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Distribution of Stream Macroalgae in Four High Arctic Drainage Basins

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ABSTRACT. Eighty-three stream reaches were sampled from four drainage basins in the central portions of Axel Heiberg and Ellesmere Islands. The streams included small snowmelt tributaries, those flowing through wetlands, pond outflows, glacial meltwaters, and large trunk rivers, some of which had become braided in their lower portions. Larger channels tended to be quite turbid, and macroscopic algae were negligible in these reaches because they lack adequate light and hard substrata for attachment. The overall stream macroalgal flora was relatively small (15 species) compared to that of other regions of the North American tundra. Cyanobacteria and Chlorophyta accounted for all but one species. The most widespread species was the colonial cyanobacterium, *Nostoc commune*. Only *Scytonema mirabile* (Cyanophyta) was a new addition to the stream macroalgal flora of arctic North America. The number of species per stream reach ranged from 0 to 5, with a mean of 1.3. The amount of stream bottom covered by macroalgae was 0 to 75%, with an average of ca. 5%. Both species number and percent cover per reach are relatively low.

Key words: Axel Heiberg Island, Chlorophyta, Cyanophyta, Ellesmere Island, *Nostoc commune*, stream macroalgae

RÉSUMÉ. On a procédé à des échantillonnages de 83 tronçons de cours d'eau situés dans quatre bassins de drainage au centre de l'île Axel Heiberg et de l'île d'Ellesmere. Les cours d'eau comprenaient de petits affluents alimentés par la fusion nivale, ceux qui traversaient des terres humides, des émissaires d'étangs, des eaux de fonte glaciaires et d'importants cours d'eau principaux, dont certains étaient devenus anastomosés en aval. Les chenaux larges avaient tendance à être relativement troubles et on ne trouvait que peu d'algues macroscopiques dans ces tronçons en raison du manque de lumière adéquat et des substrats de soutien. La flore macroalgale globale des cours d'eau était assez réduite (15 espèces) par rapport à celle d'autres régions de la toundra nord-américaine. Toutes les espèces sauf une appartenaient aux cyanobactéries et aux chlorophycées. L'espèce la plus répandue était la cyanobactérie coloniale, *Nostoc commune.* Seule *Scytonema mirabile* (cyanophycée) était une nouveauté dans la flore macroalgale de l'Arctique nord-américain. Le nombre d'espèces par cours d'eau allait de 0 à 5, avec une moyenne de 1,3. De 0 à 75 p. cent de la superficie du fond des cours d'eau était couverte par les macroalgues, avec une moyenne d'environ 5 p. cent. Le nombre d'espèces comme le pourcentage de leur couverture par tronçon étaient relativement bas.

Mots clés: île Axel Heiberg, chlorophycée, cyanophycée, île d'Ellesmere, *Nostoc commune*, macroalgues de cours d'eau

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INTRODUCTION

Stream macroalgae can be defined as those species occurring in flowing freshwaters and having a mature thallus that is benthic (attached to the bottom of the channel) and a discrete structure recognizable with the naked eye (Sheath and Cole, 1992). Morphological forms include mats, colonies, gelatinous and free filaments, tissue-like thalli, tufts, and crusts. These forms possess various adaptive features to tolerate flow-related drag (Sheath and Hambrook, 1990).

Sheath et al. (1996) summarized published and unpublished studies of tundra stream macroalgae in North America, which ranged from the north slope in Alaska in the west to southwestern Greenland in the east, and from Ellesmere Island in the north to the Belcher Islands in the south. Eighty-three infrageneric taxa were included in this survey, composed of 32 Cyanophyta (cyanobacteria), 35 Chlorophyta (green algae), 10 Chrysophyta (golden algae including diatoms), and 6 Rhodophyta (red algae). The most widespread species were the cyanobacteria *Rivularia minutula* (Kütz.) Born. et Flah., *Nostoc commune* Vauch. and *Tolypothrix tenuis* Kütz. emend. J. Schmidt, and vegetative populations of the chlorophyte genus *Zygnema*. The relative contribution of cyanobacteria compared to that of Chlorophyta increased from the Low to the High Arctic. Number of species per 20 m long stream reach ranged from 0 to 7 with a mean of 2.8, and varied little between the Low and the High Arctic. The percentage of stream bottom covered by macroalgae extended from 0 to ca. 75%; mean cover values for Low and High Arctic streams were ca. 12% and 8%, respectively. Tundra macroalgae tended to be more abundant and diverse in less rigorously flowing stream sections.

The macroalgae inhabiting streams of the polar desert and semidesert on the Queen Elizabeth Islands are poorly studied. Croasdale (1973) included eight algal species that could be classified in this category in her survey of freshwater algae of

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the Lake Hazen area, Ellesmere Island. However, the focus of the collection was microscopic, lake-inhabiting taxa. In addition, characteristics of the few stream habitats examined were not measured. There are also no detailed whole drainage basin studies of macroalgae in the Arctic. The present study was initiated to fill these gaps in our knowledge.

