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Distribution of benthic tubificids in Finnish coastal waters in relation to hydrography and pollution

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Tubificids were identified in 335 bottom samples from 14 coastal areas of Finland. Altogether eight tubificid species were found. Tubificids were the dominant bottom animals at most stations sampled in the coastal areas of the Bothnian Bay, where the bottom fauna is in general poor in species and the densities of bottom animals are low. In more southern and more saline areas, where the bottom fauna is richer in species and the marine lamellibranchiate *Macoma baltica* occurs abundantly, tubificids seldom dominated in the samples, except in the polluted innermost parts of some study areas, where other bottom animals were weakly represented. The most euryhaline and euryoxybiontic species in the material were *Potamothrix hammoniensis* and *Psammoryctes barbatus*. These species, together with *Limnodrilus hoffmeisteri*, usually occurred also in polluted conditions. *Limnodrilus* spp. and *Peloscolex ferox* were observed only in oligohaline areas. The lowest salinities at which the species *Tubifex costatus* and *Clitellio arenarius* were found were 4.25 and 5.74‰, respectively.
The character of the substratum seemed to be one of the main factors influencing the occurrence of the species. No clear correlation was found between the abundance of tubificids and the concentration of total phosphorus in the water.

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Определяли тубифицид в 335 донных пробах из 14 прибрежных участков в Финляндии. Найдено всего 8 видов. Тубифициды являются доминирующими донными формами в большинстве обследованных участков Ботнического залива, где донная фауна в целом бедна по набору видов и численности животных. В более южных и более засоленных участках, где донная фауна богаче по числу видов, и где многочисленным видом оказывается представитель морских Lamellibranchiata – *Macoma baltica* – тубифициды редко доминируют в пробах, за исключением загрязненных самых внутренних частей некоторых участков исследования, где другие донные животные представлены слабо. Наиболее эвригалинные и эвриоксигалинные виды в собранном материале – *Euilyodrilus hammoniensis* и *Psammoryctes barbatus*. Эти виды вместе с *Limnodrilus hoffmeisteri* также обычно всречаются в загрязненных местах. *Limnodrilus* sp. и *Peloscolex ferox* найдены только в олигогалинных участках. Самые низкие показатели солености, при которой обнаружены *Tubifex costatus* и *Clitellio arenarius* составляли 4,25 и 5,74‰ соответственно.
Характер субстрата свляется по-видимому одним из важных факторов, определяющих распространение видов. Четкие корреляции между обилием тубифицид и концентрацией общего фосфора в воде не были установлены.

1. Introduction

Tubificids were identified in samples of benthic organisms collected during the summers of 1966–1970 in several coastal areas of Finland. The aim of the study was to examine the distribution and abundance of the species in relation to some chemical and physical properties of the water and sediment, and to consider the relation of the group and individual species to the strength of pollution. The distribution of oligochaetes in some coastal areas of Finland has previously been dealt with by Laakso (1967, 1968, 1969a and b), Leppäkoski (1967) and Särkkä (1968 and 1969).

2. Material and methods

The material consists of 335 bottom samples from 14 coastal areas (Fig. 1). In this connection one bottom sample means one–three (usually two) individual samples per locality taken with the van Veen grab (0.1 m^2) or two–four (usually three) samples per locality taken with the Ekman-Birge apparatus (0.027 m^2). All the samples taken with the van Veen grab were washed with running sea water on board M/S Aranda; the other samples were washed by shaking on the surface of the sea. The sieve used in 1966–67 had a mesh size of 1 mm, while that used in 1968–70 had a mesh size of 0.6 mm. The tubificids were picked up from the sieve and preserved in 70 per cent ethanol. For identification they were treated with polyvinyl-lactophenol and mounted on slides.

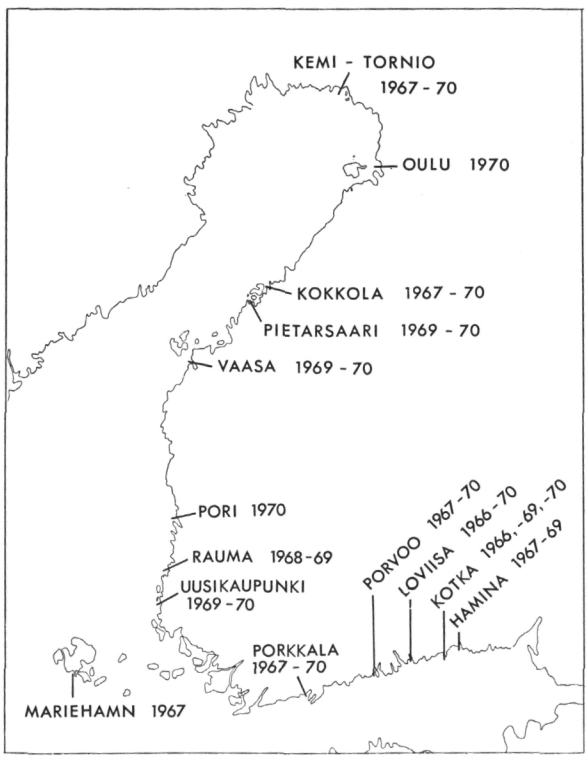


Fig. 1. Sampling areas and years.

Hydrographic and chemical determinations were made in connection with the bottom samplings, according to the standard methods used at the Institute of Marine Research.

3. Results

The material covers 14 coastal areas (Figs. 2–12). The short descriptions of each area given here include information on the following points:

type and source of the main waste waters and other allochthonous material discharged to the areas,
depths at the sampling stations,
character of the bottoms,
salinity of the bottom water,
oxygen concentration of the bottom water (percentage of saturation),
concentration of total phosphorus (mg/m^3) as the mean value of the water column at each station,
distribution and abundance of tubificids and remarks on other benthic animals.

3.1. Kemi-Tornio

Load: the allochthonous material (especially humus) carried by the rivers Kemijoki and Tornionjoki, sewage and pulp-mill wastes.
Depth: 4–10 m at Sts. 1–4 and 9, 12–20.5 m at other stations.
Bottom: sand at Sts. 3, 11 and 12, bark and fibre on sulphidic deposits at Sts. 1 and 2, sulphidic silt, sand or clay at other stations.
Salinity: in 1967: 0.05–1.74‰, in 1968–70: 1.19–2.87‰.
Oxygen: more than 60%.
Total P: in 1967 more than 10 mg/m^3 at all stations, 32 mg/m^3 at St. 1 and over 20 mg/m^3 at Sts. 2 and 8. During the other sampling periods the concentrations of total P were low, except at Sts. 1 and 2. Especially low values were recorded in 1968 when the salinity was high.

