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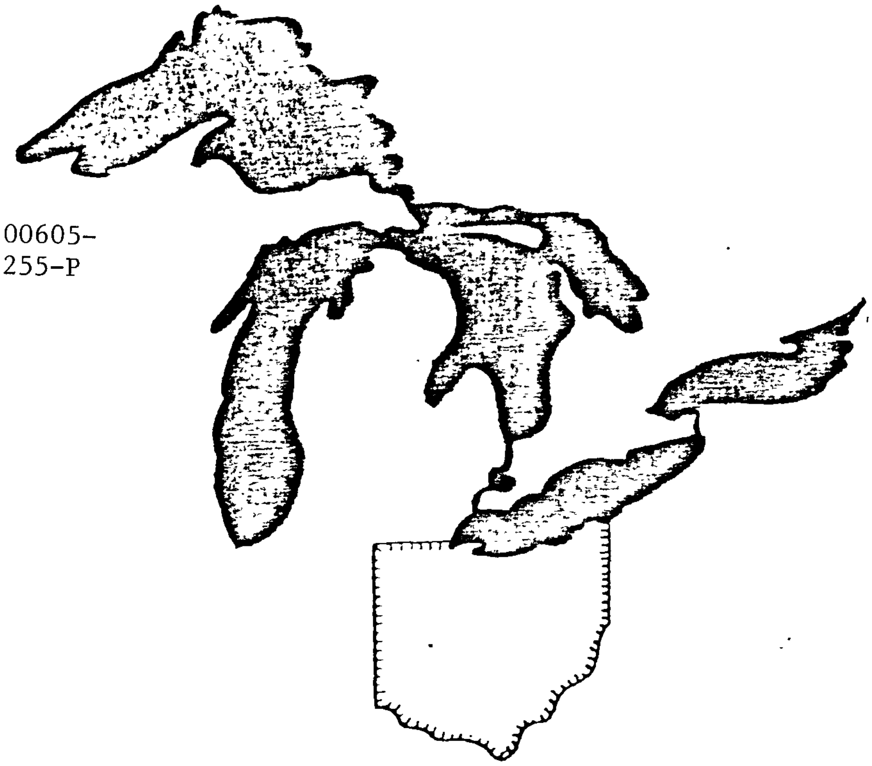

A PRELIMINARY REPORT ON THE DISTRIBUTION OF CLADOPHORA IN THE WESTERN BASIN OF LAKE ERIE

Prepared by

Mark E. Monaco

Richard C. Lorenz

Charles E. Herdendorf

Prepared for

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Project Officer: Clifford Risley, Jr.

OHIO STATE UNIVERSITY
CENTER FOR LAKE ERIE AREA RESEARCH
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INTRODUCTION

Cladophora is usually associated with eutrophic waters and is referred to as a nusiance alga, even though recent works indicate the important role it plays in the nearshore community. The alga grows profusely in the nearshore region of western Lake Erie and it commonly colonizes many different substrates both natural and artificial, such as boats and breakwalls.

Recently a considerable amount of knowledge on the growth dynamics and potential management of Cladophora in the Great Lakes has been gained. As part of the Great Lakes International Surveillance Plan (GLISP) the Lake Erie Cladophora Surveillance Program (LECSP) was initiated in 1979. The Center for Lake Erie Area Research has investigated the growth dynamics of Cladophora for the past three years at two routinely monitored sites visited bimonthly from April to November. This paper is a part of the western Lake Erie program that was sponsored by the USEPA.

The two routinely monitored sites are located at Stony Point, Michigan and at South Bass Island, Ohio. To expand on this study, a survey of the western basin of Lake Erie was conducted in late June of 1981 to determine the areal and vertical distribution of Cladophora.

Cladophora Survey of the Western Basin

The survey was conducted using a coordinated effort consisting of a boat, SCUBA tecniques and low-level aircraft to identify the major areas of colonization (fig. 1). At 10 of the 23 stations visited, light was measured as Photsynthetic Active Radiation (PAR) in units of $\mu\xi/n^2$sec, Secchi disk transparency, surface water temperature, biomass filament length, % coverage, and maximum depth of growth was determined. At the other stations, the presence of Cladophora and other major epilethic filamentous algae were additionally noted.

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.

Exposed bedrock is found along the shorelines and as shelves in the eastern sides of most of the islands and as isolated peaks on the tops of the major reefs.

