

New records of scalpellids: Are scalpellids (Cirripedia: Scalpellidae) in the Nordic Seas confined to specific oceanographical regimes?

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Records of cirriped species in the family Scalpellidae from the Nordic Seas are scarce. New records of the four species *Amigdoscalpellum hispidum* (G. O. Sars, 1890), *Ornatoscalpellum stroemi* (M. Sars, 1859) *Tarasovium cornutum* (G.O. Sars, 1879) and *Weltnerium nymphocola* (Hoek, 1883) from the eastern part of the Norwegian Sea are reported. The record of *W. nymphocola* is the first from the Norwegian coastline, found on the shelf slope, and the rarely found *T. cornutum* was found in a depth representing the lower depth range for this species. Based on new data from the Norwegian Sea and from the literature the species' connection to specific oceanographical regimes is discussed.

Key words: Cirripedia, Scalpellidae, Nordic Seas, oceanography, biogeography

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INTRODUCTION

There are about 30 species of thoracic cirripeds known from the Nordic Seas (Norwegian, Greenland and Iceland Seas). Knowledge of these species is scarce and based on a limited number of records represented by a handful of specimens from each cruise or expedition only (Nilsson-Cantell 1978). This is in contrast to the more than thousand cirriped species found world-wide, especially in tropical and warm-water areas (Nilsson-Cantell 1978), where a single sample can contain an abundance of species with high densities (Foster & Buckeridge 1995). The limited number of records in the Nordic Seas might reflect both biogeography and sampling intensity. The only detailed accounts of scalpellids in the Nordic Seas have been Broch (1924, 1953) and Nilsson-Cantell (1978), the work by Nilsson-Cantell (1978) being a review mainly based on existing collections in north European museums together with reference to earlier publications. A total of nine species of Scalpellidae are found in the area (Nilsson-Cantell 1978), of which four are found in the survey presented here. Material previously reported by Nilsson-Cantell (1978) is not repeated.

The coastal shelf off the west coast of Northern Norway is rather narrow, being only 10 km wide off Andenes. A steep slope from the shelf break extends towards the Lofoten Basin

at almost 3500 m depth. In this area the University of Tromsø arranged four cruises to investigate the bottom fauna in the Norwegian Sea in the period 1979 to 1983 (Holthe 1984). These investigations were undertaken by sampling transects from the coastline to the great depths, and stations from 50 m to 3500 m were sampled. Although few specimens were found, they represent records from the continental slope in areas where the number of deep-sea investigations is limited. Nevertheless, it is obvious from previous work that scalpellid material from the Nordic Seas in general is scarce, which urged us to bring these findings forward.

The area covered in these cruises is also interesting in terms of depth transects and oceanography, as it includes different water masses and oceanographical regimes. Suggestions for distribution of different scalpellid species according to water temperature and water masses (Broch 1953) are given.

Along the coast of Norway coastal water (CW) from the Norwegian Coastal Current (NCC) and warm saline Atlantic Water (AW) from the Norwegian Atlantic Current (NAC) dominate. In shelf areas in Northern Norway the topography is characterised by shallow banks and trenches separating them

(Sundby 1984), which strongly influences the distribution of water-masses in the area. On the shelf lateral movements of NAC and NCC have a great influence on the hydrography in shelf waters (Orvik et al. 1995, Nordby et al. 1999). In deeper parts of the shelf and in the trenches AW is found beneath CW. Off the shelf AW has been found to dominate (Nordby et al. 1999) while it tends to mix with Norwegian Deep Sea Water (NDSW, $S < 35$; $T < 0$ °C) in the upper slope off the shelf break. Below the 700 m isobath, Nordby et al. (1999) found NDSW to prevail. Although Nordby et al. (1999) carried out their studies over a single year, it is reasonable to predict that AW usually is present under CW on the shelf, in the trenches, and in the upper slope off the shelf break, and that NDSW dominates at similar depths as is reported in the steep slope. Concerning temperature ranges reported in connection to the biogeographical distribution of some of the scalpellid species, these facts should be considered.

The aim of this paper is to present new records of four scalpellid species found on the shelf slope off Northern Norway, where records for both horizontal and vertical distribution are documented. The biogeography of the nine species known to occur in the Nordic Seas is also discussed.

