Sublittoral Macro-infauna of Musquash Estuary

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SUBLITTORAL MACRO-INFAUNA OF MUSQUASH ESTUARY

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ABSTRACT

Wildish, D. J. 1977. Sublittoral macro-infauna of Musquash estuary. Fish. Mar. Serv. MS Rep. 1463, 13 p.

Taxonomic data for nine sublittoral benthic stations worked in the Musquash estuary during June 1973 indicate that the macro-infauna is impoverished, with densities ranging from 5 to 205 individuals per m^2 and wet weight biomass of 0.45 to 43.05 g per m^2. Species diversity is also low, only 36 species being found for the nine stations. The trophic group for the most landward stations is primarily suspension feeding. The dominant macrobenthic community for the most seaward part of the estuary is deposit swallowing or surface deposit feeding.

Key words: Musquash estuarine benthos, species diversity, density, biomass

RESUME

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D'après les données taxonomiques recueillies dans neuf stations benthiques infralittorales de l'estuaire de la Musquash, en juin 1973, il y aurait appauvrissement de la macrofaune endobenthique. Les densités varient de 5 à 205 organismes par m^2, et la biomasse (poids frais), de 0,45 à 43,05 g/m^2. La diversité est aussi faible, avec 36 espèces seulement pour les neuf stations. Les groupes trophiques des stations les plus près des rives sont surtout suspensivores. Les communautés macrobenthiques dominantes des stations les plus éloignées avalent les dépots ou se nourrissent à leur surface.

INTRODUCTION

The salinity distribution was studied (Kristmanson 1976) as part of a joint program to determine the hydrography and benthic biology of the Musquash system to assess the impacts of proposed changes in freshwater flow to the estuary. Under the Musquash Watershed Management Project much of the fresh water would eventually be used to supply domestic and industrial needs of the city of Saint John. The fresh water of the west branch of the Musquash is now passed by damming to the east branch from where it is pumped to Spruce Lake, the storage system for Saint John, and the remainder passed through the turbines of the N.B. Electric Power Commission facility and thence to the estuary. The time scale for phasing out the powerhouse and reducing flow to the estuary depends on the rate at which the city of Saint John increases its freshwater consumption. Freshwater flows in 1973 were 9 x 10^6 ft^3 per 6 hr (Kristmanson 1976).

MATERIALS AND METHODS

Exact coordinates for the sampling stations worked in the estuary are not available because charts for the whole system are not printed. The outline map shown in Fig. 1 is taken from a National Topographic map. The Canadian Hydrographic Service Chart 4314 gives soundings and coordinates for the harbour below station 6 only.

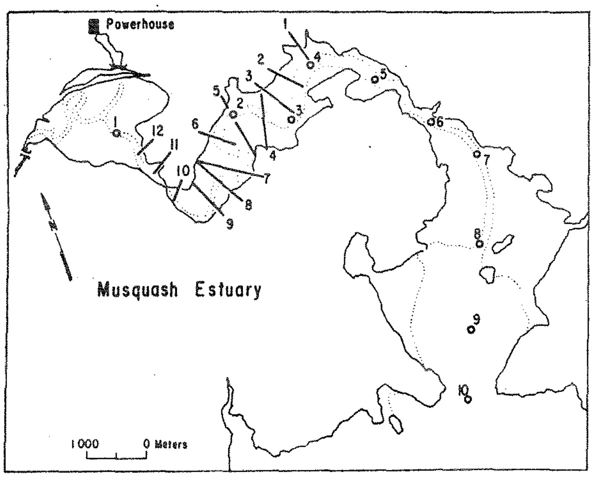

Fig. 1. Map showing topography and two series of sampling stations: central channel (1-10) and transects (1-12) in the Musquash estuary.

MACROFAUNAL SAMPLING

Samples were taken with a 0.1-m^2 Smith-McIntyre grab with a 16-cm effective digging depth in the deepest part of the mid-channel. Sampling dates were June 18-26, 1973 and 10 replicates/station were taken. Samples were sieved through a series of screens (5.0-, 2.5-, and 1.0-mm^2 mesh) and individual replicate samples removed from each screen and stored in 5% formalin in sea water and sent to the Canadian Oceanographic Identification Center, Ottawa, for identification, counting, and weighing (see their Summary Report No. 97, Reference 031B).

