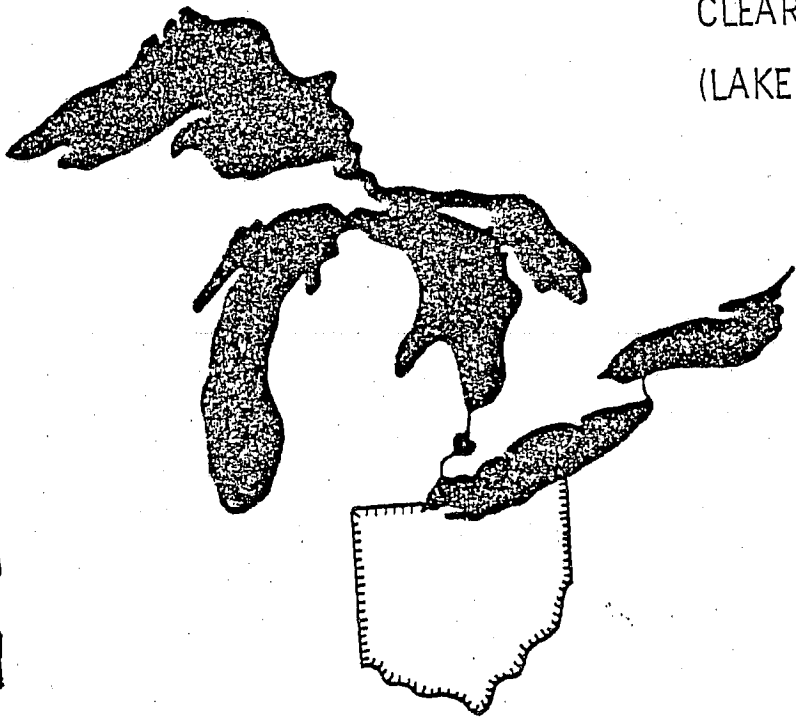


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LAKE ERIE INTENSIVE STUDY:  
NEARSHORE PHYTOPLANKTON--  
DETROIT RIVER TO HURON, OHIO

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## INTRODUCTION

The western basin of Lake Erie has been the subject of numerous phytoplankton studies since the early 1900's. Following Snow (1902), notable floristic investigations by Tiffany (1934, 1937), Downing (1970) and Taft (1971) were made in numerous habitats of the western basin and in the Bass Islands area in particular. Also, Frederick (1975) carried out a comparative floristic study in the East Harbor, Ohio region.

Limnological investigations by Chandler (1940, 1942a, 1942b, 1944) Davis (1954, 1962, 1964), Wright (1955) and Verduin (1954, 1964) were conducted in the Lake Erie western basin region. Algal distribution, ecology and physiology were studied at length in these works.

An environmental impact study conducted by the U.S. Army Corps of Engineers (1976) provided phytoplankton data for the Maumee Bay area while the Canada Centre for Inland Waters (Munawar and Munawar, 1975) studied phytoplankton communities off Sandusky, Ohio during 1970. The Center for Lake Erie Area Research has conducted limnological studies in Maumee Bay (Herdendorf et al., 1977) off Locust Point (Reutter et al., 1979) and in Sandusky Bay (CLEAR, 1975). Although numerous phytoplankton investigations have been conducted in the western basin of Lake Erie, none to date have studied the inshore and offshore differences of phytoplankton communities in a detailed manner. This study was initiated to provide data to determine differences existing between the phytoplankton communities of the inshore and offshore regions. These data may also allow the identification of variations in phytoplankton communities due to the differences in contributing land masses in Michigan and Ohio.

## METHODS

Phytoplankton samples were taken at 77 nearshore stations over a four-cruise sampling period in 1978 (Table 1). Of this total, 46 stations were considered inshore sampling stations, while 21 stations were considered offshore areas. The inshore stations were located 0.2 to 2.0 km from the shoreline, while the offshore stations were located 4.5 to 7.0 km from shore (Figure 1). Samples for the first cruise of 1979 were taken at the same stations as the previous year while samples for cruises 2, 3, and 4 were taken only from stations M3, M14, O5, O24, O35 and O46. These six stations were selected by the contractor. The 1979 cruise dates may be found in Table 1 and the stations located in Figure 1. The sampling stations were selected to indicate phytoplankton community trends located off specific geographical areas of the Michigan and Ohio shoreline.

Whole water samples were taken from the R/V Hydra using a submersible pump at one meter below the lake surface and one meter above the lake bottom. At shallow stations (<4m) samples were obtained at the surface using a small boat. Plankton samples were preserved immediately with modified Lugol's iodine solution and retained for subsequent analysis. From 0.2 to 10 ml of

the water samples were concentrated in sedimentation chambers and enumerated by the Utermohl technique (Utermohl 1958). The counting method employed utilized different magnifications for counting net, nanno, and ultraplankton. Identification of phytoplankton was made to species whenever possible while cell dimensions were recorded for biomass determinations. Although counts were recorded in cells/ml, the following biomass data are expressed as ug/l. Only surface phytoplankton information is presented in the following sections.

## RESULTS

### 1978 Comprehensive Station Biomass Data

Three types of phytoplankton biomass data are provided from this 1978 nearshore investigation: comprehensive station data reflect average values derived from the combination of inshore, offshore, and in-between stations; inshore data reflect the phytoplankton biomass for sampling stations located 0.2 km to 2.0 km from shore, and offshore data indicate the biomass data for stations 4.5 to 7.0 km from shore (Figure 1).

The 1978 comprehensive station mean biomass values for the blue-greens, greens, diatoms, chrysophytes, cryptophytes and dinoflagellates are illustrated in Figure 2 and Table 2. These figures indicate the dominance of the blue-green algae throughout most of the four-cruise period. Following cruise 1, during which the diatoms contributed the greatest proportion of the algal biomass (Table 2), the blue-greens became dominant comprising over 75 percent of the biomass encountered in the remaining cruises. The blue-greens' biomass drastically increased from cruise 1 (23 percent) to cruise 2 (75 percent) and from that point contributed the overwhelming majority of the algal biomass in the study period (Table 2).

The green algae biomass began below both the blue-greens and the diatoms in cruise 1 (Table 2 and Figure 2). After cruise 1 the greens increased to biomass values above the diatoms in cruises 2 and 3 but remained well below the blue-greens (Figure 2).

The diatoms provided the greatest proportion of algal biomass in cruise 1 and then contributed a much smaller proportion of biomass than did the blue-greens in cruises 2-4 (Figure 2 and Table 2). Aside from the first cruise, the diatoms and greens contributed similar proportions of biomass through the study (Table 2).

The dinoflagellates and cryptophytes contributed similar proportions of biomass throughout the 1978 study. Both groups provided lesser amounts of biomass than did the blue-greens, greens, and (in all but one cruise) the diatoms (Figure 2).

The chrysophyte biomass values varied a great deal from cruise to cruise (Figure 2). This group did not provide significant quantities of biomass during the study, with its greatest contribution being only 1.0 percent (Table 2).

### 1978 Inshore and Offshore Biomass Data

The inshore and offshore phytoplankton biomass data, represented in Figures 3 and 4 respectively, illustrate the greater concentrations of biomass at (the majority of) inshore rather than offshore stations. Table 5 provides further documentation of the inshore dominance by showing the percentage of total algal biomass found in inshore, compared to offshore, stations. For example, in cruise 1 the inshore areas contained 295.5 percent more green algae biomass than did the offshore areas (Table 5). Four exceptions to the inshore dominance are indicated in Table 5.

As was shown previously by the comprehensive station comparisons, the blue-greens constituted a majority of the biomass at the inshore areas of cruises 2, 3 and 4 (Figures 2 and 3) and provided a majority of the biomass in all four cruises at the offshore areas (Figure 4). In both offshore and inshore regions the group increased from its lowest values in cruise 1 and continued to increase through cruises 2, 3, and 4 (Figures 3 and 4). These increases placed the blue-greens well above the other algal groups in biomass contributions for both regions.