MATERIAL & METHODS

Specimens were obtained from material sampled during several cruises with the R/V "Johan Ruud" of the University of Tromsø. The material was sampled with traditional gear such as the triangular dredge, the "Sneli-dredge" (Sneli 1998), and a large Agassiz dredge. Transects from the shelf to abyssal depths were covered (Holthe 1984). Station data from where scalpellids were found are given in Table 1.

Measurements of capitulum length (cl.) and breadth (cb.) of each specimen are given in mm, the number of specimens is given in brackets after the station number. Some specimens were attached to hydroid specimens, but these were not identified. The material presented here is deposited in the collections at the Museum of Natural History and Archaeology, Norwegian University of Science and Technology (VM, NTNU). The taxonomy follows the "European Register of Marine Species" (Costello et al. 2001).

RESULTS

A total of 18 specimens of four species were found at seven different stations (Table 1).

Amigdoscalpellum hispidum (G.O. Sars, 1890)

Figure 1 A

Scalpellum hispidum Broch 1924: 39-41, Figure 13.– Nilsson-Cantell 1978: 28-30, Figure 12.

Material examined. Norwegian Sea, stn 868-80 (1); stn 869-80 (1); cl. 6 mm, cb. 3 mm.

Remarks. The small and triangular inframedian latus distinguishes this species from the other species previously reported from the North Atlantic (Nilsson-Cantell 1978). Both specimens were of similar size and the capitulum was covered with a setose cuticle.

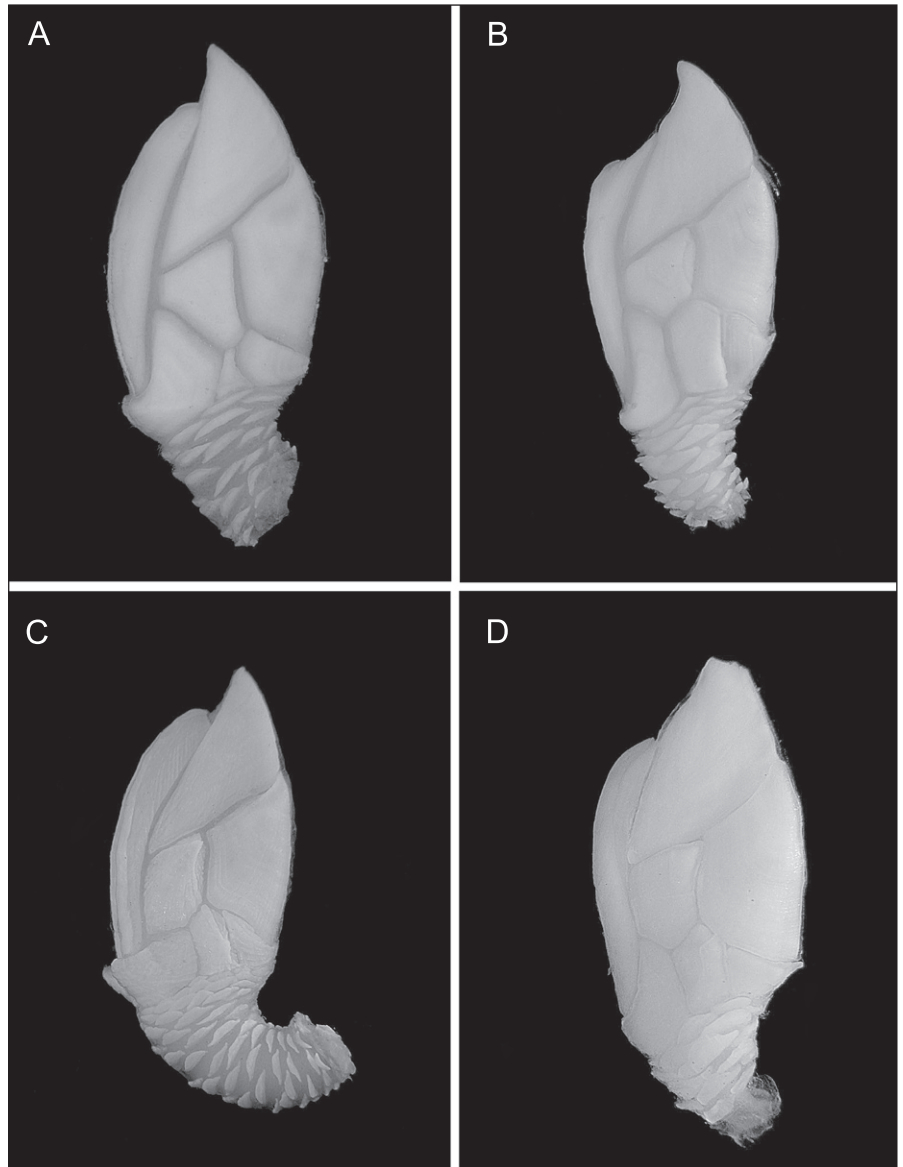
Occurrence and distribution. The species has a scattered distribution along the northern part of the Norwegian coast and the present material is found within this area. Its further distribution is from the east and west coasts of South Greenland. The depth-range is reported to 190-1096 m (Nilsson-Cantell 1978). According to Broch (1924) the Norwegian records are from 90 to 600 m, the deeper ones reported by Nilsson-Cantell (1978) are hence from Greenland (see Broch 1953). Broch and Nilsson-Cantell used 90 and 190 m respectively as the shallower depth range. This must be due to a typographical error in Broch's paper. He used 90 m in the discussion of the species' distribution, but his specimens are reported from 190 m in the material section of the paper. *A. hispidum* is in the present study found at two localities from 581 and 635 m, which is in concordance with previous records from Norwegian waters. Nilsson-Cantell (1978) stated that *A. hispidum* is an Atlantic boreal species penetrating arctic waters.

