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INTRODUCTION

On July 14-16, 1975, a brief intense multidisciplinary study of the lower trophic levels in the Cowichan estuary was undertaken. This work was initiated for several purposes: (1) to provide management with the basic data on the distribution of planktonic and intertidal benthic resources; (2) to compare with a similar but larger study on the Nanaimo estuary; (3) to evaluate the feasibility of undertaking such studies in the future. This report is a preliminary analysis of the data.

The following people participated in this study and their contributions are gratefully acknowledged: B. Cole (zooplankton), R.J. LeBrasseur (zooplankton), R.J. Naiman (benthic autotrophy), R. Page (Master, M.V. *Caligus*), K. Stephens (water chemistry, plankton autotrophy), D. Sutherland (zooplankton), B. Windecker (meiofauna, heterotrophy), B. York (meiofauna).

MATERIALS AND METHODS

LOCATION

Cowichan Bay is a small semi-enclosed bay on the east coast of Vancouver Island, British Columbia. To the east, it is partially sheltered by Saltspring Island and connected to the Strait of Georgia. The maximum depth is 77 m. An intertidal flat of 5.8 km^2 and two rivers (Koksilah and Cowichan) are located at the head of the bay. *In situ* experiments were conducted and samples taken at 7 stations on the intertidal flat and shore area (Fig. 1). Water samples were collected from standard depths at 3 stations (9-11) and 88 short plankton tows were made in the bay and adjacent waters (Fig. 2).

ANALYTICAL PROCEDURES

Salinity and temperature profiles were obtained with an *in situ* portable conductivity salinometer (Beckman model RS 5/3). Chlorophyll *a* (corrected for phaeopigments), dissolved oxygen and nutrients (NO_3, PO_4) were measured by methods outlined in Strickland and Parsons (1968). ATP was measured in a similar manner to Holm-Hansen and Booth (1968). Five hundred millilitres of sea water were filtered with a 0.22 μ Millipore filter and placed into boiling TRIS [Tris (hydroxymethyl) aminomethane] buffer (pH 7.75) for 7 min. and analysed with an ATP photometer (J.R.B. Inc.). 0.6 ml of mud were analysed in order to measure the ATP present in the sediment. Heterotrophic activity was assayed using uniformly labelled ^{14}C glucose of high specific activity by the method described by Sibert and Brown (1975). Autotrophic carbon uptake (i.e., primary productivity) was determined using $H^{14}CO_3^-$ and *in situ* incubations corrected for dark bottle uptake. These values were used to calculate daily production depending on total daily solar radiation. Downwelling photosynthetic quantum irradiance and vertical extinction coefficients were measured using submersible sensors (Lambda Inst. Corp., Lincoln, Nebraska, see Biggs *et al.*, 1971). These results will be reported separately.

Autotrophic activity in the mud was measured using an in situ incubation technique. Plexiglass chambers, 3.4 litre capacity, were positioned on the sediment by scuba divers. One experimental and one dark control chamber were used at each station. Sodium carbonate (500 μ Ci) was injected through a serum stopper into the chamber and incubation continued for 4 hours. At the end of the incubation period the chambers were carefully removed from the sediment and 6 cores taken of the benthic algae. The samples were frozen immediately and transported to the laboratory for analysis by the nitric acid extraction method of Van Raalte et al. (1974). Organic compounds extracted by this method were diluted in 0.75 m tris buffer to reduce quenching. Counting of ^{14}C lebelled compounds was done on a liquid scintillation spectrophotometer. Extrapolation to daily production was obtained by calculating the solar radiation during the experiment and comparing it to the total daily radiation.

For the enumeration of meiofauna, three plastic core tubes (2.8 cm inside diameter) were pushed into the mud at the shallow stations by scuba divers, sealed with rubber corks and transported back to the lab. The top 1 cm of each replicate was preserved in a solution of 10% formalin containing rose bengal, and counted after a series of washings and decantations through a 44 μ seive. All the animals present were counted and the harpacticoid copepods were retained for further identification.

All zooplankton samples were caught in Miller plankton samplers having a mouth opening of 0.01 m^2 and a mesh size of 351 μ towed just below the surface at a speed of 1.5 m/sec. Tows were of 5 min duration and therefore the calculated volume sampled in each tow was 4.5 m^2. Two Miller nets were used alternately and one net washed down while the other net was sampling so that there was continuous sampling along the cruise path shown in Fig. 2. Samples were counted in the laboratory in a counting chamber with a dissecting microscope (Table 6). Usually the total sample was examined but when samples were especially large (e.g., Station No. 53) they were divided in 1/2 or 1/4 using a Folsom plankton splitter.

RESULTS AND DISCUSSION

The temperature and phosphate over the mud flats were generally higher and the salinity lower than the open surface water and beach area (Table 1). High chlorophyll in the surface waters occurred at the three beach stations (1, 2 and 3) while the ATP was high at the surface at stations 9, 10 and 11 (Table 1). The autotrophic production in the water over the flats was generally lower than in the open water [stations 9, 10 and 11 (Table 2)]. The highest autotrophic activity occurred at station 10 peaking at 3 m depth. The autotrophic activity at station 10 from 0 to 5 m depth was higher than at any other station at any depth. Stations 4 and 6 had the highest heterotrophic activity of the mud flat but were still below the heterotrophic activity present at the open water stations (Table 2). Heterotrophic activity peaked at station 10 and 11 at 0 m depth. The integrated autotrophic production for stations 9, 10 and 11 are 2,460, 6,262 and 2,438 mg C m^{-2} day^{-1} to 20 m depth. These rates are much higher than those reported by Stephens et al. (1969) for the Strait of Georgia. Fig. 3, 4, and 5 salinity profiles show that the open water stations are well mixed so that the high productivity rates can be attributed to a good supply of nutrients.

