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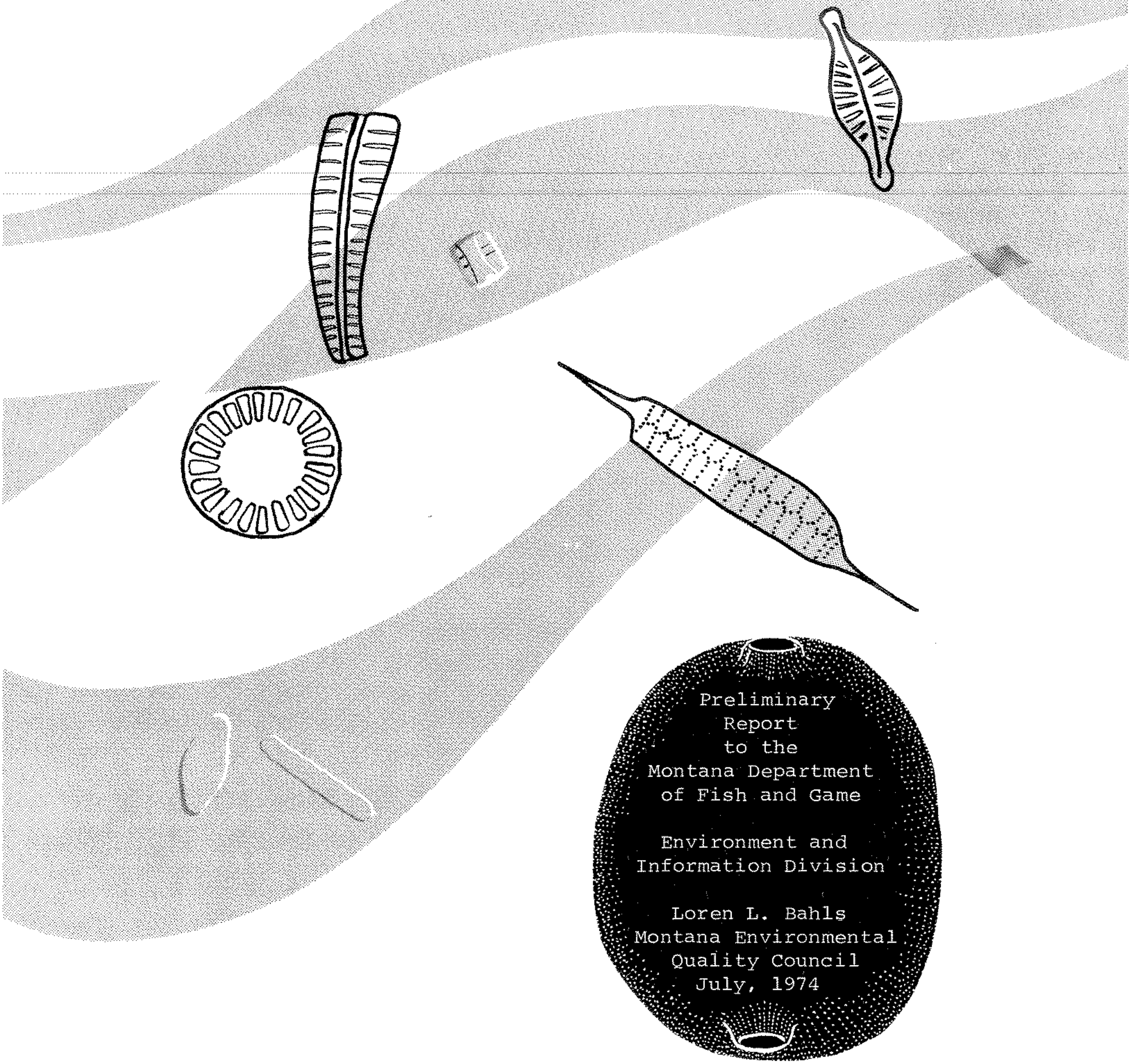
MICROFLORA of the YELLOWSTONE RIVER

MICROFLORA IN THE PLANKTON AT THE CONFLUENCE OF THE BIGHORN RIVER



Preliminary
Report
to the
Montana Department
of Fish and Game

Environment and
Information Division

Loren L. Bahls
Montana Environmental
Quality Council
July, 1974

Introduction

Algae—small, often microscopic aquatic plants—are responsible for the major share of primary production within the Yellowstone River ecosystem. Together with organic matter contributed by terrestrial plants along the river banks, algae form the base of the aquatic food pyramid that culminates in the production of such consumers as osprey and trout or sauger. Many algae are rather specific in their tolerance of habitat conditions and therefore serve as reliable indicators of community health and water quality.