The occurrence of tubificids at the 13 sampling stations is presented in Fig. 2. Tubificids dominated in the bottom fauna of almost all the stations during all the sampling periods. Their densities were, however, less than 400 specimens per m^2. In 1967, the most abundant species in the samples were *Potamothrix hammoniensis* (Mich.) and *Limnodrilus hoffmeisteri* Clap., and in all five tubificid species were recorded. During the sampling periods of 1968–1970, *P. hammoniensis* was dominant. This species occurred with low densities also at Sts. 1 and 2, where the contents of phosphorus were highest and the water and bottoms were contaminated by pulp-mill wastes.

3.2. Oulu

Load: pulp-mill wastes, nutrient-rich waste waters from a factory producing fertilizers, sewage, waste waters from a chlorine factory and allochthonous material carried by the River Oulujoki.
Depth: 8–10 m at Sts. 1–3, 13–20 m at Sts. 4, 11 and 12 and 25–55 m at other stations.
Bottom: sand at St. 7, sulphide-banded clay at Sts. 8 and 9, and sulphidic gyttja-clay at other stations.
Salinity: 1.84–1.96‰ at Sts. 1–3 and 2.41–2.93‰ other stations.
Oxygen: more than 54%.
Total P: 46 mg/m^3 at St. 1, more than 30 mg/m^3 at Sts. 3 and 4, and 10–30 mg/m^3 at other stations.

Tubificids dominated in the bottom fauna of almost all the localities. (Fig. 3). The dominant species was *P. hammoniensis. L. hoffmeisteri* occured near the harbour of Toppila, off the area that Särkkä (1967) found devoid of bottom animals and where fibre-rich bottoms were common.

3.3. Kokkola

Load: the Bay of Ykspihlaja receives mainly inorganic waste waters from chemical and metallurgical industries and sewage and wastes from the harbour. Sewage is discharged to the Bay of Kokkola.
Depth: 0.5–20 m (usually less than 10 m).
Bottom: mainly sand and silt, sulphidic clay in the deeper parts of the Bay of Ykspihlaja and organic sulphidic gyttja-clay at Sts. D and E and in the Bay of Kokkola.
Salinity: 3.3–3.8‰ (not measured in the Bay of Kokkola).
Oxygen: more than 80% in the Bay of Ykspihlaja.
Total P: usually less than 6 mg/m³, 10–15 mg/m³ at Sts. E and F. In 1970, the concentrations were higher than during the previous years and a value of 20 mg/m³ was recorded at St. B.

Many of the stations sampled near the waste outlets of the factories in Ykspihlaja had no bottom animals in 1967 (Fig. 4 and 4a). *P. hammoniensis* dominated in the bottom fauna on silt and sulphidic clay bottoms in the deeper parts of the Bay of Ykspihlaja. At St. E its

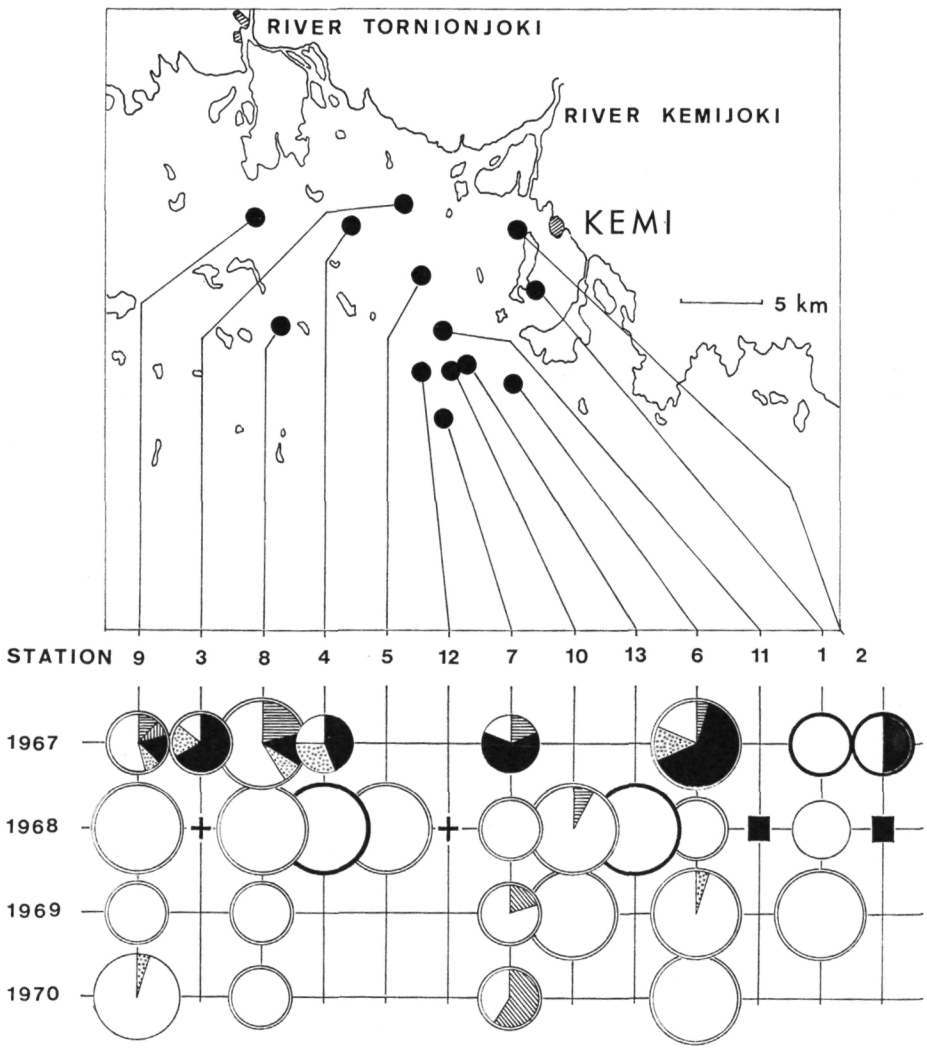
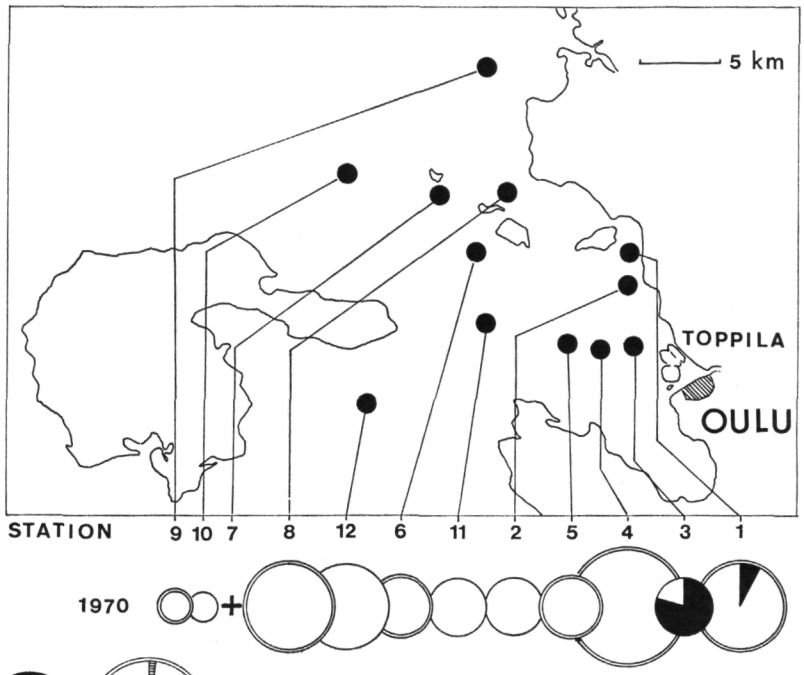