MATERIALS AND METHODS

A total of 83 stream reaches were sampled from four drainage basins in the central portions of Axel Heiberg and Ellesmere Islands (Fig. 1). The relatively large Slidre River Basin on the Fosheim Peninsula of Ellesmere Island was examined for 40 reaches, from 17–20 June 1995. The lower, eastern portion of the basin, inundated in the late Pleistocene/Holocene, has a rolling topography consisting of younger beds of sand and silt and poorly consolidated clastic rocks of the Eureka Sound Group (Edlund et al., 1990; Egginton and Hodgson, 1990). The upper part of the basin is underlain by Paleozoic bedrock of the Franklin Mobile Belt, but evidence indicates that sediments in this region resulted from expansion of the Fosheim Basin during the Early Paleocene (Ricketts, 1991). The Slidre River drainage basin contains trunk channels from the river and seven major tributaries, glacier-fed headwaters from the Sawtooth Mountains on the eastern edge, ephemeral nival (snow-fed) small streams elsewhere, and scattered pond outflows and wetland channels (Fig. 1). Sediment transport is high, particularly in the snowmelt period (Lewkowicz and Wolfe, 1994). Summers are more moderate in temperature than in most areas of the Queen Elizabeth Islands; a mean July temperature of at least 5˚C is common. Hence, the vegetation is unusually diverse for this latitude (Edlund et al., 1990). Snowmelt is also relatively early for the latitude. Portions of the basin are free of snow by mid-May, and much of the rest of melt is finished by the second week in June in some years (Woo et al., 1991).

The other three basins are smaller, located on Axel Heiberg Island, and were sampled during 14–16 June 1996. The eastern basins at Gibbs Fiord and the southwest portion of Flat Sound were sampled only in the lower halves because of extensive snow accumulations and late snowmelt in the upper parts (Fig. 1). Stream segments examined in these two basins numbered 18 and 12, respectively. Both basins are nonglacial and contain several trunk channels, small ephemeral tributaries, pond outflows, and wetland channels. This portion of Axel Heiberg Island is much like the lower basin of the Slidre River, with younger beds of sand and silt and clastic rocks of the Eureka Sound Group (Ricketts, 1994). Hence, sedimentation in streams is also high. The mean summer temperature, 1.8˚C, is also relatively high for the latitude, and the vegetation is classified as prostrate shrub-dominated except in wetlands, where sedges are abundant (Edlund and Alt, 1989). The average date of initiation of snowmelt is June 10.

Thirteen stream segments were collected in Expedition Fiord on the western side of Axel Heiberg Island (Fig. 1). This small basin contains all types of streams, including glacier-fed headwaters. Sedimentation is quite high in this basin (Gilbert, 1990), and deposits are in part the result of a relatively recent deglaciation (Lemmen et al., 1994). The climate is not as moderate as for the three other basins, with mean summer temperatures of 0.8˚C (Edlund and Alt, 1989). Herbs dominate the region, but shrubs are still present. Mean initiation of snowmelt occurs between June 15th and June 20th.

At each site, at least a 20 m stream length was entirely examined for macroalgae, and cover by each species was estimated as described previously (Sheath and Cole, 1992 and references therein). A modified Braun-Blanquet cover scale was employed to estimate algal abundance, as spatial distributions were highly heterogenous (Mueller-Dombois and Ellenberg, 1974). In this rating system, the following values were used: 0 as not present, 1 as < 1%, 2 as 1–10%, 3 as 11–25%, 4 as 26–50%, 5 as 51–75%, 6 as 76–100%. Algal samples were fixed in 2.5% $CaCO_3$-buffered glutaraldehyde for later microscopic examination with an Olympus BHS microscope. Maximum width and depth, mean current velocity, water temperature, pH, turbidity, and specific conductance were measured using the following instruments: Lufkin red folding rule, General Oceanics 2030 flow meter, Hach 2100P turbidity meter, Fisher pocket thermometer, Fisher Accumet 1001 pH meter, and Oakton TDS tester 3. Total phosphorus was measured by ICP-ES methods at the Geochemical Laboratory, Department of Mines and Energy, St. John's, Newfoundland. Pearson product-moment correlations were calculated between habitat variables measured and species or cover values, according to the Minitab statistical computing system (Ryan et al., 1985).

