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Benthic algae and vascular plants of the lower Merrimack River and adjacent shoreline

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BENTHIC ALGAE AND VASCULAR PLANTS OF THE LOWER MERRIMACK RIVER AND ADJACENT SHORELINE

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Introduction

The present investigation was initiated as a part of a broad ecological study of the Merrimack River Estuary in Massachusetts (Miller, *et al.*, 1971). The project was conducted by Normandeau Associates for the U. S. Army Corps of Engineers in order to predict the biological effects of a possible fresh water diversion on the ecology of the Estuary. Jerome, *et al.* (1965) have evaluated the marine resources of the Estuary, but they have conducted only limited botanical studies. In the present account we summarize the composition and distribution of seaweeds and vascular plants from the Merrimack River Estuary. A comparison with the algal species diversity in the Hampton-Seabrook and the Great Bay Estuary Systems of New Hampshire is also given.

Collections and observations of intertidal algae and vascular plants were made at 19 stations in the Merrimack River Estuary during the summer and fall of 1971 (Fig. 1). Vascular plants were studied at 15 stations (Table I), while algae were studied at 13 locations (Table II). Representative specimens of plants from each site were collected and have been deposited as voucher specimens in the Herbarium of the University of New Hampshire (NHA). The type and quantity of substrate available for benthic plants at each site were noted. The nomenclature of the Second Revised British Checklist (Parke and Dixon, 1968) was applied for most taxa of seaweeds, while the Eighth Edition of Gray's Manual (Fernald, 1950) was employed for vascular plants.

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The breakwater at station 1 provides the maximum amount of stable substrate for benthic organisms. The intertidal areas at the remaining stations are composed primarily of scattered rock outcrops, boulders, pebbles and junk, interspersed with sand or mud. The largest amount of solid rock is usually evident in the upper intertidal zone and the substrate tends to grade into sand-mud in the lower shore. From the mouth of the river to station 11 there is a reduction in the amount of rock (particularly large outcrops) and a progressive increase in the deposition of mud on the shore. A buildup of extensive peat-like material is evident in the upper intertidal zone at many stations throughout the estuary, where the roots of *Spartina* spp. stabilize muddy surfaces and allow colonization of seaweeds, vascular plants and invertebrates.

Miller, *et al.* (1971) summarized the salinity distribution in the Merrimack River Estuary. A typical gradient is evident, with maximum salinities of 30 o/oo or higher on the open coast at Salisbury Beach and fresh water upstream near stations 18 and 19. Brackish waters are found between the two extremes. Salinity encroachments at open coastal levels occur from 2 to about 5 miles upstream, depending upon the season. At high tide the limits of salt intrusion vary from 4.3 to 10.9 miles from the mouth; they range from 3.1 to 6.8 miles at low tide. Gross fluctuations of temperature and salinity are evident (both daily and seasonally) at any site, particularly in the intermediate brackish water areas.

Vascular Plants

Thirty-one taxa of vascular plants were found in the marshy habitats of the Merrimack River Estuary (Table I). A fairly uniform distribution of salt-marsh plants was apparent from stations 4 to 12. Species consistently present included *Solidago sempervirens*, *Spartina alterniflora*, *S. patens*, *Salicornia europaea*, *Atriplex patula* and *Limonium carolinianum*. Station 13 was characterized by a diminished salt-marsh flora. New associations were present at stations 16 and 17 in the form of *Scirpus validus, Scrirpus maritimus, Acorus calamus* and *Zizania aquatica.* These four species are essentially brackish to freshwater inhabitants and represent a marked change in association away from some of the more persistent halophytes such as *S. alterniflora, S. patens, Salicornia europaea* and *Solidago sempervirens.* A detailed description of species composition at each station investigated is presented in Table I.