With the imminent potential for massive coal development in the Yellowstone basin, including possible large-scale diversions and a major impoundment, a thorough knowledge of the existing biological system is an urgent must both for defining existing conditions and for predicting future changes. Benthic algae, along with aquatic bacteria and fungi, belong to the periphyton or aufwuchs community. Relatively little is known of the periphyton community of the Yellowstone River system. Roeder (2) studied the diatom assemblage of the Gardner River, a tributary of the Yellowstone in Yellowstone National Park. Wright and Soltero (6) described the algal flora of Bighorn Lake on the Bighorn River. Stadnyk (3) measured biomass standing crop and autotrophic index of the periphyton community at three stations between Gardiner and Billings but did not determine species composition. Westinghouse (4) identified the suspended algae and counted organisms of the "phytoplankton" community at two stations near the mouth of Armells Creek. And Williams (5) determined the percent occurrence of plankton algae at Sidney over a one year period.

The present report concerns three net samples taken on April 2, 1973 at the following locations: Yellowstone River at Myers Bridge (001), Bighorn River at Bighorn (002), and the Yellowstone River at Custer (003). The samples were collected at midafternoon by suspending a small net from a bridge for five minutes. The samples were preserved in formalin and supplied to me by Mr. Al Wipperman.

Methods

A portion of the raw sample was used to prepare a wet mount which was examined under 400 X. The wet mount was scanned until most of the algal genera were identified and their approximate rank by volume was estimated. Members of the microfauna were also indentified when possible.

About half the raw sample was acidified and oxidized over heat to remove the organic matter. The remaining material, consisting mostly of empty diatom frustules along with particles of silt and clay, was washed and a portion taken to prepare a permanent diatom mount.

Each diatom slide was then examined. First it was scanned and a flora for that slide was prepared. Then, beginning at the edge of the coverslip, successive fields were observed until between 300 and 400 diatom cells were identified and tabulated. Abundance or the percentage contribution of each taxon was then computed. Taxa observed during the scanning but not later were tabulated with a "t" (trace).

Results

Each raw sample consisted of between 85 and 90 percent unidentifiable and mostly organic detritus. In addition, insect appendages were common in all three samples. Identifiable members of the microfauna included a "little water bear" (Tardigrada), a tiny chironomid larva, and a *Vorticella*, all at sation 001.

The remaining 10 to 15 percent of each raw sample consisted of algae, comprising four divisions and 28 genera (see Table I). In all cases, the most abundant alga by volume was *Cladophora*, a common sessile, branched, filamentous green alga. All specimens of *Cladophora* were in a degenerate condition, however. As a group, the diatoms were the most abundant and diverse. One genus of red and two genera of bluegreen algae were also present.

No less than 75 varieties and 23 genera of diatoms were identified from the acid cleaned material (see Table II). The diatom species composition of the three samples was similar, differing primarily in relative abundance of individual taxa. Nitzschia dissipata (Fig. 1) was the most common diatom species, followed in order by Cocconeis placentula var. euglypta, Gomphonema olivaceum, and Achnanthes minutissima.

Of the diatoms found at the three stations, 29 taxa are sessile, growing attached to the bottom or to other plants. Forty-five taxa are either mobile over some substrate or quasi-planktonic and forming short filaments resting upon but not attached to a substrate. Only one species, Fragilaria crotonensis (Fig. 2), is truly planktonic and capable of living indefinitely suspended in open water. F. crotonensis was common only in the Bighorn River sample where it ranked third in volume (Table I). Of the remaining 10 genera identified in the raw samples, four are sessile and attached and six are quasi-planktonic.