The green algae and the diatoms contributed similar amounts of biomass in at least three of the four cruises of the inshore comparison (Figure 3). During the first cruise the diatoms exceeded the greens but in cruises 2, 3, and 4 the two groups constituted similar proportions of the total biomass (Table 3) at the inshore stations. The green algae biomass remained below the biomass levels of the blue-greens throughout the four cruises while the diatoms only exceeded the blue-greens in the first cruise (Figure 3). In the offshore region the greens and diatoms contributed similar amounts of biomass in the third and fourth cruises. The diatoms constituted greater proportions of biomass than the greens in cruise 1 and lesser proportion in cruise 2 (Figure 4). The greens and diatoms remained well below the blue-greens throughout the four cruises in the offshore zone.

The dinoflagellates and cryptophytes follow similar biomass trends in the inshore regions along with contributing similar proportions of biomass throughout the study (Figure 3 and Table 3). These groups are below the biomass concentrations of the greens and diatoms and well below the biomass contributions of the blue-greens in the inshore region.

In the offshore areas the dinoflagellates and cryptophytes again follow similar biomass trends through the 4 cruises (Figure 4). The cryptophytes exceed the greens and diatoms in the second cruise and the diatoms alone in cruise 3. The dinoflagellates and cryptophytes remained below the greens and diatoms in the first and fourth cruises (Figure 4). The dinoflagellates and cryptophytes remained well below the blue-greens throughout the four cruises in the offshore areas (Table 4).

The chrysophytes present similar biomass trends at in- and offshore regions (Figures 3 and 4). The group remains well below the other five groups throughout the study period in both inshore and offshore areas and contributes comparatively insignificant proportions of biomass (Tables 3 and 4).

### Comparisons of 1978 Phytoplankton Biomass by Reach

The 1978 nearshore data was also examined in order to locate the differences in phytoplankton communities by reaches or the areas of land off which the samples were taken (Figure 1 and Table 1). These data are divided by comprehensive station, inshore and offshore portions as were the data in the previous sections (Figures 5, 6 and 7). Biomass totals representing all six major algal groups for each reach are presented in (Tables 6, 7 and 8).

The comprehensive station biomass values (Table 6) indicate a general increase in total values for the 7 reaches over the 4 cruises (Figure 5). Reaches 2, 3, 6 and 1 begin above and remain at greater levels than reaches 7, 4 and 5 (Figure 5). Following cruise 1, reach 6 was found to contain greater amounts of biomass than the other areas sampled with reach 3 containing the greatest biomass in cruise 1. Reaches 4 and 5 contributed the least biomass in cruise 1 and along with reach 7 contained the least biomass in cruises 2, 3, and 4 (Figure 5).

The inshore biomass values (Figure 6) reflect a general increase in biomass for the 7 reaches over the 4 cruises as was seen in the comprehensive reach values (Figure 5). Reaches 3, 2, 6 and 1 began at biomass levels above reaches 7, 5, and 4 and remained at greater levels over the 4 cruises. Reach 6 began below reaches 3 and 2 in cruise 1 but increased above the other reaches in cruises 2, 3, and 4. Reaches 2, 3, and 1 contained similar amounts of biomass throughout the study and remained above the biomass of reaches 7, 5 and 4 (Figure 6). Reach 6 will only be considered as an inshore reach. The area will not be included in the presentation of the offshore data because of a lack of stations outside the bay that could be considered offshore. Sandusky Bay (reach 6) is a homogeneous area in terms of the limnological conditions in the bay as well as the phytoplankton communities contained there. These similarities do not allow the designation of offshore areas within the bay.

The offshore biomass figures are represented in Figure 7. Offshore reaches 1-5 all increase from cruise 1 to cruise 2 followed by differing cruise-to-cruise biomass trends for those reaches (Figure 7).

Reaches 2 and 3 maintain similar biomass totals in cruises 1-3 with differing totals at cruise 4 (Figure 7). These two areas (reaches 2 and 3) contained the greatest biomass of the 6 reaches considered in the offshore area. Reach 3 falls below reaches 4 and 5 in the fourth cruise and well below reach 2, which had contained lesser biomass in cruises 1, 2 and 3 (Figure 7).

### Comparisons of 1979 Phytoplankton by Cruise and by Reach

According to USEPA specifications, following cruise 1, 1979, a single station was sampled in reaches 1-3 and 5-7 (M13, M14, O5, O24, O35 and O46). Therefore the three forms of data presented for 1978 will not be possible for 1979 phytoplankton material. The stations sampled in 1979 are located in areas considered to be offshore in the 1978 data (Figure 1); consequently, any comparisons of 1978 and 1979 algal group contributions will be made between 1978 and 1979 offshore data only.



The 1979 phytoplankton biomass data are illustrated in Figure 8 and 1978 offshore values in Figure 4. In 1979, the blue-greens dominated concentrations of biomass in cruises 2, 3, while the diatoms contributed the most biomass in cruise 1. The blue-greens biomass was well above the other groups in these last three cruises of 1979 (51 percent, 88 percent, and 83 percent as was found in offshore 1978 (79.9 percent, 84.3 percent, 89.0 percent) (Tables 2 and 4). The greens and diatoms, although different in cruise 1, provided similar amounts of biomass in cruises 2, 3, and 4, as was the case with the 1978 offshore data. The dinoflagellates followed a similar cruise-to-cruise biomass pattern in 1978 and 1979, while no such similarity was evident with the cryptophytes. The cryptophytes provided similar amounts of biomass in cruises 1-3 in 1979, with a comparatively larger increase from cruises 3-4. The chrysophytes did not follow the 1978 cruise-to-cruise pattern, but did contribute the least biomass of the groups sampled in 1979 as they had in 1978.

The 1979 biomass totals for the 6 algal groups in reaches 1-7 are illustrated in Figure 9. Similar cruise-to-cruise patterns of biomass occurred in reaches 1, 2, 5, 6, and 7 while reach 3 differed from the other reaches in its cruise-to-cruise trends. Reach 4 data is available for only cruise 1. In comparison to the 1978 offshore stations (Figure 4), the 1979 reach totals spanned a lesser range of biomass values. No single reach presented a greater amount of biomass in a majority of cruises in 1979 although reach 6 had the greatest biomass of that year during cruise 4 (Figure 9).

#### CONCLUSIONS

- 1) Blue-greens dominated biomass concentrations in all time periods sampled in both years except for spring (cruise 1), when diatoms contributed greater amounts of biomass.
- 2) Inshore biomass concentrations were greater than those offshore in 1978.
- 3) In 1978 and 1979 the blue-greens, greens, and diatoms constituted greater amounts of biomass than did the dinoflagellates, cryptophytes, and chrysophytes.
- 4) The chrysophytes contributed much smaller amounts of biomass in both years compared to the other algal groups.
- 5) Reaches 2, 3 and 6 contained greater amounts of biomass in 1978 while lesser differences were seen in the 1979 reach data.

