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Cladophora Surveillance Program - Western Basin of Lake Erie, 1982 Season

Final Report

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Introduction

In response to the increasing concern for Great Lakes water quality, the Lake Erie Cladophora Surveillance Program was initiated in 1979 by the International Joint Commission as a component of the Great Lakes International Surveillance Program. The Cladophora surveillance program was established as a means of assessing management strategies. For the past four years, the Center for Lake Erie Area Research (CLEAR), under sponsorship of the U. S. Environmental Protection Agency, has investigated the growth dynamics, ecology, and the light and nutritional requirements of Cladophora to determine the utility of this algae to evaluate management tactics.

This final report contains the 1982 field season results and conclusions. The results presented are from the routinely monitored site (CS-2) located on the southeast side of East Point, South Bass Island, Ohio, 41°39' latitude, 82°48' longitude (Figure 1). Substrate at this site is gently sloping dolomite bedrock. South Bass Island is approximately 10 km north of the Ohio mainland and is representative of mid-western basin water quality. The Stony Point, Michigan (CS-1) sampling site was excluded from the 1982 monitoring program.

The results and discussion for the 1982 Cladophora survey of the western basin are reported. This survey has been conducted during peak biomass in late June of 1980, 1981 and 1982 to determine the areal and vertical distribution of Cladophora.

Refer to Lorenz and Herdendorf (1981), Monaco and Herdendorf (1982), for detailed methods and discussions about the Cladophora study and western basin surveys. Results of the first two years of this study, Growth Dynamics of Cladophora glomerata in Western Lake Erie in Relation to Some Environmental Factors, have been published in the Journal of Great Lakes Research. A reprint of this paper was included in the preliminary report. A report on the entire

four years of the Cladophora monitoring study will be submitted in the spring of 1984.

Methods

Visual observations and collections through the ice and around the shoreline were conducted from January to March 1982. Routine sampling began 19 May 1983 (Table 1). CS-2 was visited bimonthly with roughtly 15 days in between samplings during optimum growth.

At the site, five sampling stations were established to investigate variations in biomass with depth. The depths monitored were splash zone, ½, 1, 2, and 3 m of water. At each station, the following parameters were measured when applicable: biological -- percent coverage, filament length (maximum and mean), standing crop expressed as wet, dry, ash and ash-free weight; physical -- depth, temperature (surface and bottom), vertical light profiles, secchi depth and weather; water nutrients -- soluble reactive phosphorus (SRP), total filterable phosphorus (TFP), total phosphorus (TP); plant internal nutrients -- total tissue phosphorus (TTP), total tissue nitrogen (TTN), and total tissue carbon (TTC).

Samplings operations were based out of a 21-foot boat and SCUBA gear was utilized for collection and observation. Standing crop samples were collected within a ¼-square meter (m^2) ring placed on the bottom. Collection was via hand-picking with support of SCUBA. Separate sub-samples were taken for chemical analysis. Coverage and length were measured in situ. Water samples were collected at each depth with a Kemmerer water bottle. TTC and TTN were determined with a Perkin-Elmer 240 elemental analyzer with a 1.0- to 1.5- mg sample of algal material. TTP was determined after a persulfate digestion with a Technician auto analyzer.

Results

Biological

Cladophora's biomass peaked between 22 June and 6 July 1982 and dropped significantly thereafter (Table 2). Ninety-five percent of the *Cladophora* beds at all depths, except the splash zone, had detached by 20 July 1982. The months of August, September, and half of October supported very little *Cladophora* biomass. A small fall pulse of biomass was observed, representing approximately 35 percent of the summer biomass.

Cladophora at depths of ½ m and greater exhibited the biannual growth pattern and detachment generally associated with the alga. However, the splash zone growth and marker buoys supported *Cladophora* throughout the summer and fall, with die back in the late fall due to frost.

Physical

Water temperatures peaked at 24.4°C on 20 July and remained constant until 19 August (Table 3). Temperatures between ½ and 3 m varied about 1° C, with higher temperatures at shallower depths. Secchi depth ranged from 0.6 - 1.75 m (Table 3) corresponding with the variable light intensities recorded (Figure 2).

Chemical

Nutrient levels in western Lake Erie may fluctuate dramatically from day to day, however, there is not a great difference in nutrient values at the various depths at CS-2 during a sampling period. Only phosphorus levels were monitored for the 1982 field season. Total phosphorus levels fluctuated throughout the season with the highest peak attained in early spring (Table 4). Soluble reactive phosphorus fluctuated slightly throughout the season. Values of SRP, at 2 m, ranged from 7.0 ppb on 7 June to below detection on 15 September.

