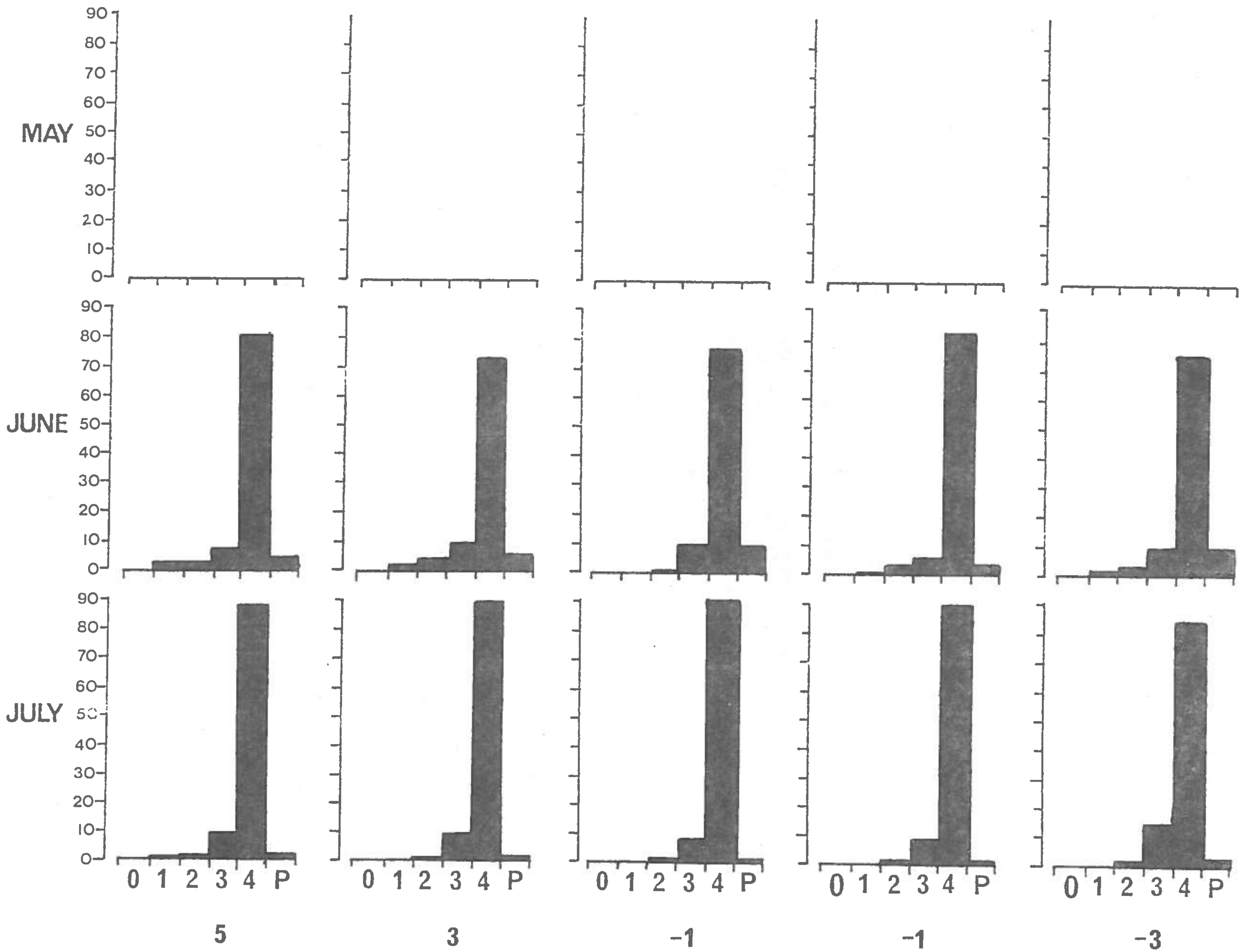
FIGURE 17 : PARTICLE SIZE DISTRIBUTION OF SEDIMENTS COLLECTED ALONG TRANSECT C IN MAY, JUNE AND JULY. RESULTS ARE PRESENTED AS % OF THE SAMPLE WEIGHT IN EACH PHI SIZE CLASS. NUMBERS 0-4 REFER TO PHI UNITS AND P REFERS TO THE PAN FRACTION OF THE SAMPLE. NUMBERS AT THE BOTTOM EDGE OF THE PAGE INDICATE SAMPLE STATION NUMBER.


MAY
JUNE
JULY
0 10 20 30 40 50 60 70 80 90
0 1 2 3 4 P
15
13
11
9
7



MAY
JUNE
JULY
0 10 20 30 40 50 60 70 80 90
0 1 2 3 4 P
5
3
1
−1
−3
−5

FIGURE 18 : PARTICLE SIZE DISTRIBUTION OF SEDIMENTS COLLECTED ALONG TRANSECT D IN MAY, JUNE AND JULY. RESULTS ARE PRESENTED AS % OF THE SAMPLE WEIGHT IN EACH PHI SIZE CLASS. NUMBERS 0-4 REFER TO PHI UNITS AND P REFERS TO THE PAN FRACTION OF THE SAMPLE. NUMBERS AT THE BOTTOM EDGE OF THE PAGE INDICATE SAMPLE STATION NUMBER.



MAY
JUNE
JULY
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10
20
30
40
50
60
70
80
90
0 1 2 3 4 P
5
3
−1
−1
−3

I. Water Content

(ii) Water and Organic content of sediments. Mean (May, June and July) water content of the sediments collected along transect A, B, C and D are shown in Figure 20. The general trend indicates a reduction in water content as one moves east along the transects. D Transect was characterized by the greatest variability in water content (23 to 37%) and Transect A exhibited the narrowest range of this condition (22 to 26%).

Trend analyses was performed by calculating the mean water content for samples collected at stations 9, 7, 5, 3 and 1 first by month (Table 25) and secondly by transect (Table 27). Table 26 indicates that there was no statistically significant difference between the mean values for the May, June and July values presented in Table 25. Differences are, however, apparent between the transects. Table 28 shows that transect A had a significantly lower water content than the other transects. The two farthest apart of the remaining transects (B and D) were also significantly different.

2. Organic content

The organic content values were low with mean values ranging from 0.92 to 2.8% of the sample weight. Profiles of the mean organic content along transects A, B, C and D are shown in figure 24. Similar to the results of the water content determinations the greatest variability in water content occurred at transect D and the narrowest range of this condition was observed at transect A. Trend analysis was also performed as for water content. Seasonally, the mean organic content value for

for May was significantly greater than those determined for June and July (Tables 29 and 30). June and July values were not different. Transect by transect analysis also indicates similarity with the water content results. Mean organic values for transect A are statistically smaller than values at B or C (table 31 and 32). No values are available for transect D.

TABLE 22 : MEAN % WEIGHT OF 3 PHI SEDIMENT FRACTIONS FOR TRANSECTS A, B, C AND D IN MAY, JUNE AND JULY.

		MAY	JUNE	JULY
3 ø	A	32.0	24.7	45.2
	B	25.2	25.7	38.0
	C	22.7	11.2	13.5
	D	-	10.8	7.9

TABLE 23 : MEAN % WEIGHT OF 4 PHI SEDIMENT FRACTIONS FOR TRANSECTS A, B, C AND D IN MAY, JUNE AND JULY.

		MAY	JUNE	JULY
4 ø	A	59.4	54.7	51.9
	B	66.8	67.9	59.1
	C	61.9	73.4	67.2
	D	-	74.7	89.1

TABLE 24 : MEAN % WEIGHT OF PAN SEDIMENT FRACTIONS FOR TRANSECTS A, B, C AND D IN MAY, JUNE AND JULY.

		MAY	JUNE	JULY
Pan	A	6.3	6.4	0.9
	B	12.5	8.9	1.1
	C	20.4	4.4	1.4
	D	-	7.6	1.6

FIGURE 23 : MEAN WATER CONTENT OF SEDIMENTS ALONG TRANSECTS A, B, C AND D. VALUES ARE PRESENTED AS % OF THE TOTAL SAMPLE WEIGHT.

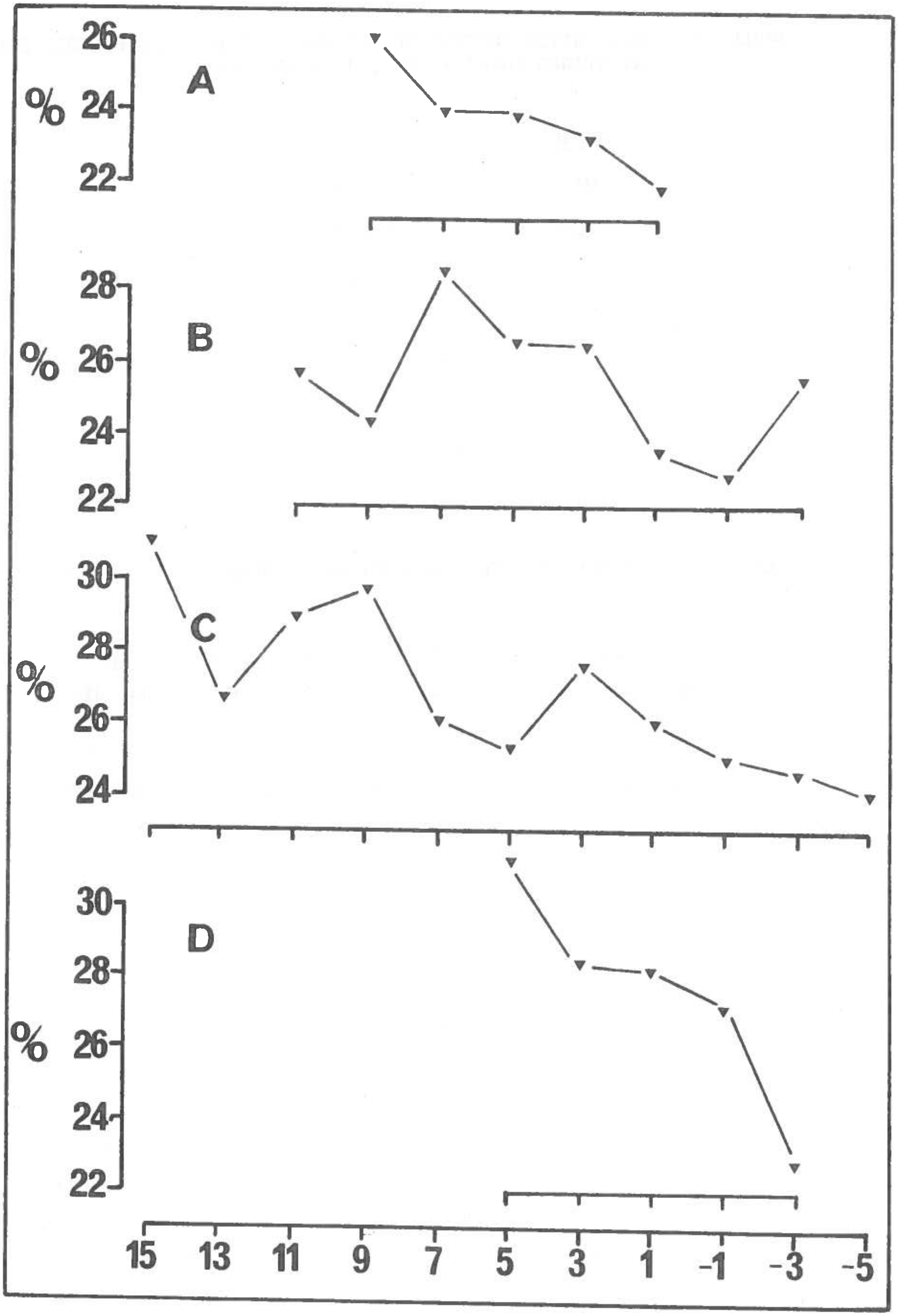
A
%
26
24
22
B
%
28
26
24
22
C
%
30
28
26
24
D
%
30
28
26
24
22
15
13
11
9
7
5
3
1
-1
-3
-5

TABLE 25 : MEAN WATER CONTENT OF SEDIMENTS (% by weight) COLLECTED AT STARRS POINT IN MAY, JUNE AND JULY.