Fig. 2. Occurrence of tubificids in the Kemi-Tornio area. Explanation of the symbols: A cross means that benthic animals were absent, a square that tubificids were absent, a double line around the circles means that tubificids were dominant, and a thick black line means that they were the only benthic macroscopic animals found. The diameter of the circles indicates the number of tubificid specimens per m² as follows: 3.75 mm = 1–24 specimens, 7.5 mm = 25–99 specimens, 11.25 mm = 100–499 specimens and 15 mm = more than 500 specimens/m². The sectors in the circles indicate the percentages of the total tubificid specimens formed by different species. *Tubifex costatus* is represented by crossed lines, *Psammoryctes barbatus* by horizontal lines, *Limnodrilus udekemianus* by vertical lines and *Limnodrilus profundicola* by diagonal lines. Black sectors represent *Limnodrilus hoffmeisteri*, white sectors *Potamothrix hammoniensis* and dotted sectors *Peloscolex ferox*. The sectors with the symbols ×× represent *Clitellio arenarius*.

Fig. 3. Occurrence of tubificids in the Oulu area. For explanations see Fig. 2.



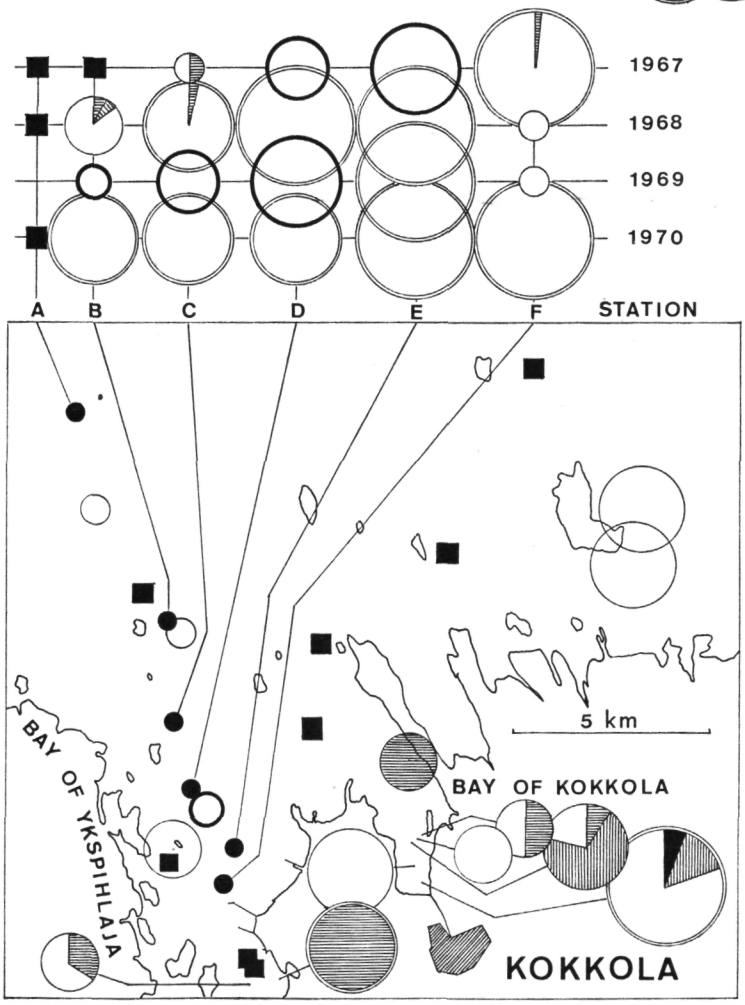


Fig. 4. Occurrence of tubificids in the Kokkola area. The area near the metal and chemical factories is presented separately

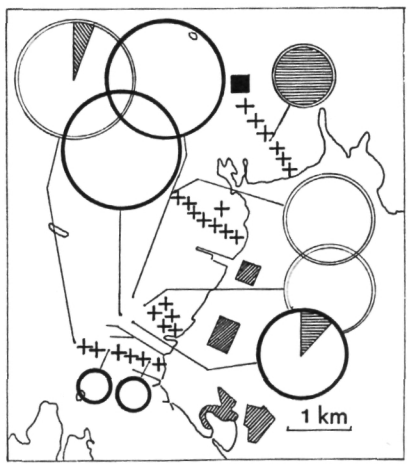


Fig. 4a. All the samples in this area and in the Bay of Kokkola have been taken in 1967. For explanations see Fig. 2.

