Notes on the distribution of organic nitrogen in the seabottom of the Danish Waddensea

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Determination of organic nitrogen in the seabottom of a tidal area along the coast of western Denmark has been performed at bi-weekly intervals throughout one year. Temperatures, salinities and some environmental factors affecting intertidal communities have been noted; grain size determinations have been performed on a selected number of samples.

Introduction

Attempting to estimate the food available to the lugworm Arenicola marina (L.) an annual survey of the distribution of organic nitrogen in the seabottom of the Danish Waddensea has been completed. Since it is felt that the results already obtained could be of interest to other workers on intertidal ecology and pollution research the results are published as mere raw data with some comments on the area examined.

Location and methods

From May 1968 to April 1969 three positions were visited every second week provided weather conditions would permit.

Table 1. The amount of organic nitrogen (μg N/ g substrate) in vertical cores at Skallingen 1968/69.

Station 1 1968

cm	2/5	16/5	30/5	10/6	27/6	11/7	27/7	8/8	22/8	5/9	20/9	4/10	31/10	28/11
0–1	482 445 408	291 292 293	235 236 237	406 538 669	126 128 130	186 185 184	256 239 222	341 298 254	665 598 531	550 509 468	287 280 272	365 360 354	330 334 337	445 441 436
1–2	231 271 311	246 297 347	215 214 212	389 323 257	113 121 128	191 196 201	241 249 257	224 255 285	576 532 488	344 305 265	270 269 267	272 274 276	291 290 289	283 305 326
2–3	224 219 213	252 240 227	210 235 259	438 366 294	113 111 108	187 187 186	245 251 257	241 238 234	343 338 333	281 272 262	265 259 252	291 287 282	271 272 272	297 319 340
3–4	174 170 165	259 267 275	239 240 241	408 352 296	102 104 106	230 229 228	235 241 247	288 263 237	300 314 328	258 264 269	203 207 211	316 318 319	290 290 290	295 293 290
4–5	160 167 173	226 225 223	197 193 189	361 347 333	102 101 100	273 273 272	227 229 231	279 265 250	315 311 306	238 239 239	287 293 298	248 251 254	248 255 262	256 257 258
5–6	160 155 150	224 257 290	209 205 201	275 265 255	90 93 95	275 274 273	311 284 257	236 231 226	271 274 276	259 253 246	255 258 260	318 314 310	249 245 241	252 257 262
6–7	153 145 137	224 221 218	212 216 220	239 239	95 96 97	253 247 240	232 226 219	262 242 222	270 406 542	270 263 256	262 331 400	284 291 297	202 202	244 245 246
7–8	183 181 179	197 188 178	207 213 218	207 221 235	114 109 103	243 237 230	180 194 208	310 320 330	243 252 260	330 312 294	209 206 202	247 247 246	223 225 227	231 238 244
8–9	187 187 186	182 176 170	173 171 168	208 226 244	115 117 118	240 241 241	227 227	271 268 264	218 220 221	251 244 237	185 179 173	263 256 248	189 195 200	227 228 228
9–10	220 244 268	153 157 161	173 171 169	192 198 204	144 149 154	250 247 244	193 196 199	221 219 216	219 228 237	245 242 238	206 209 211	273 274 274	216 217 217	231 233 234
15	160 173 186	292 296 300	252 256 259		231 228 224			534 521 507						