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TABLES

TABLE 1

NUMBER AND LOCATION OF REACHES SAMPLED  
AND LISTING OF SAMPLING STATIONS

Reach No.	Location	Stations		
		Comprehensive	Inshore	Offshore
1	Detroit River to Brest Bay	M-1 thru M-11	M-1, 2, 4, 7, 10, and 11	M-3, 6 and 9
2	Brest Bay to Maumee Bay	M-11 thru M-25	M-11, 12, 16, 17, 18, 22 and 23	M-15, 21 and 25
3	Maumee Bay	M-23 thru M-27; 0-1 thru 0-13	M-23, 26 and 27; 0-1, 2, 8, 9, 10, 11 and 12	M-25; 0-7 and 13
4	Maumee Bay to Toussaint River	0-12 thru 0-21	0-12, 14, 15, 16 and 21	0-13 and 20
5	Toussaint River to Sandusky Bay	0-21 thru 0-28	0-21, 22, 23, 26 and 27	0-25 and 28
6	Sandusky Bay	0-27 thru 0-40	0-27, 29, 30, 33, 34, 36, 37 and 40	0-28, 31, 32, 35 and 39
7	Sandusky Bay to Old Woman Creek	0-40 thru 0-50	0-40, 41, 43, 44 and 48	0-42, 47 and 50

TABLE 2  
 COMPREHENSIVE BIOMASS AND PERCENT COMPOSITION  
 OF BIOMASS PER CRUISE FOR THE MAJOR  
 ALGAL GROUPS IN 1978

ALGAL GROUP	CRUISE NO.			
	1	2	3	4
BIOMASS ( $\mu\text{g}/\text{l}$ ) AND COMPOSITION (%)				
Blue-Greens	21,020	962,858	1,387,562	1,590,771
	23%	75%	78%	87%
Greens	11,085	119,978	138,944	100,298
	12%	9%	8%	5%
Diatoms	50,366	65,630	117,618	109,428
	55%	5%	7%	6%
Dinoflagellates	3,486	43,912	61,469	5,632
	4%	3%	3%	0.30%
Chrysophytes	548	30	665	296
	1%	0.00%	0.03%	0.02%
Cryptophytes	4,570	89,933	52,097	18,823
	5%	7%	3%	3%

TABLE 3  
 INSHORE BIOMASS AND PERCENT COMPOSITION OF BIOMASS  
 PER CRUISE FOR THE MAJOR ALGAL GROUPS IN 1978

ALGAL GROUP	CRUISE NO.			
	1	2	3	4
BIOMASS ( $\mu\text{g}/\text{l}$ ) AND COMPOSITION (%)				
Blue-Greens	8,994	615,806	820,450	935,322
	16.5%	75.1%	75.9%	87.3%
Greens	8,397	78,694	98,250	61,964
	15.4%	9.6%	9.0%	5.7%
Diatoms	32,572	56,428	79,406	58,265
	59.9%	6.8%	7.3%	5.4%
Dinoflagellates	592	24,109	52,819	2,833
	1.0%	2.9%	4.8%	0.26%
Chrysophytes	146	9	387	121
	0.26%	0.00%	0.03%	0.01%
Cryptophytes	3,642	44,443	29,073	11,743
	6.7%	5.4%	2.6%	1.0%

TABLE 4  
 OFFSHORE BIOMASS AND PERCENT COMPOSITION  
 PER CRUISE FOR THE MAJOR ALGAL GROUPS IN 1978

ALGAL GROUP	CRUISE NO.			
	1	2	3	4
	BIOMASS ( $\mu\text{g}/\text{l}$ ) AND COMPOSITION (%)			
Blue-Greens	9,166	237,341	307,886	401,221
	44.0%	79.9%	84.3%	89.0%
Greens	2,123	20,471	16,562	16,650
	10.2%	6.8%	4.5%	3.6%
Diatoms	8,229	5,175	22,777	26,778
	39.5%	1.7%	6.2%	5.9%
Dinoflagellates	780	10,804	4,784	1,557
	3.7%	3.6%	1.3%	0.34%
Chrysophytes	216	14	208	61
	1.0%	0.0%	0.05%	0.01%
Cryptophytes	270	23,057	12,586	4,045
	1.2%	7.7%	3.4%	0.89%



TABLE 5

PERCENT DIFFERENCE BETWEEN 1978  
INSHORE BIOMASS ( $\mu\text{g}/\text{l}$ ) AND OFFSHORE  
BIOMASS ( $\mu\text{g}/\text{l}$ ) FOR THE MAJOR ALGAL GROUPS

ALGAL GROUP	CRUISE NUMBER				
	1	2	3	4	
Blue-Greens	2*	160	167	133	PERCENT DIFFERENCE INSHORE BIOMASS OFFSHORE BIOMASS
	8,994	615,806	820,450	935,322	
	9,166	237,341	307,886	401,221	
Greens	295	284	493	272	PERCENT DIFFERENCE INSHORE BIOMASS OFFSHORE BIOMASS
	8,397	78,694	98,250	61,964	
	2,123	20,471	16,562	16,650	
Diatoms	296	991	249	118	PERCENT DIFFERENCE INSHORE BIOMASS OFFSHORE BIOMASS
	32,572	56,428	79,406	58,265	
	8,229	5,175	22,777	26,778	
Dinoflagellates	32*	123	1,004	82	PERCENT DIFFERENCE INSHORE BIOMASS OFFSHORE BIOMASS
	592	24,109	52,819	2,833	
	780	10,804	4,784	1,557	
Chrysophytes	48*	55*	86	97	PERCENT DIFFERENCE INSHORE BIOMASS OFFSHORE BIOMASS
	146	9	387	121	
	216	14	208	61	
Cryptophytes	1,253	93	131	190	PERCENT DIFFERENCE INSHORE BIOMASS OFFSHORE BIOMASS
	3,642	4,443	29,073	11,743	
	270	23,057	12,586	4,045	

\*Offshore greater than inshore biomass

TABLE 6  
 TOTAL REACH BIOMASS ( $\mu\text{g/l}$ ) BY CRUISE  
 FOR 1978 COMPREHENSIVE STATIONS

CRUISE REACH	1	2	3	4
1	7,612	182,396	290,104	204,980
2	22,447	264,018	296,127	244,679
3	39,582	238,089	516,713	401,876
4	816	84,752	83,936	106,805
5	894	15,224	64,441	96,424
6	25,378	573,789	550,939	871,248
7	8,792	45,969	52,683	62,028

TABLE 7  
 TOTAL REACH BIOMASS ( $\mu\text{g}/\text{l}$ ) BY CRUISE  
 FOR 1978 INSHORE STATIONS

CRUISE REACH	1	2	3	4
1	5,199	123,136	217,762	126,919
2	13,397	152,840	126,051	132,212
3	30,181	140,514	307,165	257,426
4	475	66,641	57,402	93,192
5	770	2,440	48,301	61,720
6	355	385,025	341,204	492,157
7	4,269	23,005	29,279	36,338

TABLE 8  
 TOTAL REACH BIOMASS ( $\mu\text{g}/\text{l}$ ) BY CRUISE  
 FOR 1978 OFFSHORE STATIONS

CRUISE REACH	1	2	3	4
1	2,069	47,860	29,006	12,052
2	5,061	33,034	91,502	13,363
3	3,753	24,770	63,782	36,849
4	227	7,237	14,285	28,496
5	94	1,773	6,892	22,300
6	11,230	183,726	200,350	333,869
7	1,573	14,461	12,906	---

TABLE 9

COMPREHENSIVE BIOMASS AND PERCENT COMPOSITION  
OF BIOMASS PER CRUISE FOR THE MAJOR ALGAL GROUPS  
IN 1979

ALGAL GROUP	CRUISE NUMBER			
	1	2	3	4
	BIOMASS ( $\mu\text{g}/\text{l}$ ) AND COMPOSITION (%)			
Blue-Greens	42,404	63,320	239,214	529,085
	24%	51%	88%	83%
Greens	4,457	28,736	10,540	21,367
	3%	23%	4%	3%
Diatoms	122,728	16,748	14,424	66,539
	69%	13%	5%	10%
Dinoflagellates	1,978	11,916	800	472
	1%	10%	0.30%	0.07%
Chrysophytes	693	57	34	332
	0.40%	0.05%	0.01%	0.05%
Cryptophytes	4,812	3,513	5,472	16,329
	3%	3%	2%	3%

TABLE 10

- TOTAL REACH BIOMASS ( $\mu\text{g/l}$ ) BY CRUISE  
FOR 1979 COMPREHENSIVE STATIONS

CRUISE REACH	1	2	3	4	TOTAL
1	20,472	16,116	78,043	23,234	137,864
2	30,661	20,101	101,529	53,806	206,098
3	10,189	32,709	68,062	91,434	202,393
4	10,410	---	---	---	10,410
5	12,328	5,591	12,148	145,132	175,193
6	39,648	19,188	---	284,413	343,249
7	39,398	4,114	11,700	9,015	64,226

