Pecks Cove Mudflat Ecosystem Study: Observations in 1978

Donald C. Gordon, Jr, Paul D. Keizer,
Jacqueline Dale and Peter J. Cranford

Marine Ecology Laboratory
Bedford Institute of Oceanography
Ocean and Aquatic Sciences - Atlantic
Department of Fisheries and Oceans
Dartmouth, Nova Scotia
B2Y 4A2

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Marine Ecology Laboratory
Bedford Institute of Oceanography
Dartmouth, N.S. B2Y 4A2

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ABSTRACT

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In 1978 the Marine Ecology Laboratory initiated an ecological study of the Pecks Cove mudflat located in Cumberland Basin at the head of the Bay of Fundy. This report summarizes the field measurements made the first year in the upper part of the intertidal zone. Preliminary analysis of the data illustrates the pronounced seasonal variability of critical environmental components and processes and the importance of making frequent observations all months of the year. One important energy flow pathway in the mudflat ecosystem is the food chain comprising the sediment microflora, the selective deposit-feeding amphipod Corophium volutator, and migratory shorebirds. This study will be expanded in 1979 and will include observations in the lower intertidal zone and experiments on the flooded mudflat and in the water column under high tide conditions.

Keywords: Bay of Fundy, Cumberland Basin, Pecks Cove mudflat, intertidal ecology.

RESUME

Gordon, D.C. Jr., P.D. Keizer, J. Dale and P. Cranford. 1980. Pecks Cove mudflat ecosystem study: Observations in 1978. Can. Tech. Rep. Fish. Aquat. Sci. No. 928.

En 1978, le laboratoire écologique de la mer a mis en oeuvre une étude écologique de la vasière de la crique de Pecks située dans le bassin Cumberland, dans la partie supérieure de la baie de Fundy. Le rapport résume les mesures su le terrain faites la première année dand la partie supérieure de la zone d'oscillation de la marée. Une analyse préliminaire de données met en lumière une variabilité saisonnière prononcée des composantes et procédés environnementaux critiques et souligne l'importance de procéder à de fréquentes observations tous les mois de l'année. Un important véhicule de transfert d'énergie dans l'écosystème de la vasière est la chaîne alimentaire qui comprend des sédiments de microflore, l'ampliphode détrivore sélectif, le Corophium volutator, et les oiseaux de littoral migrateurs. Cette étude prolongée en 1979 comprendra des observations faites dans la zone inférieure d'oscillation de la marée et des expériences menées sur les vasières inondées et dans la colonne d'eau à marée haute.

Mots clé: Baire de Fundy, bassin Cumberland, vasière de la crique de Pecks, écologie de la zone d'oscillation de la marée.

INTRODUCTION

In the spring of 1978, the Marine Ecology Laboratory initiated a study of the Pecks Cove mudflat ecosystem. The Pecks Cove mudflat is located just inside the Cumberland Basin, on the western (New Brunswick) shore, near the head of the Bay of Fundy (Fig. 1), a region typified by large tides (average range at Pecks Cove being about 11 m) and high suspended sediment concentrations (at times exceeding 10 g l^{-1}). The purpose of this study is two-fold. The first is to understand the structure and dynamics of the mudflat ecosystem as it exists today and to construct a model of the carbon (energy) flow. The second purpose is to use the basic information obtained to help predict the possible environmental impacts of the tidal power project that has been recommended for Cumberland Basin (Bay of Fundy Tidal Power Review Board, 1977). Until this study began, ecological information from the Cumberland Basin region was almost non-existent. Those few ecological investigations undertaken in the intertidal zone of the upper reaches of the Bay of Fundy have been conducted in the Minas Basin/Cobequid Bay region (for example, Bleakney, 1972; Hargrave, 1978; and Risk et al., 1977).

The purpose of this report is to summarize and present the data collected during the first year of the study. Detailed analysis and interpretation of the data and publication will be postponed until the end of the three year field program.

DESCRIPTION OF SAMPLING SITE

On the basis of reconnaissance trips in late 1977, a site at the southern end of the Pecks Cove mudflat was selected for study (Fig. 2). It is easily reached by road and a nearby stream supplies water for cleaning up. High land also shelters the site from the predominant westerly winds which improves working conditions, especially in cold weather. Yeo (1977) made some observations on sediment properties and the macrofauna at this site on 8 June 1977 (his Rockport Flats transect).

Samples were collected and experiments conducted at four stations (marked with stakes) along a transect which began about 200 m southeast of the road bridge crossing the stream and extended offshore along a bearing of about 50°T (Fig. 2).