Discussion

Previous quantitative biomass data is scattered and incomplete except Kishler's (1967) and Lorenz and Herdendorf's (1981) data. Some of the wide ranges of biomass values reported are due to different sampling mechanisms by investigators and whether splash zone growth was incorporated into the data since it does not exhibit the biomodal growth pattern. This study has utilized a consistent sampling scheme for the past 4 years. Maximum standing crop data from the routinely monitored sites at South Bass and Stony Point, Michigan (CS-1) are presented in Table 7. Biomass has not fluctuated dramatically at CS-2 over the years. Peak biomass conditions have occurred between 0.5 - 2 m depths each year. Since nutrients and substrate are not limiting Cladophora colonization at CS-2, it appears that light penetration is the controlling environmental factor. This statement is consistent with Lorenz's (1981) work in the laboratory and the field.

To expand on this theory, Cladophora surveys of the western basin of Lake Erie were conducted during peak biomass periods in late June of 1980, 1981 and 1982 (Figure 1). The objective of these surveys were to determine both the areal and vertical distribution of Cladophora in the basin. A manuscript of this component of the Cladophora study in in preparation.

The 1982 survey results are presented in Table 5. Cladophora was present throughout the western basin and was generally found wherever suitable natural or artificial substrate was available. Verber (1957) reported that 3.0% of the western basin of Lake Erie consisted of natural substrate for Cladophora colonization. Cladophora standing crop ranged from 3.0 to 220.0 g/m^2. Water nutrient concentrations around the basin were above critical levels for Cladophora growth (Wong and Clark 1976). Total tissue P and N concentrations in Cladophora were greater than critical values defined by Gerloff and Fitzgerald (1976).

The depth to which Cladophora was found on the island shelves and reefs varied with location (Table 5). Depth of colonization was generally greater the further north the site was located. Correspondingly, Secchi disk transparencies were greater and the extinction coefficients of light (K) were smaller at the northern sites (Table 5). From the data generated during the survey and the four years of routine monitoring, a field light value of approximately 50 $\mu\Sigma/m^2$ sec or less was hypothesized to be limiting the vertical distribution of Cladophora.

Conclusions from Routine Monitoring and Survey

1. Two distinctive Cladophora growth patterns were observed: 1) the splash zone growth, which appeared in April and remained present througout the season; 2) the infralittoral growth appeared mid-April and reached maximum biomass late June, with subsequent detachment in July and recurrence of growth in the fall.
2. Maximum depth of growth is influenced by light penetration.
3. Water temperatures between 20 - 24.4° C were associated with maximum growth.
4. Nutrients appear not to limit Cladophora colonization.
5. Cladophora will colonize on all suitable natural and artificial substrate.
6. A major portion of the western basin does not have suitable substrate to support Cladophora. Much of the United States shoreline is low-lying, consisting of unconsolidated sediments and the Canadian side has steep erodable bluffs. The largest extent of bedrock is located in the island region of the basin.

As evident by the above conclusions and previous reports and manuscripts prepared over the past 4 years, we are obtaining an understanding about the growth dynamics, nutritional, and light requirements of Cladophora glomerata in Lake Erie. However, there are many unanswered questions to be addressed.

A firm hypothesis has not yet been developed to explain the consistent growth of the splash zone Cladophora throughout the season. Also, the importance of this alga in providing substrate for food-chain organisms is imperfectly known. Cladophora should be investigated as a monitoring organisms since it is capable of bioaccumulatory pesticides (Meeks 1966), heavy metals (Bjerkelund and Ongley 1980), radioisotopes (Neil 1975), and toxic substances (Anderson et al. 1982). The ecology of Cladophora in the Great Lakes is just now beginning to be understood. If we are to utilize this alga as an indicator of pollution episodes or develop strategies for its control (if such control is deemed advisable), then basic studies of this organism must continue.