Table 1. Station data for cruises with R/V «Johan Ruud», University of Tromsø, in the Norwegian Sea (1979-1983) where specimens of Scalpellidae were found.

Station No.	Latitude, N	Longitude, E	Depth (m)	Sampling gear	Date
868-80	69° 24'	15° 15'	581	Sneli-dredge	28 May 1980
869-80	69° 26'	15° 11'	635	Triangular dredge	28 May 1980
871-80	69° 27'	15° 20'	780	Agassiz dredge	28 May 1980
884-80	69° 19'	14° 40'	770	Sneli-dredge	29 May 1980
1212-81	69° 30'	15° 46'	500-470	Sneli-dredge	28 Aug 1981
1230-81	68° 08'	10° 10'	860	Sneli-dredge	28 Aug 1981
2664-83	69° 37.5'	15° 51.5'	610	Triangular dredge	29 Aug 1983

Figure 1

Photographs of specimens from the presented material from the Norwegian Sea. A, *Amigdoscalpellum hispidum* (G.O. Sars, 1890), stn 869-80 carinal length 6 mm; B, *Ornatoscalpellum stroemi* (M. Sars, 1859), stn 1230-81 carinal length 8 mm; C, *Tarasovium cornutum* (G.O. Sars, 1879), stn 884-80 carinal length 6 mm; D, *Weltnerium nymphocola* (Hoek, 1883), stn 868-80 carinal length 3 mm.

***Ornatoscalpellum stroemi* (M. Sars, 1859) Figure 1 B**

Scalpellum stroemi Broch 1924: 23-30, Figures 6-8.– Nilsson-Cantell 1978: 19-21, Figure 8.

Ornatoscalpellum stroemii Foster & Buckeridge 1995: 175-176, Figure 9.

Material examined. Norwegian Sea, stn 871-80 (1); stn 1212-81 (8); stn 1230-81; (1); stn 2664-83 (3); cl. 1 - 8 mm, cb. 0.5 - 4.5 mm.

Remarks. This is a species where the capitular valves are very variable and according to Nilsson-Cantell (1978) other species have erroneously been identified as *O. stroemi*. Capitulum length of fully-grown specimens in this species can reach 10

mm, hence the present material includes both fully grown and juvenile specimens.

Occurrence and distribution. *O. stroemi* is a boreal Atlantic species and is widely distributed in the North Atlantic (Nilsson-Cantell 1978). It is well known from the Norwegian coast, and is found from the Murman coast to the west coast of Denmark, Shetland Islands, the Faroe-Iceland area, Spitzbergen and Greenland. It is also found in Davis Strait, Baffin Bay and on the east coast of America. The depth range for *O. stroemi* is 2-1600 m. Foster & Buckeridge (1995) reported this species from 355 m depth off the coast of Morocco as the southernmost record.