MONTH	N	$\overline{X}$
MAY	15	25.348
JUNE	15	25.647
JULY	15	25.848

TABLE 26 : STUDENT'S T-TEST COMPARISON OF MEAN VALUES IN TABLE 25.

test	t	d.f.	prob.	sig.
MAY with JUNE	0.3161736	28	>0.5	not diff.
MAY with JULY	0.5602489	28	>0.5	not diff.
JUNE with JULY	0.2168814	28	>0.5	not diff.

TABLE 27 : MEAN WATER CONTENT OF SEDIMENTS (% by weight) FOR TRANSECTS A, B, C AND D.

TRANSECT	N	$\overline{X}$
A	15	23.90333
B	15	25.9632
C	15	27.024
D	6	29.26517

TABLE 28 : STUDENT'S T-TEST COMPARISON OF THE MEAN VALUES IN TABLE 27.

test	t	d.f.	prob.	sig.
A with B	2.620378	28	<0.02	diff.
A with C	4.039352	28	<0.001	diff.
A with D	3.931074	19	<0.001	diff.
B with C	1.335160	28	>0.1	not diff.
B with D	2.398796	19	<0.05	diff.
C with D	1.637289	19	>0.1	not diff.

FIGURE 24 : MEAN ORGANIC CONTENT OF SEDIMENTS ALONG TRANSECTS A, B, C AND D. VALUES ARE PRESENTED AS % OF THE TOTAL DRY WEIGHT OF THE SAMPLE.

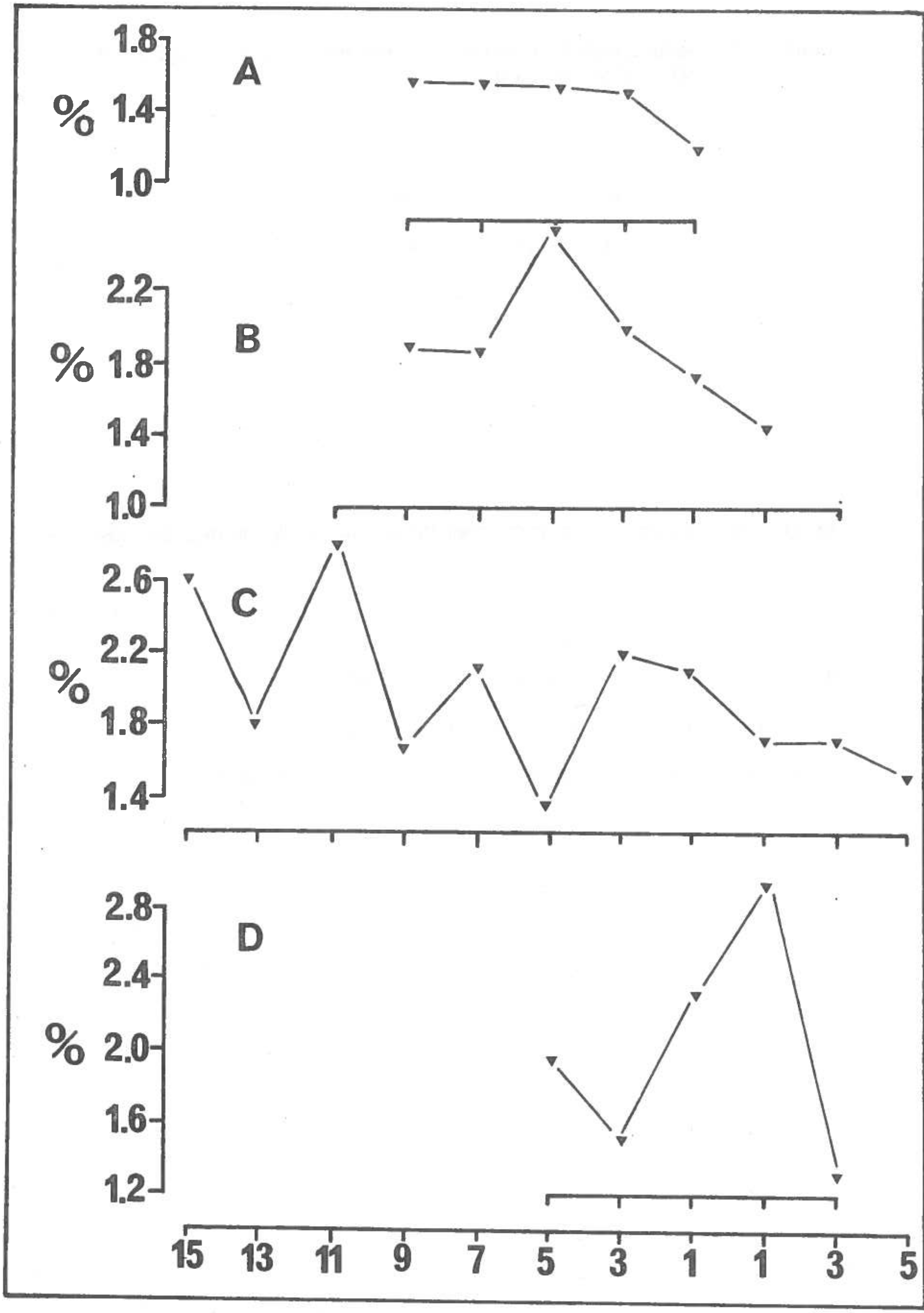
A
%
1.8
1.4
1.0
B
%
2.2
1.8
1.4
1.0
C
%
2.6
2.2
1.8
1.4
D
%
2.8
2.4
2.0
1.6
1.2
15 13 11 9 7 5 3 1 1 3 5

TABLE 29 : MEAN ORGANIC CONTENT OF SEDIMENTS (% by weight) IN MAY, JUNE AND JULY

	N	$\overline{X}$
MAY	13	2.247692
JUNE	15	1.634333
JULY	15	1.653867

TABLE 30 : STUDENT's T-TEST COMPARING THE MEAN VALUES IN TABLE 29.

test	t	d.f	prob.	sig.
MAY with JUNE	2.9781999	26	<0.01	diff.
MAY with JULY	2.95397818	26	<0.01	diff.
JUNE with JULY	0.12206200	28	>0.9	not diff.

TABLE 31 : MEAN ORGANIC CONTENT OF SEDIMENTS (% by weight) FOR TRANSECTS A, B, AND C.

TRANSECT	N	$\overline{X}$
A	15	1.4568
B	13	2.030846
C	15	1.827067

TABLE 32 : STUDENT's T-TEST COMPARING THE MEAN VALUES IN TABLE 31.

Test	t	d.f.		Sig.
A with B	3.666319	26	<0.01	diff.
A with C	1.850943	28	<0.1	diff.
B with C	0.9311135	26	>0.2	not diff.

DISCUSSION AND SUMMARY

The distribution and abundance has been described for the 27 species of invertebrates encountered in the lower intertidal region of the Starrs Point mudbar. This low density-high density situation was dominated by a relatively small number of species, most importantly *Heteromastus filiformis*, *Spiophanes bombyx*, *Eteone longa* and *Corophium volutator*.

Preliminary investigations considering the length-weight relationships of *Corophium volutator* have unearthed an interesting seasonal trend associated with the presence of eggs in females. Calorimetry has further shown that juvenile *C. volutator* (<4.5 mm) have an appreciably higher calorific value than adults (>4.5) present in the same sample.

The sediments of the Starrs Point mudbar are composed predominantly of fine sands and coarse silt. Although a seasonal trend was not apparent, differences in sediment particle size distribution between transects were illustrated. Generally, particle size increased from transect D through to transect A.

Differences also existed in terms of water and organic content of sediments. Transect A was most different having both a lower mean water and organic content. Organic content of the entire mudflat averaged higher in May than in June or July.

The differences in sediment conditions observed in this study are probably related to the distribution and abundance patterns determined for the various invertebrate species. Yeo (1977) established relationships between *Corophium volutator*, *Mya arenaria* and *Macoma balthica* and the sediment parameters he considered. Gratto

(1977, 1978) observed obvious distributional trends in several invertebrate species in the southwestern Minas Basin. He has related these trends to the consistency of the substrate and the depth of the hard clay-like layers.

In this study, I found Spiophanes bombyx and Clymenella torquata to be characteristic of Transect A which had the sandiest sediment and lowest water and organic content. Several abundant species, Heteromastus filiformes, Nephtys caeca, Glycera dibrancheata and Chaetozone setosa show trends of increasing abundance from transects A to D. This pattern parallels with the observed changes in particle size distribution which changed gradually from fine sand at transect A to that dominated by coarse silt at D. One species Streblospio benidicti showed a narrow range of distribution occurring in appreciable numbers at transects C and D only. This species may be limited to areas of relatively fine substrate.

Further analysis of data, presented in this report and from aspects of this study still in progress will help to better define the invertebrate-substrate relationships that we have observed. We hope that similar studies will be conducted during the summer of 1979.

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ASPECTS OF THE BIOLOGY OF GREAT BLUE HERONS (*ARDEA HERODIAS HERODIAS* L.) IN COLONIES ON BOOT AND BON PORTAGE ISLANDS, NOVA SCOTIA.

FORWARD

This study concerning the reproductive and foraging biology of colonial nesting Great Blue Herons was a two year endeavor initiated in 1977. This project has been funded over the two years by a variety of sources. In the summer, 1978, the Federal Summer Job Corp Project provided manpower for this project and as a result a section summarizing this study has been included in the report. The work represents the graduate research of Terry Quinney who was assisted in the 1978 field season by Brian Miller.

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INTRODUCTION

This study had three major objectives; firstly, we sought to determine the recruitment per pair of the populations on each island; secondly, we wished to record the rates of growth and development of the nestlings; thirdly, we were interested in comparing and constrasting the development of feeding behaviour of the newly fledged young with the foraging behaviour and efficiency of the adults.

The rationale for this study was based upon the great difference in immediate environment between the two island situations. Boot Island (45°N, 65°W) has supported a heron colony since the early 1960's. This island is located in the Minas Basin, King's County, Nova Scotia. Waters surrounding this island are extremely turbid due to the high sediment load and tidal action. This situation is in marked contrast to that of Bon Portage Island (43°N, 65.5°W), located some two miles off the coast of Shelburne County, Nova Scotia in the Atlantic where herons have nested at least since the early Fifties. The waters surrounding Bon Portage Island are relatively clear as there is little suspended sediment. An additional contrast between the two situations concerns the differences in tidal amplitude. Spring tides rise as much as 15. and 4.5 m above the low-water level in the Minas Basin and around Bon Portage Island, respectively. This is particularly significant in the Minas Basin where extensive mud-flats are exposed at low-water and are utilized by the herons as foraging areas.

MATERIALS AND METHODS

The first season of field work was conducted from April through August 1977. Our operations were centred on Boot Island where we alternated days of nest checks with observation periods in a number of ground blinds that had been erected earlier. Bon Portage Island was visited on four occasions during this first field season. In 1978, the first six weeks of the field season (April 1-May 14) were spent on Bon Portage Island after which we moved back to Boot Island, commuting daily to the colony on this island at a high tide period, and spending 1 1/2-2 hours collecting the information we desired. Bon Portage Island was visited a further four times until the end of July.

Nest trees were climbed or reached by ladder. Nest products were lowered to the ground where various measures such as weights, culmen, tarsus and wing lengths were taken. Pipe cleaners of various colors were used to individually mark chicks until they could be permanently banded.

Observations on feeding behavior were conducted at the mouth of the Gaspereau River in the Minas Basin during a low tide period using 20-60X Zoom telescopes.