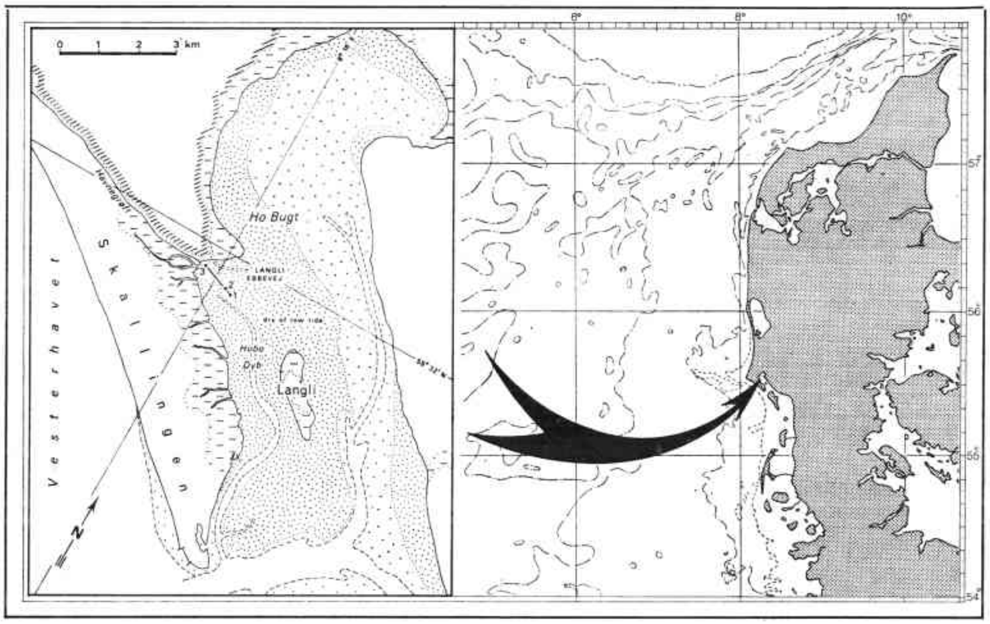

Fig. 1.
Map showing the locality.

1969

10/1	23/1	7/2	25/2	7/3	21/3	17/4
						228 239 249
						172 158 144
						183 193 203
						127 131 134
						134 133 131
						136 135 133
						138 136 134
						147 144 140
						150 146 141
						126 127 127
						126 121 166

The stations were situated in the northernmost part of the Northeuropean Waddensea (fig. 1) in a tidal area, which was studied earlier (*Jacobsen* 1967). They were chosen where lugworms are abundant viz. 20–40 per m^2 and with a percentage of submersion of 100, 60 and 15 at station no. 1, 2 and 3 respectively. As an extensive commercial digging for lugworms (for bait) takes place in the Waddensea, it was ascertained that no such digging took place nearer than 30 meters from each fixpoint.

At station no. 1 ripple marks were very abundant. Station no. 2 was situated on a sandy bar near a tidal gully (priel). Ripple marks were less abundant than at station no. 1. The innermost station (no. 3) was situated near the outflow of a smaller gully and no ripple marks were noted. At all three stations occasionally large brownish areas covered by assimilation-bubbles revealed the abundance of diatoms.

From the middle of December 1968 to mid-January 1969 and from the middle of February to the late part of March 1969 the area was icecovered in a varying degree. The thickness of the ice at station 3 reached up to 10 cm. Also packing of the ice took place to some extent at this station. For security reasons, only station 3 was visited during the iceperiod.

Collecting and chemical treatment of the bottom samples followed the procedure described earlier (*Jacobsen* 1967) the only alteration being, that the samples after being dried at 105° C, were kept at –20° C until analysed. To determine the surface salinity, water samples were taken at the stations at ebb tide by collecting sub-

Station 2 1968

cm	2/5	16/5	30/5	10/6	27/6	11/7	27/7	8/8	22/8	5/9	20/9	4/10	31/10	28/11
0–1	129 127 125	157 165 172	155 151 146	191 192 192	121 130 138	165 163 161	174 172 169	237 234 231	289 288 286	239 248 256	225 232 239	206 216 225	258 265 272	
1–2	86 85 84	109 134 158	109 106 102	136 148 160	166 159 152	135 137 139	135 137 138	141 139 137	260 246 231	165 163 161	176 184 188	178 194 209	156 158 160	
2–3	121 122 123	76 78 79	112 116 120	127 129 130	124 127 129	188 164 140	141 135 129	180 175 169	127 131 135	159 159 158	181 176 170	151 146 141	145 140 134	
3–4	131 135 138	82 82 81	118 118 117	154 166 173	 154 154	215 219 222	148 146 143	150 172 193	165 161 157	175 174 172	144 147 150	117 115 112	129 130 130	
4–5	126 131 136	102 104 106	92 100 108	132 130 128	155 155 155	126 124 122	134 132 130	143 141 138	147 144 140	161 158 155	141 144 146	105 107 108	122 123 124	
5–6	111 113 115	109 116 123	118 117 115	135 137 138	165 174 183	117 119 121	125 132 138	124 123 122	150 151 152	152 154 155	117 120 123	94 95 95	133 133 133	
6–7	106 104 111	135 136 137	126 124 122	144 136 127	188 183 178	136 143 149	134 139 144	133 132 131	171 170 169	166 166 165	120 124 127	118 113 107	133 135 137	
7–8	79 80 80	125 121 116	141 142 143	143 143 143	152 153 154	146 140 134	141 133 124	153 147 141	159 159 159	170 167 163	133 129 124	121 123 125	130 130 130	
8–9	70 72 74	80 80 80	129 132 134	158 155 151	128 133 137	138 133 128	115 115 114	143 145 146	143 138 133	120 134 148	117 122 126	134 135 136	110 112 114	
9–10	56 56 55	99 96 92	110 108 106	143 142 141	129 128 126	125 126 127	105 107 108	138 138 137	124 127 129	135 129 122	111 114 117	115 126 137	112 111 109	
15	47 50 52	77 82 86	146 142 137	95 95 94	88 90 92	91 95 98	101 88 75	86 90 94	90 91 91	103 106 109	94 90 85	96 94 92	85 90 95	