TABLE 11

AVERAGES, BY REACH, OF THE TOTAL INSHORE  
BIOMASS ( $\mu\text{g}/\text{l}$ ) AND OFFSHORE BIOMASS ( $\mu\text{g}/\text{l}$ )  
IN FOUR 1978 CRUISES

REACH	INSHORE	OFFSHORE
1	118,254	22,747
2	106,125	35,740
3	183,822	82,288
4	54,428	12,561
5	28,308	7,764
6	304,865	182,294
7	23,223	9,647

FIGURES



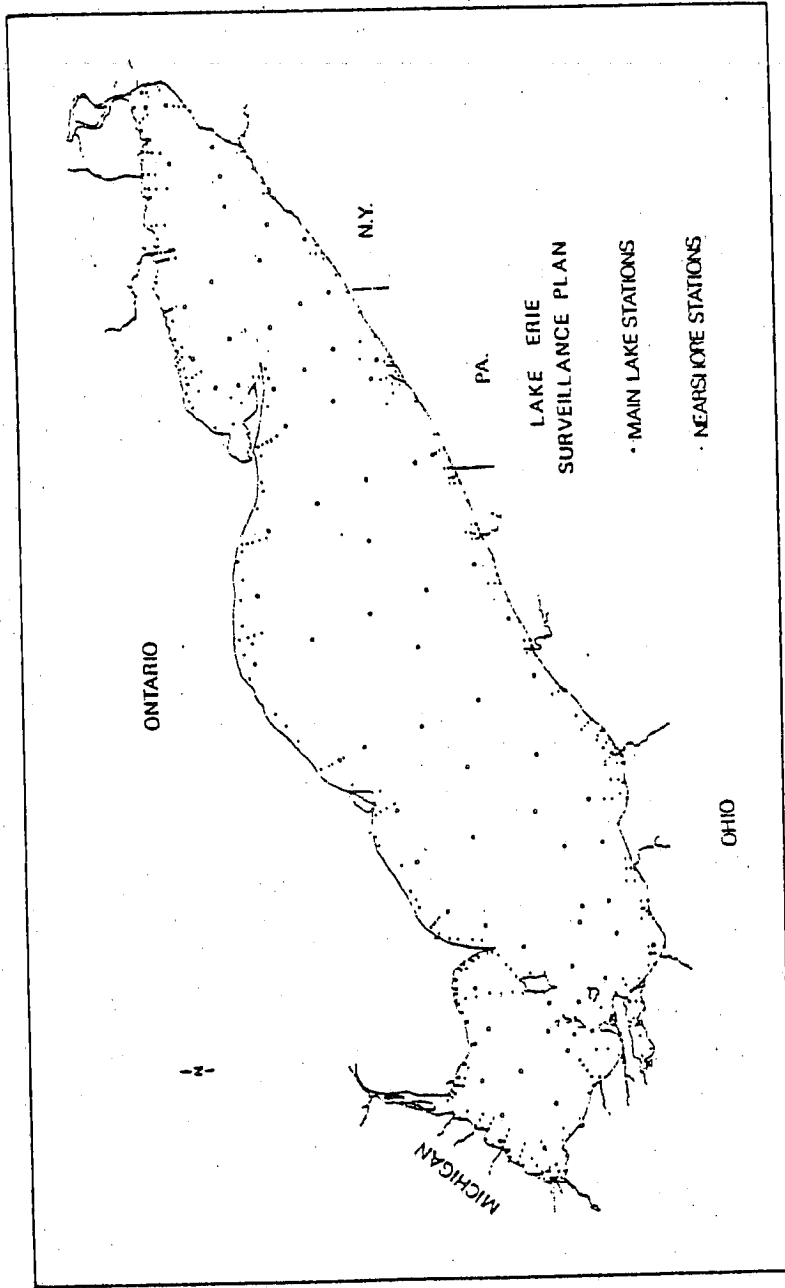


Figure 1. Lake Erie Main Lake and Nearshore Surveillance Stations, 1978-1979.

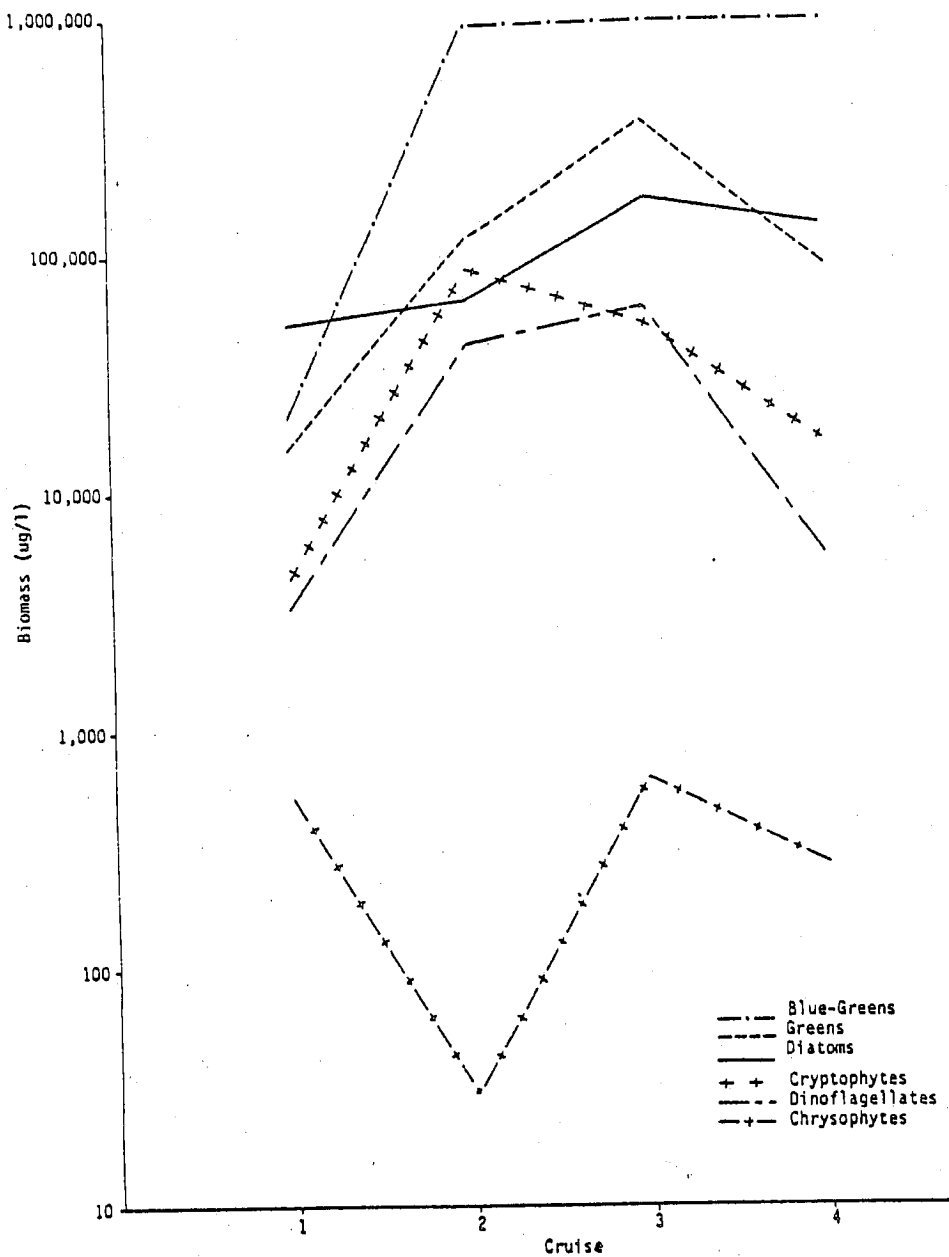


Figure 2. Comprehensive Station Biomass ( $\mu\text{g/l}$ ), by Cruise, for the Six Algal Groups in 1978.