The greatest number of harpacticoids occurred at stations 1 and 3 (beach area) while the nematodes were high over most of the estuary and beach area (Table 3). Station 4 had the highest numbers of animals followed by stations 1, 8 and 2.

Large differences in harpacticoid distribution are obvious between the seven stations sampled (Fig. 6). The percent gravid females at each station varied from 4% at station 6 to 18% at station 4. Species distribution over the flats and beach area cannot be dismissed as a possible explanation for this difference. Further analysis would be necessary to determine the species composition. The overall variation in total numbers shows some relationship to the sediments which were coarse and gravelly at station 2, semi-sandy at 1 and 3 and very silty at station 6. This is reflected in the dry weights of the sediments (Table 4). Interstitial spaces would be smallest at station 6 where the fewest animals were found. A sandy environment, such as at stations 1 and 3, appears to be most suitable for the harpacticóid copepods. There is an inverse relationship between density of harpacticoids and measures of chlorophyll and heterotrophic activity are high (stations 6, 7, 8), while at stations 1 and 3 the reverse occurs (Table 4).

The stations for the zooplankton Miller net tows are shown in Fig. 2. The 5-min. surface tow with the Miller net was chosen because it was the net haul used in a more extensive 6-mo. survey of the Nanaimo River estuary and surrounding nearshore environment. The Nanaimo environment was sampled immediately before and after the Cowichan survey so that a comparison could be made between the two systems. The Nanaimo samples were taken at specific stations and not in continuous transects and therefore do not show the gross patchiness which is evident in the Cowichan series, e.g., station 42 to station 58 show a large patch of Oikopleura (C 71) (Table 5) 7,200 m long on the dimension sampled and station 42 to station 54 show a patch of Podon sp. 5,400 m long (Table 6). It is also evident that the Cowichan system is more favourable to decapods and the larval decapods (YH 1) again show up in patches.

In general the Cowichan Bay samples were quite similar to Nanaimo River estuary zooplankton samples and especially similar to those samples taken at sheltered stations. The two most common copepods Acartia (SBO) and Centropages (SMO) were present in nearly all stations sampled except for those stations which were exposed in the Strait of Georgia. The zooplankton fauna of Cowichan Bay was considered to be typical for a protected estuarine habitat in mid summer.

LITERATURE CITED

Biggs, W. W., A. R. Edison, J. D. Eastin, K. W. Brown, J. W. Maranville and M. O. Clegg. 1971. Photosynthesis light sensor and meter. Ecology 52: 125-131.

Holm-Hansen, O. and C. R. Booth. 1966. The measurement of adenosine triphosphate in the ocean and its ecological significance. Limnol. Oceanogr. Vol. 11: 510-519.

Sibert, J. and T. J. Brown. 1975. Characteristics and potential significance of heterotrophic activity in a polluted fjord estuary. J. Exp. Mar. Biol. Ecol. 19: 97-104.

Stephens, K., J. D. Fulton, and O. D. Kennedy. 1969. Summary of biological oceanographic observations in the Strait of Georgia, 1965-1958. Fish. Res. Board Can. Tech. Rep. 110.

Strickland, J. D. H. and T. R. Parsons. 1968. A practical handbook of seawater analysis. Bull. Fish. Res. Board Can. No. 167: 311 pp.

Van Raalte, C., W. C. Stewart, and I. Valiela. 1974. A ^{14}C technique for measuring algal productivity in salt marsh muds. Bot. Mar. Vol. 17: 186-188.

Table 1. Physical and chemical characteristics of water samples.

Station	Secchi m	Depth m	Sal. ‰	Temp. C	NO_3 µg at/ℓ	PO_4 µg at/ℓ	O_2 mg at/ℓ	ATP ug/ℓ	Chl a µg/ℓ	Phaeo. µg/ℓ
1		0	28.83	13.15	4.6	0.97	0.517	0.474	10.34	7.14
		1	29.11	12.05						
2		0	29.00	13.02	1.1	0.80	0.638	0.565	13.16	7.14
		0.5	29.00	12.83						
3		0	26.64	14.80	4.5	1.50	0.586	0.618	18.33	9.87
		1	29.00	12.54						
4		0	25.08	15.80	1.5	1.40	0.478	0.331	3.21	3.92
6		0	12.62	16.33	0.3	1.13	0.481	0.119	2.16	3.88
7		0	23.58	15.33	1.0	1.75	0.432	0.067	1.79	1.62
		1	28.67	14.13						
8		0	26.61	15.73	1.7	1.21	0.498	0.426	8.46	5.07
		1	29.00	13.11						
9	3	0	28.21	13.05	5.1	0.66	-	1.663	5.40	3.05
		1	29.27	11.97	0.3	0.60	-	1.514	19.27	7.80
		3	29.63	11.81	4.5	0.92	-	1.578	13.39	6.62
		5	29.63	11.23	1.8	0.74	-	1.880	30.40	15.68
		10	30.00	11.23	13.3	1.60	-	0.383	7.99	3.29
		20	30.00	10.62	14.3	1.74	-	0.424	6.58	4.13

Table 1. (cont'd)

Station	Secchi m	Depth m	Sal. ‰	Temp. C	NO_3 μg at/ℓ	PO_4 μg at/ℓ	O_2 mg at/ℓ	ATP ug/ℓ	Chl a μg/ℓ	Phaeo. μg/ℓ
10	3.5	0	27.03	13.62	0.5	0.56	-	1.720	10.81	4.98
		1	28.69	13.53	0.6	0.65	-	1.810	16.92	10.15
		3	29.15	11.79	2.2	0.69	-	2.152	27.20	12.16
		5	29.21	11.32	4.4	0.90	-	1.390	29.60	16.41
		10	29.53	11.27	10.4	1.41	-	0.561	10.10	5.40
		20	30.20	9.93	17.6	2.00	-	0.151	0.99	1.01
11	5	0	26.29	13.22	1.6	0.64	-	0.735	6.34	3.24
		1	28.31	13.13	1.6	0.61	-	1.040	10.57	5.78
		3	29.24	12.53	2.5	0.75	-	1.234	11.98	6.06
		5	29.76	11.13	12.0	1.34	-	0.417	6.11	2.91
		10	29.96	10.43	15.3	1.79	-	0.410	1.24	1.15

Table 2. Autotrophic and heterotrophic activity of water samples.