Intertidal Algae

A total of 31 taxa of benthic algae was collected (Table II). Twelve Chlorophyceae (green algae), eleven Phaeophyceae (brown algae) and five Rhodophyceae (red algae) were identified. A detailed evaluation of the Cyanophyceae (blue-green algae), Xantophyceae (yellow-green algae) and Bacillariophyceae (diatoms) was beyond the

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FIGURE 1

Intertidal Collecting Stations In the Merrimack River Estuary

1. Open ocean side of the breakwater at Salisbury Beach
2. Estuarine side of the breakwater at Salisbury Beach
3. Breakwater near Badgers Rocks
4. Western bank of Plum Island River underneath the bridge connecting Plum Island
5. Black Rock Point
6. Morrill Creek
7. Rocks just upriver from Coffin Point
8. Waterfront at Newburyport just west of the power generating station
9. Twin Rocks, on the Salisbury side of the river
10. North End Boat Club
11. Rock promontory on Ram Island
12. In the main channel on a rocky promontory of Carr Island
13. North side of the river across from Eagle Island
14. Rock promontory at Salisbury Point
15. On the north shore just upriver of the factories
16. On the north shore just upriver of the Seahorse Marina
17. On the south shore just down river of the Artichoke River
18. On the south shore between the Artichoke and Indian Rivers
19. South shore just upriver of the Groveland Bridge

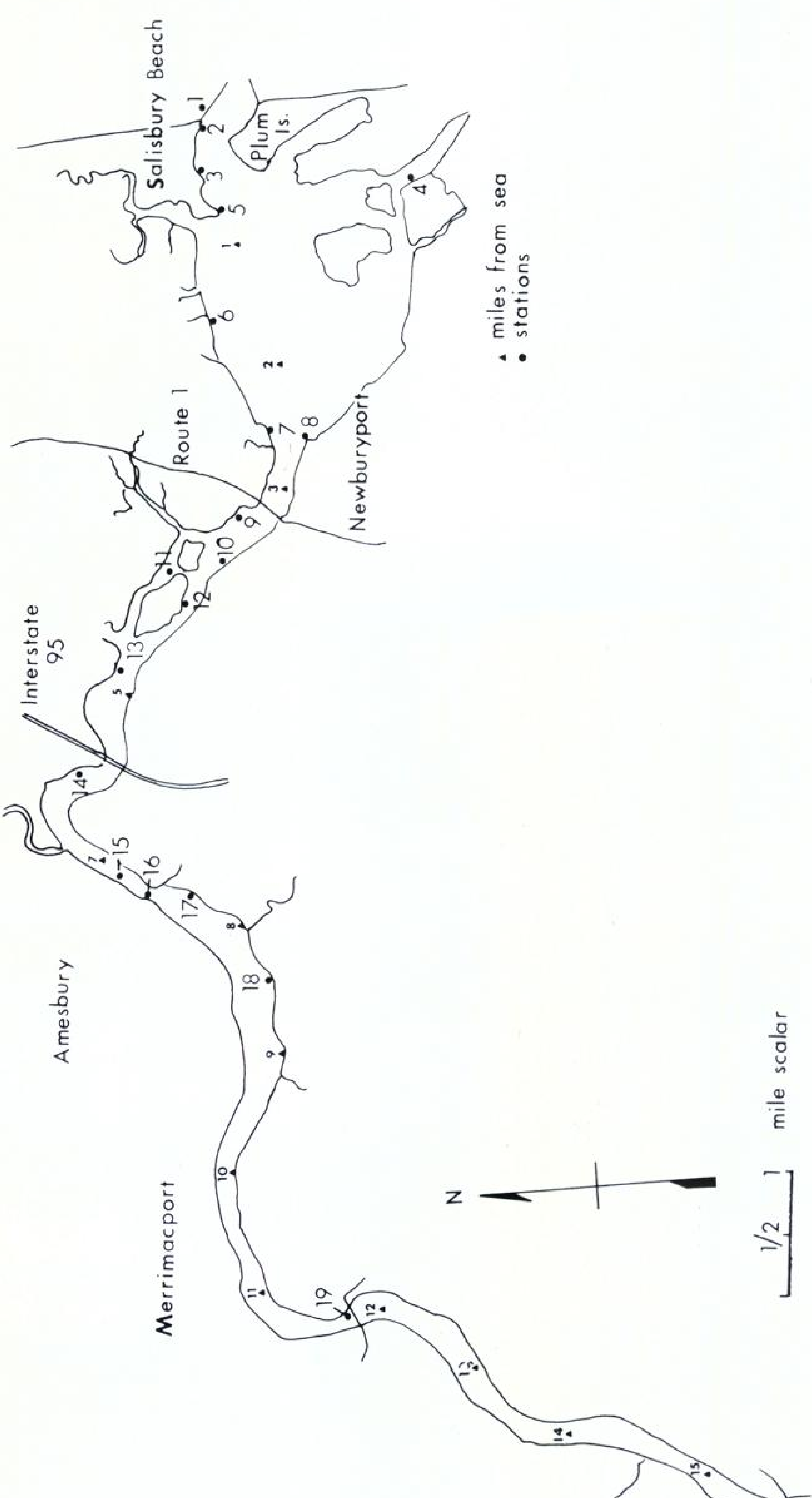
Salisbury Beach
Plum Is.
Route 1
Newburyport
Interstate 95
Amesbury
Merrimacport
miles from sea
stations
N
1/2
1
mile scalar