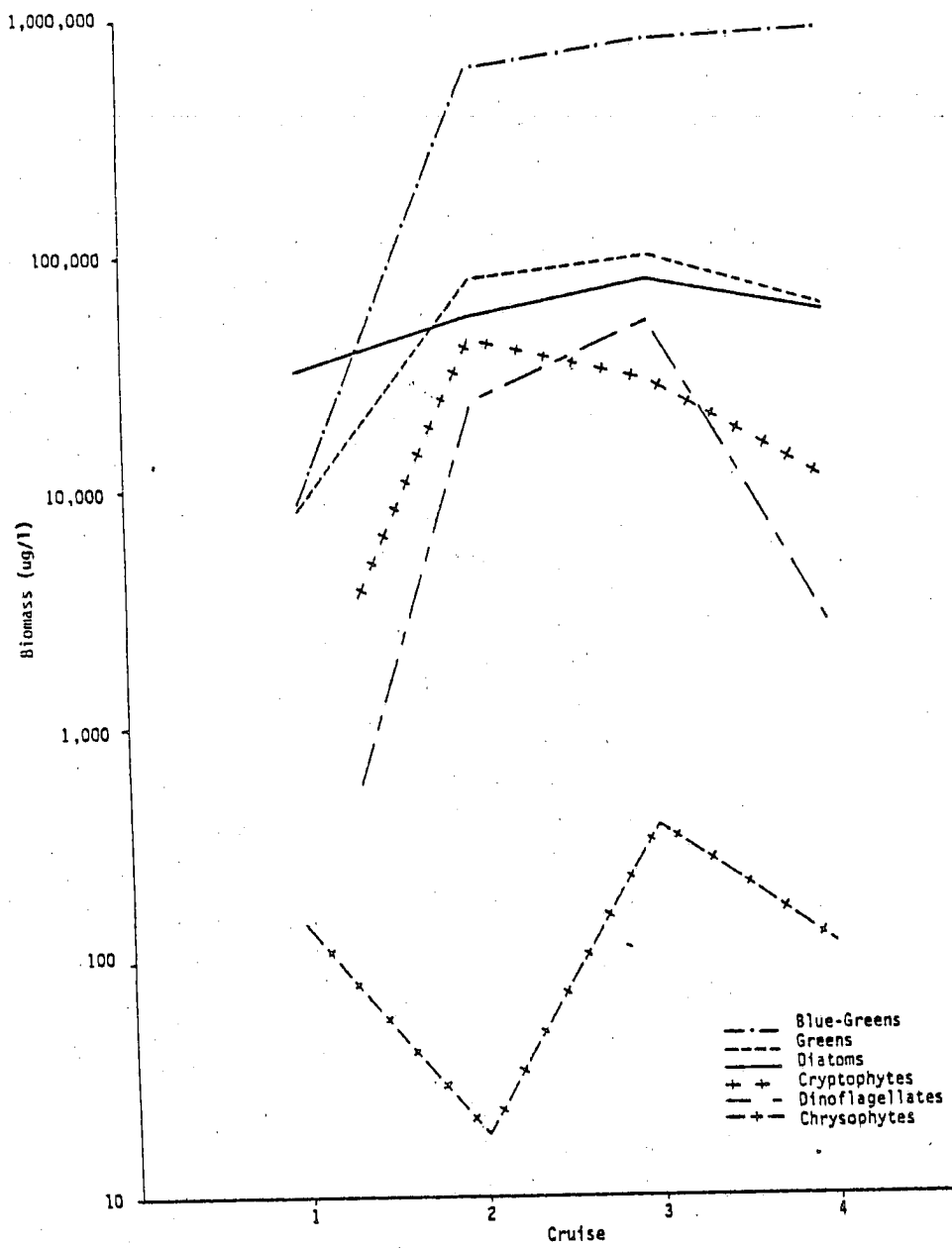


Figure 3. Inshore Biomass ( $\mu\text{g/l}$ ), by Cruise, for the Six Algal Groups in 1978.

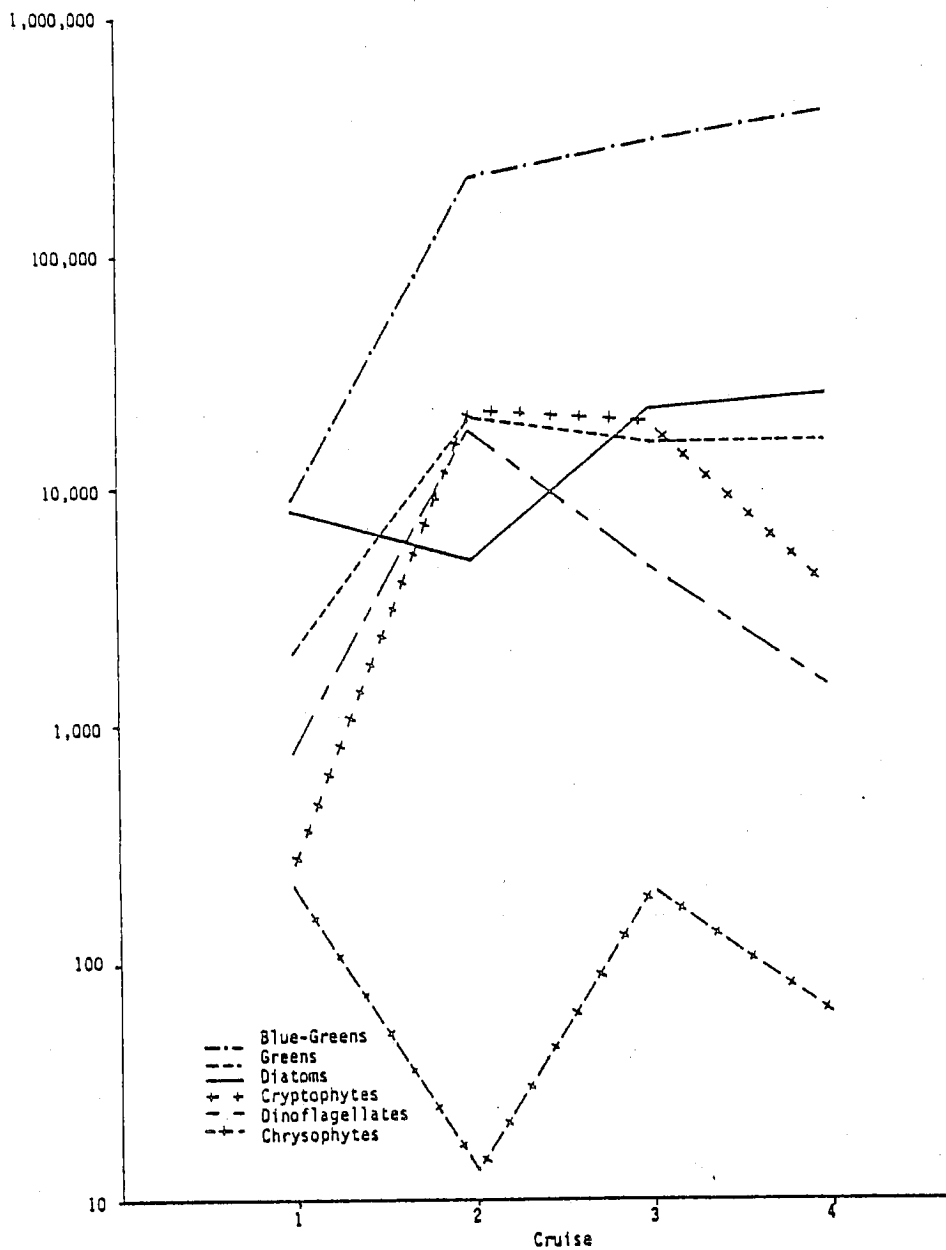


Figure 4. Offshore Biomass ( $\mu\text{g/l}$ ), by Cruise, for the Six Algal Groups in 1978.