The ecological requirements of each of the more common diatom species were determined according to Patrick and Reimer (1). A summation of these requirements and the number of times they were repeated is given below:

nutrient enriched (6)
circumneutral (5)
oligohalobe (4)
salt indifferent (4)
alkaline (4)
fresh to slightly brackish (4)
eurytopic (3)
cool (3)
moderately hard (2)
flowing (2)
high oxygen (2)
alkaliphil (1)
highly calcareous (1)
brackish (1)
moderate conductivity (1)

Based on these affinities, the water at the confluence of the Bighorn and the Yellowstone might be described as nutrient enriched, circumneutral, alkaline, moderately brackish, moderately hard, cool, well oxygenated, and flowing. The relatively high diatom diversity indicates stability and health in the periphyton community.

Although not abundant, two additional taxa were found that are very characteristic of brackish water : Biddulphia laevis (Fig. 3) and Mastogloia sp. A single cell was found of Pinnularia subcapitata var. paucistriata (Fig. 4), a diatom preferential to fresh water of low mineral content.

Discussion and Conclusions

With one exception, the algae identified in net samples from the Yellowstone and Bighorn Rivers in April 1973 were members of the periphyton or aufwuchs community. That exception, Fragilaria crotonensis, was significant only in the Bighorn River sample where it ranked third in abundance. Wright and Soltero (6) reported F. crotonensis as the most important organism of the phytoplankton in Bighorn Lake on a cell volume basis and the dominant member of the early spring diatom pulse. The colonies of F. crotonensis observed at the mouth of the Bighorn River were probably produced in Bighorn Lake, discharged from the dam, and carried downstream with the current of the river. In this reach the so-called "phytoplankton" of the Yellowstone River therefore consists of sessile algae dislodged from the bottom, giving the appearance of a plankton. Nevertheless, this pseudo-plankton may be important downstream to filter feeding fish such as the paddlefish. The findings of Williams (5) indicate that something approaching a true river phytoplankton may develop in the lower reach of the river.

The degenerate quality of the Cladophora at these stations leads one to suspect that either (1) conditions are not suitable for growth in the immediate vicinity and the filaments observed originated far upstream or (2) early spring is normally a period of scenescence for this taxon. Although the latter may be true, Cladophora requires a firm, rocky substrate which may not be available in this stretch of river. Diatoms are more adaptable and may colonize a rock, sand, silt or mud bottom. In the upper reaches of the Yellowstone River, Stadnyk (3) reported that "diatoms made up the vast majority of the autotrophic fauna (sic) at all stations." He also observed a significant increase in siltation at his lowest station (Laurel). Below this point conditions for growth of sessile green algae may be less than optimum with the diatom flora achieving additional dominance. Westinghouse (4) found no filamentous green algae at the mouth of Armells Creek; the flora was almost completely dominated by diatoms.

The flora of the Yellowstone at its intersection with the Bighorn is intermediate between that of a high mountain stream and a lowland plains river. It probably coincides quite closely with the transition zone between a cold water and a warm water fishery. The Yellowstone does not appear to be influenced appreciably by the introduction of the Bighorn, at least in terms of the algal flora on the date these samples were collected.

The relative abundance of algae reported herein may not be truly representative of their abundance in the periphyton community since they were not collected from their natural growth habit. Additionally, net samples may be selective toward the larger forms since the extremely small species may pass through the meshes of the net.

Recommendations

1. Future periphyton collections should be made without the use of nets, which are selective for larger species. (For proper procedure, see "SUGGESTED SAMPLING SCHEME", L. L. Bahls, April 15, 1974.) A fine-meshed plankton tow

net may be used for sampling dislodged and drifting algae but invertebrate drift and bottom sampler nets are much too coarse.

2. In addition to the stations suggested in the sampling scheme of April 15, 1974, stations should be added from the upper Yellowstone, particularly above and below the site of the projected Allenspur Dam.

3, The stomach contents of a number of paddlefish should be analyzed to determine what role, if any, drifting components of the periphyton community play in the food habits of that fish.

Literature Cited

1. Patrick, R. and C. W. Reimer. 1966. The diatoms of the United States exclusive of Alaska and Hawaii. Vol. 1: Fragilariaceae, Eunotiaceae, Achnanthaceae, Naviculaceae. The Academy of Natural Sciences of Philadelphia. Monograph 13.

2. Roeder, T. S. 1966. Ecology of the diatom communities of the upper Madison River system, Yellowstone National Park. Ph.D. Thesis, Montana State University, Bozeman.