Station 3 1968

cm	2/5	16/5	30/5	10/6	27/6	11/7	27/7	8/8	22/8	5/9	20/9	4/10	31/10	28/11
0–1	475 616 734	609 613 616	628 592 556	542 538 533	397 402 407	 369 369	379 380 380	384 389 374	564 535 506	477 470 462	282 281 279	528 584 639	335 346 357	330 315 300
1–2	443 448 452	453 461 468	412 411 410	447 446 444	428 430 431	294 285 275	344 348 351	315 308 300	399 380 361	455 455 455	253 253 253	439 432 425	300 300 	241 251 260
2–3	478 474 470	356 367 377	429 433 437	409 408 407	403 396 389	383 387 390	526 530 534	252 255 257	294 301 307	573 564 556	253 248 242	415 407 398	475 458 441	217 223 228
3–4	391 389 387	438 328 418	412 407 401	390 402 414	361 370 379	321 319 316	440 438 435	225 230 235	357 352 346	522 551 579	246 243 239	303 307 311	323 319 314	228 231 234
4–5	285 288 291	359 368 376	376 369 362	382 384 385	358 359 359	296 291 286	372 364 355	218 225 231	345 354 363	397 382 376	242 249 255	205 265 263	246 239 244	253 255 259
5–6	220 226 232	290 294 298	362 365 368	368 358 348	332 337 341	307 308 309	344 348 351	221 218 215	345 346 347	397 397 397	242 243 244	205 210 215	246 246 246	253 255 256
6–7	190 192 193	215 203 190	310 315 319	308 309 310	318 316 313	279 275 270	334 330 326	203 197 186	249 251 252	347 349 351	293 296 298	177 179 180	230 229 228	213 219 225
7–8	128 122 115	178 181 183	233 228 223	204 208 212	259 264 268	208 197 185	268 269 270	195 189 183	284 273 262	244 242 240	256 251 246	168 164 159	189 181 173	236 236 235
8–9	113 116 119	147 157 166	190 192 193	170 166 161	196 200 204	204 203 202	228 229 229	165 163 160	204 202 200	221 223 224	255 254 253	157 155 152	151 155 158	189 195 200
9–10	114 112 110	163 170 177	172 173 174	131 131 130	167 164 160	193 194 194	190 187 183	154 153 152	184 180 175	224 227 229	227 231 234	164 159 154	151 153 154	209 215 220
15	83 84 85	109 117 125	162 148 134	133 132 132	166 167 167	128 132 135	130 130 130	122 122 122	115 116 117		191 192 192	140 140 140	161 156 151	148 146 144

1969

10/1	23/1	7/2	25/2	7/3	21/3	17/4
						165 176 187
						137 134 130
						117 116 115
						110 110 109
						112 111 110
						97 98 98
						91 95 98
						126 107 88
						94 97 99
						81 85 88
						128 128 127

1969

10/1	23/1	7/2	25/2	7/3	21/3	17/4
668 541 415	347 331 315	518 507 495	 515 515	340 326 311	216 213 209	1007 974 941
593 575 556	332 324 316	567 559 550	393 417 441	273 270 267	211 187 172	793 774 755
515 520 524	295 312 329	518 579 640	414 421 427	221 246 271	249 231 213	657 675 693
487 514 540	288 286 284	504 513 522	375 377 378	204 207 209	237 233 228	630 632 633
430 418 406	298 301 303	366 358 349	372 358 343	200 216 232	250 259 267	631 641 650
360 359 357	297 302 307	345 354 363	310 300 290	225 225 225	255 262 269	541 545 549
281 279 276	315 309 304	281 292 302	274 291 307	228 238 248	209 210 210	389 392 395
252 245 237	349 343 337	241 240 239	258 257 256	216 231 246	234 235 235	426 409 391
199 204 209	385 402 419	192 195 197	209 211 213	195 196 197	246 230 213	466 462 458
183 183 183	245 249 253	172 176 179	199 201 202	181 184 187	216 187 162	395 390 384
159 159 159	122 125 127	119 119 118	150 156 161	173 173 173	137 140 142	307 308 309