BREEDING CYCLE CHRONOLOGY

The typical breeding cycle of the Great Blue Heron in Nova Scotia starts in April although the exact dates vary in different years. Both sexes arrive at the breeding grounds at about the same time and the occupation of the colony is gradual beginning with the birds roosting there. Unpaired males choose a site, perhaps containing an old nest and defend it against all conspecifics. These "solo" males display to the colony at large eventually attracting one or more "satellite" females to his vicinity. During this early period the bill and legs become reddish under hormonal control. When a satellite female gets close to the male he may perform agonistic displays and attack, driving her away repeatedly. Eventually, the courting male allows one female onto his nest site. The new alliance can be very tense and ritualized. "Bill Duelling" may erupt frequently. Nest building is a cooperative affair with the male usually collecting sticks and the female placing them. Copulations can occur any time after the female is accepted onto the nest and are repeated irregularly until the eggs are laid. Once the first egg is laid male-female displaying decreases sharply. Incubation commences after the first or second egg producing an asynchronous hatch, lasts 25-29 days and is shared by both sexes. The egg laying interval is about two days.

Apart from disturbance one or another parent constantly guards the nest until the chicks are four weeks old at which time both parents are usually absent from the nest foraging. Double broods were not recorded but replacement clutches can be common and in this study were caused by corvid predation of the first clutch.

The hatched eggshells are dropped over the side of the nest and there is a second peak of stick-bringing at hatching. The intervals from first to last hatching when all eggs hatched were 5-8 days. Both nocturnal and diurnal feeding of chicks occurs. Feeding is by both parents and the intervals between feeds become increasing longer as the young develop. Feeding is by regurgitation into the floor of the nest with the chicks soliciting by bill-grasping their parents. Fledging of the chicks is usually at about 7-8 weeks of age but they may still return to the nest for a further three weeks to be fed and/or roost. For further details on breeding cycle chromology, displays in particular, the reader is referred to the excellent work of Milstein et al (1970) and Mock (1976).

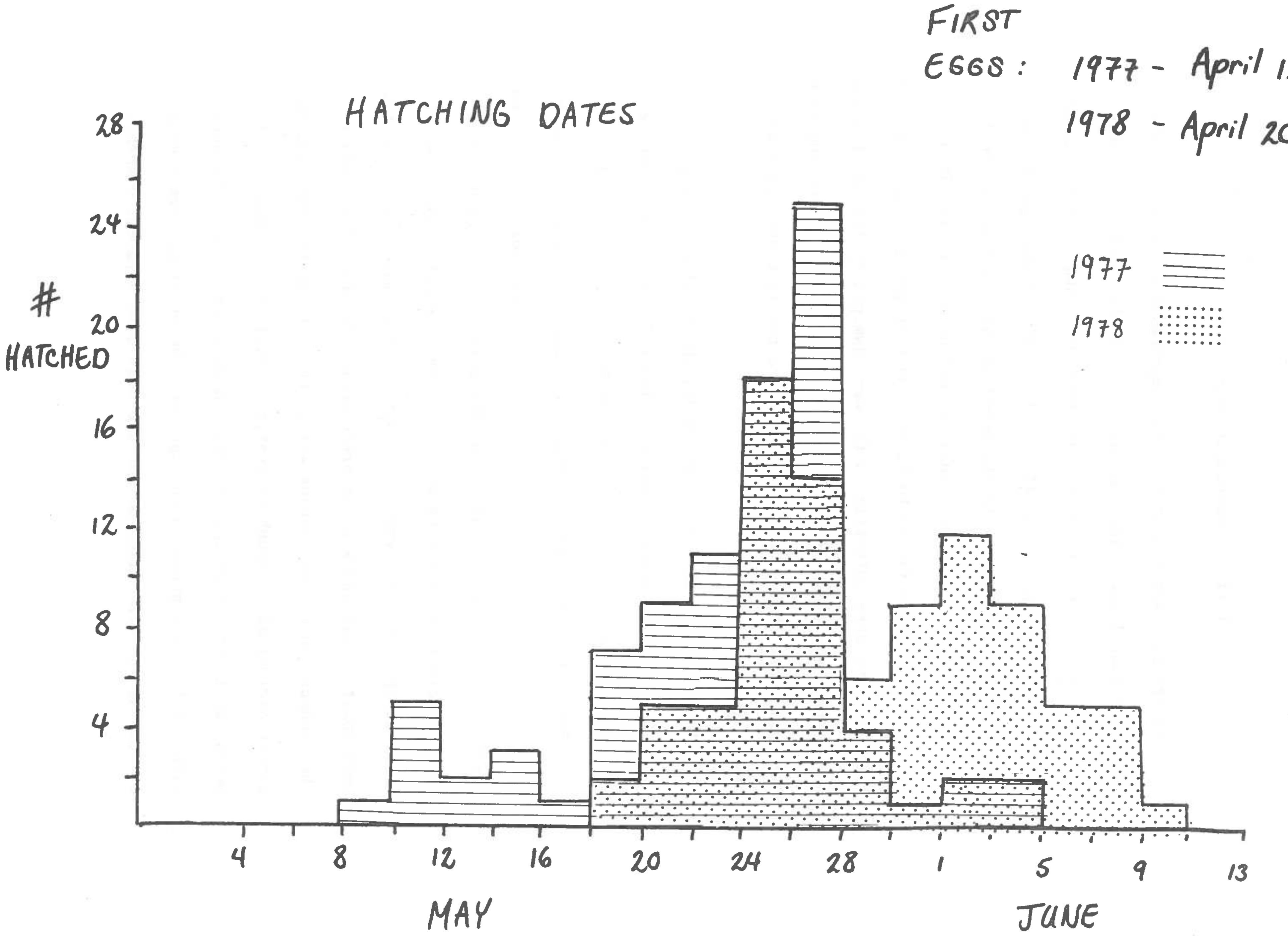
RESULTS

Part 1. Egg-Laying and Hatching Chronology

Figure 1 gives the dates of initial egg laying and subsequent hatching chronology over the two seasons of the study on Boot Island. The first egg was laid a full week later in 1978 than in 1977. The available data suggest a strong correlation between the onset of laying and air temperature.

While hatching started and ended later in 1978 the hatching period was actually four or five days shorter than in 1977, that is, more compressed. The dates May 25 through 28 in both years are particularly interesting. 47% of all the hatching in 1977 and 35% in 1978 occurred on these dates with 40% before these dates in 1977 and 50% after in 1978. So despite the initial hatch dates and regardless of the length of the hatch period there appears to be a great deal of synchrony among these birds within a given year and even across the years.

FIGURE 1 : Hatching Dates, 1977 and 1978.


FIRST EGGS: 1977 - April 12
1978 - April 20
HATCHING DATES
HATCHED
28
24
20
16
12
8
4
1977
1978
4
8
12
16
20
24
28
1
5
9
13
MAY
JUNE

Part 2. Reproductive Success

Tables 1, 2 and 3 summarize the reproductive success of the herons on Boot Island over the two years of the study. In Table 2, in those nests which hatched at least one young on Boot Island about 80% of the eggs laid hatched with 7-16% of the eggs being lost to predators mainly early in the breeding cycle before the full clutch was laid or serious incubation had begun. Up to 15% of the eggs in these nests failed to hatch. Most of the eggs which didn't hatch on Boot were unfertile, a few were damaged by the adult birds in the nest and a few of the chicks died before fully emerging from the egg. Most of the unfertile eggs were the last ones laid in their clutches.

Approximately 85-90% of the chicks which hatched fledged with only 10-15% dying before fledging. Almost 30 chicks died before fledging in the years 1977 and 1978 on Boot Island (Table 4).

For 23 of these young we know their order of hatch and their age at death. 70% of those dying before fledging were the last to hatch in their clutches and 74% of the chicks that died did so within their first ten days of life. These results show clearly the influence of the asynchronous hatch. Nest mates can be a full week apart in age and with no preferential feeding by the adults, the youngest chicks succumbing within their first ten days due so almost exclusively through starvation. Table 4 also shows that mortality is low after the initial ten days until the fifth week of life. This corresponds to the age when the nestlings begin wing exercising and travelling out of the nest onto adjacent branches

TABLE 1

SUMMARY OF NESTING SUCCESS

	BOOT 1977		BOOT 1978		BON PORTAGE 1977		BON PORTAGE 1978	
Nests with Eggs (one time or another)	56		26		50		11	
Nests which Hatched Young	36		25		48		6	
Total Eggs Laid	244		131		Min 195	Max	42	
Nests which Fledged Young	36		24		48		3	
Average Clutch Size (Nests which hatched young)	4.64		5.04		4.50		4.67	
Predated Eggs	Min 79	Max 84	Min 8	Max 11	Min 4	Max	Min 11	Max 18
Eggs Failing to Hatch	8	12	17	27	5		1	
Eggs Broken by Handlers	3		3		0		0	
Eggs Damaged in Nest but not Predated	2		1		0		1	
Young Hatched	126	143	89	94	162		18	24
Young Fledged	107		78		151		10	
Young Dying before Fledging	20	36	11	16	11		8	14

TABLE 2.

REPRODUCTIVE SUCCESS AT BOOT ISLAND IN 1977 and 1978

	BOOT 1977	BOOT 1978
% EGGS HATCHING	79	78
% FAILING TO HATCH	5	15
% PREDATED	16	7
% CHICKS FLEDGING	85	88
% CHICKS DYING	15	12

TABLE 3

REPRODUCTIVE SUCCESS (COASTAL COLONIES)

Location	Years	Nests Hatching Chicks	Nests Fledging Chicks	Clutch Size	Number Fledged/ Successful Nest	Source
Audobon Canyon California (38°N)	1970	48	38	3.6	1.9	Pratt (1974)
	1971	35	30	3.0	2.0	" "
	1972	39	36	3.3	2.2	" "
	1973	52	42	3.2	2.0	" "
Columbia R. Oregon (45°30')	1974	150	--	---	2.7	Werscaul et al (1977)
Wheeler Oregon (45°30')	1974	35	--	---	2.2	" " " "
Tobacco Is. N.S. (45°N)	1971	36	35	4.17	3.1	McAloney (1973)
Bon Portage N.S. (43°30')	1977	48	48	4.5	3.2	This Study
Bon Portage	1978	5	3	4.7	1.7	" "
Boot Island (45°N)	1977	36	36	4.6	3.0	" "
Boot Island	1978	25	24	5.0	3.3	" "

TABLE 4

CHICK MORTALITY 1977 and 1978

ORDER OF HATCH		NUMBER DYING
1st		1
2nd		3
3rd		3
4th & 5th	last	16
	Total	23

AGE AT DEATH (DAYS)		NUMBER DEAD
1-10		17
11-20		2
21-30		0
31-40		4
	Total	23

whereupon they may fall. This time period also corresponds to the point where we stopped handling the young.

With the exception of Bon Portage Island in 1978 Table 3 shows that Nova Scotian colonies have been fledging about 3 young per successful nest while colonies in California and Oregon have been fledging 2 and 2 1/2 young respectively. Given the age-specific mortality rates and assuming that these birds begin breeding as two-year olds Henny (1971) estimated that 1.9 young must be fledged per breeding pair in order to maintain a stable population. The Nova Scotia populations again with the exception of Bon Portage Island in 1978 have been fledging 2.5-3.0 young per breeding pair.

PART 3. GROWTH AND DEVELOPMENT OF NESTLINGS

Further analysis of growth data is required before a satisfactory results section can be completed. Figures 2-5 provide tentative results.

Adult measures were obtained from a number of sources and the following represent means from a minimum of 37 adults of both sexes and a maximum of 63. There is extensive overlap among the sexes in these measures.

Weight:	2230 grams
Culmen:	137 mm
Tarsus:	173 mm
Wing Chord:	463 mm.

Figure 2 shows the change over time of these measures among the nestlings.

Figure 3 shows a strong linear relationship between age and tarsal length at least through Day 30. The correlation coefficients and sample sizes for the two seasons on Boot are shown. A total of 250 tarsus measurements make up the points for 1978, 140 for 1977. With a relationship such as this anyone entering a heron colony should be able to give an approximate age to any "average" chick.