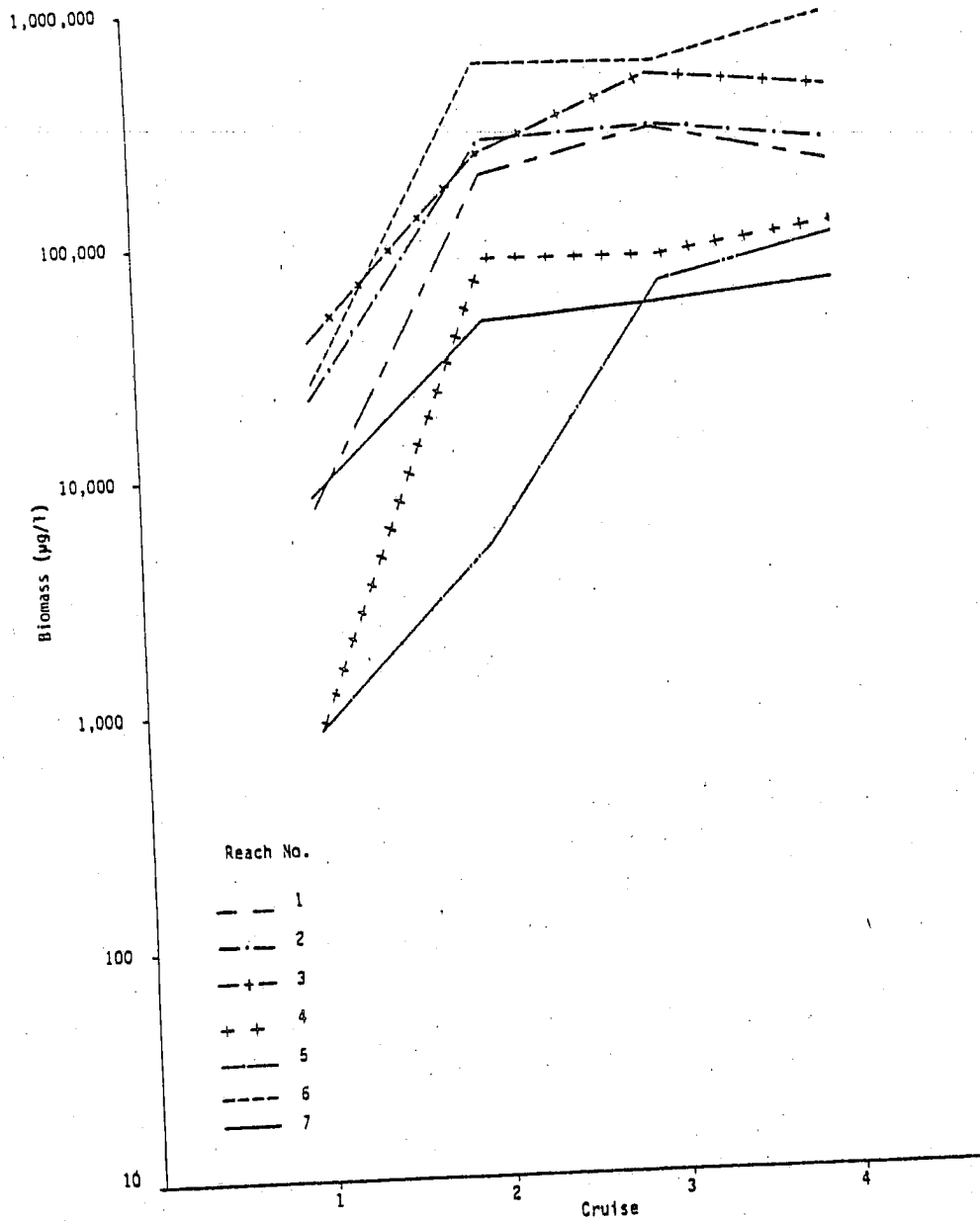


Figure 5. Biomass Totals ( $\mu\text{g/l}$ ), by Cruise, for the Seven Reaches of the 1978 Comprehensive Stations Over a Four Cruise Period.

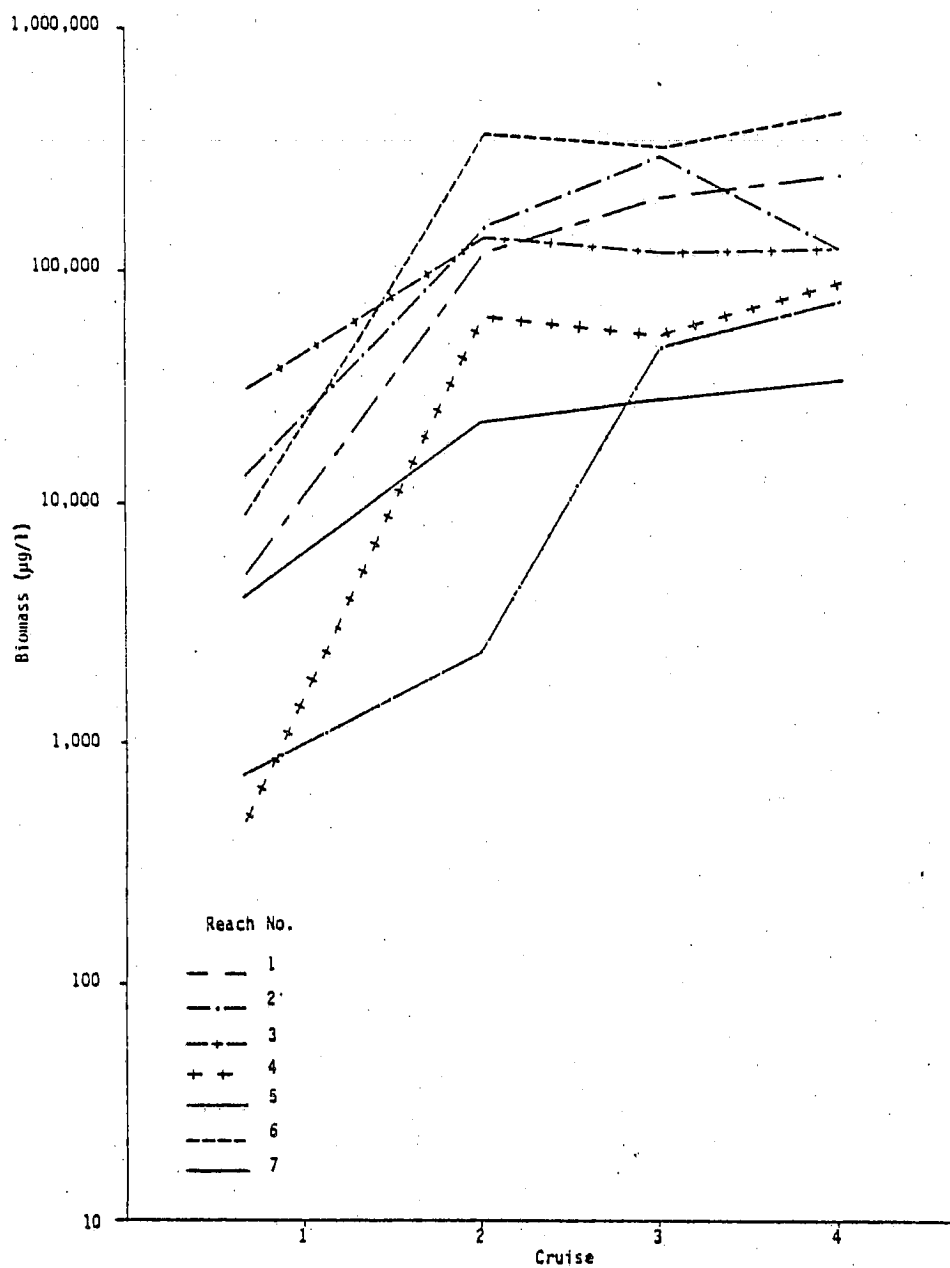


Figure 6. Biomass Totals ( $\mu\text{g/l}$ ), by Cruise, for the Seven Reaches of the 1978 Inshore Stations.