samples in natural depressions, for instance in funnels produced by the lugworms. Therefore periods of heavy rain are easily recognized by the very low salinities. Temperatures were measured by inserting mercury-thermometers in the uppermost centimeter of the seabottom. Since station 1 normally was visited first and the visits normally took place in the morning hours, there is a slow increase in temperature going from station no. 1 to station no. 3.

Grain size determination. After a thorough but gentle washing in tap water and distilled water the samples were treated with 6 % and 35 % hydrogenperoxide at 60° C until effervescence stopped. Next they were dried at 105° C and finally passed through a series of screens for 15 minutes (A.S.T.M. sieve nos. 10, 18, 35, 60, 120 and 230 corresponding to a meshopening of 2, 1, 0.5, 0.25, 0.125 and 0.062 mm respectively). The quartiles (D_{25} and D_{75}) and the median (D_{50}) were computed since in all cases they fell on a straight line on the semi-logarithmic graph paper.

Results

Table 1 depicts the content of organic nitrogen in various depths of the seabottom at the three stations. The amount is expressed as μg N per g dry sand. Mr. K. P. Andersen, Danish Institute for Fishery and Marine Research has kindly performed a statistical analysis on the data, in which he concludes:

"A natural way for estimating the measuring error would have been to use the duplicate titrations directly. However, a closer inspection of the data gave the impression that something was wrong with the second titration. Unfortunately it was not possible to specify what had happened, but as the duplicate titrations were made in succession, it is possible that the two titrations were not independent.

The measuring error has therefore been estimated from the first titrations only, by means of an analysis of variance based on the model:

$$y_{i\gamma} = \mu + \tau_i + \varphi(d_\gamma) + \gamma(i, d_\gamma) + \varepsilon_{i\gamma}$$

where $y_{i\gamma}$ is the figure found for time **i** in depth d_γ, μ is the general overall mean, τ a factor depending on time only, φ (d) a fifth grade polynomial depending on depth (d) only, (i, d_γ) a fifth grade polynomial depending on time and depth and the ε's are the measuring errors supposed to be independent and normally distributed $(0,\sigma^2)$.

The result of the analyses of variance on this model is for station no. 1 (which for reasons of convenience is the only station analysed):

Table 2. Grain size analysis of the vertical cores. Date: May 2, 1968.

Depth	Station no. 1				Station no. 2				Station no. 3			
(cm)	D_{25}	D_{50}	D_{75}	So	D_{25}	D_{50}	D_{75}	So	D_{25}	D_{50}	D_{75}	So
1	0,134	0,169	0,213	1,262	0,139	0,170	0,209	1,227	0,129	0,165	0,211	1,280
2	0,135	0,170	0,214	1,261	0,139	0,171	0,209	1,229	0,132	0,168	0,215	1,278
3	0,137	0,172	0,217	1,260	0,139	0,171	0,209	1,227	0,131	0,166	0,209	1,263
4	0,140	0,176	0,222	1,258	0,141	0,173	0,211	1,224	0,134	0,169	0,213	1,261
5	0,136	0,172	0,218	1,264	0,142	0,174	0,212	1,223	0,137	0,172	0,216	1,254
6	0,137	0,175	0,222	1,275	0,142	0,173	0,212	1,222	0,139	0,173	0,215	1,244
7	0,133	0,169	0,215	1,271	0,142	0,173	0,212	1,223	0,140	0,174	0,215	1,239
8	0,138	0,177	0,228	1,282	0,142	0,174	0,212	1,223	0,139	0,173	0,214	1,240
9	0,140	0,178	0,228	1,278	0,142	0,174	0,212	1,222	0,140	0,173	0,214	1,236
10	0,143	0,194	0,265	1,364	0,142	0,174	0,212	1,222	0,139	0,173	0,214	1,241

Table 3. Grain size analysis of the vertical cores. Date: August 8, 1968.

