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THE LOCAL OCCURRENCE OF AGARUM CRIBROSUM IN RELATION TO THE PRESENCE OR ABSENCE OF ITS COMPETITORS AND PREDATORS

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In a sublittoral survey of 6 sites on the Atlantic and Fundy shores of Nova Scotia, 3 main types of community structure were found. In the first, *Agarum cribrosum* occurred in association with 2 *Laminaria* species (competitors) and sea urchins (predators). In the other 2 types, *A. cribrosum* was absent where either (a) the competitor or (b) the predator occurred, but not both.

Introduction

The occurrence of sublittoral seaweed zones in Nova Scotia has been reported by Edelstein et al. (1969) and Mann (1972). Commonly a *Laminaria* zone dominates the shallow sublittoral with *Agarum cribrosum* forming nearly homogeneous stands in deeper water. A similar distribution has been reported by Vadas (1968) for the northeastern Pacific. Vadas showed experimentally that the absence of an *Agarum* population in shallow water is a result of interspecific competition with other laminarian species. The development of a deep-water *Agarum* zone was shown to result from the selective grazing of sea urchins which are attracted to kelp species other than Agarum.

As will be shown, the development of a deep-water *Agarum* population and a shallow-water *Laminaria* population as described by Edelstein et al. (1969), Mann (1972) and Vadas (1968) is typical of only 1 class of shore in Nova Scotia. *Agarum* is absent from 2 other types of shore depending on the presence or absence of *Laminaria* species and/or sea urchins. We report here on the results of a survey of 6 sites on the Atlantic and Fundy shores of Nova Scotia. These data are compared with the experimental analyses of Vadas (1968).

Methods

The survey was done in July and August 1979. The 6 sites chosen are shown in Figure 1. Dramatic changes in the sublittoral community structure have occurred in St. Margaret's Bay, Nova Scotia (Mann 1977). We therefore attempted to choose sites not obviously undergoing gross biotic changes. Observations at 4 of the sites over many years have shown minimal changes.

At each of the sites a transect line was run perpendicular to the shore out into the sublittoral zone. Quadrats (0.5 m x 0.5 m) were cleared of all kelp species (if present) at various depths along the transect. Sea urchins were recorded as present or absent at each site. The kelps collected in each quadrat were recorded and weighed by species.

Water transparency was measured at each site with a Secchi disc.

Results

The biomass distribution of kelps by species is shown in Table I. One or more species occurred in each of 5 sites. No kelps were found at Mill Cove where sea urchins (*Strongylocentrotus droebachiensis*) dominated the benthos. Sea urchins were