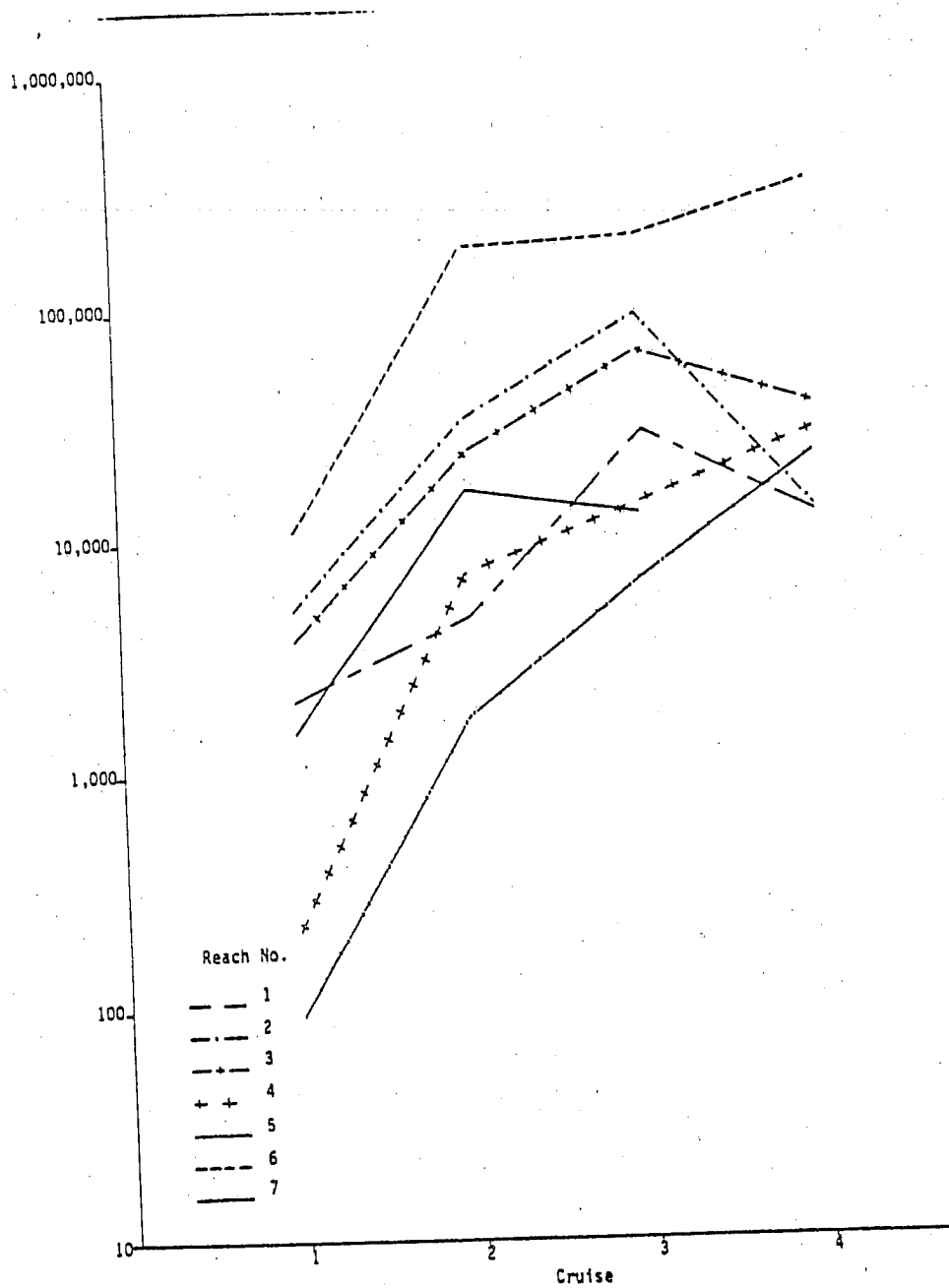


Figure 7. Total Reach Biomass ( $\mu\text{g/l}$ ), by Cruise, for 1978 Offshore Stations.

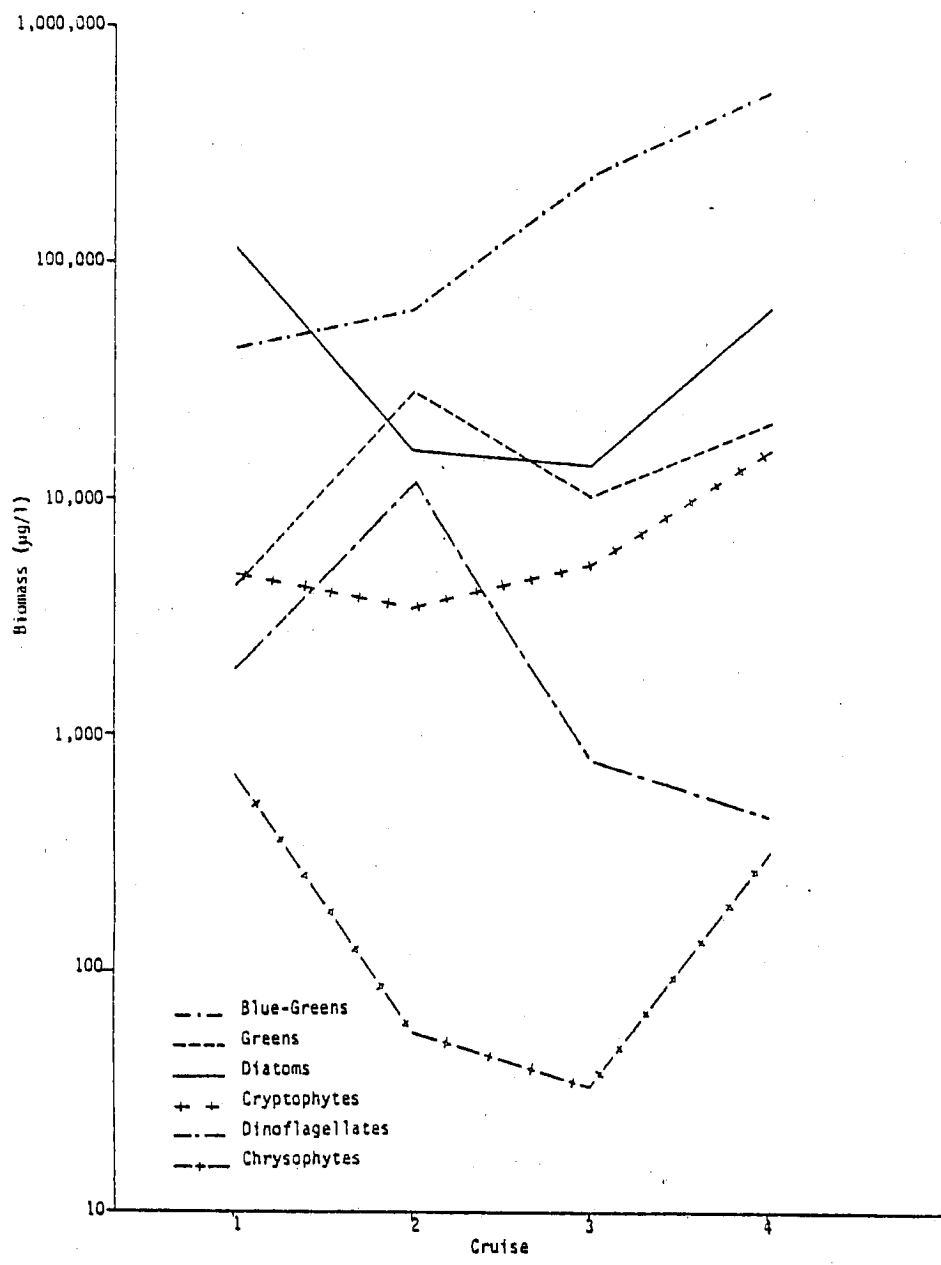


Figure 8. Comprehensive Station Biomass ( $\mu\text{g/l}$ ), by Cruise, for the Six Algal Groups in 1979.