The profile and major features of the transect are shown in Fig. 3. The transect began at the base of a wave-cut cliff which is about 10 m high. The first portion consisted of a steeply sloping beach composed of cobble-sized material. This beach was completely flooded on spring high tides but only partly flooded on neap tides. A very sharp boundary at the base of the beach marked the beginning of the mudflat. A band of marsh grass (presumably Spartina alterniflora) approximately 25 m wide occurred along the upper edge of the mudflat. Station A was positioned at its seaward edge. Station D was positioned 160 m seaward just before the transect was terminated by an impassable tidal creek. The elevation difference between all four stations was less than half a meter. On an average tidal cycle, the four stations were flooded for approximately five hours and exposed for about seven and one half hours.

METHODS

During 1978, the transect was visited monthly from May through December on days when low tide occurred between 1200-1300 h (neap tide conditions). Solar radiation was measured with a Belfort pyranometer. Epibenthic primary production and benthic metabolism were measured using a method described by Peter Neame in Hargrave (1978). Briefly, changes in dissolved oxygen concentration were measured in light and dark cores which had been filled with filtered seawater, sealed, and incubated for 1 to 3 h; oxygen concentrations were measured on the spot with a portable YSI oxygen meter. The cores were subsequently recovered and upon return to the laboratory the contents were sieved through a 1.19 mm mesh screen. The larger invertebrates were identified and counted.

Surface sediment (0-5 mm) for pigment analysis was collected with a metal spatula and placed immediately in 10 ml of 85% acetone containing two drops of saturated $MgCO_3$ solution. Extracts were handled and analyzed fluorometrically using the procedures described by Hargrave (1978). The fluorometer was calibrated with chlorophyll a and results expressed as 'chlorophyll' and 'phaeophytin'. Both fractions contain a mixture of unknown pigments and the concentrations reported are only estimates. Surface sediment for organic carbon and nitrogen analysis was also collected with a metal spatula and stored in glass vials. After drying at 50 to 70°C, the sediment was ground with a mortar and pestle to a fine silt and a 50 to 70 mg subsample was analyzed with a Perkin-Elmer Model 240 CHN analyzer. Sediments were not treated to remove carbonate carbon (subsequent tests have indicated that 5 to 15% of the total carbon in Pecks Cove sediment is carbonate in origin).

RESULTS

GENERAL OBSERVATIONS

Because of the 'plastic-dilatent' nature of Cumberland Basin intertidal sediments (see Yeo, 1977, for a description of sediment physical properties at Pecks Cove), footprints in the mudflat persisted for months. By November

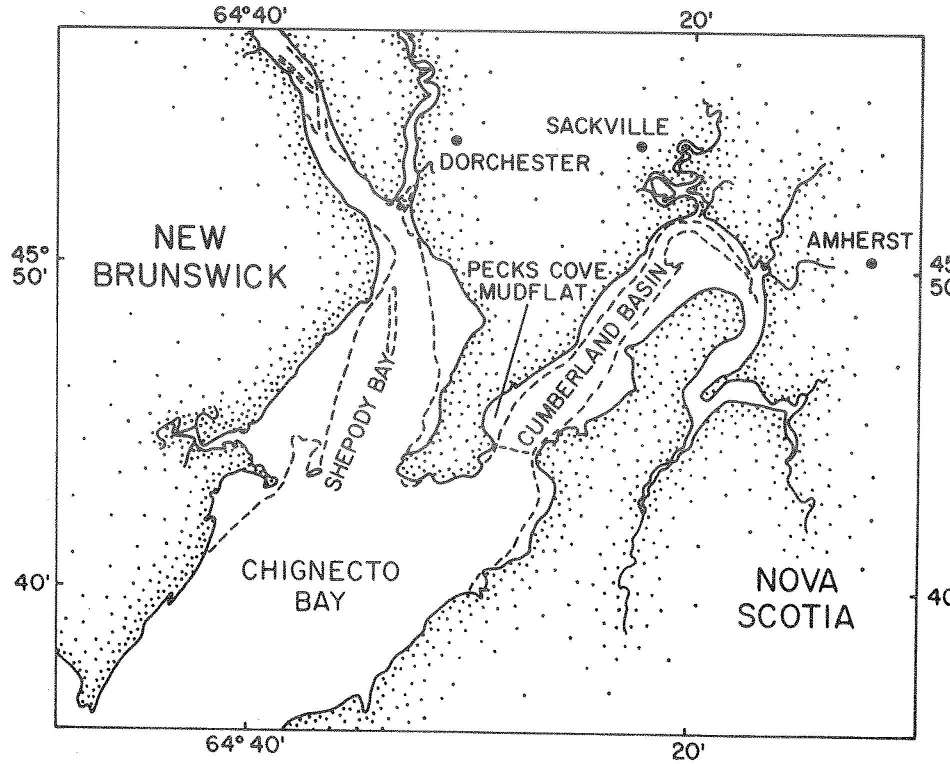

Fig. 1. Location of the Pecks Cove mudflat in Cumberland Basin in the upper reaches of the Bay of Fundy. The dashed line represents the approximate low tide mark. The dashed line across the mouth of Cumberland Basin from Pecks Point, N.B. to Boss Point, N.S. indicates the preferred location of the proposed tidal power station.