RESULTS

The diversity of stream types sampled is depicted in Figure 2. The stream segments varied from small nival tributaries (minimum width 0.5 m and depth 4 cm) to large trunk rivers (maximum width 25 m and depth 100 cm) (Table 1). Stream channel width and depth were significantly correlated ($p < 0.001$). Mean current velocity also exhibited quite a range (0–136 cm s^{-1}), and this variable was correlated to both channel width and depth ($p < 0.001$).The stream segments ranged from those that were quite clear (minimum turbidity 0.5 NTU) to those that were very turbid (maximum turbidity > 1000 NTU); turbidity was correlated to current velocity ($p < 0.001$). All four basins had turbid trunk rivers as predicted based on sediment transport (Gilbert, 1990; Lewkowicz and Wolfe, 1994).

Most of the stream segments tended to have alkaline pH values (range 6.6–8.9) (Table 1). This would be expected given the extent of marine-derived sediments through most of these basins (Edlund et al., 1990; Ricketts, 1991, 1994). However, the specific conductance readings exhibited a large range (25–1600 µS cm^{-1}). In spite of the fact that sampling in both years took place near the end of snowmelt, water temperatures ranged from 0.5° to 9°C. Larger streams tended

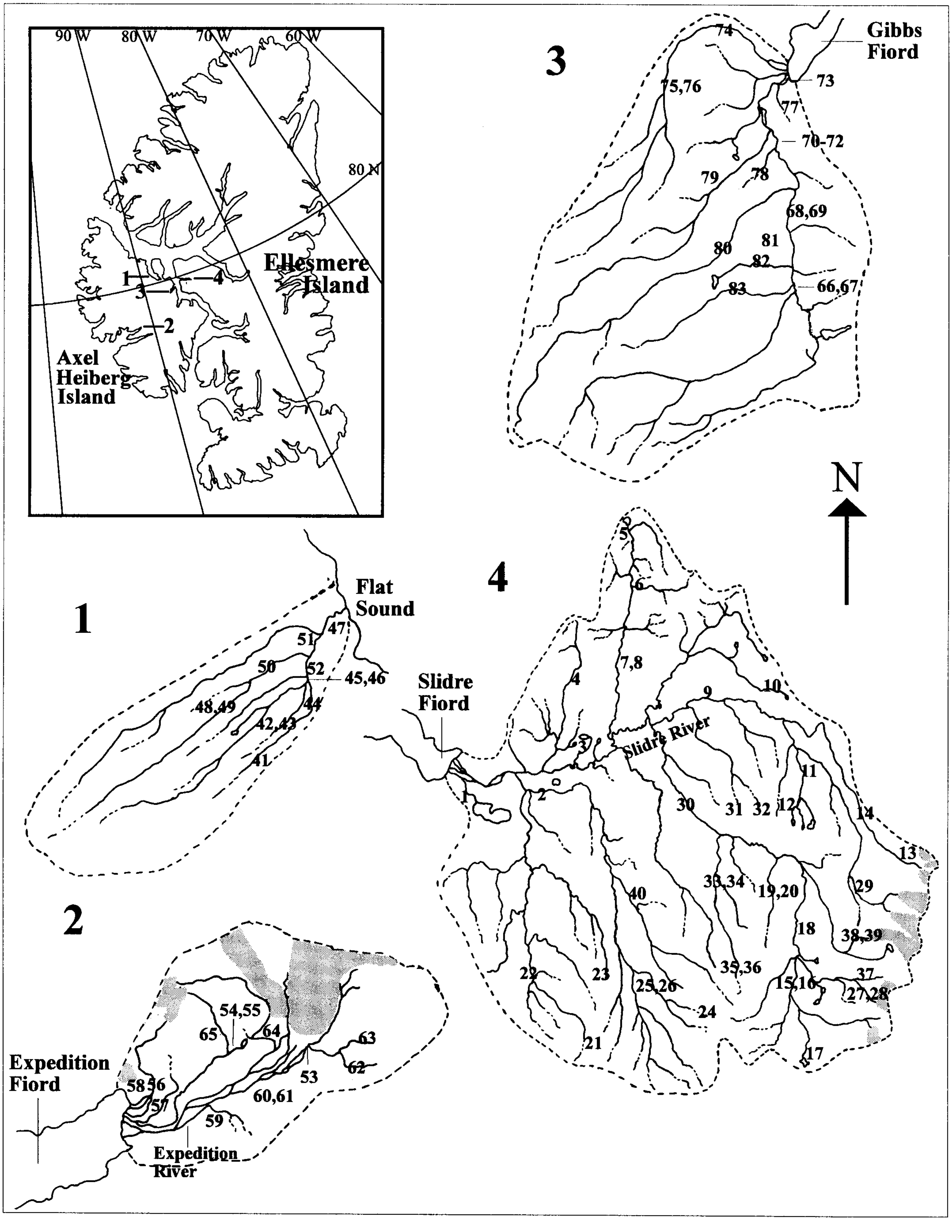

FIG. 1. Location of the four drainage basins sampled on Axel Heiberg and Ellesmere Islands. Numbers represent sampling sites and correspond to those in Table 1. Shaded portions indicate glaciers.