Numerically dominant species are defined as those with >3 individuals found for all 10 replicate samples. Ranking according to wet weight (correct to 0.01 g inclusive of shell) gave a biomass dominance estimate for each station. An estimate of species diversity, the α index of Fisher et al. (1943), and the equilibrium species number or S_{max} value (Wildish, in preparation) were calculated for each station.

Further sampling using two or three single Smith-McIntyre grab samples along 12 transects in the upper part of the estuary was made on November 14-15, 1973. Sediment subsamples were taken from the grabs and the rest of the material sieved as previously. The living, dominant animals were identified directly on the screens to determine their estuarine penetration.

SEDIMENT SAMPLING

Sediment samples were available from the transect samples and from a series of 10 grab samples made in 1974 at the mid-channel sample stations. The stations were referred to by shore landmarks.

Sediment sorting characteristics and Walkley-Black organic carbon values were determined as previously (Akagi and Wildish 1975). In addition, volatile solids were determined as a percentage of loss in weight of a dried whole sediment on combustion at 500°C for 1 h.

RESULTS

TAXONOMY

A complete species list for the June 1973 sampling is shown in Table 1. Species (S) times individuals (N) or biomass (B) matrices are recorded in Appendices 1 and 2 for each of the 10 replicates. Table 1 shows the species name corresponding to a 3-digit number used throughout this report.

ECOLOGICAL ANALYSIS

The species present may be divided into three major groupings based on biomass and numerical dominants (Table 2) as follows:

Stations 1-4 - a *Mya*, *Corophium*, and *Nereis* association
Stations 5 & 6 - an impoverished association of *Nepthys ciliata*, *Balanus crenatus*, and *Nereis diversicolor*
Stations 7 & 8 - a *Sternaspis scutata*, *Clymnella torquata*, and *Nepthys incisca* association

At station 9 a very impoverished association characterized by *Sthenelais limicola* is present. This polychaete, as found also in Saint John Harbour, is associated with a highly thixotropic sediment.

A classification of dominants according to trophic group (Table 3) shows that the stations landwards of station 6 are primarily suspension feeders with a single surface deposit feeder (*Corophium volutator*). Seawards of station 6 the group is deposit swallowing or surface deposit feeding.

Only 36 species of macrofauna were found for the 9 stations worked with a total effort of 90 Smith-McIntyre grab samples. The α value of Fisher et al. (1943) and its standard error (S.E.) are shown in Table 4. Also shown is the species equilibrium number (S_{max}) derived from the S versus S/N fitting.

ESTUARINE PENETRATION

The sampling locations worked in November 1973 for the 12 transects shown in Fig. 1 are given in Table 5. Only 4 species were taken in sufficient numbers to determine their estuarine penetration (Table 6). Because of the low density of common species in the Musquash estuary, upstream limits probably cannot be determined precisely by the sampling method used. There is evidence for a change in estuarine penetration for *C. volutator* and *N. diversicolor* between the two sampling times (Table 7). The salinity data shown in Fig. 2 can be used to determine the estuarine limits of the species in Table 7. Thus the maximum salinity at high water by each species in June was ≈10 o/oo salinity, except for *N. diversicolor* where it was ≈25 o/oo. Each of the four species shown in Table 7 would have been exposed to fresh water under low water conditions. The penetration of *Nepthys* sp. in such conditions was unexpected and requires further investigation. Possible explanations include: the presence of relatively saline conditions within the sediment; the presence of a euryhaline polymorph of *Nephtys* sp.; or mistaken taxonomic identification. Considerable variation in salinity, particularly at LW, was noted by

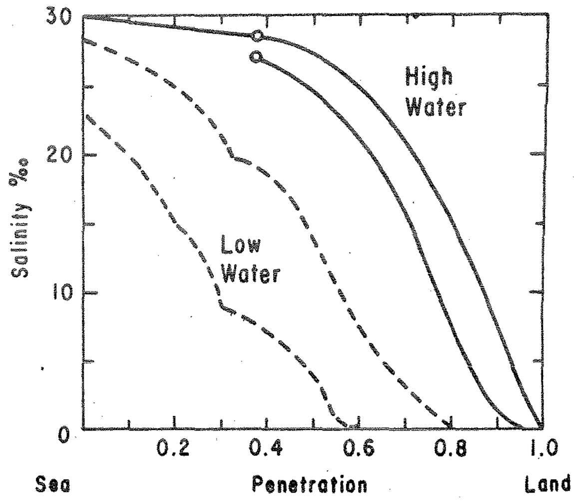

Fig. 2. Estuarine penetration fraction and max/min salinity at high and low water (from Kristmanson 1976) in the Musquash estuary.