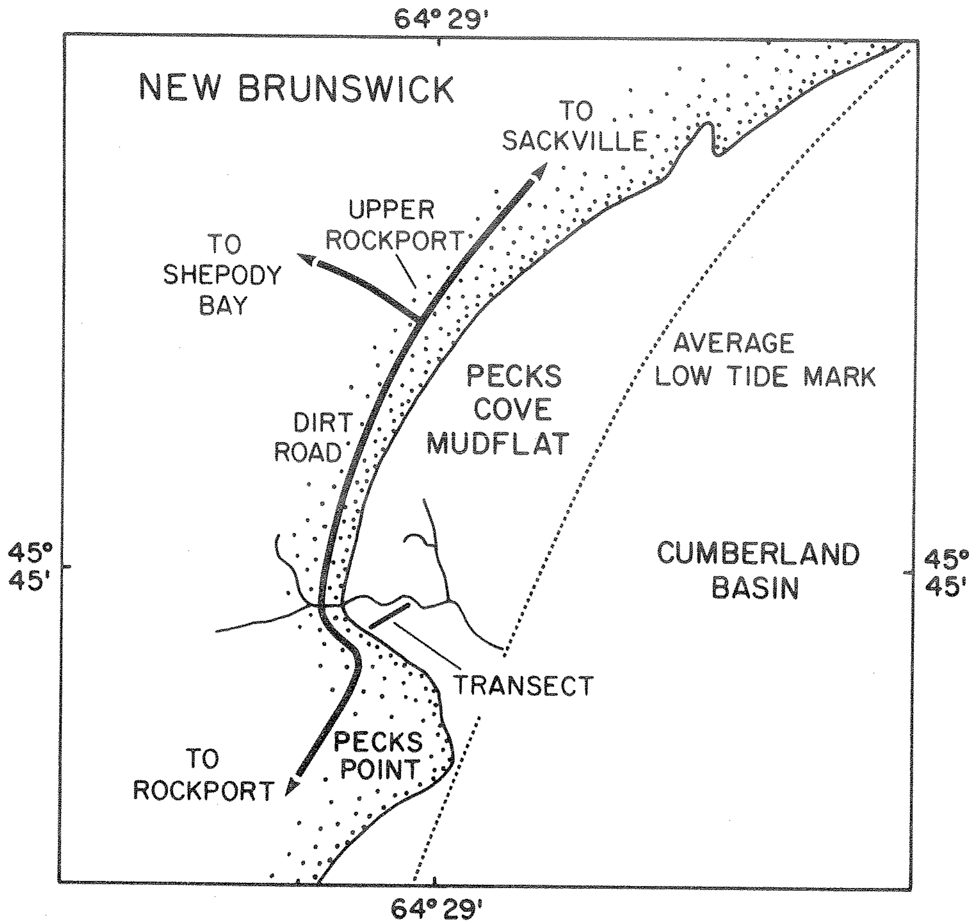

Fig. 2. Map of the Pecks Cove mudflat showing the location of the transect sampled in 1978.

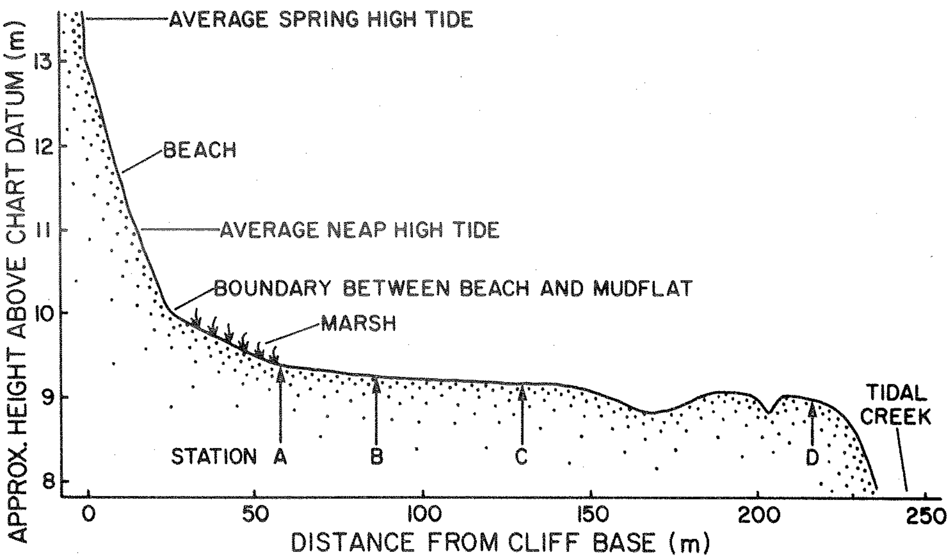

Fig. 3. Profile of transect as measured on 24 November 1978. Elevations were estimated using the observed high tide mark on the day measurements were made and the elevation predictions published in the tide tables by the Hydrographic Service.