3. Stadnyk, L. 1971. Factors affecting the distribution of stoneflies in the Yellowstone River, Montana. Ph.D. Thesis, Montana State University, Bozeman.

4. Westinghouse Environmental Systems. 1973. Colstrip generation and transmission project. Applicant's Environmental Analysis. Report prepared for the Montana Power Company and four Northwest utilities. November.

5. Williams, L. G. 1962. Plankton population dynamics. National Water Quality Network--Supplement 2. Public Health Service Publication No. 663. U.S. Department of Health, Education, and Welfare, Washington, D.C.

6. Wright, J. C. and R. A. Soltero. 1973. Limnology of Yellowtail Reservoir and the Bighorn River. EPA Ecological Research Series No. EPA-R3-73-002. Office of Research and Monitoring, USEPA, Washington, D.C.

Table I

ALGAL GENERA IDENTIFIED IN RAW SAMPLES

(Number indicates approximate rank of importance according to volume)

Genera	Yellowstone R. @ Custer	Bighorn R. @ Bighorn	Yellowstone R. @ Myers
CHLOROPHYTA			
Cladophora	1	1	1
Microspora	14		
Mougeotia			12
Oedogonium		12	
Spirogyra	13		
Ulothrix	15	13	13
CHRYSOPHYTA			
Achnanthes	26		21
Biddulphia	19	4	5
Caloneis	24		19
Cocconeis	12	7	9
Cymatopleura	21		16
Cymbella	8	10	7
Diatoma	5	5	4
Epithemia	17		
Fragilaria	6	3	8
Gomphonema	7	6	10
Gyrosigma	22		17
Hannaea	18		18
Melosira	23		20
Meridion	25		
Navicula	3	2	2
Nitzschia	4	8	3
Rhoicosphenia	10	16	14
Surirella	16	9	
Synedra	9	15	11
RHODOPHYTA			
Audouinella	11	11	6
CYANOPHYTA			
Oscillatoria	2	14	15
Spirulina	20		

Table II

RELATIVE ABUNDANCE (%) OF DIATOM TAXA

Taxa	Yellowstone R. @ Custer	Bighorn R. @ Bighorn	Yellowston R. @ Myers
Achnanthes deflexa	1.3		0.6
Achnanthes lanceolata	0.3	0.5	0.3
Achnanthes minutissima	9.2	4.8	9.7
Amphora ovalis v. pediculus	3.6	6.4	7.3
Biddulphia laevis		t	
Caloneis amphisbaena	0.3	t	t
Cocconeis pediculus	0.7	7.2	2.7
Cocconeis placentula v. euglypta	9.9	11.9	13.4
Cyclotella glomerata	0.3	0.8	0.3
Cymatopleura solea			t
Cymbella affinis	1.0	0.3	0.3
Cymbella microcephala	0.7		
Cymbella prostrata		t	t
Cymbella sinuata	4.6	0.5	2.7
Cymbella turgida			t
Cymbella ventricosa	2.0	0.8	0.9
Diatoma anceps	1.3		
Diatoma tenue			t
Diatoma vulgare	0.7	3.2	1.8
Diatoma vulgare v. breve			t
Epithemia sorex	0.7	t	0.3
Epithemia zebra v. saxonica			t

t = trace

Relative Abundance (%) of Diatom Taxa (Continued)

Taxa	Yellowstone R. @ Custer	Bighorn R. @ Bighorn	Yellowstone R. @ Myers
Fragilaria construens	0.7		
Fragilaria construens v. venter			t
Fragilaria crotonensis		2.9	t
Fragilaria vaucheriae	1.0	t	0.9
Fragilaria vaucheriae v. novum			0.3
Fragilaria sp.	t(1)		
Gomphoneis herculeana	0.3		t
Gomphoneis sp.	t(1)		
Gomphonema bohemicum		0.5	0.6
Gomphonema olivaceum	8.9	12.7	11.6
Gomphonema olivaceum v. calcarea			t
Gomphonema parvulum	0.7	1.1	
Gomphonema parvulum v. micropus			0.3
Gyrosigma obtusatum			t
Gyrosigma sp.	t(1)	t(1)	
Hannaea arcus	0.7		0.3
Mastogloia sp.		0.3(1)	
Meridion circulare			t
Navicula anglica v. subsalsa		t	t
Navicula arvensis		t	
Navicula cryptocephala	2.3	1.9	1.2
Navicula cryptocephala v. veneta	4.6	3.7	6.1
Navicula grimmei		t	
Navicula heufleri v. leptocephala			0.3
Navicula luzonensis			0.6

t = trace

Relative Abundance (%) of Diatom Taxa (Continued)