FIG. 2. Representative stream reaches sampled. a) small nival tributary, site #59, Expedition Fiord (EF), Axel Heiberg Island (AH); b) wetland stream, site #29, Slidre River Basin (SR), Ellesmere Island (EI); c) pond outflow, site #17, SR, EI; d) glacial-fed river, site #58, EF, AH; e) braided trunk river, site #61, EF, AH; f) Highly sedimented trunk river, site #60, EF, AH.

to be warmer, with temperature and maximum channel width being positively correlated ($p < 0.05$). Total phosphorus levels varied throughout the Slidre River basin from 5 to 27 $\mu g\ l^{-1}$ (Table 1).

The overall stream macroalgal flora of these four drainage basins was relatively small (15 species, Table 2). The morphological forms represented in the collections were limited to mats (9 species), colonies (4 species) and tufts (2 species). The cyanobacteria accounted for ten species, followed by the Chlorophyta with four species and the Chrysophyta with one species. The presence of heterocysts indicate that five of the cyanobacterial species potentially fix N_2.

TABLE 1. Physical and chemical characteristics, number of macroalgal species and cover in streams sampled.

Stream segment	Temperature (˚C)	pH	Specific conductance (µS cm^{-1})	Turbidity (NTU)	Maximum width (m)	Maximum depth (cm)	Current velocity (cm s^{-1})	Total Phosphorus (µg 1^{-1})	Number of species	Cover rank[1]
Slidre River										
1	8	8.4	1000	160	2	16	0	16	1	2
2	4	8.2	1310	149	1.7	20	3	7	0	0
3	11	7.9	350	1.7	2.5	35	0	11	2	2
4	11	8	160	88	3.5	-	19	17	1	2
5	9	8	120	14.2	4.2	22	32	0	1	2
6	5	8.4	60	47.5	5	25	87	8	0	0
7	9	7.8	100	31	16.2	35	55	7	1	1
8	9	7.8	130	9.1	9	35	45	7	4	2
9	7	8	140	2.9	4.2	35	50	6	3	2
10	7	7.8	180	0.9	2	10	25	6	1	2
11	7	7.9	110	17.7	12.9	50	105	11	1	1
12	6	7.9	165	3.6	5.9	38	13	13	1	2
13	0.5	7.8	65	15.3	15	50	115	6	0	0
14	7	7.9	240	0.5	20	35	15	17	1	2
15	1	8	50	3.9	30	32	65	10	0	0
16	2	7.8	70	4.4	6.2	25	68	7	0	0
17	2	7.8	50	1.7	1.4	24	24	6	4	3
18	3	7.8	70	7	20.3	35	83	9	0	0
19	5	7.7	100	14.2	2.3	32	38	7	1	2
20	4	7.7	80	7.8	15	50	97	7	0	0
21	2	-	110	>1000	1.7	20	86	17	0	0
22	9	7.8	335	>1000	7	70	5	16	0	0
23	4	7.6	100	162	1.2	27	57	27	1	1
24	8	8	250	96.8	1.2	10	10	7	0	0
25	7	-	110	4.6	3.6	29	67	11	3	3
26	3	7.8	25	71.9	15	35	135	9	0	0
27	2	7.9	80	52.4	50	-	69	20	0	0
28	3	7.8	170	15.4	0.7	15	4	11	2	2
29	6	7.8	120	3.7	2.8	19	19	9	1	1
30	4	7.9	70	9.5	4.2	18	16	0	0	0
31	3	8	200	6.9	5.2	15	31	6	2	2
32	5	8.7	180	0.2	5.5	23	31	8	4	2
33	3	7.8	70	1.2	1.1	23	6	5	4	2
34	2.5	8	100	6.8	20	100	98	9	0	0
35	2	8	110	9.8	2.1	15	56	14	5	2
36	2	8	135	34.2	8.6	20	57	17	0	0
37	0.5	7.9	80	3.3	9.6	25	38	6	2	2
38	1	7.8	110	3.3	4.6	20	34	8	0	0
39	2	8	140	0.8	5.3	20	47	7	3	2
40	5	8	110	21.9	25	30	76	5	0	0
Flat Sound										
41	1	6.9	20	31.3	4	18	67	-	1	1
42	5	7.4	45	473	3	15	50	-	2	1
43	4	7.4	25	597	8	15	65	-	1	1
44	7	7.3	40	5.4	2	15	13	-	3	5
45	5.5	7.7	70	396	3	15	55	-	1	1
46	5	7.4	30	>1000	10	60	79	-	0	0
47	9	7.4	110	>1000	12	10	10	-	0	0
48	1	7	40	232	3	13	39	-	1	1
49	5	7.4	50	84.7	1.5	10	13	-	2	3
50	6	7.5	100	4.3	3	5	8	-	2	2
51	4	7.5	80	419	4	15	40	-	1	1
52	4	7.8	130	621	4	15	59	-	1	1
Expedition Fiord										
53	3.4	7.3	60	646	5	23	74	-	0	0
54	9.2	6.6	430	6.7	1.5	29	62	-	2	2
55	4.5	8	350	5.2	1.5	12	25	-	2	2
56	8.2	7.9	200	26.2	1.5	13	17	-	2	1
57	7.1	7.8	120	89.4	6	15	54	-	1	1
58	2.3	8.0	90	>1000	6	23	128	-	0	0
59	9	7.4	200	16.6	1	15	25	-	1	1
60	5	6	350	>1000	6	20	45	-	0	0
61	5.5	7.1	500	411	6	20	84	-	1	1
62	13	8	1500	4.3	0.5	13	17	-	1	1
63	10	7.9	195	1.1	2.5	40	25	-	3	2
64	2	7.8	170	>1000	8	15	95	-	0	0
65	8	7.8	270	8.2	2.5	15	63	-	3	2

