DET KGL. NORSKE VIDENSKABERS SELSKAB
MUSEET

GUNNERIA

48

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STUDIES ON THE MARINE FOULING AND WOOD-BORING ORGANISMS OF THE TRONDHEIMSFJORD (WESTERN NORWAY)

TRONDHEIM 1984

STUDIES ON THE MARINE FOULING AND WOOD-BORING ORGANISMS OF THE TRONDHEIMSFJORD (WESTERN NORWAY)

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ABSTRACT

Santhakumaran, L.N. & J.-A. Sneli 1984. Studies on the Marine Fouling and Wood-boring Organisms of the Trondheimsfjord (Western Norway). *Gunneria 48*: 1-36[1].

A study on the systematics, seasonal density, growth-rate and vertical distribution of wood-infesting organisms of the Trondheimsfjord collected from a series of short-term and long-term panels exposed at three stations for overlapping periods during 1977-78, have been summarised. Natural resistance of 32 timber species and also performance of pine-wood, treated with Creosote and Boliden salt, against attack of marine organisms were tested and the results are briefly reviewed.

Important wood-borers in Trondheimsfjorden are *Psiloteredo megotara*, *Xylophaga dorsalis*, *X. nidarosiensis*, *X. noradi*, and *Limnoria lignorum*, their combined infestation can result in heavy destruction of timber.

Of the 110 species or groups of animals and algae identified as fouling organisms, hydroids, bryozoans, tubiculous polychaetes, barnacles, star-fishes and ascidians are the most dominant.

For the molluscan borers the peak period of attack was found to be July-August. While *P. megotara* preferred to settle on panels fixed at higher levels, *X. dorsalis* and *L. lignorum* concentrated their attack on panels near the sea bed. Settlement of wood-infesting organisms down to a depth of 100 m were observed. Settlement of fouling organisms was severe during late spring and summer, and density was heaviest at higher levels. The growth-rate of borers and foulers was rapid. Chironomid larvae occurred on panels at considerable depth.

Treated pine wood panels failed to prevent growth of foulers, although they were free from borer attack.

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[1] Contribution No. 228 from Biological Station, Trondheim, Norway.

CONTENTS

INTRODUCTION

The problem of marine fouling and timber-boring organisms has always been of economical significance to maritime nations, because of the loss involved due to the infestation on marine construction. Therefore, even a slight improvement in the efficiency of anti-fouling devices would offer a very significant contribution to the economic effectiveness of the oil, shipping and fishing industry. However, any attempt at preventing the ravages of these organisms must first take into account the different species involved in a particular locality. The entire spectrum of their biology and ecology, in addition to information on the natural durability of different species of timber to wood-borers and the response of borers and foulers to various preventive methods should be studed. Efficacy of antifouling paint formulations against different organisms also needs to be understood properly. Although considerable work has been done on various aspects of this problem (Anonymous 1952, Clapp & Xenk 1963, Jones & Eltringham 1971, Purushotham & Satyanarayana Rao 1971), no single solution has yet been found because of its very complex nature.

Knowledge on the marine fouling and timber-boring organisms from the Norwegian coast is still inadequate except for some limited work, especially from the Trondheim (Dons 1927a, 1929b, 1940-49) and Bergen areas (Nair 1962, Dybern 1967). In the former area, sedentary organisms have never been studied from the fouling point of view. Therefore, as a contribution in this field, a comprehensive study on various aspects of fouling and wood-boring organisms of the Trondheimsfjord was carried out during 1977-78, and the results obtained are reviewed in this paper.

MATERIAL AND METHODS

Wood-borers and foulers were mainly collected from experimental panels immersed regularly for varying periods at different depths in selected localities in the Trondheimsfjord during the year 1977-78 (Fig. 1). Some material was also obtained from damaged piles and from fishing boats at Trondheim harbour, Borgenfjorden and Hitra. Specimens of wood-borers in the collections of the Museum

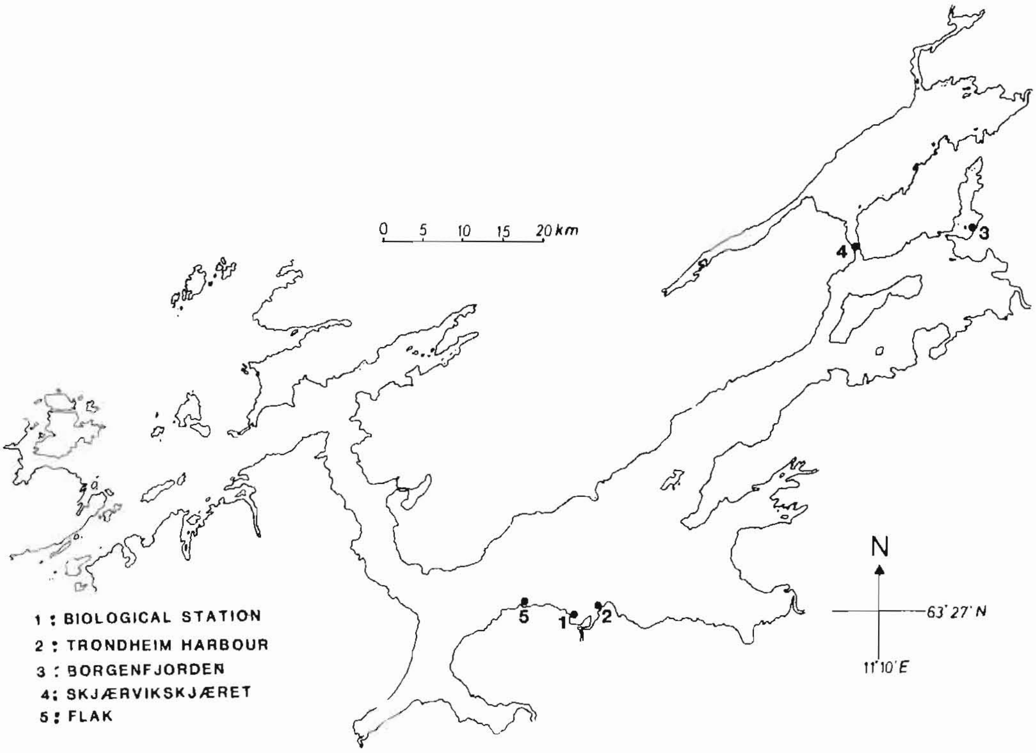

Fig. 1. Map of Trondheimsfjorden showing the position of the test sites.

of the Royal Norwegian Society of Sciences and Letters in Trondheim were also examined.

Information on seasonal density and vertical distribution was collected by exposing, in selected sites and at different depths, a series of panels for overlapping periods. The intensity of settlement by borers and foulers was then assessed. The panels were then cut open and as many borer specimens as possible were collected alive and uninjured in order to study their characteristics.

Studies on the natural durability of various species of timber were conducted by exposing samples in selected localities and examining them for incidence of wood-borers after a period of approximately 13 months. Creosoted and 'Boliden'-treated panels, at a retention of 220 kg per m^3 and 6 to 7 kg salts per m^3 respectively, were used for the experiments on the performance of treated wood. These were also continuously immersed for a period of about 13 months before final observation.

Experiments conducted were as follows:

Experiments	Station investigated	Period of exposure of panels	Depth of installation	No. of panels	Remarks
Seasonal settlement intensity studies	Biological Station	March 1977 to May 1977	1.5 m & 10 m	76	Immersed for varying overlapping periods
	Trondheim Harbor	March 1977 to May 1978	1.5 m & 10 m	78	
	Borgen-fjorden	May 1977 to May 1978	6 m to 7 m	28	
Vertical distribution studies	Biological Station	March 1977 to July 1977	Intertidal to 30 m	11	At every 3 m
		July 1977 to March 1978	Intertidal to 30 m	11	At every 3 m
	Flak	July 1977 to Nov. 1977	40 m, 70 m & 100 m	9	3 panels at each depth
		Nov. 1977 to June 1978	40 m, 70m & 100 m	9	3 panels at each depth
Natural durability studies	Biological Station	April 1977 to May 1978	20 m	32 x 2	30 timber species; only one set examined
	Trondheim Harbour	April 1977 to May 1978	10 m	29	29 timber species
	Borgen-fjorden	April 1977 to May 1978	8 m	27 x 2	27 timber species; only one set examined
	Skjaervik-skjaeret	April 1977 to May 1978	10 m	22	22 timber species
Durability of treated timber	Biological Station	April 1977 to May 1978	1.5 m	3	2 treated and one control panel
	Trondheim Harbour	May 1977 to May 1978	10 m	6	4 treated and 2 control panel
	Borgen-fjorden	May 1977 to May 1978	1.5 m	3	2 treated and one control panel
			10 m	3	2 treated and one control panel

OBSERVATIONS AND DISCUSSION

A. LIST OF SPECIES AND REMARKS

Wood-borers: The wood-borers collected during the course of the investigation were *Psiloteredo megotara* (Hanley), *Xylophaga dorsalis* Turton, *X. praestans* Smith, *X. nidarosiensis* Santhakumaran, *X. noradi* Santhakumaran and *Limnoria lignorum* (Rathke). In addition to these, specimens of *Nototeredo norvegica* (Spengler), collected from a damaged log and material available in the Trondheim Museum, were examined. *Teredo navalis* Linné from Hitra, present in the collections of the Swedish State Museum of Natural History, Stockholm, were also examined. Observations of special interest are:

1. Total absence of *N. norvegica* in test panels
2. Increased activity of *X. dorsalis* successfully establishing itself as a predominant borer in Trondheimsfjorden
3. Morphological variations in *X. dorsalis* and *X. praestans*
4. Discovery of two new species of *Xylophaga*

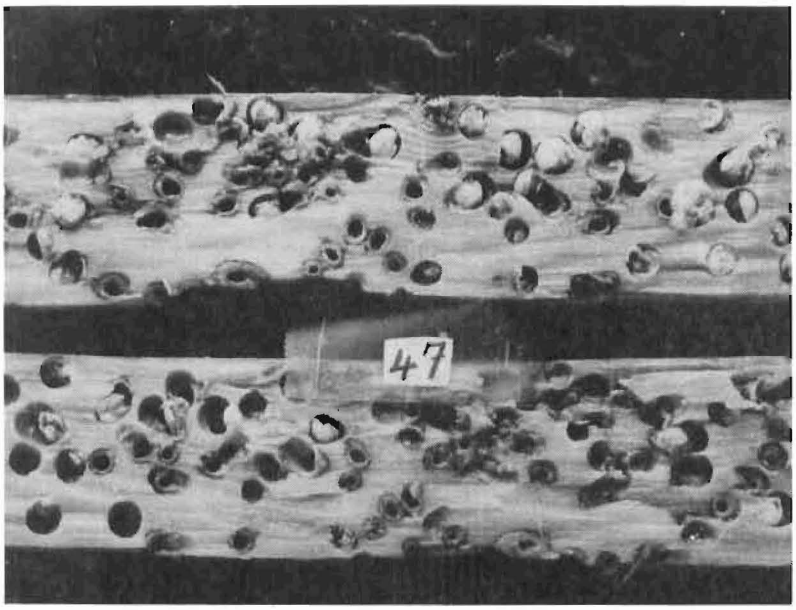

Fig. 2. Portion of pine-wood panel, immersed from 4 Aug. 1977 to 7 Aug. 78 at 1.5 m below low tide level at the Biological Station, split open to show heavy damage by *Xylophaga dorsalis*.

Considerable faunistic changes seem to have taken place in the species composition of wood-borers along the coasts of Norway since the investigations of Dons and Nair. For example, *X. dorsalis*, which has never been reported as a borer causing serious damage to timber construction, has turned out to be a major destructive organism during the present studies, keenly competing for space with *P. megotara* and *L. lignorum* (Fig. 2). This is surprising, as it is found that along the swedish coast, the density of *X. dorsalis* is low (Norman 1976a, 1976b). It has also been observed that *N. norvegica* is not encountered on test blocks or other structures exposed in Norwegian waters. Its total absence has earlier been reported by Knudsen (1974). Nair (1962) found the species both important and widely distributed along Western Norway, and Dons (1946) has indicated its presence in Trondheimsfjorden. Grieg (1897, 1913) observed *N. norvegica* doing considerable damage to marine structures, expecially at Måløy and in Hardangerfjorden.

Several variations from the earlier descriptions of *X. dorsalis* and *X. praestans* have been brought to light. In *X. dorsalis*, in contrast to previous accounts (Turner 1955, 1971), excurrent siphons have never been found to truncate just posterior to the valves, but extend upto 1/4 to 1/3 the length of the incurrent siphon and rarely as much as 1/2 of its length (Fig. 3A). In fully extended condition, the siphons are 2 to 5 times the length of the shell. In several specimens, the posterior adductor muscle scar is found to be somewhat elongate oval and not nearly circular as recorded in earlier literature (Fig. 3B). Variations in the shape of the mesoplax are most common (Fig. 3C). The denticular ridges on the ventral side of the beak are close-set and those on the dorsal side further apart in some, whereas in others such crowding of the ridges are not observed (Fig. 3D). The ratio length/height of the shell valves varies from 0.87 to 1.28. The above findings have brought *X. dorsalis* nearer to *X. olobosa* Sowerby than reported before.

Similarly, in the earlier descriptions of *X. praestans* (Knudsen 1961, Turner 1971), it has been mentioned that the excurrent siphon is only slightly shorter than the incurrent one. Again according to Knudsen (1961), the beak of the shell extends somewhat less than half the distance to the ventral margin of the shell and carries several ridges which are widely spaced on the

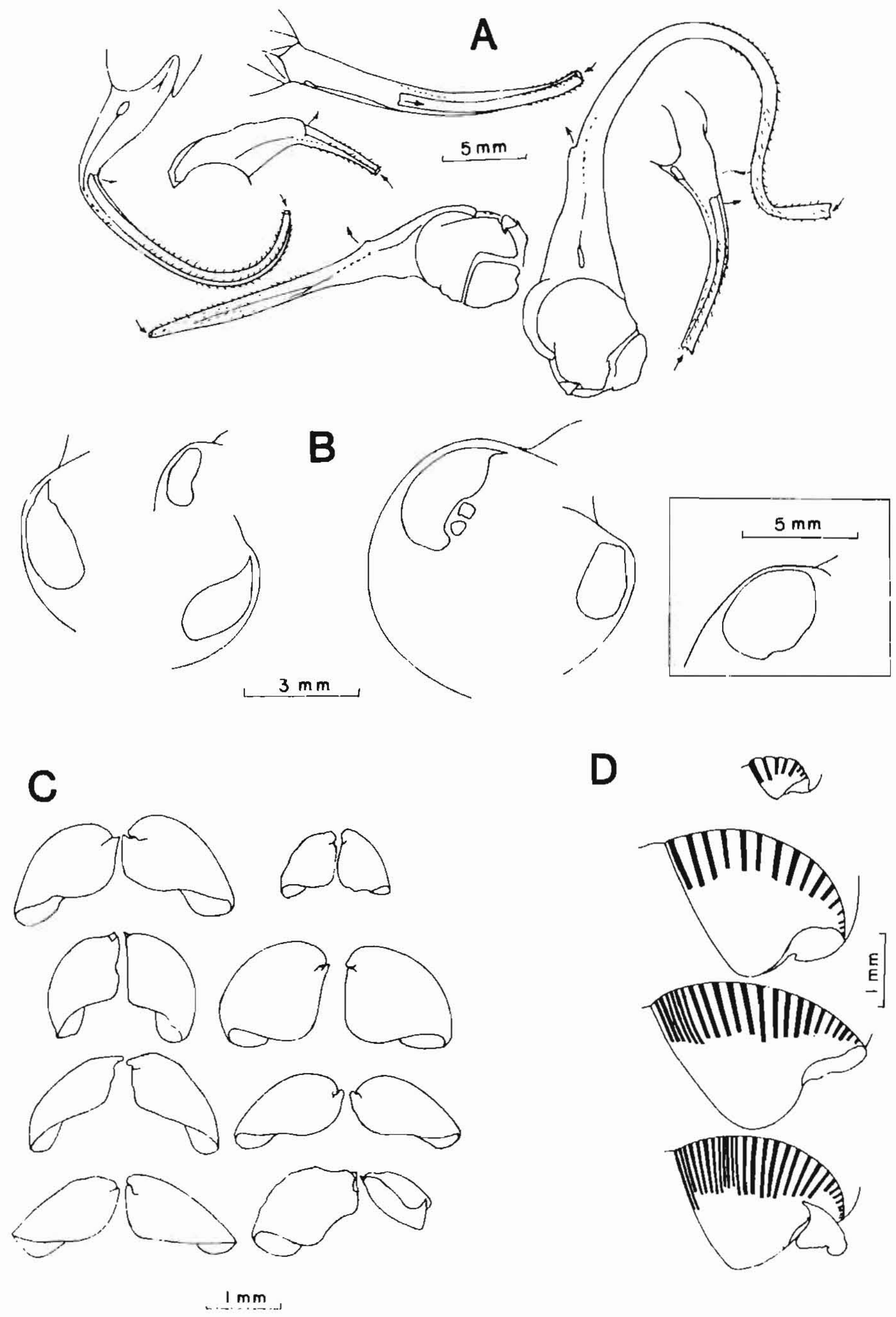

Fig. 3A. Fully extended siphons of *Xylophaga dorsalis* showing comparative size of incurrent and excurrent siphons.
Fig. 3B. Posterior adductor muscle scar of *X. dorsalis* showing variation in shape.
Fig. 3C. Mesoplax of *X. dorsalis* showing variations in shape.
Fig. 3D. Beak of *X. dorsalis* showing variations in arrangement of ridges.

dorsal part, the breadth of the interstices being 2 to 3 times that of the ridges. Towards the ventral edge, they are more close-set, and in larger specimens, the space between the ridges is less than the breadth of the ridge. In contrast to the above, it is found that, in live specimens, the length of the excurrent siphon is highly variable but much shorter than the incurrent siphon (Fig. 4A). In most specimens, the ridges on the beak are widely spaced, the interstices being 2 to 6 times the breadth of the ridge. This space is more towards the ventral portion of the beak than towards the dorsal part except in a few cases, where they are close-set on the ventral portion of the beak (Fig. 4B). Length/height ratio of the valves varies from 0.96 to 1.12. The shape of the mesoplax is variable (Fig. 4C). The beak normally reaches less than half the distance along the ventral edge of the shell, except in a few cases where it extends more than half its distance (Fig. 4D). In some cases, the oblique striations of the posterior adductor muscle scar are Y-shaped on its anterior half (Fig. 4D).