Survey results identified Cladophora on the vast majority of all suitable substrate in the western basin, including rocky shorelines, submerged shoreline shelves, reefs and man-made structures such as concrete, stone, wood and metal breakwalls, buoys and ships. In areas with unsuitable natural substrate, the alga was observed on man-made structures, such as breakwalls and buoys.

The depth to which *Cladophora* was found on the island shelves and reefs varied with location (Table 1). Depth of colonization was generally greater the further north the site was located. Correspondingly, Secchi transparencies were greater and the extinction coefficients of light (K) were smaller at the northern sites. Depth distribution of *Cladophora* was greatest on the isolated reef areas, not located near land.

From the data generated during the survey and the three years of routine monitoring, a field light value of approximately 50 $\mu E/m^2 sec$ or less was hypothesized to be limiting the vertical distribution of *Cladophora* colonization in the western basin of Lake Erie.

LIGHT GRADIENT EXPERIMENT

To investigate the hypothesis that light levels of approximately 50 $\mu E/m^2 sec$ or less are limiting *Cladophora* growth, a light gradient experiment was performed in the laboratory at South Bass Island. The light gradient experiement was designed to quantify the requirement to sustain *Cladophora* growth, under conditions as close to the natural lake environment as possible. These values were then compared to the survey results.

The gradient consisted of ten 114 liter tanks with a flow through water system. Water was pumped from the lake into the lab at a flow rate of 57 l/hr. Water temperature was maintained at 15^0 C. and each tank was agitated by two air lines venting near the bottom to provide water movement and a constant temperature. Light levels were regulated in the tanks from 0-170 $\mu E/m^2 sec$. Light was measured using a Li-Cor Corporation quantern light meter with a spherical sensor. Phosphorous and nitrogen were routinely monitored and were not found to be limiting.

Values of PAR capable of supporting *Cladophora* growth were assessed by the increase in filament length. The data presented in Table 2 represents the average increase in filament length on a weekly basis under the various light levels. After one week, growth was evident at light levels of approximately 50 $\mu E/m^2 sec$ and greater (fig. 3).

Two growth regimes are evident in fig. 3. At light levels of approximately 50 $\mu E/m^2 sec$ and greater a much higher rate of growth was obtained than at the lower light levels. Light levels of approximately 30-50 $\mu E/m^2 sec$ supported a minimal amount of growth, as evident by the steeper slope of the plots. At values less than 30$\mu E/m^2 sec$, growth was not supported. From this data it was concluded that under laboratory conditions that 30-50 $\mu E/m^2 sec$ represented the minimal critical light value capable of supporting *Cladophora* growth.

DISCUSSION

In extrapolating the results from the light gradient experiments to the natural environment, several factors must be considered. The light levels in the gradient were constant for the total 14 hour light period being instantly turned on or off resulting in either 100% light or darkness. The 14 hour laboratory photoperiod, as compared to the natural environments twilight effect results in a 40% greater total daily illumination in the lab.

If the light value of 50 $\mu E/m^2sec$, which was generated from field observations is corrected for the 40% reduction due to the twilight effects, the equivalent of the field value to a constant light intensity is 30 $\mu E/m^2sec$. This value correlates with the minimum light level of 30 $\mu E/m^2sec$ observed to support growth in the laboratory experiment. Thus a light level of approximately 30 $\mu E/m^2sec$ is limiting to growth under the constant light level conditions in the laboratory which corresponds to a light value of 50 $\mu E/m^2sec$ under natural daylight conditions.

To test the hypothesis that a value of approximately 50 $\mu E/m^2sec$ would be expected to occur under average conditions for the site. I has been shown that,

$$I_Z = I_O e^{-KZ} \qquad (1)$$

where: I_Z = PAR at depth Z

I_O = incident PAR

K = extinction coefficient

Z = depth

The extinction coefficient (K) for each site was calculated from light profile data taken at each site. Equation 1 may be rewritten as follows, to solve for K.

$$K = \frac{\ln I_O - \ln I_Z}{Z} \qquad (2)$$

Once the extinction coefficient is know the depth at which 50 $\mu E/m^2sec$ will occur at each site can be calculated by rewriting Equation 1 as,

$$Z = \frac{\ln I_O - \ln I_Z}{K} \qquad (3)$$

where: K is site specific calculated value

I_Z is 50 $\mu E/m^2sec$, the minimum light value for growth

I_O is indicent light

An average incident light (I_0) value of 2000 μE/m²sec was used in all calculations to eliminate the variability between sites sampled at different times of the day and under different weather conditions. The 2000 μE/m²sec recorded at the two routinely monitored sites, from May - July, 1980. Equations 3 thus becomes,

$$Z = \frac{\text{In}2000 - \text{In}56}{\text{site specific } K} \qquad (4)$$

where: Z represents the depth at which PAR will be 50 μE/n²sec.