Depth	Station no. 1				Station no. 2				Station no. 3			
(cm)	D_{25}	D_{50}	D_{75}	So	D_{25}	D_{50}	D_{75}	So	D_{25}	D_{50}	D_{75}	So
1	0,139	0,175	0,221	1,261	0,141	0,172	0,210	1,222	0,144	0,180	0,225	1,250
2	0,139	0,175	0,222	1,265	0,136	0,167	0,207	1,233	0,143	0,179	0,223	1,248
3	0,137	0,174	0,220	1,265	0,138	0,170	0,209	1,230	0,144	0,178	0,221	1,241
4	0,138	0,174	0,219	1,262	0,140	0,172	0,211	1,228	0,144	0,178	0,220	1,238
5	0,138	0,174	0,220	1,264	0,141	0,173	0,211	1,225	0,144	0,178	0,220	1,237
6	0,138	0,175	0,223	1,271	0,141	0,173	0,212	1,224	0,143	0,177	0,220	1,240
7	0,137	0,175	0,224	1,277	0,141	0,173	0,211	0,223	0,146	0,180	0,224	1,239
8	0,138	0,178	0,229	1,289	0,142	0,173	0,212	1,223	0,146	0,181	0,225	1,241
9	0,139	0,177	0,227	1,279	0,142	0,173	0,212	1,224	0,147	0,183	0,227	1,242
10	0,140	0,179	0,228	1,275	0,143	0,174	0,213	1,222	0,148	0,185	0,230	1,245

Table 4. Grain size analysis of the vertical cores. Date: October 31, 1968.

Depth	Station no. 1				Station no. 2				Station no. 3			
(cm)	D_{25}	D_{50}	D_{75}	So	D_{25}	D_{50}	D_{75}	So	D_{25}	D_{50}	D_{75}	So
1	0,139	0,176	0,222	1,267	0,140	0,172	0,211	1,226	0,142	0,179	0,224	1,255
2	0,138	0,175	0,222	1,268	0,141	0,172	0,211	1,225				
3	0,135	0,172	0,218	1,270	0,139	0,171	0,210	1,226	0,143	0,180	0,227	1,261
4	0,138	0,174	0,220	1,266	0,140	0,171	0,210	1,225	0,143	0,178	0,222	1,247
5	0,138	0,174	0,220	1,265	0,139	0,170	0,209	1,227	0,143	0,179	0,222	1,245
6	0,138	0,175	0,222	1,270	0,140	0,171	0,210	1,225	0,143	0,178	0,221	1,245
7	0,138	0,176	0,224	1,272	0,139	0,171	0,209	1,225	0,144	0,178	0,221	1,242
8	0,139	0,177	0,226	1,277	0,140	0,172	0,210	1,224	0,145	0,180	0,223	1,241
9	0,142	0,183	0,236	1,290	0,139	0,171	0,210	1,226	0,147	0,183	0,228	1,245
10	0,139	0,182	0,239	1,310	0,140	0,172	0,210	1,224	0,147	0,184	0,229	1,247

Table 5. Grain size analysis of the vertical cores. Date: April 17, 1969.

Depth	Station no. 1				Station no. 2				Station no. 3			
(cm)	D_{25}	D_{50}	D_{75}	So	D_{25}	D_{50}	D_{75}	So	D_{25}	D_{50}	D_{75}	So
1	0,139	0,171	0,210	1,228	0,141	0,173	0,212	1,225	0,130	0,167	0,216	1,290
2	0,140	0,172	0,211	1,228	0,140	0,172	0,212	1,229	0,133	0,171	0,220	1,286
3	0,137	0,169	0,208	1,233	0,141	0,173	0,212	1,225	0,137	0,180	0,236	1,311
4	0,133	0,165	0,205	1,243	0,142	0,174	0,213	1,226	0,135	0,174	0,225	1,292
5	0,133	0,165	0,206	1,245	0,139	0,171	0,210	1,229	0,135	0,174	0,224	1,287
6	0,135	0,167	0,207	1,240	0,140	0,172	0,211	1,229	0,139	0,178	0,229	1,281
7	0,136	0,168	0,208	1,237	0,139	0,171	0,210	1,231	0,141	0,179	0,227	1,271
8	0,136	0,168	0,208	1,237	0,139	0,171	0,212	1,234	0,141	0,179	0,226	1,266
9	0,135	0,168	0,208	1,240	0,139	0,171	0,211	1,234	0,143	0,184	0,236	1,283
10	0,135	0,168	0,208	1,240	0,139	0,171	0,211	1,233	0,143	0,183	0,234	1,279