Kristmanson (1976) depending on freshwater flows and tidal conditions.

SEDIMENTS

The composition of sediment from the stations at which replicated macrofaunal samples were taken is shown in Table 8. The presence of sand in significant proportions was found at stations 3, 4, 6, and 10. Sorting characteristics for the sediments (Table 9) suggest that complex tidal currents influence the pattern of median particle diameters and sorting coefficient values. The presence of sand or particles >2 mm diameter suggests that tidal currents near the bottom are strongest at 6, 4, 3, then 5. This is modified by the sorting coefficient (QDØ) values. The high value for 6 is because all the sediment is sand or >2 mm particles which are not well sorted. Tidal currents are strongest near the bottom at 6 then 4, 3, 5, 1, and 2. At station 3 the high QDØ value may be associated with re-deposition of sediment. All six stations in this part of the system are probably net exporters of sediments and particulate carbon. The flooding tide suspends fine sediments from the intertidal banks, particularly in the 4-5 area; while at full flood some settles out (2-3 area), and on the ebb the bulk of the suspended material is carried to the Harbour and thence into the Bay of Fundy. Additional transect data (Appendix 3A and B) suggest that the zone between stations 1 and 2 also has fast bottom currents. Station 1 is in the most landward zone of tidal erosion and deposition. In this river-like section of the estuary these two zones are separated distinctly by topographic features: wide intertidal flats - narrow rapids -

wide intertidal flats - narrow rapids which probably correspond with tidal excursion limits. The pattern is continued in the lower part of the estuary with a wide depositional area and narrow rapids at the mouth of the estuary. Tidal energy is lower here because of the wider and deeper channel present. There may be some transport of sand into the estuary mouth from the Bay of Fundy (see station 10). Station 9 is probably an erosion area on a flooding tide.

DISCUSSION

Viewed as an ecosystem, the Musquash estuary and contiguous marsh may be described as follows:

1. A marsh in the process of building, where colonizing plants *(Zostera marina)* are stabilizing and building *(Spartina alterniflora)* soils.

2. The resultant dynamic interaction between tidal currents and stabilized sediment causes an erosion process of the finer sediments and particulate carbon.

3. The estuary is a means of transferring fine sediments as well as particulate and dissolved carbon produced from the marsh plants into the Bay of Fundy.

4. The freshwater flow into the system probably plays an important role in the rate of this transport. Thus, if the freshwater flow is reduced, it should result in a slower release of carbon and other nutrients to the Bay of Fundy.

5. Standing stock biomasses of macro-infauna are low, possibly because the physical conditions, particularly salinity, are so variable.

The benthic macrofaunal and sediment data and inferences from them regarding maximum speeds of bottom currents are in good agreement. The fauna at, and landward of, station 5 are primarily suspension feeding; seawards of 5 the fauna are deposit feeders. Suspension feeders are characteristic of areas with relatively high bottom tidal currents. In this zone (Fig. 3, open dots) the sorting coefficients are linearly related to the carbon values (volatile solids), suggesting that tidal currents selectively remove the lighter organic matter particulates throughout the whole region above station 5. This relationship is obviously important to suspension feeders and also in export of energy originally produced by marsh plants. Stations 6 and 10 fall above the linear plot shown in Fig. 3 (closed dots). This is because particulate carbon in these stations is in the form of large, waterlogged, woody particles, many of which were retained on the 1.0- and 2.5-mm^2 mesh during sieving of the macrofauna. Smaller particles of woody material were also present at 7 and 8, but none at station 9.

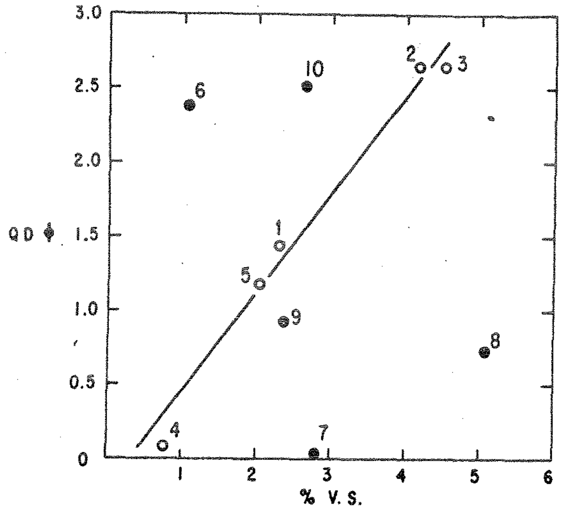

Fig. 3. Relationship between the percentage volatile solids and the sorting coefficient (QDØ) of sediments in the mid-channel stations of the Musquash estuary.