Figure 4 shows the change in weight with age of the 4 young that were present in Nest #32 this season. Five eggs were laid, four of these hatched, one was infertile. Seven days of age separate the eldest from the youngest in the clutch. Chicks 1 and 2 hatched on the same day with #3 following two days later than these. The slower growth rate here is characteristic of the last chick to hatch.

Yet even with a seven day disadvantage this chick did very well, all of these young fledged.

Figure 5 shows the growth of a different brood (Nest #24, 1977). Chicks 1, 2 and 3 hatched on the same day, #4 the last to hatch followed two days later. Again we see the initially slower rate of growth of the youngest. It is interesting to note here that Young #1 hatched from the heaviest egg in the clutch. There may be a relationship between the fresh weight of the egg and subsequent growth rate and fledging success. However, the first eggs laid are definitely not necessarily larger and heavier than the last egg hatched.

FIGURE 2 : Tarsus, Culmen, Weight and Wing Growth Curves.

Growth Curves

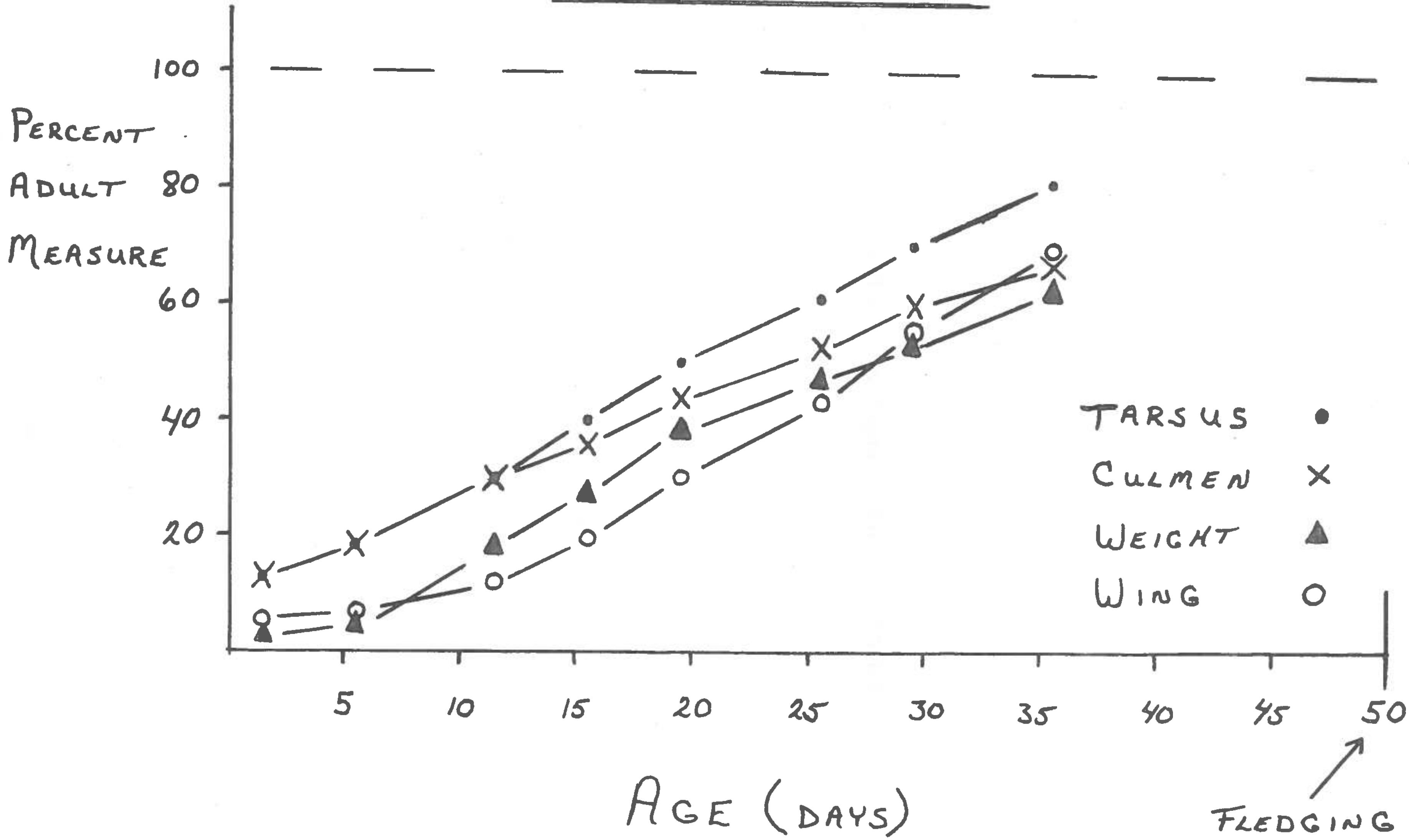


FIGURE 3 : Tarsus Length vs. Age Growth Curve.

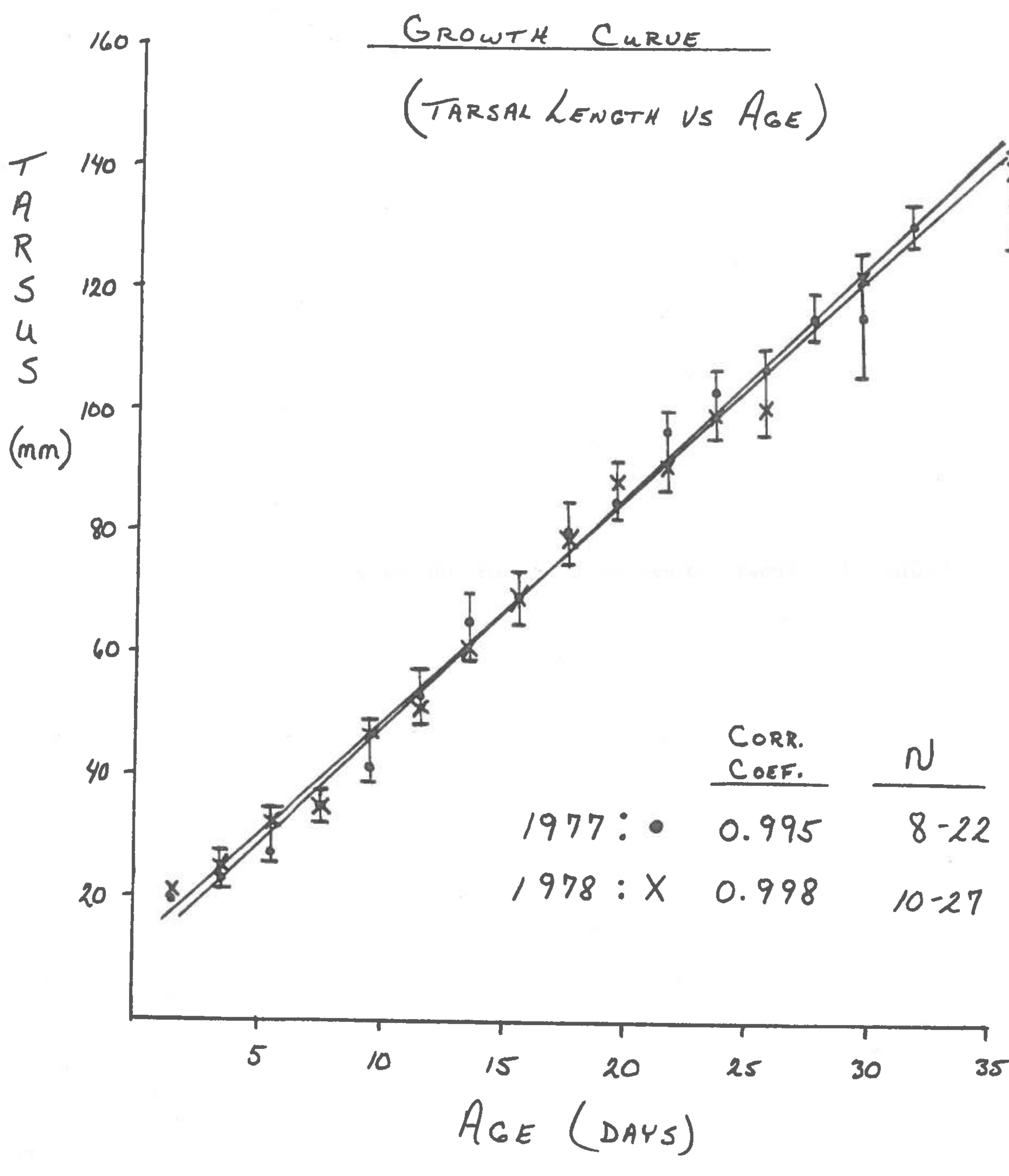

GROWTH CURVE
(TARSAL LENGTH VS AGE)
TARSUS (mm)
160
140
120
100
80
60
40
20
5
10
15
20
25
30
35
AGE (DAYS)
CORR. COEF.
N
1977 : • 0.995 8-22
1978 : X 0.998 10-27

FIGURE 4 : Growth Curve by Order of Hatching.