Two new species of *Xylophaga* from the area have been described in an earlier publication (Santhakumaran 1980), one species with a prominant protuberance on the left valve anterior to the chondrophore and with a circular mesoplax has been named *X. nidarosiensis* and the other with both siphonal openings at the tip, *X. noradi*.

Marine fouling: Fouling organisms collected and identified from the various test panels are:

Protozoa	:	Foraminiferans, Folliculinids, Suctorians on hydroid foulers and *Mirofolliculina limnoriae* on *Limnoria*.
Coelenterata	:	*Laomedea* sp., *Tubularia larynx*, *Hydractina* sp., *Bougainvillia* sp., *Coryne* sp., and *Dynamena* sp. on algal foulers.
Nemertini	:	*Amblictona gracilis* and planarians.
Bryozoa	:	*Tegella unicornis*, *Callopora craticula*, *C. dummerili*, *C. lineata*, *Crisia eburnea*, *Plagioecia patina*, *Electra pilosa*, *E. pilosa verticillata*, *E. monostachys*, *Membraniporella nitida*, *Tubulipora flabellaris* (?), *Scrupocellaria scruposa*, *Celleporina hyalina*, *Schizoporella unicornis*, and *Cribrilina annulata*.

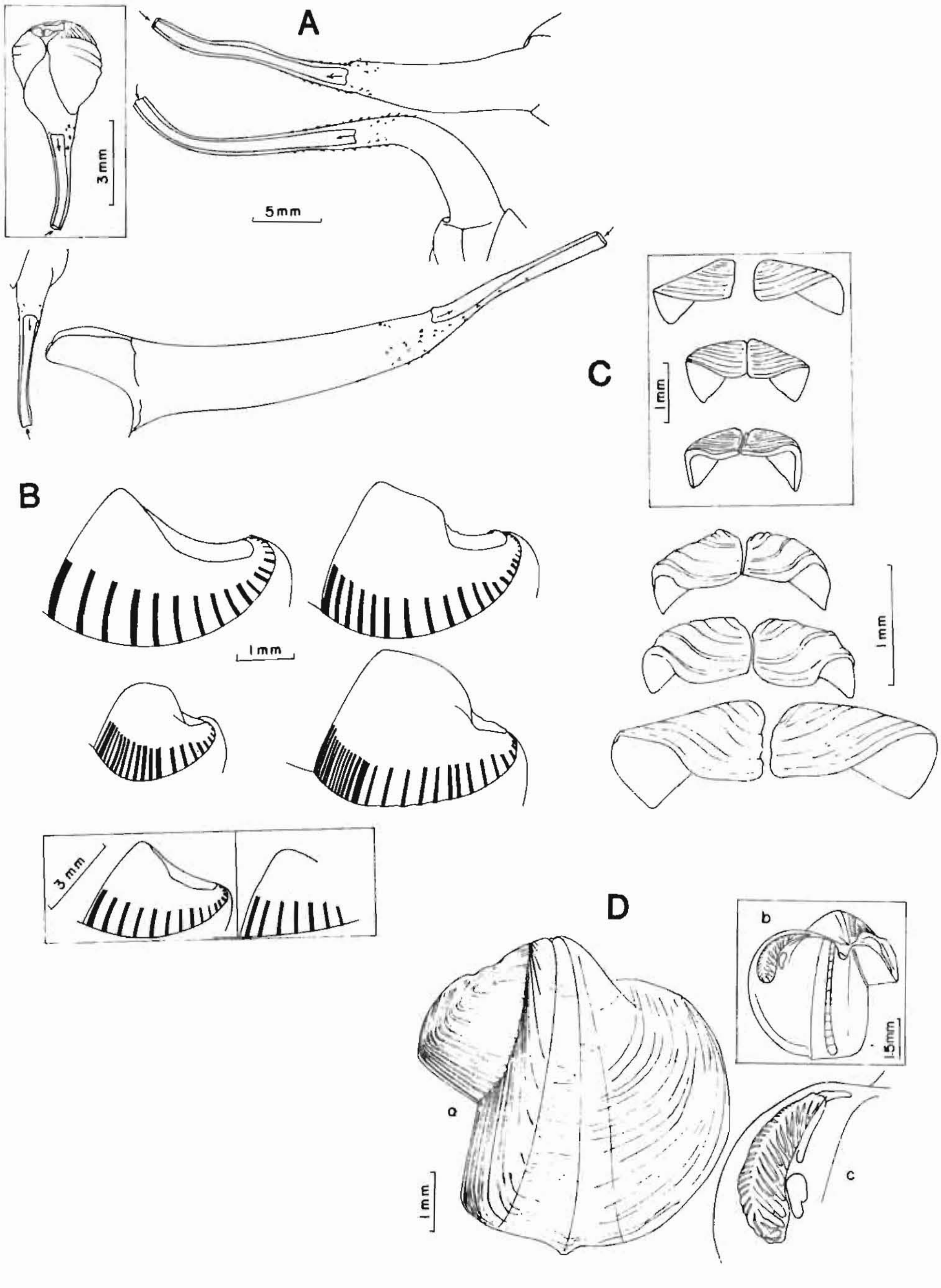

Fig. 4A. Fully extended siphons of *Xylophaga praestans* showing comparative size of incurrent and excurrent siphons.
Fig. 4B. Beak of *X. praestans* showing variations in arrangement of ridges.
Fig. 4C. Mesoplax of *X. praestans* showing variations in shape.
Fig. 4D. Valve of *X. praestans* with large beak. a) outer view, b) inner view, c) posterior adductor muscle scar showing nature of striations.

Polychaeta	:	*Harmothoe imbricata, Pholoe minuta, Eulalia viridis, Anaitides* sp., *Nereis pelagica, Nereimyra punctata, Autolytus prolifer, Glycera* sp., *Capitella capitata, Flabelligera affinis, Cirratulus cirratus, Amphitrite cirrata, Nicolea zostericola, Polydora ciliata, Microspio mecznikowianus, Pomatoceros triqueter, Hydroides norvegica, Serpula vermicularis, Chitinopoma greenlandica, Microserpula inflata, Spirorbis (Dexiospira) pirillum, S. (Laeospira) borealis, S. (Laeospira) tridentatus* and *S. (Paradexiospira) vitreus.*
Arthropoda	:	Copepods, Unidentified amphipods, *Corophium* sp., *Gamarella* sp., *Jaera albifrons, Astacilla longicornis, Idotea* sp., *Nymphon* sp., *Caprella* sp., *Aspidoconcha limnoriae, Balanus crenatus, B. balanus, Verruca stroemia, Halocarus basteri, Halocarus* sp., and *Halocladius variabilis.*
Mollusca	:	*Mytilus edulis, Modiolus* sp., *Hiatella arctica, Heteranomia squamula, Mya* sp., *Pecten* sp., *Cardium* sp., *Rissoa* sp., *Littorina* spp, *Lacuna* sp., *Akera bullata, Acmaea testudinalis, Buccinum undatum, Hydrobia ulvae, Margarites groenlandicus, Coryphella verrucosa, Dendronotus frondosus, Eubranchus pallidus, E. exiguus, Trinchesia foliata, Tenellia pallida, Favorina branchialis, Facelina* sp., and *Onchidoris bilamellata.*
Echinodermata	:	*Asterias rubens, Echinus* sp., *Ophiura robusta, Ophiopholis aculeata,* and *Ophiocantha* sp.
Ascidiacea	:	*Ciona intestinalis,* and *Styela* sp.

In addition to the above, a few ostracods, prawns, crabs and fishes were also occasionally seen in the fouling complex. Algal fouling was mainly due to the profuse growth of *Desmarestia viridis, Sponogonema tomentosum, Enteromorpha intestinalis, Fucus* sp., *Laminaria* sp., *Antithamnion plumula, Antithamnion* sp., *Blachista fucicola, Ceramium strictum, Rhizoclonium implexum,* and *Spongomorpha aeruginosa.*

Among the fouling organisms, the most important ones are *Laomedea* sp., *Tegella unicornis, Callopora craticula,* and *Crisia* *eburnea*, *Hydroides norvegica*, *Spirorbis* spp, *Pomatoceros triqueter*, *Harmatoe imbricata*, *Capitella capitata*, and *Polydora ciliata*, *Balanus crenatus* (Fig. 7), *Mytilus edulis*, *Asterias rubens*, and *Ciona intestinalis*. Among algal growth, *Desmaerestia viridis*, *Spongonema tomentosum*, *Fucus* sp., and *Laminaria* sp. are dominant.