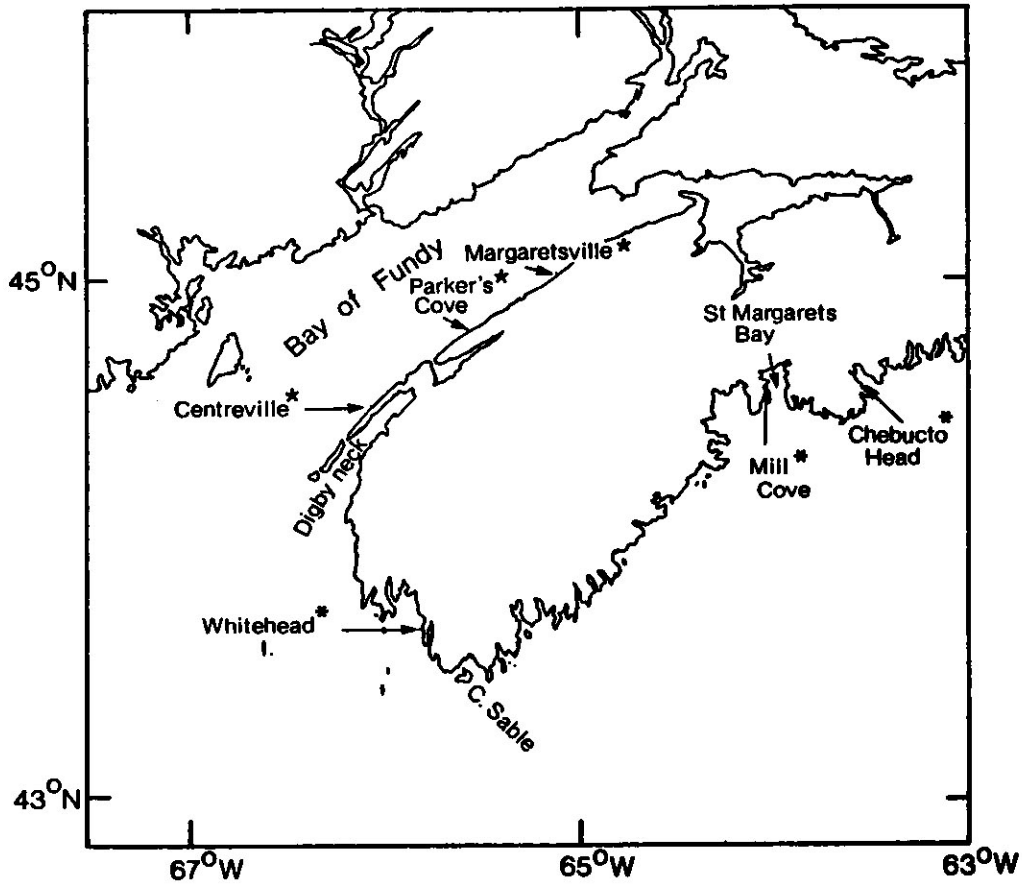

Fig 1. Study site location. Sites examined are marked with an asterisk.

present at all sites except Whitehead Island off the Pubnico peninsula. *Agarum* was found only at sites where both sea urchins and *Laminaria* species were present. At Whitehead Island, where both sea urchins and *Agarum* were absent, *Laminaria* species penetrated into depths at which *Agarum* populations are normally found.

Water turbidity and tidal amplitude were greatest in the Bay of Fundy sites (Table II).

Discussion

Vadas (1968) discussed the depth distribution of *Agarum* at sites where both sea urchins and other kelp species were present. This type of benthic structure is only 1 among 3 found in our survey of southern Nova Scotian shores. The other types found were (1) shores with sea-urchins, without *Agarum* and without other kelp species, and (2) shores with *Laminaria* species, but without *Agarum* and without sea urchins. The existence of community structures other than that described by Vadas (1968) does not detract from his view that the occurrence of deep-water *Agarum*

Table I. Fresh mass (g) of 4 kelp species in 0.25-m^2 quadrats by depth at 5 sites. Depths are in metres below chart datum.

Depth (m)	*Alaria esculenta*	*Agarum cribrosum*	*L.longicruris*	*L.digitata*
		CHEBUCTO HEAD (+ sea urchins)		
22	0	364	0	0
20	0	208	0	0
17.5	0	102	0	0
14.5	0	70	0	0
12.5	0	85	0	0
11.5	0	40	0	0
8.5	0	0	152	129
7	0	0	25	327
5.5	77	0	35	292
1.5	96	0	333	207
0	0	0	0	0
		WHITEHEAD ISLAND (No sea urchins)		
18	0	0	0	0
16	0	0	468	23
14.5	0	0	133.5	81.5
13	0	0	123.5	117.5
11.5	0	0	0	2
10	0	0	353.5	677.5
7.8	0	0	0	760
6.5	0	0	368.5	590
4.5	0	0	1652.5	112.5
1.5	0	0	0	1410
0.8	0	0	827.5	0
		CENTREVILLE (+ sea urchins)		
11	0	88	0	0
8.5	0	101.5	0	0
7.5	0	138.5	0	0
6	0	181	0	0
5	0	122.8	0	0