1978, a well-worn path had developed along the mudflat portion of the transect and was being enlarged by erosion. The soft surface layer of the mudflat was on the order of 5 to 10 cm thick and appreciably thinner at Station D than at other stations. It was underlain at all stations by a very hard substrate layer making it a safe mudflat to walk on. According to Yeo (1977), these deep hard-packed sediments differ from surface sediment only in water content, not in grain size.

Except for the growth and decline of the marsh grass, there were no pronounced visible changes along the transect from May to November. However the transect was quite different when visited on 27 December. The soft surface sediment layer was noticeably thicker at all stations and marked changes were apparent in the shape and course of the tidal creek channel adjacent to the transect. The stakes marking station locations were gone, presumably removed by ice, but the location of the transect was faintly marked by the path along its axis, now much less apparent. There was scattered ice on the mudflat and continuous ice along the beach.

On 17 January 1979, the site was visited by helicopter and the entire transect was covered with ice. A hole was dug through the ice (20-30 cm thick) and the underlying surface sediment was frozen solid.

SEDIMENT CHEMISTRY

Chlorophyll concentrations and the percent chlorophyll of total pigment concentrations in surface sediment (0-5 mm) are summarized in Table 1. There were no appreciable differences between the four stations along the transect. There was however, considerable temporal variation with the highest concentrations (about 15-30 g g^{-1}) occurring in June and August (Fig. 4). The lowest concentrations occurred under the ice in January (2-3 g g^{-1}).

Total carbon and nitrogen concentrations are summarized in Table 2. Concentrations at Stations A to C were similar while those at Station D were slightly lower. The C:N ratio was generally about 7 indicating that most of the total carbon is organic in origin. Seasonal variation of concentrations was considerable (Fig. 5). Concentrations of carbon and nitrogen both decreased steadily from May to October and then rose sharply in early winter.

TEMPERATURE AND RADIATION

The mudflat surface temperatures and radiation data recorded during incubation experiments are summarized in Table 3. Temperature followed by a relatively smooth seasonal curve with a maximum value of 20.1°C recorded on 27 July. Radiation data were much more erratic because of daily weather variations.

PRODUCTION AND RESPIRATION

Epibenthic primary production (both net and gross) and benthic community respiration data are summarized in Table 4 (no acceptable data were obtained on 24 November because of problems with the oxygen meter). There were no appreciable differences between the four stations. Seasonal variations however were pronounced and are shown in Fig. 6. Both net and gross production increased in June, dropped markedly in July, recovered to give maximum values in August, and dropped gradually thereafter. Net production was negative in May, July and October indicating that on these dates more organic carbon was being consumed than was being produced in the cores during the incubation period. The pronounced drop in production during late July was accompanied by similar decreases in sediment chlorophyll concentration and percent chlorophyll of total pigments (Table 1 and Fig. 4). Respiration reached a maximum in July, when the temperature was greatest (Table 3), and gradually decreased thereafter. Gross production is normalized for variation in radiation on different dates in Table 5.

MACROFAUNA

The most abundant benthic macroinvertebrates at the study site were the amphipod Corophium volutator, the mollusc Macoma balthica, and the polychaete Heteromastus filiformis. Nereis (Neanthes) virens was occasionally encountered. The population densities of Corophium and Macoma are summarized in Tables 6 and 7, respectively. Quantitative data for Heteromastus are not presented because the deep sediment was not properly screened on the first several trips. There was no gradient in Corophium densities along the transect while Macoma densities did decrease with increasing distance from shore. Seasonal variations in abundance are shown in Fig. 7, the most pronounced demonstrated by Corophium. Numbers were very low in May and June (200 m^{-2}) but exploded to over 2000 m^{-2} in July. After a substantial drop in August, numbers increased and averaged about 1500 m^{-2} through the end of December.

Yeo (1977) observed the same dominant species and similar densities at the same site in June 1977.

DISCUSSION

Several interesting observations with important implications should be noted at this preliminary stage of the study. They will be

Table 1. Pigment concentrations (g g^{-1}) in surface sediment (0-5 mm). Ten replicates at each station. Standard deviation given in parenthesis.

