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The effects of ferry traffic (artificial wave action) on the rocky shore macrofauna in the southern Åland archipelago in the northern Baltic. 2. The Fucus zone (a quantitative study)

H.-P. Fagerholm

Institute of Biology, Åbo Akademie, Åbo, Finnland

Abstract

In summer the effects of ferry traffic in the southern Åland archipelago on animal number and biomass is less pronounced in the *Fucus* zone than in the *Cladophora* zone. – In the autumn the combined effects of wave action and low temperature are shown to cause a differentiated effect in exposed and unexposed sites, the number of macroscopic animals beeing reduced at an earlier stage in the former. On a qualitative basis *Gammarus* sp.and *Idotea baltica* in addition to *Mytilus edulis* best endure the mechanical stress induced.

Zusammenfassung

Der Einfluß des Fährverkehrs (Künstliche Welle) auf die Felsküsten-Makrofauna im südlichen Åland-Archipel in der nördlichen Ostsee. 2. Die Fucus-Zone (eine quantitative Studie)

Im Sommer sind die Einflüsse des Fährverkehrs im südlichen Åland-Archipel auf Tierzahl und Biomasse in der *Fucus*-Zone weniger ausgeprägt als in der *Cladophora*-Zone. – Im Herbst verursachen die kombinierten Wirkungen von Wellen und niedriger Temperatur an exponierten und nicht exponierten Standorten einen unterschiedlichen Effekt, indem die Anzahl makroskopischer Tiere an exponierten Standorten in einem früheren Stadium reduziert wird. Qualitativ gesehen haben *Gammarus* sp und *Idotea baltica* zusammen mit *Mytilus edulis* die besten Überlebenschancen bei mechanischem Streß.

Introduction

Quantitative studies on the *Fucus* zone macrofauna in the Baltic are scarce. SEGERSTRÅLE (1928, 1944), OHM (1964), HAGERMAN (1966), OERTZEN (1968), HAAGE and JANSSON (1970), HAAGE (1975, 1976), JANSSON A.-M. and KAUTSKY (in press) and SKULT (in preparation) have presented quantitative data for the macrofauna associated with *Fucus* fronds in the Baltic region.

In 1971 an investigation was initiated to study possible effects of artificial wave action (ferry traffic) in the hydrolittoral and the sublittoral zones in the Southern Åland archipelago. The littoral vegetation has been studied by RONNBERG (1975 a, b), and the macrofauna of the *Cladophora* zone (FAGERHOLM, 1975, 1976), and the *Fucus* zone has been investigated by the present author. Physical aspects of the wave action have also been studied by STRÖM (1977).

Study area, material and methods

Thirteen ferries passed the study area daily (speed 17 knots). Sampling was conducted between 11.00 and 13.00 hrs when the area had been undisturbed for at least 6 hours. The characteristics of the localities (Fig. 1) investigated correspond to the description