Three major areas of high tidal energy are present which, on the flood tide, cause erosion in an area just landwards of them. The three areas are: station 1 and just seaward of it, stations 5 and 6, and stations 9 and 10. These areas are associated with very low standing stocks of macrobenthic biomass.

Although the total production of plant detritus by the marsh, or the annual proportion exported, is unknown, it is likely to be substantial. Transport of organic detritus as well as dissolved nutrients is controlled partly by freshwater flow rates. In view of this and the plan to curtail freshwater flow, future work should be directed to estimate amounts and rates of this process. Detritus is known to be the basis of heterotrophic food chains which directly lead to inshore fish productivity.

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Table 1. Species list for stations in the Musquash estuary sampled June 1973.

Number	Name
032	*Nassarius trivittatus* (Say, 1822)
034	*Lunatia heros* (Say, 1822)
040	*Littorina saxatilis* (Olivi, 1792)
101	*Nucla delphinodonta* Mighels and Adams, 1842
104	*Mytilus edulis* Linné, 1758
117	*Macoma balthica* (L., 1758)
118	*Mya arenaria* Linné, 1758
201	*Nereis virens* Sars, 1835
202	*Nephtys (caeca ?)* (Fabricus, 1780)
203	*Nephtys incisa* Malmgren, 1865
204	*Nephtys ciliata* (O.F. Müller, 1789)
215	*Nephtys* sp.
221	*Sthenelais limicola* (Ehlers, 1864)
222	*Nereis diversicolor* O.F. Müller, 1771
4	*Nereis* sp.
269	*Goniada maculata* Oersted, 1843
276	*Clymenella torquata* (Leidy, 1855)
281	*Ninoe nigripes* Verrill, 1873
3	*Lumbrinereis* sp.
286	*Phyllodoce mucosa* Oersted, 1843
341	*Pectinaria hyperborea ?* (Malmgren, 1866)
353	*Brada villosa* (Rathke, 1843)
357	*Sternaspis scutata* (Renier, 1807)
358	*Polycirrus medusa* Grube, 1850
2	Unidentified polychaetes
401	*Edotea montosa* (Stimpson, 1853)
402	*Idotea phosphorea* Harger, 1873
430	*Balanus crenatus* Bruguiere, 1789
451	*Crangon septemspinosus* Say, 1818
454	*Carcinus maenas* (Linnaeus, 1758)
504	*Gammarus oceanicus* Sergestråle, 1947
508	*Leptocheirus pinguis* (Stimpson, 1853)
514	*Gammarus lawrencianus* Bousfield, 1956
1	*Gammarus* sp.
521	*Corophium volutator* (Pallas, 1766)
751	*Edwardsia* sp.? *elegans* Verrill, 1869

Table 2. Dominance estimates based on 10 replicates of 0.1 m^2 per station. Numbers refer to species as in Table 1.

Station	$N/m^2 > 3$	$B/m^2 > 1.0$ g
1	118	-
2	118,521	118,117
3	118,521,514,204,504,4,1,222	118,454,104
4	204,118,117	118,104,117
5	430,222,204	430
6	204,203	204
7	357,276,401,508,215,203,281,204,269	357,276,202,203,215
8	357,215,203,281,269	357,222,215
9	221	-

Table 3. Classification of dominants according to trophic group.

Trophic group	Species number
Suspension feeders	104,117,118,222,430,251,508
Surface deposit feeders	117,508,521,203,357
Deposit swallowers	281,276
Algal scrapers	401,504,514,1
Predators	222,269,202,203,204,215,454

Table 4. Species diversity data for the Musquash estuary.

Station	S	N	α ± % S.E.		S_{max}
1	7	76	2.2	21	9
2	2	4	-	-	-
3	11	75	3.1	20	12
4	12	55	4.5	21	(12)
5	11	44	4.5	27	14
6	3	55	0.8	25	-
7	17	217	4.5	14	21
8	12	191	2.9	16	(12)
9	5	12	-	-	-

Table 5. Sample station numbers along 12 transects worked in the Musquash estuary, November 1973.