Date	Station A		Station B		Station C		Station D		All Stations	
	CHL	% of total	CHL	% of total	CHL	% of total	CHL	% of total	CHL	% of total
1 May 1978	12.57(3.00)	50	13.74(5.58)	57	12.91(2.79)	59	8.53(1.57)	55	11.94	55
28 June	18.83(6.74)	50	33.21(11.15)	54	30.05(8.80)	56	39.65(12.53)	64	30.44	56
27 July	9.34(2.25)	42	7.93(0.97)	38	9.40(1.07)	40	8.09(1.02)	45	8.69	41
24 August	20.40(5.47)	44	14.49(6.29)	33	10.66(2.61)	37	8.34(1.49)	44	15.97	40
26 September	11.08(1.91)	63	8.97(1.05)	59	7.03(1.06)	54	10.69(3.55)	62	9.44	60
24 October	7.91(1.80)	58	6.38(0.58)	52	6.15(0.91)	49	3.89(0.47)	46	6.08	51
24 November	7.74(1.08)	55	6.70(0.81)	56	6.88(1.05)	59	6.60(2.00)	61	6.98	58
27 December	4.48(0.81)	36	6.63(1.08)	41	6.55(1.93)	40	4.82(1.31)	40	5.64	39
17 January 1979	-	-	2.59(0.09)	22					2.69	22
Mean*	11.59	50	12.22	49	11.20	49	11.33	52		

* Excluding 17 January 1979

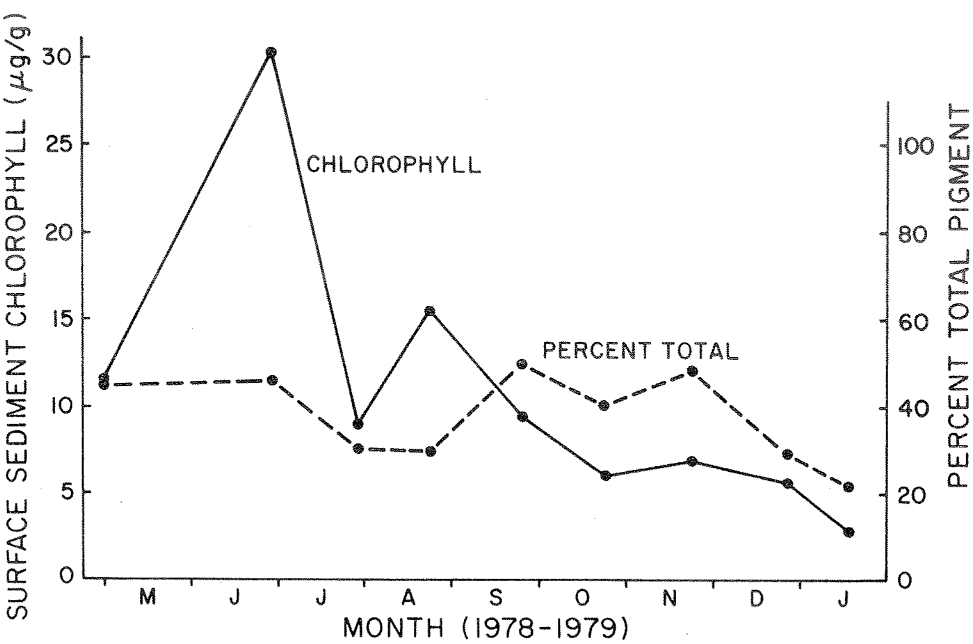

Fig. 4. Temporal variations of surface sediment pigment concentrations; all four stations averaged.

Table 2. Total carbon and nitrogen in surface sediment (0-5 mm) expressed as percent dry weight (1% = 10 mg g^{-1} sediment). Six replicates at each station except on 17 January 1979 when ten were collected. Standard deviation given in parentheses.