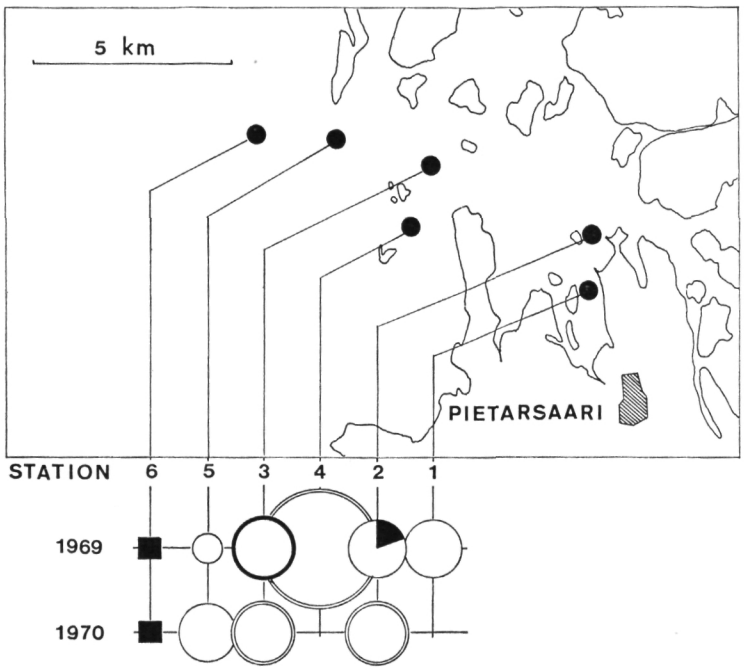


Fig. 5. Occurrence of tubificids in the Pietarsaari area. For explanations see Fig. 2.

density exceeded 3,100 specimens per m^2. At the outermost stations in the bay the dominant animal species was the amphipod *Pontoporeia affinis* Lindstr. and the numbers of tubificids were small. *Limnodrilus udekemianus* Clap. was found in the Bay of Kokkola where the bottom consisted of sulphidic gyttja-clay with a high content of detritus. *Psammoryctes barbatus* (Grube) occurred mostly in shallow water on silt and sand-mixed clay bottoms.

3.4. Pietarsaari

Load: pulp-mill wastes and sewage.
Depth: 4–9 m at Sts. 1 and 2, 16–23 m at other localities.
Bottom: mainly sulphidic clay, sand at St. 6 and fibres at Sts. 1 and 4.
Salinity: 3.35–3.83‰.
Oxygen: more than 75%.
Total P: 40–10 mg/m^3 at Sts. 1–3, less than 10 mg/m^3 at other stations in 1969. In 1970, the contents ranged from 10 to 15 mg/m^3 at all the stations studied.

Compared with those in the Kokkola area, the densities of tubificids were low in the sea area off Pietarsaari (Fig. 5), which receives waste waters mainly from pulp mills. *P. hammoniensis* was the most abundant benthic species in the middle reaches of the area. Chironomid larvae dominated at the shallow innermost localities and *Macoma baltica* (L.) and *Pontoporeia affinis* at the outermost localities.

3.5. Vaasa

Load: sewage and waste waters from various small factories.
Depth: 3–10 m at Sts. 1–5, 12–16 m at other stations.
Bottom: silt at Sts. 3, 7 and 8, black gyttja-clay at Sts. 1 and 4 and sulphidic clay or silt at other stations.
Salinity: 4.3–5.1‰ (3.7‰ at St. 4).
Oxygen: more than 75%.
Total P: 40 mg/m^3 at St. 1, 25–15 mg/m^3 at Sts. 2–6, and ca. 8 mg/m^3 at Sts. 7 and 8 in 1969. In 1970, more than 10 mg/m^3 at all the stations studied.

Tubificids dominated only in the fauna of the bay of the town (St. 4), where the density of *Limnodrilus hoffmeisteri* exceeded 1,000 specimens per m^2 (Fig. 6). This area receives a great part of the waste waters discharged from the town. At stations off the bay, *Macoma baltica* and *Pontoporeia affinis* dominated in the fauna and the densities of tubificids were low, the commonest species being *Psammoryctes barbatus.*

3.6. Pori

The bottom fauna of the estuary of the River Kokemäenjoki has been studied by Särkkä (1969), who found seven tubificid species living in the area. Our material from this area was obtained from only two stations, sampled in 1970. At one of these stations we found *Tubifex costatus* (Clap.) specimens. The find is the northernmost in our material.

3.7. Rauma

Load: waste waters from docks and a sodium base pulp mill, and sewage.
Depth: 11–20 m.
Bottom: sand and gravel at Sts. 4–6 and 10, sand-mixed clay at Sts. 3, 7 and 8, and sulphidic gyttja-clay at Sts. 1, 2 and 9. Oil spots were observed in the sediment at Sts. 7 and 9.
Salinity: 5.7–6.0‰.
Oxygen: more than 80%.
Total P: 30 mg/m^3 at St. 1, 10 mg/m^3 at Sts. 2 and 9 and less than 7 mg/m^3 at other stations in 1969. In 1970, there was 40 mg/m^3 at St. 9 and 10–20 mg/m^3 at Sts. 1–3.

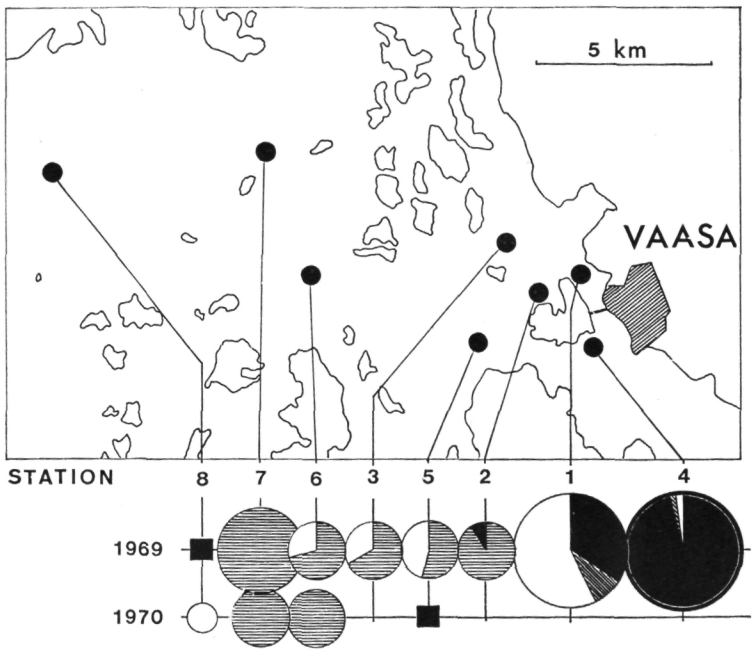


Fig. 6. Occurrence of tubificids in the Vaasa area. For explanations see Fig. 2.

The densities of tubificids were low at all the stations studied (Fig. 7). At St. 1, which is situated near the outfall of the waste waters from the pulp mill, no bottom animals were observed. In the middle parts of the area, where *Macoma baltica* was the most abundant benthic species, tubificids were weakly represented. *Potamothrix hammoniensis* was found at Sts. 2 and 9 and *Tubifex costatus* at St. 3. The outermost sandy stations (4–6) were characterized by the occurrence of *Clitellio arenarius* (Müll.) and the amphipod *Bathyporeia pilosa* Lindstr.