TABLE I

VASCULAR SHORELINE PLANTS OF THE MERRIMACK RIVER ESTUARY

PLANT	STATIONS 1	2	3	4	5	7	8	9	11	12	13	14	16	17	18
Triglochin maritima								×							
Artemiain stelleriana			×	×											
Artemisia stelleriana			×	×											
Ammophila breviligulata			×												
Solidago sempervirens			×	×	×	×	×	×	×	×		×	×		
Spartina alterniflora				×	×	×	×	×	×	×	×	×	×		
Spartina patens				×	×	×	×	×	×	×	×	×	×		
Salicornia europaea				×	×	×		×		×					
Plantago juncoides				×	×										
Atriplex patula var. *hastata*				×		×	×	×	×	×	×				
Limonium carolinianum				×				×	×	×					
Lythrum salicaria					×				×						
Cakile edentula					×										
Aster novi belgii					×										
Plantago oliganthos					×										
Carex salina					×										
Hudsonia tomentosa					×										

(continued)

TABLE I (continued)

PLANT	STATIONS 1	2	3	4	5	7	8	9	11	12	13	14	16	17	18
Acnida cannabina						×	×	×	×			×	×		
Potentilla egedei var. *groenlandica*						×			×	×	×				
Juncus gerardi						×			×						
Spergularia marina						×									
Eleocharis acicularis						×									
Ranunculus sp.						×									
Scirpus validus								×				×	×	×	×
Scirpus maritimus var. *fernaldi*									×	×		×	×	×	×
Distichlis spicata									×						
Typha latifolia												×	×		
Sium suave													×		
Acorus calamus														×	×
Zizania aquatica														×	×
Polygonum hydropiper														×	
Aster subulatus														×	
TOTAL			4	9	11	11	5	9	11	8	4	7	9	6	4

TABLE II

SPECIES COMPOSITION AND DISTRIBUTION OF CONSPICUOUS INTERTIDAL ALGAE IN THE MERRIMACK RIVER ESTUARY

	STATIONS												
SPECIES	1	2	5	6	7	9	10	11	13	15	17	18	19
CHLOROPHYCEAE:													
Blidingia minima	×	×	×		×	×							
Enteromorpha erecta	×	×	×	×	×	×	×	×	×	×			
Enteromorpha groenlandica					×								
Enteromorpha intestinalis	×	×	×		×	×	×						
Enteromorpha linza	×	×	×	×									
Monostroma oxyspermum					×	×	×						
Pseudendoclonium marinum	×	×	×										
Rhizoclonium riparium							×						
Spongomorpha arcta	×												
Ulothrix flacca	×		×	×									
Urospora penicilliformis		×											
Ulva lactuca	×		×										
SUBTOTAL	8	6	7	3	5	4	4	1	1	1			
PHAEOPHYCEAE:													
Ascophyllum nodosum	×	×	×	×	×								
Ectocarpus confervoides	×												
Elachista fucicola	×												
Fucus vesiculosus	×	×											
Fucus vesiculosus var *spiralis*			×	×	×	×							
Laminaria digitata	×												