Transect	North bank	Channel	South bank
1	1	2	-
2	3	4	-
3	5*	6	-
4	7	8	9
5	10	11	12*
6	13*	14	15
7	16	17	18*
8	19	20	21
9	24*	23	22*
10	-	26	25*
11	-	28	27*
12	-	30	29

*Numbers indicating sediment sorting data are given in Appendix 3.

Table 6. Presence (indicated by number/grab) and absence (0) data for four common species at transect stations 1-30.

Sample station	*C. volutator*	*M. arenaria*	*N. diversicolor*	*N. ciliata*
1	0	0	0	0
2	0	0	0	1
3	0	0	0	3
4	0	0	0	1
5	0	0	0	0
6	0	0	0	4
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	3
12	28	0	0	1
13	12	0	0	0
14	0	1	0	0
15	0	0	0	0
16	16	0	0	1
17	14	3	0	2
18	0	0	4	3
19	8	0	0	0
20	0	1	0	0
21	0	9	19	0
22	0	11	11	0
23	1	10	15	0
24	0	0	1	0
25	0	0	3	0
26	0	0	1	0
27	0	2	0	0
28	0	0	0	0
29	0	0	0	0
30	0	1	0	1

Table 7. Upstream estuarine penetration limits as Milne fractions (distance from mouth divided by total estuarine penetration as in Kristmanson (1976)).

Species	June	November
C. volutator	>0.87	0.73
M. arenaria	>0.87	>0.86
N. diversicolor	0.58	0.81
N. ciliata	>0.87	>0.86

Table 8. Sediment characteristics of Musquash estuary mid-channel stations occupied in October 1974.

Station	>2 mm	Sand	Silt/clay
1	24.7	10.4	65.9
2	0.5	5.2	94.3
3	2.4	63.6	34.0
4	3.4	90.1	6.5
5	38.0	1.7	60.3
6	22.9	77.1	0
7	0	3.0	97.0
8	0	1.1	98.9
9	0	2.3	97.7
10	0.6	35.9	63.5

Table 9. Sediment sorting characteristics and organic carbon content of mid-channel stations in the Musquash estuary.

				Organic carbon, dry weight basis	
Station	MdØ	QDØ	SkqØ	% Walkley-Black	% volatile solids
1	6.08	1.44	+0.26	0.81	2.34
2	6.85	2.65	+1.85	0.93	4.18
3	1.27	2.65	+1.85	0.67	4.52
4	1.66	0.16	-0.14	0.07	0.87
5	6.80	1.35	+0.42	0.42	2.06
6	0.30	2.38	-2.13	0.04	1.10
7	5.92	0.09	+0.07	0.63	2.81
8	6.22	0.72	+0.39	1.71	5.10
9	5.63	0.93	+0.32	0.50	2.37
10	5.25	2.51	-0.64	0.44	2.68

Appendix 1. S x N matrix for stations in Musquash estuary, June 1973.

S	1	2	3	4	5	6	7	8	9	10
Station 1										
2							1			
117				2						
118							28		1	13
203						1				
204						1				
215								2		
514							1			
521	3					1	10	1		11
Station 2										
118	1		2							
215	1									
521			1							
Station 3										
1					1				5	
104					1				1	
118	3				4	2		3	1	3
204	1		7							
215		1		1						
222	2	2	1							
4								1	1	4
454						1				
504	1					1		1	3	
514	1				3	1	1		2	
521	1	1	4			3		1		5
Station 4										
1									1	
040			2							
104		1						1		
117		2					1		1	
118	4	2	2	3	1		1	4		
201					1					
203								1		
204	2	3	3	1	3	2	2			5
222				2						
504							1			
521									2	
751	1									
Station 5										
1								3		
2								1	1	
104								1		
201	1						2			
204	2				1					1
222	2	1		1			2			
4			3							
402								2		
430								18		
451								1		
514								1		

Appendix 1 (cont'd)

S	1	2	3	4	5	6	7	8	9	10
Station 6										
203					1	5		1		
204	5	1	8	2	4	4	8	8	4	3
357										1
Station 7										
3						1	1			
101				2						
117					2					
202			1				1			
203				1	4			2		
204	2			2						
215		3				3	1			1
221				1						
269			1	1			1	1		
276	6	3		4	6	14	5	5		
281	1	1		1		1	1			
286	1									
341					1		1			
353							1			
357	18	5		10	35	8	23	5		
358	1									
401			1	4	2	3	5	4		
508	1	2			2	1	1			2
Station 8										
032									1	
034		1								
101									1	
203	6	6			4				3	
215			11	6		6	6	9		3
222				1		1				
269			1		1				1	1
281		1			3			1		
357	7	14	10	11	15	14	16	15	3	7
402									1	
451										1
508							2			1
Station 9										
2								1		
202										1
215		1								
221			2	1		1	1	1	1	1
281										1

Appendix 2. S x Biomass matrix for stations in Musquash estuary, June 1973.