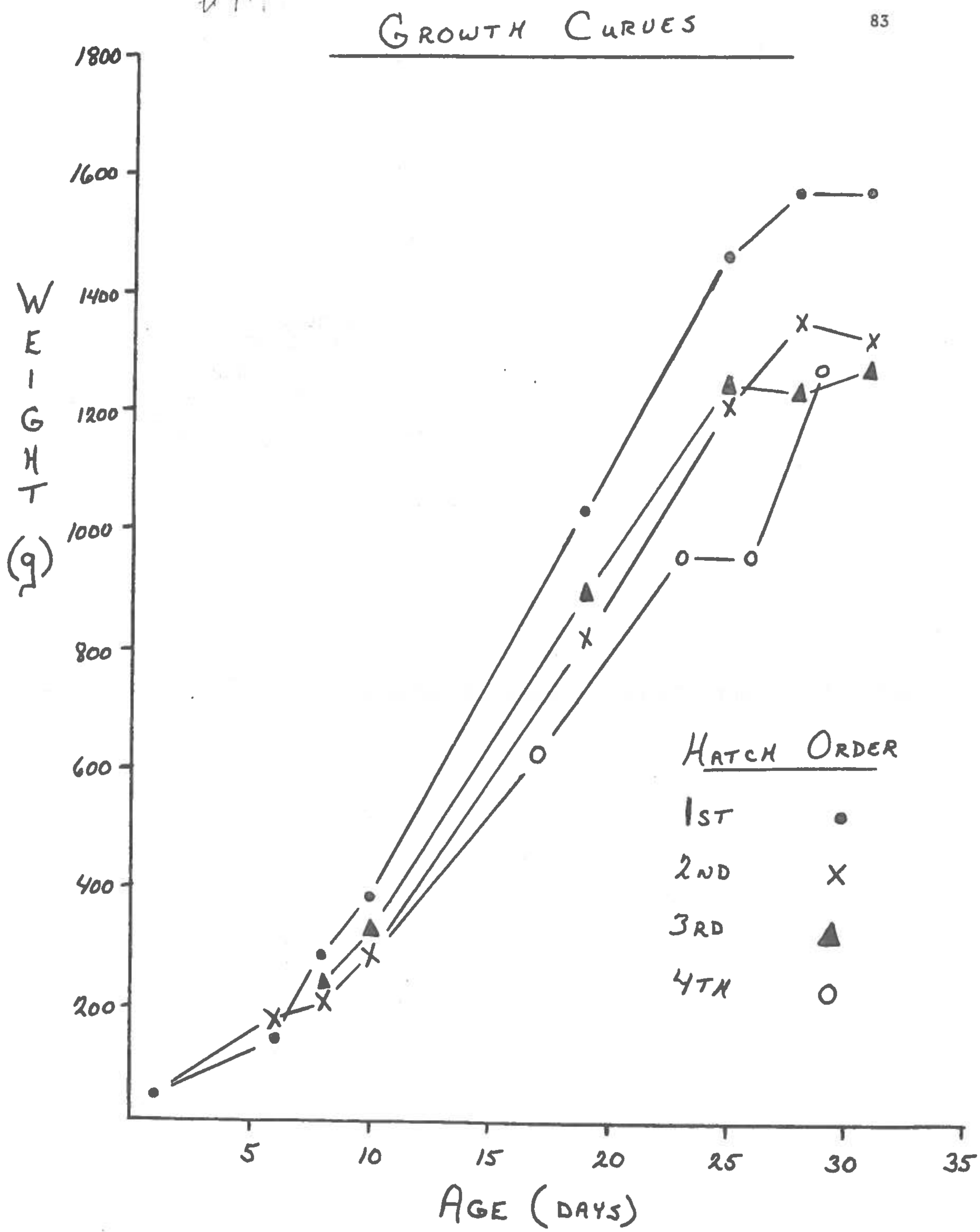
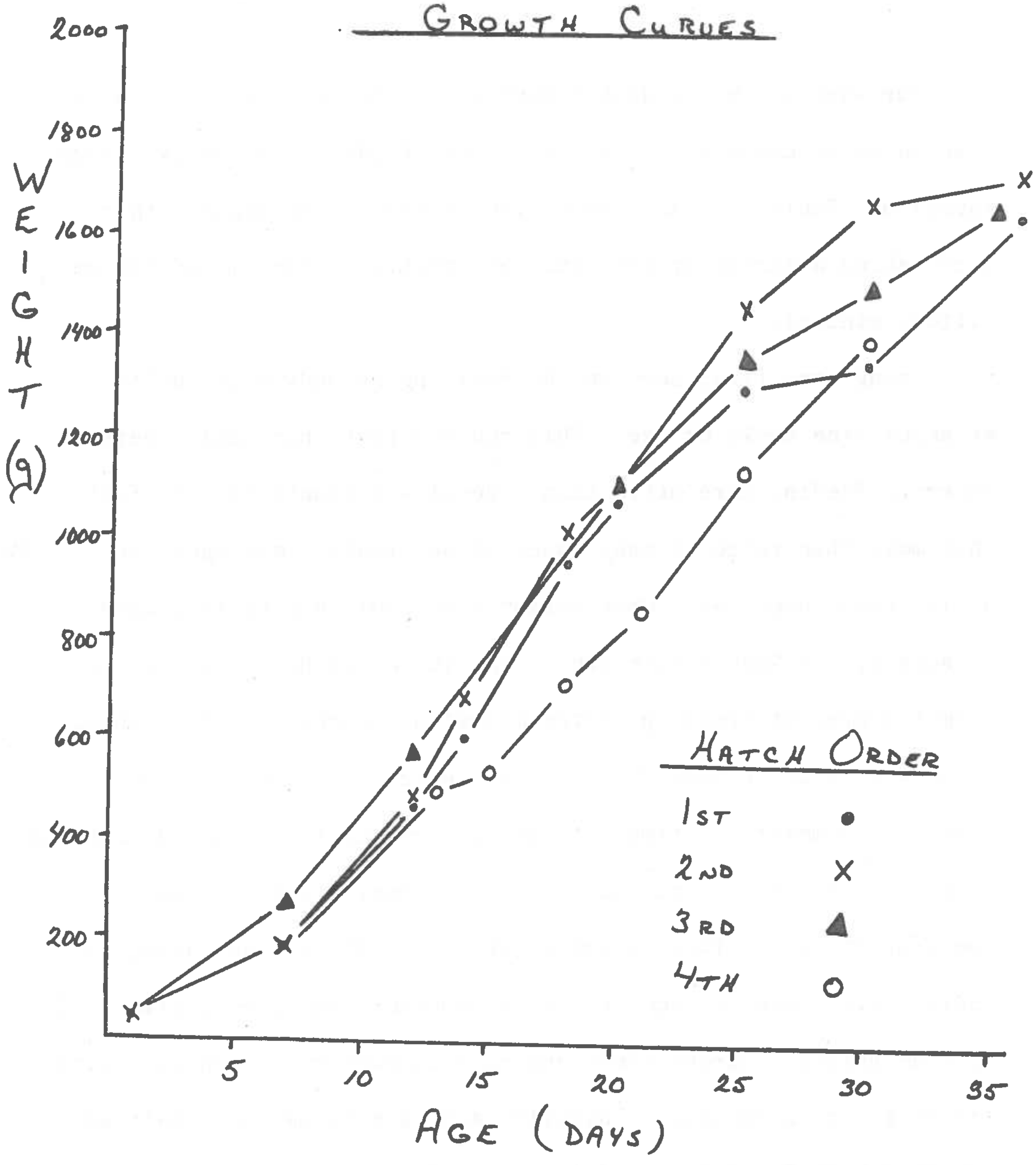

GROWTH CURVES
WEIGHT (g)
1800
1600
1400
1200
1000
800
600
400
200
AGE (DAYS)
5
10
15
20
25
30
35
HATCH ORDER
1ST
2ND
3RD
4TH

FIGURE 5 : Growth Curve by Order of Hatching


Growth Curves
Weight (g)
2000
1800
1600
1400
1200
1000
800
600
400
200
5
10
15
20
25
30
35
Age (days)
Hatch Order
1st
2nd
3rd
4th

PART 4. FORAGING

Our work on the feeding behaviour of the Great Blue Heron has enabled us to compare the success rates of adults and newly fledged juveniles (Table 5). An observation period always began with a bird making a strike at the water and continued for either ten or fifteen minutes.

Young were first seen on the foraging grounds with adults at about nine weeks of age. This and the fact that adults were observed feeding more often than juveniles accounts for the fact that more than twice as many observation minutes were spent on adults than juveniles. Observation time could not be increased because by mid-August both adults and juveniles begin dispersing from the area of breeding, later migrating southward. Even though more than twice as many observation minutes were spent on adults, juveniles committed 7 times as many errors (capturing and discarding inappropriate items) and made 5 times as many probes as adults)pecking at the surface of the water). The figures appearing in Table 5 are stated without regard to weather conditions, time of day, or tide height. Strong winds and rain in particular can dramatically affect foraging success. Juveniles are seen to be about half as successful at foraging as adults. Juveniles were seen to improve their foraging success over time. On July 31/78 6 different young were observed to make 61 strikes and 11 captures for an 18% success rate in 57 minutes of observation. These young were about 67-74 days old on this date. By August 8 the success rate had increased to 55% with 92 strikes and 51 captures by 7 different young in 86 minutes of observation. On this day the young present were 75-82 days old.

TABLE 5

FORAGING 1978

	Birds Observed	Observation Time (Minutes)	Paces	Strikes	Captures	Probes	Errors
ADULTS	46	605	6457	462	287	25	1
JUVENILES	26	264	3122	243	82	125	7

Percent Success (Captures/Strikes)

ADULTS	62%
JUVENILES	34%

DISCUSSION

The heron colony on Boot Island has had among the highest values for fledging success recorded in any study, both in 1977 and 1978. Only the colonies on Tobacco Island (McAloney 1973) and Bon Portage Island 1977 (this study) have comparable figures.

Both of the latter island colonies are located off the Atlantic coast of Nova Scotia, where the water is clear. Thus, because of the high turbidity of the waters that provide foraging areas for the herons in the Minas Basin, we had initially speculated that the herons on Boot Island might have a lower reproductive success than those on Bon Portage or Tobacco Island. However, the difficulty in feeding caused by the high turbidity of the water in the Minas Basin has been apparently countered by its extremely high productivity; the herons on Boot Island are able to fledge as many young as has ever been recorded for this species.

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McAloney, K. 1973. The breeding biology of the Great Blue Heron on Tobacco Island, Nova Scotia. Can. Field-Nat. 87: 137-140.

APPENDIX A : INVERTEBRATE IDENTIFICATION KEYS FOUND USEFUL IN THIS STUDY.

TABLE AI : INVERTEBRATE IDENTIFICATION KEYS USED IN THIS STUDY.

BRINKHURST, R.O., L.E. LINKLETTER, E.I. LLOYD, S.A. CONNORS and M.J. DADSWELL. 1976. A preliminary guide to the littoral and sublittoral marine invertebrates of Passamaquoddy Bay. Department of Environment. 166 pp.

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APPENDIX B : INVERTEBRATE DENSITIES AT TRANSECTS A, B, C AND D DURING MAY, JUNE AND JULY 1978.

TABLE B1 : INVERTEBRATE DENSITIES ($\#/m^2$) ALONG TRANSECT "A" DURING MAY 1978.

	10	9	8	7	6	5	4	3	2	1
N.a.	22	-	-	-	-	-	-	-	-	-
C.l.	67	89	-	22	22	-	22	-	-	-
T.e.	-	599	66	-	-	-	-	-	-	-
H.t.	-	-	-	-	22	22	-	-	-	-
L.h.	22	-	-	-	-	44	22	-		-
N.o.	22	-	-	-	-	-	-	-	-	-
B.u.	-	22	-	22	-	22	22	22	-	-
E.d.	-	-	-	-	-	-	-	-	-	-
G.g.	-	44	-	-	-	44	22	44	-	-
M.a.	22	-	22	22	67	44	-	-	-	67
M.b.	-	-	-	-	-	22	-	-	-	-
P.m.	-	-	-	-	22	178	-	44	-	-
E.h.	44	-	-	-	-	-	-	-	-	-
E.l.	44	22	-	-	-	-	-	-	-	-
G.d.	-	22	22	-	-	-	-	-	-	-
N.c.	44	67	133	67	155	67	89	178	22	-
N.v.	-	-	-	-	-	-	-	-	-	-
H.f.	511	1687	2553	1798	800	977	1487	2708	2131	22
C.t.	1621	1376	111	-	44	-	22	22	-	-
S.i.	-	-	-	-	-	-	-	-	-	-
P.e.	-	-	-	-	-	-	-	-	-	-
S.b.	18803	10745	6327	3152	2020	2020	2842	977	644	22
S.a.	88	-	-	-	-	-	-	-	-	-
C.s.	44	-	-	-	-	22	44	22	-	-
F.s.	-	-	-	-	-	-	-	-	-	-
O.s.	67	155	22	67	-	-	44	22	-	-
C.v.	22	-	-	89	266	22	-	-	2595	4018

TABLE B2 : INVERTEBRATE DENSITIES (#/m^2) ALONG TRANSECT "A" DURING JUNE 1978.

	10	9	8	7	6	5	4	3	2	1
N.a.	-	-	-	-	-	-	-	-	-	-
C.l.	-	-	-	-	-	44	244	44	44	-
T.e.	-	-	-	-	-	-	-	-	-	-
H.t.	-	-	-	-	-	-	-	-	-	-
L.h.	-	-	-	-	-	22	-	-	-	22
N.o.	-	-	-	-	-	-	22	-	-	-
B.u.	-	-	-	-	-	-	22	-	-	-
E.d.	-	-	-	-	-	-	22	-	-	-
G.g.	-	-	-	-	-	-	-	-	-	-
M.a.	-	-	-	-	22	-	22	-	44	-
M.b.	44	-	-	-	-	-	22	-	-	-
P.m.	22	22	-	67	-	-	89	-	-	-
E.h.	-	-	-	-	-	-	-	-	-	-
E.l.	178	1199	1243	844	955	1021	377	2819	577	-
G.d.	-	22	-	-	22	-	-	-	-	-
N.c.	-	67	22	44	89	44	-	133	-	22
N.v.	-	-	-	-	-	-	-	-	-	-
H.f.	710	755	3152	1332	910	466	977	2287	2153	22
C.t.	1066	355	22	44	89	22	89	44	-	-
S.i.	-	-	-	-	-	-	-	22	-	22
P.e.	*	*	*	*	*	*	*	*	*	-
S.b.	14252	9635	1732	1066	1909	3219	1354	932	400	355
S.a.	-	-	-	44	-	22	-	-	-	-
C.s.	-	22	-	-	-	-	44	333	-	-
F.s.	-	-	-	-	-	-	-	-	-	-
O.s.	22	133	-	-	-	67	67	22	44	-
C.v.	488	133	311	3596	910	533	89	444	14696	355

TABLE B3 : INVERTEBRATE DENSITIES (#/m^2) ALONG TRANSECT "A" DURING JULY 1978.