If 50 μ E/m² sec is the minimum level of PAR capable of supporting Cladophora the calculated depth from Equation 4 should be similar to the field observed depth of deepest colonization at that site. The calculated depth at which 50 μ E/m² sec was obtained and actual depth to which the alga was observed compated well (Table 3). The several reef areas where the 50 μ E/m² sec depth was greater than the observed depth of growth can possibly be explained by the movement of sediment on and off deeper portions of the reefs. For example, areas of sand were encountered on Chickenolee Reef. Cladophora filaments may also have detached at the deeper depths prior to the time of the survey in late June. Old holdfasts were evident at the deeper deptsh of Gull Island Shoal.

The results of routine monitoring, the light gradient experiment, and the survey of the western basin all support the theory that Cladophora in western Lake Erie is light-limited at PAR levels below approximately 50 μ E/m² sec. The depth at which light attenuates to 50 μ E/m² sec in the western basin varies from less than 2 m to over 7 m. The increase in the turbidity of western Lake Erie over the past century that has contributed to the decline of aquatic vascular plants (Stuckey 1979) may also have decreased the total colonizable substrate available to Cladophora. If in the future the turbidity of the basin decreases in response to decreased loadings and phosphoros levels remain above 1 μg P/l the quantity of Cladophora would increase due to a greater vertical distribution.

TABLE 1

WESTERN BASIN CLADOPHORA SURVEY OBSERVATIONS, 1980 AND 1981

Location*	Substrate	Deepest depth of growth (m)	Secchi Transparency (m)	k**	Surface Water Temperature (°C)
1981					
Marblehead Peninsula	Limestone Bedrock	2.5	0.80	1.59	22
Catawba Point, Ohio	Dolomite Bedrock	1.5	0.55	----	22.5
East Kelly's Island	Limestone Bedrock	4.5	2.00	0.89	21
Gull Island Shoal	Limestone Bedrock	3.2	1.50	0.78	21
North Bass Island	Dolomite Bedrock	4.5	1.50	1.06	23.
Chickenolee Reef	Limestone Bedrock	6.0	2.15	0.68	22
West Sister Island	Limestone Bedrock	2.0	1.05	----	22.5
Middle Sister Island	Limestone Bedrock	3.0	1.45	----	22
East Sister Island	Limestone Bedrock	4.5	2.60	0.74	23.5
Colchester Reef	Limestone Bedrock	7.0	2.25	0.61	22
Middle Ground Shoal	Limestone Bedrock	4.0	2.15	0.40	21
South Bass Island	Dolomite Bedrock	3.0	1.30	1.13	21
Stony Point, Mich.	Limestone Bedrock	1.5	0.50	1.90	21
1980					
East Kelly's Island	Limestone Bedrock	3.4	1.60	----	21
Gull Island Shoal	Limestone Bedrock	3.8	1.95	0.88	22
Chickenolee Reef	Limestone Bedrock	4.6	2.20	0.49	23

*See F

**Extinction coefficient

TABLE 2

CLADOPHORA FILAMENT LENGTH (CM) INCREASE DURING THE LIGHT GRADIENT EXPERIMENT

LIGHT LEVEL ($\mu E/m^2$ sec)	from 10/30-11/6 (cm)	11/6-11/12 (cm)	11/12-11/18 (cm)	11/18-11/25 (cm)	TOTAL (cm)
0	0	0	0	0	0
6	0	0	1.5	0	1.5
14	0	0	0	0	0
29	0	1.5	2	2	5.5
44	0	2	1.5	4	7.5
55	0.5	2	4	3.5	10.0
79	2.5	4	11	12.5	30
168	5	16	11	22.5	54.5