(continued)

TABLE II (continued)

SPECIES	STATIONS 1	2	5	6	7	9	10	11	13	15	17	18	19
PHAEOPHYCEAE (continued)													
Laminaria saccharina	×												
Petalonia fascia	×												
Pilaiella littoralis	×		×	×									
Ralfsia verrucosa	×	×											
Scytosiphon lomentaria	×												
SUBTOTAL	10	3	3	3	2	1							
RHODOPHYCEAE:													
Hildenbrandia prototypus	×	×	×		×								
Polysiphonia fibrillosa			×										
Porphyra leucosticta	×												
Porphyra umbilicalis	×												
Ptilota serrata	×												
SUBTOTAL	4	1	2		1								
XANTHOPYCEAE:													
Vaucheria sp.			×	×		×	×	×	×	×	×	×	
SUBTOTAL			1	1		1	1	1	1	1	1	1	
BACILLARIOPHYCEAE:													
Amphipleura rutilans		×	×	×		×							
Melosira sp.								×					
SUBTOTAL		1	1	1		1		1					
TOTAL	22	11	14	8	8	7	5	3	2	2	2	0	0

scope of the present investigation, although some data was collected. For example, the colonial diatom, *Amphipleura rutilans,* was a conspicuous component at stations 2, 5, 6 and 9. *Vaucheria* sp. and various blue-green algae such as *Lyngbya, Oscillatoria* and *Merismopedia* formed a conspicuous mat amongst *Spartina* roots at stations 5, 6, 9, 10, 11, 13, 15 and 17.

Details of species composition and distribution of seaweeds are summarized in Table II. The maximum number of species was found at stations 1, 2 and 5; beyond station 5 there was a rapid and progressive reduction in species numbers. Red algae appeared to be least tolerant of reduced salinities. Three of the five species dropped out at station 2, and no red algae were found beyond station 7. Brown algae showed a wider distribution than red algae, but even so they were not found upstream of station 9, and their largest number of species was found at station 1. Green algae were the most cosmopolitan of the three major groups, with *Enteromorpha erecta* extending to the low salinities of station 15. The yellow-green alga, *Vaucheria* sp., and the green alga, *E. erecta,* were the most widespread of all seaweeds. Several blue-green algae are probably equally tolerant to reduced salinities, but a lack of specific identifications precluded a precise evaluation.

An inspection of Table II indicates that most seaweeds exhibit a cosmopolitan distribution, for they occur both on the open coast and within the estuary. *Vaucheria* sp., *Enteromorpha groenlandica, Monostroma oxyspermum, Fucus vesiculosus* var. *spiralis,* and *Polysiphonia fibrillosa* are considered to be truly estuarine, for they were never found on the open coast. *Spongomorpha arcta, Porphyra leucosticta,* and *Ptilota serrata* appear to be coastal forms, since they were not found within the mouth of the river.

Discussion

The variety and abundance of rock are major factors restricting growth and distribution of algae in the Merrimack River Estuary. The breakwater at stations 1 and 2 provided maximum stability and surface area for the growth of seaweeds, and the highest species numbers and biomass of algae were evident at these two sites. The reduced species and biomass (based on a qualitative assessment of all species) upstream of station 5 can be attributed, at least in part, to unsuitable substrate. Most rocks upriver of this station were mud covered, and it is obvious that films of mud and silt will inhibit the attachment and growth of many algal species. In addition, small cobbles and pebbles, characteristic of upriver stations, are unsuitable as substrate for many larger plants, because of their instability. Only crustose algae such as *Hildenbrandia prototypus* and *Pseudendoclonium marinum* were found on such rocks. *Vaucheria* sp., *Enteromorpha* spp., and various blue-green algae were the only forms collected on the muddy surfaces stabilized by the roots of *Spartina alterniflora* and *Spartina patens*. The *Spartina* spp. play an important role in the formation of substrate suitable for algal colonization.