	10	9	8	7	6	5	4	3	2	1
N.a.	-	-	-	-	-	-	-	-	-	-
C.l.	-	-	-	-	-	44	44	-	-	-
T.e.	-	-	-	-	-	-	-	-	-	-
H.t.	-	-	-	-	-	-	-	-	-	-
L.h.	-	-	-	-	-	-	-	-	-	-
N.o.	-	-	44	-	-	-	-	-	-	-
B.u.	-	-	-	-	-	-	-	-	-	-
E.d.	-	-	-	-	-	-	-	-	-	-
G.g.	-	-	-	44	-	-	-	-	-	-
M.a.	-	-	-	-	44	-	22	-	-	-
M.b.	-	-	-	-	22	-	-	-	-	-
P.m.	-	-	-	-	-	89	-	-	-	-
E.h.	-	-	-	-	-	-	-	-	-	-
E.l.	44	311	488	977	311	494	444	2575	266	-
G.d.	-	44	-	-	-	-	44	44	-	-
N.c.	44	44	222	-	44	44	-	-	-	-
N.v.	-	-	-	-	-	-	-	-	-	-
H.f.	-	1421	844	1376	266	355	1598	2620	1293	133
C.t.	178	-	89	44	44	-	44	44	-	-
S.i.	-	-	-	-	-	-	-	-	-	-
P.e.	-	*	-	*	*	*	*	*	-	-
S.b.	10079	2531	1820	1332	977	577	932	44	-	-
S.a.	-	-	-	-	-	-	-	-	-	-
C.s.	-	-	-	44	-	44	44	311	-	-
F.s.	-	-	-	-	-	-	-	-	-	-
O.s.	-	-	-	-	-	-	-	-	44	-
C.v.	7237	2708	1687	7015	6171	2930	5905	6982	11189	4262

TABLE B4 : INVERTEBRATE DENSITIES (#/m^2) ALONG TRANSECT "B" DURING MAY 1978.

	11	10	9	8	7	6	5	4	3	2	1	0	-1	-2	-3
N.a.	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C.l.	44	-	-	22	44	22	-	22	22	22	-	22	22	-	44
T.e.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H.t.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L.h.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N.o.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B.u.	-	-	-	-	-	-	-	-	-	-	-	22	-	-	-
E.d.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G.g.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M.a.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M.b.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P.m.	-	-	-	-	-	-	-	-	-	-	-	22	-	-	44
E.h.	22	3286	-	-	-	-	-	-	-	-	-	-	-	-	-
E.l.	22	-	111	-	266	178	67	89	22	-	-	-	-	-	-
G.d.	89	-	44	44	-	-	67	-	67	44	22	-	22	-	22
N.c.	89	22	89	311	311	133	89	22	22	111	622	244	22	44	89
N.v.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H.f.	3885	3929	6127	4418	5173	2020	1893	1909	2220	2131	5554	3574	4307	377	111
C.t.	289	-	-	22	-	-	-	-	-	111	22	178	-	-	-
S.i.	-	-	-	-	22	-	-	-	-	-	-	-	-	-	-
P.e.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S.b.	2620	-	355	289	3818	6393	3951	3152	1887	133	67	666	-	-	5394
S.a.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C.s.	22	-	111	67	1154	-	22	533	-	-	178	-	-	-	-
F.s.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
O.s.	-	-	-	-	-	-	-	-	-	111	22	22	-	-	-
C.v.	89	-	2842	-	2975	-	-	3152	5461	155	-	67	22	-	44

TABLE B5 : INVERTEBRATE DENSITIES (#/m^2) ALONG TRANSECT "B" DURING JUNE 1978.

	11	10	9	8	7	6	5	4	3	2	1	0	-1	-2
N.a.	-	-	-	-	-	-	-	-		-	-	-	-	-
C.l.	-	-	-	-	-	-	44	44	-	44	-	-	-	-
T.e.	-	-	-	-	-	-	-	-	44	-	-	-	-	-
H.t.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L.h.	-	-	-	-	-	-	-	-	-	44	44	-	-	-
N.o.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B.u.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E.d.	-	-	-	-	-	-	-	-	-	-	44	-	-	-
G.g.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M.a.	-	-	-	-	-	-	-	-	-	-	-	44	-	-
M.b.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P.m.	-	-	-	-	-	-	44	-	-	-	-	-	-	-
E.h.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E.l.	-	44	-	222	266	44	222	-	222	-	178	89	67	-
G.d.	133	44	133	-	44	44	-	-	-	44	44	44	22	-
N.c.	89	-	44	-	89	89	44	133	-	-	44	-	22	133
N.v.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H.f.	3863	3730	4396	6882	6305	3374	1954	2531	4870	2930	2398	2309	3241	799
C.t.	799	-	89	-	-	-	44	-	-	-	44	178	44	-
S.i.	-	-	-	44	44	-	-	-	-	44	-	-	-	-
P.e.	*	*	*	*	*	-	-	*	*	*	-	-	-	-
S.b.	844	-	888	710	4396	4840	5195	266	1732	89	-	844	111	15140
S.a.	-	-	-	-	-	-	-	-	-	44	-	-	44	-
C.s.	-	-	89	133	178	-	44	1154	44	89	-	44	-	-
F.s.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
O.s.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C.v.	222	17627	2176	32323	18470	1199	20557	11011	23132	5150	6749	222	1487	577

TABLE B6 : INVERTEBRATE DENSITIES (#/m^2) ALONG TRANSECT "B" DURING JULY 1978.

	11	10	9	8	7	6	5	4	3	2	1	0	-1	-2	-3
N.a.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C.l.	-	44	44	44	-	44	-	44	-	-	44	44	-	-	-
T.e.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H.t.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L.h.	-	-	-	-	-	44	44	-	-	-	-	-	-	-	-
N.o.	-	-	-	-	-	-	44	-	-	-	-	-	-	-	-
B.u.	-	44	-	-	-	-	-	-	44	-	-	-	-	-	-
E.d.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G.g.	-	44	-	-	-	-	-	44	-	-	-	-	-	-	-
M.a.	-	-	-	-	-	-	44	-	-	-	-	-	-	-	-
M.b.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E.h.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E.l.	89	-	533	311	-	1288	89	577	355	400	400	666	666	1465	666
G.d.	89	-	44	-	44	-	-	-	-	44	44	-	-	-	44
N.c.	-	-	44	89	178	133	89	89	178	178	44	-	44	-	89
N.v.	-	44	-	-	-	-	-	-	-	-	-	-	-	-	-
H.f.	1998	1243	4618	3863	1954	3151	1154	1865	2975	2708	3818	3108	3508	755	400
C.t.	-	-	-	-	44	-	-	-	44	-	-	-	-	-	-
S.i.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P.e.	-	-	-	*	-	*	*	*	*	*	*	*	*	*	-
S.b.	222	-	1293	444	1243	1909	1776	1820	799	89	-	932	-	89	3374
S.a.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C.s.	-	-	-	-	-	44	178	89	488	533	-	-	-	-	44
F.s.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
O.s.	178	-	44	-	-	-	-	-	-	44	-	-	44	44	-
C.v.	-	12388	89	7504	178	-	355	-	710	178	8836	-	4218	1332	3463

TABLE B7 : INVERTEBRATE DENSITIES (#/m^2) ALONG TRANSECT "C" DURING MAY 1978.

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5	-6
N.a.	-	22	-	-	22	-	-	-	-	-	-	-	22	-	-	-	-	-	-	-	-	-
C.l.	44	-	133	89	22	22	-	244	-	22	-	88	-	-	44	22	89	-	22	22	-	-
T.e.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H.t.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L.h.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N.o.	-	-	-	-	-	-	-	-	-	-	-	-	-	22	22	-	-	-	-	-	-	-
B.u.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E.d.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G.g.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M.a.	-	-	-	-	-	-	-	-	-	-	-	-	-	22	-	-	-	-	-	-	-	-
M.b.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	466
E.h.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E.l.	22	200	111	178	266	44	178	44	244	155	111	200	444	200	89	133	44	-	-	22	-	22
G.d.	89	44	22	44	22	67	44	67	89	44	44	89	-	133	44	89	44	-	67	22	-	-
N.c.	22	289	266	155	111	133	67	178	111	688	448	444	111	44	133	22	89	-	67	155	-	155
N.v.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H.f.	1354	6438	7148	6904	4595	6260	5061	5861	5728	5950	5483	4973	5328	3685	4951	6638	5839	-	1443	622	3130	3397
C.t.	755	-	-	-	-	-	-	-	-	-	-	133	22	-	-	-	-	-	44	44	-	111
S.i.	67	400	111	89	89	67	22	-	22	-	22	67	-	-	-	44	-	-	-	-	-	-
P.e.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S.b.	3552	2842	5661	1066	777	1776	111	178	2198	8103	533	3508	555	89	67	22	67	-	67	22	-	4640
S.a.	-	22	-	-	-	67	22	22	-	44	-	44	-	22	44	-	22	-	-	-	-	-
C.s.	22	466	1043	799	533	2309	89	-	289	555	200	1909	311	289	799	22	22	-	-	-	-	-
F.s.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
O.s.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	-
C.v.	-	44	2464	844	311	178	67	-	-	22	-	22	89	1820	111	755	-	-	-	-	244	-

TABLE B8 : INVERTEBRATE DENSITIES (#/m^2) ALONG TRANSECT "C" DURING JUNE 1978.

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5	-6
N.a.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
C.l.	-	-	-	-	-	44	44	-	-	-	-	-	-	-	44	-	-	-	-		-	-
T.e.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
H.t.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
L.h.	-	-	133	-	44	-	-	44	-	-	-	-	-	-	-	-	-	-	-		-	-
N.o.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
B.u.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
E.d.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
G.g.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
M.a.	-	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
M.b.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
P.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
E.h.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
E.l.	355	222	755	488	133	533	222	533	89	266	355	178	444	409	533	488	222	266	89		89	222
G.d.	44	44	-	44	-	133	-	44	44	44	-	44	89	-	-	-	89	44	-		-	89
N.c.	133	44	89	89	44	44	89	-	533	44	-	222	-	89	-	133	222	400	266		-	44
N.v.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
H.f.	3019	7193	6438	5594	4396	7237	9013	4529	10212	4840	6438	3774	8436	6266	5772	6616	3108	4529	2087		3152	5816
C.t.	1598	44	44	-	44	-	-	-	-	-	-	133	-	-	-	-	-	-	-		-	89
S.i.	89	2176	311	266	266	133	222	311	178	178	400	488	311	133	400	1687	133	400	44		-	-
P.e.	-	-	*	*	-	*	*	-	-	*	*	*	*	*	*	*	*	-	*		-	-
S.b.	5328	2442	6616	12654	9590	3330	222	1021	3152	1288	2486	2131	1376	133	44	-	-	133	44		222	1643
S.a.	-	-	-	-	-	-	-	-	-	-	89	-	-	-	-	-	-	-	-		-	-
C.s.	89	622	577	799	666	1820	1332	133	1909	1332	266	2575	488	3253	1820	533	-	311	-		-	44
F.s.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
O.s.	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	44	-		755	-
C.v.	400	-	266	-	89	-	7370	-	533	133	266	-	23621	13938	20424	3818	9457	44	400		6305	1687

TABLE B9 : INVERTEBRATE DENSITIES (#/m^2) ALONG TRANSECT "C" DURING JULY 1978.