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DATA TABLES OF RESULTS

TABLE 1

CLADOPHORA SAMPLING DATES SOUTH BASS ISLAND, OHIO 1982

Month/Day	Julian Date	Comments
January 5	05	Visual observations along shore
January 15	15	Visual observations and collections through ice
February 15	46	Visual observations along shore
March 15	74	Visual observations and collections through ice
May 19	139	Begin routine sampling
June 7	158	Routine sampling
June 22	173	Routine sampling
July 6	187	Routine sampling
July 20	201	Routine sampling
August 5	216	Routine sampling
August 19	230	Routine sampling
September 1	243	Visual observations
September 15	258	Routine sampling
October 23	296	End routine sampling
December 17	352	Visual observations

TABLE 2

CLADOPHORA STANDING CROP DATA SOUTH BASS ISLAND, OHIO 1982

Date	Depth (m)	Coverage (%)	Length (cm) Mean	Length (cm) Max	Biomass per ¼ m^2 (g) Wet	Dry 64°C	Dry 104°C	Ash	Ash-Free
139	0.5	40	3.5	6					
	1.0	30	2.5	5	trace amounts - biomass not collected				
	2.0	30	2	2.5					
	3.0	T							
158	0.5	70	15	25.5	116.5	11.83	11.08	3.38	7.70
	1.0	55	10	15	87.75	12.22	11.83	6.65	5.18
	2.0	45	7	10	11.00	3.09	3.05	2.34	0.71
	3.0	T							
173	0.5	70	15	30	100.79	16.21	15.09	5.74	9.35
	1.0	70	10	20	108.64	18.02	16.83	7.64	9.19
	2.0	50	7	15	20.24	7.44	7.16	6.31	0.85
	3.0	T							
187	0.5	80	30	75	227.6	21.94	21.29	5.87	15.42
	1.0	T	--	--					
	2.0	T	--	--	trace amounts - biomass not collected				
	3.0	T	--	--					
201	0.5	T							
	1.0	T	old dead		trace amounts - biomass not collected				
	2.0	T	holdfasts						
	3.0	T							
216	0.5	T							
	1.0	T	old dead		trace amounts - biomass not collected				
	2.0	T	holdfasts						
	3.0	T							
230	0.5	0							
	1.0	0	very few		tetraspora present - biomass not collected				
	2.0	0	holdfasts						
	3.0	0	present						

TABLE 2 (Continued)

Date	Depth (m)	Coverage (%)	Length (cm) Mean	Length (cm) Max	Biomass per ¼ m^2 (g) Wet	Dry 64°C	Dry 104°C	Ash	Ash-Free
243	0.5	0							
	1.0	0	very few		biomass not collected				
	2.0	0	holdfasts						
	3.0	0	present						
258	0.5	T	1-2		trace amounts - biomass not collected				
	1.0	T							
	2.0	T							
	3.0	T							
296	0.5	85	12	15	54.98	7.61	7.12	2.55	4.57
	1.0	T							
	2.0	T							
	3.0	T							
352	0.5	70	10	25	biomass not collected				
	1.0	T							
	2.0	T							
	3.0	T							

T = trace amounts

TABLE 3

CLADOPHORA PHYSICAL AND METEOROLOGY DATA
SOUTH BASS ISLAND, OHIO 1982
(CS-2)

Date	Depth (m)	Temperature Surface	Temperature Bottom	Secchi (m)	Waves (ft)	Weather Clouds (%)	Weather Air Temp. °C
139	0.5	---	---	---	1-2	70	7.2
	1.0	18.0	17.5	B			
	2.0	18.0	17.5	1.75			
	3.0	17.5	17.0	1.75			
158	0.5	19.0	19.0	---	1-2	40	18.3
	1.0	19.0	19.0	.60			
	2.0	18.0	18.0	.79			
	3.0	18.0	18.0	1.30			
173	0.5	20.0	20.0	---			
	1.0	20.0	20.0	B	0	25	18.3
	2.0	19.5	19.5	1.32			
	3.0	20.0	20.0	1.36			
187	0.5	23.0	22.7	---			
	1.0	23.0	22.5	B	0-1	30	28.9
	2.0	23.0	22.8	1.20			
	3.0	23.0	22.8	1.10			
201	0.5	24.4	24.4	---			
	1.0	24.4	24.4	B	0.5-1	0	29.4
	2.0	24.2	24.1	1.21			
	3.0	23.9	23.9	1.22			
216	0.5	24.4	24.4	---			
	1.0	24.4	24.4	B	0-1	95	29.4
	2.0	24.4	24.4	B			
	3.0	24.4	24.4	1.30			
230	0.5	23.3	23.3	---			
	1.0	23.3	23.3	B	0-1	10	23.3
	2.0	23.3	23.0	1.08			
	3.0	23.3	23.0	1.30			

TABLE 3 (Continued)