TABLE 1 – *continued*

Stream segment	Temperature (˚C)	pH	Specific conductance (µS cm^{-1})	Turbidity (NTU)	Maximum width (m)	Maximum depth (cm)	Current velocity (cm s^{-1})	Total Phosphorus (µg l^{-1})	Number of species	Cover rank[1]
Gibbs Fiord										
66	8.1	7.6	150	47	2	14	5	-	2	2
67	4.3	7.5	70	25.9	4.5	14	3	-	1	2
68	2.7	8.1	70	41.3	4	23	47	-	3	1
69	5.8	7.7	130	16	5	37	64	-	1	2
70	5.2	8	745	>1000	3	25	99	-	0	0
71	5.7	6.8	30	46.2	0.8	4	2	-	3	6
72	5.7	7.5	200	>1000	14	25	97	-	0	0
73	5.3	7.6	330	>1000	20	27	136	-	0	0
74	3	7.3	200	414	6	23	49	-	0	0
75	7.4	7.1	110	45.4	2	10	7	-	3	4
76	2.3	8.4	200	33.4	20	4	49	-	2	1
77	5	8	210	14.9	3	20	49	-	1	1
78	4	7.4	80	20.1	1.2	5	10	-	2	2
79	4	7.9	1600	2.9	5	15	36	-	2	2
80	5	7.7	1390	6.9	1.4	13	10	-	1	1
81	5.5	7.1	70	27.7	3	47	18	-	2	2
82	3	7.8	80	13.9	5	22	31	-	1	2
83	1	7.1	40	38.5	4	15	35	-	1	1

[1] Cover rank; 0 = 0%, 1 = < 1%, 2 = 1–10%, 3 = 11–25%, 4 = 26–50%, 5 = 51–75%, 6 = 76–100%
"-" = no measurement

TABLE 2. Distribution of stream macroalgae in the four drainage basins sampled on Axel Heiberg and Ellesmere Islands.

Taxon	Basin[1]	Number of Sites	Stream Segments[2]
Cyanophyta			
Gloeocapsa sanguinea (C.Ag.) Kütz	2	1	61
Lyngbya aestuarii (Mert.) Lieb.	4	1	31
Microcoleus sociatus W. et G.S. West	3	3	50, 79, 82
Phormidium subfuscum Kütz.	1, 3, 4	10	4, 9, 28, 35, 42, 44, 52, 71, 75, 83
Nostoc commune Vauch.	1, 2, 3, 4	31	3, 5, 8, 9, 10, 12, 14, 17, 19, 32, 33, 35, 37, 42, 43, 44, 49, 50, 51, 56, 57, 59, 63, 65, 66, 71, 75, 77, 78, 80, 81
Rivularia haematites (D.C.) C.Ag.	4	2	8, 35
R. minutula (Kütz.) Born. et Flah	2, 3, 4	10	7, 11, 25, 32, 33, 35, 39, 63, 65, 68
Schizothrix calcicola (C. Ag.) Gom.	1, 2, 3, 4	12	1, 17, 25, 37, 45, 49, 54, 62, 68, 75, 76, 79
Scytonema mirabile (Dillw.) Born.[3]	3	1	81
Tolypothrix tenuis Kütz. emend. J. Schmidt	2, 3, 4	7	8, 9, 25, 32, 35, 39, 66
Chlorophyta			
Microspora tumidula Hazen	2	1	54
Rhizoclonium hieroglyphicum (C. Ag.) Kütz.	4	1	17
Zygnema sp. 1	1, 2, 3, 4	13	8, 33, 41, 44, 48, 55, 63, 67, 68, 69, 71, 76, 78
Z. sp. 2	4	6	17, 28, 31, 32, 33, 39
Chrysophyta			
Tribonema viride Pasch.	2, 3, 4	5	3, 23, 55, 56, 65