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5	-6
N.a.	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	-
C.l.	44	89	-	-	-	-		-	-	-	-	44	-		-	-	-	44	-	-	-	-
T.e.	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	-
H.t.	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	-
L.h.	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	-
N.o.	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	-
B.u.	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	44	-	-
E.d.	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	-
G.g.	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	-
M.a.	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	44
M.b.	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	-
P.m.	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	44	-	-
E.h.	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	-
E.l.	44	222	577	355	311	577		1110	311	1332	444	888	266		89	44	311	355	622	89	-	488
G.d.	44	133	44	44	44	-		44	44	268	-	-	44		-	44	44	-	44	-	44	89
N.c.	-	44	44	89	-	222		133	89	222	-	89	89		44	44	89	89	89	89	-	178
N.v.	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	-
H.f.	932	4840	8258	8525	4307	9990		9102	2220	5550	4529	2220	4085		4262	577	3241	1554	1865	1154	2176	5372
C.t.	2703	-	44	44	178	-		-	-	-	-	44	-		89	-	-	-	-	133	-	133
S.i.	-	44	355	311	89	311		178	-	311	377	356	178		-	-	-	-	-	-	-	-
P.e.	*	*	*	*	*	*		*	*	*	*	*	*		*	*	*	*	-	-	*	*
S.b.	4928	2131	2842	4706	6438	2131		1066	2575	1021	1243	977	266		44	-	-	89	178	89	44	977
S.a.	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	-
C.s.	44	89	400	2220	1288	1909		311	133	9368	488	2930	977		488	-	133	223	-	-	89	-
F.s.	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	222
O.s.	89	133	-	-	44	-		-	-	-	-	-	-		-	-	-	-	44	-	-	-
C.v.	133	-	44	89	44	44		222	133	44	-	44	-		89	-	1154	666	1909	3641	1993	89

TABLE B10 : INVERTEBRATE DENSITIES (#/m^2) ALONG TRANSECT "D" DURING JUNE 1978.

	5	4	3	2	1	0	-1	-2	-3
N.a.	-	-	-	-	-	-			
C.l.	-	-	-	44	-	-			
T.e.	-	-	-	-	-	-			
H.t.	-	-	-	-	-	-			
L.h.	-	-	-	-	-	-			
N.o.	-	-	-	-	-	-			
B.u.	-	-	-	-	-	-			
E.d.	-	-	-	-	-	-			
G.g.	-	-	-	-	-	-			
M.a.	-	-	-	-	-	-			
M.b.	-	-	-	-	-	-			
P.m.	-	-	-	-	-	-			
E.h.	-	-	-	-	-	-			
E.l.	133	266	178	44	266	89			
G.d.	-	44	-	89	44	67			
N.c.	-	-	-	-	-	-			
N.v.	-	-	-	-	-	-			
H.f.	6660	2886	5150	1554	10300	2131			
C.t.	89	-	44	-	-	-			
S.i.	-	-	89	-	44	-			
P.e.	*	*	*	*	*	*			
S.b.	-	400	89	-	-	-			
S.a.	-	-	-	-	-	-			
C.s.	-	44	222	-	-	-			
F.s.	-	-	-	-	-	-			
O.s.	-	-	-	-	-	-			
C.v.	10700	-	89	7637	6527	888			

TABLE B11 : INVERTEBRATE DENSITIES (#/m^2) ALONG TRANSECT "D" DURING JULY 1978.

	5	4	3	2	1	0	-1	-2	-3
N.a.	-	-	-	-	-	-	-	-	-
C.l.	-	-	-	-	-	-	-	-	-
T.e.	-	-	-	-	-	-	-	-	-
H.t.	-	-	-	-	-	-	-	-	-
L.h.	44	-	-	-	-	-	-	-	-
N.o.	-	-	-	-	-	-	-	-	-
B.u.	-	-	-	-	-	-	-	-	-
E.d.	-	-	-	-	-	-	-	-	-
G.g.	-	-	-	-	-	-	-	-	-
M.a.	22	-	-	-	-	-	-	-	-
M.b.	-	-	-	-	-	-	-	-	-
P.m.	-	-	-	-	-	-	-	-	-
E.h.	-	-	-	-	-	-	-	-	-
E.l.	355	577	932	266	89	222	89	488	1954
G.d.	44	-	-	-	-	-	44	-	44
N.c.	89	89	-		44	-	-	44	-
N.v.	-	-	44	-	-	-	-	-	-
H.f.	2309	8747	8125	3818	11500	2374	666	6438	5328
C.t.	-	-	-	-	-	-	-	-	-
S.i.	44	-	-	44	1909	133	-	533	-
P.e.	3286	1465	710	1376	1776	-	355	-	-
S.b.	-	44	89	44	-	44	-	44	44
S.a.	-	-	-	-	-	-	-	-	-
C.s.	710	89	44	1066	3019	577	133	2353	133
F.s.	-	-	-	-	-	-	-	-	-
O.s.	-	-	-	-	-	-	-	-	-
C.v.	-	44	-	44	799	1066	44	755	3436

APPENDIX C : LENGTH, DRY WEIGHT AND PRESENCE OF EGGS IN FEMALE AND MALE *COROPHIUM VOLUTATOR* (PALLAS) COLLECTED AT STARRS POINT IN MAY, JUNE AND JULY 1978.

TABLE C1 : LENGTH AND DRY WEIGHT MEASUREMENTS FOR FEMALE *COROPHIUM VOLUTATOR*.

#	MAY			JUNE			JULY		
	EGGS	L(mm)	Wt.(mg)	EGGS	L(mm)	Wt.(mg)	EGGS	L(mm)	Wt.(mg)
1	+	7.8	1.736	-	7.8	0.720	-	7.1	1.199
2	+	5.9	1.145	-	7.4	0.631	-	7.2	1.495
3	+	7.5	2.727	-	5.1	0.265	-	8.7	1.522
4	-	7.5	2.094	-	5.4	0.348	-	5.4	0.990
5	+	7.6	1.967	-	5.2	0.310	-	4.5	0.259
6	-	4.8	0.563	-	6.0	0.450	-	4.0	0.227
7	+	7.2	1.620	+	8.4	1.813	-	6.0	0.610
8	+	7.6	2.025	+	9.5	2.498	-	2.7	0.047
9	+	8.1	2.665	+	9.7	2.312	-	2.8	0.064
10	-	7.3	2.517	-	9.4	1.960	-	7.8	1.645
11	+	7.1	2.510	+	7.3	1.186	-	4.6	0.324
12	+	6.7	1.791	-	4.7	0.272	+	9.0	1.836
13	+	7.0	2.159	-	4.9	0.279	-	3.7	0.138
14	+	6.1	1.134	-	4.7	0.331	-	7.7	1.514
15	-	7.6	2.627	-	4.9	0.333	+	7.3	1.391
16	+	4.5	0.423	-	5.2	0.963	+	8.4	1.750
17	-	5.8	1.443	-	8.2	1.499	-	8.9	1.433
18	-	6.9	1.954	-	4.2	0.148	-	3.4	0.096
19	-	7.5	2.181	-	7.0	1.185	-	3.7	0.111
20	+	6.5	1.502	+	9.1	2.505	-	6.2	0.757
21	+	7.6	1.799	-	6.4	0.804	-	3.3	0.123
22	+	7.4	2.059	-	6.0	0.593	-	5.2	0.406
23	+	6.9	1.395	-	5.1	0.328	+	7.5	1.632
24	+	7.1	2.203	+	8.1	1.582	-	3.8	0.123
25	+	9.6	3.591	-	5.0	0.355	-	6.2	0.654
26	+	8.3	1.927	-	9.3	1.651	-	7.6	1.546
27	+	7.5	2.606	-	5.1	0.386	-	5.2	0.547
28	+	7.1	1.458	+	8.0	1.589	+	7.6	1.528
29	+	4.7	0.423	-	6.6	0,806	-	5.7	0.692
30	-	8.6	2.345	-	4.9	0.239	+	8.7	0.788
31	+	6.34	1.093	+	8.3	1.084	-	7.6	1.469
32	+	3.5	0.205	+	7.4	1.482	-	3.9	0.175
33	-	6.8	1.046	-	4.7	0.266	-	7.4	1.460
34	+	7.5	1.636	-	3.4	0.064	-	3.7	0.172
35	+	5.7	0.577	-	3.3	0.089	+	6.5	1.011
36	-	5.5	0.727	-	3.2	0.078	-	6.5	1.131
37	-	7.2	1.902	-	9.4	2.163	-	4.5	0.330
38	+	7.8	1.382	-	9.7	2.558	+	8.3	1.656
39	+	6.3	2.060	+	9.3	2.415	-	3.7	0.148
40	-	7.8	2.856	+	9.8	2.325	-	3.9	0.161
41	+	6.8	1.344	+	9.5	2.176	-	7.2	1.415
42	-	5.8	0.806	-	3.4	0.099	+	6.5	0.837
43	+	7.5	1.984	-	4.5	0.182	-	6.0	0.899
44	+	7.5	1.816	-	6.3	0.430	-	7.7	1.321
45				-	5.9	0.330	+	4.4	0.310
46				-	3.6	0.111	-	5.4	0.791

TABLE C1 : LENGTH AND DRY WEIGHT MEASUREMENTS FOR FEMALE *COROPHIUM VOLUTATOR*. (cont'd)

		MAY			JUNE			JULY	
#	EGGS	L(mm)	Wt(mg)	EGGS	L(mm)	Wt.(mg)	EGGS	L(mm)	Wt.(mg)
47				-	3.0	0.067	-	7.7	1.415
48				-	4.0	0.152	-	7.3	1.373
49				-	4.2	0.303	+	5.7	0.566
50				-	6.1	0.739	-	6.4	0.773
51							-	8.2	1.949
52							+	6.6	0.925
53							-	5.5	0.773
54							-	4.0	0.267
55							-	7.4	1.622
56							-	4.7	0.332
57							-	5.2	0.409
58							-	7.1	1.430
59							-	4.0	0.202
60							-	3.7	0.175
61							-	4.9	0.375
62							-	4.0	0.177
63							-	4.7	0.323
64							-	5.7	0.785
65							-	4.6	0.364
66							-	3.8	0.173
67							-	4.8	0.368
68							-	3.4	0.127
69							-	4.7	0.314
70							-	4.4	0.333
71							+	8.0	1.290
72							+	8.0	1.481
73							+	8.2	1.747
74							+	8.0	1.017
75							-	6.6	0.876
76							-	3.9	0.173
77							-	5.9	0.560
78							-	6.3	0.552
79							-	6.7	0.692
80							-	4.7	0.364
81							-	5.7	0.552
82							-	5.4	0.475
83							-	8.8	2.119
84							-	2.8	0.065
85							+	8.2	1.432
86							-	2.7	0.024
87							-	2.8	0.054
88							-	2.7	0.023
89							-	2.5	0.021
90							-	2.8	0.061

TABLE C1 : LENGTH AND DRY WEIGHT MEASUREMENTS FOR FEMALE *COROPHIUM VOLUTATOR*. (cont'd)

	MAY			JUNE			JULY		
#	EGGS	L(mm)	Wt.(mg)	EGGS	L(mm)	Wt.(mg)	EGGS	L(mm)	Wt.(mg)
91							-	2.7	0.035
92							-	2.5	0.038
93							-	2.7	0.067
94							-	2.9	0.056
95							-	2.4	0.029
96							-	2.7	0.053
97							-	2.6	0.050
98							-	2.6	0.050
99							-	9.4	7.734
100							-	8.0	1.115

APPENDIX D : PARTICLE SIZE DISTRIBUTION OF SEDIMENTS COLLECTED AT TRANSECTS A, B, C AND D IN MAY, JUNE AND JULY 1978.

TABLE C2 : LENGTH AND DRY WEIGHT MEASUREMENTS FOR MALE *COROPHIUM VOLUTATOR*.