Station		Autotrophic activity			Heterotrophic activity		
		prod./hr mg $C/m^3/hr$	prod./day mg $C/m^3/day$	Vr hr^{-1}	Vp hr^{-1}	Y	Vt hr^{-1}
1		17.501	165.41	0.0105	0.0177	0.628	0.0282
2		26.969	254.90	0.0191	0.0399	0.676	0.0590
3		34.801	328.92	0.0178	0.0555	0.757	0.0738
4		3.705	35.01	0.0321	0.1104	0.775	0.1425
6		3.253	30.74	0.0524	0.1602	0.754	0.2126
7		3.403	32.16	0.0367	0.0460	0.556	0.0827
8		17.511	165.50	0.0220	0.0217	0.497	0.0437
9	0 m	15.668	164.55	0.1546	0.1287	0.454	0.2833
	1	32.905	345.57	0.1255	0.1617	0.563	0.2872
	3	25.085	263.45	0.0614	0.0833	0.576	0.1447
	5	23.739	249.31	0.0556	0.0946	0.630	0.1502
	10	5.548	58.26	0.0267	0.0396	0.597	0.0663
	20	0.438	4.60	0.0180	0.0273	0.603	0.0453
10	0 m	67.858	712.66	0.1908	0.1920	0.502	0.3828
	1	75.476	792.67	0.1393	0.1699	0.549	0.3092
	3	99.118	1040.90	0.0519	0.0603	0.537	0.1122
	5	51.766	543.66	0.0509	0.0541	0.515	0.1050
	10	9.171	96.31	0.0401	0.0416	0.509	0.0817
	20	0.194	2.03	0.0093	0.0070	0.429	0.0163
11	0 m	20.181	211.94	0.1817	0.2097	0.536	0.3914
	1	21.423	224.99	0.0927	0.1294	0.583	0.2221
	3	18.919	198.69	0.0477	0.0581	0.565	0.1028
	5	22.814	239.59	0.0408	0.0569	0.582	0.0977
	10	8.362	87.82	0.0200	0.0207	0.509	0.0407
	20	1.900	19.95	0.0095	0.0095	0.500	0.0190

$$Vr = \frac{\ell r}{L \cdot t}$$

$$Vp = \frac{\ell p}{L \cdot t}$$

$$Vt = \frac{\ell r + \ell p}{L \cdot t}$$

$$Y = \frac{\ell p}{\ell p + \ell r}$$

ℓr = DPM respired
ℓp = DPM particulate
L = DPM added
t = Incubation time

Table 3. Results of meiofauna counts; numbers of animals per 10 cm^2 (3 replicate cores).

	Mean ± SE per station						
Animal	1	2	3	4	6	7	8
Harpacticoid	896 ± 126	316 ± 172	889 ± 176	367 ± 112	28 ± 13	279 ± 81	336 ± 64
Harpacticoid and eggs	82 ± 21	49 ± 27	75 ± 16	67 ± 24	1 ± 1	30 ± 19	43 ± 9
Nauplii	125 ± 23	458 ± 340	485 ± 240	336 ± 267	52 ± 37	260 ± 69	329 ± 133
Nematod	1595 ± 310	1319 ± 347	540 ± 170	1943 ± 858	1065 ± 790	551 ± 118	1580 ± 312
Worms	97 ± 44	146 ± 47	66 ± 16	263 ± 53	24 ± 5	128 ± 60	224 ± 20
Amphipod	15 ± 11	17 ± 11	-	1 ± 1	-	5 ± 3	25 ± 4
Cumacean	31 ± 17	4 ± 4	6 ± 1	-	-	2 ± 1	31 ± 17
Ostracod	25 ± 12	20 ± 7	1 ± 1	3 ± 2	1 ± 1	6 ± 4	24 ± 7
Eggs	8 ± 8	-	-	-	-	-	-
Bivalves	-	1 ± 1	1 ± 1	-	-	-	-
Ectroprocta	-	1 ± 1	1 ± 1	-	-	-	7 ± 4
Insects	-	-	-	-	4 ± 4	-	-
Acarina	-	1 ± 1	-	-	-	1 ± 1	-
Tanadacean	-	-	-	1 ± 1	-	-	-
Thalassinidea	-	1 ± 1	-	-	-	-	-
Total animals	2,874	2,333	2,064	2,981	1,175	1,262	2,599

Table 4. Biochemical characteristics and activity of sediment samples.

Station	Chl µg/ml	ATP µg/ml	Dry weight gm/ml	Heterotrophic activity				Autotrophic activity mgC/m^2/day ± SD
				Y	Vr	Vp	Vt	
1	0.742	0.467	1.503	0.779	0.0275	0.0967	0.1242	-
2	1.396	0.342	1.760	0.803	0.0248	0.1011	0.1259	-
3	0.450	0.607	1.450	0.797	0.0190	0.0746	0.0936	-
4	2.230	0.068	1.423	0.775	0.0321	0.1104	0.1425	10 ± 3
6	5.617	0.140	1.031	0.697	0.0457	0.1053	0.1510	152 ± 56
7	0.990	0.032	1.366	0.803	0.0334	0.1361	0.1695	121 ± 60
8	5.318	0.037	1.219	0.763	0.0579	0.1859	0.2438	-

Table 5. Key to zooplankton code used in Table 6.