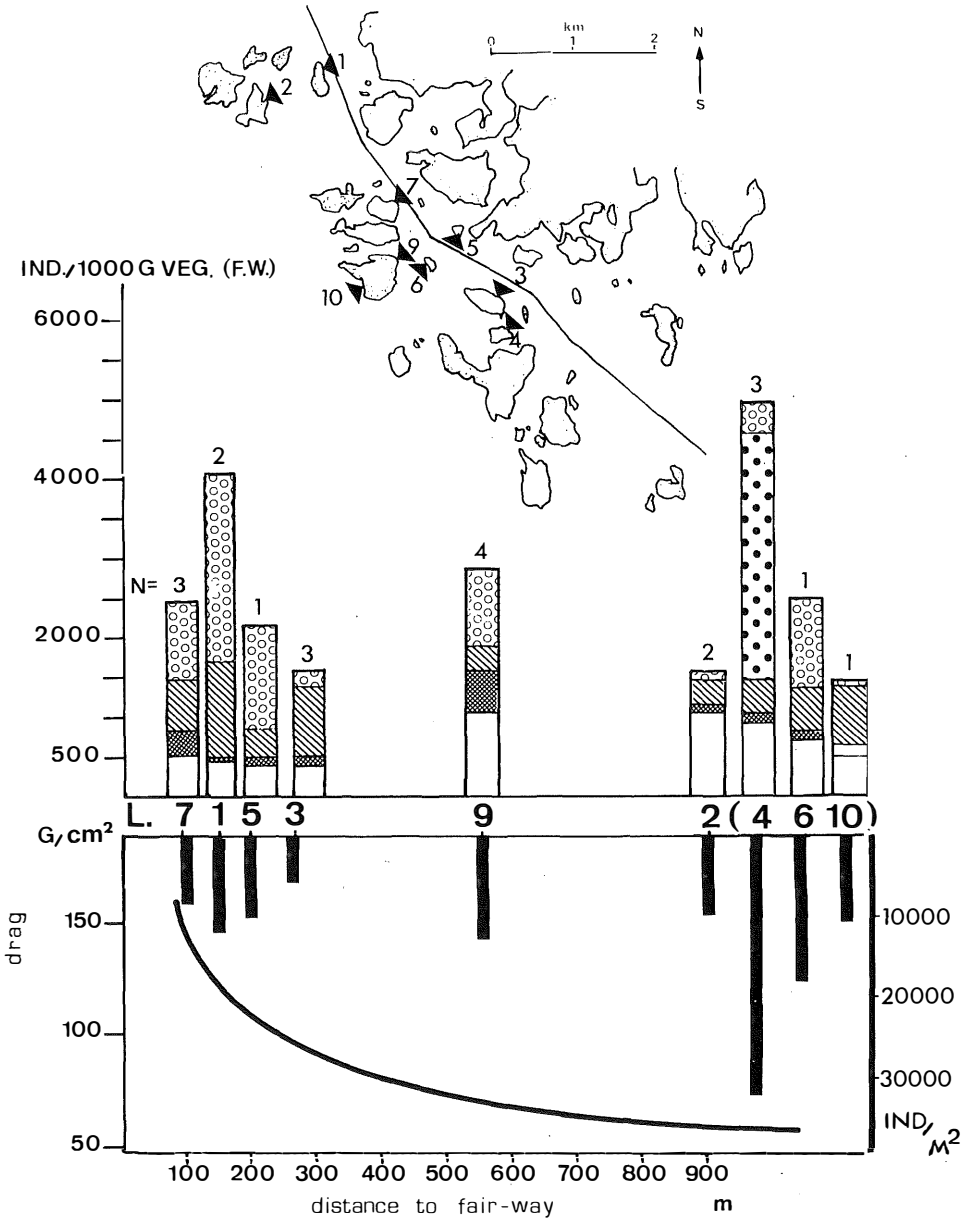

Figure 1

Animal abundance in summer samples (July – August, 1971 and 1973) in the sampling localities shown, and related to the drag measured at the waters edge (curve from RÖNNBERG, 1975 a).

given in the first part of the study (FAGERHOLM, 1975). The salinity, 5.5 – 6.5 ‰, is rather constant whereas the temperature fluctuations are considerable during the year (Fig. 4). The wave action which was caused by the ferries clearly outranged that of normal wave action in the area (Fig. 1). The vertical and horizontal range of strong water movements was restricted to 3.5 m (300 m off the fairway) and some 400 m (to both sides) respectively (Fig. 1).

Fucus samples were taken by the use of SCUBA technique according to the Finnish IBP-PM group (1969) (depth 1.5 – 2 m, bag ∅ 41 cm, max. mesh size 0.5 mm). The animals were sorted while alive and abundance and biomass were determined. Results are presented as ind./1000 g *Fucus* veg. fresh weight (= fw) and g (fw)/1000 g *Fucus* veg. (fw). In addition, abundance and biomass have been calculated per square meter based on covering and biomass values of the vegetation by RÖNNBERG (1975 a, b).

Single samples were taken monthly for one year (n = 9) in two localities (loc. 3 and loc. 4). In July and August samples were taken in 7 additional localities (n = 16).

Results

The single monthly samples from locality 3 and the control locality 4 (Fig. 2 and 3) gave as an average 928 ind./1000 g veg. (fw) (= 3400 ind./m²) and 3204 ind./1000 g veg. (fw) (= 21300 ind./m²) in the respective localities. In the exposed locality *Gammarus sp.* (mainly *G. oceanicus*) made up almost half of the total average animal number (Table 1). *Mytilus edulis*, *Idotea sp.* and *Hydrobia ulvae* (a single mass occurrence) were considerably less abundant. Juvenile *Cardium sp.* dominated in the control locality in addition to *Mytilus edulis*, *Gammarus sp.* and *Theodoxus fluviatilis*.