***Tarasovium cornutum* (G.O. Sars, 1879) Figure 1 C**

Scalpellum cornutum Broch 1924: 33-35, Figure 11.– Nilsson-Cantell 1978: 24-26, Figure 10.

Material examined. Norwegian Sea, stn 884-80 (1); cl. 6 mm, cb. 4 mm.

Remarks. The species is easily recognised by the horn-shaped carinal latus projecting outwards beyond the carina. According to the measurements given by Nilsson-Cantell (1978) the specimen is almost fully grown.

Occurrence and distribution. *T. cornutum* is distributed from the Faroes, Norwegian Sea, Barents Sea to Russian arctic waters. It is an eastern arctic species that penetrates boreal waters (Nilsson-Cantell 1978). Only a few records from the Norwegian Sea are previously reported, most of them from the southern part. The single specimen represents a new location from the Norwegian coast. It was found at a depth of 770 m, which is stretching the previously reported depth range of 32-760 m (Nilsson-Cantell 1978).

***Weltnerium nymphocola* (Hoek, 1883) Figure 1 D**

Scalpellum nymphocola Broch 1924: 30-33, Figure 10.– Nilsson-Cantell 1978: 21-24, Figure 9.

Material examined. Norwegian Sea, stn 868-80 (2); cl. 3 mm, cb. 1.5 mm.

Remarks. This species might be difficult to distinguish from *O. stroemi* (Nilsson-Cantell 1978). In one of the present specimens the umbo of the inframedian latus is clearly placed in the middle of the plate, which is used as a character to distinguish the two species (Nilsson-Cantell 1978). In the other specimen, however, this is not as prominent. Both specimens have a smoothly curved carina with umbo at the margin of the tergum, a distinguishing character for this species (Broch 1924). The length of the capitulum in fully grown specimens is 7-8 mm, with a breadth of 4-5 mm (Nilsson-Cantell 1978). This should indicate that the present specimens are juvenile. Both specimens were attached to the same hydrocaulus of an indeterminable hydroid.

Occurrence and distribution. The species is reported as circumpolar (Broch 1924) and stenothermal as it has been found in temperatures between -1.8 °C and 1.5 °C (Nilsson-Cantell 1978). The depth ranges from 28 to 1358 m. *W. nymphocola* is an arctic species also recorded in boreal waters (Nilsson-Cantell 1978). The present material represents a new record for the Norwegian coast, and it is one of very few from the Norwegian Sea. Nilsson-Cantell (1978) did not fully support Broch's claim that *W. nymphocola* is circumpolar, and this needs further investigation.

DISCUSSION

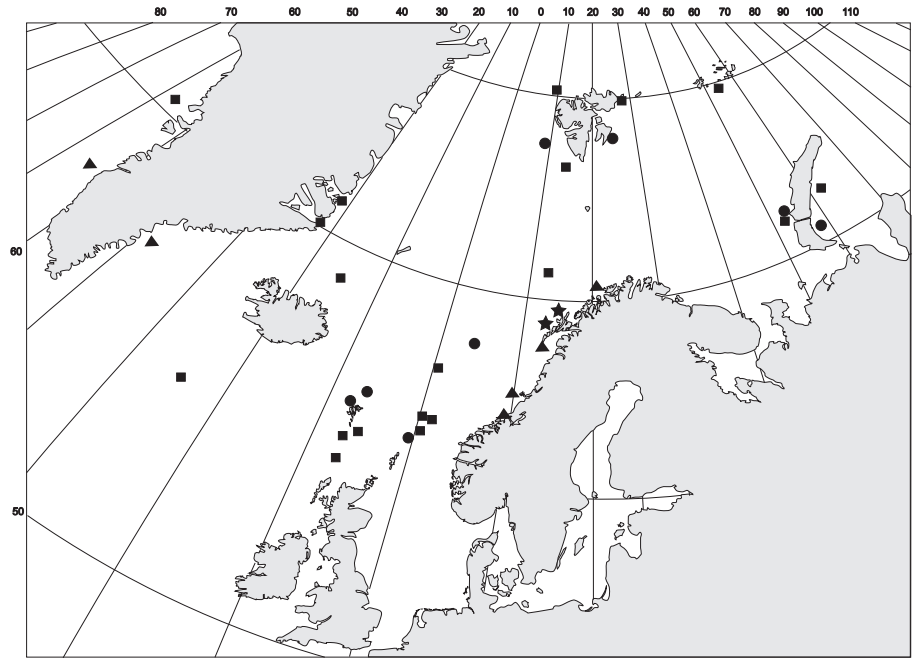
Although the present material consists of a limited number of specimens it contributes to the knowledge of distribution and biogeography of scalpellids in the Nordic Seas. Within the area only Broch (1924; 1953) and Nilsson-Cantell (1978) have given detailed accounts of this group (Figure 2). The records are scarce but they are nevertheless interesting from a biogeographically point of view, as the species previously have been suggested to be stenotherm and restricted to uniform oceanographical regimes (Broch 1953). The warm Atlantic water along the Norwegian coastal shelf seems to restrict the distribution of the scalpellids to deeper waters where cold deep-water mix with warmer water. Except for *O. stroemi* and *S. scalpellum*, the other scalpellids in the Norwegian fauna are only found off the shelf break (see Broch 1953 for further discussion). The shallow records of the northern boreal and arctic scalpellids are from arctic waters (Broch 1924; 1953; Nilsson-Cantell 1978), following a pattern where deep-water species are found in more shallow water in higher latitudes. Similar patterns have been studied for abyssal molluscs in the Norwegian Sea (Bouchet & Warén 1979), who found a distinct abyssal fauna with only a few species also present in the North Atlantic. They considered the area north of the Shetland-Faroe ridge and Denmark Strait a separate zoogeographical unit, based on their data. Mollusc data also indicate a typical bathyal fauna consisting of species mainly found in the slopes, with distribution ranges further south to the Bay of Biscay, indicating that trenches in the ridges are transportation routes (Bouchet & Warén 1979).