PA3	-	Medusae gen.
PRO	-	Polychaete gen.
PIO	-	Pleurobrachia sp.
REO	-	Cladocera gen.
RF2	-	Podon sp.
RQO	-	Pseudocalanus sp.
RNO	-	Calanus plumchrus
RMO	-	C. marshallae
SBO	-	Acartia sp.
SMO	-	Centropages sp.
SWO	-	Eurytemora sp.
UYO	-	Harpacticoid gen.
UGO	-	Epilabidocera sp.
VY1	-	Barnacle nauplii
WUO	-	Gammarid amphipods
XG9	-	Parathemisto sp.
XS1	-	Decapod zoea
XG5	-	Hyperoche sp.
YH1	-	Larval decapods
C71	-	Oikopleura sp.

Table 6. Species of zooplankton #/10 m^3.

Stn.	PA3	PRO	PIO	REO	RF2	RQO	RNO	RMO	SBO	SMO	SWO	UYO	UGO	VY1	WUO	XG5	XG9	XS1	YH1	C71
1	18		4	18	59				26	7	7	7				2			238	2
2	7	4		4	18	2			15	7									176	
3	20		2	9	20	4			24	2	7					9			99	
4	57		4	13	11	4			18	4	11					9	9		70	
5	53		11	18	4	35			2		2					4			35	2
6	9		7	9	9		18		70								9		26	9
7	18		35	18	88	176	35		53							35			35	53
8	53			53	141		18		176		18						35		18	158
9	18		18		18	53	187		18				18				18		106	53
10	18		18		53	282	35		35				18				264		123	53
11	35		35		18	35	18		18	18							70		53	70
12				35	18	158				70	35						18		53	70
13			18	53	53	53			123										35	140
14				70	123	53			88	35									158	123
15				35	282	35			176										70	140
16				35	563				141										141	
17					332	18			123											106
18		18			88	880			105				35		106		35		88	18
19						106		18	123	53	18									141
20					105				106						18					88
21									18	18			18						70	70
22	18	70	18	53					53	106					18				123	53
23	9	70		53					35	88		35						18	229	53
24	35		35	35	35					70									194	35
25	35	53			35			18	35			18							141	70
26				53	18				106			18							158	194
27		26	26	44					44	9									88	79
28	26			28					8	40		4					4	4	79	30
29	12		2	18	9				57	42		4						4	103	11
30	4		2	33		2			53	9				8				2	66	26
31	11			59					44	40				4				2	22	35
32	48	2		59		11			31	106				20					77	22
33				9		112		18	26	152							9		18	35
34	20					2			2	20				11					53	24

Table 6 (cont'd)

Stn.	PA3	PRO	PIO	REO	RF2	RQO	RNO	RMO	SBO	SMO	SWO	UYO	UGO	VY1	WUO	XG5	XG9	XS1	YH1	C71
35	20			9		7			11	31				13					44	18
36	44			9					26	18				9					18	35
37					53				9	35		9							18	88
38	9	9		26	39				26	35									26	132
39		9		4					66			9		9				4	13	22
40		35		13					172	4		12		4	40		9		18	
41		18		18					70	18					18				141	53
42	18	35		18	53				53	53	18					35			70	299
43		53		35	194					88		18		229					35	264
44	53	88		88	352				39					106			35		35	194
45	35	35			158				53					53			18		18	352
46	18			35	440				88	44				26			18		61	475
47	211		2		1078				35	18				950	2		4	22	53	3009
48	53	158			1003				163			2		475					18	4488
49	158	158			158				106	18				348			4	4	44	3379
50	4	4	4	18	185		2		31	31		31		9	18	4	4		26	44
51					334				35	18						18				141
52	88		18		176	18			53	88				106		35	18		299	493
53	106		211		317			211	211	18			2	528			2	4752	106	6230
54		158	2		53			106	158	229			53	317			15	1690	194	3115
55		53	18					53	264	440			211	634			4	2218	123	3326
56	53		11						106	581			211	528				1742	246	2746
57		53	53						106	281			158					299	18	2481
58										1038				53					1108	264
59			9							272								18	112	9
60				9						202		9							44	9
61				4					2	57		2						2	61	4
62	18									70									26	9
63	79			18	53					141									18	70
64					106				18	70									70	141
65				35	35					70				70				35	475	194
66		18		18	18	18								176					246	334
67	18	35	35		106				35	194				53		18		35	1179	405
68	18	18		18	141					106									264	317

Table 6 (cont'd)

Stn.	PA3	PRO	PIO	REO	RF2	RQO	RNO	RMO	SBO	SMO	SWO	UYO	UGO	VY1	WUO	XG5	XG9	XS1	YH1	C71
69	18			18	334					156				35					246	229
70		35		35	493	18			70	88				123	18		88			370
71	70	106	18	53						18		18		176			18		176	387
72	141	18		35	246				88					53		35		35	246	440
73			12	6	37	15		11	2	42				7		11			37	4
74	20		24	4	11	4		4	4	46						7	4	2	9	7
75	20		53	4	22	4		2	2	40							4			11
76	26		11	7	7			2		77						13	4		7	4
77	9				66	4			9	119						48			4	13
78		2		7	24				15	4		13				13			2	2
79	15		26	2	15				2	51				2		2	7		4	
80			9	53	61				18	114		9							4	40
81	35	4	9		44	13				198		4						4	101	9
82	35		18	9	35	18				97							9	9	229	35
83	70			106		35	18		53	282		18		18			53		264	141
84	70		18	35	18				88	194									106	158
85	18		35	88				35	18	158		53					18		246	158
86	158	53	80	211					18	862				18			53		669	422
87	35		18		18					422		18		88			35		1056	141
88	53			35						299		18		18			18	53	422	141