Date	Station A			Station B			Station C			Station D			All Stations		
	%N	%C	CN	%N	%C	CN	%N	%C	CN	%N	%C	CN	%N	%C	CN
1 May 1978	0.13 (0.01)	1.01 (0.16)	7.57	0.13 (0.02)	1.04 (0.07)	7.86	0.12 (0.01)	0.95 (0.05)	7.81	0.09 (0.01)	0.78 (0.07)	8.90	0.12	0.95	7.92
28 June	0.14 (0.02)	0.96 (0.09)	7.14	0.15 (0.01)	1.06 (0.06)	6.90	0.13 (0.01)	0.85 (0.08)	6.80	0.11 (0.01)	0.73 (0.08)	6.85	0.13	0.90	6.92
27 July	0.09 (0.02)	0.70 (0.13)	7.72	0.10 (0.01)	0.74 (0.09)	7.63	0.11 (0.02)	0.84 (0.09)	7.47	0.10 (0.01)	0.82 (0.12)	8.02	0.10	0.78	7.80
24 August	0.10 (0.01)	0.76 (0.09)	7.70	0.09 (0.01)	0.66 (0.06)	7.50	0.08 (0.01)	0.58 (0.07)	6.99	0.07 (0.01)	0.55 (0.06)	7.49	0.09	0.64	7.11
26 September	0.07 (0.01)	0.53 (0.06)	7.50	0.06 (0.01)	0.43 (0.03)	7.02	0.06 (0.01)	0.47 (0.05)	7.97	0.05 (0.01)	0.41 (0.03)	7.74	0.06	0.46	7.67
24 October	0.06 (0.01)	0.42 (0.04)	7.28	0.07 (0.01)	0.43 (0.03)	6.37	0.06 (0.02)	0.41 (0.03)	6.51	0.06 (0.01)	0.40 (0.04)	6.53	0.06	0.42	7.00
24 November	0.08 (0.01)	0.54 (0.07)	7.22	0.07 (0.01)	0.43 (0.02)	6.47	0.97 (0.01)	0.44 (0.04)	6.72	0.08 (0.02)	0.48 (0.04)	5.79	0.08	0.47	5.88
27 December	0.01 (0.03)	0.60 (0.07)	7.00	0.10 (0.01)	0.74 (0.05)	7.22	0.01 (0.01)	0.72 (0.02)	7.61	0.07 (0.01)	0.51 (0.04)	7.90	0.09	0.64	7.11
17 January 1979	-	-	-	0.16 (0.01)	1.09 (0.03)	7.04	-	-	-	-	-	-	0.16	1.09	7.04
Mean*	0.10	0.69	6.90	0.10	0.69	6.90	0.09	0.66	7.33	0.08	0.59	7.38			

* Exluding 17 January 1979

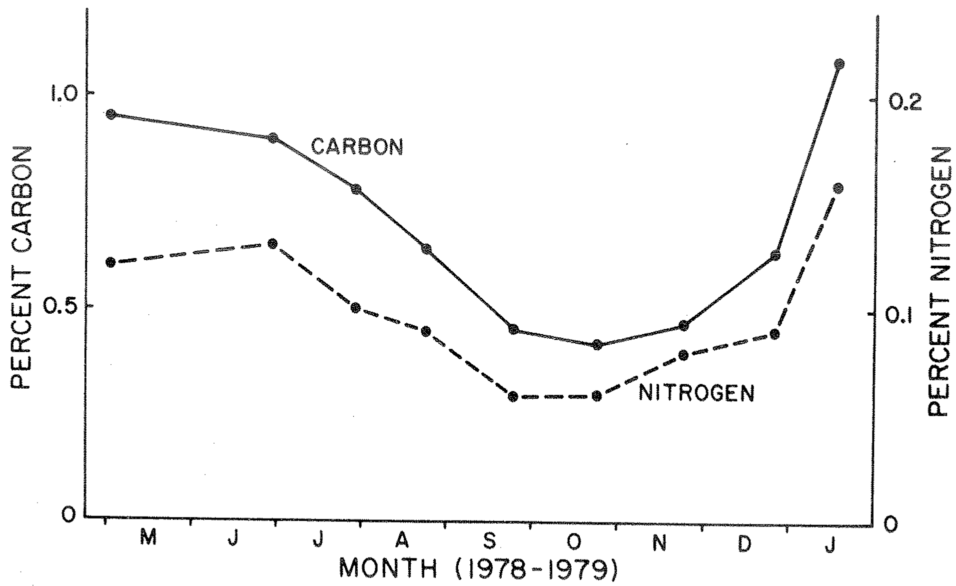

Fig. 5. Temporal variations of surface sediment organic carbon and nitrogen; all four stations averaged.

Table 3. Average mudflat surface temperature at the start of incubation experiments and total radiation received during experiments.

Date	Temperature(C)	Radiation ($g\ cal\ cm^{-2}\ h^{-1}$)
1 May	5.8	54
28 June	17.4	31
27 July	20.1	65
24 August	17.7	Not recorded
26 September	9.4	26
24 October	5.7	49
24 November	3.2	Not recorded

Table 4. Primary production and respiration rates observed in sediment isolated in cores during incubation experiments.