B. SEASONAL INTENSITY

Wood-borers: During the year 1977, settlement of *Psiloteredo megotara* was recorded from early July to September with peak incidence during July and August (Tab. 1). Settlement was greater on the lower surfaces of the panels than on the upper surfaces. Huge specimens of *P. megotara* (measuring over 300 mm, maximum size 457.5 mm) were found on the test panels immersed for a period of 8 to 10 months at the Biological station and Trondheim harbour, bringing about complete destruction of the panels (Fig. 5). They had grown to an average size of 8.25, 73.40, 171.50, 248.20 and 397.10 mm in 45, 90, 180, 233 and 300 days respectively (Tab. 3). This is less than the value obtained by Dons (1940: 480 mm in 10 months) and Nair (1962: 286 mm in 4 1/2 months), but greater than that reported by Kramp (1927: 240 mm in 10 months). Growth seems to be faster during winter months, as observed by Dons (1940). Attack by *Limnoria lignorum* was rather erratic on panels immersed for short periods and they were observed in appreciable numbers, causing damage to the surface of the timber, only on long-term panels (Tab. 1 and Fig. 6). Nevertheless, migratory activity was noticed during March to May 1977 and also from October 1977 to February 1978, when fresh attack on short-term monthly panels was observed (Tab. 1). The general trend of invasion is almost the same as reported by Kramp (1977) at Hirtshals, Sømme (1940) in Flødevigen and Nair (1962) at Bergen. During 1977, attack by larvae of *Xylophaga dorsalis* on panels installed at 10 m depth started during the first week of July and continued until the end of October, with a peak during July-August (Tab. 1). Sparse settlement even during winter cannot be ruled out, because it was observed that adult specimens extracted from panels at different times of the year and kept in the laboratory readily discharged ripe ova. At 100 m, the larval settlement was noted from mid June and probably extends to the

Fig. 5. Pine-wood panel, immersed at 10 m below low-tide level from 6 May 1977 to 28 April 78, at Trondheim Harbour, split open to show extensive destruction by *Psiloteredo megotara*.

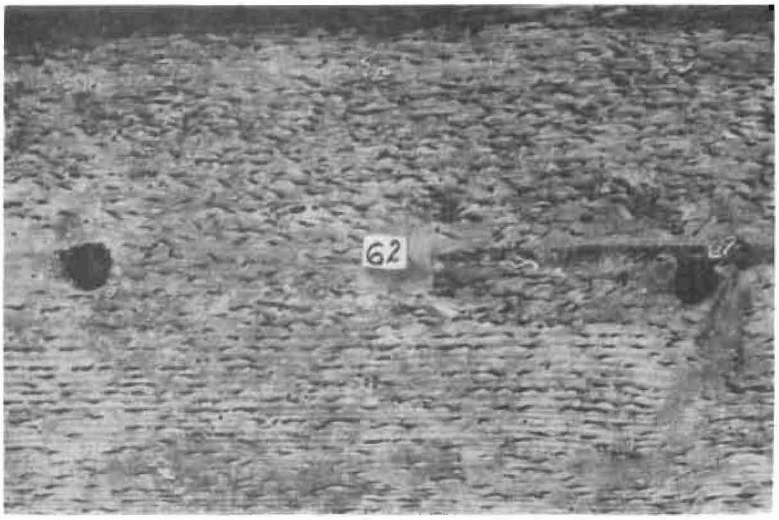

Fig. 6. Pine wood-panel, immersed at 10 m below low-tide level from 11 Aug. 1977 to 3 May 78 at Trondheim Harbour showing heavy surface attack by *Limnoria lignorum*.

winter months. Maximum length of burrow noticed for *X. dorsalis* was 58.5 mm attained in about 233 days (Tab. 3) and this was greater than the value reported by Dons (1940) and Norman (1977). *X. praestans*, which was extremely scarce, produced tunnels measuring 73 mm in 10 months (Tab. 3).

For *P. megotara* and *X. dorsalis* the period of fresh infestation is almost the same as reported from the Swedish West coast (Norman 1976a) but the duration is shorter and the intensity reduced. The density of wood-borers was very much less at Borgenfjorden, probably on account of the heavy fouling of timber by *Ciona intestinalis*.

Fouling-organisms: Fouling was severe and the organisms settled in large numbers especially during late spring and summer, completely covering the panels (Tab. 1 and 2; Figs 7, 8). During April dense settlement of *Balanus crenatus* was observed, with new additions of *Laomedea* sp., *Mytilus edulis* and polychaete larvae during May. By the end of June, the barnacles had grown very rapidly and because of the overcrowding become tubular with a height of 26.5 mm and with an extremely narrow base providing them a very precarious foot-hold on the panel. At higher levels the luxurient growth of coelenterates had almost buried the barnacles. Bivalves also settled abundantly having a convenient initial foothold on the hydroids. By the end of July, fouling became very complex, thickly covering the entire panel surface and the continued growth of barnacles and *Laomedea* sp. attracted free-moving foulers such as polychaetes, nudibranchs and echinoderms. By this time the coelenterate colonies were mostly dead not only as a result of predation by nudibranchs, but also by being smothered by the growth of immense number of bivalves that had earlier settled on them. By August, barnacles, coelenterate stumps and bivalves constituted the dominant foulers forming a very thick layer together with other free-moving organisms leading to a climax community especially on panels immersed at higher levels at the Biological Station and at Trondheim Harbour. At Borgenfjorden, after initial settlement of *B. crenatus* and *Laomedea* sp., the epifauna on the timber soon consisted entirely of *C. intestinalis*.

Algal fouling was important only on panels at higher levels sepecially during autumn and winter. Although on all the sub-tidal panels, the dense settlement of fouling organisms during

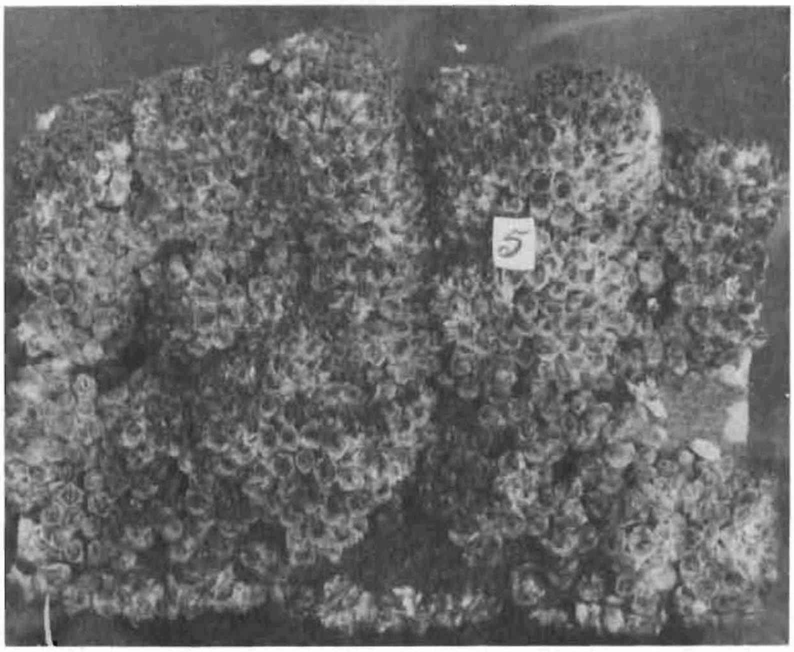

Fig. 7. Intensity of settlement of *Balanus crenatus* on a test panel immersed at the Biological Station from 15 March to 15 May 77, at 3 m below low-tide level. Probable date of settlement: last week of April.

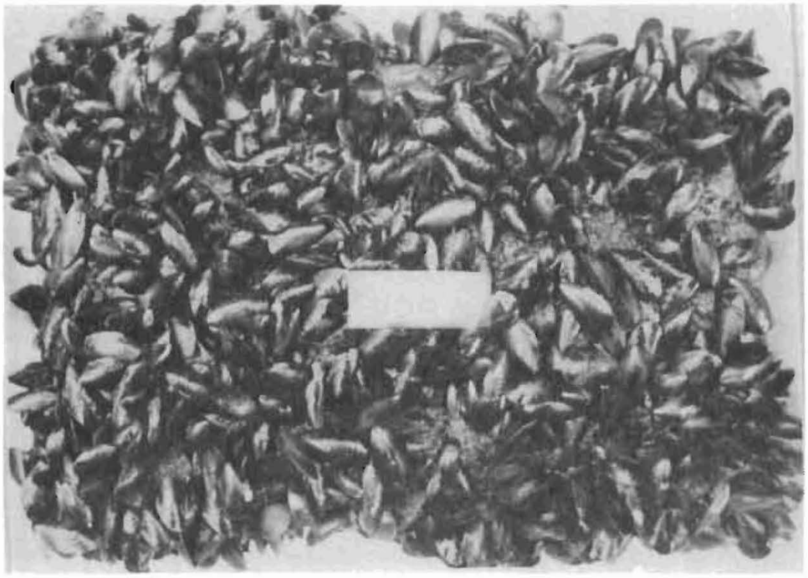

Fig. 8. Intensity of settlement of bivalves on a test panel immersed at Trondheim Harbour from 6 May 1977 og 28 April 78, at 1.5 m below low-tide level.

spring and summer had soon outgrown the algae and these panels were completely covered by a thick layer of epifauna and silt.