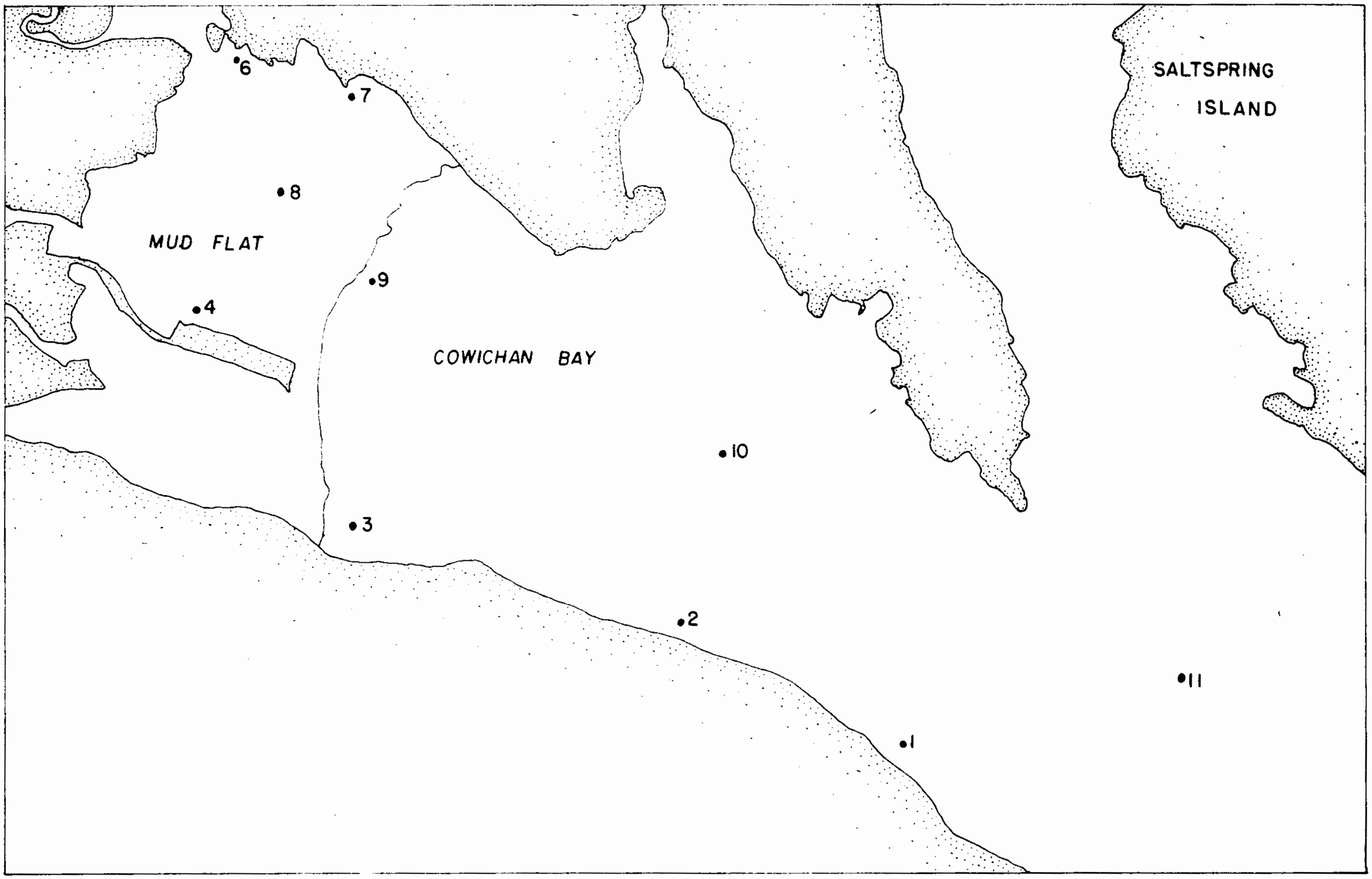

Figure 1. Cowichan Bay showing locations of sediment and water sampling stations.