In contrast, the rocky substrate at stations 1 and 2 was not suitable for attachment and colonization of estuarine vascular plants, and progressive increases in numbers of estuarine vascular plants were observed in relation to a decrease in the amount of rocky substrate upstream. Therefore, an increase in biomass and species numbers of vascular plants upriver can be attributed to suitable substrate, including small rocks and fibrous peat. Maximum species numbers occurred at stations 5, 7 and 11. Beyond station 11 the reduction in species number (but not biomass) probably resulted more from sub-optimal hydrographic factors than from suitability of substrate. *Scirpus validus*, *Scirpus maritimus*, *Acorus calamus*, and *Zizania aquatica* accounted for nearly all the plant biomass at many of the latter stations.

Spatial and temporal variations of hydrographic factors in the Merrimack River Estuary, particularly the low upstream salinities, restrict the longitudinal distribution of many species (Mathieson and Burns, 1971; Mathieson, *et al.*, in press). Algal species having limited tolerances to temperature and salinity changes would not be expected to migrate upstream for any distance. As suggested earlier, *Spongomorpha arcta, Porphyra leucosticta,* and *Ptilota serrata* have a distinctly coastal distribution, and they did not extend inland of station 1. Other species exhibited gradations of tolerances to temperature and salinity fluctuations within the estuary. The most tolerant ones exhibited the widest distributions (e.g., *Enteromorpha erecta* and *Vaucheria* sp.), while the less tolerant ones had limited estuarine distributions (e.g., *Elachista fucicola* and *Petalonia fascia*). For the algae the most conspicuous reduction in species diversity occurred between stations 5 and 6; it was probably caused by the greater fluctuations of temperature and salinity and the limited amount of solid substrate.

Pollution is an important limiting factor in algal distribution and abundance (North, *et al.*, 1964; Patrick, 1964). A comparison of the species composition of seaweeds from the Merrimack River Estuary with that of the Hampton-Seabrook Estuary (Mathieson and Fralick, 1972) and the Great Bay Estuary Systems (Mathieson, Reynolds, and Hehre, in press) of New Hampshire indicates a paucity of total species and species numbers per station in the Merrimack. A total of 118 taxa of seaweeds was collected from the Hampton-Seabrook Estuary and the adjacent open coast, while over 150 species were found within the vicinity of the Great Bay Estuary System. The low algal species diversity (only 31 taxa) from the Merrimack River Estuary is probably also due to the extreme domestic and industrial pollution of this interstate river. Jerome *et al.* (1965) and Miller, *et al.* (1971) indicate that the Merrimack is one of the most polluted rivers in New England.

The concept of species diversity has been applied extensively in evaluating eutrophication of freshwater habitats. In general, a decrease in species diversity is a typical response to an increase in either domestic and/or industrial pollution (Patrick, 1964). Under polluted conditions, a few tolerant species tend to dominate in large numbers and high biomass. The abundance of many Ulotrichalean green algae such as, *Enteromorpha* spp., *Ulva lactuca,* and *Monostroma* sp. typifies a polluted estuarine habitat (Cotton, 1910; Fritsch, 1935). These species are not only tolerant of extremes in pollution, but of gross fluctuations in hydrographic factors.

In summary the paucity of the algal flora may be attributed to the following: (1) limited solid substrate for benthic species; (2) probably to the high degree of pollution of the Merrimack River Estuary. The abundance of certain algae definitely seems to be related to the pollution factor.

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