Taxa	Yellowstone R. @ Custer	Bighorn R. @ Bighorn	Yellowstone R. @ Myers
Navicula minima	0.3		
Navicula muralis			0.6
Navicula pelliculosa	0.3	0.3	
Navicula pupula	t	t	
Navicula tripunctata	t	12.5	4.3
Navicula viridula	1.0	0.8	2.1
Navicula viridula v. avenacea	4.3	4.8	4.0
Navicula viridula v. linearis		0.3	
Navicula sp.	1.3(3)	t(1)	0.3(3)
Nitzschia acuta	t	0.3	
Nitzschia capitellata	0.7		
Nitzschia dissipata	15.5	11.1	15.8
Nitzschia epiphytica	10.2	1.1	6.7
Nitzschia fonticola	0.7		
Nitzschia frustulum	0.7		
Nitzschia hungarica			0.3
Nitzschia hybrida			t
Nitzschia kutzingiana	0.7	0.3	t
Nitzschia palea	0.7	t	0.3
Nitzschia romana	1.3	0.3	0.6
Nitzschia sigmoidea	t	0.3	0.3
Nitzschia sublinearis	0.3	0.3	
Nitzschia sp.		0.5(1)	
Pinnularia subcapitata v. paucistriata			t

t = trace

Relative Abundance (%) of Diatom Taxa (Concluded)

Taxa	Yellowstone R. @ Custer	Bighorn R. @ Bighorn	Yellowstone R. @ Myers
Rhoicosphenia curvata	3.3	6.1	0.6
Surirella ovata	1.6	1.6	0.9
Synedra acus	1.0	0.3	0.3
Synedra ulna v. contracta	0.3		0.3

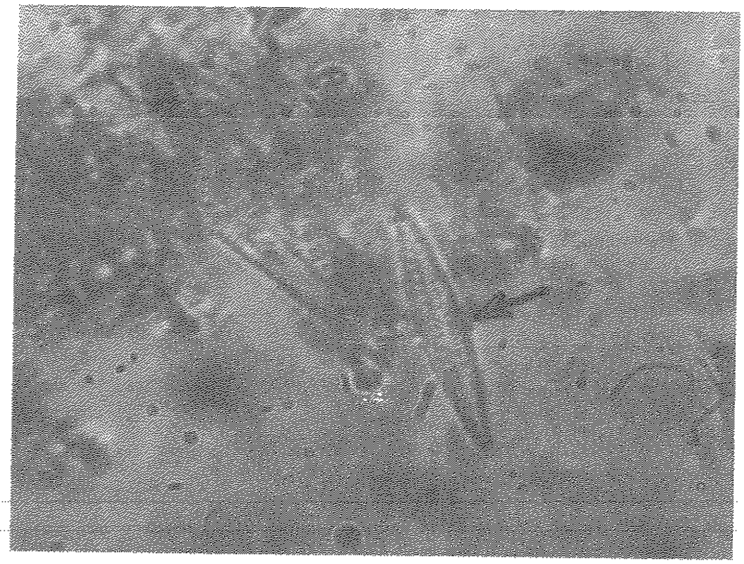


Figure 1. Nitzschia dissipata (arrow), the most common diatom species at the confluence of the Yellowstone and Bighorn Rivers in early April 1973. (1000X)