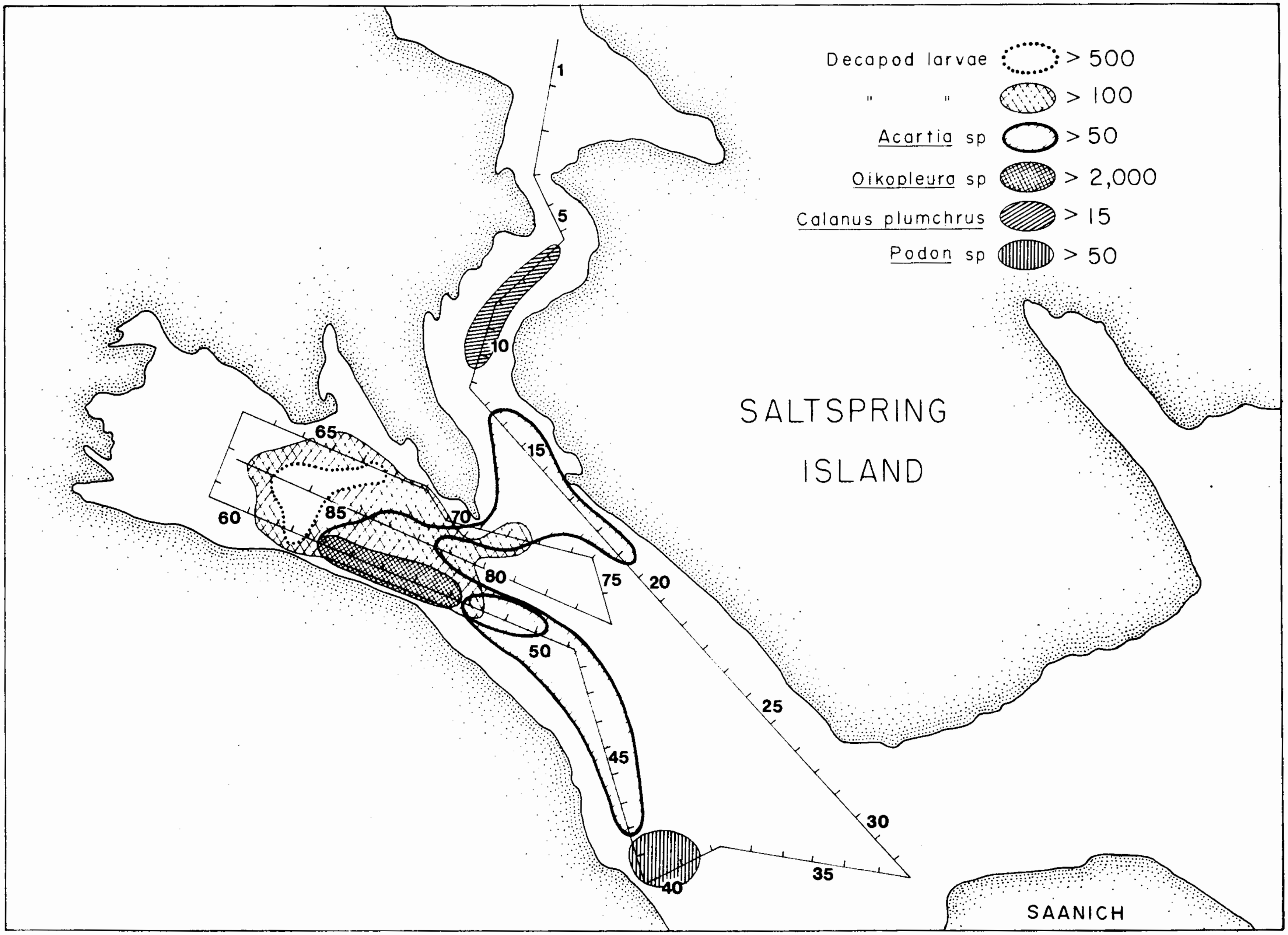

Figure 2. Cowichan Bay and adjacent waters showing the ship's track for zooplankton sampling and the distribution of major zooplankton patches.

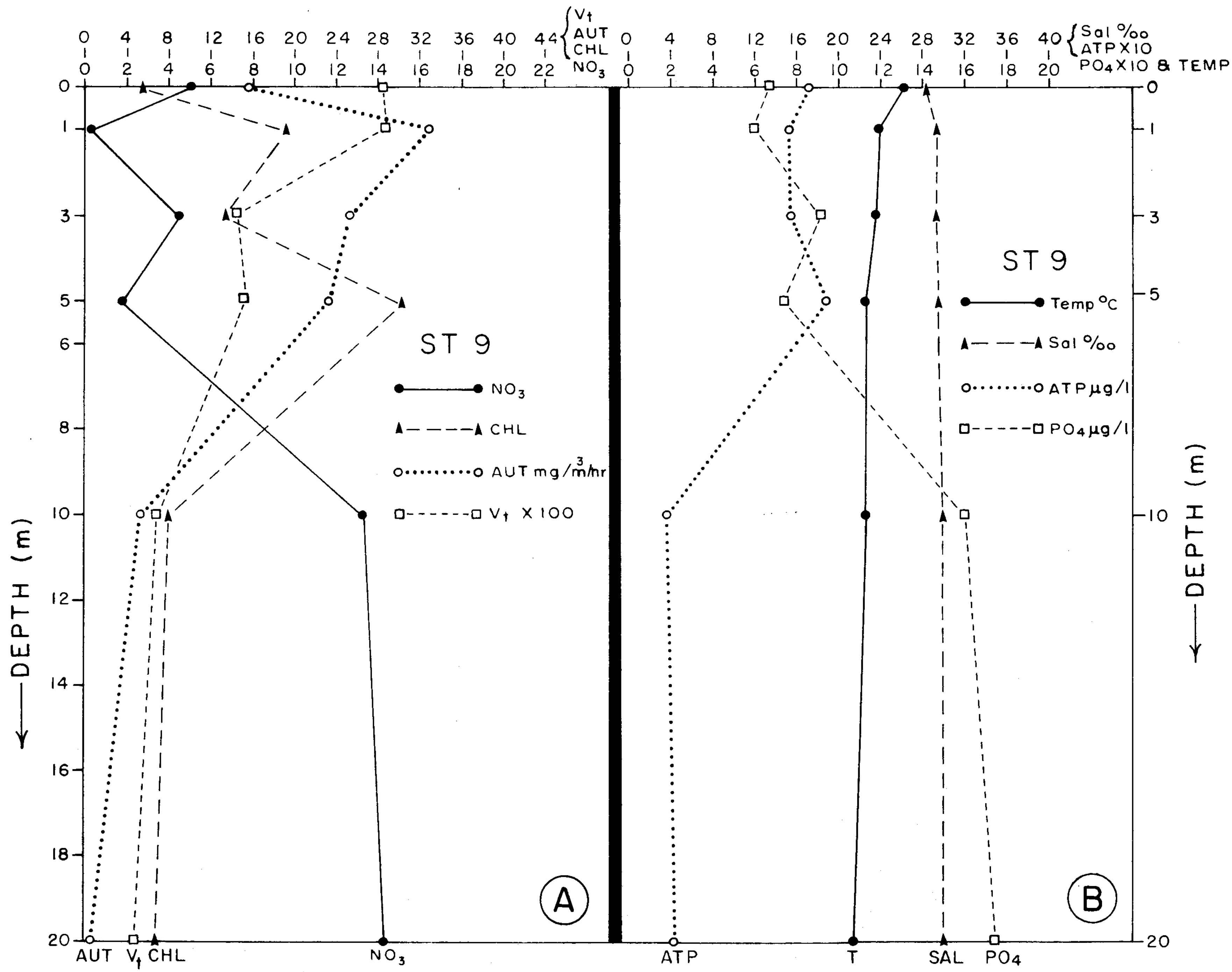

Figure 3. Vertical distribution of properties at Station 9.