	MAY		JUNE		JULY	
	L(mm)	Wt.(mg)	L(mm)	Wt.(mg)	L(mm)	Wt.(mg)
1	7.2	2.244	4.9	0.317	7.1	1.442
2	7.2	2.482	9.0	3.425	6.9	1.167
3	5.7	1.050	4.8	0.304	6.7	1.088
4	5.5	1.059	4.7	0.252	6.9	1.345
5	6.8	2.109	4.5	0.285	6.9	1.765
6			4.3	0.113	7.6	2.275
7			4.9	0.243	7.7	2.592
8			8.3	2.911		
9			8.8	3.423		
10			6.1	0.902		

APPENDIX D : PARTICLE SIZE DISTRIBUTION OF SEDIMENTS COLLECTED AT TRANSECTS A, B, C AND D IN MAY, JUNE AND JULY 1978.

TABLE D1 : PARTICLE SIZE DISTRIBUTION OF SEDIMENTS COLLECTED AT STARRS POINT DURING MAY 1978.

		PERCENT OF SAMPLE WEIGHT IN EACH PHI (Ø) SIZE CLASS						
STATION	SAMPLE WT(g)	-1	0	1	2	3	4	Pan
9A	185.0	0.02	0.16	0.34	1.00	14.82	69.15	14.51
7A	145.5	-	0.52	1.28	0.99	46.56	46.38	4.28
5A	-	-	-	-	-	-	-	-
3A	135.8	0.02	0.06	2.36	0.51	33.97	61.41	1.67
1A	158.9	0.02	0.13	0.86	1.36	32.48	60.55	4.60
11B	142.5	-	0.41	4.62	2.84	29.07	46.76	16.31
9B	115.1	0.03	0.04	0.05	0.14	38.26	49.13	12.35
7B	103.0	-	-	0.08	0.18	8.44	71.38	19.93
5B	136.1	-	0.07	0.56	1.18	26.72	63.8	7.67
3B	87.3	-	0.22	0.47	1.15	9.63	74.2	14.33
1B	124.0	0.11	0.09	0.15	0.44	15.57	75.46	8.10
-1B	162.9	0.03	0.14	2.32	1.32	35.83	54.01	6.36
-3B	126.7	-	0.02	0.07	0.17	53.29	41.70	4.75
15C	86.6	-	0.08	1.01	2.77	14.55	11.21	70.39
13C	100.5	-	0.03	0.15	0.23	1.54	71.53	26.52
11C	92.7	-	0.10	0.15	0.42	5.92	66.37	27.04
9C	51.1	-	0.10	0.10	0.35	3.75	63.14	32.56
7C	139.3	-	0.08	0.40	1.25	44.20	48.88	5.19
5C	-	-	-	-	-	-	-	-
3C	136.0	-	0.05	0.36	0.91	16.88	57.98	23.82
1C	122.6	-	0.08	2.43	0.27	4.16	73.10	19.96
-1C	166.1	-	0.23	3.09	1.87	64.53	26.91	3.37
-3C	118.7	-	0.03	0.10	0.16	8.81	80.70	10.19
-5C	120.0	-	0.21	0.05	0.18	52.04	38.42	9.11

TABLE D2 : PARTICLE SIZE DISTRIBUTION OF SEDIMENTS COLLECTED FROM STARRS POINT DURING JUNE 1978.

		PERCENT OF SAMPLE WEIGHT IN EACH PHI(Ø) SIZE CLASS						
STATION	SAMPLE WT(g)	-1	0	1	2	3	4	Pan
9A	110.2	0.05	0.03	1.98	2.47	36.09	52.64	6.74
7A	129.9	-	-	1.03	2.43	42.24	49.50	4.80
5A	125.3	0.06	-	1.23	1.84	27.52	61.81	7.54
3A	136.4	0.24	0.33	1.69	3.08	33.21	55.00	6.43
11B	120.9	-	0.16	1.56	3.42	12.10	70.16	12.6
9B	132.2	-	0.06	1.50	1.46	12.84	64.47	14.68
7B	108.5	-	2.82	0.8	2.77	20.22	69.94	6.21
5B	124.7	-	0.11	1.52	3.01	19.39	70.26	5.69
3B	123.9	-	0.17	2.33	2.12	20.42	68.05	6.90
1B	140.3	-	0.03	0.83	1.83	19.76	66.52	11.03
-1B	131.0	-	0.07	1.73	1.74	22.74	62.49	11.23
-3B	124.8	-	0.04	0.69	2.79	29.15	62.55	4.79
15C	93.4	-	-	3.02	3.63	11.14	78.99	3.22
13C	122.0	-	0.01	1.43	2.87	9.37	82.22	4.26
11C	115.5	-	-	1.97	2.55	7.55	84.80	3.13
9C	105.0	-	-	2.49	7.14	11.71	77.34	1.33
7C	131.0	-	-	0.68	3.65	7.81	85.57	2.30
5C	115.2	-	-	0.88	2.23	8.77	79.86	8.24
3C	127.2	0.01	-	1.03	1.83	13.65	80.27	3.21
1C	111.3	-	0.12	0.01	4.54	14.21	74.37	6.75
-1C	131.1	-	0.01	1.07	1.65	15.09	81.35	0.80
-3C	124.9	-	-	0.61	2.35	18.67	69.64	8.74
-5C	133.9	-	0.05	0.35	1.76	32.30	58.23	7.30
5D	114.59	-	-	2.7	2.92	6.82	81.75	5.81
3D	131.0	0.30	0.34	3.30	4.74	9.59	74.36	7.37
1D	103.81	-	0.04	0.51	1.34	10.80	77.83	9.49
-1D	102.6	-	0.02	2.17	3.99	6.86	83.18	3.78
-3D	127.5	-	0.10	1.81	2.41	9.10	75.86	10.73

TABLE D3 : PARTICLE SIZE DISTRIBUTION OF SEDIMENTS COLLECTED AT STARRS POINT DURING JULY 1978.

		PERCENT OF SAMPLE WEIGHT IN EACH PHI (Ø) SIZE CLASS						
STATION	SAMPLE WT(g)	-1	0	1	2	3	4	Pan
9A	212.9	-	0.01	0.70	1.40	36.85	59.24	1.70
7A	219.6	-	-	0.25	0.88	54.52	43.33	1.02
5A	219.5	-	-	0.92	1.52	67.17	29.88	0.50
3A	226.1	-	-	0.64	0.73	32.37	65.36	0.89
1A	216.5	-	0.06	1.05	1.42	35.24	61.73	0.46
11B	216.3	-	0.01	0.23	1.07	10.20	87.11	1.38
9B	225.1	-	0.02	0.73	1.65	37.45	59.22	0.92
7B	224.0	-	0.08	1.09	1.44	32.14	64.54	0.72
5B	229.3	-	0.11	0.64	1.36	25.41	70.93	1.55
3B	216.1	-	0.03	0.27	1.18	30.81	66.82	0.88
1B	215.0	-	-	0.03	0.48	27.92	70.27	1.31
-1B	234.3	-	0.02	0.68	1.87	65.42	31.67	0.31
-3B	190.1	-	-	1.06	1.45	62.53	34.58	0.38
15C	174.2	-	0.01	0.94	1.59	9.19	87.08	1.17
13C	193.6	-	-	0.16	0.56	5.86	92.07	1.35
11C	177.9	-	-	0.34	1.64	10.36	86.85	0.79
9C	180.60	-	-	0.94	2.25	7.63	88.09	1.08
7C	212.7	-	-	0.66	1.56	7.31	87.60	2.87
5C	234.8	-	-	0.17	1.32	24.80	73.15	0.57
3C	226.9	-	-	0.50	0.70	13.40	83.88	1.50
1C	201.5	-	.04	.14	.70	14.49	83.28	0.85
-1C	211.2	-	-	2.00	1.07	12.15	84.23	0.44
-3C	224.3	-	0.01	0.20	0.49	21.32	76.48	1.19
-5C	199.8	-	0.02	0.42	1.07	24.89	69.86	3.48
5D	235.3	-	0.03	0.45	1.58	9.31	87.17	1.46
3D	230.8	0.02	0.03	0.37	0.60	7.70	89.16	2.13
1D	247.8	-	-	0.17	0.73	6.78	91.04	1.25
-1D	253.5	-	-	0.37	0.75	7.44	90.3	1.12
-3D	225.8	-	0.06	0.10	1.02	13.11	84.49	1.22

APPENDIX E : WATER AND ORGANIC CONTENT OF SEDIMENTS COLLECTED AT STARRS POINT DURING MAY, JUNE AND JULY 1978.

TABLE E1 : WATER CONTENT OF SEDIMENTS (%H_2O by weight) COLLECTED AT STARRS POINT DURING MAY, JUNE AND JULY 1978.

STATION	MAY	JUNE	JULY	MEAN	S.D.
1A	22.00	20.91	22.68	21.86	0.8940
3A	22.55	24.32	22.72	23.20	0.9737
5A	22.48	24.66	24.58	23.91	1.2374
7A	22.74	24.87	24.36	23.99	1.2342
9A	22.87	29.93	24.89	25.90	3.6360
-3B	23.91	26.20	26.65	25.59	1.4676
-1B	23.40	21.82	23.32	22.85	0.8889
1B	24.07	22.67	23.90	23.55	0.7641
3B	26.23	27.29	26.05	26.53	0.6723
5B	28.99	25.79	25.06	26.61	2.0930
7B	28.07	30.60	27.03	28.57	1.8373
9B	25.88	23.11	24.31	24.44	1.3889
11B	---	26.64	24.69	25.67	1.3739
-5C	23.35	24.90	24.19	24.14	0.7738
-3C	24.57	22.99	26.42	24.66	1.7192
-1C	25.72	24.91	24.41	25.01	0.6602
1C	24.30	25.99	27.77	26.02	1.7362
3C	26.37	26.02	30.57	27.67	2.5105
5C	25.60	23.86	26.72	25.39	1.4416
7C	25.41	25.96	27.05	26.14	0.8327
9C	30.66	28.74	30.03	29.81	0.9806
11C	27.83	27.78	31.19	28.93	1.9545
13C	28.16	26.10	26.06	26.77	1.2008
15C	38.00	31.96	23.29	31.08	7.3943
-3D	---	21.93	23.60	22.77	1.1872
-1D	---	28.02	26.46	27.24	1.1045
1D	---	29.03	27.31	28.17	1.2169
3D	---	24.82	32.00	28.41	5.0784
5D	---	29.19	33.25	31.22	2.8765

TABLE E2 : PERCENT ORGANIC MATTER (by weight) OF SEDIMENTS COLLECTED AT STARRS POINT DURING MAY, JUNE AND JULY 1978.

STATION	MAY	JUNE	JULY	MEAN	S.D.
1A	1.22	0.84	1.43	1.16	0.3021
3A	1.82	1.25	1.35	1.47	0.3050
5A	1.42	1.42	1.72	1.52	0.1752
7A	1.99	1.77	0.93	1.56	0.5568
9A	2.01	1.38	1.31	1.57	0.3862
-3B	0.67	1.30	0.77	0.92	0.3397
-1B	1.84	1.62	0.91	1.46	0.4887
1B	2.53	1.33	1.34	1.73	0.6899
3B	3.00	1.55	1.66	2.07	0.8081
5B	3.44	2.30	1.85	2.53	0.8214
7B	2.24	1.79	1.58	1.87	0.3383
9B	2.62	1.54	1.61	1.92	0.6052
11B	---	2.24	---		
-5C	---	1.38	1.62	1.50	0.1676
-3C	2.17	---	1.22	1.69	0.6725
-1C	1.98	1.74	1.27	1.67	0.3609
1C	2.40	1.87	2.18	2.15	0.2656
3C	---	1.67	2.72	2.20	0.7424
5C	---	1.14	1.483	1.31	0.2425
7C	2.57	2.12	1.76	2.15	0.4058
9C	1.96	2.57	1.97	1.66	1.0645
11C	3.59	2.02	2.79	2.80	0.7850
13C	2.11	1.89	1.42	1.81	0.3548
15C	3.66	2.81	1.41	2.62	1.1387
-3D	---	1.33	---	---	---
-1D	---	2.95	---	---	---
1D	---	2.31	---	---	---
3D	---	1.54	---	---	---
5D	---	1.95	---	---	---