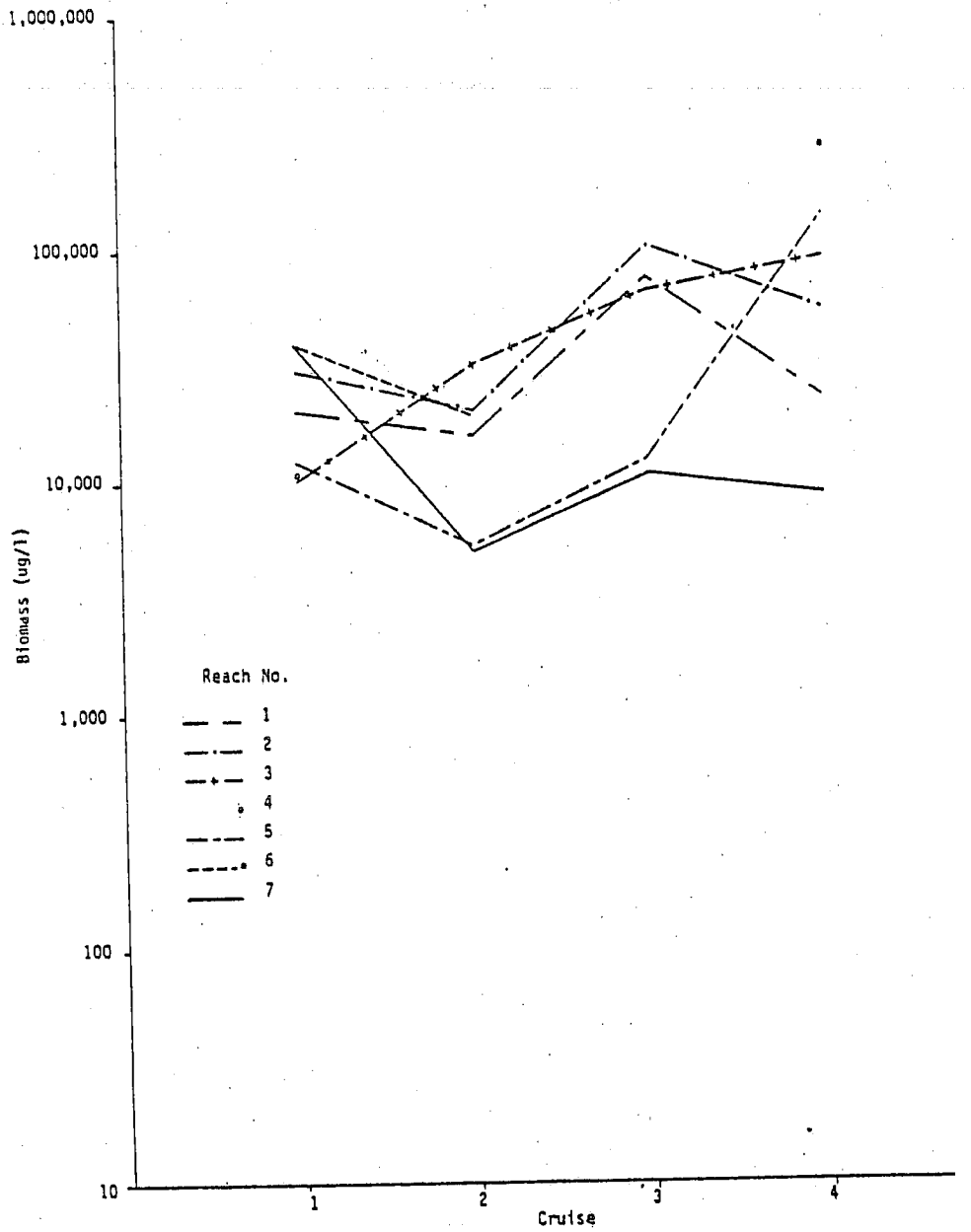


Figure 9. Total Reach Biomass, by Cruise, for the 1979 Comprehensive Stations.

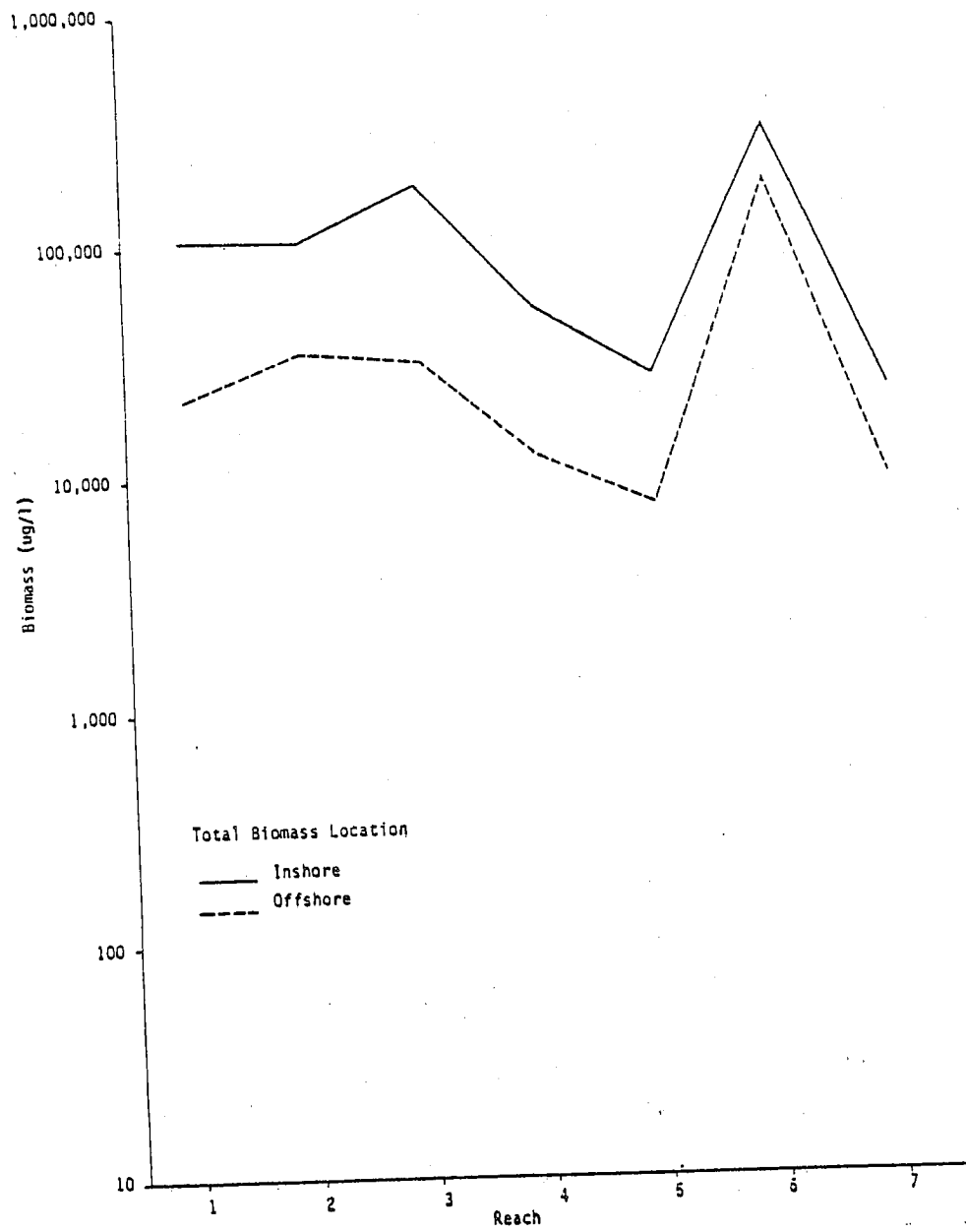


Figure 10. Average Values for 1978 Total Biomass Found in the Four Cruises of Each Inshore and Offshore Reach.