Date	Depth (m)	Temperature Surface	Temperature Bottom	Secchi (m)	Waves (ft)	Weather Clouds (%)	Weather Air Temp. °C
258	0.5	22.0	22.0	---			
	1.0	22.0	22.0	1.00	0-1	10	21.1
	2.0	21.0	22.0	1.21			
	3.0	21.0	22.0	1.08			
296	0.5	11.0	11.7	---			
	1.0	11.0	11.2	.80	1-2	60	9.0
	2.0	11.5	11.5	.90			
	3.0	11.5	11.5	1.00			
352		6.0			2-3	15	1.7

B = Bottom (Secchi disk visible on bottom)

TABLE 4

CLADOPHORA WATER NUTRIENT DATA
SOUTH BASS ISLAND, OHIO 1982

Date	Depth (m)	SRP (ppb)	TFP (ppb)	TP (ppb)
139	0.5			
	1.0	64.0	59.18	83.03
	2.0	2.2	15.33	21.88
	3.0	2.0	3.08	25.43
158	0.5	8.7	19.73	36.37
	1.0	2.6	7.48	28.70
	2.0	7.0	10.29	24.50
	3.0	4.4	10.00	24.60
173	0.5	---	34.13	78.54
	1.0	---	28.98	45.44
	2.0	---	15.90	37.68
	3.0	---	15.80	63.49
187	0.5	4.9	9.35	27.86
	1.0	4.0	9.10	27.96
	2.0	2.6	7.57	22.44
	3.0	3.0	7.76	21.32
201	0.5	2.4	7.67	28.05
	1.0	2.7	7.39	39.08
	2.0	3.7	16.92	35.44
	3.0		20.57	31.80
216	0.5	2.5	7.57	31.79
	1.0	2.6	9.44	31.79
	2.0	2.7	5.80	34.60
	3.0	2.7	6.54	34.41
230	0.5	8.8	5.61	35.53
	1.0	2.0	6.08	33.38
	2.0	2.7	5.80	40.11
	3.0	3.4	8.23	44.13

TABLE 4 (Continued)

Date	Depth (m)	SRP (ppb)	TFP (ppb)	TP (ppb)
258	0.5	---	10.28	33.66
	1.0	---	9.44	33.75
	2.0	---	10.28	33.66
	3.0	---	11.69	33.94
296	0.5	1.5	11.13	26.93
	1.0	5.5	14.50	35.62
	2.0	3.7	14.02	38.62
	3.0	7.8	14.96	39.08

SRP = Soluble reactive phosphorus
TFP = Total filterable phosphorus
TP = Total phosphorus

TABLE 5

COMPARISON OF OBSERVED WESTERN LAKE ERIE DEPTH OF CLADOPHORA GROWTH (m) WITH PREDICTED GROWTH DEPTHS, BASED ON A 50 $\mu\Sigma m^{-2}$ sec^{-1} LIMITING LIGHT REGIME 1982

Location	K^1	Predicted	Max. Observed	Percent Difference
Marblehead Peninsula	2.00	1.7	1.6	5.8
Kelleys Island	0.79	4.7	4.0	14.9
Gull Island Shoal	0.90	4.1	2.5	39.0
North Bass Island	0.64	5.8	5.0	13.8
Chickenolee Reef	1.1	3.3	5.0	87.1
East Sister Island	1.21	3.1	3.5	12.9
Colchester Reef	0.52	7.1	7.0	1.4
Middle Ground Shoal	0.71	5.2	4.3	17.3
Stony Point	2.52	1.5	1.7	13.3
South Bass Island	0.96	3.8	3.0	21.1
West Sister Island	0.72	5.1	3.5	31.4
Catawba Cliffs	1.86	1.8	1.8	0.0
Average				21.5

K^1 = Light extinction coefficient

TABLE 6

CLADOPHORA TISSUE NUTRIENTS
SOUTH BASS ISLAND, OHIO 1982

Date	Depth (m)	TTC%[1]	TTN%[2]
139	S[3]	14.78	0.50
	0.5	8.94	1.12
	1.0	19.61	1.32
	2.0	16.33	1.30
158	S		
	0.5	35.43	4.05
	1.0	27.03	3.33
	2.0	23.50	2.56
173	S	37.54	3.10
	0.5	35.50	2.77
	1.0	30.96	4.25
	2.0	16.91	1.51
187	S	37.53	2.28
	0.5	32.16	2.66
	1.0	19.18	1.37
201	S	8.95	1.92
	0.5	21.50	1.67
230	S	34.64	1.61
296	S	38.78	2.88
	0.5	29.60	4.53
	1.0	35.12	3.56
	2.0	36.18	3.34