[1] 1 = Southwestern Flat Sound, 2 = Expedition Fiord, 3 = Gibbs Fiord, 4 = Slidre River (see Fig. 1)

[2] numbers refer to sample sites in Figure 1

[3] new addition to the tundra stream macroalgal flora of North America

The most widespread species was the colonial cyanobacterium, *Nostoc commune,* which occurred in all four basins and 31 stream segments. Given its broad distribution, this species occurred in a diverse set of environmental conditions (Fig. 3). Nonetheless, it exhibits higher frequencies of occurrence under certain conditions: slightly alkaline pH (7.8–8.0), relatively low specific conductance (51–200 µS cm^{-1}), low turbidity (1–10 NTU), small stream size (0–2.5 m maximum width, 11–15 cm maximum depth) and little current velocity (0–10 cm 5^{-1}). Other common taxa included *Phormidium subfuscum* (3 basins, 10 segments), *Rivularia minutula* (3 basins, 10 segments), *Schizothrix calcicola* (4 basins, 12 segments) and *Zygnema* sp. 1 (4 basins, 13 segments) (Table 2).

In terms of number of macroalgal species per stream reach, the range was 0 to 5 and the mean was 1.3 (Table 1). Species number per reach was negatively correlated to turbidity, maximum width and depth, and mean current velocity ($p < 0.05$ to 0.001) and to no other conditions, including total phosphorous in the Slidre River Basin. Hence, the streams