3.8. Uusikaupunki

Load: nutrient-rich waste waters from a factory producing fertilizers, wastes from a dock and from the harbour, and sewage.
Depth: 4–5 m at St. 1, 10–20 m at Sts. 2–7, 9 and 10, and 23–57 m at other stations.
Bottom: mainly silt and sulphidic silt in 1969; sulphidic

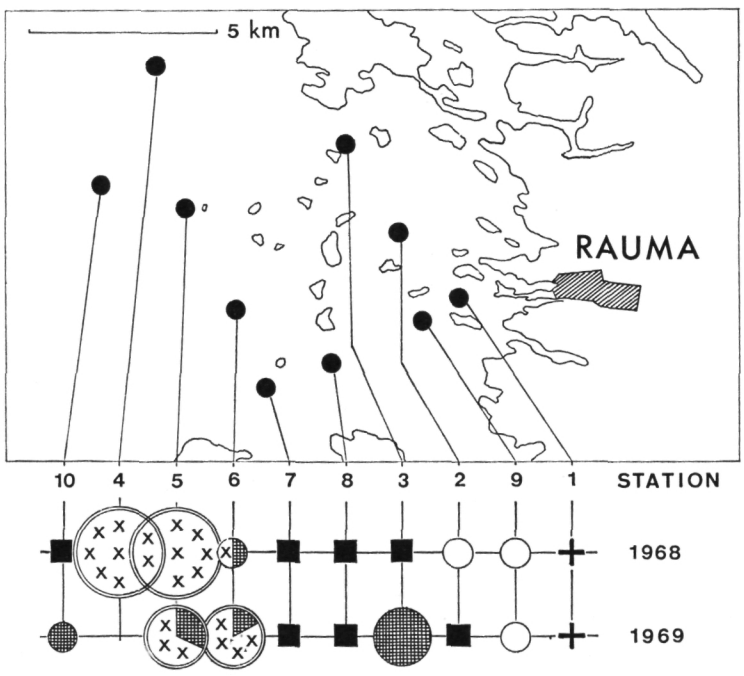


Fig. 7. Occurrence of tubificids in the Rauma area. For explanations see Fig. 2.

gyttja-clay at St. 5, and sand at Sts. 13 and 14. In 1970, there was soft clay at Sts. 2–4, 10 and 11, soft clay with detritus at Sts. 1, 8 and 9, sulphidic clay at Sts. 5–7 and silt or sandmixed clay at Sts. 12 and 13.
Salinity: 5.82–6.13‰.
Oxygen: 0% at St. 5 in 1969–70, 2% at St. 4 in 1970; and less than 30% at Sts. 2, 4 and 6 in 1969 and at St. 3 in 1970.
Total P: 240 mg/m³ at St. 2, more than 100 mg/m³ at Sts. 1, 3 and 6, 30–100 mg/m³ at Sts. 4, 5 and 7–10, and 6–10 mg/m³ at Sts. 11–14 in 1969. In 1970 there was 160–170 mg/m³ at Sts. 1, 2 and 5, and 30–100 mg/m³ at Sts. 3, 4 and 6–10.

Tubificids were richly represented in the sea area off Uusikaupunki, which is eutrophicated by waste waters from the town and from the factory producing fertilizers (cf. Bagge and Lehmusluoto 1971) (Fig. 8). However, in both sampling years they dominated in the fauna only at St. 3 (situated near the outlet of the factory). In 1969, *P. hammoniensis* was the most abundant species at St. 5, where the oxygen concentration in the bottom water was 0%. In 1970, the same station was inhabited by chironomid larvae, *P. hammoniensis* and *Psammoryctes barbatus*. *Macoma baltica* dominated in the middle and innermost parts of the area, where the commonest tubificids were *Psammoryctes barbatus* (in 1969) and *P. hammoniensis* (in 1970). The bottom at these stations was silt or sulphidic silt in 1969 and soft clay in 1970. *Tubifex costatus*, which in 1969 was not recorded nearer the town than at Sts. 9 and 10, occurred in 1970 at Sts. 8 and 4, where the concentration of oxygen was only about 2% of saturation.

3.9. Mariehamn

Load: no apparent waste waters, except those from the harbour.
Depth: 17–39 m.
Bottom: gyttja-clay and detritus or sulphidic clay in the innermost parts and silt or gravel in the outermost parts.
Salinity: 6.50–6.95‰.
Oxygen: more than 55%.
Total P: 10–40 mg/m³.

No tubificids were found at the five stations studied in the sea area off Mariehamn in 1967.

3.10. Porkkala

Load: small amounts of sewage and wastes from a sugar mill and a cable factory.
Depth: 10–20 m at Sts. 1–3, 7 and 8, and 23–42 m at other stations.
Bottom: sulphidic silt and clay at Sts. 1–4, sulphide-banded clay at St. 9 and sand-mixed clay or silt at Sts. 5–8.
Salinity: 5.84–7.00‰.
Oxygen: more than 60%.
Total P: 10–25 mg/m³.

The abundance of tubificids was low in samples collected from the sea area west of Obbnäs (Porkkala) (Fig. 9). Only *Tubifex costatus* was found. *Macoma baltica* superdominated at almost all the localities.

3.11. Porvoo

Load: waste waters from a oil refinery and a pulp mill.
Depth: 26–64.5 m.