In general, species composition and also dominant constituent in the marine growth on a test panel depended on the season of the year the panels were immersed (related to the spawning activity and availability of larvae for fresh settlement), depth of installation and finally the sequence of succession of fouling organisms. Of these, succession of fouling is again influenced by 1) the period of larval settlement and the growth-rate of foulers involved (slow-growing forms gradually replacing the fast growing ones), 2) overcrowding by a fast growing dominant species leading to its self-elimination (e.g. barnacles), 3) smothering effect of later settlers on those already present (e.g. bivalves on hydroids), 4) beneficial effect of an already existing fouler in facilitating the subsequent attachment of others (e.g. crowding of serpulids on barnacle bases; bryozoans on a toxic surface forming a base for subsequent settlers), 5) size of the species (large volumes of a fouler being advantageous to cover the surface rapidly in a bid to outgrow competitors (e.g. growth of ascidians), and 6) all the effects of free-moving predators, which can change the entire complexion of fouling by their feeding activity (e.g. starfishes on bivalves; nudibranchs on hydroids). It may however, be emphasised that the hydrographic parameters including pollution in a locality are also decisive factors for the presence or absence of a specimen in an area and thereby in a fouling community.

Laomedea sp., *B. crenatus* and *M. edulis* were the most important foulers at the Biological Station; *Laomedea* sp., *B. crenatus, M edulis, T. unicornis, C. graticula, C. eburnea, Spirorbis* spp and *H. norvegica* at Trondheim harbour, and *Laomedea* sp., *B. crenatus* and *C. intestinalis* in Borgenfjorden. The growth of the foulers was very rapid (Tab. 3), barnacles measuring 17 mm (average 15.70 mm) in basal diameter in 68 days and 19.75 mm (average 18.55 mm) in 101 days; *Laomedea* sp. having a length of 106.50 mm (average 104.05 mm) in 64 days and 292 mm (average 287.20 mm) in about 6 1/2 months; and *C. intestinalis* attaining 75 mm in 2 months and 167 mm in one year. The growth rate of *B. crenatus* was found to be much greater than that reported by Corlett (1948) and Nair (1962). However, Pyefinch (1948) has recorded values comparable to the present results.

A comparison of the present work with that of Nair (1962) has brought out several notable variations in the activities of fouling and wood-boring organisms from the Trondheim and Bergen areas. Among wood-borers, one of the remarkable features is the emergence of *X. dorsalis* as the predominant borer in Trondheimsfjorden while the attack of this species has been insignificant at Bergen. The presence of *N. norvegicus*, *T. navalis* and *Chelura terebrans* at Bergen and their complete absence in Trondheimsfjorden was another salient difference worth mentioning. Among foulers, while *H. imbricata*, *N. pelagica*, *N. punctata* and *C. capitata* was important errant polychaetes noticed in Trondheimsfjorden, *N. diversicolor* and *Lepidonotus squamatus* were dominant at Bergen. Important tubicolous polychaetes in the fouling complex were the same, represented by *P. triqueter*, *H. norvegica*, *S. sperillum* and *S. borealis*. Absence of the bivalve *H. arctica* on panels at Bergen was very conspicuous, whereas it settled in countless numbers on panels during the present studies. The nudibranchs were totally different but for the presence of *Dendronotus* sp. at both places. The number of bryozoan species collected during the present work was less than those reported by Nair (1962). Among the common dominant species *T. unicornis* and also *C. craticula* and *C. eburnea* to some extent, were important. Otherwise, species composition was considerably different. Contribution of *Asterias rubens* to the fouling complex was remerkable in Trondheimsfjorden compared to their incidence on panels at Bergen. The ascidian fauna on panels at Bergen was diverse and at least slight settlement of 45 observed ascidian species from this area have been recorded by Nair (1962). During the present investigation two out of 15 present species were observed with *C. intestinalis* as common to both places. Nevertheless, there is no comparison in the intensity of settlement by this species, while a maximum number of 48 specimens (Nair 1962: Tab. 21) has been reported on one of the panels at Bergen, during the present work they settled in abundance, and on one panel exclusively fouled by *C. intestinalis*, its weight was 70.4 kg per m^2. Gulliksen (1972) found that in Borgenfjorden only *C. intestinalis* would settle on eternite test panels. In 1970 a huge settlement occurred in June. In three months they had produced 40-50 kg per m^2 and in 1 1/2 year they were all dead. The compound ascidians reported from fouling at Bergen were absent on panels in Trondheimsfjorden.

A unique feature among the sedentary fauna in Trondheimsfjorden, which is also of considerable ecological interest, is the presence of larvae and pupae of *H. (Halocladius) variabilis* (Diptera: Chironomidae). Although few in number, chironomid larvae and pupae were met with among the fouling communities on several panels installed even at 10 m below the low tide level. They were present among a variety of fouling communities, from panels with sparse fouling to those with extremely heavy settlement of bivalves, barnacles, coelenterates, bryozoans, serpulids, ascidians or algae, together with thick debris composed of silt and faeces of polychaetes and wood-borers. The larvae were observed in empty tunnels of *Limnoria* and in tubes of *Corophium* and *Pylydora*. Faeces of wood-borers and of *C. capitata*, agglutinated by a secretion from the larvae and fortified with algal filaments, were all used in the construction of pupal cases. Their presence at such great depth as 10 m is all the more important as they are intertidal in habitat. It is also interesting that they were not reported on panels immersed at Bergen (Nair 1962), although Koskinen (1968a, 1968b) has recorded their presence in abundance in the area. These insect larvae belong to the holeuryhaline group. They were unaffected by distilled water and could withstand salinities as high as 70.55 directly transfered from distilled water and after acclimation 97.05. Larvae, which were motionless after two days in 134.65 S recovered completely and became active on being transferred to normal sea water (Santhakumaran, Sneli & Sundnes, Sarsia, in press).

C. VERTICAL DISTRIBUTION

Wood-borers. In studies conducted to a depth of 30 m, *P. megotara* was observed throughout the water column although incidence was much less below 15 m (Tab. 4). Attack was mostly concentrated down to a depth of 15 m, with most settlement between 3 to 9 m depth. A faster growth could also be registered between these levels (Tab. 5). In panels immersed from 22 July 1977 to 13 March 1978, specimens measuring 265 mm were noticed. One specimen of *P. megotara* was present in a panel installed at 40 m during the period 7 July 1977 to 7 Nov. 1977. The result is in general agreement with the depth preference reported earlier for this species

(Kramp 1927, Lyngnes 1958, Norman 1976), although the range has now been extended to 40 m.

Intensity of attack of *X. dorsalis* was found to increase with depth and maximum attack occurred near the mud-line (Tab. 4). Incidence was greater on panels installed near the mud-line at a depth of 10 m than on panels at 10 m depth where the bottom level was at 30 m depth. An increase in the rate of growth and boring activity was also discernable in deeper levels (Tab. 6). During these investigations, the bathymetric distribution of *X. praestans* was extended to a depth of 100 m from the previously known 82 m. Another interesting observation is the incidence of *Xylophaga* larvae, few in number, at 30 m and 60 m from the bottom. Occurrence of the larvae at such levels has been considered unusual (Turner 1973).

Attack of *L. lignorum* was also, like *Xylophaga*, more severe near the bottom and the intensity decreased rapidly a few metres above the bottom (Tab. 4). Only very sparse settlement was observed at higher levels. A similar pattern of vertical distribution has also been reported by earlier workers (Johnson & Miller 1935, Sømme 1940, Black & Elsey 1948, Nair 1962).

The selective vertical incidence of *P. megotara* and *X. dorsalis* eliminates interspecific competition for space which has a great survival value to these organisms with a restricted habitat. The extent of their destructive activity can be judged from the fact that, on the same panel, while *P. megotara* settled in greater numbers on the lower surface *X. dorsalis* preferred the upper silted surface, thereby totally destroying the wood. *L. lignorum* shares the same depth preference as *X. dorsalis*, but works only on the upper thin layer of wood.

Fouling Organisms. Fouling was extremely heavy at levels down to a depth of 9 m, important settlers being *Laomedea* sp., *B. crenatus*, *M. edulis*, *Modiolus* sp., and *H. arctica*. These organisms, along with polychaetes (*H. imbricata* and *C. capitata*) and copepods, were present at all depths, especially on panels exposed from 15 March 1977 to 15 July 1977 (Tab. 4). On the intertidal panels, *Laomedea* sp., *M edulis* and *A. rubens* dominated. Algal growth was also observed, but completely covered by bivalves. At 3 m below low-tide, fouling was exclusively by *B. crenatus* (Fig. 7), and at lower levels all the species were present with fouling intensity gradually decreasing. The abundant settlement of *A. rubens* on intertidal panels might have been facilitated by the presence of countless numbers of juvenile bivalves, on which they could feed. Similarly, the lush growth of *Laomedea* could be the reason for the presence of large number of nudibranchs (*C. verrucosa*) on the lower surface of an intertidal panel.