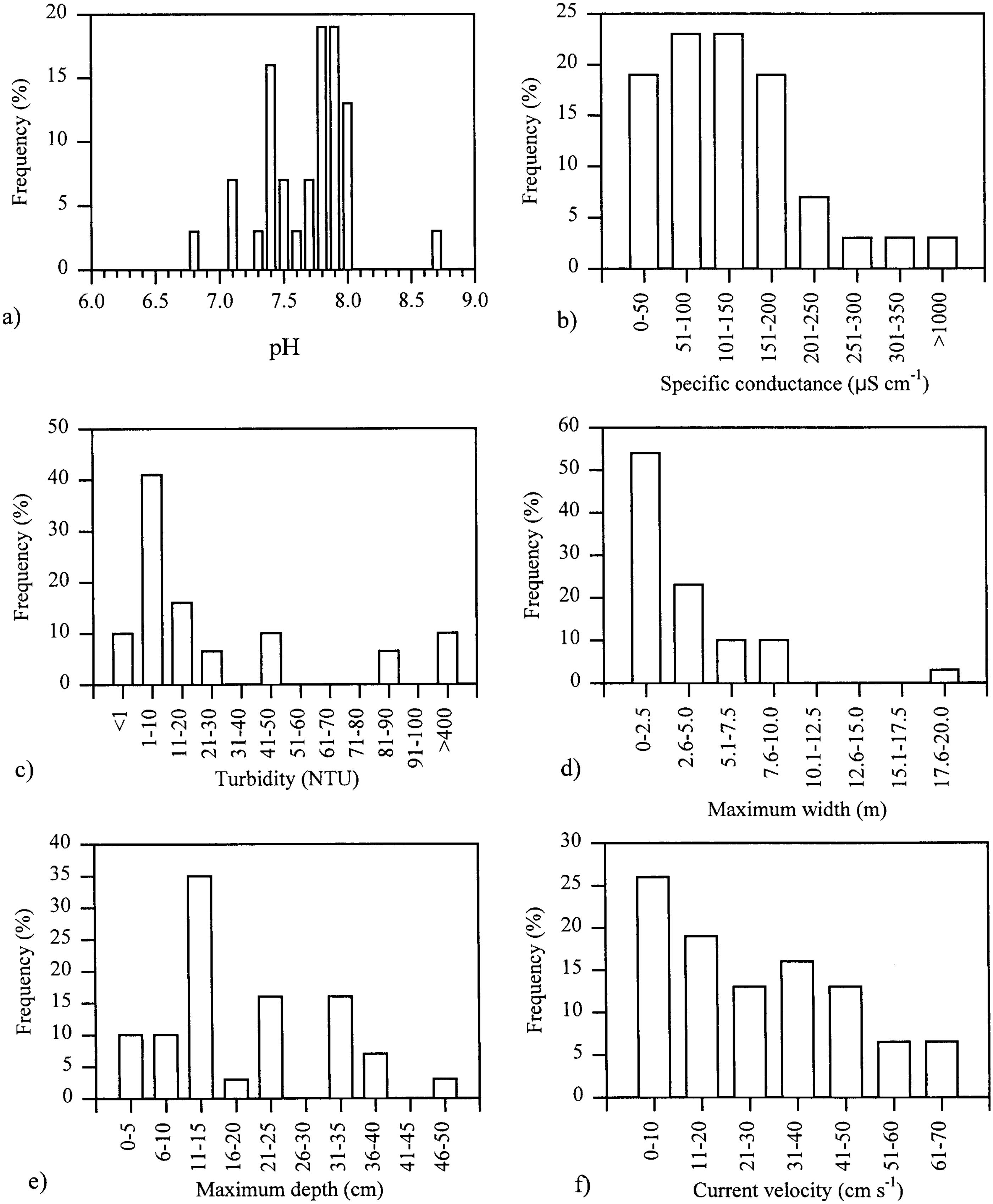

FIG. 3. Frequency of *Nostoc commune* distribution in 31 stream segments in relationship to various environmental factors.

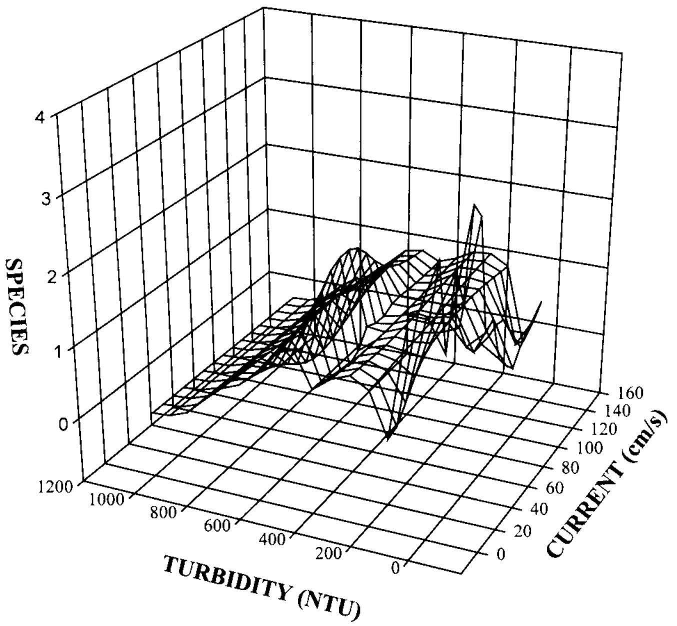

FIG. 4. Relationship of macroalgal species numbers with turbidity and current velocity. Note peak of species numbers at low turbidity and moderate current velocity.

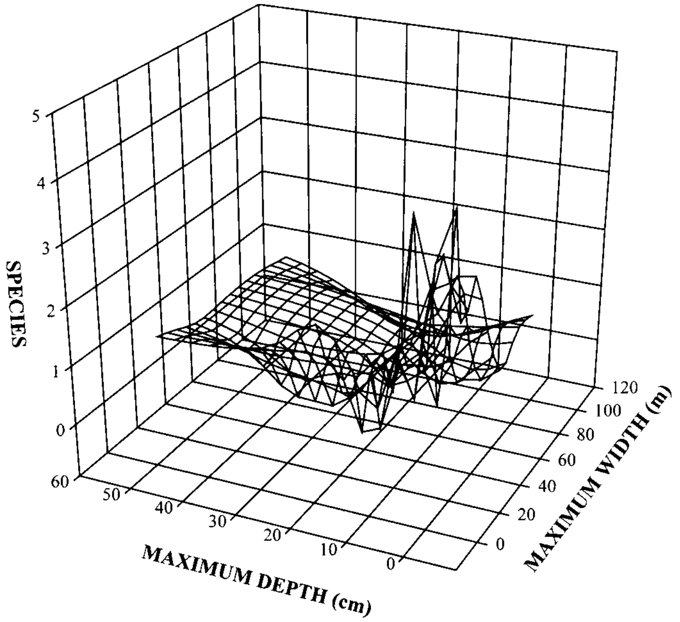

FIG. 5. Relationship of macroalgal species numbers with stream channel size. Note peak of species numbers at low maximum depth and moderate widths.

with more than one species, which tended to have little turbidity, moderate current velocity, and small channel size (Figs. 4 and 5), were largely small nival tributaries or those streams flowing through wetlands or pond outflows (Fig. 2). In contrast, most trunk reaches and large glacial rivers had few or no macroalgae. Thus, the high sediment load carried by many of the larger streams limits colonization by macroalgae because it reduces light penetration for photosynthesis and available hard substrata for attachment.

The amount of stream bottom covered by macroalgae extended from 0% to over 75% (Table 1). Species numbers and cover values in each stretch were positively correlated ($p < 0.001$). Cover was also negatively correlated to current velocity ($p < 0.05$), but not to turbidity, channel size, or other conditions. The mean cover among the 83 stream reaches sampled was ca. 5% (Table 1).