The summer samples from localities 1–7 and 9 showed no large differences in total animal abundance related to the differentiated artificial wave action (Fig. 1). In the exposed localities the dominance of *Gammarus sp.* in addition to *Mytilus* was evident. *Gammarus sp.* was also the dominating group in a locality (loc. 10) exposed to the open sea. In localities not situated close to the fairway generally Chironomidae, *Cardium sp.*, *Lymnaea peregra*, *Hydrobia ulvae*, *Theodoxus fluviatilis* and to some extent Turbellaria and *Prostoma obscurum* were found to be more abundant.

Discussion

One problem in all littoral studies is to quantify the energy status of the localities investigated in respect to exposure. The method used in this study (JONES and DEMETROPOULOS, 1968) only gives maximum values of the wave action (cf. RÖNNBERG, 1975 a). More sensitive dynamometers combined with continuous long-term registration could be used to quantify exposure also in more sheltered situations. Then some relative methods as the one presented by MUUS (1968) could be calibrated to be used in routine work.

Artificially exposed shores with a constantly repeated pattern of wave action cannot be directly compared with wind exposed localities. There are however analogous structural and dynamic trends in the upper *Fucus* belt macrofauna in the fairway localities when compared with natural high energy shores. HAAGE (1975, 1976) has presented comparable quantitative data from the Askö area (100 g *Fucus* veg. (dw) are comparable to 500 g *Fucus* veg. (fw); RÖNNBERG, pers. comm.).

The combined effects of low temperature and mechanical stress are found to be an important factor in the upper *Fucus* zone in respect to macrofauna. Already in October

Table 1

Animal abundance in the upper *Fucus* zone (ind./1000 g *Fucus* veg. (fresh weight)). Monthly samples in locality 4 (control)

	1972 25.05	20.06	20.07	15.08	18.09	16.10	28.11	1973 04.01	13.04	Σ	Σ/9	%
Prostoma Obscurum			2	6						8	1	0.02
Turbellaria	30		35	102	15	18	14	9	3	228	25	0.8
Theodoxus Fluviatilis	221	102	612	743	681	441	262	65	5	3132	348	10.9
Hydrobia sp.	1	2	51	49	26	94		3	5	233	26	0.8
Lymnaea Peregra	9	4	3	27	6	7	12	3	3	75	8	0.2
Mytilus Edulis	203	36	43	602	562	1378	483	319	492	4117	457	14.3
Cardium sp.	1			9516	1932	2553	862	19	13	14897	1655	51.6
Idotea sp.	8	11	62	264	158	189	572	42	47	1353	150	4.7
Jaera sp.	22	4	172	34	56	352	199	93	190	1123	125	3.9
Gammarus sp.	15	55	1082	107	86	459	133	41	1390	3370	374	11.7
Chironomidae	8	2	148	26		3		2	33	222	25	0.8
Pisces		1	3	2			4			12	1	0.04
Others			21	4	4	12	7	2	27	76	8	0.3
Total	519	216	2234	11489	3530	5507	2549	599	2210	18846	3204	

Table 2

Animal abundance in the upper *Fucus* zone (ind./1000 g *Fucus* veg. (fresh weight)). Monthly samples in locality 3 (exposed to artifical wave action)

	1972 25.05	20.06	20.07	15.08	18.09	16.10	28.11	1973 04.01	13.04	Σ	Σ/9	%
Prostoma Obscurum							1			1	+	
Turbellaria				12		1	3			17	2	0.2
Theodoxus Fluviatilis		12	29	229	18		16	7	4	316	35	3.8
Hydrobia sp.					870	1				872	97	10.4
Lymnaea Peregra												
Mytilus Edulis	21	33	42	319	62	127	265	289	152	1309	146	15.6
Cardium sp.				385	198	51	17	26		678	75	8.1
Idotea sp.	24	1	55	279	339	142	77	21		938	104	11.2
Jaera sp.		3	38	103	19	3	23	21	11	220	24	2.6
Gammarus sp.	685	62	1859	267	111	85	28	24	553	3675	408	43.9
Chironomidae	24	10	218	4		3	2		23	285	32	3.4
Pisces				4		1				5	1	0.5
Others		1				5	5	26		38	4	0.5
Total	755	123	2241	1603	1617	481	437	415	743	8355	928	