	Station	Net Production	Respiration	Gross Production
		$mg\ O_2\ m^{-2}\ h^{-1}$		
1 May	A	32.0	0.0	32.0
	B	-15.7	24.4	8.7
	C	-16.6	46.6	30.0
	D	-13.1	39.6	26.5
	Mean	- 3.3	27.6	24.3
28 June	A	40.1	27.7	67.8
	B	33.0	12.7	45.7
	C	30.6	21.2	51.8
	D	53.5	17.4	70.9
	Mean	39.3	19.8	59.1
27 July	A	-44.4	46.4	2.0
	B	-34.3	52.3	18.0
	C	-30.2	30.6	0.4
	D	-21.3	42.3	21.0
	Mean	-32.5	42.9	10.4
24 August	A	35.9	31.4	67.3
	B	54.8	29.1	83.9
	C	86.5	36.6	123.1
	D	20.9	38.5	59.4
	Mean	49.5	33.9	83.4
26 September	A	24.5	16.4	40.9
	B	23.6	25.3	48.9
	C	0.0	25.2	25.2
	D	43.5	9.2	52.7
	Mean	22.9	19.0	41.9
24 October	A	-3.7	4.8	1.1
	B	-12.3	7.2	-5.1
	C	-12.1	13.5	1.4
	D	-19.2	12.8	-6.4
	Mean	-11.8	9.6	-2.2

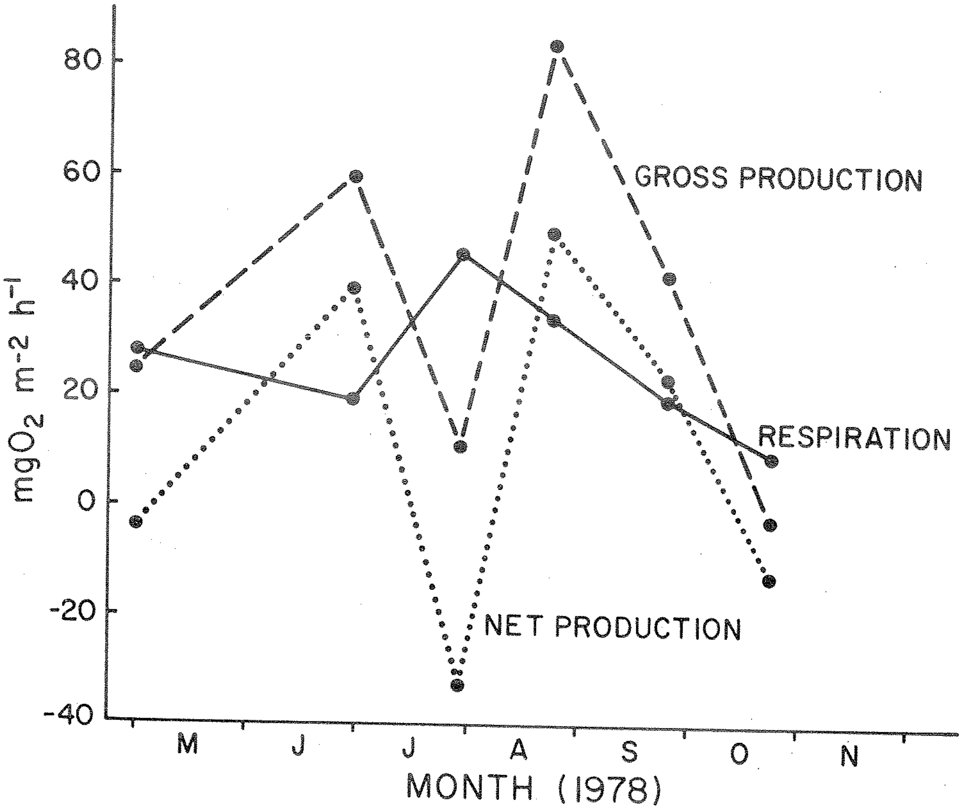

Fig. 6. Temporal variations of primary production and respiration in surface sediment; all four stations averaged.

Table 5. Gross production (mg O_2 m^{-2} h^{-1}) normalized for radiation variations (g cal cm^{-2} h^{-1})

Date	mg O_2 (g cal)$^{-1}$
1 May	4.5×10^{-5}
28 June	19.1×10^{-5}
27 July	1.6×10^{-5}
24 August	-
26 September	16.1×10^{-5}
24 October	-0.5×10^{-5}

Table 6. Population density of the amphipod <u>Corophium volutator</u> (numbers m^{-2})

Date	Station A	Station B	Station C	Station D	Mean All Stations
1 May	68	68	542	68	187
28 June	203	0	135	68	102
27 July	1557	2501	2776	2505	2335
24 August	1219	1151	1151	609	1030
26 September	1895	542	1286	2234	1489
24 October	2505	1015	1828	1286	1659
24 November	1422	812	880	2166	1320
27 December	2856	0	136	3264	1564
Mean	1466	763	1092	1525	

Table 7. Population density of the bivalve *Macoma balthica* (numbers m^{-2})

Date	Station A	Station B	Station C	Station D	Mean All Stations
1 May	68	68	204	0	85
28 June	204	272	136	68	170
27 July	272	68	68	0	95
24 August	68	272	272	204	204
26 September	408	340	204	0	238
24 October	136	340	0	68	136
24 November	271	135	0	203	152
27 December	272	0	0	0	68
Mean	212	188	113	71	