DISCUSSION

The overall macroalgal composition in the four basins examined, 15 species in 83 stream segments, is quite low in comparison to findings of our surveys of other parts of the North American tundra. We have identified 68 infrageneric taxa from 150 stream segments in 20 locations, ranging from the north slope of Alaska in the west to southwestern Greenland in the east, and from southeastern Bathurst Island in the north to the Belcher Islands in the south (Sheath et al., 1996). The four basins studied on Axel Heiberg and Ellesmere Islands are farther north (ca. 80°N) than those previously reported (ca. 56.5°–76°N). However, as noted earlier, summer temperatures in three of the basins examined in this study are more moderate than would be expected for the latitude (Edlund et al., 1990), and hence harsh growth conditions do not account for the low macroalgal diversity. We also examined a large range of stream types (Table 1), which should yield a higher number of species. While the low phosphorus concentrations in the streams examined on Ellesmere Island (5–27 $\mu g\ l^{-1}$) probably limit growth, they are not lower than concentrations in other parts of the Arctic (e.g., Harper, 1981; Murray and Svoboda, 1989; Miller et al., 1992). The one striking difference between many of the stream segments on Axel Heiberg and Ellesmere Islands and those examined elsewhere in the tundra is the high degree of sedimentation, which reduces the amount of hard substrata for attachment and light penetration for photosynthesis (e.g., Sheath and Hambrook, 1990).

The predominance of cyanobacteria followed by the Chlorophyta in these four High Arctic basins is typical of other parts of the North American tundra (Sheath et al., 1996), as well as of Antarctic streams (Vincent et al., 1993). It is of interest that Tang et al. (1997) demonstrated that most polar cyanobacteria are psychotrophs; that is, they are tolerant of low temperatures rather than adapted to them. They also noted that cyanobacteria have other competitive advantages for growth in the Arctic, such as tolerance to desiccation, freeze-thaw cycles, and bright, continuous solar radiation. The lack of freshwater Rhodophyta in the streams of the four drainage basins examined here is atypical of much of the North American tundra (Sheath et al., 1996), and we have found the red alga *Batrachospermum gelatinosum* (L.) DC. in a small stream north of Greely Fiord on Ellesmere Island (Vis and Sheath, 1997).

The colonial cyanobacterium *Nostoc commune* was present in 37% of the stream segments examined and all four basins. We have previously collected this species from 13 out of 20 locations in other parts of the North American tundra (Sheath et al., 1996). Prescott and Vinyard (1965) noted that *N. commune* is the most widespread cyanobacterium in the tundra worldwide. It is also common in streams of the Antarctic (Vincent et al., 1993) as well as terrestrial habitats in temperate and tropical regions (Fogg et al., 1973). In both the Arctic and Antarctic, *N. commune* can add to the available nitrogen through N_2 fixation (Stutz, 1977; Davey and Marchant, 1983). The conditions of highest frequency of occurrence of this species on Axel Heiberg and Ellesmere Islands are similar to those previously reported for this species in the North American tundra (Sheath et al., 1996).

In the flora of the four drainage basins on Ellesmere and Axel Heiberg Islands, the cyanobacterium *Scytonema mirabile* is a new addition to the overall macroalgal flora of the tundra region of North America (Table 2; Sheath et al., 1996). Like the majority of the arctic flora, this species also occurs in temperate habitats (e.g., Prescott, 1962). Among the eight species of stream macroalgae reported by Croasdale (1973) for the Lake Hazen area of Ellesmere Island, only *Schizothrix calcicola*, *Nostoc commune,* and *Microspora tumidula* are in common with the list from this study. The species reported by Croasdale and not in our collection are *Microcoleus vaginatus* (Vauch) Gom., *Microspora stagnorum* (Kütz). Lagerh., *Schizothrix mexicana* Gom., *Tolypothrix distorta* Kütz., and *Tribonema affine* G.S. West. Nonetheless, the taxonomy of a number of these taxa is in flux (e.g., Whitton, 1992).

A negative correlation between current velocity and either macroalgal species numbers or cover, as seen in these four High Arctic basins, has also been reported for a stream at Resolute, Northwest Territories on Cornwallis Island (Sheath et al., 1996). The effect of high current velocities is particularly compounded in the stream segments studied on Axel Heiberg and Ellesmere Islands by the relatively low amount of stable, hard substrata for attachment in the highly sedimented stream channels, as previously noted. Like species numbers, mean cover among the 83 stream reaches sampled is low, ca. 5%. This value is smaller than in other areas in the Arctic (8 and 12%, for High and Low Arctic, respectively) (Sheath et al., 1996).

In summary, the stream reaches in the four basins on Axel Heiberg and Ellesmere Islands have abnormally low diversity and abundance of stream macroalgae, and high sedimentation is a key factor producing this trend.

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