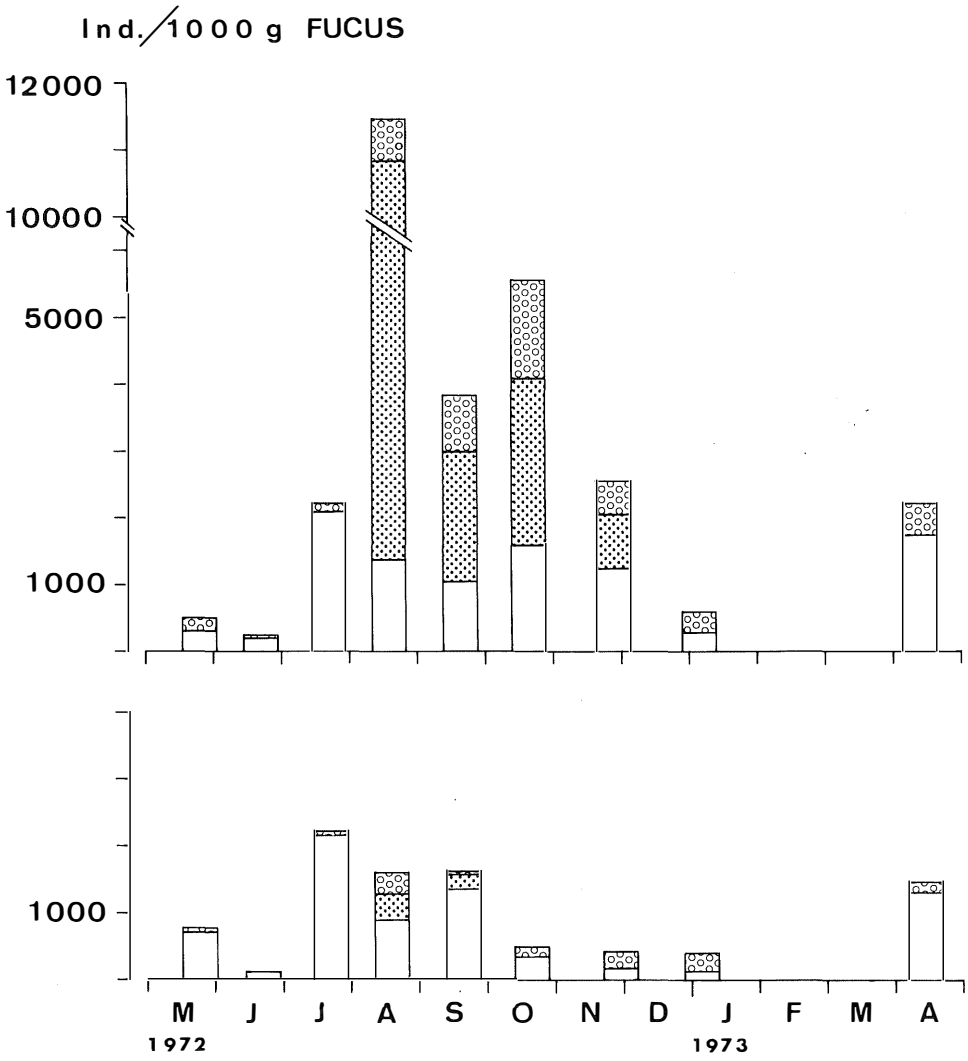

Figure 2

Animal abundance (ind./1000 g *Fucus* veg. (f.w.)) in monthly samples in locality 3 (below) and 4 (above). Monthly samples 1972 – 73 (for more details comp. Table 1 and 2)

the animal abundance is strongly reduced in the fairway site investigated. In the control locality this does not take place until January. Several of the species found reach a maximum of abundance in summer, whereas the biomass values often are biggest in late autumn. The unusually rich occurrence of *Cardium sp.* in 1972 is strictly distributed as to favour unexposed sites, although this lamellibranch was also abundantly found below 3.5 m depth in the fairway region.