TTC[1] = Total tissue carbon
TTN[2] = Total tissue nitrogen
S[3] = Splash zone

TABLE 7

CLADOPHORA MAXIMUM STANDING CROP AND DEEPEST DEPTH OF COLONIZATION VALUES FOR THE STONY POINT AND SOUTH BASS ISLAND SITES, 1979-1982

Site	Year	Month	Depth (m)	64° C Dry Weight* Max.	Maximum Depth (m) of Colonization	Filament Length (cm) Max.	Filament Length (cm) Mean
Stony Point (CS-1)	1979	July	0.5	100	2	37	23
	1980	November	0.5	184	2	13	8
	1981	June	0.5	96	2	30	25
South Bass (CS-2)	1979	June	2.0	102	3	60	30
	1980	June	0.5	214	3	40	30
	1981	June	2.0	172	3	28	20
	1982	July	0.5	88	3	75	30

Mean Maximum Standing Crop

CS-1 127 g/m^2

CS-2 143 g/m^2

*Dry Weight 104° C

FIGURES

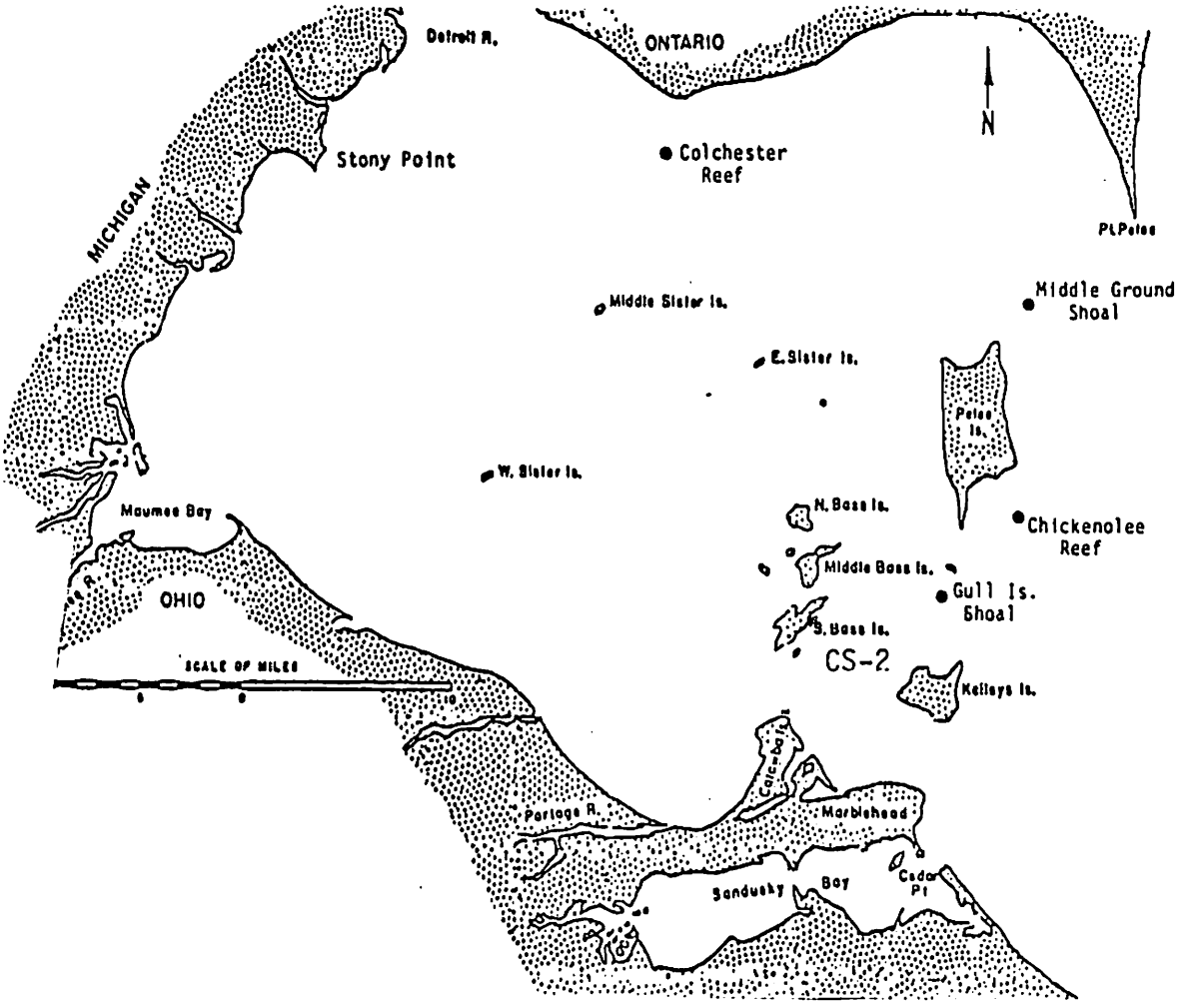

Figure 1. Western Lake Erie Cladophora Survey Station Locations, 1980-1983.