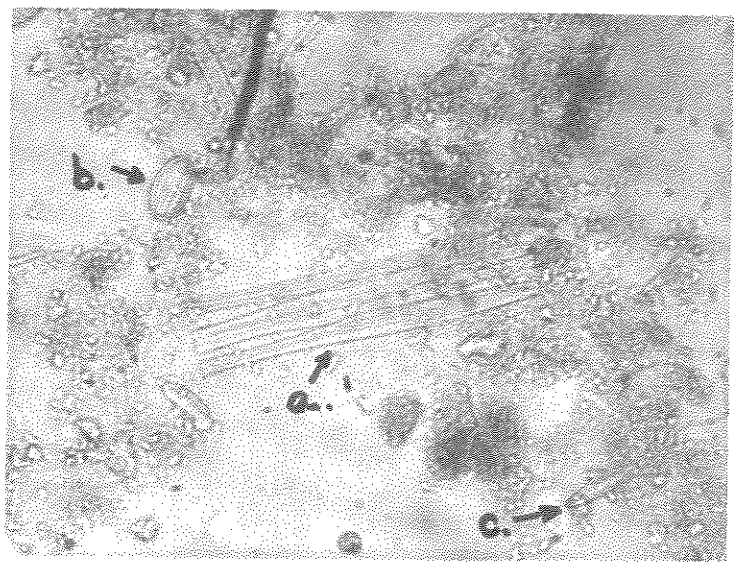


Figure 2. a. Fragilaria crotonensis, a true planktonic diatom probably derived from Bighorn Lake. b. Cocconeis placentula var. euglypta. c. Achnanthes minutissima. (400X)

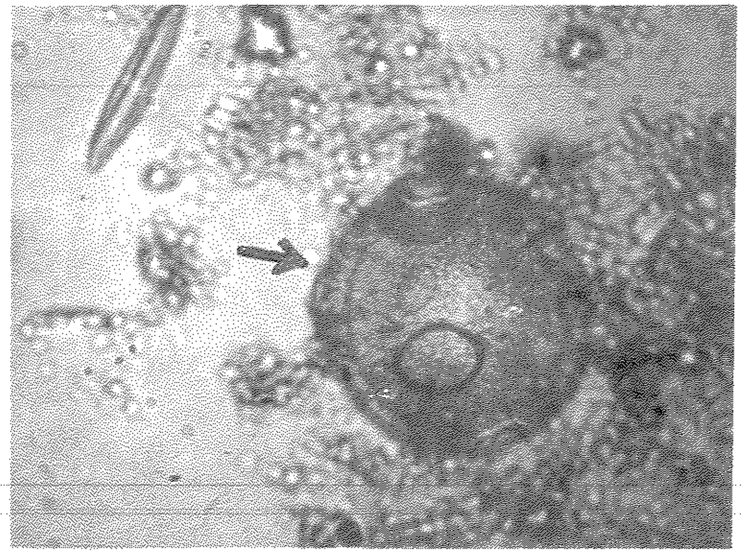


Figure 3. Biddulphia laevis (arrow), a very large diatom characteristic of brackish water. (400X)

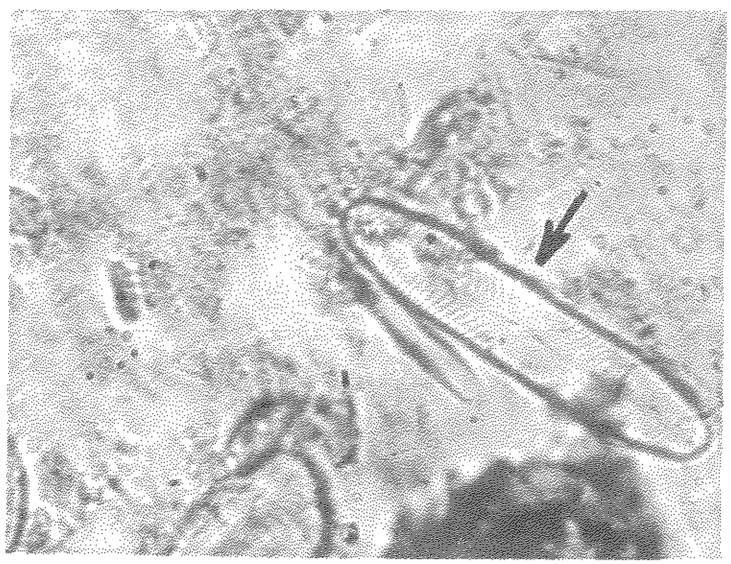


Figure 4. Pinnularia subcapitata var. paucistriata (arrow), a diatom prefering water of low mineral content and an anomaly in the Yellowstone River. (1000X)

APPENDIX A

SUGGESTED SAMPLING SCHEME

YELLOWSTONE RIVER MICROFLORA

Loren L. Bahls
April 15, 1974

Objective:

To determine the basic characteristics of the periphytic and planktonic components of the Yellowstone River microflora prior to potential massive development of Fort Union region coal deposits.