Depth (m)	*Alaria esculenta*	*Agarum cribrosum*	*L. longicruris*	*L. digitata*
3.3	0	0	0	0
3	0	0	0	1498
0	0	0	0	1602
+0.5	1013	0	0	458.5
+0.8	275	0	0	446.5
+1.0	0	0	0	0
		PARKER'S COVE (+ sea urchins)		
4.8	0	0	0	0
4.3	0	0	0	0
3	0	0	0	0
2.2	0	0	0	0
1	0	0	0	0
0.5	0	0	0	194
+0.1	80	0	0	0
+1.0	0	0	0	0
		MARGARETSVILLE (+ sea urchins)		
5	0	0	0	0
3.5	0	10	0	0
3	0	8	110	0
1.6	0	0	530	0
0.7	0	0	735	0
0.4	0	0	0	458
+0.2	0	0	0	0

Table II. Secchi transparencies and large tide amplitudes at 5 sites.

Site	Secchi transparency (m)	Tidal amplitude[1] (m)
Chebucto Head	> 7.5	2.1
Whitehead I.	3.3	4.2
Centreville	4.2	8.2
Parker's Cove	2.75	9.8
Margaretsville	1.06	11.5

[1]From Fisheries and Environment Canada (1979)

beds depends on the predatory activities of sea urchins, and on the competitive interactions of other kelp species. On the contrary, our data lend weight to the thesis of Vadas. The biological variation among the shores of Nova Scotia provides a "natural" experiment in the sense of Estes et al. (1978). Among the classes of community structure examined we found that *Agarum* occurred only in sites where both its predator (sea urchins) and competitive superior (*Laminaria*) were present together. Where only either the predator or competitor, but not both, were found, *Agarum* was absent. At Whitehead Island, where sea urchins were absent, *Laminaria* populations penetrated to 16 m depth. Presumably members of this genus are able to out-compete *Agarum* in its usual depth range in the absence of selective grazing by sea urchins.

Where *Laminaria* is absent, *Agarum* is destructively grazed by sea urchins. This is known with certainty for Fox Point in St. Margaret's Bay where we have observed the destruction of a mixed kelp forest by urchin grazing. *Laminaria* species were destroyed first, leaving *Agarum* as the only surviving kelp species. *Agarum* was finally consumed, leaving barren grounds dominated by sea urchins and encrusting coralline algae.

During conversion of a kelp forest to sea urchin-dominated barrens, *Agarum* can thus be found as the only kelp species present with sea urchins. However, this combination occurs only briefly during a period of disequilibrium. Under periods of equilibrium, *Agarum* is not expected to occur as the only kelp species associated with sea urchins.

Parker's Cove, a site in the Bay of Fundy, requires separate consideration. Here *Agarum* would have been expected as a member of the benthos, given that sea urchins and *Laminaria* were present. The absence of *Agarum* is related to the small-scale structure of the shore community. Below 0.5 m depth, macro-algae were absent from the sea urchin-dominated barrens. In the wave-swept intertidal fringe urchins were absent. Here a narrow refugium dominated by *Alaria esculenta* and *Laminaria digitata* was found. Narrow refuges from sea urchin grazing are common on wave-swept shores of Nova Scotia. Semi-sheltered sites are commonly grazed into the intertidal and are thus free of kelp (e.g. Mill Cove in this study).

The variations in biological interaction among the sites considered here are manifested, in part, by the presence or absence of *Agarum*. The sites also varied in their abiotic characteristics, notably exposure to surf action, tidal amplitude, and water transparency. All of these differences are related to some of the data variation between sites shown in Table I. For example, *Alaria esculenta* was found only in sites exposed to strong wave action. Similarly, the lower depth limits of each of the kelp species were quite different at Chebucto Head, a site with clear water and small tidal amplitude, than at Margaretsville, a site with turbid water and large tidal amplitude (Table II). It is necessary to be cognizant of the importance of these abiotic effects when attempting to interpret the results of biological interaction.

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