Analysis of variance (station no. 1)

Due to	Degrees of freedom	Sum of squares	square Mean
m (Est. of μ)	1	8952862	
t (Est. of τ)	14	495325	35380
f (Est. of φ)	5	233111	46622
g (Est. of γ)	70	339035	4843
Remainder	60	35731	596 = s^2
Total	150	10056064	

The remainder mean square s^2 is the wanted estimate of the variance σ^2 of the measuring error (supposing the model adequate) and thus we find:
Standard deviation of the measuring error
$s = 24{,}4$ µg N/g sand . "

The distribution of the organic nitrogen in general follows the same trend as revealed by the few samples collected in October 1963, June 1964 and July 1964 (cf. *Jacobsen* 1967), viz. a maximum in the uppermost centimeter normally followed by a rapid decrease towards the deeper layers. Contrary to expectation the prolonged ice period did not cause any noticeable decrease in the content of organic nitrogen in the seabottom.

Tables 2, 3, 4 and 5 show the quartiles (D_{25} and D_{75}) and the median (D_{50}) plus the degree of sorting for each sample at the stations at 4 selected dates of the year. The dates were selected in order to represent the widest span of the survey and furthermore to depict the state of grain size distribution following different weather conditions. The substratum is fine sand with D_{50} ranging from 165µ to 216µ and it is very well sorted (S_o-range 1,222 to 1,364). The S_o-values from station no. 2 furthermore display remarkable small differences.

Table 6 summarizes the observations collected during the sampling visits, viz. temperature, salinity, the depth to which the oxidized surfacelayer extends and notes on icecover and coverage by decaying algae. Furthermore some notes on the fauna have been included.

Biological notes

As noted in the introduction the reason for initiating this study was to collect data on the food available to the lugworm Arenicola marina (L.). Therefore the observations were specifically related to this animal (cf. table 6).

The ice cover did not restrict the activity of the lugworms. Cutting through the ice for subsequent sampling of undisturbed vertical cores, well-developed funnels and faecal heaps were seen. A freezing of the bottom was never observed. Only during the melting period the area showed signs of scraping due to the moving fragments of the ice. Signs of activity (funnels and faecal heaps) were levelled out and the oxidized surface-layer, which is easily recognized towards the dark deeper layers (containing ferrous sulphide) did extend further down. Under conditions without ice this surface-layer had a thickness of 1–3 cm while the scraping did expand the oxidized layer down to 5–11 cm. The sulphide system recently described by *Fenchel & Riedl* (1970) thus also became affected.

As an indication of the severity of a winter, the amount of cold can be used for comparison. The amount of cold is calculated by adding the negative average daily temperatures of the frost period. By comparing the amount of cold of the winters 1927/28 to 1941/42 (*Smidt* 1944) with the amount of cold of the winter 1968/69 (table 7 and table 8) it is seen that the latter must be regarded as a rather severe winter, although it is not reaching the amounts of cold of the heavy winters in the early 1940's. Smidt (l.c.) recorded the catastrophic effects on the bottom fauna induced by the severe winters 1940–42. During these winters the seabottom at the tidal zone was supposed to be frozen to a depth of several decimeters. No such effects were observed during the present study and only once – between the two ice periods – a slight mortality of Cardium edule L. was noted. Although no quantitative investigation has been performed on the fauna composition in the course of this study, the notes taken at the bi-weekly inspections of the sampling area seem to reflect the state of the fauna in a reliable way.

During the visit to the area on October 4, 1968 at stations no. 1 and no. 2 a large amount of dead molluscs was immediately noted. Normal conditions prevailed at station no. 3. A few days later a mass-mortality of lugworms was reported from the entire Danish Waddensea. At the same time a bloom of a dinoflagellate (*Gymnodinium sp.*) did occur in the North Sea. In the harbour of Esbjerg, which is situated about 10 km from the sampling area, the number of specimens reached 7–8 mill./liter. The bloom, which is the first Gymnodinium-bloom recorded in Danish waters, although not fully proved, seemed to execute a profound effect on the bottom fauna. Dead, decaying lugworms for some days formed a foamy border at the highwater line. It was noted, that the young generation of lugworms was not affected, while elder generations were almost completely exterminated. This may be due to greater susceptibility of the latter during the spawning period, which falls in the late autumn. I have noted that during this period the lugworms are very delicate and difficult to handle in experimental work.