Methods:

Plankton: Although it is doubtful that the Yellowstone has a true self-sustaining phytoplankton community, dislodged members of the periphyton community, together with bits of detritus, other microorganisms and drifting aquatic insects may be significant as a food source to such filter feeding components of the ecosystem as the paddlefish.

For collecting plankton, the small net described on pp. 239-241 of Welch's Limnolgical Methods may be used. No. 25 standard silk bolting cloth is the grade usually used, however this or a coarser mesh size (greater than 64 microns) may not trap many of the smaller algal forms, particularly the diatoms.

The net should be suspended or towed in the current a minimum of 5 minutes or until several cubic centimeters of material are collected. The sample should be adequately labelled and may be preserved in a 5 percent solution of commercial formalin.

Periphyton: The periphyton community is probably much more important from the standpoint of primary production in the Yellowstone. This community consists of sessile algae, including diatoms, growing on the mud, rocks, logs or higher plants of the river bed.

Collecting periphyton is simple but care must be exercised to get a representative and composite sample. Algal growths are scraped with a carefully cleaned pocket knife from whatever substrates on which they happen to occur. Substrates (mud, rocks, logs and higher plants) should be sampled in proportion to their importance at a given station. Also, the sample should be roughly representative of different habitat types (pool, riffle and run) present in the river at or near the station. Extra care and effort may be required to locate and sample the not-so-conspicuous diatom growths that may appear as gelatinous brown masses feeling slimy to the touch. No attempt need be made to get a quantitative sample.

Alternative to the above sampling procedure, a small amount of periphyton may be scraped from Dendy plant type samplers if such are used concurrently for invertebrate collection. Other artificial (glass or plastic) substrates may be used for periphyton collection if desired.

All periphyton collections from one station on one date may be mixed in a single bottle, labelled, and preserved with a 5 percent solution of commercial formalin.

Stations:
The following eleven sampling stations were selected as being longitudinally representative of the lower Yellowstone River and tributaries:

Yellowstone River	Tributaries
1. Custer	2. Bighorn River
3. Myers	
4. Forsyth	
	5. Rosebud Creek (optional)
6. Miles City (above(below?)Tongue R.)	
	7. Tongue River
	8. Powder River
9. Terry	
10. Glendive (optional)	
11. Sidney (optional)	

Three stations, Rosebud Creek and the Glendive and Sidney stations, are optional and may be deleted for logistic reasons. Likewise, stations may be omitted or added depending on Fish and Game interests and purposes. Both the periphyton and plankton communities should be sampled, however slack water in the tributaries at certain times of the year may preclude collecting a plankton sample.

Schedule:
Monthly samples over the course of a year should be sufficient for survey purposes and for accomplishing the primary objective.

Results:
Analysis of plankton and periphyton samples from the Yellowstone and tributaries will yield the following types of results:

1. Relative composition of the microplankton in terms of planktonic algae, sessile algae, microinvertebrates, and detritus.

2. Species composition of the periphyton community.

3. Seasonal and longitudinal trends in the relative abundance of periphyton species and groups interpreted as indicators of water quality and habitat conditions.

4. Contribution of tributary streams to the microflora of the Yellowstone River.

5. Diversity of the Yellowstone River periphyton community as influenced by (a) tributary streams, (b) human-related activities and (c) seasonal climatic fluctuations.

STATE OF MONTANA

APPENDIX B

Environmental Quality Council

John W. Reuss

EXECUTIVE DIRECTOR

CAPITOL STATION, HELENA, MT. 59601

July 9, 1974

Mr. James A. Posewitz, Administrator
Environment and Information Division
Montana Department of Fish and Game
Mitchell Building
Helena, Montana 59601

Dear Jim:

I am enclosing a preliminary report on the algae of the Yellowstone River. The report covers three net samples taken on April 2, 1973 near the mouth of the Bighorn River.

In this report I have made three recommendations for future study of the Yellowstone River microflora. I hope that you and your people will give these consideration.

The Yellowstone offers a rare opportunity to study the natural longitudinal biotic succession of a major river. I think that we should make the most of this opportunity to show the value of this unique "natural laboratory" in its free-flowing state.

Sincerely,

Loren

Loren L. Bahls
Ecologist

cc: John Reuss