S	1	2	3	4	5	6	7	8	9	10
Station 1										
2							0			
117				1.97						
118							14.23		0.05	15.24
203						0.04				
204						0.01				
215								0.01		
514							0			
521	0.02					0.01	0.02	0.01		0.05
Station 2										
118				0.44						
215	0.01									
521			0							
Station 3										
1					0				0.02	
104					0.25				1.43	
118	5.91				0.48	0.14		1.95	1.01	0.33
204	0.06		0.50							
215		0.02		0.05						
222	0.35	0.32	0.08							
4								0.03	0.01	0.27
454						10.00				
504	0.05				0.05			0.09	0.09	
514	0.01				0.02	0	0.01		0.02	
521	0	0	0.01			0		0		0.02
Station 4										
1									0	
040			0.04							
104		2.34						2.27		
117		1.40					1.56		0.42	
118	20.16	0.21	1.37	4.95	0.22		0.68	4.55		
201					0.25					
203								0.02		
204	0.05	0.23	0.21	0.06	0.14	0.03	0.15			0.07
222				0.25						
504							0.01			
521									0.01	
751	1.40									
Station 5										
1								0.01		
2								0	0	
104								0		
201	0.25									
204	0.08				0.02					0.06
222	0.12	0.22		0.09			0.04			
4			0.64							
402								0.04		
430								1.32		
451								0		
514								0		

Appendix 2 (cont'd)

S	1	2	3	4	5	6	7	8	9	10
Station 6										
203					0.49	0.08		0.04		
204	0.07	0.01	0.48	0.12	0.05	0.10	0.19	0.16	0.17	0.05
357										0.24
Station 7										
3						0.21	0.04			
101				0.04						
117					0.30					
202			0.82				0.62			
203				0.05	0.16			1.17		
204	0.03			0.77						
215		0.50				0.47	0.01			0.01
221				0.04						
269			0.07	0.12			0.07	0.03		
276	0.70	0.24		0.79	0.60	2.30	0.35	0.74		
281	0.03	0.02		0.04		0.06	0.07			
286	0									
341					0.07		0.06			
353							0.02			
357	2.58	0.07		2.43	5.05	0.28	3.11	1.12		
358	0.03									
401			0.01	0.03	0.02	0.03	0.05	0.04		
508	0.01	0.08			0.07	0.06	0.04			0.06
Station 8										
032									0.09	
034		0.02								
101									0.05	
203	0.19	0.15			0.08				0.05	
215			0.23	0.14		0.10	0.10	0.19		0.53
222				1.40		0.38				
269			0.07		0.08				0.05	0.11
281		0.08			0.21			0.10		
357	1.85	3.51	3.32	3.19	3.26	3.58	4.02	3.27	0.67	1.46
402									0.02	
451										0.11
508							0.05			0.05
Station 9										
2								0		
202										0.05
215		0.01								
221			0.04	0.02		0.02	0.01	0.01	0.02	0.01
281										0.02

Appendix 3A. Sediment sorting characteristics of Musquash transect samples taken mainly on intertidal mud banks.

Station	MdØ	QDØ	SkqØ	% Walkley-Black	% volatile solids
5	6.55	1.13	+0.45	1.69	2.01
12	7.20	1.04	+0.24	3.88	2.56
13	6.40	0.97	+0.45	1.04	1.24
18	2.90	2.36	+1.40	1.39	1.24
22	6.60	1.10	+0.41	1.94	1.93
24	1.00	0.89	-0.23	0.34	0.47
25	0.75	0.73	-0.12	0.59	0.67
27	0.75	0.67	-0.12	0.45	0.32

Appendix 3B. Percentage major fractions in transect samples from intertidal mud banks of the Musquash estuary.

Station	>2 mm	Sand	Silt/clay
5	0	1.2	98.8
12	0.1	2.3	97.6
13	0.2	1.5	98.3
18	0.2	50.7	49.1
22	0	1.8	98.2
24	0.3	85.8	14.9
25	0.2	87.5	13.3
27	1.4	92.2	6.4