Species recorded in the Nordic Seas clearly have a northern distribution, and of the nine taxa recorded all but *Ornatoscalpellum stroemi* have a boreal and/or arctic distribution. The southernmost record of *O. stroemi* from off the coast of Morocco (Foster & Buckeridge 1995) makes this a widely distributed taxon. It must be considered an amphi-atlantic lusitanian-boreal species that also penetrates arctic waters as it is found in East Greenland waters, in Baffin Bay and Davis Strait, as well as on the east coast of America. According to Nilsson-Cantell (1978) it prefers high temperatures, and the depth-range is supposed to be related to temperature. Its vertical distribution ranges from depths of 2 to 1600 m but it is in general found deeper than 100 m.

Amigdoscalpellum hispidum is considered to be an atlantic-boreal species (Nilsson-Cantell 1978). Its amphi-atlantic distribution with records from the coast of Norway and both east and west coasts of Greenland indicates that it also should be present in intermediate areas, in suitable habitats. It is found from 190 m to 1096 m in waters with temperatures between 3.3 °C and 3.8 °C (Nilsson-Cantell 1978), these limits being from records in Greenland waters (Broch 1953). It is not likely that this species should be found in greater depths in the Nordic Seas, considering the known lower temperature limit. The water-masses on shelf depths in the sampling area are dominated by AW, and

Figure 2

A plot of the distribution of three of the four species found in the present study in the Nordic Seas and immediate adjacent areas. Additional data on each species' distribution is from Nilsson-Cantell (1978). Each symbol may represent several nearby localities for each species. Plots for *Ornatoscalpellum stroemi* are omitted as the species is widely distributed within the area. (★) New localities from the present study, *Weltnerium nymphocola* (■), *Tarasovium cornutum* (●), *Amigdoscalpellum hispidum* (▲).



considering the shallower records in the Lofoten-Vesterålen area (Broch 1924), temperatures are, at least seasonally, anticipated to be significantly higher than 4 °C (Nilsson-Cantell 1978). It is likely that AW masses are mixed with NDSW off the shelf break (Nordby et al. 1999). It is therefore reasonable to assume that *A. hispidum* could have a wider temperature-range than previously reported, and therefore also a wider horizontal distribution in the Nordic Seas.