In addition to the direct mechanical effects of the wave action which also transmits erosion by suspended sediments and ice (in winter), some differences in local temperature and salinity can be recognized (FAGERHOLM, 1976). The detritus content in the algal fronds, acting as substrate and food for several species, is also affected.

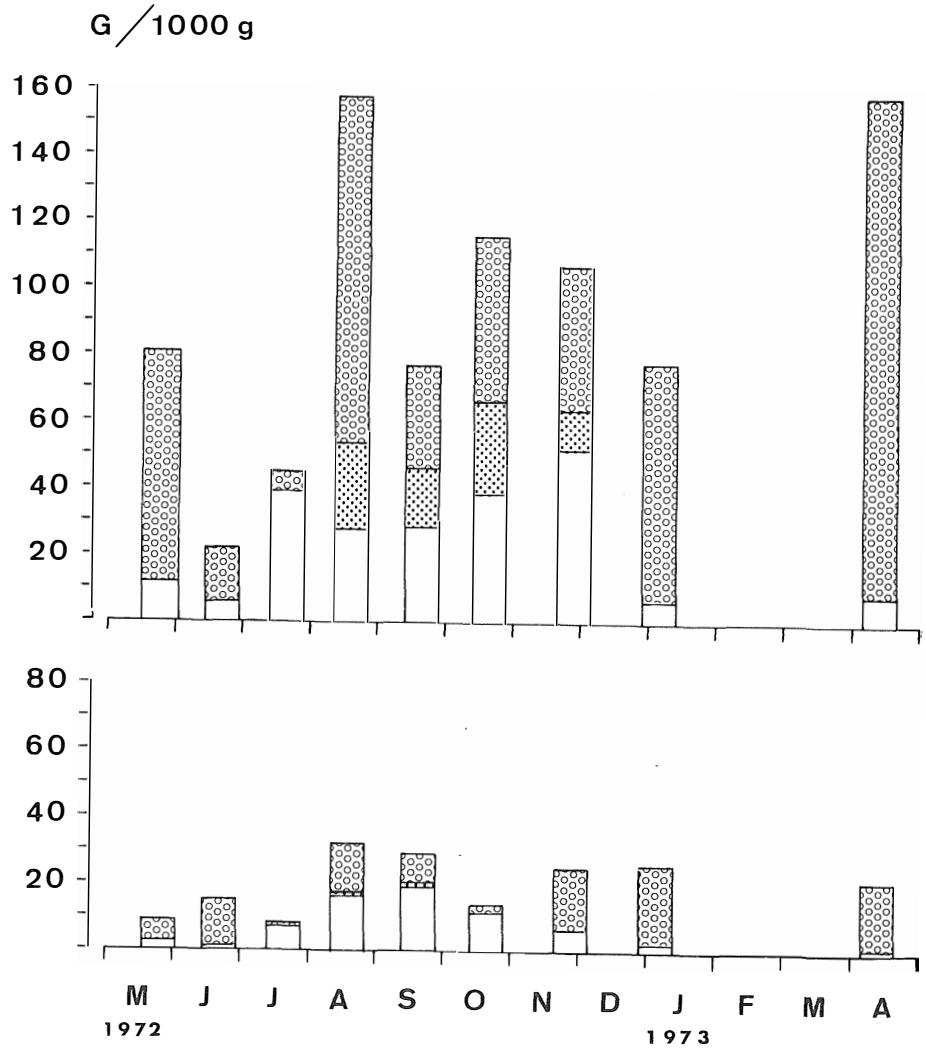

Figure 3

Biomass (g(f.w.)/1000 g *Fucus* veg. (f.w.)) in locality 3 (below) and 4 (above). Monthly samples 1972 – 73

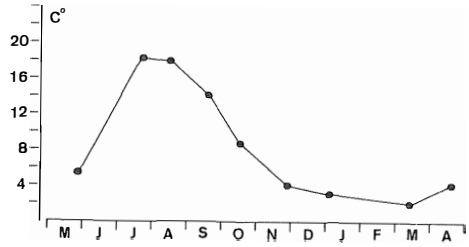

Figure 4

Monthly water temperatures (surface) in 1972 – 73 at locality 3

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