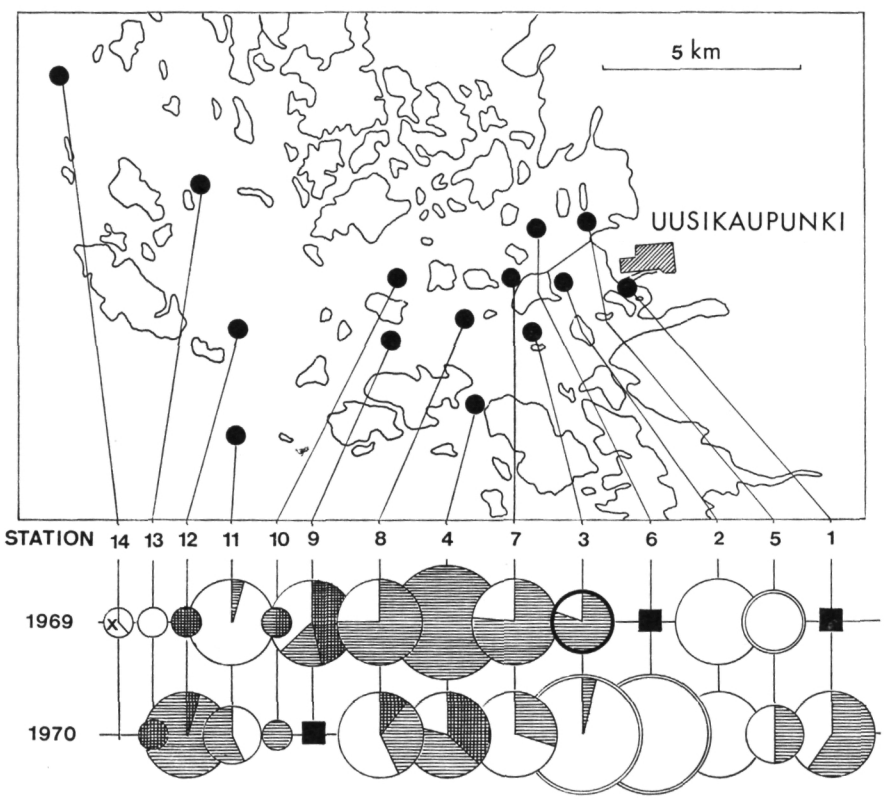


Fig. 8. Occurrence of tubificids in the Uusikaupunki area. For explanations see Fig. 2.

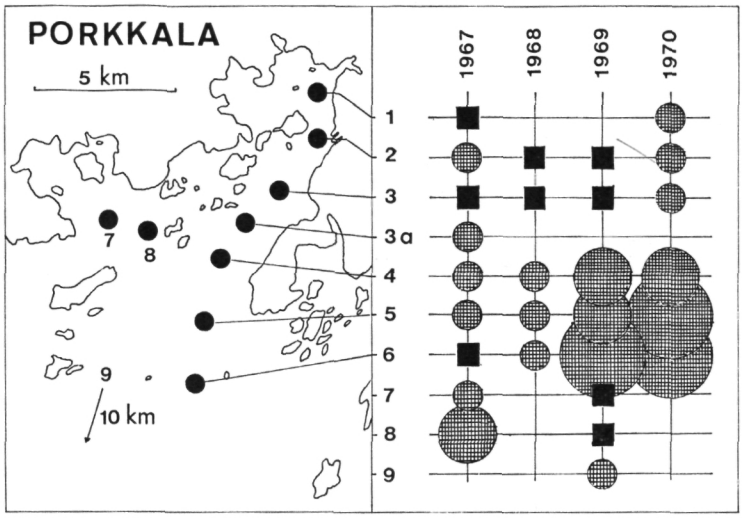


Fig. 9. Occurrence of tubificids in the Porkkala area. All the samples taken in 1967 are not included in the figure. For explanations see Fig. 2.

Bottom: sulphidic gyttja-clay at Sts. 2–5, silt and gravel at St. 1.
Salinity: 5.4–7.1 ‰.
Total P: 10–30 mg/m³ (the greatest values were recorded at the outermost stations).

Only a few specimens of *Tubifex costatus* and *Potamothrix hammoniensis* were observed in the sea area west and south of Emäsalo (Fig. 10). *Pontoporeia affinis* usually dominated in the fauna of the three innermost stations. *Macoma baltica* was the most abundant benthic animal at St. 3 in 1968–69.

3.12. Loviisa

Load: sewage from the town and wastes from the harbour.
Depth: 11–20 m at Sts. 1–6, 8 and A, 20–40 m at Sts. 7, 9 and 10, and 54–67 m at St. 11.
Bottom: mainly sulphidic gyttja-clay, sand-mixed clay or silt and iron-manganese concretions were found at Sts. 4, 8 and 9, and sulphidic silt at St. 11.
Salinity: 4.52–7.14 ‰.
Oxygen: minimum values 32 % at Sts. 1–3 and 47 % at other stations.
Total P: usually ca. 10–30 mg/m³. The maximum values were usually recorded at the outermost localities.

The benthos of the deep basins of the sea area off the town Loviisa is poor in species (see Bagge and Voipio 1967) (Fig. 11). The main reason for the paucity of the fauna is probably that the exchange of water is limited by the sills situated south of the basins. The commonest tubificid species in the basins was *P. hammoniensis*, which dominated in the fauna of the deeper parts of Loviisa Bay (Sts. 1–3), to which sewage is discharged from the town. Other tubificids occurred sparsely in the sill areas of the basins (Sts. 4 and 9), where the bottom consisted of sediments with a larger fraction of sand.

3.13. Kotka

Load: pulp-mill wastes and sewage and the material carried by the River Kymijoki.

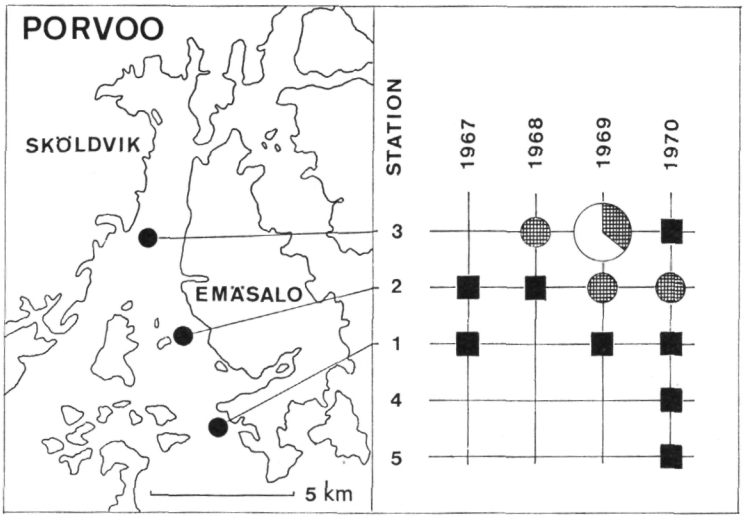


Fig. 10. Occurrence of tubificids in the Porvoo area. The stations 4 and 5 are situated outside the map.
For explanations see Fig. 2.