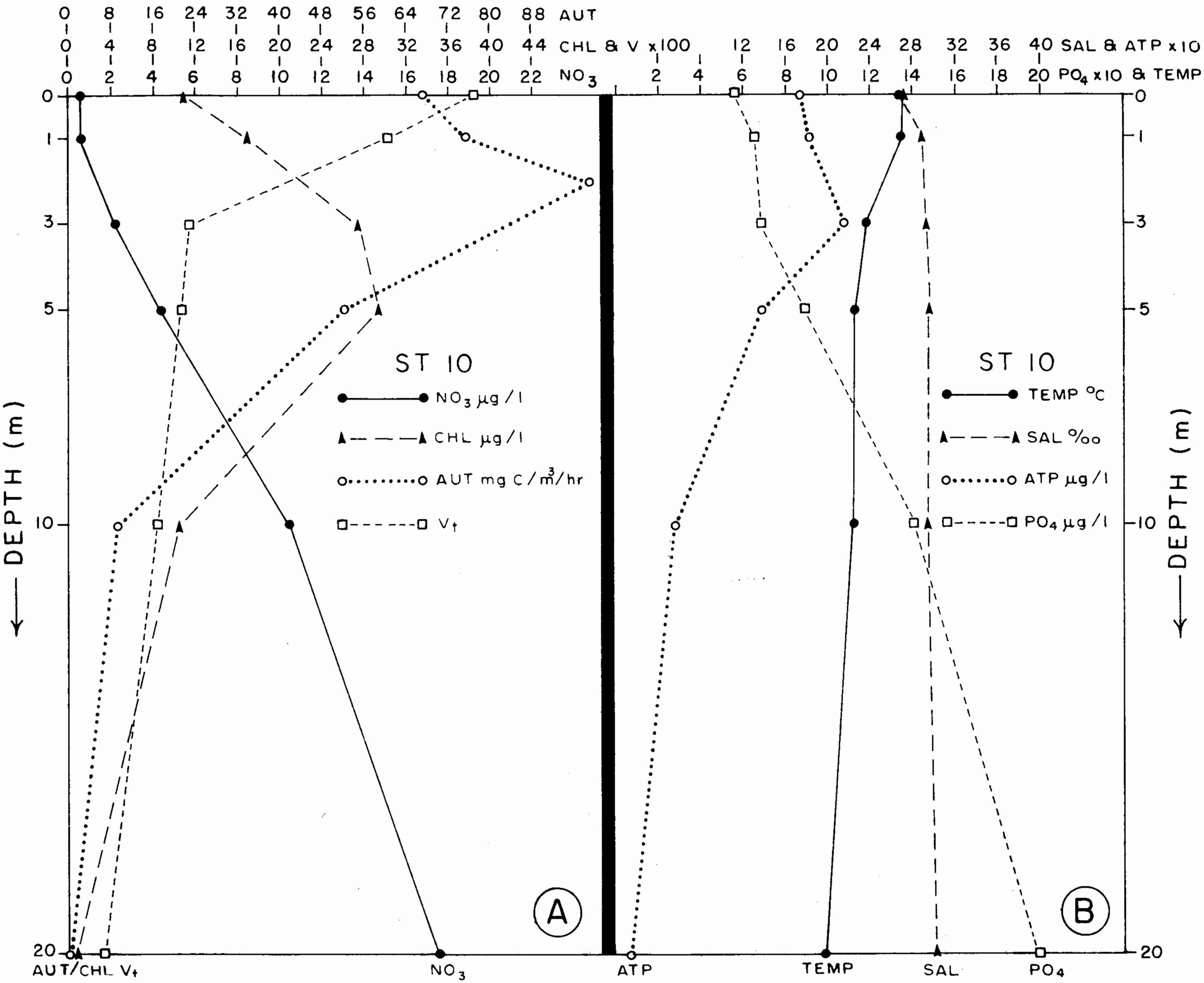

Figure 4. Vertical distribution of properties at Station 10.