TABLE 3

COMPARISON OF OBSERVED DEPTH OF CLADOPHORA COLONIZATION

TO PREDICTED 50$\mu E/m^2$.sec DEPTH

LOCATION 1981	K	PREDICTED Z_{50} $\mu E/m^2$.sec (m)	MAX. OBSERVED DEPTH (m)
Marblehead Peninsula	1.59	2.3	2.5
East Kelly's Island	0.89	4.1	4.5
Gull Island Shoal	0.78	4.7	3.2
North Bass Island	0.73	5.1	4.5
Chickenolee Reef	0.68	5.4	6.0 *
East Sister Island	0.74	5.0	4.5
Colchester Reef	0.61	6.1 **	7.0
Middle Ground Shoal	0.48	7.7	4.8 ***
Stony Point	1.90	1.9	1.5
South Bass Island	1.13	3.3	3.0
1980			
Gull Island Shoal	0.88	4.2	3.8
Chickenolee Reef	0.49	7.5	4.6 *
Stony Point	1.87	2.0	1.8
South Bass Island	0.95	3.8	3.0

* portions of reef covered with sand

** light reading late in the day

*** deepest depth not located due to flat and level topography of the reef and the presence of gill nets

K - extinction coefficient

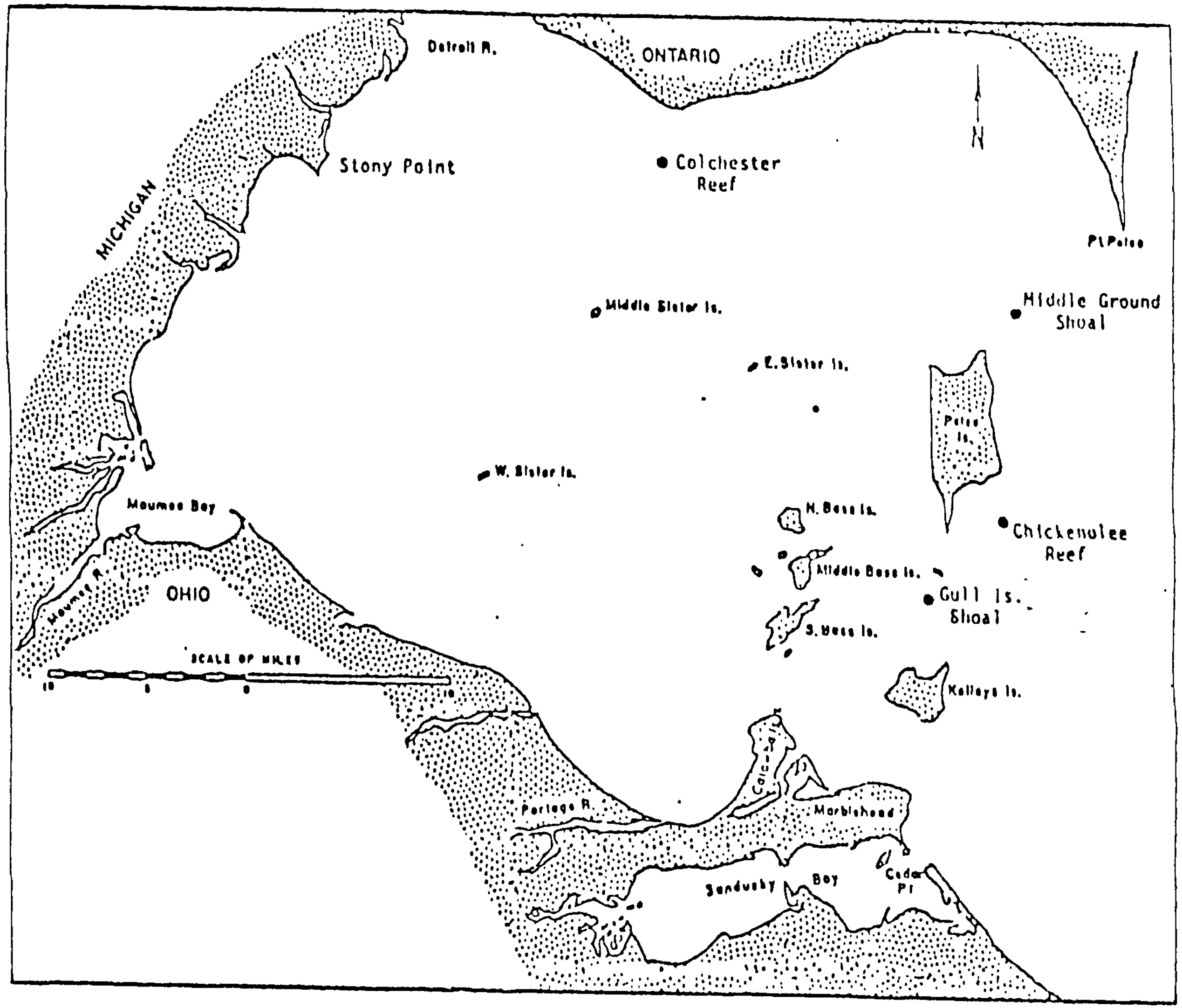

Figure 1 Western Lake Erie *Cladophora* Survey Station Locations.