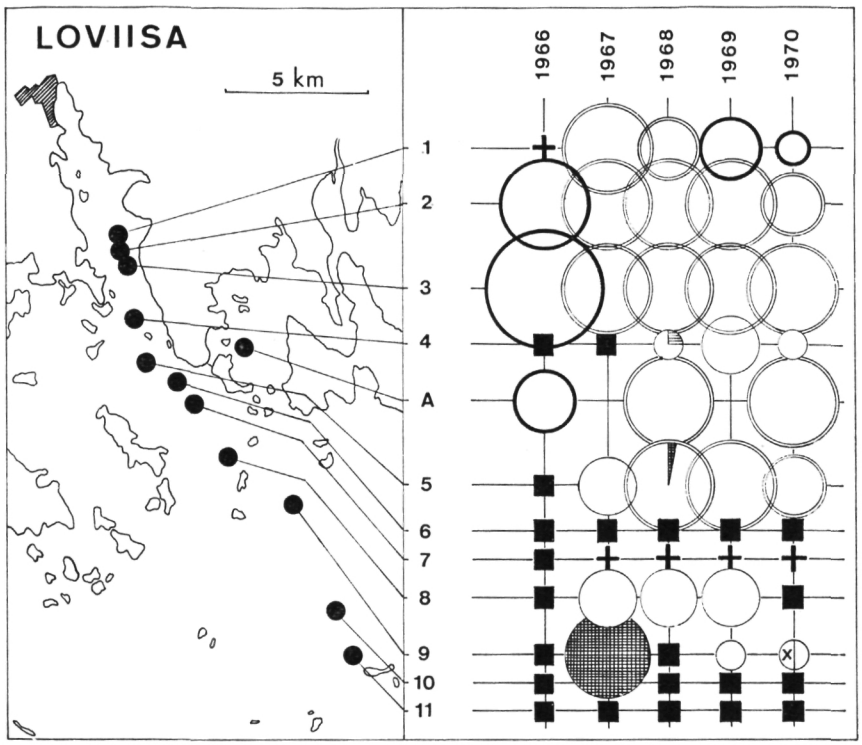


Fig. 11. Occurrence of tubificids in the Loviisa area. For explanations see Fig. 2.

Depth: 16.5–40.5 m.
Bottom: sulphidic gyttja-clay at St. 5, glacial clay with gravel at Sts. 2–4, and sand-mixed sulphidic clay at St. 1.
Salinity: 4.52–6.93‰ (highest in 1969).
Oxygen: more than 29%.
Total P: 10–40 mg/m³ (maximum at St. 5 in 1970).

The bottom fauna at five stations in the sea area off the town Kotka was sampled in 1966 and 1969–1970 (Fig. 12). Tubificids were weakly represented in the samples, the amphipod *Pontoporeia affinis* usually being dominant. The most abundant species at St. 5, which is situated about two km from the outfalls of waste waters and where the bottom consisted of sulphidic gyttja-clay, were larvae of the *Chironomus plumosus* type in 1969 and *P. hammoniensis* in 1970. *Tubifex costatus* was the commonest tubificid species at deeper stations.

3.14. Hamina

Load: sewage and wastes from the harbour and a pulp mill.
Depth: 12–15 m at Sts. 1–3 and 8, and 18.5–28 m at Sts. 4–6.
Bottom: sulphidic clay with gravel at Sts. 4, 6 and 8, and St. 1 in 1968, silt (St. 5) and clay or sand-mixed clay at other stations.
Salinity: 4.22–5.38‰.
Oxygen: more than 44%.
Total P: 10–20 mg/m³ (maxima at the innermost localities).

The bottom fauna of seven stations in the sea area off the town Hamina was sampled during the years 1967–68 (Fig. 12). In 1969, samples were taken at only two stations. The tubificids were moderately well represented in the samples. The commonest tubificid species in the innermost parts of the area were *Psammoryctes barbatus* (on sand-mixed clay) and *P. hammoniensis* (on sulphidic clay). *Tubifex costatus* was observed at the five outermost stations.

4. Discussion

Only eight tubificid species were observed in our material. This number is small compared with the 21 species found in the Finnish coastal waters by Laakso (1967, 1969a and b) and Särkkä (1969). The paucity of species is probably due to the fact that the water depths at most of our sampling stations are greater than 10 m and only a few samples were taken in the littoral zone, where the number of species is highest (see Laakso 1969a). The sieves used by us were also rather coarse (0.6 and 1.0 mm mesh), and many small species and specimens were probably lost.

The frequency of occurrence of the tubificid species in the different coastal areas studied is presented in Tab. 1.

As seen in the table, the number of tubificid species was highest in some coastal areas of the Bothnian Bay and in the Quark (Vaasa). *Limnodrilus* spp. and *Peloscolex ferox* (Eisen) were found only in those areas where the salinity of the water is relatively low (oligohaline areas). Tubificids were the dominant bottom animals at most stations sampled in the sea areas off Kemi-Tornio and Oulu and at many stations off Kokkola. The bottom fauna of these areas is in general poor in species and the densities of bottom animals are low. In more