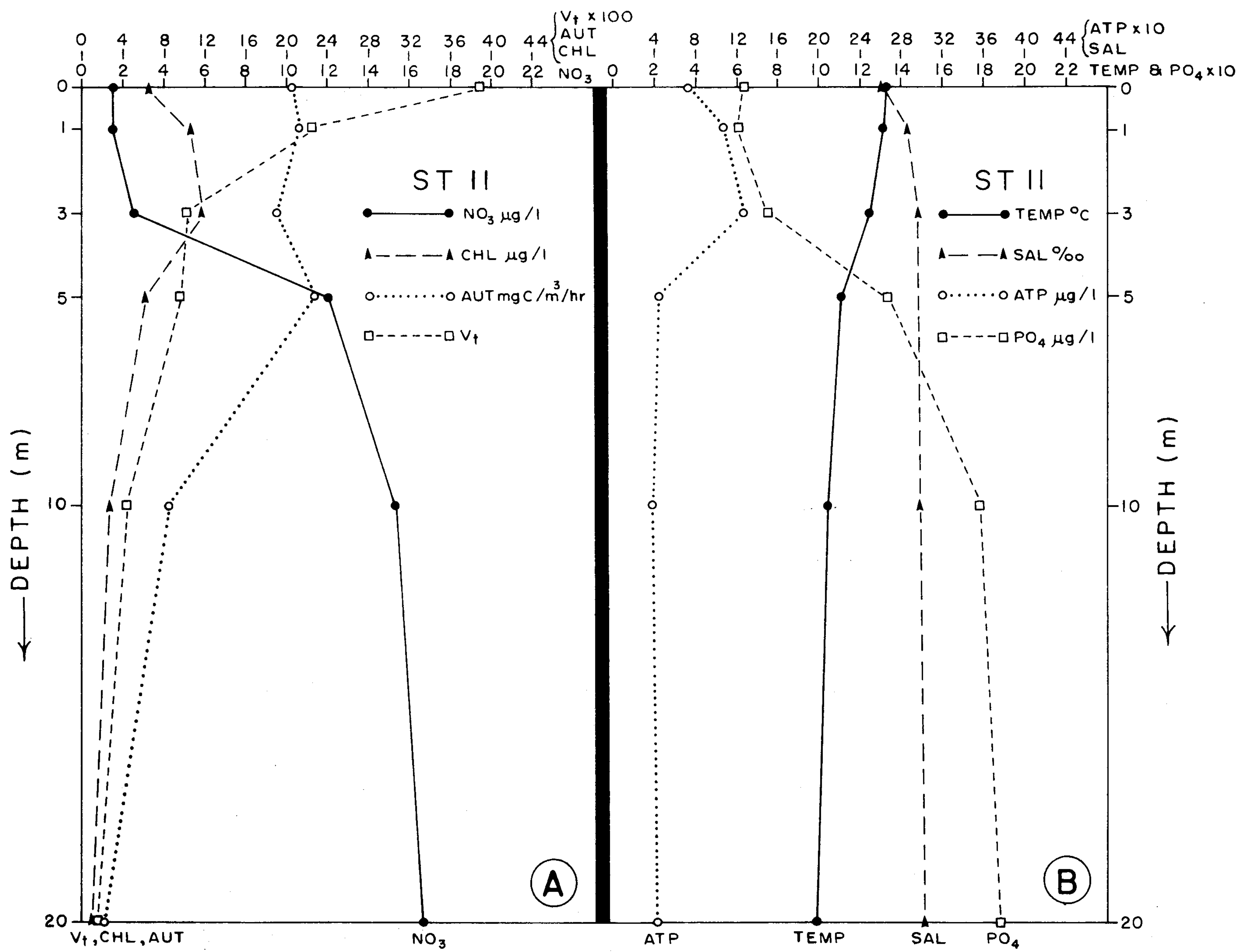

Figure 5. Vertical distribution of properties at Station 11.

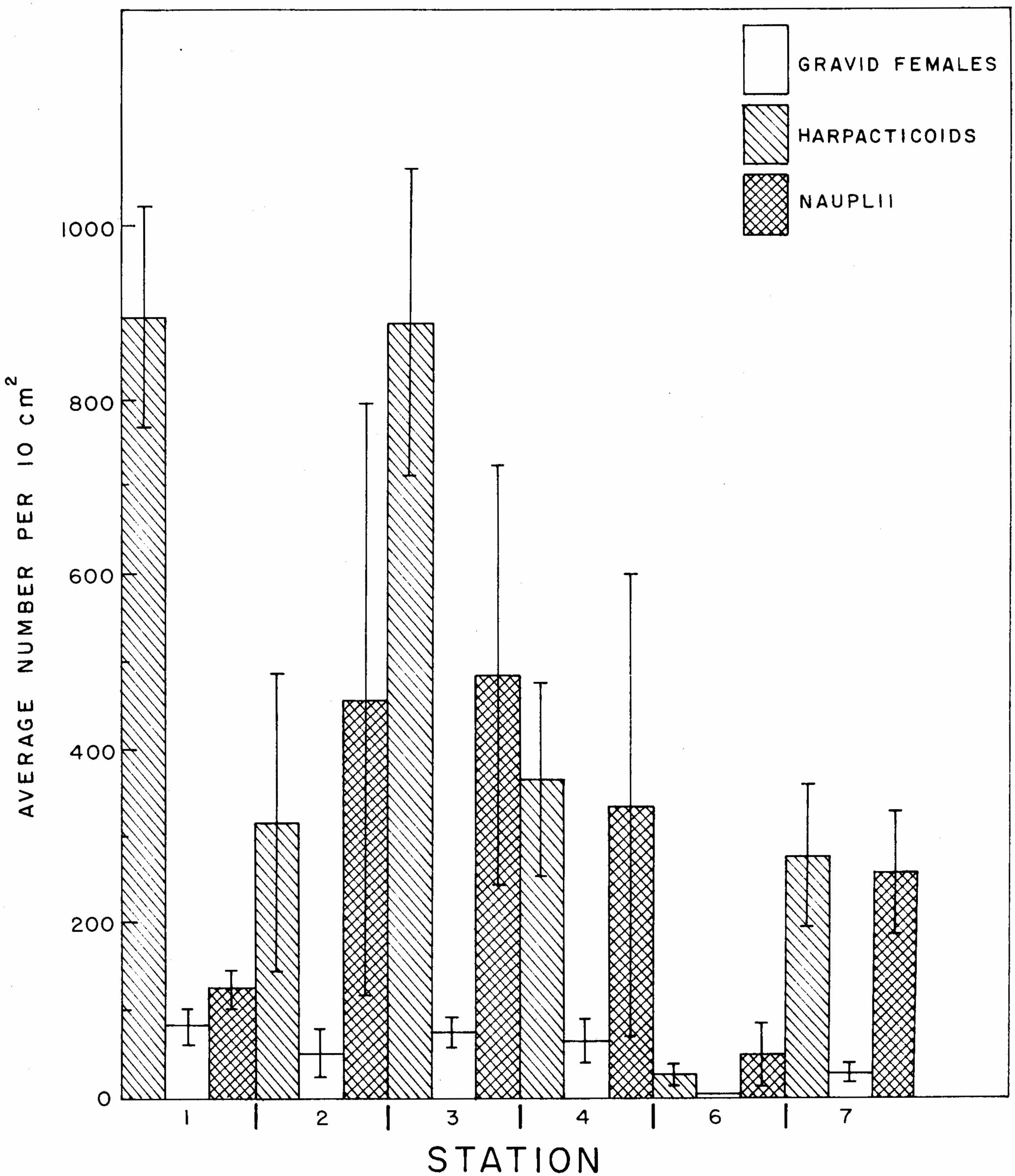

Figure 6. Abundance of harpacticoid copepods in sediment cores. Bars indicate one standard error on either side of the mean.