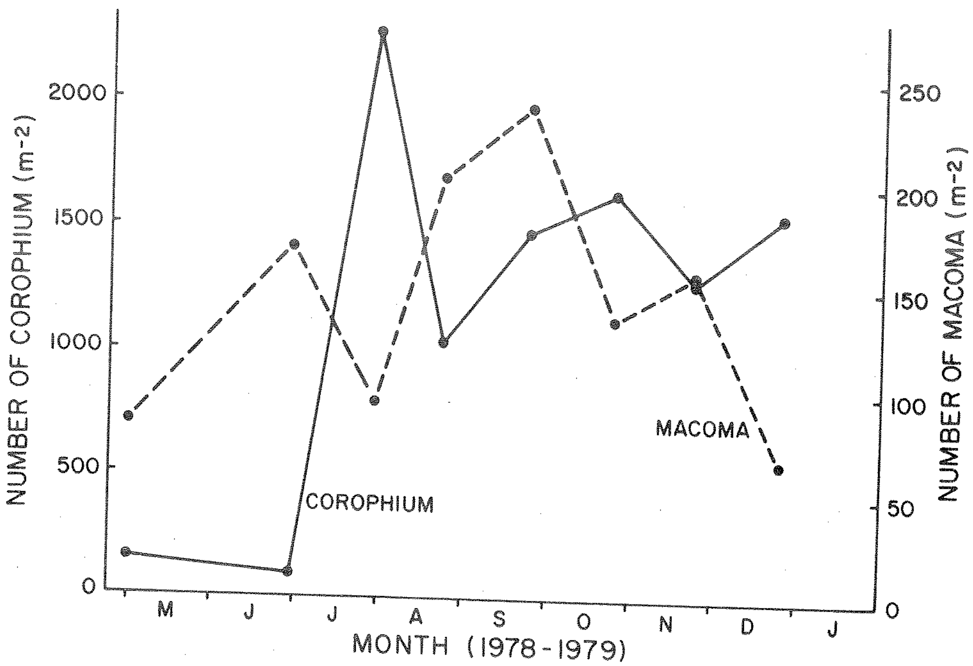

Fig. 7. Temporal variations of Corophium and Macoma population densities; all four stations averaged.

examined in more detail as the study continues. The first is the importance of Corophium and its interrelationships with other components of the mudflat ecosystem. This selective deposit-feeding amphipod was quite sparse in the spring. High population densities did not develop until well after sediment pigment concentrations and primary production rates in surface sediment had increased markedly (Figs. 5 and 7). When the Corophium population exploded in late July (Fig. 7), sediment pigment concentrations and primary production rates plummeted suggesting that the amphipods (more than 2000 m^{-2}) were grazing a large portion of the sediment microflora biomass. The Corophium explosion occurred just at the start of the fall migration when millions of shorebirds pass through the Bay of Fundy region. The most numerous of the shorebirds visiting the Pecks Cove mudflat is the semipalmated sandpiper which preys heavily on Corophium (P. Hicklin, personal communication). By the end of August, the numbers of Corophium had dropped markedly (Fig. 7), presumably because of shorebird predation, and the sediment pigment concentrations and primary production rates recovered (Fig. 4-6). This recovery was probably brought about in part by reduced grazing by Corophium, but increased nutrient supply from shorebirds droppings may also have been a factor. This microflora - amphipod - shorebird food chain appears to be a major carbon flow pathway on the Pecks Cove mudflat.

Another interesting observation is the lack of correlation between sediment pigment and organic carbon/nitrogen concentrations in surface sediment (Fig. 4 and 5). The highest organic carbon/nitrogen concentrations occurred during the winter when the sediment pigment concentrations were lowest, and when the sediment pigment concentrations increased during spring and summer the organic carbon/nitrogen concentrations dropped. The photosynthetic microflora appear to constitute only a small percentage of the sediment organic matter. The reasons for the high sediment organic matter concentrations during the winter are not clear. They could reflect either increased supply or reduced consumption, or a combination of both. The consistency of the C:N ratio with season suggests that the high winter concentrations are not caused by an influx of nitrogen-poor terrestrial material.

These preliminary data illustrate the important events that occur on the mudflat during the winter months, most of which are probably controlled directly or indirectly by ice. These events include erosion and deposition of sediment, increase in sediment organic matter, and the almost complete removal of Corophium. It is obvious that environmental studies must include observations made at all seasons of the year if the results are to be meaningful and applicable to predicting environmental impacts.

The Pecks Cove mudflat ecosystem study will be expanded in 1979. A greater number of variables will be measured, more frequent trips will be made, observations will be made in the lower portion of the intertidal zone, the mudflat will be studied under flooded as well as exposed conditions, and numerous seawater variables will be measured.

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