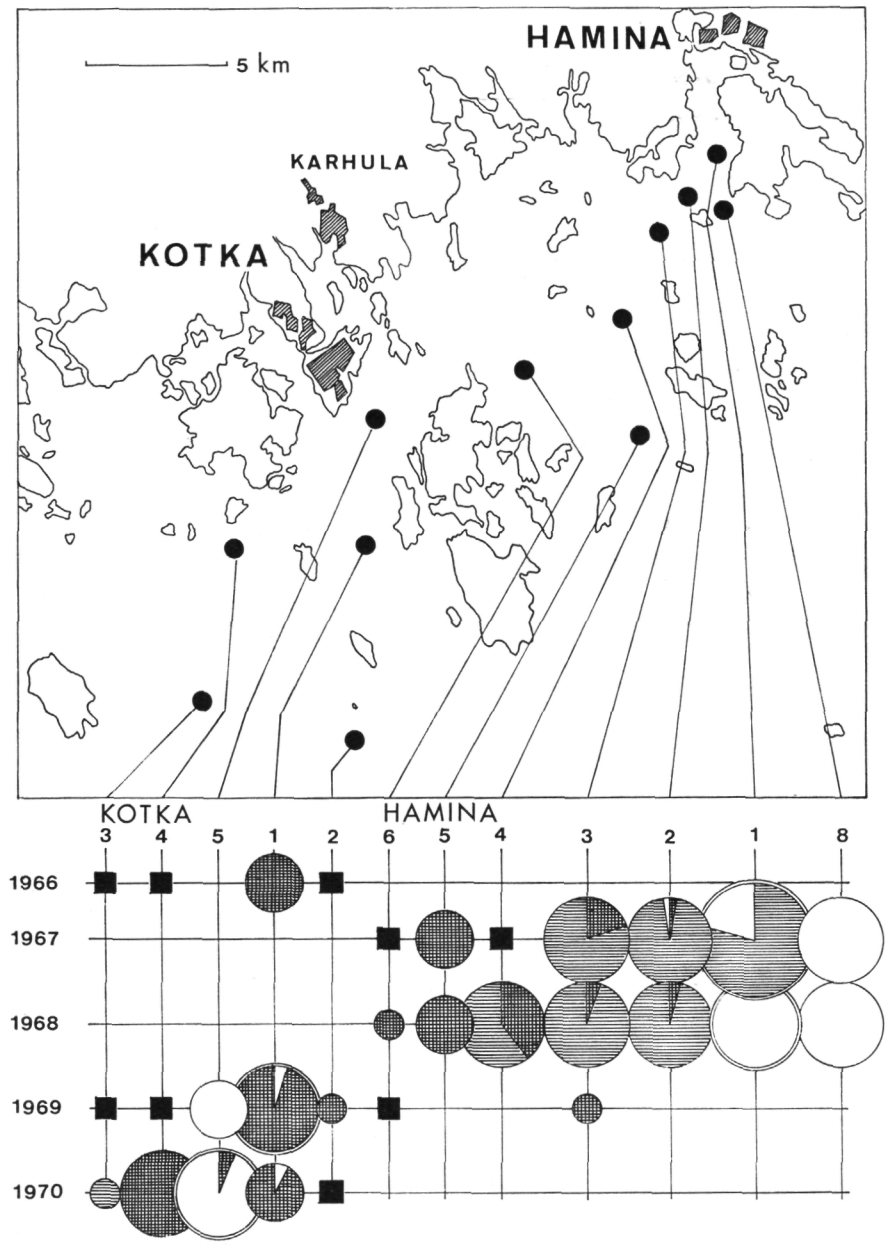


Fig. 12. Occurrence of tubificids in the sea areas off Kotka and Hamina. For explanations see Fig. 2.

southern and more saline areas, where the bottom fauna is richer in species and the marine lamellibranchiate *Macoma baltica* occurs abundantly, tubificids seldom dominated in the samples, except in the polluted innermost parts of some study areas, where other animals were weakly represented. The numbers of tubificid species and their densities were especially low in the sea areas off Porkkala and Porvoo and they were totally absent at the five sampling stations off Mariehamn. These are the most oligotrophic and the most saline areas in our material and many of the sampling stations especially at Porvoo, are relatively deep.

In many areas the densities of tubificids were highest in the shallow innermost localities and decreased towards the deeper outermost areas. The decrease of the densities at greater depths may be connected with low production of organic matter, or the low temperatures of the deep bottom water, which may limit the propagation of the species (see Kennedy 1966).

The greatest depths, lowest and highest salinity values and lowest oxygen values in localities where different species were found are presented in Tab. 2.

Potamothrix hammoniensis and *Psammoryctes barbatus* were the most euryhaline and euryoxybiontic species in the material. These species, together with *Limnodrilus hoffmeisteri*, were usually found also in polluted condi-

Tab. 1. Frequency of occurrence of the tubificid species in the areas studied.

Area	Hamina	Kotka	Loviisa	Porvoo	Porkkala	Mariehamn	Uusikaupunki	Rauma	Pori	Vaasa	Pietarsaari	Kokkola	Oulu	Kemi-Tornio
Number of samples	16	14	58	12	37	5	27	19	2	12	10	80	12	31
								Frequency						
Tubifex costatus	9	6	2	4	19	–	7	5	1	–	–	–	–	–
Psammoryctes barbatus	6	1	1	–	–	–	16	–	–	7	–	11	–	5
Limnodrilus hoffmeisteri	–	–	–	–	–	–	–	–	–	3	1	1	2	7
Limnodrilus udekemianus	–	–	–	–	–	–	–	–	–	–	–	2	–	1
Limnodrilus profundicola	–	–	–	–	–	–	–	–	–	2	–	2	–	2
Peloscolex ferox	–	–	–	–	–	–	–	–	–	–	–	–	–	7
Potamothrix hammoniensis	5	4	30	1	–	–	18	3	–	6	8	39	11	27
Clitellio arenarius	–	–	1	–	–	–	1	5	–	–	–	–	–	–

tions (see also Laakso 1968 and Särkkä 1969). *Clitellio arenarius*, *Tubifex costatus* and *Limnodrilus profundicola* Verrill seemed to avoid the areas where the waste load was great.

The character of the substratum seems to be one of the main factors influencing the occurrence of the species. However, the correlation between the quality of the substratum and the occurrence of the species is not easy to prove, since the quality of the sediment depends on many factors including the configuration of the bottom, the exchange of water, the load of allochthonous material and the intensity of the biological cycles in the sediment. *Psammoryctes barbatus* was found on many bottom types but most often on sand-mixed clay or silt bottoms. *Tubifex costatus* seems to prefer these kinds of bottoms, too. *Clitellio arenarius* occurred sparsely on sandmixed clay bottoms but reached maximum densities on sand and gravel. *P. hammoniensis* was found on all kinds of bottoms from gyttja to gravel, but the greatest densities of this species were observed on sulphidic gyttja-clay. *Limnodrilus hoffmeisteri* preferred shallow localities with soft detritus-rich gyttja-clay bottoms.

No clear correlation between the abundance of tubificids and the concentration of total phosphorus in the water was found.

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Tab. 2. Greatest depths, lowest and highest salinity values and lowest oxygen saturation values in localities where different tubificid species were observed. The oxygen values given in the table are largely provisional, since the oxygen conditions in the sediment were not studied.

	Salinity range ‰	Deepest record m	Oxygen minimum %
Tubifex costatus	4.25–6.99	57	2.3
Psammoryctes barbatus	0.17–5.15	39	0.0
Limnodrilus hoffmeisteri	0.05–4.31	20	?
Limnodrilus udekemianus	0.17–3.00	9	?
Limnodrilus profundicola	2.32–4.31	20	83.0
Peloscolex ferox	0.05–2.76	18	77.0
Potamothrix hammoniensis	0.05–6.20	55	0.0
Clitellio arenarius	5.74–6.00	26.5	80.0

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Discussion

Leppäkoski: You give very important and really the first quantitative information on the N. Baltic tubificids. The densities were rather low, however. In the polluted area of Turku, SW-Finland, I have counted total tubificid densities up to 20–30,000 ind/m^2. Could you, Mr. Elmgren, find values exceeding these in your meiofauna samples from the Askö region?

Elmgren: Since I have, so far, taken no samples in polluted areas, I have found very few tubificids in my samples.

Ilus: We know that our sampling method is not very applicable to the quantitative sampling of tubificids, but we had to use it when collecting all the macroscopic animals. Further, most of our samples are from depths greater than 10 m; thus the densities of tubificids are rather low. The density values given in this report are, however, in rather good accordance with corresponding values given by Laakso (1968) from the sea area off Helsinki and by Särkkä (1969) from the sea area off Pori.

Dybern: Which species can be found outside paper and pulp mills?

Ilus: We have only a few samples quite close to paper and pulp mills. *Potamothrix hammoniensis* and in the Bothnian Bay also *Limnodrilus hoffmeisteri* seemed to be the tubificids most resistant to paper and pulp mill wastes.