From late May 1968 to late November 1968 the three sampling stations were covered by a varying amount of algae predominantly Enteromorpha clathrata. Station no. 3 generally had a greater percentage of coverage – often approaching 100 %. The algal layer did not seem to interfere with the activity of the lugworms. Beneath the layer, which was often 5–10 cm thick – or even on top of the layer – well-developed faecal heaps were found.

Table 6. Salinity, water temperature and biological notes.
1968

2/5	16/5	30/5	10/6	27/6	11/7	27/7	8/8	22/8	5/9	20/9	4/10	31/10	28/11
13,0	9,0	22,0	15,5	14,5	12,0	20,6	20,3	16,0	17,5	–	12,0	–	7,3
14,0	12,0	23,0	16,5	15,0	12,0	21,0	21,0	16,8	17,0	11,8	11,5	–	–
14,0	12,0	23,0	17,5	15,5	12,5	23,3	21,4	17,2	17,0	12,0	12,3	–	7,3
20,98	22,03	25,33	22,65	23,14	9,80	23,09	27,74	18,76	18,38	20,00	22,44	20,02	14,59
23,63	23,66	26,28	23,47	19,60	10,32	23,87	27,92	23,06	18,78	21,61	18,98	–	–
25,51	24,44	26,47	24,10	22,17	14,56	23,55	27,87	24,05	22,07	21,72	18,75	–	21,26
					Heavy rain	Al: 50 %			Strong population of diatoms		Many dead molluscs. Only juvenile lug-worms abundant		
			Al: 50 %		Al: 50 % Heavy rain	Al: 50 %	ox: 1 cm	Brown layer of diatoms	New generation of lugworms		Many dead molluscs. Only juvenile lug-worms abundant	Al: 60 %	
		Al: 80 %	Al: 80-90 %	Al: 100 %	Al: 100 % Heavy rain	Al: 100 % ox: 1 cm		Al: 100 %	Al: 90 %	Al: 70 %	Few adults, but many juvenile lugworms abundant	Al: 80 %	Al: 90 %

Explanation: Al: Algal cover at the station; ox: Thickness of oxidized layer; I: Station covered by ice.

It is known that microphytobenthos and microzoobenthos are responsible for far the greater part of the production in the seabottom. Apparently the decaying algae do not contribute significantly to the accumulation of organic nitrogen in the seabottom since the amount of organic nitrogen found during the present study was of the same magnitude as in 1963–64 (*Jacobsen* l.c.), where no such cover was noted in the same area.

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10/1	23/1	7/2	25/2	7/3	21/3	17/4	
–	–	–	–	–	–	5,5	Station no. 1 Water-
–	–	–	–	–	–	10,5	Station no. 2 temper-
−1,5	4,5	1,5	−1,0	−0,5	0,0	8,5	Station no. 3 ature °C
–	–	–	–	–	–	25,54	Station no. 1
–	–	–	–	–	–	27,47	Station no. 2 Salinity
25,10	16,30	21,49	16,99	14,40	20,26	26,96	Station no. 3 ‰
I: 100 %			I: 100 %	I: 100 %	I: 50 %	ox: 6-7 cm	General remarks Station no. 1
I: 100 %			I: 100 %	I: 100 %	I: 50 %	ox: 7-11 cm	General remarks Station no. 2
I: 100 %	ox: 3-5 cm	ox: 2-3 cm Low activ- ity	I: 100 % ox: 5 cm	I: 100 % ox: 5 cm Strong activ- ity	I: 50 % ox: 5-8 cm	ox: 1 cm	General remarks Station no. 3

Table 7 (after Smidt 1944).

Winter	The amount of cold at Nordby (Fanø)
1941/42	456,7
1940/41	297,2
1939/40	349,9
1938/39	61,6
1937/38	35,9
1936/37	79,4
1935/36	50,3
1934/35	37,8
1933/34	34,2
1932/33	94,2
1931/32	63,5
1930/31	72,8
1929/30	23,9
1928/29	325,2
1927/28	128,3

Table 8[1]. The amount of cold at Skallingen during the winter 1968/69.

December 1968	− 30,6
January 1969	− 20,2
February 1969	− 58,1
March 1969	− 9,3
Total	− 118,2

1. The data for the compilation of table 8 have kindly been put at my disposal by the Climatological Department of the Danish Meteorological Institute.