Important differences between panels of series I (those immersed from 15 March 1977 to 15 July 1977) and series II (from 22 July 1977 to 13 March 1978) are manifested by the absence of *T. larynx*, *Heteranomia squamula* on the former, and by the absence of *B. crenatus*, *Verruca stroemia* and *Halocladius variabilis* on the latter. Moreover, intensity of settlement, especially by bivalves and *B. crenatus* on panels of series I was very heavy, whereas on series II, bryozoans, serpulids together with molluscan and crustacean wood-borers registered a high rate of infestation. A scrutiny of data given in Table I reveals that the differences noted above can be traced to the restrictions imposed by the period of exposure of the panels.

A perusal of the data on fouling intensity on the Series I and II panels given in Table 4, indicates the possible effect of fouling on borer infestation. On panels of Series I, the foulers virtually formed a complete matting, prior to the appearance of borer larvae in early July, thereby denying access of the latter to the timber surface. On the other hand, on panels of Series II having been immersed after the peak season of fouling settlement and at a time when borer larvae were present in the water, borer incidence was very much facilitated without interference from the foulers. This is also illustrated by the high rate of attack by *X. dorsalis* on the panel immersed at 1.5 m depth below low-tide level from 4 Aug. 1977 to 7 April 1978, at Biological Station (Fig. 2). Although, this borer species normally concentrates its infestation at deeper levels, especially close to the bottom and mud-line, its unusual ocurrence at 1.5 m could be a result of the panel having been immersed at a time when the larvae abounded in the water and also when the period of intense fouling growth was over.

At 40 m, 70 m and 100 m depths, important foulers were *Laomedea* sp., *T. larynx* and *H. norvegica*.

For *B. crenatus*, maximum average growth of 16.3 mm, in basal diameter, was observed at 3 m depth in about 2 1/2 months (Fig. 7), probable date of settlement being the last week of April. Rate of growth for the species decreased with increasing depth. For *Laomedea* growth rate increased with increasing depth down to 12 m and declined thereafter (Tab.1). At the 12 m level, average length of the colony was 105.80 mm, a size attained in about 2 months with probable date of settlement being middle of May.

D. STUDIES ON NATURAL DURABILITY OF DIFFERENT TIMBER SPECIES

Timber species[1] selected for exposure trials were *Ocotea rubra* (Vanah), *Lovoa klaineana* (Bibolo), *Xylia xylocarpa* (Irul), *Intsia palembanica* (Merbau), *Aningyeria* sp. (Aniegre), *Tectona grandis* (Teak, both from India and Malaysia), *Pterocarpus marsupium* (Bijasal), *Millettia laurenti* (Wenge), *Triplochiton scleroxylon* (Abachi), *Carya tomentosa* (Hickory), *Nauclea diderrichi* (Bilinga), *Swietenia krukovi* (Honduras mahogny), *Tetramerista glabra* (Punah), *Gonystylus* sp. (Ramin), *Eucalyptus gigantea* (Tasmanian oak), *Calophyllum elatum* (Poon), *Quercus rubra* (Red oak, from America and Jugoslavia), *Q. grosseserrata* (Japanese oak), *Chlorophora excelsa* (Iroko), *Diplotropis purpurea* (Sucupira), *Terminalia superba* (Limba), *Sequoia sempervirens* (Red wood), *Balfourodendron riedelianum* (Paumarfim), *Entandrophragma cylindricum* (Sapeli Mahogny), *Guibourtia arnoldiana* (Mutenye), *Betula pubescens* (Birch), *Picea abies* (Spruce), *Ulmus glabra* (Elm), *Aucoumea klaineana* (Gaboon), *Pseudotsuga taxifolia* (Oregon pine), *Pinus silvestris* (Norwegian pine), and Arcolito.

After immersion for a period of about 13 months from April 1977 to May 1978, the wood-borers encountered on the panels were *P. megotara*, *X. dorsalis*, *X. praestans*, and *L. lignorum*. The number of borers present and their growth were taken as the criteria for assessing the durability. Attack by *Xylophaga* was observed on all the wood species, though on timber such as *Xylia xylocarpa*, *M. laurenti*, *T. grandis* (Indian), *P. marsupium*, *I. palembanica*, *C. rubra*, *L. klaineana*, *Aningyeria* sp., and *T. scleroxylon*,

[1] *Local trade names are given in brackets. For Arcolito, a Scientific name could not be ascertained.*

most of them were only able to make small indentations. The first five listed species were also totally free from *Limnoria*. Attack by *P. megotara* was noticed only on *C. tomentosa*, *Aningyeria* sp., *E. gigantea*, *B. pubescens*, *B. riedelianum*, *Q. grosseserrata*, *Q. rubra*, *Gonystylus* sp., *A. klaineana*, *P. taxifolia*, *U. glabra*, *P. abies*, and *P. silvestris*, and though destruction was slight on all except the last two species, the few that settled grew to very large size, indicating lack of resistance, even though the incidence was low. The activity of borers was influenced by the dense settlement of foulers, the panels being exposed during April, foulers thereby preceding the appearance of borers. The low temperature during the summer of 1977 could also be a limiting factor. Further, the reduced rate of attack could be a result of the position of the panels, being installed at 8 m, 10 m and 20 m below low tide and 2 m from the bottom. As mentioned earlier, *P. megotara* mostly concentrates at higher levels and *X. dorsalis* prefers to live close to the bottom mud-line with intensity greatly reduced a few metres from the mud level. The results are indentical with the findings of Dons (1941) and Nair (1962) when comparing timber species common in all three investigations. A detailed account is available in Santhakumaran & Sneli (1978).

E. DURABILITY OF TREATED TIMBER

Response of various fouling organisms to chemically treated wood exposed in the Trondheimsfjord was also studied during 1977-78. At the dosage given (creosote: 220 kg per m^3, and Boliden: 3-7 kg salts per m^3), both preservatives failed to give any protection against the settlement of fouling organisms, and fouling was very severe after 3 to 4 months of immersion. As many as 67 species or higher taxa were recorded, of which *Laomedea* sp., *T. unicornis*, *C. craticula*, *C. eburnea*, *P. patina*, *S. spirillum*, *S. borealis*, *H. norvegica*, *B. crenatus* and *C. intestinalis* among animals, and *D. viridis*, *S. tomentosum* and *Laminaria* sp. among algae were important. Some of the foulers were found in their reproductive stage on the toxic substratum. Presence of chironomid larvae and pupae on treated panels, even at a depth of 10 m was also observed. In general, settlement of animals and algae was greater on Boliden-treated panels than on creosoted ones.

Although the preservatives did not provide any additional protection against foulers, the treated panels were free from borer attack. The controls were however, totally destroyed by *P. megotara*, *X. dorsalis*, and *L. lignorum*. Of the localities investigated, Trondheim Harbour had the greatest number of species.

ACKNOWLEDGEMENTS

The above investigations were carried out at the Trondheim Biological Station during the tenure of a fellowship awarded to one of the authors (L.N. Santhakumaran) by the Norwegian Agency for International Development (NORAD) through the Ministry of Education and Social welfare, Government of India. The authors are extremely grateful to Prof. Dr. Gunnar Sundnes for his keen interest and encouragement during the course of the investigation. Thanks are also due to Mr. Harry Følstad, Mr. Roald Andreassen, the late Mr. Lars Sundnes and Mr. Einar Lund, and also to Mr. Bjarne Søreng and Mr. Reidar Arnesen of R/V 'Harry Borthen I' for assistance at the test site; Cand.real. Torleif Holthe for help in the identification of polychaetes; and to Cand.real. Else Nøst Hegseth for indentifying the algae. The authors are also indebted to Dr. M.C. Tewari and Mr. J.C. Jain of Forest Research Laboratory, Bangalore (India) for their encouragement and support in carrying out the studies.

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Table 1. Intensity of settlement of fouling and wood-boring organisms on short-term monthly panels immersed in Trondheimsfjorden during 1977-1978 based on four panels immersed every month at Biological Station and Trondheim harbour (one panel at 10 m and the other at 1.5 m below low-tide level). Maximum incidence on any one of the four panels by a species has been indicated. Panel for the month of June was removed from the sea on 4th July, and the borers were all in the pediveliger or just metamorphosed stage indicating very recent incidence 2 to 4 days old.

Key to symbols: For all species other than protozoans, hydroids, copepods, barnacles and bivalves: VR = very rare (up to 5); R = rare (6 to 20); M = moderate (21 to 40); C = common (41 to 60): VC = very common (61 to 90); A = abundant (91 to 150); MA = above 151; - = absent. For hydroids (individual colony), barnacles and bivalves; VR = upto 25; R = 26 to 50; M = 51 to 75; C = 76 to 100; VC = 101 to 150; A = 151 to 300; MA = above 300. For protozoans and copepods grouping was done by visual assessment.