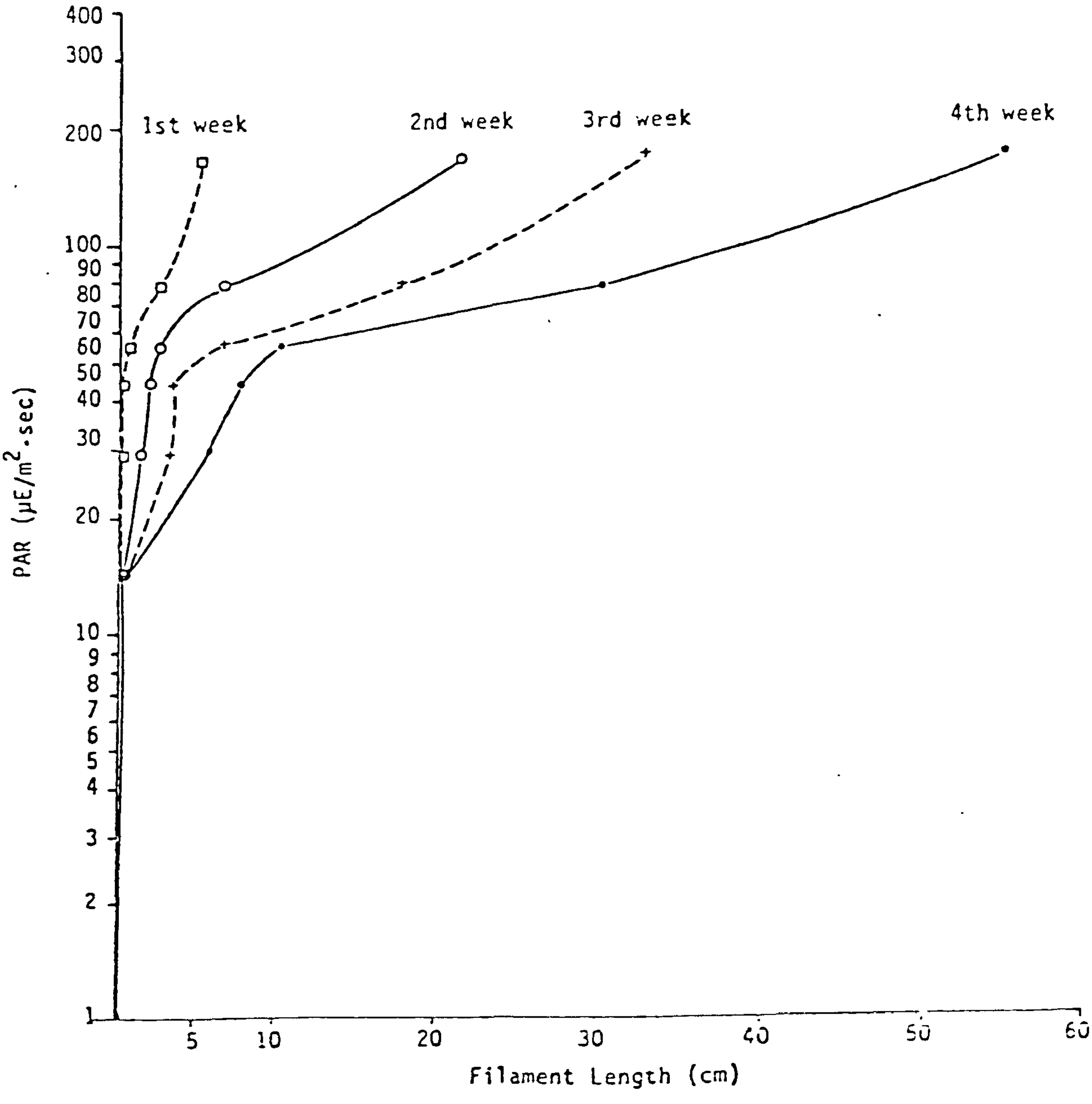

Figure 3 Cladophora Light Gradient Experiment, Filament Length Increase at the Various Light Levels.