Tarasovium cornutum and *Weltnerium nymphocola* are both considered arctic species that penetrate boreal waters (Nilsson-Cantell 1978). However, Broch (1924) stated that *W. nymphocola* is circumpolar, although known records do not confirm this. *T. cornutum* is confirming to the general picture that shallow records occur in arctic areas while deeper records are from somewhat lower latitudes. Broch (1953) stated that one specimen found north-east of the Faroe Islands in water-masses with a temperature of 5.3 °C was an exception with regard to vertical distribution, as all other known records were from waters colder than 0 °C. The present record confirms that this species might well thrive in warmer waters. The same is found for *W. nymphocola* which has only exceptionally been recorded in areas with positive temperatures (Broch 1953). *Weltnerium nymphocola* is, like *T. cornutum*, a stenotherm species with a known temperature range from -1.8 °C to 1.5 °C (Nilsson-Cantell 1978).

A species not found in the present material, *Scalpellum scalpellum* Linnaeus, 1758, is an East Atlantic lusitanian-boreal species distributed from Northern Norway to West Africa including the Mediterranean and the Azores (Nilsson-Cantell 1978). Recorded depth range is 10-540 m but this species is usually found between 30 and 200 m. According to Nilsson-

Cantell it is not common near the northern limit of the boreal zone, an area in which the present material is sampled. As the temperature regimes where the eurythermal *S. scalpellum* is found differ from 16° to 0°C, it must be concluded that it is a true lusitanian-boreal species.

The ridge systems separating the North-Eastern Atlantic from the Norwegian Sea, the Iceland-Faroe Ridge and the Wyville-Thompson Ridge (Hansen 1985), are with their rather shallow sill depths possible distribution barriers for scalpellids preferring deep and cold waters. Except from the shallow dwelling species *S. scalpellum* and *O. stroemi*, there are no species known from both the Nordic Seas and the North Atlantic (Young 1998). Trenches in the ridge system do not seem to be transportation routes for the planktonic larvae of scalpellids, but larval biology for scalpellids is poorly known as it is described from only a few species (Nilsson-Cantell 1978), and there seems to be a great variation in development. Such trenches were suggested to be transportation routes for some mollusc species from the upper limits of the abyssal range (Bouchet & Warén 1979). There is some evidence that scalpellid species have spread within the Nordic Seas divided by deep basins, like *W. nymphocola* (Broch 1953).

Records of scalpellids in the Nordic Seas are still scarce and the knowledge of both taxa, their distribution, horizontally as well as vertically, and abundance is obviously not well known, which is evident when such a scarce material as is presented here contributes with several new observations. Results from the BIOFAR and BIOICE programmes, around the Faroe Islands and Iceland respectively, will most likely give valuable contributions to the knowledge of the group within the area.

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We are grateful to Per Pethon, Jon-Arne Sneli and Torleif Holthe who together with the crew of R/V "Johan Ruud" sampled the Lofoten Basin for four years. Holthe brought the material forward for identification and inclusion in the collections of the NTNU, Museum of Archaeology and Natural History and gave us access to valuable unpublished information about the cruises he was in charge of. Comments by referees were appreciated, and they improved the quality of the manuscript.

SAMMENDRAG

Nye funn av scalpellider: Er scalpellider (Cirripedia: Scalpellidae) i de Nordiske hav avgrenset til bestemte oseanografiske vannmasser?

Nye funn av fire arter fra cirripediegruppen Scalpellidae representerer interessante observasjoner fra Norskehavet. De fire artene *Amigdoscalpellum hispidum* (G. O. Sars, 1890), *Ornatoscalpellum stroemi* (M. Sars, 1859), *Tarasovium cornutum* (G.O. Sars, 1879) og *Weltnerium nymphocola* (Hoek, 1883) er bare få ganger rapportert fra de Nordiske hav (Grønlandshavet, Islandshavet og Norskehavet). Tidligere funn sammenfattet i tre større publikasjoner representerer forholdsvis få individer. Det foreliggende materialet inneholder også få individer, men på bakgrunn av hva tidligere arbeider viser av kunnskap om gruppen, er materialet av stor interesse. Hjalmar Broch knyttet funn av arter i denne gruppen til vanntemperaturer og dybder. Det er derfor av interesse å se på hvilke typer vannmasser artene er knyttet til. Det er også nærliggende å se på teorier hvorvidt arter av scalpellider i de Nordiske hav er knyttet til bestemte vannmasser i et oseanografisk perspektiv. Det er ikke mulig å komme nærmere en konklusjon tatt i betraktning at det foreliggende materialet består av få individer og er samlet inn i et lite område, men funnene er i seg selv et bidrag til å sette nærmere søkelys på disse teoriene.

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