Organisms	Intensity of settlement during									
	March	April	May	June	July	Aug.	Sept.	Oct.-Nov.	Dec.-Jan.	Jan.-Febr.
Foraminiferans	-	-	VR	VR	A	VR	VR	VR	VR	VR
Folliculinids	-	-	-	-	A	R	M	VR	VR	VR
Suctorians on hydroids	-	-	A	A	-	-	-	-	-	-
Laomedea sp.	-	-	M	A	A	A	VR	VR	VR	-
Tubularia larynx	-	-	-	-	M	C	VR	VR	VR	VR
Callopora craticula	-	-	-	VR	R	R	-	R	-	-
Callopora dumerilli	-	-	-	-	R	-	-	-	-	-
Tegella unicornis	-	-	-	VR	R	R	-	R	-	-
Harmothoe imbricata	R	VR	VR	VR	VR	VR	-	VR	-	-
Nereimyra punctata	-	-	-	VR	VR	-	-	-	-	-
Capitella capitata	-	-	-	VR	-	R	VR	VR	-	-
Polydora cilita	-	-	-	-	R	-	-	-	VR	-
Spirorbis spp	-	-	VR	R	VC	VR	C	M	M	VR
Pomatoceros triqueter	-	-	VR	VR	C	C	M	R	M	-
Copepods	R	R	C	M	C	C	C	R	VR	A
Amphipods	M	R	R	VR	C	R	VR	VR	-	R
Corophium sp.	-	-	-	-	-	-	VR	-	-	-
Halocarus basteri	-	-	-	-	R	R	VR	VR	R	-
Larvae of *Halocladius* (*Halocladius*) *variabilis*	-	-	-	R	R	VR	-	VR	-	-
Balanus crenatus	-	A	VR	MA	R	R	-	-	-	-
Verruca stroemia	-	-	-	-	R	-	-	-	-	-
Mytilus edulis	-	-	MA	MA	MA	M	VR	VR	VR	VR
Modiolus sp.	-	-	VR	R	M	C	VR	VR	VR	-
Hiatella arctica	-	-	VR	A	C	R	VR	VR	-	-
Heteranomia squamula	-	-	-	-	-	VR	-	VR	-	-
Mya sp.	-	-	-	VR	M	C	-	-	-	-
Littorina spp	-	-	-	-	A	C	-	VR	-	-
Buccinum undatum (juveniles)	-	-	-	-	-	-	VR	VR	-	-
Coryphella verrucosa	-	-	-	-	VC	VC	-	VR	-	-
Eubranchus pallidus	-	-	-	-	VR	-	-	-	VR	-
Dendronotus frondosus	-	-	-	-	-	-	-	VR	-	-
Asterias rubens	-	-	-	R	C	VR	-	VR	-	-
Ophiura robusta	-	-	-	-	-	-	-	VR	VR	-
Psiloteredo megotara	-	-	-	11	50	4	2	-	-	-
Xylophaga dorsalis	-	-	-	42	177	32	1	1	-	-
Limnoria lignorum	3	15	3	-	-	-	-	5	16	18

Table 2. Intensity of settlement of fouling and wood-boring organisms progressively for periods ranging from one to twelve months on panels immersed in Trondheimsfjorden during 1977-1978. The table is based on four panels for each period (one panel each exposed at 10 m and 1.5 m below low-tide level at Biological Station and Trondheim harbour). Maximum incidence on any one of the four panels by a species has been indicated. Panel for the period March to June was removed from the sea on 4th July, and the borers were all in the pediveliger or just metamorphosed stage indicating very recent incidence 2 to 4 days old. N = Numerous, difficult to count due to heavy surface damage. For other symbols, Key same as in Table 1.

	Intensity of settlement during									
	March	March-April	March-May	March-June	March-July	March-Aug.	March-Sept.	March-Nov.	March-Jan.	March-Febr.
Foraminiferans	-	-	-	-	C	C	C	MA	C	A
Folliculinids	-	-	-	-	MA	MA	MA	MA	MA	VR
Suctorians on hydroids	-	-	A	-	-	-	-	-	-	-
Mirofolliculina limnoriae on *Limnoria*	-	VR	VR	VR	-	R	C	A	A	C
Laomedea sp.	-	-	VC	MA	MA	MA	MA	A	C	MA
Tubularia larynx	-	-	-	-	-	M	VR	VR	VR	VR
Planarians	-	-	-	-	VR	VR	VC	M	R	VR
Amblictona gracilis	-	-	-	-	-	-	C	MA	R	R
Callopora craticula	-	-	-	*VR*	*VR*	*R*	*R*	*VR*	*VR*	*VR*
Tegella unicornis	-	-	-	VR	VR	R	C	R	VR	-
Electra pilosa	-	-	-	-	-	VR	VR	-	-	-
Plagioecia patina	-	-	-	-	-	VR	C	VR	-	-
Crisia eburnea	-	-	-	-	VR	R	C	R	VR	VR
Schizoporella unicornis	-	-	-	-	-	VR	-	-	-	-
Tubulipora flabellaris	-	-	-	-	-	-	-	-	R	-
Harmothoe imbricata	R	C	R	VR	A	VC	A	MA	VR	VC
Nereis pelagica	-	-	-	-	M	C	A	MA	C	VC
Nereimyra punctata	-	-	VR	VR	C	VC	A	MA	C	M
Capitella capitata	-	-	VR	VR	C	A	A	MA	A	MA
Eulalia viridis	-	-	-	-	-	-	-	-	VR	R
Cirratulus cirratus	-	-	-	-	-	R	R	M	VR	VR
Amphitrite cirrata	-	-	-	-	-	-	VR	VR	VR	VR
Polydora ciliata	-	-	*R*	-	-	-	-	-	*VR*	-
Spirorbis spp	-	-	-	-	VR	R	R	VC	MA	A
Pomatoceros triqueter	-	-	-	-	VR	-	-	VR	VC	VC
Copepods	R	R	VR	R	R	R	C	MA	A	MA
Amphipods	M	VC	VC	C	-	-	VR	-	VR	VR
Corophium sp.	-	VR	-	-	-	VR	-	VR	VR	-
Halocarus basteri	-	-	-	-	R	R	M	R	R	R
Larvae of *Halocladius (Halocladius) variabilis*	-	-	-	-	VR	VR	R	R	R	R
Balanus crenatus	-	MA	MA	MA	MA	MA	MA	MA	MA	MA
Verruca stroemia	-	-	-	-	A	M	M	VR	VR	-
Aspidoconcha limoriae (mostly on *Limnoria*)	-	VR	VR	VR	-	R	R	C	A	M
Mymphon sp.	-	VR	-	-	-	-	VR	-	-	-
Mytilus edulis	-	-	MA	MA	MA	MA	MA	MA	MA	MA
Modiolus sp.	-	-	M	M	C	A	A	R	C	VR
Hiatella arctica	-	-	A	A	MA	MA	VC	M	VR	R
Heteranomia squamula	-	-	-	-	VR	M	R	VR	R	VR
Mya sp.	-	-	-	-	VR	R	VR	-	-	-
Pecten sp.	-	-	-	-	-	-	-	-	VR	-
Gastropods (*Littorina* spp, *Buccinum undatum*)	-	-	-	-	-	VR	M	-	-	VR
Coryphella verrucosa	-	-	-	-	R	R	R	R	R	VR
Dendronotus frondosus	-	-	-	-	-	VR	-	-	VR	-
Eubranchus pallidus	-	-	-	-	-	-	-	VR	-	-
Favorina branchialis	-	-	-	-	-	-	-	VR	-	-
Trinchesia foliata	-	-	-	-	-	-	-	-	VR	-
Facelina sp.	-	-	-	-	-	-	-	-	R	-
Tenellia pallida	-	-	-	-	-	-	-	-	VR	-
Onchidoris bilamellata	-	-	-	-	-	C	VC	A	VR	-
Asterias rubens	-	-	-	R	MA	MA	A	MA	M	C
Ophiura robusta	-	-	-	-	VR	-	R	VR	VR	R
Echinus sp.	-	-	-	-	R	R	M	VR	R	VR
Ciona intestinalis	-	-	-	-	-	-	-	-	VR	-
Psiloteredo megotara	-	-	-	3	18	28	22	3	7	5
Xylophaga dorsalis	-	-	-	18	34	155	453	213	402	180
Xylophaga praestans	-	-	-	-	-	-	-	5	7	38
Limnoria lignorum	3	37	51	8	6	153	229	892	N	584

Table 3. Growth-rate of important wood-borers and foulers for varying periods

Species	Periods of growth (in days)	Range N = 5	Average
	30	51.00 to 64.50	55.50
	64	100.25 to 106.80	104.05
	74	114.50 to 131.28	122.00
Laomedea sp.	124	161.75 to 207.00	178.95
(Length of colonies)	160	174.75 to 236.50	206.20
	194	281.75 to 292.00	287.20
	7	1.00 to 1.20	1.10
	40	7.00 to 8.00	7.45
	68	14.50 to 17.00	15.70
	101	18.00 to 19.75	18.55
Balanus crenatus	134	18.25 to 19.60	19.07
(Basal diameter)	166	18.75 to 21.50	20.30
	203	19.25 to 20.75	20.20
	261	19.75 to 23.50	21.40
	306	19.25 to 20.50	19.80
	45	2.25 to 5.25	3.60
Xylophaga dorsalis	90	11.75 to 17.50	14.75
(Length of burrow)	180	28.75 to 41.50	35.50
	233	47.50 to 58.50	52.55
	45	2.50 to 4.50	3.40
	90	16.00 to 28.50	23.25
Xylophaga praestans	180	34.00 to 45.00	39.10
(Length of burrow)	233	48.00 to 57.00	52.20
	300	54.00 to 73.00	60.20
	45	7.25 to 9.00	8.25
	90	58.50 to 98.00	73.40
Psiloteredo megotara	180	154.26 to 186.25	171.50
(Length of burrow)	233	238.00 to 265.00	248.20
	300	366.00 to 457.50	397.10