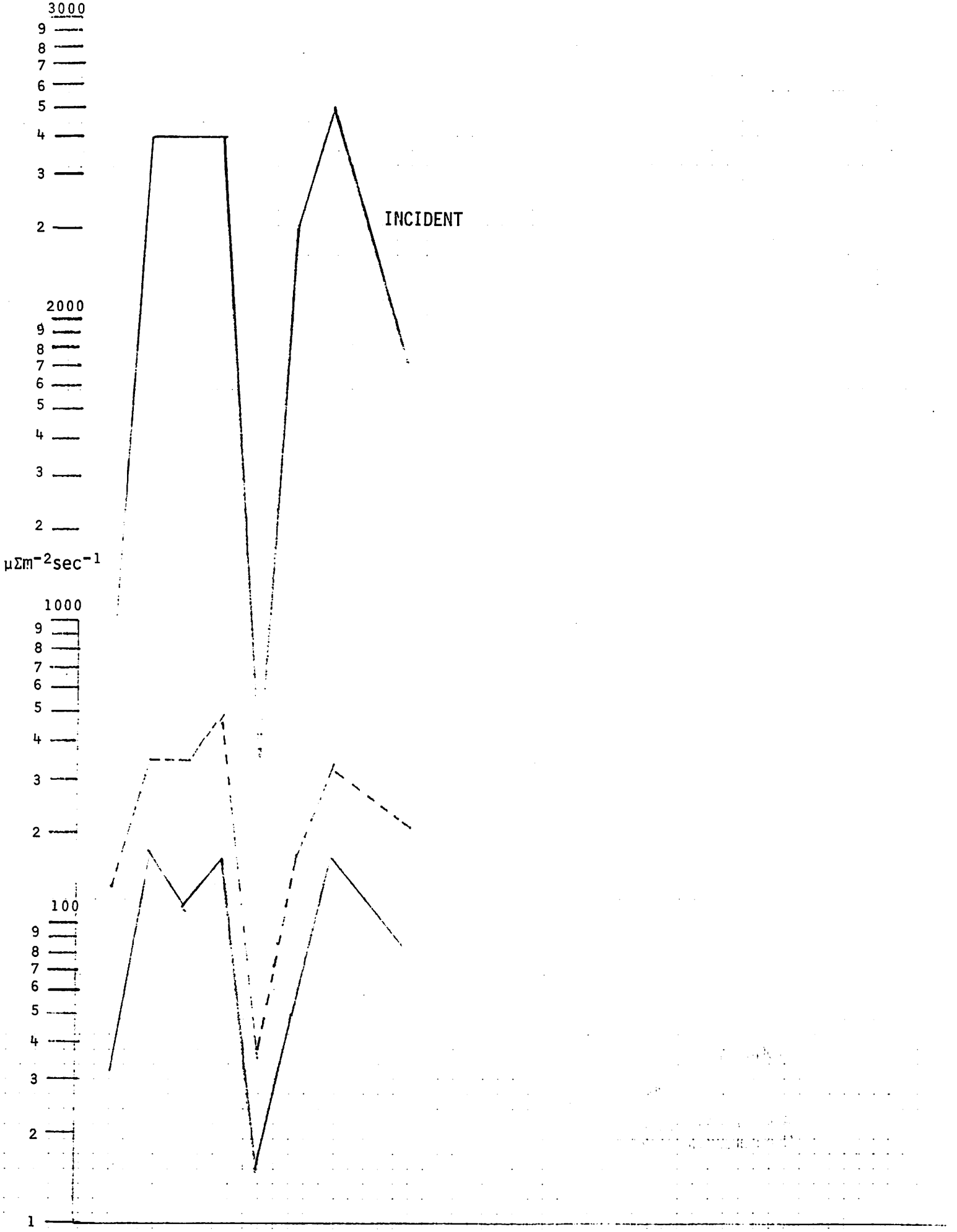

Figure 2. Photosynthetically Active Radiation at South Bass Island (CS-2), Ohio 1982