Table 4. Vertical distribution of fouling and wood-boring organisms on panels immersed at Biological Station

	Intensity of settlement																					
	From 15 March to 15 July 1977											From 22 July 1977 to 13 March 1978										
	IT	3	6	9	12	15	18	21	24	27	30m	IT	3	6	9	12	15	18	21	24	27	30m
Folliculinids	VR	-	-	VR	-	VR	-	VR	VR	VR	VR	-	VR	VR	VR	VR	VR	VR	VR	VR	VR	VR
Foraminiferans	VR	-	VR	VR	-	VR	VR	VR	VR	VR	VR	-	-	-	VR	VR	VR	VR	VR	VR	VR	VR
Suctorians on hydroids	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Laomedea sp.	MA	MA	MA	MA	MA	MA	MA	MA	MA	A	R	MA	MA	MA	MA	MA	MA	-	-	-	-	-
Tubularia larynx	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	R	R	R	R	M	C	R
Hydractina sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-
Planarians	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*Bryozoans	-	-	-	-	-	-	-	-	-	VR	-	-	VR	-	-	VR	VR	VR	-	VR	VR	M
Harmothoe imbricata	A	C	M	R	VR	VR	VR	VR	VR	VR	R	-	-	-	-	-	VR	VR	-	R	R	-
Capitella capitata	M	M	R	R	VR	VR	VR	VR	VR	VR	VR	-	M	R	R	R	R	M	M	VR	R	R
Nereis pelagica	C	M	VR	R	VR	VR	VR	VR	-	VR	VR	-	VR	-	-	-	VR	VR	VR	-	-	-
Nereimyra punctata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	VR	-	-	VR	VR	VR	VR
Autolytus prolifer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	VR	VR	VR	-	-	-	-
Cirratulus cirratus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	VR	VR	-	R
Amphitrite cirrata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	VR	VR	-	VR
** Serpulids	-	-	M	VR	-	VR	VR	VR	-	-	R	-	VR	R	A	M	VC	A	M	A	MA	MA
Balanus crenatus	VC	MA	MA	MA	A	VC	R	M	VR	R	M	-	-	-	-	-	-	-	-	-	-	-
Verruca stroemia	-	-	C	C	C	R	R	-	VR	VR	VR	-	-	-	-	-	-	-	-	-	-	-
Balanus balanus	-	-	VR	VR	-	VR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copepods	M	VR	VR	VR	VR	VR	VR	VR	VR	VR	VR	-	VR	VR	-	VR	VR	VR	-	VR	VR	VR
Amphipods	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Halocarus spp	MA	-	-	-	-	VR	-	-	-	-	-	VR	R	R	VR	VR	VR	VR	VR	VR	VR	VR
Larvae of *Halocladius (Halocladius) variabilis*	MA	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
Mytilus edulis	MA	MA	MA	MA	MA	MA	MA	MA	M	M	C	VR	R	-	VR	VR	VR	VR	-	VR	VR	-
Modiolus sp.	MA	MA	MA	MA	A	A	A	MA	R	VR	VR	VC	VR	VR	VR	VR	VR	-	-	VR	VR	-
Hiatella arctica	-	MA	MA	MA	MA	MA	MA	A	MA	MA	MA	-	-	-	C	VR	R	VR	-	VR	-	-
Littorina spp	MA	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
Heteranomia squamula	-	-	-	-	-	-	-	-	-	-	-	-	VR	VR	VR	R	R	VR	VR	VR	VR	VR
Pecten sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	VR	-	R	-	-	VR	-	-
Lacauna sp.	-	-	R	VR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coryphella verrucosa	M	-	-	-	-	-	-	-	-	-	-	-	VR	R	-	VR	-	VR	VR	VR	VR	-
*** other nudibranchs	-	-	-	-	-	-	-	-	-	-	-	-	R	R	-	VR	-	VR	VR	R	R	-
Asterias rubens	MA	A	M	R	-	VR	-	-	-	-	VR	-	-	-	-	-	-	-	-	-	VR	-
Ophiura robusta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	VR	-	-	-	-
Echinus sp.	R	R	VR	VR	VR	-	-	-	-	-	VR	-	-	-	-	-	-	-	-	-	-	-
Ciona intestinalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	VR	VR	-	-
Psiloteredo megotara	3	-	-	5	4	-	-	-	-	-	2	-	21	28	22	16	9	2	5	-	1	4
Xylophaga dorsalis	-	-	-	-	-	-	1	-	1	-	1	-	2	21	126	128	211	220	287	267	315	492
Xylophaga praestans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	8	3
Limnoria lignorum	-	-	-	-	-	-	-	-	-	2	13	-	-	-	-	-	-	1	1	1	9	418

IT = Intertidal
* = Includes *Callopora craticula*, *C. dumerili*, *Electra pilosa*, *E. monostachys*, *Crisia eburnea*, *Cribrilina annulata*, *Tubulipora flabellaris* and *Plagioecia patina*.
** = includes *Pomatoceros triqueter*, *Hydroides norvegica* and *Spirorbis* spp
*** = includes *Dendronotus frondosus*, *Eubranchus pallidus* and *Trinchesia foliata*.
Key to other symbols, same as in Table 1.

Table 5. Growth-rate of *Psiloteredo megotara* at different depths in panels of Series II (22 July 1977 to 13 March 1978)

Depth (m) below low tide level	Length of burrow (mm) Range	Average	Number of specimens measured
IT	-	-	-
3	194.00 to 242.00	221.80	5
6	205.00 to 265.00	232.60	5
9	186.00 to 225.00	203.40	5
12	184.00 to 243.00	215.20	5
15	188.00 to 232.00	209.00	5
18	128.00 to 181.50	154.75	2
21	180.00 to 201.00	190.00	5
24	-	-	-
27	174.00	174.00	1
30	144.00 to 235.00	183.12	4

IT: Intertidal (30 cm above low-tide level).
Probable date of settlement: immediately on exposure of panels.

Table 6. Growth-rate of *Xylophaga dorsalis* at different depths in panels of Series II (22 July 1977 to 13 March 1978)

Depth (m) below low tide level	Length of burrow (mm) Range	Average	Length of shell (mm) Range	Average	Number of specimens measured
IT	-	-	-	-	-
3	0.20 to 14.00	7.10	0.20 to 4.40	2.30	2
6	12.50 to 17.50	15.05	0.69 to 5.91	3.82	13
9	18.50 to 23.00	21.20	3.28 to 7.07	5.18	51
12	25.00 to 29.00	26.50	2.76 to 7.33	5.98	60
15	24.00 to 37.00	30.60	4.14 to 7.63	6.30	74
18	31.00 to 40.50	36.90	5.00 to 7.76	6.61	88
21	36.50 to 51.00	43.25	3.41 to 7.63	6.31	86
24	41.50 to 58.50	50.40	3.36 to 7.84	6.47	114
27	33.75 to 44.50	38.35	4.44 to 8.02	6.54	124
30	33.50 to 40.00	36.15	2.84 to 7.93	6.30	93

Number of burrows measured: 5
IT: Intertidal (30 cm above low-tide level).
Probable date of settlement: immediately on exposure of panels.

Table 7. Growth-rate of *Laomedea* sp. and *Balanus crenatus* at different depths in panels of Series I (15 March 1977 to 15 July 1977)

Depth (m) below low tide level	*Laomedea* sp Length of colony (mm)		*Balanus crenatus* Basal diameter (mm)	
	Range	Average	Range	Average
IT	39.25 to 53.75	46.25	11.50 to 14.25	13.03
3	34.75 to 61.25	48.63	15.00 to 17.75	16.30
6	71.75 to 100.25	86.35	13.25 to 17.50	15.63
9	64.25 to 89.50	73.50	13.00 to 15.25	13.78
12	83.75 to 131.25	105.80	8.25 to 12.25	11.05
15	81.50 to 114.50	99.98	9.75 to 11.25	10.43
18	62.50 to 92.25	74.80	10.25 to 12.25	10.83
21	47.00 to 82.00	60.53	10.25 to 11.25	10.73
24	52.00 to 76.75	64.75	7.50 to 11.00	9.20
27	42.50 to 76.00	52.20	7.00 to 9.75	8.40
30	9.25 to 13.25	10.90	7.75 to 10.00	8.71

Number of specimens measured: 10

IT: Interdidal (30 cm above low-tide level).

Probable date of settlement of *Laomedea* sp. was middle of May and of *Balanus crenatus* last week of April.